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A History of the European Space Agency

1958 – 1987

Volume II

The story of ESA, 1973 to 1987

by

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Authors' Preface

This volume deals with the history of the European Space Agency from 1973, the year which concluded Volume I of our study, to 1987, a year punctuated by a Ministerial Conference in The Hague at which a very ambitious programme intended to carry the European space effort into the new millennium was voted. It thus deals with the implementation of the palette of programmes in space science and applications, as well as the Ariane and Spacelab programmes, adopted by Ministers in the First and Second Package Deals in 1971 and 1973 respectively.

The material is divided into six main parts. The first provides an overview of the entire period. It deals, in chapter 1, with transition from ESRO and ELDO, which was wound down and dismantled, to the setting up of ESA in 1975. Chapter 2 comprises two elements; one summarises the main programmes handled in the rest of the book, the other describes the new space plans proposed by ESA Director General Reimar Lüst and his Executive to Ministers in Rome (1985) and then in The Hague, and surveys the decisions adopted on these occasions.

Part II of the book is dedicated to the science programme. It traces the evolution and consolidation of this activity in the ESA framework, describing the crisis which surrounded its funding in the early 1980s, the struggle to find a place for new space science disciplines like microgravity research, and the emergence of the Horizon 2000 Programme, with its concept of *cornerstones*.

Applications are covered in part III. One chapter each is devoted to the implementation of ESA's telecommunications, meteorological and aeronautical satellite programmes. The last was a failure, but the other two played a valuable role in consolidating Europe's presence in these two key sectors, and in the development of two operating agencies, Eutelsat and Eumetsat.

Ariane, Spacelab and the Space Station each have a section to themselves. The programmatic decisions regarding the European heavy launcher, its upgrade via Ariane-2 and Ariane-3 to Ariane-4, and the decision to develop an entirely new generation of launchers for the end of the century (Ariane-5) are described in Part IV. The difficulties surrounding the construction of Spacelab, and the definition of a scientifically meaningful programme to exploit it, are dealt with in Part V. The complexities of international collaboration in the space area with the United States, which is one of the leitmotifs of the story of the building of Spacelab, also inform the analysis of the Space Station presented in Part VI. Here the changing priorities of the United States weighed particularly heavily on the Europeans, but on Europeans who had learnt from their past mistakes and who were sufficiently self-confident and clear-sighted to build some protective measures into the agreements they reached.

A brief epilogue confronts the ambitious space programme adopted at The Hague with the realities of the new international order heralded by the dismantling of the Berlin Wall, and the new place which space activities, and international collaboration had for the United States and European governments after 1989.

The sources used for this book were those described in our Preface to Volume I. We shall not repeat them here. Certain people not mentioned before have also been particularly valuable sources of information and advice: Jean Arets, Michel Bignier, Luise Clemens, Gabriel Lafferranderie, André Lebeau, Dieter Lennertz, Raymond Orye, Heinrich Pfeffer, Bob Pfeiffer, Ian Pryke, Régis Tessier, and George Van Reeth. Bruce Battrick, Johann Oberlechner and Nathalie Tinjod, have all contributed to the production of this book. To them, and to all have helped us in countless ways to bring this huge project to fruition, we present our heartfelt thanks.

Abbreviations and Acronyms

AFC	Administrative and Finance Committee (ESRO, ESA)
AGARD	Advisory Group for Aerospace Research and Development (NATO)
ARPA	Advanced Research Projects Agency (USA)
ATT	American Telephone and Telegraph
AWG	Astrophysics Working Group (ESRO)
BAC	British Aircraft Company
BNCSR	British National Committee on Space Research
CALTECH	California Institute of Technology
CASDN	Comité d'Action Scientifique de la Défense Nationale (France)
CCTS	Coordinating Committee on Telecommunications Satellites (CEPT)
CEPT	Conférence Européenne des Postes et des Télécommunications
CERN	Centre Européen pour la Recherche Nucléaire
CETS	Conférence Européenne des Télécommunications par Satellites
CNES	Centre National d'Etudes Spatiales (France)
CNR	Consiglio Nazionale delle Ricerche
COPERS	Commission Préparatoire Européenne de Recherche Spatiale
COS-B	Cosmic Ray Satellite "B"
COSPAR	Committee on Space Research
CRS	Comité de Recherches Spatiales (France)
CSAGI	Comité Spécial pour l'Année Géophysique Internationale
CSO	Committee of Senior Officials (ESC)
CTS	Communications Technology Satellite (Canada)
DFG	Deutsche Forschungsgemeinschaft
DVLR	Deutsche Versuchsanstalt für Luft- und Raumfahrt
EBU	European Broadcasting Union
ECS	European Communications Satellite
EEC	European Economic Community
ELDO	European Launcher Development Organisation
ERS	Earth Resources Satellite
ESA	European Space Agency
ESC	European Space Conference
ESDAC	European Space Data Acquisition Centre
ESLAB	European Space Research Laboratory
ESOC	European Space Operations Centre
ESRANGE	European Space Range (Sounding Rockets and Related Research Programmes)
ESRIN	European Space Research Institute
ESRO	European Space Research Organisation
ESTEC	European Space Research and Technology Centre
ESTRACK	European Space Tracking and Telemetry Network
EUI	European University Institute
EXOSAT	European X ray Observatory Satellite

FIAT	Fabbrica Italiana Automobili Torino
FPP	Fundamental Physics Panel (ESRO)
GEERS	Groupe d'Etudes Européen pour la Recherche Spatiale
GEOS	Geostationary (Scentific) Satellite
GTST	Groupe de Travail Scientifique et Technologique (COPERS, also STWG)
HAEC	Historical Archives of the European Community (EUI)
HEAO	High Energy Astrophyiscs Observatory
HELOS	Highly Eccentric Lunar Occultation Satellite
HEOS	Highly Eccentric Orbit Satellite
HSD	Hawker Siddeley Dynamics
IAPC	Interim Application Programmes Committee
ICBM	Intercontinental Ballistic Missile
ICSU	International Council of Scientific Unions
IGY	International Geophysical Year
IRBM	Intermediate Range Ballistic Missile
ISEE	International Sun - Earth Explorer
ITU	International Telecommunication Union
IUE	International Ultraviolet Explorer
LAFWG	Legal, Administrative and Financial Working Group
LAS	Large Astronomical Satellite
LPAC	Launching Programmes Advisory Committee (ESRO)
LPSC	Launching Programmes Sub Committee (ESRO)
MARECS	Maritime European Communications Satellite
MAROTS	Maritime Orbiting Test Satellite
MAU	Million Accounting Units
MBB	Messerschmitt-Bölkow-Blohm
MFF	Million French Francs
MIT	Massachusetts Institute of Technology
NACA	National Advisory Committee on Aeronautics (USA)
NASA	National Aeronautics and Space Administration (USA)
NATO	North Atlantic Treaty Organisation
OAO	Orbiting Astronomical Observatory (NASA)
OECD	Organisation for Economic Cooperation and Development
OEEC	Organisation for European Economic Cooperation
OGO	Orbiting Geophysical Observatory (NASA)
ONERA	Office National d'Etudes et de Recherches Aéronautiques (France)
OSO	Orbiting Solar Observatory (NASA)
OTS	Orbiting Test Satellite
PAS	Perigee-Apogee System (ELDO Europa II rocket)
PB-TEL	Telecommunications Programme Board (ESRO)
PG	Preparatory Group (ELDO)
PSAC	President's Science Advisory Committee (USA)
PTT	Post, Telegraph and Telephone Administration
RAE	Royal Aircraft Establishment (UK)

SAS	Small Astronomical Satellite (NASA)
SEREB	Société pour l'Etude et la Réalisation d'Engins Ballistiques
SETIS	Société pour I'Etude et l'Intégration de Systèmes Spatiaux
SIRIO	Satellite Italiano per la Ricerca Industriale Operativa
SNIAS	Société Nationale Industrielle Aérospatiale
SPB	Scientific Programme Board (ESRO)
SPC	Science Programme Committee (ESA)
SSD	Space Science Department (ESA)
SSWG	Solar System Working Group (ESRO)
STC	Scientific and Technical Committee (ESRO)
STP	Supporting Technology Programme (ESRO)
STV	Satellite Test Vehicle (ELDO Europa I rocket)
STWG	Scientific and Technical Working Group (COPERS, also GTST)
TD	Thor-Delta (rocket)
TPS	Technical Planning Staff (CETS)
TWTA	Travelling Wave Tube Amplifier
UKATS	United Kingdom Application Technology Satellite
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USAF	United States Air Force
UVAS	Ultraviolet Astronomy Satellite
WIFAS	Wide-Field Astronomy Satellite
ZWO	Nederlandse Organisatie voor Zuiver Wetenschappelijk Onderzoek

Chapter 1: The Transition from ESRO and ELDO to ESA and the Drafting of the ESA Convention

J. Krige

Towards the end of 1970 the tensions that had characterised the collaborative European space effort for several years eventually came to a head. The attempts by France and Germany, strongly supported by Belgium, to persuade their partners of the need for a comprehensive programme including launchers, application satellites and science seemed to be getting nowhere. The British in particular maintained their opposition to building a European launcher, believing it to be politically unnecessary and commercially non-viable. With one of the big four European states resolutely opposed to a major component of the overall programme, most of the smaller countries opted for prudence.

In Chapter 11 of Volume 1 of this study we explained how two package deals resolved this impasse. The first was adopted in the framework of ESRO in 1971. In it Member States committed themselves to the development of applications satellites in the fields of telecommunications, aeronautical navigation, and meteorology, along with a mandatory space programme. The second, adopted by the European Space Conference meeting in 1973, saw the formal birth of the huge Ariane and Spacelab projects, and a maritime communications satellite.

In parallel with these programmatic choices there were ongoing discussions on the reforms to be made to ESRO and to ELDO, and of the modalities of a new, single European space agency. This chapter follows those debates in some detail paying particular attention to the institutional issues involved and to how they were eventually reflected in the Convention setting up the European Space Agency.

1.1 The reform of ESRO

At a meeting of the European Space Conference in November 1970 the delegations from Belgium, France and Germany announced that they were determined to go ahead with a comprehensive space programme on their own. They invited others to join them if they so chose. At the core of their programme was the development of communications satellites, which in turn meant (for them) the development of an independent launch capability. They also recognised the political and technical advantages of collaborating with the United States in the post-Apollo programme. To launch their new programme, however, and to maintain ESRO intact as a framework for pursuing it, it was essential, they believed, to reduce costs wherever possible, to re-distribute resources between different activities and to establish mechanisms which took account of the different priorities of the partners. ESRO had been set up as a scientific research organisation with a mandatory science programme to which all its Member States contributed on the basis of GNP. Thanks to a flexible interpretation of certain clauses of its Convention, and of Article VIII in particular, originally invoked to solve the TD crisis, it had been possible to pursue pre-operational applications programmes as "Special Projects" inside the organisation. Now the time had come, on the basis of past experience and political realities, to reform the organisation along the lines demanded by the new situation.

At the ESRO Council meeting held in December 1970 the delegations from Belgium and France identified some of the areas where they were looking for changes.[1] The French delegate wanted four main procedural reforms. Firstly, there would no longer be financial envelopes accorded globally to the organisation within which individual projects would be funded. Rather, decisions would be taken project-by-project, Member States would be free to choose the projects they participated in, and they would accept to see it through to completion, thus avoiding three-year ceilings. Secondly, the votes in

[1] The minutes are ESRO/C/MIN/35, 12 January 1971, meeting held on 22 December 1970. The statements by the Belgian and French delegations are in Annex II and III respectively.

each project would be weighted according to the level of participation in it by a Member State. Thirdly, when designing and costing a project ESRO had to make maximum use of the facilities in each participating State, and to decide whether to allocate the work involved to one of its establishments, to a national establishment or to European industrial consortia. Finally, all satellites had to be designed to be compatible with the European launcher. This project-by-project approach, France and Belgium pointed out, called for new methods of accounting and of project management in ESRO such that capital and running costs were clearly identified and charged to the specific project to which they belonged.

Both delegations insisted that, granted the enormous financial load that their 'coherent' programme imposed, they would have to reduce their contribution to a science programme. The Belgian delegate said that it was not prepared to participate in any such programme whose three-year envelope for 1972-74 exceeded 70 MAU (rather than the 112 MAU proposed by the ESC six months before). This collaborative Scientific Programme could be supplemented by other Scientific Programmes and applications programmes involving those states that wished to participate in them, within the framework of Article VIII of the Convention. France agreed and, to signal her determination, indicated that she would withdraw from ESRO in 1972 if her wishes were not met. Denmark also indicated that she would leave the Organisation, though essentially for financial reasons.

Many Member States of ESRO were angered by France's warning - some called it a threat - that it might denounce the Convention. All agreed that reforms were needed, but they resented the pressure being put on them by a major participant, and even threatened to retaliate in kind. In the event the Council decided "that negotiations shall start immediately among the delegations with a view to establishing, at the latest by 30 June 1971, a proposal for a revision of the existing procedures and rules relating to the start and execution of projects (...)". The incoming Council Chairman, Giampietro Puppi, was asked to conduct these negotiations. The French delegation agreed to let him finish his work before deciding whether or not to denounce the Convention, this denunciation still being effective from 1 January 1972 notwithstanding the delay.[2]

During the first few months of 1971 the ESRO Secretariat, led first by DG Herman Bondi, and then by his replacement Alexander Hocker, who took over from Bondi in the spring, set up a Steering Committee to define its own position.[3] They prepared, along with Puppi, an "Aide-Mémoire with a view to negotiations" which was circulated to all delegations.[4] Puppi then visited each delegation in turn, beginning with France on 24 March.[5] A month later, his tour of capitals over, he submitted his proposals for the reform of ESRO to all Member States.[6] They were first discussed by the Council at its 38th session in May 1971.[7] This first *tour de table* led to the formulation of a lengthy Draft Resolution (eight sections and three annexes) which was again debated by the Council meeting on 13 and 14 July 1971.[8] Here the four major Member States, Britain, France, Germany and Italy agreed to participate in three applications satellite programmes, thus establishing the backbone of what became known as the first package deal. It took another six months, however, for delegates to agree on all the interlocking components of this package deal in which the science programme, along with its various components – satellites, sounding rockets (at ESTRANGE in Kiruna, Sweden) and basic research (at

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2 ESRO/C/XXXV/Rev. 2 bis, 23 December 1970.
3 The deliberations of this committee are available in file ESRO6647 in the ESA archives in Florence.
4 The Aide-Mémoire is document ESRO/C/APP(71)7, 19 March 1971.
5 A report on his visit to each Member State capital is available in file ESRO6364 in the ESA Archives in Florence.
6 The Puppi Report is ESRO/C/APP(71)9, 3 May 1971, attached to ESRO/C(71)24, 4 May 1971.
7 Minutes ESRO/C/MIN/38, meeting held on 25-26 May 1971, document dated 11 June 1971.
8 The minutes are ESRO/C/MIN/39, the meeting of 14-15 July 1971, document dated 3 August 1971. The attached resolution is ESRO/C/XXXIX /Res. 3.

Esrin in Frascati) – was the major loser. The final resolution on the reform of ESRO was, in fact, only adopted by the Council at its 44th session on 20 December 1971.[9]

We have described the content on this package deal briefly on several occasions in Volume 1 of this study. We shall inevitably repeat some of that information here. However, we restrict our discussion to those institutional and procedural elements needed for building a coherent narrative of the transformation of ESRO (and, below, the demise of ELDO) and their eventual replacement by a single space agency, ESA.

1.1.1 The main programmes

The reform of ESRO was undertaken to formalise and institutionalise the ongoing transformation of the Organisation from one that had only a mandatory science programme to one entrusted with the development of applications satellites and which made provision for 'special projects' (like the TD satellite programme) in which not all Member States participated. This greater flexibility was coupled with better harmonisation of national, bilateral and international projects to avoid duplication and to cut costs. It was not be achieved at the expense of the cohesion of the Member States, however, since costs would become prohibitive, especially for the smaller countries, unless several major partners were engaged in each important programme.[10]

Three applications satellites at various stages of development were candidate programmes for the new structure. First and foremost, a telecommunications satellite already agreed by the European Space Conference. Final decisions on this programme were scheduled for June 1971. Then an aeronautical satellite, to be developed in collaboration with the United States. A decision to proceed was expected by the end of the year. Finally there were potential meteorological and Earth resources satellites, which were still in the study stage. It was assumed from the outset that these three programmes would be optional.

It was clear to all that, with a major and extremely costly applications programme to be decided, the science programme could no longer enjoy the central position and the level of funding it had previously had in ESRO. From the inception of the discussions around its future it was presumed that, given the budgetary constraints, sounding rockets and basic research not directly linked to the scientific or applications programmes had become luxuries which the organisation could no longer afford. ESRO would now have to concentrate its activities on scientific satellites. Attention thus focussed on the suitable level of such a programme in a context in which applications had become the priority. This also put a question mark over the future of Esrange and Esrin.

The Executive based its first estimates of a reasonable level for the Scientific Programme assuming that the existing commitments to satellites would be respected. This meant taking the three current satellites, TD, HEOS-A2 and ESRO IV, to completion and going ahead with COS-B and GEOS. The Executive estimated costs at 39 MAU, 38 MAU and 31 MAU in the years 1972, 1973 and 1974 respectively.[11] Provision also had to be made to start new projects. DG Bondi thus suggested that 50 MAU annually would be needed for producing a worthwhile Scientific Programme (excluding sounding rocket activities, Esrange and Esrin). This, he felt, should be a compulsory programme for all Member States. Recognising that "science is not easy to sell", Bondi also thought that, in addition, "a really ambitious and large scientific project (planetary mission, space station module)" costing about 150 MAU "could attract genuine political support" and could "serve as a locomotive".[12]

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9 The minutes are ESRO/C/MIN/44, 6 January 1972, to which is attached the final version of the resolution, ESRO/C/XLIII/Res. 3 (Final).

10 This is based on the Aide Mémoire prepared in anticipation of the discussions between Puppi and the Member State delegations, in file ESRO6364.

11 *ESRO Reform and Negotiations,* 2 March 1971 (ESRO6647).

12 2nd Meeting of the Steering Committee, 20 January 1971 (ESRO6647).

These proposals were discussed with Puppi in Milan on 1 March. He too believed that current commitments should be respected. But he felt that 50 MAU annually was unrealistic; he preferred to see the minimum level of the science programme pegged at 30-35 MAU annually. This could not be reached immediately if the current programme was not to be disturbed. Hence Puppi foresaw a transition period in which budgets would fall progressively from 40 MAU in 1971 to 30 MAU in 1974/5. These savings would come by "using knowledge and technologies acquired under former projects, more than has been done in the past", and by having fewer satellites. The Council Chairman, like Bondi, also saw the advantage of having an additional voluntary large project every five years over and above the core science programme.[13]

When it came to defining the make-up of the core science programme, Puppi felt that it should preferably engage projects of a size beyond the limits of individual Member States and that, to be viable, i.e. to keep a "forward-looking and active" space science community in being in Europe, a new project needed to be started every 12-15 months. However, in his opening Aide-Mémoire to governments the Council Chairman left open the possibility that the satellite programme be optional.[14] He proposed two variations. In one, Member States would be obliged to contribute to a set of basic activities (feasibility studies relating to future possible scientific and applications programmes, technological research, technology dissemination through documentation) and the fixed common costs covering the overheads of the Organisation plus one programme, which could be the core science programme, but need not be. The alternative included the core science programme in the compulsory activities. Additional special scientific projects, like the major quinquennial mission, would be optional, just as the applications programmes.

Puppi agreed with the French that applications satellites could be funded on a project-by-project basis since the participants committed themselves to a precisely defined technical and scientific objective within a given period of time and at a given cost. But he felt that this was not suitable for science, where the idea of allocating a financial envelope to cover a particular time period was still preferable. Here the project by project approach threatened to deepen divisions between the various fields of the space science community and to unduly politicise the decision-making process. It was preferable to work with a financial ceiling for a given period. Within this ceiling the scientists could allocate their resources to different projects, "the development plans and funding of which (could) be made the subject of mutual trade-offs allowing their inclusion in a three-year or five-year envelope".[15]

What of costs?[16] Puppi estimated that the global ESRO budget would rise from about 75 MAU in 1971 to 150 MAU in 1974, stabilising at that level for the next three years (1975/76/77), and then falling off in two equal steps to 110 MAU in 1979 if no new applications programmes were started. Spread over these eight years, 400 MAU were for the telecommunications satellite, and about 85 MAU each for the aeronautical and meteorological satellite projects. Scientific satellites were to cost overall about 325 MAU, a stable envelope of 35 MAU being established in 1974 and retained thereafter (it averaged 39 MAU in the three preceding years). These figures, it should be noted, were now to include the costs of project staff, testing, data-acquisition, and data-processing facilities which, in the new budgetary structure being put in place, would be charged to individual projects. About 11 MAU annually were proposed for other scientific activities (notably sounding rocket campaigns). Puppi estimated the basic activities to cost 8-10 MAU annually, and the fixed common costs at 6 MAU annually. Globally then it was proposed that the three applications satellites absorb about 50%, and science about 37% of ESRO budget for the next decade.

After consulting with delegations between the end of March and the end of April, Puppi decided to make no major revisions to his original proposals. He more or less retained the original levels of the line items and the distribution across the decade, only making additional provision for starting another

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13 *Notes concerning a meeting held on 1 March 1971 in Milan between the Council Chairman, Gibson, Dattner and Kaltenecker,* 2 March 1971 (ESRO6647).

14 The Aide Mémoire is document ESRO/C/APP(71)7, 19 March 1971.

15 From the Aide Mémoire just cited.

16 From the Aide Mémoire just cited.

application satellite (+70 MAU). What was new was his conviction that a transition period of three years, lasting from 1972 to 1974 was formally required. This transitional phase would be conducted under the regime of the existing Convention. During it the Scientific Programme would remain mandatory, special projects in the sense of Article VIII could be carried out, one applications satellite would be started, and work would get under way on drafting a revised version of the Convention and devising procedures for the execution of applications programmes. In the subsequent period the revised Convention would apply, and the scientific satellite programme would no longer be mandatory. The "joining fee" for ESRO would now become participation in basic activities and common costs, plus one programme, though not necessarily science.

We mentioned above that Puppi had begun with the idea that the scientific satellite programme could be either compulsory or optional. As we see, he now suggested that it initially be compulsory, obviously so as to ensure that the current programme was not disturbed, but that it become optional from 1975 onwards. This was almost certainly a gesture towards the French delegation. When Puppi met with them at the Quai d'Orsay on 24 March, they made it clear that, while they agreed that there had to be a "viable" Scientific Programme, and would probably participate in some scientific projects, their budgeting would be based on an envelope amounting to 50% of the level being suggested by the Council Chairman.[17] France, they said, had a real financial problem, it was impossible to satisfy the demands from scientists, and the French space science community was overloaded with work anyway. France also confirmed that she had "no particular interest in the sounding rocket field nor in Esrin", and "strongly contested" the Space Science Department in ESTEC having its own Scientific Programme, arguing that this led to competition with national groups. Faced with the wish to preserve existing commitments, to maintain a sensible funding envelope for science in the future, and to maintain France's commitment to ESRO, Puppi no doubt concluded that the best way forward was to change the status of the Scientific Programme from mandatory to optional after the end of a brief transition period.

The Puppi report was first discussed collectively by the delegates to the ESRO Council at the 38th session towards the end of May.[18] Three points emerged. Firstly, that several countries, notably France and Spain, felt that they simply could not support an ESRO programme that doubled in cost from 75 MAU to 150 MAU in the next three years. Secondly, that a start should be made as soon as possible on the telecommunications satellite. And thirdly, that the science programme should be made mandatory even beyond the transition period.

Several reasons were given for keeping the science programme mandatory. At one level the concern was technical: an optional programme would demand a fundamental revision of the Convention which would call for parliamentary approval, a prospect which always raised the fear that the whole enterprise would be put in question. More profoundly, there were genuine worries that if science were optional it would simply collapse or, as the British delegate put it, "there was a danger that a scientific project would become too costly if a certain number of Member States decided not to take part in it". And he gave an example. The UK was contributing £15 million to GEOS over the years 1972-74, a satellite on which its scientists had one experiment. It was obvious that if this programme became optional thereafter Britain might withdraw from it as soon as legally possible. In short, the ESRO science programme was a fragile thing, all the more so since there were always other opportunities to fly experiments: as the French delegation put it, "scientists considered that there was a market for the experiments, namely within the national programmes, within the NASA programmes and within the ESRO programmes, and that they selected the cheapest bargain". To protect it, and to retain the confidence of the scientific community in ESRO, it was essential that it remain mandatory. This policy, the German delegate pointed out, would have the additional advantage that it would, in the immediate future, "give a certain cohesion and stability to the Organisation" and would represent for

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17 *Resumé of discussion between the ESRO delegation and the French delegation...on 24 March 1971,* 3 April 1971 (ESRO6363).

18 ESRO/C/MIN/38, meeting on 25-26 May 1971, document dated 11 June 1971.

some time to come "a basis for technological progress", the results of which might be used in applications programmes.[19]

A major step forward in consolidating the future of ESRO and, indeed, the entire the European satellite programme, was taken by the Council delegates meeting six weeks later on 13 and 14 July 1971.[20] Here the four major contributors Britain, France, Germany and Italy, committed themselves to engaging in a science programme and three applications satellites, namely a communications satellite, the aeronautical satellite being negotiated with the United States and a meteorological satellite (in fact France proposed that its geostationary Meteosat then under development by CNES be 'Europeanised').[21] They agreed that all of these programmes be mandatory *for these four participants*. In fact such were the fears of the British delegate, Mr. Hosie, that his partners would not keep this deal, so leaving the UK with a heavier burden of applications than it was willing to bear, that when it came to vote he insisted that all the four concerned raised their hands at the some moment. The chairman counted 1, 2, 3, and on 'three' the four hands went up![22] Their accord was fundamental for other Member States, which could choose whether they wanted to participate in an application programme knowing that the bulk of the cost was taken care of. Participation in the science programme (and basic costs, including common costs) were however, obligatory for all Member States.

Indicative financial commitments were also made at this meeting.[23] An overall figure of 450 MAU was proposed for the communications satellite. Along with that the big four proposed minimum annual budgets for the applications and Scientific Programmes. Following Puppi, they distinguished between a 'transition period' (1972/73) and a 'cruising period' (1974 to 1980). For applications they were prepared to support budgets (which would include participation by their partners of course) climbing from 27 MAU in 1972 to 53 MAU in 1973 to a minimum of 70 MAU in 1974 (in mid-71 prices). This level, a minimum of 70 MAU annually, would be retained for the cruising period. For the scientific satellite programme – and this figure distressed many delegations – the minimum level of expenditure for the cruising period was set at 27 MAU, a level, said France, that would enable one satellite to be launched every two years. This could be increased during the transition period to satisfy existing engagements. In particular it was suggested that ESRO complete the three scientific projects then being executed, that the COS-B and GEOS development contracts be awarded on 1 January 1972 and 1 January 1973, respectively, that the organisation collaborate with NASA in the SAS-D programme, and that during the transition period it take measures enabling the development contract for a new satellite to be awarded no later than 1 January 1975.[24] Finally it was proposed that the annual level of ESRO's basic and common costs be fixed at 10 MAU, and that this would include a technology programme "directly linked with the Organisation's programmes and (...) coordinated with the industrial policy of each Member State and with the relevant national programmes".

It was not possible to settle all the elements of the package deal at once. In fact it took another six months for an overall consensus to be reached on all its interlocking components. This was done in a long resolution adopted by the ESRO Council meeting just before Christmas, on 20 December 1971.[25] By then the commitment to the telecommunications satellite had become more prudent. The big four, along with Belgium, Sweden and Switzerland (ad referendum) now only agreed to fund phase 2, the experimental phase of the programme lasting from 1972 to 1976, up to a maximum of 100 MAU. The

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19 The quotations are from the 38th Council meeting.

20 ESRO/C/MIN/39, document dated 3 August 1971.

21 Detailed studies of these programmes have been made by Arturo Russo (for communications, chapter 6, this volume), John Krige (for the meteorological satellite, chapter 7, this volume) and Lorenza Sebesta (for the aeronautical satellite, chapter 8, this volume).

22 We are indebted to George van Reeth for this anecdote.

23 The cost figures are in ESRO/C/XXXIX/Res.3, rev.2 (draft), 14 July 1971, chapters I, II, III and VII.

24 The science programme has been described extensively by Arturo Russo in Volume 1 and in chapters 3, 4 and 5 of this volume.

25 ESRO/C/XLIII/Res. 3 (Final), 20 December 1971 adopted at the 44th meeting of the Council held on 20 December 1971, ESRO/C/MIN/44, document dated 6 January 1972.

decision to proceed with the successive phases was to be taken by a double two-thirds majority in the first half of 1975. Otherwise there were only minor shifts in the provisions adopted in July 1971. The big four along with Belgium, the Netherlands, Spain, Sweden and Switzerland (ad referendum) confirmed their commitment to the aeronautical satellite and set its overall envelope at 100 MAU. All these countries bar Spain also agreed to fund a meteorological satellite with a maximum level of resources set at 115 MAU. For planning purposes the minimum annual level of expenditure during the cruising period remained 70 MAU for applications and 27 MAU for scientific satellites. Basic and common costs, too, were confirmed at 10 MAU annually. The terms of the transition period remained unchanged but for a 10% reduction and slight redistribution of the 150 MAU originally set aside for applications in 1972, 1973 and 1974.

One remark by way of conclusion. The guarantees given to the science programme concerned its status and budget envelope, without regard to its content which was normally the affair of the scientists themselves. The significance of this distinction emerged in 1974, when the new French government of President Valéry Giscard d'Estaing decided to favour the European programme at the expense of some of its national activities. Explaining the implications of this decision to the ESRO Council in October that year, the French delegation remarked that, in their view, just as Ariane was to be used for all geostationary missions envisaged by ESRO/ESA, so Spacelab was "destined to become the sole instrument of the scientific missions, unless in a few special cases it becomes evident that the facilities in question are incompatible with the nature of the operation".[26] The results of this were felt immediately. The subsequent Council sessions held on 6 and 20 December 1974 were to fix the level of resources for 1975 to 1977, and to give a provisional estimate of expenditure for 1978 to 1980.[27] The French delegation shocked some of its partners by insisting that it wanted to turn the already-agreed Exosat programme into a Special Project, and to use the money thus saved from the mandatory programme for scientific experiments with Spacelab. The resistance to this suggestion was sufficiently united to put brakes on the scheme. But the Council was unable to do more than adopt a level of resources for 1975, leaving the new ESA to concern itself with the subsequent years. Its resolution also coupled the figures for those years to a "critical review of ESA's total programme (...) in Spring 1975 within the framework of available resources, and bearing in mind the requirements of Spacelab utilisation and possible collaborative projects".[28]

1.1.2 Esrange and Esrin

Esrange and Esrin together cost about 10-12.5 MAU annually not including common costs. It was clear from the outset that their status would be changed in a reformed ESRO striving to make savings in the science programme. Indeed in his Aide Mémoire Puppi suggested that neither was necessarily an “indispensable part of an international space research organisation”, and he wondered how, if at all, they could be retained. Should they be “Special Projects” to which a limited number of Member States contributed?[29] Or should they be handed back to their host states and placed at the disposal of scientists from other countries, under the terms of a suitable arrangement?

Puppi and the Executive discussed some of these ideas with the Swedish delegation in Stockholm at the end of March. This is how Jan Stiernstedt, the head of the delegation from the Ministry of Education and former head of the Swedish delegation to the ESA Council described the meeting. “I still remember how during his visit to Stockholm in March 1971 (Puppi) eloquently presented his case to the Swedish delegation and how his proposals were received by me and my colleagues with silence or non-committing or even negative comments”.[30] They were emphatic that ESRO’s science programme should be compulsory, and that 35 MAU annually was at the limit of what was possible for a viable programme. They were also open to suggestions about the future of Esrange, and were

[26] Annex II to ESA/C/MIN/69, meeting held on 30 October 1974, document dated 8 November 1974.
[27] Minutes ESA/C/MIN/71, dated 19 December 1974, and ESA/C/MIN/72, dated 7 January 1975.
[28] ESA/C/LXXII/Res. 1, 20 December 1974.
[29] Aide Mémoire, document ESRO/C/APP(71)7, 19 March 1971.
[30] J. Stiernstedt, “ESA’s Mandatory Programme”, in *Twenty Years of the ESA Convention, Munich, Germany, 4-6 September 1995* (Noordwijk, ESA SP-387, November 1995), 35-7.

willing to consider the “Special Project” solution or a complete “hand-over” of the Kiruna range to Sweden. Stiernstedt, made one thing clear, however: this was also a political question and the Swedish government’s position on the future of ESRO as a whole would be affected by the solution eventually adopted.[31] After Puppi had left, according to Stiernstedt, the Swedish delegation had the distinct feeling that ESRO would soon become a purely applications satellites organisation, and that if Sweden was to retain an active science programme it would have to be based on sounding rockets and on bilateral cooperation.[32]

Following this meeting Puppi, in his final report, proposed that the sounding rocket programme at Esrange become optional, and that about 8 MAU be devoted annually to launching 14 payloads, half of them stellar pointing payloads.[33] The general idea was immediately accepted by Britain and Germany, two of the staunchest supporters of the science programme.[34] In July, when the basis of the package deal was established, and the principle of having a mandatory European science programme accepted, the broad outlines of an agreement with Sweden began to be drawn up.

The Swedish delegation’s view was that it was important to concentrate satellite research in ESRO and to “discontinue those parts of the programme that could be executed by a single Member State or on the basis of bilateral arrangements”. To this end Sweden was prepared “to take over the launching range, which would then continue to provide launching services to the interested national groups in the Member States”. A draft agreement was submitted as Annex II to the draft resolution formulating the package deal. It allowed for the ownership of all facilities owned by ESRO at Esrange and the associated observatory station to be transferred to Sweden as from 1 July 1972. In return Sweden agreed to maintain a sounding rocket programme at Kiruna for the subsequent five years. But there was an “indispensable condition” that had to be met. Users (outside the Swedish national programme) had to guarantee an average of 30 launches annually over this period, including a number of “fairly large” rockets. If that condition was not met, or compensation paid, the country had the right to close the range.[35]

With these principles established, discussions with the interested parties over the next six months formalised the arrangements over the use of Esrange as a Special Project. It was confirmed that Sweden would take over Esrange from 1 July 1972. During the transition period ESRO would launch 16 of the remaining 36 firings planned, these being payloads whose integration was either completed or near completion. Help to complete their payloads would be given to the experimenter groups concerned in the remaining 20 firings.[36]

In taking over Esrange (its name was kept) Sweden agreed to invest 400.000 AU with a view to reducing launching costs and making them comparable to those of similar ranges. To extend the scope of sounding rocket activity the Swedish government made a parallel arrangement with the Royal Norwegian Council for Scientific and Industrial Research (NTNF) whereby the Andøya range would also be kept operational for at least five more years. The two ranges would be managed exclusively by the Swedish and Norwegian authorities, respectively. ESRO’s role would be reduced to providing a Secretariat for, and scientific advice to, the Programme Advisory Committee. This committee, comprising representatives of all the participating states, as well as Sweden and the NTNF, would choose the launching campaigns and associated priorities, and deal with other matters concerning the use and management of the ranges.

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31 *Resumé of the meeting between the Swedish and ESRO delegations, Stockholm, 31 March 1971* (ESRO6364). Stiernstedt has published his own account of the Swedish space effort, which will shortly be available in English.

32 Stiernstedt, in *Twenty Years...*(footnote 30)

33 ESRO/C/APP(71)9, 3 March 1971.

34 ESRO/C/MIN/38, meeting 25-26 May 1971, document 11 June 1971.

35 ESRO/C/MIN/39, meeting 13-14 July 1971, document 3 August 1971.

36 ESRO/C/XLIII/Res.3 (Final), attached to ESRO/C/MIN/44, meeting of 20 December 1971, chapter 7 and Annex II.

A total of 40 operational weeks per year at the two ranges was foreseen. They were to be distributed between the participants *pro-rata* to their contributions to the basic maintenance costs of both Esrange and Andøya, which amounted to 830.000 MAU excluding the contributions of Norway and Sweden. Germany and the United Kingdom were scheduled to be the main users (12 weeks each), the other contributors being Belgium and France (who had little demand for the range but who contributed in the interests of consolidating the package deal), the Netherlands, Switzerland and Denmark. In addition to their contributions to the basic maintenance costs, participants would pay 5000 AU per operational week actually used within their quota of 40 weeks.[37]

The formal vote on the Esrange Special Project was taken at the 44th meeting of the ESRO Council just before Christmas, 1971. It was at this meeting that the long resolution adopting the package deal on the reform of ESRO was voted. Although the Esrange Special Project was not, strictly speaking, part of that deal, the Swedish delegation made it clear that it expected potential participants to accept the project if it was to vote the package deal. This is how Stiernstedt describes the day:

> *When the meeting started in the morning, I still did not know whether my Government was ready to join the package deal or not. I did not hear anything for hours and I became more and more pessimistic. When at last the phone call came, I could not believe my ears – we were instructed to join all three applications programmes. I remember also the reactions around the table when I had the pleasure of announcing this. I still believe that the other participants had already started to calculate the costs of the deal without Swedish participation.*[38]

As the minutes record it, the Swedish delegation announced that "it had just received instructions enabling it to participate in all the programmes (of the package deal) subject to parliamentary ratification and provided that the Esrange special project was approved".[39] But the tension was not over. It turned out that the Netherlands had to vote in favour of the special project – but it had no instructions to do so. A telephone call to The Hague settled the issue, and a Declaration of intent to submit the draft agreement on the special project to their governments was voted by Belgium, France, Germany, the Netherlands (ad referendum), Sweden, Switzerland and the UK.[40] The meeting was then adjourned briefly to enable the ESRO DG and the head of the Swedish delegation to sign the Agreement transferring Kiruna to Sweden.

It proved rather more difficult to settle the future of Esrin. In 1971 the centre had a staff of 75 people and it cost about 2 MAU annually. Although it was agreed that the work done there was of high scientific calibre, it was also realised that it was not directly related to the ESRO operational programme. The Italian delegation recognised this from the outset, and was willing to consider some reorientation of the research activities in Frascati towards more relevant topics of research if that was essential.[41] This idea was taken up by Puppi in his proposed reform of ESRO. Here he indicated that it might be desirable to make of Esrin a "technological laboratory with the task of carrying out theoretical analysis related to the study of Earth resources and meteorological phenomena". If this were done Esrin could be retained as an ESRO establishment, and its cost charged to the relevant applications programme. Alternatively, Puppi suggested that the Italian government should be asked to take over the centre in Frascati and to 'nationalise' it under the terms of a special agreement with the Organisation.[42]

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37 For the above see ESRO/C(71)57, 25 October 1971, and ESRO/AF(71)99, rev.3, 29 November 1971, the Agreement between Sweden, other Member States of ESRO, and ESRO, defining the Special Project,

38 Stiernstedt, *Twenty Years...* It is impossible to be sure of the order in which the various steps described here took place.

39 ESRO/C/MIN/44, meeting of 20 December 1971, document dated 6 January 1972.

40 ESRO/C/XLIV/Dec. 2, 20 December 1971, attached to minutes.

41 *Resumé of meetings between Italian and ESRO delegations, Rome, 1 and 2 April 1971* (ESRO 6364).

42 ESRO/C/APP(71)9, Annex I, 3 May 1971.

When these proposals were first discussed the Italian delegation immediately rejected the second alternative; it wanted Esrin to remain an ESRO establishment – it was the only such establishment on its soil, anyway –, adapting its work better to the Organisation's programme. The UK delegation pointed out that this would not necessarily save Esrin, since if the nature of the research changed the existing staff would need to be replaced, and the new contingent need not be based in Frascati.[43] Notwithstanding this position, reaffirmed by the Italian delegation when the Council next met in July, the draft resolution prepared by the bureau for that Council meeting included a clause stating that the Council "Regretfully concludes that circumstances enforce consideration of closing down Esrin and would welcome any viable solution that may be found outside the Organisation".[44]

The head of Esrin, Nicola d'Angelo addressed the ESRO Council on behalf of its staff at its 41st session towards the end of October.[45] He emphasised that their preferred solution was to maintain Esrin as an ESRO establishment dedicated to scientific research. Its scientific output had received international recognition, and several eminent European scientists had gone public expressing their support for the continued functioning of Frascati, which only cost 3% of the ESRO budget. d'Angelo went on to say that his team were quite willing to re-orient their activities towards the operational programme, and in fact had already done some work for it. If, notwithstanding the centre's qualities, this solution was not possible, he proposed that a commitment should be made to retain Esrin's activities steady in terms of staff and budget pending the findings of an ad hoc study group set up to discuss, with the staff and other interested parties, the future of Frascati. This plea had only moderate effect. After a prolonged discussion the Council confirmed that it wanted the current scientific activities terminated by September 1973, with budgets dropping to 1.5 MAU in 1972 and 1 MAU the year after. It did however recognise the wish of the Italian delegation to maintain Esrin within the ESRO framework, and asked for a paper spelling out possible ways of doing so.

Attempts to find a suitable activity for Esrin within the framework of the Organisation were intensified during the next two weeks. The transfer of the documentation service (26 staff) seemed to be the only feasible activity from ESRO's point of view, and even here the Director of Administration had strong reservations. The Italian delegation was unyielding, however. This was of "no interest". It wanted a scientifically significant activity to be retained at Frascati. To make matters worse the Italian delegation now said that its government was increasingly reluctant to stand as one of the guarantors of the three applications programmes, as originally agreed in July. This risk to the entire basis of the package deal might be reduced though, and "Italy's financial difficulties linked with its participation in all the space application programmes might be smoothed out if a satisfactory solution was found to the Esrin problem".[46]

The Italians retained their determination when the time came to vote the entire package deal in December. The delegation made it clear that his "country's participation in the Organisation's future depends closely on a satisfactory solution to the problem of Esrin. Our Parliament, our leading circles, and our public opinion", he went on, "were severely shaken when (after the Council meeting in July) the rumour spread that Esrin would close down after a transition period of liquidation". Our opposition to this solution, he added, was "founded on political considerations – quite apart from any scientific and technological considerations – to which we attach the highest importance".[47] Italy eventually voted the package deal and accepted to have the Documentation Service transferred to Esrin late in 1972 or early in 1973, but wanted further work, sufficient to enable it to maintain its then-current level of activity, to be awarded to Frascati.[48]

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43 ESRO/C/MIN38, 11 June 1971.

44 ESRO/C/XXXIX/Res.3, rev.2 (draft), 14 July 1971, chapter 7; ESRO/C/MIN/39, Annex II.

45 ESRO/C/MIN/41, Annex II for d'Angelo's speech, ESRO/C/XLI/Res. 3.3, 26 October 1971 for the resolution, both attached to the minutes of the 41st Council meeting on 26-27 October.

46 ESRO/C(71)56, ESRO/C(71)59, 11 November 1971, ESRO/C/MIN/42, meeting 23-24 November 1971.

47 ESRO/C/MIN/43, Annex II, meeting held on 8 December 1971.

48 ESRO/C/XLIII/Res. 3 (Final), chapter VIII, attached to minutes of 43rd Council meeting.

In subsequent negotiations it emerged that the Italian CNR was willing to take over the experimental building and the attached land as well as some of the experimental material at Esrin. It remained extremely difficult, however, to find a sufficiently 'noble' activity for that part of the establishment that remained in ESRO. The most promising idea seemed to be to install a new computer and a software group in Italy. This was unpalatable to many; not only because policy was to contract out as much as possible of this work to industry, but because it seemed unwise to establish such a group at a site other than ESOC.[49] The space research activities were eventually wound up in Frascati in September 1973. The Scientific Documentation Service at Neuilly (Paris) along with its ancillary computer staff in Darmstadt were transferred to Italy and immediately took delivery of a new IBM 360/50 computer to handle their database.[50] Although it was hoped that they might cover some of their costs by selling their services to non-space customers, they never managed to do so fully, and a so-called SDS subsidy had to be included in the budget to cover their losses.

1.1.3 Other matters: launchers, coordination

From the outset of the negotiations on the reform of ESRO, France insisted that a launcher policy be adopted which was coherent with the orientation of the organisation towards applications, notably communications satellites.[51] This policy did not have to engage Europe in constructing its own launcher, as the Belgian delegation explained. What was required was to devise an agreement which left open the possibility that the US might refuse to launch experimental and operational applications satellites. This approach enabled the text of a provisional resolution on launchers to be adopted in July 1971 which was deemed satisfactory.

The provisional policy for launchers had two clauses.[52] The first repeated the Bad-Godesberg 125% rule: that if the USA agreed to launch all satellites, experimental and operational, foreseen in the package deal, ESRO would purchase launchers either in the US or in Europe, giving priority to the latter if its cost was less than 125% of the equivalent American launcher. On the other hand, and this was clause (b), if the US refused to make such an undertaking then ESRO would either buy an existing European launcher adapted to its missions, paying the cost price and excluding development cost (and here one was not just thinking of ELDO's Europa but also of France's Diamant). Alternatively, ESRO would ask ELDO or European industry to develop a suitable launcher.

The United Kingdom did not like this arrangement. It voted the resolution ad referendum, and it was confirmed in its doubts by the failure of the maiden flight of Europa II on 5 November 1971. When the ESRO Council met three weeks later Britain thus argued that it was against the policy because it committed ESRO to using European launchers for *all* missions after the US failed to make an undertaking to launch all of Europe's satellites, be they experimental or operational. That, said the UK, was economically unwise. Hence it proposed a new version of the resolution which, in the event of an American refusal for a *particular* mission, "left open the possibility of reverting to American launchers for subsequent missions if this seemed desirable for economic reasons".[53]

This suggestion of course demolished the guarantee of procurement for European launchers in the event of difficulties with the US, which France and some other delegations felt was imperative if industry was to embark on launcher production. There was no sense, said her delegate, "to manufacture launchers for which there is no prospect of payloads". The need for a European launcher seemed all the more pressing since it was proving extremely difficult to get cast-iron guarantees out of the United States regarding the launch of European operational satellites for telecommunications. Attempts to find a compromise between Britain and France failed, however, and the French delegation

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49 ESRO/C (72)39, and ESRO/C/MIN/47, 12 July 1972.

50 N.E.C. Isotta, "The Space Documentation Service - A progress report", *ESRO/ELDO Bulletin,* No. 23, November 1973, 2-8.

51 ESRO/C/MIN/38, meeting on 25-26 May 1971, document 11 June 1971.

52 ESRO/C/XXXIX/Res. 3, rev. 2 (draft), debated at the 39th Council meeting on 13-14 July 1971.

53 ESRO/C/MIN/42, meeting on 23-24 November 1971, document, 3 December 1971, and ESRO/C/XLII/Res. 3 (draft), Addendum 1, rev. 1, 24 November 1971.

agreed to come forward with a new text. It added that it was so disappointed with the results of the negotiations during this November session that it was not ready to lift its denunciation of the Convention, due to take effect in six weeks time.[54]

The deadlock was broken at the Council meeting on 8-9 December 71. The solution found was to make a broad commitment to buy European launchers, and to distinguish the period after the denial to launch a European satellite, should such a situation arise, from that before such a denial had taken place. Initially the 125% rule applied for all missions until a denial to launch came from outside Europe. If or when that happened, for any subsequent mission ESRO would buy a European rocket, if one was available, *without now being constrained by the Bad Godesberg formula*. Previously the French delegation's idea had been effectively to disqualify the US as a supplier of launchers if it refused just one mission. Now it was prepared to meet the UK half-way by suggesting that, after such a denial, a European launcher had always to be used if one was available regardless of its cost compared to an equivalent US launcher. This proposal was accepted at the Council meeting on 8-9 December, the Netherlands, Sweden and the United Kingdom voting ad referendum. About two weeks later, just before Christmas, these qualifications were lifted when the whole package deal was voted unanimously.[55]

The only other major clause of the package deal that we have not mentioned concerned the coordination of space activities in the European theatre. Puppi made much of this in his original Aide Mémoire and in his final report. ESRO, he said, would have to assume "a multiple role: it would have to be the *executive body* in respect of those programmes that were directly entrusted it to by the Member States, the *co-ordinating and harmonising body* in respect of all European space activities - international, multilateral, and national - so as to achieve maximum rationalisation and integration of the overall European effort, and, lastly, the *valid interlocutor vis-à-vis non-European countries*". Several areas where harmonisation was essential were identified. One was telemetry and tracking, where Europe had three centres for the control and operation of spacecraft in orbit (while only one was said to be necessary) and ten ground stations when only seven or eight were required. Another was test facilities, where a more coordinated use of national and ESRO installations was required. Then there was the exploitation of technological developments already made: these tended to be ignored when new spacecraft were being designed, thus duplicating work already done and adding to cost. Finally Puppi insisted that ESRO should be a genuine forum for valid consultation and exchange of information between its partners. To avoid unnecessary duplication it was essential, he wrote, that "ESRO be informed as early as possible of national plans concerning scientific and application programmes as well as of the capital investment plans envisaged in the Member States".[56]

These aims were enshrined in Chapter V ("Coordination") of the package deal.[57] It conferred on ESRO "a coordinating and concerting role in respect of all space programmes for peaceful purposes originating within the Organisation and national agencies". But the decision lacked conviction. To achieve this objective ESRO was simply to collect and disseminate information, provide assistance, and keep contact with various members of the space community. What is more, Member States were simply recommended, not obliged, to collaborate. No formal body for discussing possible coordination was suggested, nor were any procedures laid down for enforcing it.[58] These were eventually defined in the new ESA Convention, which we shall discuss later, though even here it proved difficult to balance

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54 *Ibid*., and ESRO/C/XLII/Res. 3 (draft) Add. 1, rev. 2, 24 November 1971.

55 ESRO/C/MIN/43, meeting on 8-9 December 1971, and ESRO/C/MIN/44, meeting on 20 December 1971, resolution ESRO/C/XLIII/Res. 3 (Final), chapter IV on launchers.

56 The paragraph is based on ESRO/C/APP(71)7, 19 March 1971 and ESRO/C/APP(71)9, 3 May 1971.

57 ESRO/C/MIN/44, meeting on 20 December 1971, resolution ESRO/C/XLIII/Res. 3 (Final), chapter V on coordination.

58 ESRO/C(71)XXXIX/Res. 3, Annex III, 14 July 1971, is the original set of principles concerning the revision of the ESRO Convention. It was originally suggested that the ESRO committee structure should be changed to enable it to play a "coordinating and concerting role in respect of all space programmes of the European Community", but this came to nought.

the needs of individual countries to maintain a measure of sovereignty with the potentially conflicting requirement that they collaborate effectively in a joint European programme.

1.2 The demise of ELDO[59]

The history of ELDO in the 1960s was one of technological failure, cost overruns and political dispute. Within a year of the organisation coming into being its original financial envelope was doubled to 400 MAU. In 1966 a Ministerial Conference agreed to increase this further to 626 MAU. At the same time they defined the technical aims of the organisation more precisely: it was to develop a rocket fitted with a “perigee-apogee” system and inertial guidance, and capable of putting 150 kg into geostationary orbit (Europa II). These objectives were seriously challenged in the following two years. While the first British-built stage of the rocket continued to function impeccably there were failures, first of France’s second stage, and then of the third stage built in Germany. There were cutbacks to the programme enforced by the refusal of Britain and Italy to support additional cost-overruns. At the same time, with a view to remaining competitive in the commercial telecommunications market it was decided to embark on studies of Europa III, able to put 400 to 700 kg into geostationary orbit.

The tide seemed to be turning in 1970. At a ministerial meeting in November that year the Belgian, French and German delegates, frustrated by the reluctance of their partners to commit themselves to building a European launcher, announced that they would go ahead on their own with anyone else who wished to associate themselves with their efforts. The US government suggested that Europe participate in the post-Apollo programme, and design studies for possible contributions to this were confided to ELDO. The last launch of the Europa I rocket from the base in Woomera, South Australia also boded well for the future. Only minor technical difficulties stopped the rocket putting a satellite into orbit.

Against this background the firing the first of Europa II from the new equatorial launch base in Kourou, French Guiana (flight F11), proved to be a turning point in the history of ELDO. The rocket exploded 150 seconds into flight. The subsequent disappointment and disarray were proportional to the optimism that had been building up over the previous 18 months. “The only important fact”, said Brigadier Abate speaking for the Secretariat at a meeting of the ELDO Council held two weeks later, “is that F11, in which we all had high confidence, failed. This failure is the most serious set-back in the Europa-II development programme”.[60] A Commission of Enquiry into the cause of the explosion was immediately set up under incoming ELDO Secretary-General, General Robert Aubinière. Delegates were not only concerned now about whether a flight ready version of Europa II would be available to launch the Franco-German Symphonie satellite in 1974. Doubts about the Europa III programme also emerged. The French delegation to the Council promoted a Resolution intended to reaffirm the determination to continue the Europa III pre-development phase. His Belgian delegate favoured such a move, but the German delegate hesitated. “His Authorities”, said Mr Loosch, “had always maintained that they wished the launcher programme to continue, but it was clearly necessary to re-examine the future in the light of the report of the Commission set up to review the Europa II project. He hoped therefore that delegations would not insist on a new Resolution until this was available”.[61]

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59 There is additional material on this in Volume 1, chapter 11 (dealing with the second package deal) and in chapter 9, this volume, dealing with the birth of Ariane. See also the Secretariat’s report on the liquidation of ELDO, ELDO/C(75)1, 15 May 1975, which has a fine summary of the life of ELDO.

60 See ELDO/C(71)PV/4, minutes of Council meeting on 23 September 1971, for sentiments before the launch and ELDO/C(71)PV/6, minutes of meeting on 18 November 1971, for reactions to the explosion. The quote is from the second of these meetings.

61 ELDO/C(71)PV/6, minutes of the 53rd Council session meeting on 18 November 1971, document dated 6 January 1972.

Cracks were appearing in the tripartite agreement to form a European rocket ‘club’ so boldly put forward just one year before. To add insult to injury in December 1971 the UK delegation announced that it had decided that it was illogical for it to remain a full Member State of ELDO. It had thus decided to withdraw and to seek observer status. This decision, it reassured its partners, did not affect its undertaking to guarantee the availability of Blue Streak for the Europa II programme for several years to come.[62]

In February 1972 a plan of action for saving Europa II was adopted. Clear lines of responsibility were defined inside ELDO for particular projects. G. Chauvallon was appointed responsible for the Europa II programme and Y. Sillard was nominated to head Europa III. These appointments were to go along with an increase in the powers of the Secretariat to place contracts with industry directly, rather than indirectly through the Member States. A new target plan was also established. It was agreed to launch F12 early in 1973, F13 in the second half of the year, with F14 being used for Symphonie early in 1974.[63]

Two months later the final report of the preparatory phase of the Europa III rocket was laid before the ELDO Council.[64] At this time the teams involved in Europa III work (be it full-time for test personnel, or part-time for design and manufacturing staff) amounted to the equivalent of 650 people.[65] The rocket was designed to place 750 kg into geostationary orbit. Its first stage used low risk technology derived from the French rockets Diamant and Coralie and a generation of Viking turbo pump motors already developed in Europe. The second stage was innovative, using cryogenic techniques, and was intended to enable European industry to close the gap in this technology with other major space powers. It had the same diameter as the first stage and the engines for it still had to be developed. The development cost was estimated at 565 MAU (3.138 million French francs) in spring 1971 prices, including a 20% contingency margin. The German delegation thought this was far too expensive, though the Secretariat insisted that a number of so-called low-cost alternative configurations would not result in significant savings and would not have the same growth potential as their Europa III.[66] The ELDO Council was not in a position to engage in a major project of this kind, and passed the buck to the Ministers, due to meet in July.

The final report of Aubinière’s Commission of Enquiry was submitted the month before.[67] It identified poor management and technical difficulties with the third stage as the main causes of the failure of firing F11 of Europa II. The project had suffered above all from the absence of a strong centralised project management scheme. This lack of strong overall project management had been particularly serious as regards the third German stage. Here the report identified major failures in quality control and evidence of sloppy workmanship: “Its design is complicated and its wiring needs to be thoroughly revised. Its integration has been particularly deficient”. Indeed it was here that the proximate cause of the explosion lay: the inertial guidance system had failed because of electrical interference of a few volts between the checkout line connecting its computer to its power supply. Notwithstanding these problems Aubinière’s Commission felt that with a further 21-27 MAU, and an improved system of management, “the Europa II vehicle should achieve a normal probability of proper functioning similar to that for comparable space projects”. The ELDO Council concluded that it would be for the Ministers to decide, at the meeting of the European Space Conference scheduled for 11 and 12 July 1972, the kind of commitment to be made to the Europa II development and construction programmes, and particularly if they should continue with firings F17 and F18 as originally planned.

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62 ELDO/C(71)PV/7, minutes of meeting held on 15-16 December 1971, document dated 6 March 1972.

63 ELDO/C(72)PV/1, meeting held on 17 February 1972, document dated 17 May 1972.

64 ELDO/C(72)13, 5 April 1972.

65 ELDO/C(71)32, 13 December 1971.

66 ELDO/C(72)14, 30 May 1972.

67 ELDO/C(72)18, 19 May 1972. See ELDO/C(72)PV/3, meeting of Council on 8 June 1972, document dated 16 June 1972 for the quotes. A later report on the state of the rocket just before cancellation is ELDO/C(73)18, 10 April 1973.

In the event the Ministerial conference was delayed and ELDO's fortunes continued to plummet in the second half of 1972. First, the United States authorities withdrew the offer of collaboration with Europe on the space tug in the framework of the post-Apollo programme and reduced the possibilities of participation in the construction of the Shuttle to a few items of low technological interest. The group of ELDO engineers who had been working on the tug for two years was officially disbanded on 31 July 1972 and all of the Organisation's contractual obligations with industry were liquidated.

Secondly, Germany's doubts about pushing ahead with the launcher programme became reinforced by the interest in her government and her industry for taking up the US offer to build the Sortie module, or Spacelab. This was a Shuttle-borne, shirt-sleeve- environment laboratory for scientific research. Several arguments were given to support this position: that the German "Authorities had come increasingly to the same conclusion as the United Kingdom (and later Italy) that it was more economical to buy heavy launchers from the USA. than to develop them in Europe"; that at the end of the decade the Shuttle would have rendered Europe's launcher activity redundant while participation in post-Apollo would enable European managers to learn systems-management skills from their US colleagues; that the market for a European launcher was too small to justify its development; and that the fear that the US would not launch competitive European applications satellites was exaggerated.[68]

If Germany adopted these positions it was surely because the authorities were dismayed by the poor showing of their firms in the construction of the third stage of the Europa rocket. They hoped that working together with American project managers with 15 or 20 years of experience in large space projects would help transfer the necessary skills across the Atlantic into Europe. There was also the need to reassure the United States that the Federal Republic was a solid and reliable ally. Willy Brandt's Ostpolitik had destabilised the traditional balance of mistrust and menace between East and West Germany and, indeed, between the capitalist and communist blocs. The election of the Social Democrat – Free Democrat Coalition in November 1972 added a further unknown to an increasingly fluid situation. Collaboration in post-Apollo, perhaps at the expense of building a launcher in Europe, was one way for the new government to distance itself from the old, and to cement its links with Washington.

The French government was aware of Germany's growing disenchantment with the European launcher programme, but many in it were convinced of the political need to retain an independent capability in this field. In June 1972 CNES presented the Minister for Industrial and Scientific Development, François-Xavier Ortoli, with the design of a national three-stage launcher LIIIS. It comprised a first stage which was essentially that of Europa III, a second based on the first, and a third cryogenic stage. Its cost was estimated at about 2000 million French francs, including a contingency, so about 50% cheaper than Europa III. Ortoli firmly believed that France had to break the grip of "American monopoly and American domination" in this field. He was supported by Gaullist Defence Minister Debré. However, the hope of having an all-national launcher was scuttled by the Treasury who insisted that at least 35% of the costs should be borne by France's European partners.[69]

The Ministers responsible for space in Europe met informally for a first round of discussions on 8 November; they consolidated their positions six weeks later on 20 December 1972. Here it was tentatively resolved that France and Germany would take prime responsibility, respectively, for building LIIIS and the sortie module (on which studies were underway in ESRO) in a European framework. This was to be done in the framework of a new single European space organisation which would replace ELDO and ESRO. Ministers also agreed to stop all work immediately on Europa III.[70] Meeting the next day the ELDO Council stopped all Europa III contracts from 31 December 1972, and agreed that staff in the Europa III team were to be given notice as of 1 February 1973. It was a

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68 The first quote is from ELDO/C(73)PV/3, meeting on 27 April 1973, document dated 22 June 1973. See also this volume, chapter 9, and the Secretariat's report on the liquidation of ELDO, ELDO/C(75)1, 15 May 1975.

69 See this volume, chapter 9. The quotation from Ortoli is in a document reproduced in E. Chadeau (ed.), *L'Ambition technologique. Naissance d'Ariane* (Paris: Editions Rive Droite, 1995), pp. 403-8.

70 CSE/CM(Dec. 72)PV/1, PV/2. The Resolution is CSE/CM(Dec.72)8, 20 December 1972.

dramatic moment for those directly involved: one of those present, the Belgian delegate J. Van Eesbeek, left the hall in tears so as not to be present when the decision was taken.

Table 1-1. Contributions and returns on the Europa III programme.[71]

Country	Contribution (MAU)	Contribution (%)	Work allocated (MAU)	% Return
Germany	24.020	49	19.78	80.26
Belgium	2.779	6	3.084	110.98
France	21.767	44	22.355	102.70
The Netherlands	0.861	1	1.044	121.25
TOTALS	**49.427**	**100**	**45.761**	**92.58 (av)**

Table 1-1 gives a breakdown of the cost of the Europa III programme and the contributions to it by the participants. In the view of the project team, in the almost four years between the decisions to start (15 April 1969) and to terminate (20 December 1972) the Europa III project, "for an outlay of 47 MMU, the most thorough and detailed preparation ever conducted for a multinational European major technical project has been carried out", in which "the lessons and experience of earlier projects were put to use". There had been not only a thorough technical definition of the project and detailed planning, but also extensive pre-development work in all technically critical areas, a careful study of launch location, and precise and binding arrangements between the contracting authority and industry had been defined.[72]

To liquidate these assets a small group was created inside the ELDO Secretariat after the Council meeting on 2 February 1973. It was advised by a working group of Member States' representatives who were to define the principles for the liquidation of the programme. They decided that it was important to proceed quickly, that the Member States concerned in the LIIIS programme (Lanceur de Substitution de 3ème génération, the French national launcher that was to become Ariane) would be given priority, and that material judged not suitable for the new European launcher would then be made available for national programmes.[73]

LIIIS's first two stages and those of Europa III were sufficiently similar for there to be a considerable transfer of material from one programme to the other. France, for example, asked for first stage integration and first stage structure (SNIAS), first stage propulsion (SEP and MAN), the first stage thrust frame (MAN), the second stage structure (L'Air Liquide), second stage propulsion (Cryorocket/SEP) and for UDMH fuel. At the end of the day equipment items with a total purchase cost of 8 MAU were recuperated from Europa III for the LIIIS/Ariane programme and became the property of the new European Space Agency[74].

The Europa II programme was to follow a similar fate. Meeting in February 1973 the ELDO Council only accepted to vote its budget for two more months, on the understanding that a decision on whether or not to continue would be taken well before 1 April.[75]

Europa II was unceremoniously dispatched at the 64th ELDO Council meeting on 27 April 1973. The German delegate reminded those present that for almost a year his government had had doubts about the wisdom of an autonomous European launch capability. Now they had finally decided that the Europa II programme should be cancelled as from 30 April 1973, after which date Germany would

71 ELDO/C(75)1, 15 May 1975.
72 From the final report on the project, ELDO/C(73)8, 22 January 1973.
73 ELDO/C(73)14, 18 April 1973.
74 ELDO/C(73)14, 18 April 1973 and ELDO/C(75)1, 15 May 1975.
75 ELDO/C(73)PV/1, meeting on 2 February 1973, document dated 8 February 1973.

pay only the rundown costs. The French delegate accepted this suggestion immediately, leaving the Belgians stunned. Their delegate said that he had only just learnt of the proposal to cancel the rocket, and pleaded for more time to consult his Minister. His counterparts from France and Germany were unrelenting: they were not even prepared to accord him a delay of 15 days. Objecting that the Belgian government had stood by the major participants for 18 months, and that a deal between France and Germany had been brokered without his government being fully involved, the delegate left the meeting. The Council decided, in his absence, and by the votes of France and Germany, that the Europa programme was to be stopped, and that the firms concerned should be informed of this immediately by telex.[76]

The liquidation of Europa II was an operation of a quite different order of magnitude to that of Europa III. The latter was still in the early phases of development. By contrast the development of Europa II was practically over and the production line had been started up. In financial terms ELDO had spent almost 40 times more than on the post-Apollo studies, and 15 times more than on Europa III. Meeting in May 1973 the ELDO Council approved the setting up of a liquidation group comprising 47 staff. 15 were still active in July 1974 and 6 in January 1975.[77]

The Secretariat awarded a total of 430 contracts for the Europa II programme (see Table 1-2). Of these 140 were still underway when the project was stopped. The philosophy determining their liquidation was that, since most of the hardware used or built for the programme was no longer usable, it was important to dispose of it quickly and efficiently, rather than being hamstrung by unduly complex bureaucratic procedures.[78] Indeed the job was effectively over by 1 July 1974, and the remaining staff in the Organisation who so wished (40 agents) were transferred to ESRO in anticipation of the *de facto* coming into being of ESA. In September that year 57 agents who had still not found employment elsewhere were receiving indemnities.[79]

The 72nd and last meeting of the ELDO Council was held on 30 May 1975 with E.A. Plate (NL) in the chair. He drew a balance sheet of the history of the organisation, he thanked all who had done so much for ELDO, and he paid tribute to the dedication that France had shown for space affairs, “bien que les français ne soient pas toujours un partenaire très facile”. Plate ended, as is usual on such occasions, with an anecdote. We repeat it here in the hope of lightening this rather clinical narrative. A Dutch Minister was once obliged to give an important speech in his rather poor French. Turning to a friend afterwards he asked “est-ce que j’ai bien parlé?” Son ami lui a répondu plus sincèrement que poliment: “Depuis Sodome et Gomorrhe, on n’a jamais mélangé de telle façon les sexes”. Soon afterwards Plate added, “Gentlemen, this is the end of my speech. This is the end, I believe of the meeting of the ELDO Council.”[80] It was also the end of ELDO.

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76 ELDO/C(73)PV/3, meeting on 27 March 1973, document dated 22 June 1973. The decision to inform firms was taken by France, Germany, Italy, the Netherlands and the UK.

77 ELDO/C(75)1, 15 May 1975, ELDO/C(73)21, 16 May 1973.

78 *Ibid*.

79 ELDO/C(74)PV/1, meeting on 26 April 1974, document dated 3 July 1974; ELDO/C(74)11, 22 October 1974.

80 ELDO/C(75)PV/2, meeting on 30 May 1975, document 25 August 1975.

Table 1-2. Contributions and returns on the Europa II programme.[81]

Country	Contribution (MAU)	Contribution %	Work allocated (MAU)	% Return
Germany	225.647	31	176.286	78.12
Belgium	27.825	4	18.028	64.79
France	216.270	29	216.270	80.04
Italy	57.872	8	57.872	84.48
The Netherlands	22.926	3	22.926	72.19
United Kingdom	184.599	25	215.393	116.68
TOTALS	**735.139**	**100**	**648.259**	**88.18 (av)**

1.3 The Guiana Space Centre (CSG) in Kourou

The transfer of the assets of ELDO to the Ariane programme was a relatively straightforward affair. The costs of modifying the equipment inherited from ELDO and of maintaining it were included in the Ariane programme envelope. More controversial was a proposal by France made in April 1974 that the Member States of the new ESA should contribute to the running costs of the Kourou base. More controversial still was the even more costly suggestion, made six months later, after the French government decided to cancel its national launcher programme, that the CSG should be Europeanised. The States participating in the Ariane programme had assumed that launch services would be available to them at marginal cost, and had engaged their authorities accordingly. They were thus surprised and unprepared for an additional call on their resources when they had just persuaded their governments to accept an expensive package deal in a climate of great economic and geopolitical uncertainty.

France's position, as explained in April 1974, was that the base in Kourou was an indispensable support for all the payloads to be launched by ESA, notably those for applications, and that it should be considered as being of "common interest" to all the Organisation's activities. A share of its costs should thus be borne by ESA's common costs. ESA should also contribute to the equipment renewal plan for the base, the PRIE (the Plan de renouvellement des installations et des équipements). On the assumption that ESA's share amounted to 35% of the total costs of maintaining and improving the launch base, the French delegation suggested that the Member States contribute 4.25 MAU to the Kourou budget in 1974, and 4.9 MAU annually from 1975 to 1980, for a total of almost 30 MAU over the seven years concerned. As this was to be part of ESA's common costs, the burden should be shared, the French suggested, proportional to GNP.[82]

Most of France's partners were willing to contribute in some way to the basic costs of Kourou – with the exception of the British – who said that they would not contribute anything, but did not object to their partners in ESA or in the Ariane programme doing so if they wished. A number of major obstacles were, however, posed by Germany. Its starting point was that the terms of the package deal concerning Ariane, Spacelab and Marots had been settled in July 1973. It had accepted to contribute DM 40 million to the Ariane programme at that time, and the money for Kourou had to be found within that programme budget. As an alternative, a separately negotiated agreement based on a "freely negotiated scale of contributions", and to which Germany would contribute a fixed sum, was also possible. Germany refused to contribute to the costs proportionately to GNP, feeling that even a 30% share, as opposed to the 35% asked for by France, was too high, and that anyway no important contributions needed to be paid before 1976. The "insignificant claims" made on the Kourou

[81] ELDO/C(75)1, 15 May 1975.

[82] CSE/CS/KOUROU(74)2 for the cost figures. The issue was discussed in the Kourou subcommittee set up by the Committee of Alternates on 25 April 1974 and it met four times in May, June and July to discuss ways of meeting the French demand to contribute to CSG running costs (minutes CSE/CS-KOUROU(74)PV1 to PV4). A survey of the positions adopted by the delegations is to be found in CSE/CS-KOUROU(74)6, rev.1, add.1, 7 August 1974.

infrastructure before that time by the Ariane programme could, the German delegation felt, be found within the normal ESRO/ESA budgets.[83]

Belgium could not go along with this. It argued that the package deal precisely foresaw that all ESA Member States "set up the joint infrastructure needed for the execution of all the Agency's programmes, striving in the process to make the best use of existing national facilities (...)". The costs of Kourou were thus to be seen as part of ESA's common costs, and shared on a GNP basis, and "under no circumstances" as part of the Ariane programme. If debited there they would not only jeopardise that programme but also penalise France and the smaller States since some countries, and Germany in particular, had committed itself to contribute a fixed amount to Ariane development. Switzerland shared this view, as did Spain and the Netherlands.

The Swedish delegation, for its part, was extremely hesitant about the whole affair. The government had just obtained parliamentary approval for a ceiling of resources in the Swedish space budget up to the early 1980s on the basis of its interpretation of the two package deals. A GNP-related contribution to the Kourou costs would amount to 50% of the country's participation in the Ariane programme, and would now "jeopardise Sweden's space policy, a risk which the delegation could not accept at any price". There was a greater likelihood of the additional funds being obtained via a supplementary Ariane Arrangement, although even that would be very difficult.[84]

The terms of the debate were completely changed before these positions could be reconciled. Meeting on 19 October 1974, the new French government of President Valerie Giscard d'Estaing decided to wind down parts of the national space programme and to concentrate efforts in the European programme. In particular, it was decided that all national programmes at Kourou would cease as from June 1975. This meant stopping the Diamant-B P4 programme once its three scheduled launches were completed, and abandoning the Essor and Araignée balloon programmes and the national sounding rocket programme using Véronique (notably the FAUST project for studying UV celestial sources). The range in Guiana would need to be hibernated during the rest of 1975 and 1976. It would then have to be reactivated for the Ariane launch programme, which would get under way with the acceptance of the ground facilities starting in August 1977, to be ready for the first test flight of Ariane scheduled for 15 July 1979.[85] As the activities at Kourou would then be exclusively devoted to the European programme, the French authorities suggested that the base be Europeanised. This policy was coherent with the "philosophy" underpinning the 1973 package deal, they said, which involved making the best use of existing national facilities, and was embodied in Article VI.2 of the new ESA Convention. As for funding, they proposed that common costs not assignable to programmes be shared by all Member States proportional to GNP, while the costs assignable to specific launch campaigns should be borne in accordance with the scale of contributions adopted in the programme in question.[86]

The modalities and cost of this exercise were presented by the CNES authorities according to two possible scenarios.[87] In the first, the range was totally deactivated from an operational point of view, all infrastructure equipment specific to the Diamant and sounding rocket programmes was dismantled or abandoned, and there was just semi-active, *in situ* maintenance of material to be used later for the Ariane programme. This minimal configuration had several disadvantages in their view. Teams would loose their operational spirit and know-how acquired over five years of activity, the coherence of the integrated system that was the launch base would be lost, and the implementation of the PRIE would be impeded.

83 CSE/CS-KOUROU(74)6, rev.1, add.1, 7 August 1974.

84 *Ibid.*

85 See Claude Carlier and Marcel Gilli, *Les trente premières années du CNES* (La documentation Française, Paris, 1994), chapter 3; CSE/CS-KOUROU(74)9, 12 December 1974.

86 ESA/CS-KOUROU(74)12, 18 December 1974. Article VI.2 of the ESA Convention instructs the Member States and ESA, in implementing their programmes, to "endeavour to make the best use of their existing facilities and available services as a first priority, and to rationalise them (...)".

87 CSE/CS-KOUROU(74)9, 12 December 1974.

These disadvantages could be avoided with the other, alternative scenario proposed by CNES. The main idea here was to build "a coherent operational system integrating all the facilities required for the Ariane mission" around a launch activity using the US Super-Arcas sounding rockets. In particular it was suggested to pursue the *Exametnet* programme, which was intended to study local atmospheric conditions using meteorological payloads. This would maintain the base active both at equipment and at systems level through the range training operations required by the Super-Arcas launches. It would demand continuous operation of the computers, even during renewal. But above all it would keep in working order "all the CSG's nervous system, i.e. telecommunications, data transmission, time-monitoring (...)". This approach would also retain the motivation and operational spirit of the teams at Kourou, and provide ideal conditions for carrying out parts of the PRIE.

In terms of the first scenario the total staff at Kourou would be cut by 50%, from 609 in 1974 to 298 in 1976. Scenario B demanded a cut of one-third from 609 to 394. The difference was not merely quantitative, however, for on the first scheme, the technical staff was cut from 407 to 155, while on the second it was cut from 407 to 246. The 90 technicians that would be saved were just those familiar with operation of the entire, integrated system. As for cost, CNES claimed that the two schemes would cost the same overall, namely some FF 220 million for 1975/76/77 together, and FF100 million annually thereafter, for a total of FF 521million. This was equivalent to just over 93 MAU for 1975 to 1980.

The French authorities insisted that Scenario B be implemented. It was 17% more expensive in 1976, but this was offset in 1977 since the integrated system at the base would be retained in working condition. That in turn reduced the risk to the Ariane programme, since all that was required for the new launcher was the operational requalification of the technical personnel, rather than the retraining and remotivation of entirely new teams as called for on the minimalist scenario.

The European Space Conference Secretariat studied these proposals immediately. They confirmed the CNES analysis, agreeing that Scenario A was unacceptable and that option B, which preserved the coherence of the integrated telemetry system, should be adopted. Their only concern was that the CNES proposal was, if anything, too conservative and had not taken sufficient account of the changes that would be demanded by the Ariane programme. The Secretariat suggested that the rate of staff recruitment had to be higher in 1977 than that proposed by the CNES, and that the cost of the PRIE be increased by 25% over the French space agency's figures for 1975/76/77. The global budget arrived at by the Secretariat did not differ markedly from that estimated by CNES, however. It peaked at FF 102.3 million in 1977, and amounted to about FF 518 million, or just under 93 MAU for 1975 to 1980. [88]

The French proposals were first discussed inside the Kourou Subcommittee of the European Space Conference just before Christmas 1974. [89] Mingled with the usual concerns about cost and staff estimates, and demands that they be better justified, was the worry that a proposal now to Europeanise a major national facility at a cost far greater than that foreseen would completely upset the balance of the package deal. Was ESA not being asked to pick up the bill because France had decided to cancel its national launcher programme, some asked? The French delegation refused this interpretation: it was not "passing the baby" or making the Agency a "poisoned gift". It accepted that France would have to pay a "substantial percentage" of CSG costs. But it also wanted the ownership of the base to remain vested in France, and it wanted CNES to continue to manage the base on behalf of ESA for practical reasons, with suitable monitoring and control being agreed between the partners. In any event the French delegation made it clear that "a solution to the Kourou problem is for them a sine qua non for a general agreement on the issues remaining to be solved in connection with the formation of ESA". [90]

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88 CSE/CS-KOUROU(74)10, 12 December 1974.

89 CSE/CS-KOUROU(74)PV/5, minutes of meeting held on 18 December 1974, document dated 24 February 1975.

90 CSE/CS-KOUROU(74)13, 7 January 1975.

After this first exchange of views the ESC Secretariat tried to put down on paper the points on which a consensus could perhaps be reached in the committee and to “find a way through the morass of argument and counter-argument (...)”.[91] It seemed likely that Scenario B, slightly modified as suggested by the Secretariat, would be acceptable to all. A study of the range requirements was essential and urgent to establish just what the needs of the Ariane programme would be, and how the PRIE should be structured to satisfy them. No one seemed to object to CNES retaining ownership of the range, at least initially, though it was felt that ESRO/ESA should have management responsibility for Kourou, while the day-to-day running could be entrusted to the French space agency. The European Organisation should also have unrestricted rights of use of the range and absolute launch priority, though it might also be used for other programmes.

The nature and extent of financing by the Member States remained a complex issue. The ESC Secretariat suggested that 75% of the costs of the PRIE, amounting to about FF 106 million over six years, be borne by France, on the grounds that “most Member States had assumed that existing equipment at Kourou would suffice for the Ariane programme”. As for running costs, the Secretariat suggested that the contributions of Member States should be graded, beginning at 10% in 1975 and reaching 60% for 1978 to 1980. France would bear an additional burden because the CSG remained its property, and its existence in Kourou gave France an advantage which her partners did not have. On the other hand, France would be free to find other clients for the base, and the associated profits (and costs) would fall to her, always on condition that ESA’s programmes had first priority.[92]

The Secretariat’s paper was discussed by the Kourou Subcommittee on 10 January 1975.[93] It was warmly received, the French delegation calling it “pragmatic, logical and neat”. One major change was recorded: the French delegation had dropped the idea of Europeanising Kourou and now merely sought ESA participation in the costs of the Guiana Space Centre. This created some changes of substance: for example it was accepted that CNES would be the authority responsible for the technical and financial management of the base, while ESA’s role would be reduced to that of monitoring this management. There remained too some differences over details, but in general even those who had expressed most doubts about the scheme, like Germany and Switzerland, publicly affirmed that “they would spare no effort to solve the Kourou problem”. In the event it turned out that some delegations were able to suggest their possible level of contributions, even though the figures were tentative and qualified. Indeed at the end of the meeting figures amounting to 63 MAU of the total of 91.45 MAU (in January 1974 prices and exchange rates) had been made by those present. Of this France’s contribution was far and away the greatest: 50 MAU.[94] Belgium insisted that its contribution was subject to a satisfactory solution to the Redu problem (see below). Sweden similarly said that it could contribute if the Kourou issue was tied to a solution of the Esrange problem. “This mixing”, the Secretariat said, “is aimed not only at extending the present Esrange Special Arrangement (due to expire in 1976), but also to permit Sweden to transfer some funds from Esrange to Kourou”.[95]

To consolidate the situation, at the end of January 1975 the Secretary General of the ESC set up a commission to look into the CNES proposals. It was headed by an independent expert, Dr Kurt H. Debus, director of NASA’s Kennedy Space Centre until October 1974. Debus was assisted by two staff members from ESRO and two from CNES. By and large the Commission confirmed CNES’ and the Secretariat’s analysis of the situation: as the ESC Secretary General said, “while the Commission had discovered nothing that was really new, it had at least had the advantage of confirming that the solutions envisaged were not absurd and that no other radical ones existed”.[96] In particular it agreed that Scenario B, which maintained a minimum level of operational activity at the base, rather than hibernate it completely, was essential to safeguard the Ariane development

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91 *Ibid.*

92 *Ibid.*

93 The minutes of the meeting held on 10 January 1975 are CSE/CS-KOUROU(75)PV/1, 14 March 1975.

94 CSE/CS-KOUROU(75)PV/1, 14 March 1975 and the report on the meeting, CSE/CS-KOUROU(75)1, 14 January 1975.

95 CSE/CS-KOUROU(74)13, 7 January 1975.

96 CSE/CS-KOUROU(75)PV/2, 28 March 1975.

programme. Some minor financial reorganisation was suggested: 2.5 MAU of the expenditure foreseen for the PRIE were specifically required for the Ariane programme and were transferred to that heading. This reduction, along with the weakening of the French franc, led to a new global cost for the programme of 79.745 MAU (FF 495 million) in 1975 prices.[97]

During the next few months the Committee of the Alternates and the Kourou subcommittee drew up a resolution to submit to Ministers meeting in April 1975 to formally sign the ESA Convention. It emerged that many Member States were still simply not willing or able, for internal accounting reasons following on the second package deal, to make major contributions to the costs of running Kourou. France was prepared to put up 50.026 MAU of the 79.745 MAU estimated for running the base until the end of 1980. Her partners together could not guarantee more than a further 19.409 MAU, leaving a shortfall of 10.31 MAU. To overcome this difficulty the French delegation undertook to act as surety for the shortfall. At the same time it was agreed that Ministers would review the situation two years later, though their agreement to do so did not entail that they would necessarily be willing to contribute more to the running of the base in Guiana. The Ministers meeting in April, as we shall describe shortly, finally agreed on the contribution structure given in the table below after nail-biting delays in Bonn. It reflects both the political reluctance of some countries to contribute to the running costs of the launch pad, and the very tight, long-term constraints which had been imposed on the space budgets by the collaborative adoption of the major programmes in July 1973.

Table 1-3. List of contributions to the running costs of Kourou up to the end of 1980 (after CSE/CM(April 75)4, Final, Annex, Rev. 1, 4 June 1975.

Member States	Contribution	Conditions
Germany	DM 50 million = 10.65 MAU	Fixed, payable in 5 annual instalments from 1976
Belgium	1.725 MAU	Revisable
Denmark	0.45 MAU	Revisable
Spain	0.805 MAU	Revisable, payable from 1976
France	50.026 MAU	Revisable
Italy	Lit 1000 million = 0.85 MAU	Fixed, payable in 5 annual instalments from 1976
The Netherlands	0.894 MAU	Equivalent to Fl 3 million, revisable up to Fl 4 million, payable from 1976
United Kingdom	2.25 MAU	Revisable, payable in 5 annual instalments from 1976
Sweden	1.035 MAU	Revisable
Switzerland	0.75 MAU	Revisable

1.4 The new European Space Agency and its Convention

The first important revisions of the ESRO Convention, and its supporting protocols, were undertaken in parallel with the negotiations which led to the brokering of the first package deal in December 1971. Changes were needed, the French delegation insisted, to take account formally of the new place of applications in ESRO's activities and to give due weight to the role of the Organisation as a "forum for discussion where national and international programmes could be coordinated". In July 1971 the Member States agreed to set up a Working Party which was to make its proposals before the end of the

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97 The report is CSE/CS-KOUROU(75)2, 21 February 1975. See also CSE/CS-KOUROU(75)3, 27 February 1975, and CSE/CS-KOUROU(75)4, 10 March 1975.

year. A set of guidelines was drawn up to help them.[98] From this emerged a revised ESRO Convention, submitted to the Council in draft for the first time in November 1971.[99]

The events of 1972, which culminated in the agreement at the end of the year on what became the second package deal (Ariane, Spacelab and Marots), formally brokered in July 1973, demanded that this draft be revised further. This was needed, above all, to accommodate the emergence of a single space agency to replace ESRO and ELDO and to lay down guidelines for industrial policy. The European Space Agency Working Group was set by the Committee of Alternates on 21 December 1972 for this purpose, one of its aims being to produce a new Convention in anticipation of ESA coming into being on 1 January 1974.[100] In the event this date proved too optimistic and the final version of the text was eventually adopted by Ministers meeting on 15 April 1975.

There is no interest in going through each and every clause of the ESA Convention here.[101] Rather we shall concentrate on those aspects of it that reveal clearly the re-orientation of the collaborative space effort which occurred in the early 1970s with the establishment of a new European Space Agency. To do this we shall essentially compare the evolution of certain key clauses in the Convention as it was transformed from dealing essentially with a scientific organisation, into one dealing with applications,[102] and finally into the single ESA.

1.4.1 The harmonisation of programmes in a single European space organisation

From as early as 1966 it had been generally agreed that Europe suffered from having too many space organisations, and that some attempt should be made to coordinate the work of ESRO, ELDO and CETS, as well as to make a more cost-effective use of national facilities and programmes. As we have seen this resolve was confirmed when the first package deal was being worked out in 1971. At the time France took the lead, anxious as she was to have applications given their full place in the new order, and a formal commitment made to the use of European launchers. It was the turn of the British to insist on the need for harmonisation at the time of the second package deal. In 1971 the Conservative government of Edward Heath finally led the UK into the Common Market, signalling a renewed wish to play a more important role in European affairs. Michael Heseltine was made responsible for space matters in 1973. He made a point not only of ensuring that space policy at home was better coordinated than before. He also coupled London’s commitment to the European space effort with the demand that every effort should be made to dovetail national programmes with those undertaken by ESA so as to avoid unnecessary duplication and to make the most rational use of Europe’s capabilities.[103]

The ESRO Convention drawn up in the early 1960s made no reference to coordination, of course. However, in line with that part of the first package deal calling for coordination, it figured in the revised ESRO Convention arrived at in mid-1972. As we pointed out earlier, its Article II required the organisation to elaborate and implement a European space programme which was “coordinated with national programmes” and to contribute to the “harmonisation” of the national programmes

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98 ESRO/C/MIN/38, meeting of 25-26 May, 1971, and ESRO/C/XXXIX/Res. 3, rev. 2 (draft), 14 July 1971, chapter VI, and ESRO/C(71)XXXIX/Res. 3, Annex III, 14 July 1971 for the guidelines. The quotation is by the French delegation.

99 The *Draft Revised Convention* is ESRO/CONV(71)10, 10 November 1971.

100 The minutes of this group are CSE/CS/ESA(73)PVx, (74)PVx, (75)PVx. The first meeting was held on 17 January 1973.

101 The text is discussed in detail from a legal point of view in Gabriel Lafferranderie, "European Space Agency", *International Encyclopedia of Laws* (Kluwer Law International, 1996). An extensive bibliography is available in *The Implementation of the ESA Convention. Lessons from the Past. Proceedings of the ESA/EUI International Colloquium, Florence, 25 and 26 October 1993,* Edited by the European Centre for Space Law (Martinus Nijhoff, 1994), 279-283.

102 We will use as point of reference the version adopted in June 1972, ESRO/CONV(71)10, rev. 2.

103 For a very entertaining account of his role at this time see the contribution by Heseltine to the Proceedings of the Symposium organised by ESA and the Science Museum in London in November 1998 (ESA SP-436, 1999).

undertaken by its Member States.[104] Looking at the Convention again a year later the European Space Agency Working Group was, of course, particularly concerned with this issue. ESA, it said, "must be created under conditions which enable better use to be made of the financial and other resources presently devoted by Member States to space and to lead the definition of a common European civil space programme". The Secretariat, in consultation with the Member States concerned, was to "make proposals for the transfer, modification, closure, rent (or otherwise making available) of national facilities required for the whole ESA programme or, *when this is inevitable* (our emphasis), for the construction of a new facility", leaving it to the Council to decide whether or not this was of interest for the community as a whole. It was also suggested that "a consultation mechanism should be instituted forthwith whereby Member States would notify (...the DG of..) their plans for new space programmes".[105]

These ambitious aims were reflected, to some extent, in the text of the ESA Convention. If the revised ESRO Convention simply spoke of 'coordinating' national programmes with the European programme, the ESA Convention added that the former should be integrated "progressively and as completely as possible into the European space programme, in particular as regards the development of applications satellites" (Art. IIc). To achieve this coordination and integration, Member States were to inform the Agency "in good time" regarding their new space programmes (Art. V.3). An entire Annex (Annex IV: Internationalisation of National Programmes) was devoted to the procedures required for this purpose, procedures intended to restrict the possibility of countries doing just as they pleased. It encouraged each Member State to "make available for participation by other Member States, within the framework of the Agency any new civil space project which it intends to undertake" (Annex IV, Art. I), notifying the DG of this before undertaking the Phase-B project definition phase so that others could "undertake a significant share of the work involved". The initiating State was to "use its best endeavours" to accommodate the ensuing demands of its partners, and was not allowed to withdraw its proposal simply because the response to its suggestion did not live up to its original hopes. Though Member States were obviously left free to undertake bilateral or multilateral programmes with *non Member States*, Annex IV also asked them to try to ensure that these "do not prejudice the scientific, economic, or industrial objectives of the Agency", and that they be opened to wider participation with the Member States if possible (Annex IV, Art. II).

ESA was, however, not restricted to coordinating and integrating and space programmes. It was also to be an initiator, a source of new ideas and plans. It was supposed to take the lead in "elaborating and implementing a long-term European space policy", it was to "concert" the policies of its Member States "with respect to other national and international organisations and institutions" (e.g. it was to try to ensure that they spoke with one voice in the Intelsat negotiations), and it was to take the initiative in "recommending a coherent industrial policy to the Member States" (Art. II).

An entire article of the Convention was devoted to the facilities and services required by the Agency. These could be its own, like ESTEC, or ESA could use national facilities in its Member States. Once again a step was taken beyond the revised draft ESRO Convention. That document had a clause stating that the Organisation and its Member States would strive to make best use of their existing facilities.[106] The ESA Convention added that this would be done "as a first priority". It went on to say that ESA and its Member States "shall not set up new facilities or services *without having first examined the possibility of using existing means*" (Art. VI) (our emphasis). The Final Act of the Conference of Plenipotentiaries meeting in May confirmed that the Agency, "when it has need, [was] to make use of the potential and facilities of the Member States, provided that there exists an economic case for so doing."[107]

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104 ESRO/CONV(71)10, Rev. 2, 12 June 1972, *Draft Revised Convention* produced for its Council by the ESRO Working Group on the Revision of the Convention.

105 CSE/CS/ESA(73)WP/10, about March 1973.

106 Article VI of ESRO/CONV(71)10, Rev. 2, 12 June 1972.

107 Resolution No. 7 of the Final Act.

Even though these provisions reinforced the intentions expressed earlier, their request that Member States merely "examine the possibility" of avoiding duplication fell far short of the original intentions of the ESA Working Group. As we saw above, this group foresaw the need to close down some national centres and hoped that new ones would only be established when this was inevitable. If this gap had opened up between aspiration and actuality it was also because, in parallel with the drafting of the Convention, delegates were becoming aware of just how difficult it was to reconcile technical need with political exigencies. The rationalisation of European tracking and telemetry ground facilities was a case in point. This issue was so contentious that it dragged on for almost two years, all the elements of a compromise only being put in place just after the Ministerial Conference establishing ESA in April 1975.[108] It showed just how difficult it was to carry out in practice the lofty ideals informing the harmonisation of space programmes and facilities.

Two levels of activity were concerned in this case. Firstly, there was the European component of the global tracking and telemetry network. Not only was there a threat to marginalise the role of Redu in Belgium notwithstanding its historical and technical role in ESRO; other candidates for tracking facilities in France, Germany, Italy, Spain...emerged, pushed by the interest in the technology and the potential of linking a local user community to it. Secondly, there was the question of the site to be responsible for the centralisation at operational level of the control and coordination of this network. This was assumed to be ESOC at Darmstadt in Germany until France suggested it should be in Toulouse. The latter, said the French delegation, was being extensively developed as part of the government's regional policy, would be the major French space centre, and would also be ideal for tracking satellites in low-Earth orbit, which the country wished to develop as part of its national space effort.

The compromise finally reached towards the end of 1974 pertained only to ground stations for satellites in geostationary orbit. The way in which it carved up the pie was indicative of the ongoing determination of Member States to protect their national activities when technological leadership was concerned no matter how much they might sing the praises of rationalisation. We reproduce the resolution in extenso:

> *1. The processing of telemetry data and control of operations for all ESRO satellites would normally be effected by the ESOC facilities at Darmstadt;*
>
> *2. The Odenwald ground station would be used for acquiring S-band data from the scientific satellite GEOS and for the links with Meteosat (with the exception of the back-up VHF links);*[109]
>
> *3. The ground station at Villafranca del Castillo near Madrid would be used for the acquisition of the data, and the control of the experiments on the scientific IUE satellite, as well as for telemetry reception and transmission of the commands needed for controlling the Marots and Aerosat satellites (excepting the back-up VHF links);*[110]
>
> *4. The control and test station of the OTS telecommunications satellite would be located at the Telespazio facilities at Fucino. It would be moved to Redu if satisfactory contractual arrangements with the firm could not be reached;*

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108 The main debates are in ESRO/C/MIN/61, meeting on 6 December 1973, document dated 20 December 1973; ESRO/C/MIN/63, meeting on 8 March 1974, document dated 26 March 1974; ESRO/C(74)15, 25 March 1974; ESRO/C(74)31, 29 May 1974; ESRO/C/MIN/65, meeting 6 June 1964, document dated 14 June 1974; ESRO/C/MIN/68, meeting on 8 October 1974 document dated 22 October 1974; ESRO/C/MIN/69, meeting on 30 October 1974, document dated 8 November 1974.

109 The agreement between ESRO and the government of the Federal Republic of Germany is ESRO/C(74)10, rev.1, 19 July 1974.

110 The agreement between ESRO and the Spanish government is ESRO/C(74)7, rev. 1, 7 August 1974.

> *5. Redu would continue to be responsible for VHF links in the European area. It would also provide the main support for COS-B operations, be the primary station for the telecommand of the GEOS satellite, and support the VHF operations for GEOS, Meteosat, OTS Marots and Aerosat.*[111]

The Belgian delegation could not accept this situation. It insisted that rather than simply continue in its traditional role, new work should be accorded to the station on its soil. This issue was still not settled on the eve of the Ministerial conference establishing ESA. There the Belgian delegation stated that it "had often regretted that over the last few years the other installations had been entrusted with missions which would have been suitable for the Redu station and would have ensured the continuation of the Organisation's work on that site". It wanted a new activity to be identified at once, or, if that was not possible, it wanted the ESRO Council to agree that, "if such an activity could be identified within the course of the next few months, it would be agreed to establish it at Redu" without stopping such a move by appealing to decisions of principle previously taken by the Council. In particular the principle that "existing facilities, whether they belonged to the Organisation or to a Member State, should be exploited to the fullest extent before any new installation was set up" was to be waived.[112] Nobody wanted to alienate a delegation that had strongly supported the European space effort for so many years. Two days later, at its last meeting, and following the gathering of Ministers, the ESRO Council resolved that the ESA Director General would continue to seek ways in which an activity at Redu could be maintained after 1980, adding that "previous Council decisions regarding the policy relating to the installation of future ground stations should not be invoked as a reason for not conferring on Redu a new activity in this field, provided that technical requirements can be satisfied[113].

1.4.2 Industrial policy[114]

Neither the ESRO Convention, nor the revised version drawn up in 1971/72 made any specific reference to industrial policy. However, the idea that Europe should have a coordinated space programme into which national components were integrated wherever possible led to the hope that Europe's space industry may also be rationalised and become more competitive and cost-effective. Indeed the implementation of a viable industrial policy was central to ESA's mission. After all, one of the key aims of the Agency was to promote R & D in the applications area with a view to stimulating a commercially competitive activity in Europe, notably in the field of telecommunications. Space policy was now also and, for some, primarily a question of industrial policy.

The ESA Working Group had great difficulty in dealing with this "fundamental problem". It realised that any industrial policy required a definition of long-range programme requirements, had to maintain competition, had to avoid duplication and encourage specialisation, and needed to give special weight to the technological interest of contracts and not just to their financial value. However, after four meetings it was "far from clear how Member States wish an industrial policy to be defined or applied". To that end an Industrial and Contract Policy Subgroup was thus established in summer 1973.[115]

The Industrial and Contract Policy Subgroup approached the question of industrial policy with a number of considerations in mind. Firstly, if national programmes were going to be harmonised and often merged into ESA's activities, the new Agency would have a near monopoly on space activities in Europe. A coherent industrial policy would thus be essential. Secondly, they were extremely conscious of the need for European industry to compete on the world market in the new applications fields,

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111 ESRO/C/LXIX/Res. 1, 30 October 1974.
112 ESRO/C/MIN/74, meeting on 14 April 1974, document dated 28 April 1974.
113 ESRO/C/LXXV/Res. 1, 16 April 1975 attached to ESRO/C/MIN/75, meeting dated 16 April 1975, document dated 30 April 1975. See also ESRO/C(75)14, 4 April 1975.
114 See also Lafferranderie, *European Space Agency*, *op. cit.* Chapter V.
115 CSE/CS/ESA(73)WP/10, around March 1973. The issue of industrial policy was hotly debated in three meetings of the ESA Working Group, CSE/CS/ESA(73)PV/7, PV/8 and PV/9, held on 26 October 1973, 16 November 1973 and 13 December 1973 respectively.

notably telecommunications. That required that there be no externally imposed constraints on firms which could force up their costs and reduce their ability to compete in export markets.

The need to build a competitive industry was directly jeopardised by the contradictory need to respect the principle of fair return. This major instrument of policy was of course inherited from ESRO. There the notion that return coefficients should never fall below 0.8 had been institutionalised under Bondi's direction beginning in the late 1960s, and it had been reasonably well respected. Indeed the cumulated return coefficients for ESA's Member States on 1 January 1975 lay between 0.83 and 1.05, with Sweden and Switzerland at the lower end of the scale and approaching the critical value of 0.8.[116] The majority of the members of the ESA Working Group “did not consider it advantageous to change the rules and practices for fair return as presently agreed within ESRO (...)”.[117] The Industrial and Contract Policy Subgroup found itself similarly bound by this tradition which was particularly important to the smaller Member States, and the final version of the ESA Convention necessarily reflected this tension.

As we mentioned in the previous section, the ESA Convention announces, in Art. II.d that one of the purposes of ESA is to promote European collaboration in the space sector "by elaborating and implementing an industrial policy appropriate to its programme and by recommending a coherent industrial policy to the Member States". Article VII developed this idea. It specified that the aim of that policy would be to meet the requirements of the European and national space programmes "in a cost-effective manner", to "improve the word-wide competitiveness of European industry", to ensure that all European Member States participated "in an equitable manner, having regard to their financial contributions", in the programmes, to which end the Agency would wherever possible grant preference to their firms and, finally, to encourage "competitive bidding". An additional Annex (Annex V) described the procedural rules for procurement and specifically dealt with the questions of industrial return. The calculation of return coefficients was to weight contracts according to their technological interest, these weighting factors to be defined by the Council. It also stated that "Ideally the distribution of contracts placed by the Agency should result in all contracts having an overall return coefficient of 1" (Art. IV.3 of Annex V). Reflecting the prevailing situation in ESRO, the Convention also stipulated that "For the first three-year period, the lower limit of the cumulative return coefficient is fixed at 0.8". This lower limit was a minimum baseline; it could be revised by the Council for the next period if necessary, but only upwards (Art.IV.6 of Annex V).

The industrialists were particularly unhappy with Article V.2 of Annex V. This article dealt with the situation which would arise if a return coefficient for any Member State fell below the agreed lower limit (i.e. 0.8 initially, but possibly revised upwards later). If this happened the ESA Director General was to make suggestions to Council as to how to redress the deficit within one year, respecting the Agency's rules for placing contracts. However, and here was the rub, Article V.2 went on to say that "If, after this period of one year, the imbalance still persists, the Director General shall submit to the Council proposals *in which the need to remedy the situation takes precedence over the Agency's rules governing the placing of contracts* (our emphasis)". This clause was a concession to some of the smaller countries: one minute, for example, tells us that "The Swedish and Belgian representatives (to the Industrial and Contract Policy Subgroup) insisted on the need for a method of adjusting retroactively the contributions in accordance with the industrial returns, or at least for a mechanism capable of protecting the interests of Member States when deviations from the fair return principle occur".[118] The mechanism devised in Art. V.2, however, was obviously seen by the industrialists to be "a severe restriction of free competition".[119]

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116 The figures are from George P. Van Reeth, "The Evolution of Industrial Policy", *Proceedings of an International Symposium on 'Twenty Years of the ESA Convention', Munich 4-6 September, 1995* (ESA-SP387, November 1995), 101-104.

117 CSE/CS/ESA(73)WP/10, around March 1973.

118 CSE/CS/ESA(73)7, Annex I, 16 May 1973. See also the debate in CSE/CS/ESA(73)PV/4, 18 June 1973, meeting of the European Space Agency Working Group held on 23-24 May 1973.

119 CSE/CS/ESA(74)4, add.2, Annex I, 11 February 1974.

Industry was not against the principle of fair return per se. However, its representatives felt that it was only possible to respect simultaneously the otherwise contradictory aims of improving competitivity, respecting free competition and imposing a principle of fair return under certain conditions. First and foremost they felt that a far more extensive programme than that being suggested was necessary. "One of industry's strongest hopes", said one representative, "was to have long-term workloads with a large degree of internal coherence (...)".[120] A coherent ten-year programme for example, would enable firms to set up the necessary infrastructure and the specialist teams which would be required to improve competitivity and, by encouraging series production, would reduce costs. This was particularly important in the area of telecommunications, where firms would be competing directly with American and Japanese suppliers. Secondly, the industrialists felt that the policy of fair return could work if applied with flexibility and imagination. It was suggested for example that, in the event of series production, the imbalance in the return coefficients during the development period could be offset at the mass production level. Some insisted that distinctions be drawn depending on the duration, size and form of programmes. Return coefficients of unity were perhaps realisable on a major programme with limited participation like Spacelab. A limit of 0.8 to be achieved over at least five years would be more desirable for other kinds of programmes. The industrialists also stressed that space activities existed in the larger framework of advanced technology in the aircraft, electronic, computing and nuclear sectors, and that it would be far easier to apply the principle if it was applied across all these sectors globally, rather than to each space programme individually.[121]

Industry's hope that the new space agency would define an industrial policy (e.g. define a long-term coherent programme which rationalised the workload and defined an interrelated set of spacecraft and respected a flexible fair return policy) was to be stillborn. Indeed it is often remarked that the Agency has no industrial policy in this sense of the term and that it has been reduced to the policy of fair return, which has been applied with increasing degrees of rigour over the years. The lower limit of the return coefficient was revised at Ministerial conferences in Rome in 1985, in The Hague in 1987, in Granada in 1992 and in Toulouse in 1995. It has crept up in this time from 0.90 at the end of 1990, to 0.95 in 1993 and 0.96 at the end of 1995.[122] When the idea was first mooted it was said that "Geographical distribution of contracts must not be considered as an end in itself", but was to be used "for the time being", as "one of the ways of monitoring the success of the implementation of the industrial policy".[123] Successive Ministerial Council meetings have turned that ideal on its head.

The failure of fair return to discriminate between different kinds of programmes remains a bone of contention, at least for spokesmen for the larger Member States which have important national programmes and a strong space industry. In a recent, critical analysis of the policy D. Sacotte (who was at CNES at the time) insisted again that the notion of industrial return had to be "demystified", "that it was not an absolute notion", and that "to want to apply it too rigorously would be to paralyse the system".[124] He suggested that for 'political' programmes like Hermes and Columbus, i.e. programmes not primarily driven by the need to improve industrial competitivity, the principle of fair return could be strictly applied. A different approach should be taken for Scientific Programmes or, more generally, for those in which the acquisition of knowledge was the main objective (e.g. Earth observation). The interest of these programmes resided in the exploitation, treatment and interpretation of their results. Fair return overemphasised the industrial aspect of spacecraft development to the detriment of these broader and more fundamental dimensions. Finally, in the case of programmes deliberately intended to improve the competitivity of European industry on the world market (telecommunications satellites, Ariane), Ministerial demands to push the return coefficients even

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120 CSE/CS/ESA(73)12, Annex I, 24 July 1973.

121 For these suggestions see CSE/CS/ESA(73)10, Add. 1, 21 June 1973 and CSE/CS/ESA(73)12, 24 July 1973.

122 Lafferranderie, *European Space Agency, op. cit.*, p. 62. See also van Reeth, "The evolution of industrial policy", *op. cit.*

123 CSE/CS/ESA(73)7, Annex 1, 16 May 1973.

124 For this paragraph see D. Sacotte, "Les regles de l'ESA dans une perspective nationale", paper presented at the conference *The Implementation of the ESA Convention, op. cit.*, 111-123.

closer to unity were, in Sacotte's view, a "grave danger". The similarity with the opinions expressed 25 years ago by some of the representatives of Eurospace is striking.

1.4.3 Programmes and activities

One of the key aims of the revised Convention was to make allowance for programmes in which only some Member States participated, and to define their engagements and responsibilities. This core distinction between mandatory and optional activities was enshrined in the opening lines of Article V of both the revised ESRO and the ESA Conventions.[125] However, the procedure to be followed by a Member State in choosing whether or not to engage in an optional programme underwent an important modification.

The first draft of the revised ESRO Convention identified a number of mandatory activities: the Scientific Programme, basic activities (e.g. education, documentation...), information collection and dissemination, and maintaining contacts with space users. The first two of these, science and basic activities, plus a contribution to the fixed part of the common costs, constituted the basket of engagements required for being regarded as a Member State of the Organisation. Optional programmes would be notably the "design, development, placing in orbit and control of application and scientific satellites*" "in which Member States have agreed to participate*" (our italics).[126]

The Belgian delegation asked that this formulation be changed. As it stood the text "would not allow certain Member States to take part in an optional programme – even a minimal one – without going through the procedure of parliamentary ratification and approval of an international commitment (...)".[127] This would necessarily entail delays and the risk that a government which favoured participation might find itself opposed in the house of representatives. To get around this difficulty, the Belgian government proposed that, instead of participants having to decide whether they wished to take part, the Convention would start from the premise that they would indeed participate. The formal step that then had to be taken was the inverse: one had to state that one was not interested. Hence the revised ESRO Convention arrived at in June 1972 distinguished mandatory from optional programmes and activities by simply stating that the latter were those in which Member States had "declared themselves not interested". [128] The same way of distinguishing mandatory from optional activities was carried over into the ESA Convention, perhaps on Peter Creola's insistence.[129] Its Art. V.1 begins by stating that "The activities of the Agency shall include mandatory activities, in which all Member States participate, and optional activities, in which all Member States shall participate *apart from those that formally declare themselves not interested in participating therein*" (our emphasis). In Art I.2 of Annex III to the Convention, which dealt with the procedures for dealing with optional programmes, Member States were given three months to make this declaration beginning from the time when the ESA Council had agreed to undertake the programme. It should be said that, in practice, this procedure proved difficult to implement: national bureaucracies always had to be sure that the political and financial support would be forthcoming before they engaged themselves in a programme. The procedure was, however, less heavy than might otherwise have been the case.

Regarding the content of the optional programmes, provision was made in the ESA Convention for the activities added in the second package deal. Thus the optional activities were two. Firstly, the "design, development, construction, launching, placing in orbit and control of satellites" (essentially as in the revised ESRO Convention, it being understood that these could be scientific or application) "and other space systems", a reference to Spacelab (Art. V1bi). Secondly, the "design, development,

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125 At one stage it was thought to have three classes of programme: (i) mandatory with contributions on a GNP basis, (ii) funded from mandatory contributions but not supported by all Member States and not funded on a GNP basis, and (iii) special projects in which participation is entirely optional - see CSE/CS/ESA(73)WP/10, around March 1973.

126 ESRO/CONV(71)10, 10 November 1971.

127 ESRO/CONV(72)WP/6, 9 February 1972. See also ESRO/CONV(71)10, rev. 2, add. 11, 4 August 1972.

128 ESRO/CONV(71)10, rev. 2, 12 June 1972, Art V.2.

129 Peter Creola, "Switzerland and Space - How a small country succeeds", *Space Policy* **15** (1999), 41-44.

construction, and operation of launch facilities and space transport systems", a reference to Ariane (Art. V1bII).

Another novelty in the ESA Convention was reference to operational activities. The earlier revised ESRO Convention made no mention of this. The ESA Convention, by contrast, already in its preamble committed the organisation to preparing the way for operational activities. Here it was stated that the participants wished to strengthen "European cooperation, for exclusively peaceful purposes, in space research and technology and their applications, *with a view to their being used for scientific purposes and for operational space applications systems"* (our emphasis). This wish to have the long-term goal of an operational system in mind in adopting a programme was reinforced in Article V.2, in which the Convention specifically encouraged ESA to "carry out operational activities" if the users so desired and under conditions to be agreed by the Council.

The procedure for executing an optional programme was described in a protocol to the revised ESRO Convention and in Annex III to the ESA Convention. Some basic criteria to be satisfied by these rules were laid down along with the first package deal.[130] They evolved very little, with one exception which we shall discuss in a moment.

The partners in an optional activity committed themselves to a programme containing a succession of phases, along with their timing, an overall financial envelope and the sub-envelopes for each phase. The scale of contributions was to be proportional to GNP "unless all participating States decide otherwise" (Art. XIII.2 of the ESA Convention). Particular attention was paid to the circumstances surrounding engagement and withdrawal. As the guiding principles laid down in 1971 put it, a compromise was needed between two requirements, namely, "(a) No participating State must be forced to stay in the programme if the initial assumptions prove to be drastically wrong", and "(b) No State should ever be in a position to stop the programme unilaterally by discontinuing continuation".[131] Translated into the legal terms of the ESA Convention these requirements were met in several ways

To satisfy condition (a) it was decreed that if the programme included a project definition phase, the participating States could reassess the cost of the programme after that phase, and any one of them was free to withdraw if the new cost-estimate exceeded the initial indicative envelope by more than 20%. Alternatively they could withdraw if the cost overrun was greater than this revised envelope – or the initial envelope in the event that that had not been revised at the end of the project definition phase. To satisfy condition (b) it was stressed that the withdrawal of a State due to cost-overruns would not mean the termination of the programme. Instead those States that wanted to continue notwithstanding the new budget envelope could do so on terms arranged mutually between themselves.[132]

The same kind of safeguard was built into the procedure for starting each successive phase. The condition to proceed was a rather strict one: it required a double two-thirds majority, i.e. two-thirds of the participating States who also contributed two-thirds of the budget. However, if it proved impossible to satisfy this requirement, those States that wished to proceed from one phase to the next were authorised to do so on conditions agreed among themselves.[133] This was a provision which reassured the major guarantors of the optional programmes that they were not becoming locked into projects which could spiral out of their control. Correlatively, it put the smaller Member States at a disadvantage. Indeed the Netherlands and Swedish delegations specifically suggested that the decision to proceed from one phase to another in an applications satellite programme be unanimous, since only in this way could minor contributors make their presence felt, and be treated on a politically equal

130 "Principles Concerning the Revision of the ESRO Convention", Annex III to ESRO/C/XLXXX/Res. 3 (Final), 20 December 1971.

131 *Ibid*.

132 Annex III, Art. III of the ESA Convention. For some of the problems encountered subsequently see Lafferranderie, *op. cit.*, §96.

133 Annex III, Art. II of the ESA Convention.

footing to the larger European states. But of course that meant holding the programme hostage to the vote of one dissident, a risk that in the event no one wanted to take.[134]

One legally significant change that occurred was in the bodies empowered to take the decisions on programmes, and their relation with the Council. The guiding principles drawn up at the end of 1971 gave enormous autonomy to the participating States. They stated that:

> *For each of the Organisation's programmes, a Programme Board shall be set up, in which the countries taking part in the programme concerned will be represented. The Programme Board shall be the supreme body responsible for taking decisions specific to the implementation of that programme (without interfering with other programmes); it would deal, in particular, with the observance of the time schedule and the fixing of the phase envelopes of the budgets.*[135]

This was reflected in the draft ESRO Convention ready in June 1972. The proposal to start an optional programme had to be submitted to the Council and was "considered as approved unless a majority of all Member States opposes". Thereafter the Council effectively dropped out of the picture. The States participating would be represented in a Programme Board which would "assume responsibility of the programme and take all decisions relating to it". In particular the Board would adopt the annual budgets within each financial envelope by a two-thirds majority and could also revise the envelopes in the light of price level variations.[136]

As the optional programmes got under way Programme Boards were in fact set up to manage them. The draft of the Convention available at the end of 1974 made specific allowance for their presence and gave the Council and the Boards "sovereign existence in their own spheres of competence", as the Secretariat put it.[137] However the new French government which took office in May 1974 decided, after a major review of all aspects of space policy that it was inadvisable to thus dilute the powers of the Council. Instead they proposed, and their counterparts generally accepted, that explicit reference to such Boards should be deleted from the Convention.

This measure was duly taken. The ESA Convention made no explicit reference to Programme Boards and gave to the Council, not the Boards, the power to adopt annual budgets within the financial envelopes of an optional programme, and the right to revise these envelopes in the event of price-level variations (Annex III, Art. III). The Convention also instructed the Council to set up a Science Programme Committee to which it would "refer" matters relating to the science programme, and "other subordinate bodies as may be necessary". In both cases the Council would define their terms of reference by a two-thirds majority of States (Art. XI.8).

While important legally, in terms of retaining the sovereignty of the Council intact, *de facto* this made little difference to the functioning of the Boards already established. The Final Act of the Conference of Plenipotentiaries confirmed the importance of having appropriate bodies to supervise optional programmes and at the first meeting of the new ESA Council on 24 and 25 June 1975 it was resolved that "the Programme Boards for the optional programmes should continue to fulfil the attributions and to exercise the powers assigned to them under the various Arrangements relating to these programmes, currently in force".[138] This same Final Act included resolutions encouraging governments to participate widely in optional activities so as to guarantee the viability of the Agency, and emphasised the need to

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134 ESRO/C/MIN/41, meeting on 26-27 October 1971, 9 November 1971.

135 "Principles Concerning the Revision of the ESRO Convention", Annex III to ESRO/C/XLXXX/Res. 3 (Final), 20 December 1971. See also ESRO/C(71)43, 8 September 1971.

136 Art. X.4(c)i, Annex II, Art. II, and Annex II, Art. III of the the draft ESRO Convention, ESRO/CONV(71)10, rev. 2, 12 June 1972.

137 CSE/CS/ESA(74)WP/9, 4 December 1974.

138 ESA/C/I/Res. 2, 25 June 1975.

organise the necessary consultation with potential users of the application programmes that it supported.[139]

1.4.4 Launchers

The draft revised ESRO Convention produced in November 1971 was not able to propose a text on launchers; the debates over this issue in the ESRO Council were still too contentious for that (see above). The complex agreements reached in December 1971 were however built into the version submitted to the Council six months later. A (draft) protocol enshrined the 125% Bad Godesberg formula, and detailed the procedures to be followed if an appropriate launcher for a specific mission was denied from outside Europe, including the commitment to produce a launcher in Europe if need be.[140]

The decision taken by France to take responsibility for Ariane, and so to produce a new European launcher come what may changed the terms of the debate. A clause abolishing the 125% rule was presented for consideration by the French delegation in May 1973. It simply said that, as long as the "scientific, technical, economic and operational constraints" of the Organisation's missions could be satisfied by the European launcher it would be given "preference". The cost of the launcher entered only indirectly through the clause stipulating that in reaching this decision "the Council shall take into account the cost and reliability of the launchers considered".[141]

This was too loose in the eyes of some delegates. In December 1974 The French delegation insisted on a new formula. Preference would still be given to a European launcher. However, the Council could decide that such preference did not apply for any particular programme by a two-thirds majority of all Member States, which included two-thirds of the States participating in the programme in question.[142]

This was still too restrictive for France's partners. Indeed the final version of the ESA Convention left France in a weak position. Thus Article VIII, which dealt with Launchers and Other Space Transport Systems, instructed the Agency when defining its missions to take account of, and to give preference to those "developed within the framework of its programmes, or by a Member State, or with a significant Agency contribution", thus removing any obligation to use Ariane in principle. This concession to the right to use a launcher other than Ariane was further extended in the subsequent sentence. The preference in question was only to be granted "if this does not present an unreasonable disadvantage compared with other launchers or space transport means available at the envisaged time, in respect of cost, reliability and mission suitability" (Art. VIII.1). The notion of unreasonable disadvantage was deliberately vague, and more flexible than the 125% rule. But when we remember that, at this time, NASA was claiming that the cost of putting a kilogram into orbit with the reusable Shuttle would be 10% of that with an expendable launcher like Ariane, we can appreciate better the enormous concerns in France in the mid-1970s about going ahead with its development.[143] A resolution adopted with the Final Act of the Conference of Plenipotentiaries also gave some assurances to France. It recommended that the Agency should "endeavour to plan its missions and define the technical characteristics of the satellites and other space systems it develops in such a way that the fullest possible use is made of the launchers and other space transport systems existing in Europe."[144]

One last little point is worth mentioning. It will be remembered that when ESRO and ELDO were established they had different Member States, the smaller and neutral countries like Sweden and

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139 Resolutions Nos. 3, 4 and 5 of the Final Act.
140 ESRO/CONV(71)10, rev. 2, Annex III, 12 June 1972.
141 CSE/CS/ESA(73)WP/14, 28 May 1973.
142 CSE/CS/ESA(74)24, Annex II, Art.VIII, 30 December 1974.
143 This is developed at greater length in the chapters on Ariane in this volume. See also Yves Sillard, "France and Launchers" in the proceedings of the symposium organised by ESA and the Science Museum in London in November 1998 (ESA SP-436, 1999). For the subsequent evolution of launcher policy see Lafferranderie, *op. cit.* chapter VII.
144 Resolution No. 6.

Switzerland choosing not to contribute to launcher development. This was partly for reasons of cost. But it was also because of the political and military implications of launchers (after all the first stage of the European rocket was a recycled ballistic missile). In the early 1960s space was so closely identified with rivalry between the Western bloc and Communism that it was impossible to detach launchers from their bellicose implications. Now, in the early 1970s, the context had changed. In 1973 the USA and the USSR agreed on a major international collaborative space programme, the Apollo - Soyuz linkup, signalling a new era of rapprochement between the two Superpowers. More fundamentally, space was now seen predominantly as a domain for commercial activity, not military adventures. The ESA Convention recognised this in its preamble which spoke of its mission as “Desiring to pursue and to strengthen European cooperation, for exclusively peaceful purposes, in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space systems”. With that proviso countries like Sweden and Switzerland had no hesitation in joining an Organisation which was also dedicated to launcher development.

1.5 The final European Space Conference in April 1975

The Ministers meeting in Brussels on 15 April 1975 took the last measures necessary to establish the new European Space Agency.[145] They adopted the text of the Convention. They proposed the new directorate that should run the Agency once it came into being. Its members were R. Gibson (Director General), B. Deloffre (Spacelab), G. Formica (ESOC), O. Hammarström (ESTEC), A. Lebeau (Planning and Future Programmes), W. Luksch (Communication Satellites), M. Trella (Technical Inspector), E. Trendelenburg (Scientific and Meteorological Satellites), G. Van Reeth (Director of Administration).[146] They also settled the question of the costs of Kourou. This was not easy. As we mentioned earlier the costs of the base from 1975 to 1980 had been estimated at 80 MAU, of which France was prepared to 50 MAU. The balance was to be made up by her partners, with Germany taking the lead. However, as Wolfgang Finke, the first Chairman of the ESA Council explained, all that the German delegation could say on the eve of the conference was that the Federal Cabinet would look at the matter again the next day. Their decision was not a foregone conclusion.

The meeting opened at 11 am with the question of Kourou as the first item on the agenda.[147] The German delegation asked that it be postponed, but the majority of Ministers were against this. The French Minister d'Ornano, in particular, insisted that the success of the meeting depended on this issue being resolved. His German counterpart Matthöfer pointed out that it was just here that he had no liberty whatsoever to negotiate. To break the ensuing deadlock the Chairman of the meeting suggested a premature break at noon. In fact it took a decision by Federal Chancellor Schmidt, who personally overruled his Finance Minister, to resolve the crisis. The afternoon session of the Ministerial conference began with the announcement that Germany would contribute 50 Million DM or about 10 MAU to the costs of Kourou, and the conference was 'saved'.

Two important speeches outlining their vision for the new Agency were made at this meeting. One was by the Director General designate, Roy Gibson, the other by the Belgian Secretary of State for Scientific Policy, Mr Gaston Geens, who was also the host and President of the Ministerial Conference.[148] They had several features in common. Firstly and strikingly, they made no explicit reference whatsoever to the science programme. All attention was now focussed on the new missions accorded to ESA, and the application satellites programmes above all. That granted, three major themes determined both Gibson's and Geens' statements. They stressed the need for a coordinated rationalisation, integration and internationalisation of national programmes and facilities. They insisted on the importance of developing a coherent industrial policy which would foster technical

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145 The minutes are CSE/CM(April 75)PV/1, document dated 20 May 1975.

146 CSE/CM(April 75)6, Final, 18 April 1975.

147 This account is from W. Finke, "'En attendant Kourou' – 15 avril 1975", *l'Europe spatiale a vingt ans, 1964 - 1984* (ESA SP-1060, 1984), 41-43.

148 CSE/CM(April 75)6, Final, 18 April 1975, Annex II and Annex IV.

cooperation between the Member States. And they drew attention to the imminent transformation of ESA's pre-operational programmes into operational ones and the need for ongoing consultation with user communities. Gibson made two additional important points. He stressed the need for its Member States to use ESA to coordinate their voices in international forums like INTELSAT, and for them to see the Spacelab development programme as only the first step of an ongoing major collaborative effort with the USA. He also drew attention to employment policy and staff attitudes.

“Allow a new boy a first indiscretion”, Gibson told the assembled Ministers. "One understands the interest which a Member State has in seeing one of its nationals appointed to a senior post in the Agency”, but it was “cardinal to the health of the Agency that all concerned should be very, very clear that, once a person enters the Agency, he ceases to serve national interests” and act not as “national ambassadors.” He developed his view on staff relations in the first number of the ESA Bulletin.[149] Praising the professionalism and maturity of the staff in the past difficult years of insecurity, he insisted the security that the new structure would give should not stifle dynamism. "It is no one's interest", said the Director General, "to convert the Organisation into an over-paid under-employed sanctuary where the inhabitants live out their professional lives largely sheltered from the storms of reality". As the DG put it to the Ministers, "An Organisation like ours has more in common with a large industrial firm than with most other international organisations". It was a new spirit adapted to a new mission.

The ESRO Council meeting the next day resolved a number of outstanding issues, including the question of the name of the new organisation.[150] It was clear that it would take time to ratify the new Convention. What would the name of the new organisation be in the interim? And its initials? If it could be called the European Space Agency from the outset, would both the English and French ESA/ASE be used, as France preferred, or just ESA, as Germany proposed? The first issue was resolved, according to Swiss delegate Peter Creola, by exploiting a loophole in the ESRO Convention which described it as *a* rather than *the* European Space Research Organisation. This led him to conclude that the Council was competent to change its name if it wanted to. "So I suggested", writes Creola, "to change ESRO's name into ESA. And, I could not believe my ears, the proposal was unanimously adopted".[151] The political will to launch ESA as soon as possible, led the Council to agree that it function under its new name immediately. The symbols ESA/ASE were deleted from the draft final resolution. And its was agreed that it could revert to its name ESRO if the Convention had not entered into force within three years.[152]

The Convention establishing the European Space Agency was signed by ten European states on 30 May 1975 (Belgium, Denmark, France, Germany, Italy, The Netherlands, Spain, Sweden, Switzerland, and the United Kingdom). At the same time the Conference of Plenipotentiaries adopted a Final Act including ten resolutions. These made allowance for the transition from ESRO and ELDO to ESA, dealt with the question of languages and, as we saw, gave additional weight to some of the key provisions of the Convention we have just discussed.[153] Ireland signed the text on 31 December that year. In December 1978 Canada became a Cooperating State in terms of Art. XIV.1 of the Convention. In October 1979 Austria signed an Association Agreement with the Agency. For five years, pending ratification ESA functioned '*de facto*', rather than as a legally existing entity. ESA

149 ESA Bulletin, No. 1, June 1975, pp. 2-7.
150 ESRO/C/MIN/75, meeting on 16 April 1975, document dated 30 April 1975.
151 Peter Creola, *op. cit.*
152 ESRO/C/LXXV/Res. 3, 16 April 1975. More specifically, the name was to change on the date of the signature of the Final Act of the Conference of Plenipotentiaries for the establishment of the European Space Agency.
153 The full name of this document is “Final Act of the Conference of Plenipotentiaries for the Establishment of the European Space Agency”. The Conference took place on 30 May 1975.

formally came into being on 30 October 1980, when France deposited its instrument of ratification and the Convention entered into force. Norway retained its status of Observer.[154]

[154] ESA Press Communiqué No. 23, 11 November 1980. See also ESRO/C(74)10, rev. 4. Note also ESRO/C/MIN/75. add.1, 3 June 1975.

Chapter 2: The Development of ESA, 1975 to 1987

J. Krige, A. Russo & L. Sebesta

The period of ESA's history covered in this book can be divided into roughly two major phases. The first, lasting until 1980/81, was dominated by the implementation of the programmes defined in the first and second package deals. The most noteworthy feature of these programmes, as we have stressed, was the re-orientation of activities away from science towards applications satellites and space transportation systems. The second phase, lasting from the early 1980s to the two Ministerial conferences in 1985 (Rome) and 1987 (The Hague), was marked by the laying of the foundations of a new long-term plan for the Agency, including above all the decision to develop Ariane-5 and to participate in the space station being proposed for international collaboration by NASA and the Reagan administration.

The organisation of this chapter reflects this division. Its first part deals with the evolution of various programmes adopted in ESRO and the ESC in 1971 and 1973. These sections are essentially resumés of chapters and reports that we have written, and which are published in this book. They are followed by a more detailed analysis of the debates over the long-term plan, into which is integrated the two chapters presented later on Ariane-5 and the Space Station. The whole provides the reader with a brief history of ESA which supplements an earlier text covering the period up to the second package deal.[155]

2.1 The Science Programme

When ESA came *de facto* into being it inherited a number of ongoing projects from ESRO. One satellite, HEOS-1 was in its seventh year in orbit, making measurements of the magnetosphere and the solar wind. It re-entered the Earth's atmosphere in October 1975. Another satellite, COS-B, dedicated to celestial gamma rays was about to be launched. It was in fact successfully put into orbit on 9 August 1975. Four more satellites had been accepted in the ESRO period: GEOS, a geostationary satellite for studying magnetospheric phenomena; IUE (International Ultraviolet Explorer), a joint NASA/UK project in which ESRO agreed to participate; ISEE-B, one of three satellites in the International Sun-Earth Explorer programme developed with NASA; and finally Exosat, an X-ray space observatory being provided as a facility for the European observers.

In addition to pursuing these projects, the new agency had to choose the next set of missions, which had been maturing since 1973. This choice was to be taken under the budgetary constraints imposed by the first package deal, which sharply reduced the funding for science, and which made it a mandatory, but a relatively small part, of ESA's activities (see Figure 2-1). It also had to take account of the new technological opportunities to be opened up by the availability of the Shuttle/Spacelab combination in the 1980s, and the wish on both sides of the Atlantic to foster closer collaboration between NASA and ESA.

The new status of, and demands on, the science programme triggered a debate on its decision-making mechanisms. Traditionally this had been bottom-up, with senior representatives of the European space science community setting its priorities in an extremely powerful LPAC (Launching Programme Advisory Committee). In 1973 the LPAC was advised by two expert groups, the AWG (Astrophysics) and SSWG (Solar System), and it reported directly to the DG. The Executive's recommendations were passed to the Scientific and Technical Committee (STC), a delegate body which acted as interface with the Council.

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155 J. Krige and A. Russo, *Europe in Space, 1960 -1973* (ESA SP-1172, September 1994).

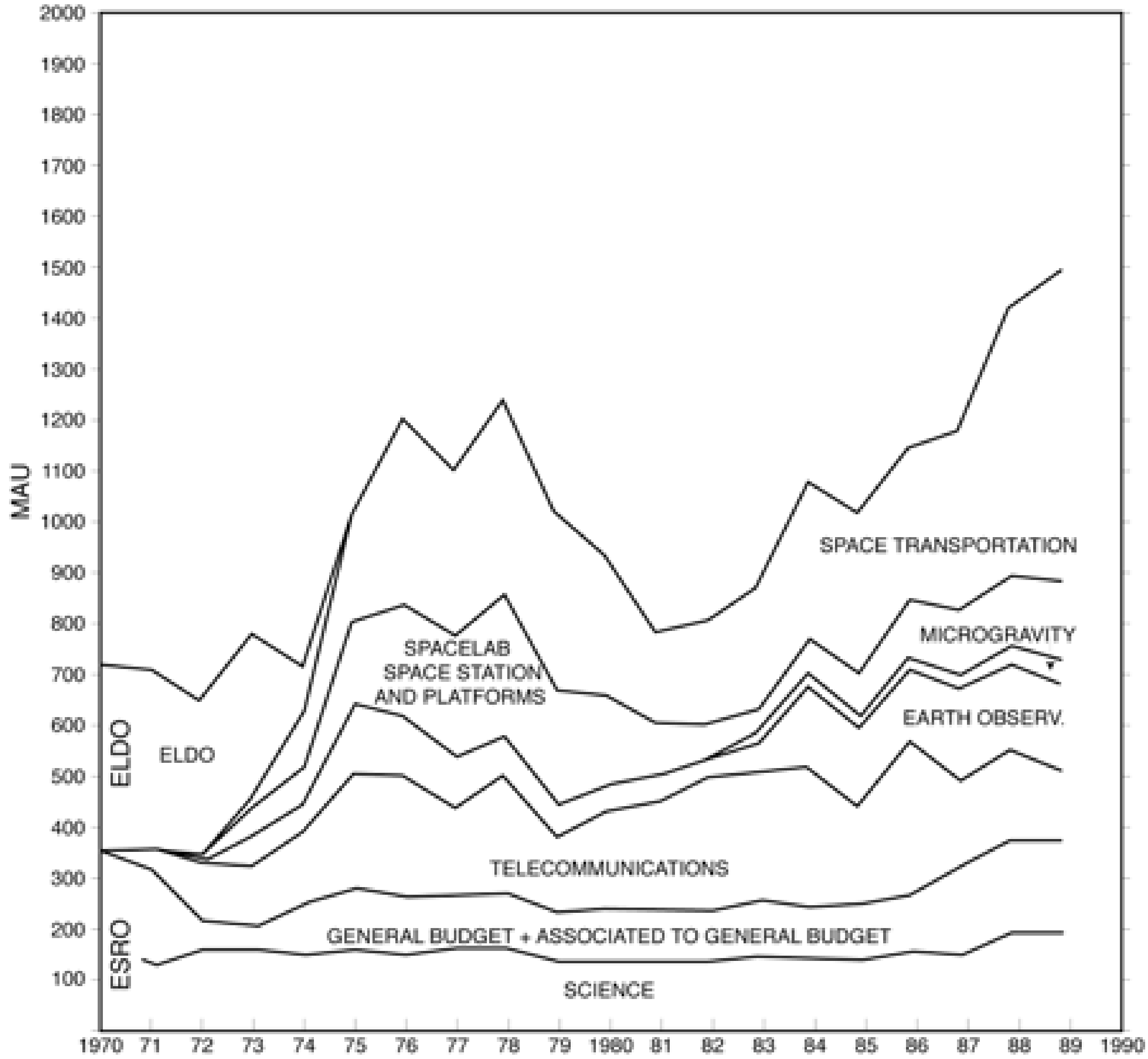

Figure 2-1: The development of programmes in ESRO, ELDO and ESA from 1970 to 1988 illustrated by their actual expenditures updated to 1988 economic conditions. For 1989 the planned budget without budget without carry forward from 1988 is given (Source. *Report by the 1989 Science Programme Review Team to the Council of the European Space Agency*, the so-called Pinkau Report, p. 8).

With the re-orientation of ESRO's role, and the institution of Programme Boards, the STC was replaced by the SPB (Science Programme Board) inside ESRO. At the same time the autonomy of the LPAC was criticised by some delegations. They felt that in the new budgetary climate, and with a need to coordinate better ESRO's science programme with those in its Member States and with NASA, independent experts who were not fully aware of these political aspects could not make meaningful choices. They proposed instead that the SPB, on which national delegations were all represented, should have far greater power to shape the programme. This suggestion was rebuffed, though it was agreed that the LPAC would keep the SPB continuously informed of its activity. The SPB, in its turn, said that it would do its best to keep a firm control over the selection process of future projects, beginning with feasibility studies.

The issue resurfaced when ESA came into being. The SPB lost some of its status, becoming the SPC (Science Programme Committee), a delegate body subordinate to the Council at the same level as the Administrative and Finance Committee. The DG replaced the LPAC with the SAC (Science Advisory Committee) reporting directly to him on all scientific matters, including those related to the new space disciplines opened up by Spacelab (life sciences and material sciences). A Life Sciences Working Group (LSWG) and Materials Sciences Working Group (MSWG) were also added to the AWG and SSWG, with all working groups reporting to the DG. This arrangement was contested by the SPC on the grounds that the entire science advisory apparatus was integrated into the Executive. To placate them it was agreed that all the information issuing from the SAC and the four working groups would be made available to the SPC.

The wish of the DG and the Executive to restrict the autonomy of the LPAC/SAC reflected a growing dissatisfaction, openly expressed by some, that the experts on it were a small clique of mandarins, conservative in approach, out of touch with the new, younger generation of space scientists, and closed to the technological and scientific opportunities expected in the 1980s. This tendency was felt to be particularly dangerous in a period when increasingly tight financial constraints went along with a growth in the number and variety of space science activities competing for resources in Europe. The "solution" was to try to limit the powers of the SAC by having the Executive, in constant consultation with the scientific community, take responsibility for a forward-looking and innovative programme. Hence ESA DG Gibson's decision, *inter alia*, to set up working groups for life sciences and materials science reporting directly to him (along with the AWG and the SSWG), both new 'space' disciplines spawned by the imminent arrival of Spacelab.

Whether or not these criticisms of the Old Guard were justified – and of course they were hotly contested – the fact remains that in the transition period from ESRO to ESA the decision-making process among the scientific community had become increasingly eclectic. The large number of groups now active was leading to a profusion of proposals which seemed to paralyse the leadership labouring under financial, political, institutional, and intellectual constraints. A new phase in the decision-making process was introduced in 1973, the so-called pre-Phase-A, dedicated to mission definition of a large number of projects. At this phase the payload would be defined clearly enough for one to assess its scientific interest, but not to assess its costs. This was intended to ensure that a first round of choices was taken on 'purely' scientific criteria; other considerations would come into play later.

Following wide discussions within ESRO's decision-making structure, as well as between ESRO and NASA about possible cooperative ventures, twelve mission definitions were undertaken by ESRO in 1974, involving the active involvement of 50 external scientists. The AWG and the SSWG were instructed to choose no more than three each of these for Phase-A studies. They submitted their reports early in 1975.

The choices made combined past tradition with novelty, and also took account of the growing links between NASA and ESA and the (presumed) flight opportunities to be offered by Spacelab. In line with tradition, projects favoured by solar physicists and planetary scientists were again given low priority. The SSWG did suggest contributing an X-ray grazing incidence telescope (GRIST) as one of a solar telescope cluster to be developed along with NASA for Spacelab, but as the American Agency's plans for the programme were increasingly vague it was decided to keep this only as a back burner project. Tradition, too, shaped the decision to finance Phase-A studies of AMPS and of EXSPOS, which confirmed the ongoing importance of atmospheric and magnetospheric studies, on the one hand, and of high energy astrophysics, on the other, in the European programme. The AMPS (Atmosphere, Magnetosphere, and Plasmas in Space) Programme was a NASA project aimed at exploring the Earth's neutral and plasma environment using sophisticated instruments on Spacelab over a 5 - 10 year programme of flights. ESA would contribute to this programme by providing the so-called LIDAR, a laser facility for sounding the atmosphere at about 100 km. EXSPOS was a Spacelab-borne X-ray spectropolarimeter, which would continue ESA's ongoing effort in X-ray astronomy inaugurated with Exosat.

The novel programmes proposed were, firstly, those in the field of astronomy. Astronomy had suffered heavily in ESRO and had been explicitly demoted in priority by the LPAC in 1970. Now two original and ambitious astronomical projects were proposed. Firstly there was the LIRTS, an infrared telescope of 2 - 3 metre diameter operating at ambient temperature and mounted on a stabilised platform on board Spacelab. This enabled European astronomers to enter the new field of infrared astronomy (as Exosat had done for X-ray astronomy before), and along with the Dutch IRAS, being developed with NASA, promised to give the Old Continent a dominant position in this field. Secondly, there was the contribution to the NASA Large Space Telescope (LST, later called the Hubble Space Telescope). The AWG was convinced of the enormous scientific value of this project, and that European astronomers should participate in the hardware so as to have a guaranteed share of the observing time. NASA accepted the principle, but the precise instrument to be built in Europe (a high-resolution camera or a faint object spectrograph) was in some doubt, as was the question of what size of telescope if any, the US Congress would fund. Notwithstanding the immense uncertainties in the US, the AWG persisted in giving priority to the LST, deciding that Europe's contribution would be a Faint Object Camera with an associated Imaging Photon Counting System, i.e. the former High Resolution Camera with an emphasis on faint objects.

Novel too was the recommendation for Phase-A studies of a joint ESA/NASA Out-of-Ecliptic (OOE) mission. For the first time in the history of astronautics two spacecraft, provided by the two space agencies respectively, would be propelled out of the flat plane around the sun in which all solar system bodies revolve, to fulfil a variety of scientific objectives in the fields of solar physics, solar wind studies and cosmic rays.

Two of these projects were down-valued in the round of discussions held in summer 1976. Firstly, the LIDAR. The AMPS programme, in fact, was under critical scrutiny in NASA and it looked as though Europe would not be able to participate in it for some years. LIDAR thus had to be seen as an independent European instrument to be flown several times on Spacelab in order to provide significant results. Under pressure from the Executive, the SSWG first supported the idea of flying the LIDAR on the first Spacelab mission, but then opposed it in July 1976 on the grounds that no guarantee existed about the financial feasibility of subsequent flights. The other project which fell in priority was EXSPOS, judged to be slightly less interesting than LIRTS and participation in the LST. This left these two and the OOE mission, which were judged to be all outstanding scientific projects. At this stage, the SAC did not assign relative priorities to these three on scientific grounds (that is, LST, LIRTS and OOE), pending more information about financial aspects and NASA plans.

In making his recommendations to the SPC in September 1976 the ESA DG, with the support of the SAC, suggested that top priority be given to Europe's participation in the Large Space Telescope. He also strongly favoured the Out-of-Ecliptic mission, though suggested that this decision could be delayed pending more information on the status of the programme in the US, as well as the resolution of financial uncertainties regarding ESA's ongoing programmes. He did not feel that the LIRTS could be supported at Phase-B level, however, both for financial reasons and because of uncertainties about the costs of the Spacelab experimental programme. The SPC accepted these recommendations, thus committing ESA to the contribution to NASA's Space Telescope and to the Out-of-Ecliptic Mission. Eventually, the latter was definitely approved only in December 1977, owing to financial difficulties deriving from the launch failure of the GEOS satellite and the decision to build a second flight model.

The joint ESA/NASA Out-of-Ecliptic mission, eventually renamed the International Solar Polar Mission (ISPM), was ill-fated. The launch of the mission was scheduled for 1983, but in 1980 NASA announced a 2-year delay due to slippage in the Shuttle programme; in 1981 the US Agency announced, quite unexpectedly, that it had decided to abandon its spacecraft altogether and to delay the launch of the European spacecraft by another year. This unilateral action caused immense bitterness in Europe. Eventually, ESA decided to go ahead with a single spacecraft programme all the same, renaming the mission Ulysses. The launch of Ulysses was delayed once more due to the 'Challenger' accident in January 1986. It was eventually put safely in orbit by the Shuttle 'Discovery' on 6 October 1990. As for the Hubble Space Telescope, which carried ESA's Faint Object Camera, its launch, scheduled for December 1983, also suffered a three-year delay, which became seven years due to the ‘Challenger’ accident. The Hubble Space Telescope was launched just before Ulysses on 24 April 1990. Europe’s contribution was not affected by the hairbreadth defect in the surface of the primary mirror and to date the FOC has taken over 6000 pictures of outstanding quality and scientific interest.

The financial pressures imposed on the science programme by the first package deal, which fixed its ceiling at 27 MAU in 1971 (equivalent to some 76 MAU in 1978 price levels), and which were exacerbated by the expansion in the size of the community and the range of disciplines seeking funding, led the SAC to discuss a long-term strategy for science in the 1980s. Guided by its new chairman, Roger Bonnet, it produced an important report at the end of 1978. It made three major recommendations.

Firstly, it insisted that the budget for the mandatory programme had to be increased by about 50% to 120 MAU/year for the classical space science disciplines, as represented in the AWG and the SSWG. Support for microgravity sciences on Spacelab was to be in addition to that, and of some 12 MAU/year. Assuming that ESA’s budget in the 1980s was some 400 MAU annually, this meant that space science should have about one-third of the available resources, on an equal footing with applications and space transportation systems.

Secondly, the SAC encouraged the financing, in addition, of optional Scientific Programmes, notably for the Earth sciences. This included a wide range of disciplines on the border between science and applications, from oceanography to climatology, from geodynamics to atmospheric physics, from geodesy to remote sensing. Even though many members of the SAC and its advisory groups were reluctant to give too much weight to such application-oriented science programmes, for fear that they would inevitably draw funds away from the traditional fields, they could hardly deny their importance in future space programmes.

Finally, the space science community was emphatic that the political need to use Ariane and Spacelab was not to be respected at the expense of science. The SAC stated clearly that neither space transport system was "adapted to the financial state of the science programme". If the Member States responsible for those programmes wanted to 'impose' them on the science programme then additional funding to that voted for the mandatory budget should be made available explicitly for that purpose.

The Council discussed what the SPC called "the deplorable state of the science budget" at its meeting in June 1979. It had no immediate solution. In fact the dramatic inflation of the mid- and late-1970s had led to a crisis in ESA, and the mandatory science budgets for 1978 and 1979 had not been adopted. Instead recourse was taken to the system of provisional twelfths whereby resources were unblocked successively as the year advanced. In any event two major Member States, France and Britain, were opposed to increasing the level of the mandatory programme. The former had never favoured an important science component in ESA; the UK had, but faced with a weak pound, limited resources for its national programme, and believing that the ESA science programme was not cost-effective, it felt obliged to oppose an increase. Council however accepted that optional programmes could be proposed, notably in the field of Earth sciences, and also invited the Executive to make proposals for microgravity sciences in the area of Spacelab utilisation.

Although the Council did not, could not, argue for an increase in the science budget, the importance of its policy choice should not be overlooked. It sanctioned, in fact, that the mandatory Scientific Programme should be restricted to the traditional space sciences for which it was intended when the first package deal was adopted: new fields were to be funded differently.

It was against this background that the next round of scientific satellites had to be chosen. Following the recommendations of the SAC and the Working Groups, four missions had been studied in 1977 and early 1978. First was the grazing incidence solar telescope, GRIST, put on the back burner earlier and now revived to satisfy the solar physics community and as the last remaining major scientific mission on Spacelab after the abandonment of LIRTS and EXSPOS. Secondly, there was an astronomical satellite for studies in the extreme ultraviolet region, called EXUV. This would bridge the gap between the traditional UV band and the X-ray region already studied, providing information on the interstellar medium, stellar atmospheres, and stellar evolution. Thirdly, there was the climatology satellite SEOCS (Sun-Earth and Climatology Satellite). Its mission, the SSWG insisted, was essentially scientific, and would enable an important study to be made of the Earth's atmosphere-surface-ocean system. Finally, there was an astrometry satellite which would make highly accurate measurements of stellar positions and be helpful for advanced studies of galactic dynamics. The latter was eventually called Hipparcos.

In the event, GRIST was definitely abandoned for its expected high costs and SEOCS was eliminated from the list and transferred to the optional Earth observation programme. The Executive then informed the scientific community that another proposal for Phase-A studies could be added to the list of candidates for decision at the end of 1979. There were two strong contenders. Firstly a cometary mission in collaboration with NASA. At about this time, in fact, the American Agency invited Europe to provide a passive probe to accompany its mission to the comet Tempel-2. This probe would be launched from the large spacecraft in 1985 during its journey towards a rendezvous with Tempel-2 in 1988. It would meet the comet Halley at the end of 1985. The second candidate was a Polar Orbiting Lunar Observatory (POLO) intended to make a geochemical and geophysical map of the Moon's surface, including its dark side and the polar regions.

After a passionate debate, both in ESA advisory committees and within the scientific community, the cometary mission was selected against POLO. It survived also after the US authorities had withdrawn support for the Tempel-2 mission, thus jeopardising the ESA probe to comet Halley. Mobilising all their energies, the promoters of the cometary mission made a strong plea for a wholly European mission to Halley. Their arguments carried the day. The SAC endorsed the idea and requested a feasibility study of such a mission, which received the name Giotto, after a fresco in Padua by the Italian artist which depicted the comet's appearance in 1301.

In view of the final choice, the competition between Hipparcos and Giotto was as harsh as that between POLO and the cometary mission. The supporters of both missions within the European scientific community strongly lobbied to have their pet project approved by ESA's decision-making bodies. Behind Hipparcos were the astronomers and the French delegation to ESA; support to Giotto came from the already established constituency of the ill-fated ESA/NASA cometary mission, from the German delegation to ESA and from the influential ESA Director of Science, Ernst Trendelenburg. The SAC also liked Giotto as it considered Hipparcos too costly and its technical feasibility not completely established.

In the event, after the feasibility study demonstrated that Giotto could be realised at a reasonable cost of 87 MAU, a compromise was agreed on in the SPC: it decided that both projects should be adopted in the ESA programme, with the cometary mission to be implemented first because of the tight schedule imposed by Halley's orbit.

The Giotto spacecraft was successfully launched by Ariane on 2 July 1985, it passed by the comet's nucleus on 14 March 1986 and, as some of its instruments survived this *kamikaze* mission, it was redirected for an encounter with comet Grigg-Skellerup, which occurred on 10 July 1992. Hipparcos, for its part, was launched on 8 August 1989, one year later than planned and, despite some technical difficulties, made accurate measurements of about 120,000 stars in its four years of activity. The success of these Ariane-launched, purely European missions, compared to the delays and setbacks suffered at that time by the out-of-ecliptic ISPM mission and the Space Telescope, were symptomatic of the collapse of NASA-ESA collaboration in the field of space science which was a marked feature of the 1980s.

The early 1980s were noteworthy for an institutional change which further consolidated the position of the classical space sciences in the mandatory science programme. The system was abolished whereby future planning was in the hands of a special directorate for that purpose (headed by André Lebeau in the late 1970s). Instead each Directorate was made directly responsible for the present and future evolution of its sector. The SAC, which had previously advised the Director General on all scientific matters, was now transformed into the SSAC (Space Science Advisory Committee). Its role became to advise the Director of Scientific Programmes on activities covered by the AWG and the SSWG. Life sciences, materials sciences and Earth observation were allocated to other directorates. An important change in leadership also occurred. The spirited and controversial figure of Ernst Trendelenburg, who had spent almost twenty years in ESRO and then ESA, was replaced as Director of Scientific Programmes on 1 May 1983 by the French space scientist Roger Bonnet, former chairman of the SAC from 1978 to 1980.

The selection of the next round of projects was scheduled for early 1983. Five candidate missions underwent Phase-A studies in 1981 and 1982; the SSWG and the AWG each selected its favourite in February 1983. The solar scientists opted for DISCO, a satellite carrying twelve instruments dedicated to solar and heliospheric studies. The astronomers chose ISO, a space telescope for infrared astronomy cooled by a liquid hydrogen/liquid helium cryostat. The latter reflected the persisting interest of European astronomers in this new field, but it had one major drawback. At an estimated cost of some 260 MAU, compared to 160 MAU for DISCO, ISO was well beyond the rule-of-thumb cost limit for individual projects applied by the SAC/SSAC. This was that no project should cost more than 1.5 times the mandatory science programme's annual budget (116 MAU in 1982 prices).

Notwithstanding this drawback, the SSAC strongly recommended that ISO be ESA's next major project. The DG concurred, arguing that it was precisely the role of ESA to put large and complex facilities at the disposal of the European space science community. Despite the protests of the solar scientists, the SPC meeting in March 1983 unanimously agreed that ISO should be ESA's next major scientific project. ISO was eventually launched by Ariane on 17 November 1995, two years later than planned, mostly due to technical problems with the telescope and the cryostat.

The next phase of the planning cycle was being undertaken in parallel with these developments. The proposals put forward at the end of 1982 for Phase-A studies had an important feature in common: the most interesting all cost about 250 MAU. At the same time the situation with the science programme budget was going from bad to worse. Cost overruns on development projects, the use of Ariane, the extension of the active lifetime of some satellites already in orbit whose performance exceeded expectations, cost increases in the joint programmes with NASA due to technical problems and launch delays, all of these were adding to the cost of existing projects and eating into the amount of money available for new missions. A number of technical ad hoc solutions were adopted in the short term, but it was clear that the ceiling imposed in 1971 had to be revised. Something had to be done to put the science programme on a better, and more stable financial basis in the long term otherwise it would be impossible for it to continue in a meaningful way.

Financial pressures were not the only ones arguing for such an approach. In the early 1980s the major European space programmes adopted in the package deals a decade before were reaching completion, and ESA itself had to lay new foundations for the future. As we shall discuss later in this chapter, a Long-Term Space Plan was worked out and presented to Ministers meeting in Rome in January 1985. Within this framework Bonnet undertook to work out a long-term scientific plan covering a fifteen to twenty-year time span. Only in this way could costly and technologically complex missions be properly prepared, the appropriate funding profiles and launching schedules established, and meaningful choices made between them.

Bonnet presented his idea to a meeting of the SPC in October 1983. The scientific community would be asked to suggest mission concepts which would be assessed by expert teams covering various disciplines in astronomy and the solar system sciences. Their proposals would be evaluated by a Survey Committee which would draw up a global model programme for the years 1985 - 2004

The exercise produced 68 mission concepts, 33 in astronomy and 35 in solar system sciences. After the expert teams had prepared their reports an historic meeting of leading members of the European space science community on the San Giorgio Island in Venice from 30 May to 1 June 1984 consolidated the choices between them and produced a long-term plan which received the name Horizon 2000.

The philosophy of Horizon 2000 was to divide projects into three classes: cornerstones, costing two annual budgets, and having long lead times; medium size projects, costing one annual budget, and of the class of then current missions like Giotto, Hipparcos and Ulysses; and low-cost projects, costing 0.5 annual budgets, typically participation in international programmes. The overall budget for the programme was set at 200 MAU annually (1983 prices) as from 1991, this level to be achieved by an annual 7% increase over the 1984 budget (about 130 MAU).

Two cornerstones each were allocated to astronomy and solar system studies. The choice of fields was shaped by the proposals received and their scientific importance, by the competence and experience already available in Europe, and with an eye on national European, American and international programmes under way or planned. The astronomers selected an X-ray spectroscopy mission intended to build a third generation of observatory-class satellites for high-energy astrophysics. Their second cornerstone was in the field of submillimetre heterodyne spectroscopy, which would enable Europe to take the lead in areas like the formation of star and planetary systems, and the evolution of galaxies. As for the solar system scientists, one of their cornerstones built on the achievements of Giotto, involving a mission to primordial bodies (comets and asteroids) with a return of pristine materials. The second, not foreseen in the original outline, sneaked in at the Venice meeting and covered the fields of solar and plasma physics. It involved combining two existing proposals, SOHO and Cluster. The former was a satellite dedicated to solar and heliospheric studies, whereas Cluster was a four-spacecraft mission for magnetospheric research.

The enormous enthusiasm generated by Horizon 2000 in the European space science community was matched by the reticence of some of the major Member States to increase the level of the science budget at the rate asked. Intensive lobbying of Ministers and even Prime Ministers preceded the Rome meeting of January 1985, as a result of which those present agreed to increase the level of the mandatory programme by 5% annually in real terms over the period 1985 - 1989. This was subsequently extended at the Ministerial Meeting in The Hague to enable the programme to reach a level of almost 217 MAU in 1992 (in 1985 prices).

We invite the reader interested in the early development of the Horizon 2000 plan to refer to Chapter 5. It only remains to conclude that the concept has remained the backbone of ESA's Scientific Programme since its adoption in Venice almost 15 years ago. Indeed Horizon 2000, and its successor, Horizon 2000 Plus, have provided the members of the European space science community with an invaluable tool for planning and financing their research and for dealing from a position of strength with their colleagues in the United States and in NASA.

2.2 The Aeronautical Satellite

Storm clouds were already gathering over the future of the aeronautical satellite when the ESRO Council adopted the first package deal in December 1971. The Member States here allocated 100 MAU (plus the usual 20% cost overrun) to Europe's share in a programme aimed at the design, development, launching and seven-year operation of a satellite air traffic control system over the Atlantic and the Pacific Oceans. The other governments interested were the USA, Canada, Japan and Australia. Notwithstanding Europe's engagement, however, protectionist forces in the United States, a re-orientation of US foreign policy concerns away from Europe and the towards the USSR, and the growing unwillingness of the users as represented by the Federal Aviation Authority (FAA) to adopt the new technology in a time of acute economic uncertainty for the airlines, were to lead to the eventual demise of the project.

The possibility of Europe engaging itself in an air traffic control satellite had been discussed by the European Space Conference meeting in Bad Godesberg in 1968. An *ad hoc group* of Member States' aeronautical experts was set up to identify user requirements, to optimise technical and cost factors, and to prepare a joint European position on an air traffic control system. In parallel technical studies were started at ESTEC, working in consultation with groups in CNES and in NASA. This helped lay the foundations for the definition of a joint NASA/ESRO air traffic control satellite system whose broad outlines were agreed at the end of July 1969, in the new 'post-Apollo' climate which was particularly favourable to US-European space cooperation. This climate led the Europeans to believe that they would be closely involved in the system "in all respects: in particular in the management of the programme, the design, the development and manufacture of the hardware, and the development and use of the software". In July 1970 the Ministers voted funds for 1970 and 1971 enabling ESRO to "make an immediate start on the project definition in cooperation with NASA" of a North Atlantic pre-operational system. The project was presented to civilian airlines by the FAA and NASA in Washington and by ESRO in Paris and discussions on the ESRO-NASA Memorandum of Understanding got under way.

New policy guidelines laid down by the Nixon Administration's Office of Telecommunications Policy (OTP) reconfigured the terms of the debate. They insisted that the FAA and the US Department of Commerce should establish "unambiguous leadership" in the setting up of pre-operational and operational systems first in the Pacific and then the Atlantic, with use of the system leased out to international users. NASA's role was reduced to R and D and technical support. The Europeans reacted by threatening to develop their own independent system. Faced with this threat, and under pressure from NASA and the Office of Management and Budget, the Department of Trade agreed to look into an international project. Meetings of interested parties in June 1971 (in Washington) and in August (in Madrid) led the Europeans to believe there was cause for optimism again: there would be a jointly developed system for the two oceans "with equal sharing of responsibilities, expenses and effort between the major parties (US/Europe) based on a system specification to be jointly prepared". Soon thereafter the FAA (for the US) reached an agreement with ESRO (for Europe), and then with Australia, Canada and Japan, on a four-satellite pre-operational system to be set up between 1974 and 1980.

Various components of the FAA/ESRO draft Memorandum of Understanding were vigorously contested by the Office for Telecommunications Policy. It objected to the clause which vested ownership of the satellites in the two government bodies, insisting that they should be privately owned. It did not like the kind of just return arrangement which ensured that there be a "fair and reasonable distribution of work among the Member States of ESRO", insisting that the most qualified bidders should be awarded contracts irrespective of country of origin. More specifically it was argued that this system would penalise the (presumed to be more competitive US firms) and involve a transfer of important technology across the Atlantic to Europe. Finally, the OTP did not like the restriction of the system's users to airline companies, believing that other clients, like the maritime services should also be considered.

Henry Kissinger, National Security Adviser to President Nixon, was called in to settle the internal dispute. On 22 November 1971 he effectively came down on the FAA's side, arguing that a US withdrawal from the joint project would have a negative impact on overall US-European relations. A month later the ESRO Council adopted the first package deal including a major commitment to the development of an aeronautical satellite with the US.

Kissinger's support for the FAA proved to be short-lived; within three months he had reversed his position and in March 1972 the Europeans were informed that the FAA would not be authorised to sign the draft MOU finalised in the closing months of 1971. This re-orientation in policy was in line with a general retreat in the US from the generous sounding terms announced earlier for European participation in the post-Apollo programme. It reflected growing concerns, spearheaded by the OTP, of the dangers of the US transferring sensitive and leading technologies to her commercial rivals and an historically rooted US preference for finding partners for the utilisation, rather than the development, of common systems. It coincided with Nixon's decision to draw closer to the Soviet Union. Indeed it was in May 1972 that the joint Apollo-Soyuz mission, under preparation since October 1970, was announced at a summit meeting in Moscow.

In fact what the US administration wanted was for commercial enterprises rather than Federal agencies to take responsibility for relatively mature space technologies. In March 1972, the chairman of Comsat's Board of Directors approached ESRO DG Alexander Hocker and suggested that there be a joint ESRO/COMSAT aeronautical satellite. It received the green light for this scheme from the OTP in September and in November that year ESRO announced that it now planned to select a qualified US industrial partner to co-finance the development of the space segment, and to enter into an agreement with US and other interested US aeronautical authorities over the use of the system.

By February 1973 Comsat along with a number of private US companies had signalled its interest in collaborating with ESRO in the development of an aeronautical satellite. The proposals of Comsat and of RCA were judged the best by the Europeans and two months later discussions were opened with both on the characteristics of the eventual system. In September 1974 the Aerosat Programme Board selected Comsat as ESRO's partner by seven votes to one (the United Kingdom) and one abstention (the Federal Republic of Germany). The UK opposed the choice since it felt that Comsat's monopoly in the field should be limited where possible and because it found the RCA offer extremely attractive.

In parallel the FAA and ESRO drew up a new draft MOU which was signed in August 1974. It differed from the previous arrangement in restricting the scope of the programme to the North Atlantic (so that Australia and Japan dropped out). It accepted that whereas ownership and pre-funding of the satellite would be in the hands of governments or their agencies in Europe and in Canada, the USA/FAA would lease its services from a private operator, in the event Comsat, which would own the space segment on behalf of the government. The joint programme specifically excluded the development of the ground sector and the costs of converting aircraft to deal with data from the new system. The US also insisted that the MOU contain a clause stating that the programme would only be executed subject to funds being available.

The international body governing the programme, the Aerosat Council, in which the USA, Europe and Canada were represented, met for the first time in Washington on 3 and 4 December 1974. Within less than a year it was in crisis. The costs of the project had increased. More fundamentally the future prospects of civil aviation looked gloomy. The general inflationary climate, and the sudden and dramatic increase in the oil price in 1973-74 retarded economic performance and caused a sharp rise in aviation fuel costs. It was estimated that air traffic across the North Atlantic would decrease by 10% in 1974, and not regain its previous levels until 1978. The introduction of the wide-bodied Boeing 747s reduced the number of flights, as did the cancellation of the American supersonic SST and the reduction in the number of Concordes, both of which had been used to justify Aerosat. With the number of aircraft in the air expected to fall, the existing number of communications frequencies seemed more than adequate for the airlines, at least until the early 1980s.

The FAA took a number of technical measures intended to keep the programme afloat. By summer 1977, however, it announced to the Aerosat Council that it was virtually certain that it would not find funding for the programme: indeed the US House and Senate Appropriations Committees had announced that in their view the programme should be abandoned, except for low-cost feasibility studies. By the end of the year the Europeans recognised "more in sorrow than in anger" that the project had little hope for survival. In the view of the European Conference of Directors of Air Navigation, in fact, "the civil aviation community at large had never yet been sufficiently confident of the need and cost-effectiveness of aeronautical satellite services. Only when the aeronautical administration and the air operators were convinced on this score", they went on, "would a way ahead have any chance of success". In short, at the end of the day it was both widespread doubts in the US and the lack of interest in the system by the potential user community that killed Aerosat.

2.3 The Telecommunications Satellite Programme

The first package deal adopted in December 1971 provided for a Telecommunications Programme aimed at developing a communications satellite meeting the needs of the European Conference of PTT Administrations (CEPT) and the European Broadcasting Union (EBU). It included the re-routing via satellite of a considerable portion of the telephone traffic managed by the PTTs, and the total replacement of the terrestrial circuits for the Eurovision system. These plans were formalised in a Telecom Arrangement adopted in September 1973 by nine of ESRO's Member States. It foresaw, firstly, the development of an experimental satellite (OTS: Orbital Test Satellite) costing some 115 MAU and to be launched in 1976. (In fact the 900 kg OTS was launched from Cape Canaveral in September 1977, and was lost on launch. A second flight unit was successfully placed in orbit in May 1978). This was to be followed by the development of two flight units of an operational European Communications Satellite (ECS). These were to be delivered to the users (PTT administrations and television companies) by 1980, one of them in orbit and the other on the ground. The users would eventually procure and launch the other flight units required to complete and maintain the envisaged ECS system. The cost of this phase (called Phase-3) was estimated at 160 to 283 MAU, depending on the configuration chosen, and the decision to embark on it was to be taken in 1975 or 1976 by a double two-thirds majority of the participating states.

The second package deal, adopted in July 1973, added Marots to the communications satellite programme. Marots was an experimental maritime communications satellite costing 75 MAU which was based on the OTS platform, and promoted strongly by the United Kingdom. Its design respected the guidelines for operational satellites formulated by the Intergovernmental Maritime Consultative Organisation, and it was confidently expected that Marots would take its place as one element in an operational system eventually to be managed by a new international organisation called Inmarsat. A Joint Board on Communication Satellite Programmes (JCB) was made responsible for both OTS/ECS and Marots.

In May 1976 the Executive proposed its development plan for the next phase of the Telecommunications Programme, nominally intended to produce two ECS spacecraft by 1980. It pitched its sights higher, however. As it explained, an earlier decision to upgrade the OTS design, and make it very similar to an operational vehicle, meant that ECS could be built for much less than originally conceived, also taking advantage of increased efficiency in industry. Costing some 86 MAU (in 1975 prices) this left 117 MAU of the minimum original budget envelope for other projects. Two in particular were proposed. Firstly, the development of a heavy platform of the 800 kg class to be used for a wide spectrum of new communications applications not foreseen in the OTS/ECS programme, like direct broadcast television, and to be launched on the fourth Ariane demonstration flight (68 MAU). Secondly, an Advanced Systems and Technology Programme (ASTP, costing 36 MAU), an R&D effort needed to ensure that Europe did not lag behind its competitors, developing new technologies in the areas of communications systems, spacecraft subsystems and microwave technologies.

This proposal received only lukewarm support in the JCB, meeting in May 1976. The crux of the problem was that neither the British nor the German PTTs were yet prepared to participate in the operational ECS system; they felt that the volume of traffic foreseen could not justify the cost to them of setting it up and managing it. According to some CEPT estimates, in fact, the cost of procuring and launching the ECS spacecraft and of building and operating the Earth stations would be much higher than the equivalent terrestrial circuits. The heavy platform was also felt to be premature by most delegations. At the end of the meeting it was decided to look again at the ECS programme and the ASTP later in the year.

A variant of the heavy-platform idea was proposed by three major European aerospace companies shortly after this meeting. SNIAS (F), MBB (FRG) and ETCA (B), who intended forming a new joint legal entity called Eurosatellite to replace the COSMOS consortium, were developing together a multi-purpose satellite platform of the Ariane class called Phebus X. They wanted ESA to be involved in the specification of the platform and in the definition of its first payload. This led the Executive to propose a new distribution of available resources for the next phase of the telecommunications programmes. ECS and ASPS would still be given 86 MAU and 36 MAU, respectively. However, the Phebus X platform, redefined as large experimental satellite anticipating the operational systems of the 1980s, and later called H-Sat, was allocated 50 MAU, which included 15 MAU for the payload. Finally, 40 MAU was allocated to an extension of the Marots programme by the construction of one additional satellite (Marots-B), in view of a possible operational maritime service. These suggestions won broad support at the JCB meeting in September 1976. The Executive was asked to refine its suggestions, bringing the total cost back to 203 MAU (from 220 MAU), placing contracts for feasibility studies of H-Sat which would ensure that the final choice respected geographical return considerations, and resolving certain legal difficulties (e.g. the Participating States of the Marots and ECS programmes were not the same).

ECS remained at the core of the programme all the same; and to win assent for ECS it was essential to have the PTTs take responsibility for an operational system in the 1980s. The terms of an arrangement were settled in negotiations in the second half of 1976 between the ESA Executive and a group of CEPT representatives. National PTTs in most European countries, Britain and Germany excluded, agreed to build, maintain and operate a ground network of 20 to 25 stations to receive and retransmit satellite signals to the telephone and Eurovision networks. This would cost them about 250 MAU. The management of the space sector would be entrusted to a new international organisation called Eutelsat, which in turn would pay ESA 55 MAU to procure, launch and maintain the satellites from 1980 to 1990. ESA, for its part, would need to find about 100 MAU more to cover its expenses, which was to be provided by the participating states in the ECS programme under the term of a so-called Phase-3-bis of the Telecommunications Programme.

The telecommunications package was one of the main issues discussed by the first ESA Ministerial Council meeting held on 14 and 15 February 1977. The Ministers agreed unanimously on the interest of extending the Marots programme. This programme had just assumed additional significance the month before with an offer by Comsat to pay 40 to 50% of the cost of another two maritime satellites. The set of four would be used to provide operational continuity to users at the end of the design life (five years) of the Marisat satellites, operated jointly by Comsat and Western Union. All other components of the package met resistance by one or another delegation. Coherent with its longstanding policy of linking Ariane and telecommunications satellites development, France agreed to contribute to an operational Phase-3-bis if the ECS and H-Sat satellites were launched with the European launcher. Germany by contrast felt that Phase-3-bis should be fully funded by the users. Both France and Germany wanted the distribution of work in the H-Sat programme to reflect their industries' already leading position in telecommunications technology; many of the smaller countries were emphatic that just return should be strictly applied to enable their industry to close the gap opened by these two countries having developed together Symphonie. In the event, a final decision on the telecommunications package deal was referred to the Council meeting scheduled for the end of June 1977. This proved to be too optimistic, for a number of reasons.

Firstly, there were the problems posed by the funding of Phase-3-bis of the ECS programme. In May 1977 Eutelsat was established by the PTT administrations, and in the course of that year its representatives negotiated with ESA the terms of an arrangement whereby the Agency would subsidise the initial operating costs of the system. The proposal arrived at by the end of the year reduced the cost of Phase-3-bis to some 44 MAU, in particular by abolishing the expensive technology research programme originally envisaged. Even these reductions were not deemed satisfactory by all Member States, notably Germany, and the Executive was instructed to arrive at better terms.

Then there were the problems posed by technical changes in the Marots programme in view of its operational extension. The Europeans had selected the Ku-band (11/14 GHz) for their satellites, as for OTS. The Marisat system used the more conventional C-band (4/6 GHz). It was imperative that the Marots system be changed accordingly if it was to use the same shore-to-satellite links, and anyway it looked as if the C-band was going to be set as the international standard by the soon-to-be-formed

Inmarsat. The unavoidable change caused delays, additional costs, and the need to change the launcher used for Marots A and B. After a meeting of interested parties (ESA, Eutelsat, Comsat and PTT authorities of countries interested in the maritime communications system) in London in December 1977, ESA undertook to provide, by the end of March 1978, its proposal for participation in the third and fourth satellites bearing this consideration in mind.

Finally there was the really thorny question of the H-Sat contractor. Both Eurosatellite and MESH submitted tenders in June 1977. There was little to choose between them, and the Executive suggested that Eurosatellite be chosen so as to avoid MESH (which had been awarded the ECS development contract) monopolising the European market. Many delegations, however, were unhappy with the geographical returns foreseen in the bid. The ensuing attempts to remedy the situation were complicated by Germany insisting that a liquid propellant apogee boost motor (ABM) derived from Symphonie should replace the foreseen solid propellant ABM. If this condition was not met, said Bonn, it would not support the H-Sat programme.

Indeed the entire H-Sat programme had indirectly been put in jeopardy in February 1977 when the basic regulations and technical parameters for future direct broadcasting satellite systems (DBS) were settled at an international conference in Geneva. The frequency spectrum was split into 40 adjacent channels and each European country was assigned a number of these (typically five) to serve the needs of small household ‘dishes’ in an area the size a single large state. Put differently, the emphasis was placed on national systems, as opposed to European-wide regional groupings. This led France, Germany and the Scandinavian countries to start planning immediately for their own DBS satellites. Germany also indicated that it might withdraw from H-Sat.

With Germany extremely loath to engage in H-Sat, and with both Bonn and Paris uninterested in the technology programme (ASTP), it was clear that a telecommunications package deal in which all interested states participated in all components to some degree or another would be impossible: each element would have to be treated independently. A compromise acceptable to all was reached in spring 1978.

Firstly, the ‘pre-operational’ ECS programme (two spacecraft, one launch, six months of in-orbit operation) was adopted at a cost of some 129 MAU. An ESA/Eutelsat draft agreement for the Phase-3-bis operational system followed soon thereafter, with the agreement of the Deutsche Bundespost. It foresaw the procurement of three more satellites, and made provision for the launch of three. Its cost over ten years was some 202 MAU, of which Eutelsat was to pay 80 MAU. Difficulties regarding the cost of Ariane launches, the scale of contributions and geographical return, and the procedures to guarantee continuity of service took a year to iron out, and were finally settled at the Council meeting in April 1979.

The first ECS satellite, eventually renamed Eutelsat 1, was successfully launched by an Ariane vehicle in June 1983. A second one was launched in August 1984 while the third was lost one year later because of a launch failure. Two other satellites were then launched in September 1987 and July 1988, respectively, thus bringing to completion the full ECS system with four satellites in orbit.

The ASTP originally interested only a few states (Austria, Denmark, Italy and Switzerland). Others, notably Spain and the UK soon joined in, but France and Germany did not. The first programme was intended to ensure that European industry remained competitive as regards state-of-the-art developments of system configuration and communications technologies, and was able to build on the lessons learnt from H-Sat, ECS and Marots. Initially for four years, it was renewed for four more in 1981. All Member States bar Ireland participated in the second programme, which had a budget of 55 MAU, and in a further extension, adopted in 1986, with a budget envelope of 130 MAU.

The Declaration adopted in March 1978 by the participants in the Marots programme made provision for procuring and launching a second flight unit (Marots B) to be made available to Eutelsat for the space segment of its maritime communications satellite programme. Marots A was to be launched into a geostationary orbit above the Atlantic Ocean in October 1980, and Marots B was to be located over the Indian Ocean after a launch in mid-1981. The designs of the two satellites were subsequently upgraded by switching from the OTS platform to the ECS platform and the names of both satellites were changed to Marecs.

As we mentioned earlier, Europe hoped to provide two further satellites Marecs C and D to guarantee continuity of service when those operated by the Marisat consortium (Comsat/Western Union) reached the end of their design lifetimes. However, when the formal offer was made to the interested parties in spring 1978, Intelsat made a counter proposal suggesting that Marecs A and B both be placed over the Pacific and that Intelsat lease maritime communications capacity from its forthcoming Intelsat V spacecraft for the remaining global coverage, so killing Marecs C and D. This was strongly contested by ESA and, after further negotiations, a new proposal was worked out which foresaw Marecs C and three Intelsat maritime payloads. The final decision was up to Inmarsat, which officially came into being on 16 July 1979.

ESA's bold face was intended to show European resolution; in fact it concealed grave doubts in some PTTs about the viability of the scheme. Indeed the German delegation confirmed that it would not participate in the Marecs C programme, fearing that Inmarsat would not accept the European offer. In fact when Inmarsat did finally adopt a policy, early in 1980, it chose not to procure a space segment but to lease maritime communications capacity on existing satellites or on those under development. This killed Marecs C altogether and even though leasing was feasible for ESA, the policy forced it to adopt a marginal cost approach (rather than charging the full cost to users) to remain competitive. After lengthy negotiations an agreed contract was signed between Inmarsat and ESA in November 1980.

Marecs A was successfully launched by the last qualification flight of Ariane on 20 December 1981 and was placed into its geostationary orbit above the Atlantic two weeks later. Marecs B was lost in an Ariane launch failure in September 1982, but a reconstituted Marecs B2, built from spare hardware was successfully launched in November 1984 and placed in orbit above the Pacific. Building on this success, in 1985 an industrial consortium led by British Aerospace won the contract for developing the second generation of Inmarsat satellites. The platform was based on the ECS and Marecs concept while the payload was provided by Hughes Aircraft Co. using a new design.

What of H-Sat? Faced with Germany's withdrawal, in March 1978 the JCB (Joint Telecommunications Programme Board) and the Council approved a preliminary Phase-B study pending a final decision on the start of the programme. The new concept based on this study was put forward by the Executive in October. It was intended to make the satellite adaptable to future DBS missions, and considered two funding scenarios, one with and one without Germany. The Executive's hope was that it could propose a design which would reconcile joint European interests with those of particular Member States. It suggested a three-phase programme. The first would provide a limited pre-operational service for those countries that intended to build their own DBS, and was based on specifications close to those sought by Germany. This satellite, to be launched in 1982, would be followed by another, this one operational and to be launched in 1984, and having a dedicated French, German or Scandinavian payload, or even a mixed payload. The third phase would involve the development of fully national systems based on the standard European platform. The scheme was rejected by Germany and now by France as well. In fact the developers of Symphonie were planning to use their acquired experience to build a new Franco-German system. Much to the distress of their partners, these two blocked all further funding for H-Sat at JCB and Council meetings in December 1978 pending completion of their national studies.

There was new cause for optimism in March 1979 when the UK delegation suggested that there seemed to be some interest in a large European telecommunications satellite using a multipurpose platform, even without France and Germany. This was confirmed by a wide-ranging market survey by the Executive, which suggested that the need for such a system would be felt in the mid-1980s and that one could hope to sell 20 to 30 platforms. They proposed a new optional programme called L-Sat comprising a multi-purpose large platform compatible with Ariane and the Shuttle, carrying a multi-element payload whose individual elements would be based on predicted market needs, interest in demonstrating a certain new service or of developing and qualifying new technologies, and the willingness of participating Member States to fund both payload and the corresponding ground equipment. Contributions would be in proportion to industrial return.

At a JCB meeting in July 1979, France and Germany definitely withdrew from the ESA project, announcing that they were going ahead with a bi-lateral DBS development programme. Meeting shortly thereafter the Council approved the L-Sat proposal with five Member States (Denmark, Italy, the Netherlands, Switzerland and the UK) participating. Belgium and Spain joined three months later. In November Selenia was selected as prime contractor. The final programme was approved in December 1981 with a financial envelope of some 388 MAU (1980 prices). The satellite was renamed Olympus, and four payloads were eventually selected for it. These were a DBS payload with two channels, a 12/14 GHz specialised services payload for communications experiments between small Earth terminals, a 20/30 GHz communications payload for experiments with new applications, and a package for gathering information on the propagation of radio waves in the atmosphere. Olympus was eventually launched by Ariane on 12 July 1989, but suffered some degradation in orbit and its useful life was terminated prematurely around August 1993.

It only remains to say that the high-power technology at the core of Olympus and the two national DBS satellites (TV-Sat in Germany and TDF in France) was obsolete before they were operational. Advances in ground based technology meant that lower powered, smaller satellites could provide the same services at a much lower cost per channel and over a far greater geographical area. These advantages were exploited by the Astra satellites, owned by a firm set up with the help of the Grand Duchy in Luxembourg, which has launched many payloads. The ECS satellites, by contrast, were extremely successful and have enabled Eutelsat to establish itself as an increasingly profitable organisation.

2.4 The Meteorological Satellite Programme[156]

Two main considerations converged to make European governments decide to embark on the joint development of a meteorological satellite in the ESA framework. Firstly, there was the desire expressed by some European meteorologists to make a contribution to the first phase of the global atmospheric research programme (GARP) of the World Meteorological Organisation. Secondly, there was the political need to bring the collaborative European space programme back from the brink of collapse.

The GARP was an international programme similar in concept to, though vaster than, the International Geophysical Year held in 1957. Swedish scientist Bert Bolin was the first President of its organising committee. One of the main objectives of the GARP, as described by Bolin, was to combine the resources of all the participating countries so as to provide data which could be used to test the adequacy of numerical models of the atmospheric general circulation. For this purpose it would mobilise existing or planned networks of surface and upper air stations (including buoys and commercial ships and aircraft) as well as satellites.

Bolin was particularly keen that Europe be represented in a satellite system being promoted by NASA and due to be established as from 1976. NASA's proposal, which was still in the planning stage at the end of 1970, was to put in place a co-ordinated global system of weather satellites. The scheme had two main components: two or three low-altitude, near-polar orbiting satellites (probably the US's Tiros-N and the Soviet Union's Meteor satellites) and four large (300 kg) geostationary satellites. Two of these geostationary satellites were to be the new generation American Synchronous Meteorological Satellites (SMSs). Japan was planning a third, while it was open to Europe to supply a fourth. Their

[156] See also John Krige, “Crossing the Interface from Research and Development to Operational Use. The Case of the European Meteorological Satellite”, *Technology and Culture* (in press).

main mission would be to survey the Earth in both the infrared and visible channels, to retransmit their data, after processing on the ground, to interested users, to collect and redistribute information from ground platforms, and to relay data from other meteorological satellites.

While the scientific interest of Europe's participating in GARP was manifest, the political situation was complicated by the fact that at least two space agencies were planning meteorological satellites in the late 1960s. Firstly, there was a team at CNES who were designing a satellite called Meteosat to be placed in the geostationary orbit between longitudes 10°E and 30°E.[157] Meteosat was foreseen as France's contribution to the global system being planned by NASA. The programme was motivated politically by the government's wish to play a major role in providing meteorological coverage over its traditional spheres of influence in north and central Africa and for long-haul aircraft on the Europe-Africa routes. It was also argued that, by participating in the GARP, France could increase her influence over the shape of the programme and in the World Meteorological Organisation. Industrial policy was also involved. The CNES engineers were devoting considerable energies to the most 'noble' part of the instrument payload, the radiometer, which was equipped with sensors providing data in the visible and infrared regions.

A second, parallel development programme was being undertaken by a small team of engineers inside ESRO. They originally designed a polar orbiting satellite but, with the plans for the GARP picking up steam, the directors of the meteorological services felt that it would be far more valuable for ESRO to provide a geostationary satellite for the international programme. Realising that European governments would never support two similar projects the President of CNES and the Director of the French meteorological services both sent a strongly worded note to ESRO's Director General Herman Bondi expressing their "shock" and "disappointment" at the orientation being proposed for the Organisation's programme, and warning him to "weigh all the consequences" of his actions before deciding to go ahead with a geostationary satellite. These threats never materialised, however. The French government decided to Europeanise Meteosat as part of the first package deal. The engineers working at CNES, it should be said, were "traumatised" to quote one of their number, but could do nothing to stop the political tide which was turning in favour of collaborative European space ventures at the expense of national ones.

With the French proposal to Europeanise Meteosat on the table, the Europeans had, to quote Bondi, a programme for a geostationary satellite which was "really European, really worthwhile and really interesting technologically." The Arrangement formalising the technical content of the space and ground segments and the cost-to-completion of the Meteosat programme (115 MAU) formally came into force in September 1972. Eight European states participated in the programme, the 'big four' Britain, France, (the Federal Republic of) Germany, and Italy, two Scandinavian countries, Sweden and Denmark, and also Belgium and Switzerland. A management scheme was devised which shared the technical control of the programme between CNES and ESA, and which protected the industrial interests of the other partners by having ESA monitor the application of the fair-return principle.

The Arrangement signed in 1972 only made provision for the launch of one satellite and for its operation for six months after the launch. The feasibility of this 'pre-operational' system demonstrated, the space ministries expected the meteorologists and those who funded them to take over its space and ground segments. This proved to be too optimistic. Between 1973 and 1980 their representatives on the Meteosat Programme Board found themselves funding one slice after the other of an extended Meteosat programme. If they did so initially it was because they were trapped between their commitment to a European participation in the first phase of the GARP, and the reluctance of the meteorologists to set up an operational system. Once Meteosat was launched, they were persuaded to

[157] See *Note sur le projet de satellite météorologique français géostationnaire* dated June 1969, RT52001, the questionnaire drawn up by H. Felix, CNES paper N°7/METEOSAT, 22 April 1960, RT52001, O. Carel's *Specifications des utilisateurs de Météosat,* CNES/PR/AM-ME/N°70T.124, 2 July 1970, RT52003, and *Le système Météosat*, prepared by H. Felix, March 1971, RT52011.

provide ongoing support for the system by the promise that an independent operating agency would be established very shortly. As a result, the space ministries eventually paid for six years of satellite operations not six months as specified in the 1972 Arrangement, and for the launch of three spacecraft, and not one, as they had originally planned.

The first concession to the meteorologists occurred over the arrangements to operate the first satellite (F1). Convinced that the community would never be ready to manage a system by 1977, when Meteosat was due to be launched, the ESRO Secretariat persuaded the participating states spend an additional 17 MAU to operate the satellite for three years. In parallel with this debate, the Programme Board also had to deal with the question of funding the launch of a second satellite, F2, a "proto-flight" model built to cover the eventuality that F1 was destroyed on launch.

On the face of it this was a fairly straightforward matter: it was obvious that some measures had to be taken to protect against launch failure and additional resources were not needed. The funds could be found within the 20% contingency for cost overruns foreseen in the original Meteosat Arrangement. The space ministries were thus easily convinced to pay for the launch of F2 from the Meteosat budget *if F1 failed*. However, the meteorologists wanted F2 to be launched *even if F1 was successfully orbited*. This was necessary, they said, to protect against in-orbit failure and to ensure that Europe played its full role in the GARP. They also wanted provision be made to launch a *third* satellite as a passenger on one of the early demonstration flights of Ariane. The qualification model built for Meteosat (prototype P2) could be refurbished at little extra cost, it was argued, and could be launched on Ariane to fill "any gap that might develop between F1/F2 and a fully operational F3 sequence onwards."

These arguments carried the day. By Spring 1977 PB-MET had agreed to launch and operate satellite F1 for three years. If F1 was destroyed on launch, or stopped functioning early on, they would also pay NASA for a second launch. However, if F1 was a success, the NASA launch slot would be sold to another customer, and F2 would be launched on Ariane at the meteorologist's expense. On the other hand the Board insisted that the operation of F2, and the launch of the refurbished prototype P2, if that was sought, would have to be paid for by the meteorologists. They were soon to change their minds, as we shall see.

On 23 November, 1977 Meteosat-1 was successfully put into orbit by a Delta 2914 rocket from Cape Kennedy. With the satellite functioning as planned, in 1978 the meteorologists began to take some positive steps towards setting up their own operating agency. Working groups were set up to explore the most desirable legal structure of an eventual European organisation (should a new organisation be set up or should the operating agency be grafted onto an existing body?) and to define the technical content and the cost envelope for an operational system in consultation with European industry. In parallel a major effort was made to promote the use of satellite meteorological data. The ESA Executive organised meetings of meteorological researchers in Darmstadt in June 1979 and again in London in March 1980. User networks were also extended and political support built by demonstrating to local forecasters in Europe and in Africa the potential advantages of the system for them.

Progress was slow, though, and since PB-MET had agreed to launch F2 on Ariane in May 1980, early in that year the ESA Executive thought it advisable to secure funding for its operation too. Their request to PB-MET to extend the operational programme beyond November 1980 by a further 30 months to cover the in-orbit life of F2 met with fierce resistance on the grounds that its costs should be borne by the users. The conflict was only resolved by a dramatic last minute appeal by the Executive "to the Member States' sense of solidarity so that the second Meteosat exploitation phase can be decided [...]."In October 1980, just a month before the agreement for the operation of F1 was due to terminate, the Meteosat Programme Board reversed its earlier decision, and agreed to a text making provision for the costs of exploitation of F2 for three more years, i.e. up to November 1983. Meteosat-2 was duly placed in orbit by Ariane in June 1981.

In January 1981 an Intergovernmental Conference organised by the meteorologists and their ministries, and convened by ESA, took place at ESA Headquarters in Paris. No one now doubted the enormous benefits of a meteorological satellite system, not simply for weather forecasting, but also for agriculture and fisheries, nor did anyone doubt that it was immensely important for Europe to make its own contribution to the world-wide system. They were spurred on by the initiatives taken by the Reagan administration to commercialise weather data, thus violating what the chairman called "the sacred principle of the free exchange of data and products". If the US could not guarantee open and free access to weather data, Europe had to have its own system. Only very few countries were, however, in a position to commit resources to the programme at this stage, their decisions being dependent on a further study of the matter and, crucially, on the number of other participants sharing the costs. A new working group was set up to prepare the system requirements and specifications for an operational system and to recommend an appropriate institutional framework for its implementation bearing in mind the points raised during the meeting.

Within a few months this working group and its subgroups, which were also chaired by meteorologists, had converged on the technical specifications, cost, and management scheme for their operational system (400 MAU at 1982 prices for a system of three identical satellites and one spare). The difficulties that remained were institutional and political. The precise legal form that the new body should take was another ongoing bone of contention. European governments had become wary of setting up new international organisations which rapidly grew in size and cost. They were eventually prepared to grant the new body, to be called Eumetsat, its own legal personality, but insisted that its structure remain light and its numbers small. This implied that Eumetsat entrust development and operation of the space and ground segments of the system to another organisation working under their supervision. But which one? ESA was an obvious candidate. However, it was anything but the meteorologists' first choice in 1981. For if the users were generally satisfied with the way the Agency handled the space segment of the pre-operational system, they became increasingly frustrated and angry in the latter half of the 1970s over the management of the ground segment. This was compounded by a growing resentment among the meteorologists that they were not being consulted by ESA and that they were being overcharged for services rendered them. By 1983 trust had been rebuilt, mostly due to the heroic efforts of Régis Tessier, who was responsible for the programme inside the Executive, and the operation of the programme was accorded to ESA.

Notwithstanding some lingering doubts about the precise legal form that Eumetsat should assume, it was decided to reconvene the intergovernmental meeting under ESA's auspices in March 1983. The overall tone was now extremely positive, and all the necessary steps were taken to prepare a conference of plenipotentiaries empowered to create a new organisation to watch over a European operational meteorological satellite system. This meeting was held in May and was attended by representatives from sixteen governments. They signed the Eumetsat Convention, which entered into force two years later in June 1986.

Of course, the success of Eumetsat required that the existing pre-operational system gave continuous service – and PB-MET (The Meteorological Satellite Programme Board) had only agreed to fund operations up to November 1983. What is more, since it took typically four years to build a satellite, this meant that the first operational Meteosat paid for by Eumetsat could not be launched until 1987 – six years after the launch of F2. What was to be done to ensure continuity of service, i.e. to cover the gap between the launch of F2 in June 1981, and the launch of this first new satellite?

The most cost-effective way of ensuring continuity was to launch the refurbished Meteosat prototype P2. The Meteosat Programme Board hesitated, then in June 1983 it again reversed an earlier decision and agreed to commit more funds from its budget for the refurbishing of P2 and for its launch on one of the first test flights of the upgraded Ariane-4 launcher. In return, the meteorologists, now in a position to engage themselves financially, took over the operating costs of the system from November 1983 onwards. It only remains to be said that Meteosat-3 was eventually launched on Ariane-401 in June 1988. Since then Eumetsat has successfully placed four operational satellites of its own in orbit, the last in September 1997.

2.5 The Ariane family of Expendable Launchers

The French launcher accepted for Europeanisation by the Ministers meeting in July 1973 was a three-stage rocket designed to place payloads of some 750 kg in the geostationary orbit. Most of its technology was derived from the experience already gained in the French 'Diamant' programme and the ELDO programme. The estimated cost of development was just over FF 2000 million (about 371 MAU in 1973 prices); this increased to some FF 2,500 million if one counted in other expenditures and the usual 20% contingency. France made a number of concessions to its partners to ensure that their industrial returns on the project would remain around 80%; pressured by concerns inside French industry that the schedule was too tight and the budget ceiling too low, she also undertook to fund herself an additional cost overrun of 15% above the 120%. In return she demanded that CNES have technical management control over the project, with the ESRO/ESA role reduced to monitoring the development programme, and ensuring that considerations of fair return were respected.

The CNES team developing Ariane did so in the face of considerable financial hostility in their own country. In May 1974 a new French President, Valéry Giscard d'Estaing took over from the Gaullist Georges Pompidou, recently deceased. Giscard had already expressed some hostility to the project as Minister of Finance in the previous government, and he now forced a major re-evaluation of France's space expenditure. It took some six months before work could proceed normally on the rocket, but even then the problems were not resolved. Yves Sillard, who was directly responsible for the development of Ariane up to July 1976, when he became CNES DG, recently remarked that there was:

> *a total lack of credibility of the programme during the first years of the development phase, especially in France. I can say that every year, starting in 1974 and until 1978, the French Ministry of Finance made every effort to terminate the programme, arguing that we would not succeed technically, that if we were successful from a technical point of view the development cost would be unacceptable, that if we met the target development cost, the launcher would never be sold due to the arrival of the Shuttle, and so on.*[158]

From a technical point of view, by contrast, no major difficulties beset the development of Ariane. It was decided, to keep costs down, that individual stages of the rocket would not be tested separately, as was traditional CNES practice. Instead funding was provided for two development firings and two qualification firings of the complete launcher. In the event the first test launch occurred from the equatorial base in Kourou in French Guiana on Christmas Eve, 1979. It was an unqualified technical success. It also inaugurated a new era in the balance of power in the international space arena. Not only did it restore Europeans' self-confidence in their capacity to manage large technological projects, and reassure politicians and industrialists that access to space for European technologies was guaranteed, it also broke the United States' hegemony in the western world over space transportation systems and created the foundations for a more equilibrated collaborative effort between America and Europe.

In the late 1970s, in anticipation of the qualification of the launcher, the ESA Executive started delegations thinking about how they might want to deal with production. This had not been foreseen in the original Arrangement, but obviously some steps had to be taken to establish the procedures needed for building and marketing Ariane.

The procedure adopted was to set up an intermediate phase between qualification and full commercialisation, a period which was neither wholly commercial nor wholly R and D. What was called a promotion series of six Arianes was foreseen, during which cost-efficiency would be

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158 Yves Sillard, "France and Launchers," in *The History of the European Space Agency. Proceedings of an International Symposium*, London 11 - 13 November, 1998 (ESA SP-436, 1999), 85 - 93, on p. 92.

improved by ruggedised construction, simplification of fabrication methods and rationalisation of management and launch operations.

From a management point of view, one original idea was to follow NASA's example, i.e. it was suggested that ESA would not only be responsible for liaising with clients and defining the technical interface between the user's satellite and the launcher, but also for overseeing the production of the rocket. This could not, however, be imported into Europe: CNES obviously had to retain a major role in the production of the launcher. The criteria for any scheme were spelt out by DG Gibson in July 1976: CNES had to have a special place in the arrangement granted the unique competence it had in Europe, the ESA - CNES relationship should be one of genuine partnership, and any scheme had to facilitate dealings with industry and with user-clients. The division of responsibility finally adopted for the promotional phase of the production programme gave ESA overall management responsibility for the manufacture of the launchers, which it delegated to CNES. The French space agency would deal with industry, applying ESA's contractual procedures, and take responsibility for launch operations up to payload separation. Users would be ESA's concern.

As for pricing policy, the great unknown here was the cost of equivalent US launchers. NASA's prices for expendable launchers were extremely variable, and changed in the course of a contract for one satellite, as well as between satellites.

As for the Shuttle, the American agency was still being evasive at this time (mid-1976): it would support a "promotional" phase of three years, after which prices would increase so as to recover the development costs of the system. After lengthy deliberations, the Programme Board proposed in summer 1977 that the prices be roughly aligned on typical US expendable launch prices for ESA and its Member States, e.g. 28.5 MAU for an Atlas/Centaur-class payload (to be compared to $30 million) and 22.5 MAU for a single Delta-class payload (to be compared to $18.5 million). Prices to third parties would be decided on a case-by-case basis.

It proved very difficult to adopt this scheme. The Participating States wanted Ariane to be used, but faced with the commercial challenge from across the Atlantic they also had to keep the cost down. This meant pre-financing production without any guarantee that the rockets would be sold and perhaps even in some cases selling below marginal cost. If this happened space ministries essentially dedicated to funding R and D would now be providing indirect financial subsidies to users and operational systems. To get around these problems, at the end of 1977 the German and Netherlands delegations suggested looking at the whole issue differently. They suggested that the promotional programme only be undertaken once clients had been guaranteed, having the users, not the space ministries, finance the production and launch of Ariane.

This approach won general assent in principle, but proved difficult to operate in practice. By summer 1978 four satellites had been assigned to Ariane, three from ESA programmes and one the French Earth observation satellite SPOT. ESA DG Gibson suggested therefore that a promotional series of five, rather than the original six launchers be embarked on. The prices would be roughly those agreed earlier and the fifth launcher would be a back-up. This led to tortuous debates about who would pay for the back-up launcher, and a flat refusal by some countries to sell SPOT at anything but its full cost price on the grounds that ESA was not there to subsidise national programmes. It also proved impossible to agree whether or not one should make provision for building additional launchers after these five.

The French delegation broke the deadlock in 1979. It was encouraged in its thinking by the decision taken by the Intelsat Board of Governors in December 1978 to use Ariane for an Intelsat V satellite. The enormous boost this gave the Europeans was reinforced by new mission model studies which suggested that anything from nine to twelve launchers would be sold in the period 1981 to 1983 covered by the promotional series. Taking the bull the horns French delegate Hubert Curien suggested that, in the light of the "factual impossibility" of reaching agreement inside ESA on a promotional production phase, the Agency should entrust the manufacturing, marketing and launching of Ariane to a private company established under French law, and temporarily named Transpace. This arrangement would be made for a renewable period of ten years, and would commence with the production of the eleventh Ariane launcher.

Transpace would comprise CNES and the firms that had developed Ariane. It would not seek direct government subsidies, but function on the basis of sales to its clients. It would try to respect the distribution of work accepted for the development phase. It would normally give priority to ESA and its Member States in the provision of launchers and launch slots. Its prices for all contracts signed up to 1984 would be those already agreed on. Prices to third parties would be entirely at the firm's discretion.

The idea of entrusting the production of Ariane to an industrial structure was warmly received by the Council. The terms of the arrangement were not easily agreed on, however. The ESA DG and some of its Member States wanted to place the firm squarely in an intergovernmental context, while the French authorities wanted the operational use of the launcher to be implemented on a purely economic basis in an industrial context on the open market. It was the latter view that prevailed.

Arianespace, as it was called, was formally established on 16 March 1980, less than three months after the first successful launch of the rocket. Its mission was to finance, produce, market and launch Ariane once the promotional series was over. The French government assumed civil liability for any damage to third parties, with the firm reimbursing it up to a maximum of 400.000 FF. The Board of Directors comprised four representatives from CNES, one each from the three French prime contractors (SNIAS, SEP and Matra) and one each from five other major participating industries outside France. ESA had one of six 'Censor' seats, which enabled its representative to participate in Board Meetings but not to vote.

Even though ESA's Member States had limited power in Ariane's Board of Directors, measures were taken to ensure that their historical links with the birth of the launcher were respected. Procedures were drawn up to protect the pacific nature of ESA's mission; in some cases Arianespace could be forbidden to sell a launch to third parties if it was judged to be of direct military importance. Complex rules were established to ensure that ESA and European governments were given priority in terms of launch services and launch windows, in return for those clients using the rocket if it did not represent "an unreasonable disadvantage" in terms of "cost, reliability and mission suitability" (as laid down in the ESA Convention). As for cost, what threatened to become a contentious issue was laid to rest by NASA's announcement that it was behind schedule with the Shuttle and that the annual number of flights foreseen was smaller than originally thought. In addition the US Senate and Comptroller General were beginning to insist that, after the initial promotional phase, NASA should charge the 'true price' for the Shuttle. Reassured by the fact that their launcher was likely to be competitive with the reusable US system after all, it was relatively easy for Arianespace and its potential clients to agree on a pricing policy.

The technical and commercial achievements of Arianespace are now legendary; the launcher is the jewel in the crown of the European space effort. That achievement was all the more laudable for having been accomplished in the face of immensely powerful competition from the Unites States. The so-called TCI affair was emblematic of this competition.

In May 1984 an American firm called Transpace Carriers Inc. accused the Europeans of "illegally dumping" their rocket on the world market. They filed a petition to this effect with the Office of the US Trade Representative, arguing that Ariane was being unfairly subsidised and asking the US President "to retaliate by prohibiting Arianespace SA from advertising and marketing its services in the United States and by imposing economic sanctions against the goods and services of the ESA Member States".

TCI's initiative has to be understood in the context of a spirited debate in the US at the time over the Phase III Shuttle pricing policy for 1988 - 1991. TCI had just acquired the Delta rocket programme from NASA, as part of the Reagan administration's efforts to privatise space activities. It was deeply concerned that, by subsidising the Shuttle to make it competitive with Ariane, NASA would make it impossible for private ELV operators like Transpace Carriers to survive. In fact NASA Administrator Beggs told the President that the only way the Shuttle could compete effectively with Ariane was if its base price was $74 million (1982 dollars), compared to the full cost of $150 million/flight if there were two flights a month. At this price level, according a Congressional Budget Office Report, domestic ELVs "had little chance of success". Obviously if they could force Ariane out of the US market the Shuttle prices could drift upwards, giving them the possibility of becoming commercially viable.

A year of lengthy negotiations ensued. The main plank of the Europeans' counter-attack was that they were not subsidising Ariane in any untoward way and that, in fact, American launch services received far more substantial government support. On 17 July 1985 President Reagan delivered the official verdict. "Many of the factual allegations [in the TCI petition] were not supported by evidence on the record," he said. Those that were substantiated, he went on, involved practices which were "not sufficiently different from US practice in this field" to merit sanctions. He accordingly refused to take "affirmative action" in TCI's favour. It only remains to add that in the wake of this affair US/European consultations got under way to establish the 'Rules of the Road' for permissible levels of government support in the commercial launch service industry.

Towards the end of 1978 the ESA Executive suggested the Member States should consider plans for upgrading the Ariane 1 rocket. The need for this was dictated above all by the evolving market for application satellites in the geostationary orbit, and competition for a share of that market with the Shuttle, along with the desire to keep the teams and facilities engaged in Ariane development active.

Ariane-2 was designed to put 1950 kg into GTO. This was achieved by increasing the thrust of the engines in the first two stages, and by increasing the capacity of the cryogenic third stage. Ariane-3 (2300 kg in GTO) differed from Ariane-2 by the addition of two solid boosters each carrying a mass of propellant of between 6 and 7 tons. The initial cost estimate of the programme was about 60 MAU in mid-1978 economic conditions.

The Member States delegations were in favour of these upgrades, but felt that for internal reasons it would be unwise to seek funding for them until the rocket had proven itself. In the event matters did not run quite as smoothly as they had hoped after the first successful flight of Ariane 1 on 24 December 1979. The main reason was that the cost of the upgrade had more than doubled to 139 MAU in mid-1979 conditions. The new figure was put forward after some delegations had already won assent for funding the new programme on the basis of the old figure, causing them considerable embarrassment.

The solution adopted by the Executive was to slightly reduce the overall ceiling for the so-called Follow-on Development Programme and to cut it into four slices. The entire FOD, as well as each slice was optional. The first slice was for making modifications to the launcher as such to bring its capability up to 2420 kg in GTO. Its cost was set at 70 MAU in mid-1979 prices, so roughly the figure already accepted by national state bureaucracies. The second slice, funded entirely by Switzerland, concerned modifications to the fairings to enable them to accommodate two satellites and satellites of larger diameter (to be compatible with the Shuttle). Slice 3 was devoted to a study of the feasibility of recovering the first stage and the boosters, a project which never came to fruition if only because the rocket was such a success that the potential economies from this added complication were not worth it. Finally Slice 4 was for the development of a second launch site deemed essential to cope with increasing demand and the need to give suitable guarantees to clients in the event that one of the pads was damaged.

Ariane-2/3 were followed by Ariane-4, the European launcher needed after 1985. This was designed to be able to launch together a direct TV and a telecommunications satellite, or one satellite of the Intelsat VI class. Its payload capability was some 4300 kg and the size of its fairings had to be substantially increased to accommodate these huge satellites. The rocket consisted of a central body derived from Ariane-3 with three powered stages surmounted by an equipment bay. Flexibility was achieved by attaching one or two pairs of boosters to the first stage, and by having sets of fairings of different shapes and sizes. Basic propulsion was provided by four Viking engines, as in Ariane-3, fed from two propellant tanks with a capacity of 220 tons, compared to 140 tons for Ariane-3.

Ariane-4 was designed to put between 2000 kg and 4300 kg into GTO, depending on its configuration (from no boosters to four liquid boosters). Its development cost was initially estimated by the Executive to be some 225 MAU in mid-1981 prices. The programme was adopted by the Council in October 1981. In June 1984 it was clear that it would overrun its envelope including the 20% contingency, and the Executive, in consultation with CNES, suggested that the new ceiling be set at 140% of the original one, i.e. 376 MAU in mid-1983 prices. All Member States agreed to accept these increases though there was some difficulty in reaching the full level of funding due to some participants' dissatisfaction with their industrial returns.

The technical changes to Ariane-2/3 were coupled with a number of innovations, funded as separate slices as before. The basic development programme was called Slice 1. Slice 2, for example, was for a carbon-fibre skirt between the second and third stages, a lightweight technology that improved rocket performance by 53 kg. Slice 5 was a technology support programme intended to improve progressively the reliability and performance of the rocket over ten years, and was of fundamental importance to the eventual success of the rocket. Ariane-4 had its first successful launch with two solid and two liquid boosters on 15 June 1988.

2.6 Spacelab and its Scientific Utilisation

In June 1972, after lengthy deliberations regarding an appropriate European participation in NASA's post-Apollo programme, a NASA delegation to ESTEC suggested that a sortie module, or Spacelab as it came to be called, would be a suitable element for a collaborative enterprise. This comprised two types of payload, which would be launched by the Shuttle: a pressurised manned laboratory module suitable for carrying out scientific experiments under low-g conditions and a series of external, unpressurised instrument platforms or pallets suitable for conducting research and application activities on Shuttle sortie missions. From NASA's point of view, the inclusion of the Europeans in the scheme was primarily for political reasons, part of the Nixon administration's wish to rebuild ties with Europe and reinforce the legitimacy of US leadership across the Atlantic during the bruising Vietnam conflict. The stakes for the Europeans were far higher. Apart from the presumed scientific interest, Spacelab provided them with a relatively cheap initiation into manned space exploration, it enabled them to build expertise through collaboration with the USA in an ongoing, complex technological programme, and it gave them access to American industrial know-how and the management of complex technological systems. The Europeans were acutely worried about this dimension of the "technological gap" with the USA, starkly revealed by the disastrous project management of the Europa rocket programme, not only at the level of ELDO, but within national firms themselves. Indeed this concern, along with a wish to "equilibrate" Willy Brandt's new 'Ostpolitik' with overt signs of solidarity with the USA, were two important reasons why Germany took main responsibility for Spacelab when the second package deal was struck in July 1973 at a cost of 308 MAU (about $250 million) in 1973 prices.

The cooperative programme was sanctioned in two diplomatic agreements signed in 1973. They foresaw that ESRO would design, develop, manufacture and deliver the first flight unit of Spacelab. NASA would provide managerial consultation and technical interface information, as well as monitoring the implementation of ESRO's activities and managing all operational activities after the delivery of Spacelab. NASA insisted on having unrestricted use of the first unit free of charge, and on the right to modify it as it wished. It also undertook to procure at least one additional Spacelab unit if it satisfied specifications, schedules and was a ‘reasonable’ price. It also accepted, on European insistence, not to build independently a Spacelab “substantially duplicating the design and capabilities” of ESRO’s, unless of course Europe failed to deliver.

NASA accepted that the first flight would be jointly planned, and agreed that European experiment proposals would be given preference over those from third parties if they were of equal merit. It was also understood that that first flight would carry at least one European crew member. However the American agency could not accept that construction of Spacelab would guarantee Europe preferential treatment in the use of the Shuttle, nor secure access for scientists to subsequent flights of the laboratory. It resolutely refused access to any technology not directly linked to the development of Spacelab, and reserved the right to impose changes on the unit due to changes in Shuttle design, with each party bearing the cost implications for their respective components; these changes, NASA agreed, would not be ‘disproportionate’. This notion, like those of ‘reasonable’ and ‘substantial’ were of course open to interpretation, and were the cause of considerable dispute as the programme evolved.

The design and development contract (Phase-C/D) for Spacelab was awarded in June 1974 to the VFW-Fokker/ERNO consortium based in Bremen, after a close contest with MBB based in Munich. The consortium was responsible for the development, integration, and test of the total system and ten European co-contractors, supported by 36 subcontractors collaborated. US firms were involved from the outset: TRW worked both for ESA and private firms such as ERNO, Matra and BTM, while McDonnell Douglas provided over 40 consultants to various European industries. The deadline for delivery of the first unit was set as April 1979. Commitment to the complex Instrument Pointing System (IPS) was postponed and the contract was eventually awarded to Dornier in June 1977.

The programme was supervised inside ESA by the Spacelab Programme Board (SLPB). It was implemented by two Spacelab Programme Directors. On the ESRO side this was usually a Frenchman, notwithstanding Germany’s financial and industrial preponderance: Jean-Pierre Causse briefly, then Bernard Deloffre then Michel Bignier. Doug Lord was Programme Director on behalf of NASA until 1980, when he was replaced by James Harrington. The day to day technical coordination was in the hands of two project managers, one from each side; Stöwer, Pfeiffer and Altmann successively for ESA, and Lee for NASA. They were assisted by a variety of consultative groups. Crucial to the success of the programme was the ongoing contact maintained between ESA DG (Gibson, until 1980, then Quistgaard) and the NASA Administrator (Fletcher, until 1977, then Frosch), an arrangement that enabled major problems to be ironed at the most senior level as they arose.

Spacelab was designed and built in a particularly inclement economic and technological climate. The run-away inflation of the 1970s posed major financial problems for the Member States involved, notably countries like Italy and the UK for whom the real cost of the project rose by around 16 or 17%. In parallel, the laboratory, which posed innovative technical problems of its own, had to be integrated into a system (the Shuttle) whose parameters were under constant revision, whose launch timetable slipped steadily, and whose pricing policy was highly uncertain.

By 1976, with the change imminent from system design on ‘paper’ to hardware manufacture, assembly and testing, the technical and managerial problems were serious. A special ESA/ERNO-NASA/Rockwell group was set up to try to limit the scope and financial implications of Shuttle/Spacelab interface changes. ESA Director General Gibson also decided to negotiate the backlog of changes that had built up inside industry by settling them in bulk, rather than one by one. A new Programme Director and Programme Manager (Bignier and Pfeiffer) were appointed, and a severe scrubbing or de-scoping (from which the IPS, costing 19 MAU in 1976 prices, was saved despite considerable opposition from some delegations) was implemented with the approval of the SLPB in January 1977. ERNO tightened up coordination with its co-contractors. Moreover Bignier persuaded NASA to bear the full costs of the tunnel linking Spacelab with the Orbiter in which the astronauts would live during the mission. In return he was soon asked to accept a further slippage in the schedule of the first Spacelab flight, a slippage which the Europeans welcomed from a technical point of view, but which added further to their financial woes.

In July 1978 it was becoming clear that it was going to be difficult to keep the Spacelab programme within the 120% limit foreseen in the optional programme, the limit beyond which any of the (European) Participating States had the right to withdraw automatically if they so chose. Gibson complained officially to NASA about the costs passed on to ESA due to the many interface changes and the delivery of more hardware than initially foreseen. Meeting with the NASA Administrator in October he suggested that ESA's financial liability be limited to a ceiling and terminate at the end of 1981. NASA stuck to the position that ESA should fund all Spacelab changes up to the delivery of the second flight unit, then scheduled for October 1982. NASA had its way, but to reduce the cost overrun to the minimum in a consensual rather than conflictual atmosphere, in March 1979 the two Agencies set up a joint ESA/NASA 'Risk Assessment Working Group' to establish mutually the responsibilities of each partner.

This March meeting dealt with another simmering source of European resentment and anxiety. ESA became aware that there were moves afoot in the USA to built a number of components not totally unlike Spacelab which could be installed in the Shuttle cargo bay. The cases discussed included Rack Integration Aids, a Pallet of Opportunity, Department of Defense Pallet and Pointing Systems and a DoD "Sortie Support System". In ESA's view the last 'substantially duplicated' Spacelab in its pallet-only configuration, in violation of the Agreement between the Agencies. A joint working group was set up to define more precisely what substantial duplication of hardware or software meant ("had similar capabilities to the proposed system"; "were of similar design or had similar interfaces to the proposed system"; "could, with minor modifications, if necessary, substitute for the proposed system or its components"). Procedures for avoiding duplication were instituted. In the particular case of the DoD's Sortie Support System, it was agreed that European firms be allowed to tender and that the Department of Defense approach them directly for bids.

The Spacelab Programme Board meeting in March 1980 finally accepted to increase the budget for building Spacelab to 140% of its original cost (i.e. about 430 MAU in 1973 prices). No Participating State exercised its right to withdraw, though the scale of the contributions had to be reassessed. In particular, Italy's contribution dropped sharply in recognition of the fact that her share of the work in excess of the 120% was negligible, while Germany's was sharply increased.

The agreement to fund to 140% was surely helped by the NASA's accepting to buy a second Spacelab flight unit in January 1980. This was not a foregone conclusion. The ESRO/NASA MOU of 1973 left scope for interpretation on this issue, and NASA Administrator Fletcher initially insisted that NASA would not consider substantial follow-on activity for Spacelab until the usefulness of the first unit had been demonstrated. This was unacceptable for European industry, of course, who needed to know long before that whether or not to produce a second craft. Europe's bargaining position was weakened by its inability to fix a price for Spacelab due to the uncertain financial and technical considerations we have just mentioned. It was agreed to go ahead anyway with Follow-on Production in 1976. When a deal was finally reached with NASA in 1980, it was up to ESA to take out a loan (refunded in full by NASA) to cover a shortfall in the American agency's budget over the three years before it would take delivery of the second unit. NASA paid ESA about 130 MAU (1979 prices) for Spacelab-2, plus financial charges for the loan (about $128 million overall), most of the money being for the industrial element.

In February 1982 first Flight Unit Configuration comprising a long module and one pallet was accepted at Kennedy Space Center. Spacelab-1 was launched on board the Shuttle 'Columbia' from the same base on 28 November 1983. Six astronauts were on board, one of them being Ulf Merbold from Germany. The laboratory carried out 72 experiments in a variety of scientific disciplines

The number of Spacelab flights was far fewer than originally planned. Indeed NASA's original mission model put forward in June 1972 suggested that there might be as many as 25 missions per year once the Shuttle was operational. In the event far less use was made of the facility. The number of annual flights of the Shuttle was revised drastically downward once it became operational: in fact it never flew more than nine times a year. The cost per flight escalated. For 1986 to 1988 it was set at $71 million per flight (in 1982 dollars), compared to the $18 million (in 1975 dollars) for the previous three year period, a real increase of 85%. As launch costs were a large part of the cost of using Spacelab, this severely limited its interest to scientists, many of whom were sceptical from the start about its value, as we shall see immediately. Spacelab-1, on which ESA and NASA programmed the flight in common, was followed by two more flights under NASA auspices, and two flights paid for by the German BMFT (D-1 and D-2), hosting experiments from the USA and Europe. Other missions followed, and by 1998 about two dozen major Spacelab flights had been chalked up.

Judgements of the Spacelab project have been very severe – a German official once called it the most expensive gift from Europe to the United States since the Statue of Liberty. Doug Lord, NASA's Programme Director, wrote that it was as if the US had hired a European development contractor to build the laboratory, only that the contractor used its own money (though it has to be said that Lord also entitled his personal recollections "Spacelab. An International Success Story"). Indeed the terms of the ESA/NASA Agreement and the subsequent evolution of the project clearly reflected the very uneven balance of power between the partners with the odds stacked heavily in favour of the USA. On the other hand, Europe achieved some of what it wanted: a cheap way into manned space flight, a quantum leap in project management experience, and the laying of the foundations, political, industrial, and personal, for a new kind of international collaborative venture with NASA and the US administration.

The Spacelab Follow-on Development Programme was indicative of this new situation. After considerable, and understandable hesitation, in October 1981 the ESA Council agreed to set up an optional programme for (i) Spacelab improvements, to make it more attractive to users and better adapted to Shuttle developments, and (ii) for the definition, development and experiments on a retrievable orbital system, or Eureca (EUropean REtrievable CArrier).

Eureca was conceived as a reusable free-flying platform weighing about 4000 kg at launch, including a 1000 kg payload, and which could fit into the Shuttle's cargo bay. After being placed in low orbit, it would be moved to an altitude of about 500 km with its on-board propulsion unit. Once there, its payload would be switched on and its experimental programme, notably in microgravity research, would proceed by remote control. Its mission completed, Eureca would return to low orbit, where it would be recovered by the Shuttle and brought back to Earth for multiple reuse. Apart from being seen as a valuable large, autonomous, European retrievable platform for both commercial and scientific experiments, Eureca was intended to contribute to future Space Station scenarios, e.g. it could be used to test essential technologies and serve as an unmanned platform element attached to the Station. With 80% of its funding (118 MAU in mid-1980 prices) guaranteed, in April 1982 work began on the definition phase of the system.

As we pointed out in section 2.1, the determination of the traditional space science disciplines to maintain existing fields of scientific research at the core of ESA's mandatory science programme posed serious obstacles to the exploitation of Spacelab, notably in new fields like life sciences and materials sciences. This resistance, it should be said at once, was informed by the strict ceiling imposed on the science budget by the first package deal in 1971, a ceiling which became simply intolerable in the early 1980s, and the problem was exacerbated by the uncertainty regarding the costs of Shuttle flights.

The proponents of Spacelab stressed the large weight and volume the laboratory and the pallets could accommodate, the re-usability of payloads, the possibility of human intervention in the experiment, the short time between successive runs of the same experiment, and the (presumed) low cost/kg compared to traditional satellite-borne experiments. The scientists consulted in 1973 in Europe and the USA were not impressed. Firstly, they were concerned about the short duration of flights (Spacelab was rather like a super-balloon or super-sounding rocket, said one), which entailed that multiple flights were necessary, and which immediately raised the question of cost. Then the human presence was actually a disadvantage, since the gases in the laboratory would contaminate the environment and the crew would cause attitude instability. This led the scientists in the traditional fields to stress that Spacelab missions should not supersede traditional automatic spacecraft and express a distinct preference for pallet-only missions.

A call for proposals for scientific use of the first Spacelab mission was made in Europe and the US in 1974. European scientists contributed 241 experiment proposals, over one hundred of them from Germany. About half the proposed experiments came from non-traditional fields, i.e. the Earth sciences, materials sciences and life sciences. Less than a quarter of the proposals were in the classical space science disciplines. To these were added proposals received by NASA and, in June 1975, a model payload was defined, the First Spacelab Payload (FSLP). The two major elements in the European complement of the FSLP were the LIDAR, the laser instrument designed for the then envisaged AMPS programme (see section 2.1), and a Sled facility for vestibular studies. Other elements included a metric camera and a microwave sensor for Earth observation and variety of instruments for materials sciences studies. The total cost was estimated at about 16 MAU, a quarter of which was for the LIDAR.

In order to find a way to fund this programme, the Executive divided the FSLP into two components, one containing instruments of general interest, the other hardware which was specific to the group proposing it. The LIDAR and the Sled fell within the first component, and it was suggested that they should be paid from the mandatory science budget. The other instruments of general interest, i.e. the remote sensing facilities for Earth observation and some material science equipment, should be dealt with as an optional programme or developed nationally. The group-specific hardware, by contrast, should be paid for from national budgets, as was the case with scientific payloads on ESRO/ESA (non-observatory type) satellites. Management and integration costs would be distributed *pro-rata*. This meant that the mandatory science budget would need to pay 7.4 MAU of the costs of the FSLP.

This proposal gained little support. France wanted that most of the FSLP to be mandatory. Germany, on the contrary, argued that only the astronomy experiments should be supported by the scientific budget. The LPAC, for their part, resented the threat to their budget and would go no further than affirm the scientific interest of the LIDAR and the Sled (if paid from outside ESRO's Scientific Programme).

In February 1976 a new attack was made on the problem, in anticipation of a final decision by an ESA/NASA working group scheduled for the middle of the year. The former distinction between ESA funded general instruments and nationally funded specific instruments was maintained. It was then suggested that the LIDAR and the Sled should be charged to the Scientific Programme, the remote sensing instrumentation to the mandatory general budget and the material science equipment to the Spacelab development programme. Management and integration was to be dealt with by a small Spacelab Payload Integration & Coordination in Europe (SPICE) group set up at the German Aerospace Research Establishment in Porz-Wahn. It was not clear how it was to be funded, however.

When ESA's SSWG and SAC (see section 2.1) discussed these proposals later in the year they decided against the inclusion of the LIDAR in the FSLP, essentially because a single flight of this facility would not provide significant results and no guarantee existed about its funding in subsequent Spacelab missions. The Sled, which was far cheaper (its estimated development cost was 1.8 MAU as against 8.4 MAU for the LIDAR), was accepted though not with enthusiasm.

In January 1977 the ESA Council approved the European component of the FSLP. Besides the Sled, the most important component was a 500 kg double rack for materials science instrumentation provided by Germany, who also provided the metric camera and the microwave sensor for Earth observation. Twenty nationally funded experiments in various fields were also included. They included a grille spectrometer for atmospheric research provided by a Franco-Belgian collaboration, and a very-wide-field camera for astronomy observations provided by a French group. NASA, for its part, provided a similar complement of experiments.

Encouraged, in April 1977 the Executive presented Council with its long-term proposals for building a Spacelab user community, the Spacelab Utilisation Programme (SLUP). It foresaw ESA playing the double role of providing services to users in the Member States, and designing and implementing a number of dedicated European missions to be funded as optional ESA programmes. Three funding regimes were suggested. In the first, lasting from 1977-1981, ESA would pay for the FSLP mission and for SPICE, and would set up the technical capability required for implementing a complete payload in Europe. This would be followed by a consolidation phase (1982-1985) and then a permanent regime phase (after 1985) during which funding for all activities, but SPICE would be progressively taken over by the users. Three mission models were presented, foreseeing European participation in as many as 13 to 23 Spacelab missions between 1980 and 1985. The Executive suggested that Council endorse a model which would cost ESA 255 MAU for 1977-1985.

The ESA Council went some way to meet this plan in October 1977. It agreed in principle that ESA undertake an optional SLUP to promote and facilitate the use of Spacelab in Europe. This was to include the FSLP and two 'demonstration' missions to be launched in the period 1981-1983. All Member States expressed an interest in participating, but funds were only made available for the FSLP (12 MAU in 1976 prices) with Germany paying about 56%. The details of the demonstration missions were to be settled later.

It was not long before this scheme was put in jeopardy. The Executive began planning the two demonstration missions immediately, only to find that only Germany and, to some extent France, were willing to commit funds to them at this stage. Then at the end of 1977 Germany announced that she was planning two national missions of her own whose objectives were similar to those foreseen by the Executive (microgravity research and Earth-oriented disciplines). A compromise was hammered out, but it did not carry much weight. In July 1978, not only did Member States have to face up to the fact that Spacelab was going to cost more than 20% above its initial estimate in real terms (see above), the cost of the FSLP was also escalating. Indeed towards the end of the year ERNO, which was developing the Sled, announced that its cost-to-completion would be much higher than originally estimated. An additional 2.7 MAU was required in order to implement the facility after a significant relaxation of the initial specifications.

Meeting in January 1979, the SPC suggested that the Sled should be cancelled and asked the ESA Executive to look into ways of using the available money in the Sled budget for other biomedical experiments. The scientific community on both sides of the Atlantic objected strongly, so that in March the SPC reversed its decision, and agreed to add the necessary funds to the Sled budget after all. The Sled's reprieve was short-lived. Nine months later, in January 1980, the NASA Administrator asked ESA to reduce the European portion of the FSLP by 220 kg, along with a parallel effort by NASA. Descoping the FSLP, the Executive suggested transferring the very-wide-field camera and grille spectrometer to a later Spacelab mission. The Spacelab Programme Board refused in the face of strong opposition from the French delegation. The Sled was removed instead, meaning that no ESA experimental facility was included on the Spacelab maiden flight.

By now it was evident that it would be impossible to fund dedicated ESA missions on Spacelab until the late 1980s. The SLUP and the idea of having demonstration missions were abandoned. Instead in 1982 the ESA Council agreed to undertake an optional microgravity programme intended to enable national experimenters take full advantage of flight opportunities on future NASA and German missions. The Sled and a general facility for biological research (Biorack) were eventually flown on the German mission D-1 in Autumn 1985. After the Challenger accident in January 1986, other ESA multi-user facilities were flown on some Spacelab missions in the 1990s.

2.7 Laying the foundations for the future. The long-term programme and the Ministerial Conferences in the 1980s

As early as 1980 the ESA DG, Erik Quistgaard at the time, and the Executive began to plan for the next decade. The four principles underlying their proposals were: (a) ESA was basically an R and D organisation, and it should not undertake programmes ready for commercial exploitation unless specifically asked, (b) users would need to be involved in projects from the definition stage to the final outcome, (c) ESA and national projects had to be complementary and not in resource-wasteful competition and (d) the Agency had an important role to play in developing European industry and in increasing its competitiveness, notably with the USA and Japan. These functions had to be satisfied with relatively limited resources: the total American space effort in the 1980s (NASA, military and private) was estimated to be 8 billion AU, while Europe's total national plus ESA space investment was about 1 billion AU. The aim was thus to be on a par with the other space powers in a few, well-defined areas and to be a "qualified partner" for major international ventures.[159]

A first round of discussions with delegations led the DG to propose an annual budget of some 450 MAU per annum (1979 prices) for the decade to come. Within this ceiling a baseline programme was defined, and a supplementary programme suggested. The latter could only be implemented if more money was available. The programme distributed resources as follows between ESA's main areas of activity:

Space science	29%
Microgravity	2.5%
Earth observation	20%
Telecommunications	17%
Space transportation systems	19.5%
Technology	12%

A striking feature of this proposal is the relatively high level of funding for the mandatory science programme in the traditional fields. Indeed the figure suggested was in line with the SAC's proposal that science should share the budget equally with applications and space transportation systems (see above). The programme was intended to serve a community of some 2000 scientists and technicians between 1980 and 1990 with three or four major projects and six or seven smaller ones. Costs would rise steadily over the decade to reach 130 MAU in the 1990s.

The Earth observation programme, for its part, was a response to the growing interest in monitoring the environment. It comprised two basic programmes: climate, ocean and ice monitoring to be achieved with the ERS-1 satellites to be launched in 1986 and 1989, and an advanced land surveillance satellite using instruments in the visible infrared and microwave regions and dedicated to agriculture, forestry and water resource management. It was planned to be complementary to the French-led SPOT programme, which entered its detailed definition phase in 1978.

In the area of space transportation systems, to which relatively little funding was accorded, the main emphasis was on upgrading the Ariane family to the level of Ariane-4 with a performance of 3500 to 4000 kg in GTO, and to building a second launch pad in Kourou. Launcher configurations beyond Ariane-4, the so-called FEL (Future European Launcher) were being studied. Possibilities being considered included manned vs. unmanned systems, expendable vs. recoverable (fully or partly) launchers; and political implications (total European dependence vs. US/European cooperation). It was

159 ESA/C(80)80, 5 November 1980 and ESA/C(81)8, 24 November 1981.

evident that a large cryogenic engine, which was already under development by CNES, would be needed whichever route was taken.[160]

The technology programme was intended to strengthen European firms in the most advanced areas of space technology. It had three components. A basic technology research programme, aimed at advancing the state of the art in main common domains of space technology for foreseen mission requirements, reaching the point of feasibility demonstration. The support technology programme advanced technology from the 'working system' to the point of demonstrated 'flight worthiness', and was intended to reduce risks during the qualification phase of a spacecraft. Finally there were technology verification missions, intended to demonstrate the 'operational viability' of mission critical technologies in flight before they were incorporated into an operational spacecraft.[161]

In suggesting the future orientation of ESA's activities, the DG noted that it was in the area of space transportation systems that the future was most unpredictable for Europe. To facilitate later decisions the Executive proposed that a preparatory programme be undertaken. Its aim was to "collect the necessary data so that the ESA Member States can decide around 1985 on the form which the European effort should assume with regard to space transportation systems after Ariane, Spacelab and the improved versions or immediate derivatives". Three themes were foreseen: possible future launcher concepts (40% of the funds), various options for establishing a European orbital infrastructure (35%), and analysis of NASA's future manned system programmes, evaluating possibilities of European participation (25%). The Executive sought 12.1 MAU (mid-1982 price levels) over four years for this programme. The Council adopted their suggestion in June 1982 and in April 1983 the first meeting of the States participating in the Long-Term Space Transportation Systems Preparatory Programme was held.[162]

In parallel with these developments NASA was preparing its follow-on to the Shuttle, which lifted off for its first two-day test flight on 12 April 1981. It announced that a permanent presence of man in space would be the objective of the next major US space programme. NASA also made it clear that this manned space programme would be open to international participation (though this could be jeopardised by Department of Defense interest). Meeting in January 1982 with various European, Canadian and Japanese representatives at the Johnson Space Center, the American Agency made "direct offers of association with the definition phase" suggesting that European industry team up with US industry for this purpose. The studies were to take place between June and December 1982, European industry would be involved with European funding, while ESA would be associated with the selection of contractors, the conduct of the studies, and the evaluation of the final results. NASA hoped that President Reagan would publicly engage the country in the programme in February 1983.[163] In the event he did so in his State of the Union Address of 25 January 1984. There the President, deliberately echoing Kennedy's commitment over twenty years before, announced that he was directing NASA "to develop a permanently manned space station and to do it within a decade". Rivalry with the Soviet Union was as evident in 1984 as it was in 1961. The project was a "demonstration of free world leadership", and the US was doing it because "We are first: we are best: we are so because we are free".[164] Indeed the Space Station was eventually named *Freedom.*

Europeans were not wrong-footed by these developments. In 1982 the governments of Germany and Italy, desiring to capitalise on the experience that their industry had gained in the Spacelab and Eureka programmes, and wanting to consolidate their political alliance with the United States, set out to secure a lead in Europe's participation in the Space Station. Bilateral contacts were strengthened between MBB/ERNO and Aeritalia, the two leading firms in the construction of Spacelab, with a view to setting up a joint project. In May 1983 German Minister Heinz Riesenhuber visited NASA

[160] For more information see this volume, chapter 12.2.
[161] We repeat that this material is from ESA/C(81)8, 24 November 1981.
[162] The quotations are from Annex III of ESA/C(81)84, 25 November 1981. See also ESA/C(82)58, 18 May 1982 and chapter 12.2, this volume.
[163] For this paragraph see ESA/C(82)47, 13 April 1982 and chapter 15 this volume.
[164] These quotations are from L. Sebesta's introduction to chapter 15, this volume.

Administrator James Beggs and suggested that he would like to coordinate European participation in the preparatory phase of the Space Station even before a final commitment was made. By the end of 1983 the nature of Europe's engagement had evolved into Columbus, a generic term for two elements, a pressurised module derived from Spacelab, which could also fit in the Shuttle's cargo bay, and which could dock with the station for long-duration missions, and a free-flying service module. On 19 January 1984, just a few days before President Reagan's State of the Union message, Germany and Italy announced that they would be offering the Columbus programme to their partners in ESA for Europeanisation.[165]

By April 1984 the kind of cooperation that NASA looked for from its partners in the Space Station was become clearer. Basically its idea was that, within its accorded budget envelope of $8 billion it would aim to complete a 'core station' within ten years. All studies of the various elements would be entrusted to US industry, whatever decisions were made by international partners to participate. This was to avoid the US becoming dependent on European industry for a component of the core station. The role of such partners would be restricted to building additional modules and peripheral elements. They would also be responsible for the use and operation of such modules, while also contributing to the operating costs of the station as a whole. As the Executive put it, then, Europe's aim of "participating in the design, development, management and technical operation of an international space station" was not reflected in the approach being followed by NASA. Europe had to choose then whether she participated in the whole programme, by developing a substantial element like Columbus, or just restricted her ambitions to using the US's system, perhaps making a peripheral contribution later. NASA expected a political decision of principle on international participation to be taken at the summit meeting of the heads of industrialised countries in London from 7 - 9 June.[166]

The ESA Council met soon after this summit, on 27 and 28 June 1984.[167] It was the last meeting with Hubert Curien (F) in the chair; responsibility was handed over to Harry Atkinson (UK) as from 1 July. It had before it the outline of a long-term European space plan which would be presented for endorsement to Ministers meeting in Rome six months later.[168] It appeared now that, after the discussions at the summit and with NASA that month, "NASA would accept a measure of European involvement in the Phase-B work [of the Space Station] without formal commitment to Phase-C/D", to quote the UK delegation. If Europe decided to participate, he went on, assurances had been given "regarding preferential European access to all facilities". There were still problems of course: some NASA centres were resisting internationalisation, and the US did not want to depend on Europe for technology, for example. In any event, in the view of the UK, "a decision by Europe not to take part, or to embark forthwith on a competing, autonomous programme would be extremely serious from a political aspect, quite apart from the severe economic implications".

Two crucial and linked enabling resolutions were adopted by the delegates at this meeting. Resolution 4, approved on 28 June, concerned the "execution of a space station related preparatory programme Columbus". It stated that "as a long-term objective Europe has to consider the possibility of an autonomous capacity for a permanent presence in manned space flight activities", and suggested that the German-Italian Columbus programme should serve this purpose, being undertaken within the ESA framework. Aware of the ambiguities surrounding the US position, the Resolution was careful to specify that the programme would be "defined with a view to ensure progressively the European autonomy in the field of the manned-space station mutually compatible with the future launching systems".[169]

The reference to future launching systems was not coincidental, of course. At the same meeting the delegates, "convinced of the need to pursue efforts to maintain in Europe an independent and

165 See chapter 15.5.
166 ESA/C(84)31, 24 April 1984.
167 Minutes are ES/C/MIN/64, 18 July 1984, meeting held on 27-28 June 1984.
168 ESA/C(84)46, 12 June 1984. Needless to say the Columbus and HM60 programmes (to be discussed shortly) completely transformed the funding profiles compared to those advanced in the early 1980s.
169 ESA/C/LXIV/Res. 4 (Final), 28 June, 1984.

competitive launch capability", and "finding that any future launcher concept requires a high-thrust large cryogenic engine", approved the execution within ESA's framework of the preparatory programme for the HM60 (or Vulcain) engine under development by CNES which France had offered for Europeanisation.[170]

The June 1984 Council meeting was the last of Erik Quistgaard's term of office as Director General; it was now up to his successor, Reimar Lüst, and his Executive to consolidate the European Long-Term Space Programme in consultation with the Member States' delegations.[171] After six months of intensive work they had drawn up a programme whose "basic features", in Lüst's words, "had won a broad consensus from all the Member States, who had agreed in particular on the prime importance of continuing with the scientific, applications and space transportation programmes on a level that would make it reasonable to undertake a manned spaceflight programme". His proposals were first discussed at a Ministerial conference in Rome on 30 and 31 January 1985.[172] A number of general considerations weighed on Ministers' minds.

Firstly, a decade after the second package deal of July 1973, ESA's major programmes had reached maturity and the ongoing health of the European space effort, and of the Agency, required that it be given a "financial boost", as the Italian Minister of Science and Technology Mr. Luigi Granelli said in opening the Rome Conference. The cost of the ongoing programmes, he pointed out, which was 853 MAU in 1985 would drop away to 303 MAU in 1990. If all the effort expended between 1973 and 1983 (totalling 7840 MAU) was not to be "frittered away" – what Granelli called an "unforgivable error" –, Europe would have to put in place a new ten-year Long-Term Space Programme. It needed a new package of programmes to guide it into the new millennium otherwise, as the Italian delegation put it, "everything we have achieved to date could be in vain and wasted, mere items in museum collections on the world history of Space."[173]

Secondly, there was the major American initiative to occupy space, with vast resources promised by the Reagan administration for the development of new technologies in the civil, commercial and military sectors. The space station was just a part of this drive. It was coupled with support for the MILSTAR and ACTS telecommunications programmes (where the Japanese were also becoming extremely active), and the Strategic Defense Initiative (SDI). Soon after a famous speech in which he characterised the Soviet Union as the "evil empire", in March 1983 Reagan announced that he was "directing a comprehensive and intensive effort to define long-term research and development programmes to begin to achieve our ultimate goal of eliminating the threat posed by strategic nuclear weapons" using a 'speed-of-light' defensive shield in space. This massive Federal investment in R and D led both Granelli and (regular) Council Chairman Atkinson to stress that Europe risked lagging behind in new technologies if did not make a major effort. As Atkinson put it:

> *The 1990s will see radically new ways of doing things in space. The implications of being able to transport man so that he can work in space, of space stations, and of robots which can repair space hardware and change payloads, are still not fully recognised or studied. In the 1990s and beyond, whether we like it or not, the whole system of space technology will be very different from the 'traditional' ways of the last 20 years. If we do not keep up with the new technology, I believe that Europe's position in space must inevitably decline, with increasing rapidity.*[174]

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170 ESA/C/LXIV/Res. 3 (Final), 28 June , 1984. See also chapter 12.2 this volume for more on HM60.

171 They had at their disposal a major "Outline of a Long Term European Space Plan" drawn up just before, ESA/C(84)46, 12 June 1984.

172 The final version of the Minutes (from which the quote from Lüst is taken), is ESA/C-M(85)MIN/1, rev. 1, dated 25 September 1985.

173 ESA/C-M(85)MIN/1, rev 1, Annex II. Opening speech at the Rome Ministerial Conference. The last quote is from Annex XIII, the Italian delegation's intervention.

174 ESA/C-M(85)1, 25 January 1985.

ESA DG Reimar Lüst reinforced the point in his proposals for the plan. "New space capabilities - such as manned or unmanned intervention in orbit and return to Earth - will soon add a new dimension to future space exploration and utilisation, and Europe", Lüst went on, "cannot forgo acquiring new capabilities".[175]

Finally, there were the imbalances in industrial capability and strength that had evolved over three decades of the European space effort. Countries with major national space programmes had the resources, human and industrial, to choose the form of collaboration that best suited their interests, or indeed not to collaborate at all. The smaller, or less technologically developed Member States, had no option but to build their space capability primarily through ESA. This imbalance had the advantage that nations like France, Germany and Italy could take the lead in promoting extremely costly and complex programmes like Ariane and Columbus. At the same time, there was always the danger that they would feel hampered by the constraints imposed (notably the fair-return principle) by working in ESA. As Lüst put it, "The Governments of some countries faced pressure from lobbies which favoured the more lucrative elements in space industry being creamed off at a national or bi-national level: others wanted a smaller less technical role for ESA." Thus, the DG added, one of the most important functions of the Rome conference was "to decide, at the highest political level, not so much on another step forward, but on the more fundamental issues of cooperation in space."[176]

The Ministers passed two resolutions in Rome. The first concerned the long-term plan, and the second dealt with Europe's participation in the Space Station. The deliberations were guided by the Director General's proposals, a 26-page document setting out a "likely scenario" for the future of the Agency and including a draft resolution.[177]

The plan proposed by Lüst was intended to be ambitious, to meet the challenges ahead, comprehensive, to cover a wide range of activities, phased, "in order to allow possible reorientation" since some key information on the long-term prospects was still lacking, integrated, to link users to the development of infrastructure elements, and balanced between short and long-term objectives. It also had to keep open all options leading to European autonomy in space, while reinforcing transatlantic cooperation through a "more equal partnership" with the United States. It foresaw an overall expenditure of 16,500 MAU over the years 1985 to 1995. The profile showed a steady rise to reach 1700 MAU in 1991, at which figure it levelled off (see Figure 2-2). The level of the new engagements can be measured by remembering that the first plan put forward four years earlier had presumed an annual expenditure of 450 MAU. This plan called for an average expenditure of about 1500 MAU per year in 1984 prices.

The science programme proposed was articulated around the Horizon 2000 plan, with its four cornerstones covering the traditional ESA fields of astronomy and solar system science: a solar terrestrial programme, a mission to asteroids and comets, an X-ray mission, and far infrared and sub-millimetre wavelength spectroscopy mission. The DG wanted the mandatory science budget to increase by 7% annually to reach 200 MAU by 1991. Recognising that most delegates could not accept this, he was emphatic that a 5% increase was the minimum needed for the Horizon 2000 programme to be viable.

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175 ESA/C-M(85)2, 19 December 1984.

176 R. Lüst, "Europe's Future in Space," *ESA Bulletin,* No. 44, November 1985, 8-15, on p. 8.

177 The resolutions are ESA/C-M/LXVII/Res.1, (Final), and ESA/C-M/LVII/Res.2 (Final), both passed on 31 January 1985. The DG's proposals are ESA/C-M(85)2, 19 December 1984.

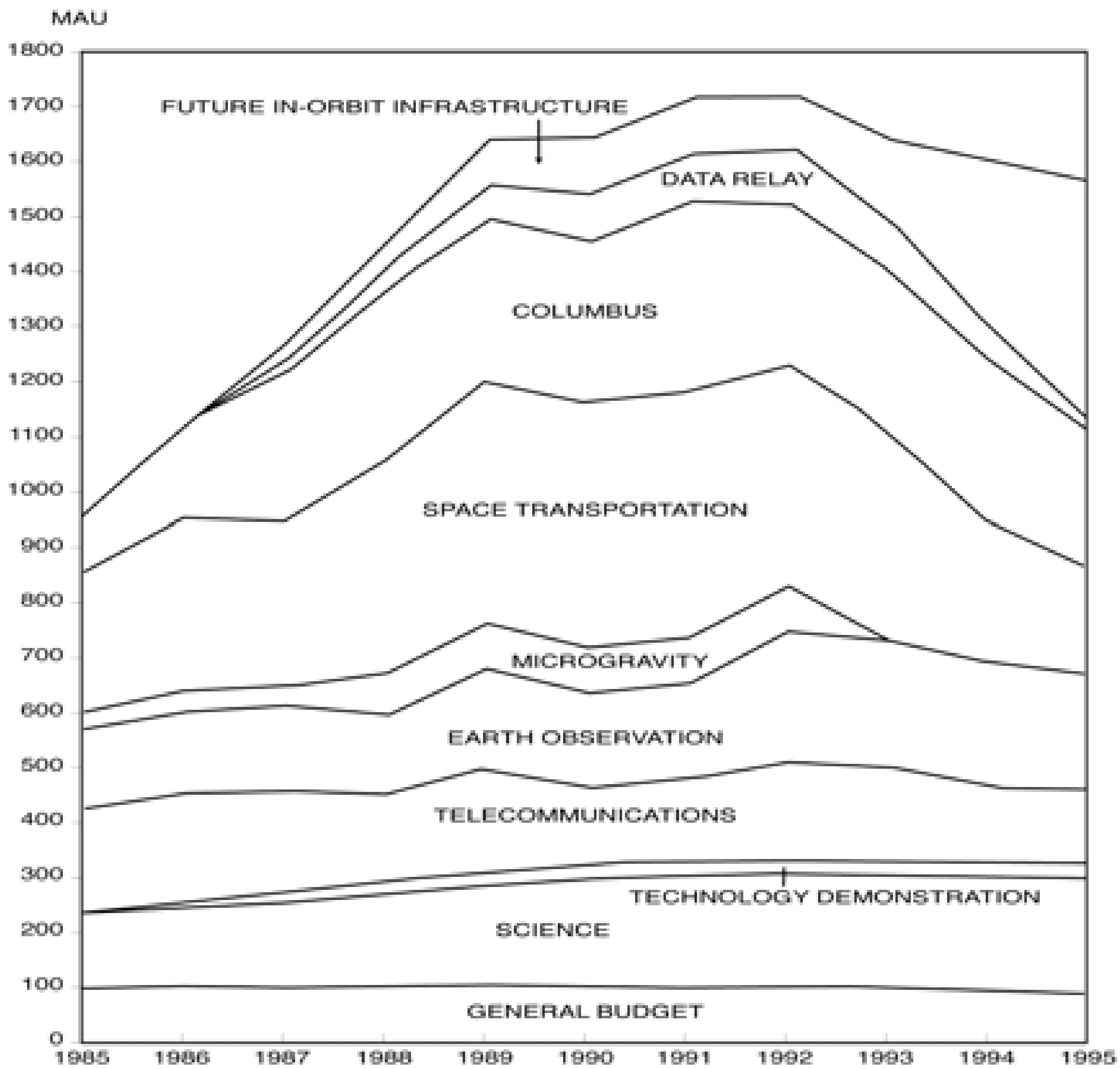

Figure 2-2: Director General Lüst's proposed breakdown of expenditure for ESA's long term space plan.
(Source: ESA/C-M(85)2, 19 December 1984, p. 14)

Table 2-1. Funding profile corresponding to various levels of annual increase for the mandatory science programme (in 1984 economic conditions). Source: ESA/C-M(85)2, 19 December 1984, p.12).

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
7%	136	140	156	167	178	191	200	200	200	200	200
5%	133	135	147	155	162	170	179	188	197	200	200
3%	131	130	139	143	147	152	156	161	166	171	176

When it came to discussing the science programme, the level of support suggested by delegations varied between 7% (Sweden and Switzerland), to 5% (Germany) to 3-4% (The Netherlands and Belgium). For Switzerland the importance of the science programme transcended the results it obtained. Its delegation led by Ambassador Muheim was concerned about what they saw as a lack of coherence in the overall programme, which just seemed to be a collage of separate items. For them "the science programme acts as a cement, holding together a group of activities that would otherwise be dangerously pulled apart by centrifugal forces"; it "forms a kind of kernel around which the fruit fleshes out, and through which the elements needed for growth can permeate."[178] Like Sweden, a 5% growth rate was the minimum that it would tolerate (this view defended also by Germany and Italy). The countries that argued for a lower level of support were not hostile to science as such, but did not like the way in which the traditional fields monopolised the mandatory programme. We have been "geared to the same disciplines and the same customers for 10, 15 even 20 years!" said the French delegate, insisting that 7% would be "difficult". Belgium thought that 3% was reasonable, though it suggested that it might revise its position if the science programme was open to other disciplines, while Spain specifically wanted the programme extended to cover microgravity, life sciences, resource management, etc. In the event, the resolution unanimously adopted by the Ministers agreed to progressively increase the funding for science by 5% to reach 162 MAU by 1989, and asked the DG "to study the possible extension of the scope of the mandatory scientific activities to other scientific disciplines, *without reducing the effort on the scientific disciplines presently covered* (our emphasis)." It also asked him to see if it would be possible to include financial support to experimenters (the cost of whose instruments were normally borne by their national authorities) in the mandatory science programme.[179]

We shall pass quickly over the general budget and the applications programmes, not because they were unimportant but because the broad programmatic features of Quistgaard's suggestions were retained here. The technology programme was funded from the general budget and had three components as before, basic, supporting and what was renamed in-orbit technology demonstration. Many of the smaller States insisted that this programme was an essential resource for their industries and the final resolution agreed that the general budget of ESA should rise to 90 MAU annually in 1989, this increase being assigned, as priority, to technology research programmes and investments.[180] The Ministers also confirmed their interest in the earlier Earth observation programme centred around the ERS-1 project already agreed, with funding to rise from 150 MAU in 1985 to an average of 190 MAU over the next decade (as requested by the DG). Space telecommunications were also endorsed, though here the level of expenditure was expected to fall from about 180 MAU in 1985 to 150 MAU over the period 1988 - 1995 so averaging out at 170 MAU over the decade (again the DG's figure).[181] This programme had an additional element, not yet ripe for decision. This was a Data Relay Satellite promoted by Italy, an in-orbit communications infrastructure intended to support all the user systems, from the Space Station to the remote sensing satellite. The decision on whether to embark on this was to be taken in 1986 along with the decision to start Phase-C/D of Columbus. Its cost of development and operation was estimated to be 560 MAU over the decade 1986-1995.

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178 ESA/C-M(85)MIN/1, rev 1, Annex XII.
179 ESA/C-M/LXVII/Res.1 (Final), adopted on 31 January 1985, chapter II.7.
180 ESA/C-M/LXVII/Res.1 (Final), adopted on 31 January 1985, chapter II.8.
181 ESA/C-M/LXVII/Res.1 (Final), adopted on 31 January 1985, chapter II.6 i) and ii).

There was little disagreement about the need to embark on the development of the large cryogenic engine needed for Ariane-5. A new rocket with improved cost-effectiveness in GEO and LEO, which had improved reliability, which had a larger shroud, and which could eventually be man-rated was imperative if Europe was to secure its independent capability in this sector. As Atkinson put it, "The US Shuttle can launch larger satellites than Ariane; and larger satellites will be needed to compete in communications, remote sensing and indeed in science. [...]."[182] What is more the Shuttle was man-rated whereas Ariane was not. The DG called for 2600 MAU over the decade beginning in 1986 for the development of Ariane-5 and HM60. He also asked that 300 MAU each be made available for continuous upgrading of Ariane-3 and 4 to the end of their useful lives, and for a programme of technology research and launcher system studies for the next generation. The Ministers endorsed the proposal to undertake the Ariane-5 programme costing 2600 MAU up to 1995 and supported the agreement to start the Large Cryogenic Engine Preparatory Programme.[183]

The detailed content of the Columbus programme depended on negotiations with NASA on the space station. The terms of partnership were the subject of a separate Resolution by the Ministers. Here it was stated that Europe accepted President Reagan's offer, but required an "appropriate" level of participation. In particular the Ministers sought European "responsibility for the design, development, exploitation and evolution of one or several identifiable elements of the space station together with responsibility for their management" and "access to, and use, on a non-discriminatory basis, of all elements of the space station system on terms that are as favourable as those granted to the most-favoured users and on a reciprocal basis". Other issues that they wanted to see dealt with in the NASA/ESA Memorandum of Understanding included the operating costs of the station, technology transfer, legal security and a "guarantee" of the "availability of the American transportation and communication facilities required for the programme, and the possibility of using European facilities as they become available for the programme."[184]

Europe's determination to seek what DG Lüst called "equitable partnership" with the US was a consequence both of the past experience with the Spacelab programme and a new self-confidence in European industry and government born of the success of ESA's major programmes.[185] It was clear to Ministers that the US had a different perception of the terms of collaboration. Certainly, with UK Minister Pattie, they were "anxious that we respond as positively and helpfully as we can to President Reagan's generous invitation to join the Space Station Programme".[186] But as French Minister Curien reminded them, the centre of decision-making on the station was still NASA. "I notice every time we refer to the US space station in draft Resolutions we discreetly call it the 'international space station'", remarked Curien. "I cannot help smiling at the label 'international' - I would be so much happier to meet this word in an American document. For the time being the station is a US civilian station that will probably be used by the military". What Europe must aim for is the point at which " the Americans themselves call it international", he concluded.[187]

These considerations weighed on the decision taken by Ministers regarding Columbus. Their Resolution, while endorsing this programme as a significant contribution to the space station, also noted that its content would "depend on the terms and conditions of the partnership agreement to be concluded with the United States". This restricted them to agreeing to undertake the Preparatory Programme, and to taking note that the entire programme was estimated to cost 2600 MAU up to 1995, which included a three-year period of operation and initial utilisation.[188]

182 ESA/C-M(85)1, 25 January 1985.
183 ESA/C-M/LXVII/Res.1 (Final), adopted on 31 January 1985, chapter II.3.
See also chapter 12.2, this volume.
184 ESA/C-M/LXVII/Res.2 (Final), adopted on 31 January 1985, Art. II.
185 The phrase is in R. Lüst, "Europe's Future in Space," *ESA Bulletin,* No. 44, November 1985, 8-15, p. 9.
186 ESA/C-M(85)MIN/1, rev 1, Annex VI.
187 ESA/C-M(85)MIN/1, rev 1, Annex XIV.
188 ESA/C-M/LXVII/Res.1 (Final), adopted on 31 January 1985, chapter II.2.

It is here that microgravity enters the picture. As we have seen this was quite specifically excluded from the mandatory science programme, much to the disappointment of some Member States. The DG suggested that it rather be seen as an integral part of the utilisation of Spacelab and Eureca and then, from 1992 onwards when the space station was expected to become available, as a user programme for the station and Columbus.[189] The Resolution adopted by the Ministers thus asked the DG to prepare a programme for microgravity research whose cost would escalate from 30 MAU in 1985 to 80 MAU over the period 1985-1992, after which the microgravity programme would be funded from the Columbus programme (as stated in the last phrase of the previous paragraph).[190]

The huge investments in Columbus, the lingering doubts about the US's willingness to treat her European partners "equitably", and demands by the French that the Ministers affirm their determination to achieve European independence, led the DG to suggest that full autonomy in the in-orbit infrastructure programme be an eventual objective. Meeting just a few weeks before the Ministerial Conference, the French Council delegation had insisted on this condition. CNES was studying a manned spaceplane Hermes to be carried aloft on Ariane-5 and the French delegation had just recently informed the ESA DG that they intended to offer this for Europeanisation. That granted, the delegate said, the French authorities could not accept that the Ministers meeting in January restrict their decisions on the in-orbit infrastructure to Columbus: the Hermes programme which was "above all a technological programme" had to be included in the package. Cooperation with the US would thus go "hand in hand with the expression of a European resolve to acquire the technologies needed to obtain autonomy in the long term." [191] Thus the general objective of the in-orbit infrastructure, as Lüst put it, became to prepare, as a long-term goal, "an autonomous capability for supporting Man in orbit, for transporting hardware and Man, for docking and robotics operations, for building, servicing and repairing space facilities and generally for exploiting the low Earth orbit."[192] The Ministers endorsed this idea, suggesting that 50 MAU per year might be envisaged for studies intended to render the Columbus complex autonomous: this would include studies on the manned space transportation capability, a polar orbiting platform for Earth observation studies, and an operational data relay system. They also took note of another possibility for a manned transport system, the UK's HOTOL spaceplane project, then under study. [193]

Industrial policy was a major source of concern in some of the smaller Member States, and rectifying what they felt to be the cumulative injustices in the system was a sine qua non of their participation in the extremely costly long-term plan. The Belgian delegation echoed the views of several of them. The problem was not only quantitative, was not just a question of return coefficients. It was also qualitative. The Executive tended to reserve "all the prime contractorships for systems or subsystems solely for the firms of the main contributors," which meant that some Belgian firms had a sub-critical workload and could not reach an advanced technological level. The problem was compounded by the tendency to assign tasks to main contractors without competition, while subcontractors had to compete for a share in the rest of the project, and were frequently forced to work on a fixed-price basis, while contractors at a higher level could benefit from more flexible contractual regulations.[194] The Belgian position was supported by Sweden and the Netherlands, both of which claimed that they had had to step outside the ESA framework to enable their industry to build capability. Thus the Dutch delegation remarked that through their IRAS scientific satellite, developed with the UK and NASA, they had been able to give their firms experience at system level "which for a small country like ours is difficult to achieve in the ESA framework."[195] Sweden too was using its national programme in this way. Their delegate remarked that in September 1985 Ariane would launch their first scientific satellite, Viking, with a twofold mission: to achieve an important 'scientific first' and "to be an industrial policy tool

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189 ESA/C-M(85)2, 19 December 1984, p. 4.

190 ESA/C-M/LXVII/Res.1 (Final), adopted on 31 January 1985, chapter II.6.iii).

191 ESA/C/MIN/66, meeting held on 12-13 December 1984, document dated 12 February 1985.

192 ESA/C-M(85)2, 19 December 1984, p. 9.

193 ESA/C-M/LXVII/Res.1 (Final), adopted on 31 January 1985, chapter II.5.

194 ESA/C-M(85)MIN/1, rev 1, Annex XVI.

195 ESA/C-M(85)MIN/1, rev 1, Annex VIII.

helping Swedish industry to expand its capabilities in the space technology area."[196] In short, as the Dutch delegation insisted, industrial policy was more than juste retour. It was also about "creating and strengthening a competitive European industrial base," and providing firms in small countries also "with a real and continuous access to high technology projects."

One entire chapter of the Ministerial Resolution was devoted to this issue.[197] It focussed on return coefficients, asking the DG to make proposals for remedying the imbalances. In particular the Ministers resolved that by the end of 1987 the cumulative return coefficients of all States had to be above 0.95, and that if they were not appropriate additional measures would have to be taken after 1988. The correction measures were to be aimed above all at increasing industrial participation in the mandatory programmes (which included the technology support programmes of course). The ideal of reaching return coefficients as near as possible to unity for all countries was confirmed.

Three major differences distinguished the decision-making contexts of the Ministerial meetings in Rome in January 1985 and in The Hague on 9 and 10 November, 1987.[198] Firstly, in the United States there was the 'Challenger' accident on 28 January 1986 in which seven astronauts representing a cross-section of the American population in terms of race, gender, geography, background and religion lost their lives. This not only caused a hiatus of two years in the Shuttle programme while NASA redesigned the solid rocket boosters which were blamed for the accident and revamped its management structure. It also fuelled critics of NASA and forced the Agency to continue to reconfigure the space station to reduce costs and to be increasingly prudent regarding technology transfer.[199] Much of the headway that had been made towards a more equitable partnership was now lost. Indeed as the Europeans saw it, the two sides' conceptions of collaboration were still as far apart as ever. For them this was always supposed to be a "joint undertaking of basically equal partners". By contrast the US, in their view, had now "asserted its predominant position in the venture which would leave the international partners including Europe mainly with the task of contributing hardware elements to a basically US space station without having a corresponding role in designing, developing, constructing and operating the station or the elements to be provided by them." [200] The negotiations had been further complicated by an increased Department of Defense interest in the station, which embarrassed the Europeans who were restricted by the ESA Convention to peaceful activities in space.

Secondly, and related to this, there was an increased emphasis placed inside Europe on the autonomous manned space programme, with a corresponding increase in costs. The complex of Hermes, Ariane-5 and Columbus, along with the Data Relay Satellite, now formed "the centre of gravity" of ESA's future programme, said DG Reimar Lüst.[201] The Phase-B work on all these programmes was now sufficiently advanced for the Executive to be able to present formal programme proposals and cost envelopes. And if before the plan foresaw a levelling off at some 1800 MAU annually in the 1990s, the new figure was about 50% higher, at some 2600 MAU. The total investment from 1985 to 1995 had previously been estimated at some 16,500 MAU; the Executive was now asking for some 31,000 MAU from 1988 to 2000 (in 1986 economic conditions). Table 2-2 and Figures 2-3 and 2-4 give the new cost figures and spending profiles proposed by the DG.

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196 ESA/C-M(85)MIN/1, rev 1, Annex IX.

197 ESA/C-M/LXVII/Res.1 (Final), adopted on 31 January 1985, chapter III.

198 For general discussions on The Hague meeting, and the Resolutions passed see, R. Lüst, "The Ministerial Conference and Beyond", *ESA Bulletin,* No 53, February 1988, 9 - 13, and K. Reuter, "The European Long-Term Space Plan," *ESA Bulletin,* No 54, May 1988, 14 - 29. For the Resolutions see *ESA Bulletin,* No 53, February 1988, 15-30.

199 See Roger D. Launius, *NASA: A History of the US Civil Space Program* (Malabar: Krieger, 1994), 115 - 124.

200 ESA/C-M(87)3, 5 November 1987.

201 ESA/C-M(87)2, 1 November 1987, p. 5.

Table 2-2: Profile of expenditure for all programmes presented in the DG's proposals to Ministers meeting in The Hague, November 1987 (Source: ESA/C-M(87)2, 1 November 1987, p. 13)

Programmes	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Total
General Budget	117.2	120.9	122.0	125.1	128.1	130.7	133.2	133.2	133.2	133.2	133.2	133.2	133.2	1676.4
Associated with General Budget	55.1	52.6	57.7	62.9	67.1	67.1	68.1	68.4	69.7	70.8	71.8	72.9	74.0	858.2
Science	176.8	185.3	196.7	206.4	216.7	227.9	232.0	232.0	232.0	232.0	232.0	232.0	232.0	2833.8
Other Technology Programmes	4.8	13.2	21.4	24.3	27.3	30.3	32.4	32.4	32.4	32.4	32.4	32.4	32.4	348.1
Earth Observation	197.5	229.5	224.2	234.9	239.7	237.2	236.9	230.7	252.3	255.9	251.4	261.1	267.4	3118.7
Microgravity	45.2	84.3	112.2	113.5	111.0	110.0	120.0	130.0	142.0	142.0	142.0	142.0	142.0	1536.2
Telecommunications	211.1	267.2	191.3	228.3	248.6	239.2	268.6	293.7	319.1	340.1	276.7	223.0	248.0	3354.9
Space Station & Platforms	229.4	277.8	306.8	407.3	472.0	490.0	513.0	550.0	600.0	678.0	681.0	890.0	877.0	6972.3
Space Transportation	540.0	666.6	775.0	887.0	994.4	1074.0	1010.0	952.0	810.0	707.0	772.0	599.0	575.0	10362.0
Grand total	**1577.0**	**1897.4**	**2007.3**	**2289.7**	**2504.9**	**2606.4**	**2614.2**	**2622.4**	**2590.7**	**2591.4**	**2592.5**	**2585.6**	**2581.0**	**31060.5**

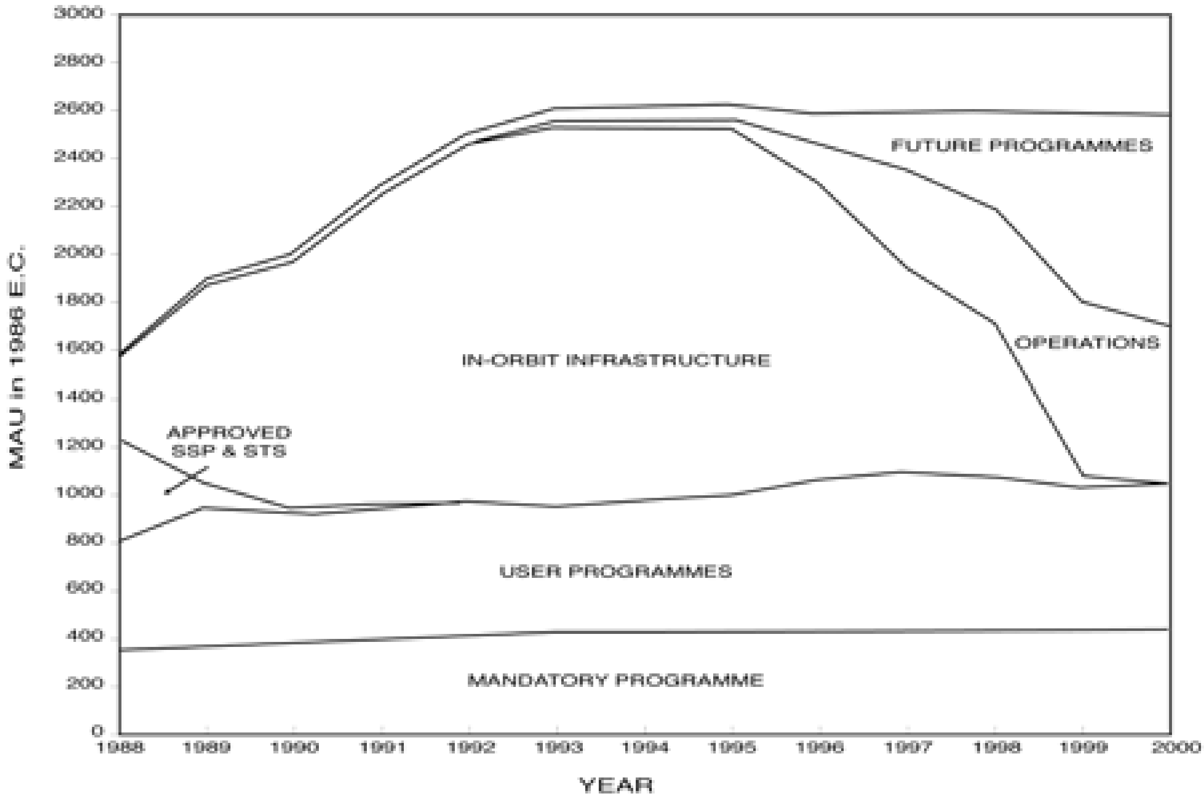

Figure 2-3. Profile of expenditure for the ESA Long-Term Plan as presented in the DG's proposals to Ministers meeting in The Hague, November 1987 (Source: ESA/C-M(87)2, 1 November 1987, p. 14).

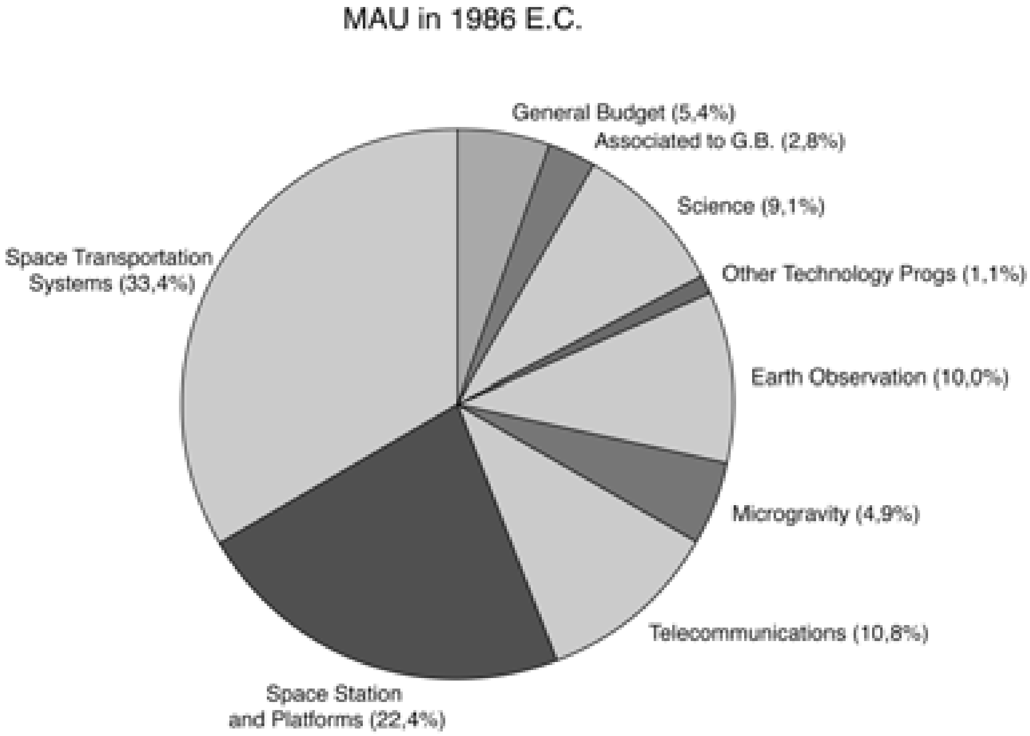

Figure 2-4: Pie-chart of percentage distribution of expenditure for the ESA Long-Term Plan as presented in the DG's proposals to Ministers meeting in The Hague, November 1987 (Source: ESA/C-M(87)2, 1 November 1987, p. 19).

Finally, there was a 180° change of direction in the position adopted by the UK representative. The British delegation to Rome was led by the Minister of State for Information, Technology and Industry, George Pattie. The day before the meeting started he had announced that the UK intended to set up a British National Space Centre whose aim was to coordinate the country's space policy more effectively. This positive move was reflected in Pattie's statement to the meeting, which began with him telling his fellow Ministers how "enthusiastically" the UK welcomed the DG's proposals for a long-term space plan. It was, Pattie went on, "very much in line with our own thinking, and brings together most skilfully the varying interests of the Member States." During the subsequent debate the delegation went out of its way to emphasise "the changed attitude of its government towards the European space programme, in which it had decided to take part with renewed ardour."[202]

This ardour was short-lived. The UK delegation to The Hague was led by the Minister for Trade and Industry, Kenneth Clarke. He was the first to make a statement – indeed he was asked to speak first for strategic reasons: he was so extremely hostile to the plan that he united all of his fellow Ministers against him, notwithstanding the fact that at least some of them shared his doubts. Clarke's basic objection was that the new plan was far more costly and ambitious than that presented at Rome and was "more about catching up with the US and the Russians (sic)" than with making effective use of Europe's limited resources. "What was seen as step by step approach has given way to a dash for

[202] ESA/C-M(85)MIN/1, rev. 1, Annex VI.

European manned capability", said the Minister, and it was inspired by "delusions of grandeur" rather than sound economic sense. The plan was incoherent, did not involve the private sector sufficiently and gave too much weight to human activities in space and crewed flights. With that the UK refused to vote in favour of the Resolution on the long-term plan adopted by her partners, adding for good measure that the abstention was "not to be interpreted as supporting a 'unanimous' decision."[203]

Clarke's colleagues agreed that the DG's plan was too costly, and that overall expenditure up to the year 2000 had to be reduced by 15 - 20%. They also accepted that the private sector had to be more closely involved, particularly in the Data Relay Satellite. But they parted ways on the role of public finance in the space sector and on the overall objectives of the European effort. "Responsibility for expanding the space infrastructure should fall to the public sector and demands public spending", said German Minister Heinz Riesenhuber.[204] French Minister Alain Madelin was even more emphatic, not to say eloquent:

> *The decisions to be taken are beyond the range of the market economy (...).What is needed from us is a political decision: we want to go forward in the conquest of space not just because we are hoping for various forms of spin-off that will benefit our economies generally but also because, deep down, we feel one and all that the best answer to Europe's so-called decline, the best way to demonstrate that Europe is taking on a new lease of life, is to play a leading role in the conquest of space, the symbol of the future, the symbol of human aspirations.*

"Let me reiterate my conviction," Madelin continued, "that by the year 2000, when Hermes and Columbus will be revolving around the Earth, we shall have made considerable progress in the construction of Europe", and through autonomy in space "break the Soviet/American duopoly of space and take up our place centre stage, in a leading role". Not surprisingly he also confirmed that, whatever doubts still remained over the future configurations of Hermes and Columbus, they along with Ariane-5 formed an "indissociable" package: "you do not build your house on the other side of a river without also building a bridge to reach it – unless, that is, you are willing to rely on a ferryman jealous of his prerogatives."[205]

The Ministers agreed with Madelin (the UK always excepted, of course). In the major Resolution adopted at the end of the Conference they accepted "in principle" to undertake the Ariane-5, Columbus, and Hermes development programmes, as well as a Data Relay Satellite (starting in 1989) as optional programmes of the Agency. The commitment to embark on the launcher, whose development was time-critical if it was to compete with the Shuttle in the mid-1990s, was immediate. The Ariane-5 programme costing an estimated 3496 MAU was approved and was to start on 1 January 1988. A phased approach was adopted for Columbus and Hermes (estimated to cost 3713 MAU and 4429.4 MAU, respectively). In both cases the Ministers approved a three year period of initial development (costing 669 MAU and 530 MAU, respectively) to begin on 1 January 1988. At the end of this period the programmes would be reviewed to see whether the cost envelope could be respected.

Columbus's future also rested on the results of negotiations with the United States during these three years. Hermes, for its part, had to be made safer in the light of the Challenger accident and a number of aerodynamic and thermal problems had to be solved.[206] Table 2-3 gives the intended percentage contributions to the programmes by Ministers as in their major Resolution on 10 November 1987.

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203 See ESA/C-M/MIN/87(Final), Minutes of the meeting on 9-10 November 1987, document dated 13 December 1988, and ESA/C-M/MIN/87(Final), Annex IV.

204 ESA/C-M/MIN/87(Final), Annex V.

205 ESA/C-M/MIN/87(Final), Annex XIV.

206 ESA/C-M/LXXX/Res. 1 (final), adopted on 10 November 1987, chapter IIIA.

Table 2-3. Financial undertakings made by delegations at The Hague Ministerial Conference on 10 November 1987 (Source: ESA/C-M/LXXX/Res. 1 (final), 10 November 1987).

Participating State	Ariane-5 (%)	Columbus (%)	Hermes (%)
Austria	0.4	-	0.5
Belgium	6.0	5.0	6.4
Denmark	0.5	1.0	0.5
France	45.0	13.8	45.0
Germany	22.0	38.0	30.0
Ireland	0.2	-	-
Italy	15.0	25.0	12.0-15.0
Netherlands	2.0-2.5	1.0-1.5	1.5-3.0
Norway	0.4	0.4	-
Spain	3.0	6.0	5.0
Sweden	2.0	-	-
Switzerland	2.0	-	1.5
United Kingdom	-	-	-

Columbus, as we mentioned earlier, was the generic name for a number of elements. It now composed the Attached Pressurised Module (ATM) which was to be designed as an integral part of the space station, and having facilities for carrying out microgravity experiments in materials sciences, fluid physics and life sciences. Then there was the Man-Tended Free Flyer (MTFF), consisting of both a pressurised module and a resource module, which was for similar purposes, and which could co-orbit with the space station being serviced regularly by Hermes. Finally there was the Polar Platform (PPF) for Earth observation disciplines, and for which the Ministers hoped that user or private-sector co-funding could be found.

The Ministers insisted that certain minimum conditions had to met for Europe to participate in the space station. They understood that NASA would have "overall programme co-ordination and direction regarding the manned base." However, they were emphatic that ESA retained "full control of the design, development, operation and utilisation" of the MTFF and the PPF. They also wanted a way to be found to reconcile the United States' interpretation of "peaceful purposes" with the stipulations of the ESA Convention[207]. Ministers also demanded that adequate and binding procedures be adopted for settling disputes between the partners and "that a legal regime safeguarding the interests of the Participating States and of European users be achieved." If satisfaction could not be obtained on these issues, they resolved that the content of the Columbus programme should be adapted as "quickly as possible" to the new situation.[208]

The Ministers also made a major further commitment to the science programme. Certainly some delegations still felt that the DG's programme was unrepresentative of the field as it had evolved, while the UK, which had always staunchly supported science, now declared that it would not accept increases in the science programme beyond the already agreed 1989 level. DG Lüst strongly defended the Horizon 2000 programme, however, and insisted that new disciplines could not be included inside the proposed budgetary profile. He won the day. The Ministers resolved that science could continue to

207 The Preamble to the ESA Convention committed the States parties to it to cooperate in space research and technology "for exclusively peaceful purposes".

208 ESA/C-M/LXXX/Res. 2 (final), adopted on 10 November 1987.

increase at 5% per annum for the next three year period after 1989, reaching the level of 216.7 MAU by 1992.[209] As for applications, the programmes adopted in Rome were given further support.

Finally, there was the question of industrial policy. In his report to the Council the DG pointed out that, although some Member States had been justifiably worried about their industrial returns, the situation was not quite as serious as it had seemed at Rome. Being more specific, he claimed that over 16 years the return coefficients of all countries had been brought close to 95% for a weighted amount of contracts of 5.5 billion AU. There were imbalances in geographical distribution, he admitted, but they amounted to no more than some 100 million AU, or 2% of the total expenditure.[210] Thus encouraged, the Ministers resolved that return coefficients of 0.90 should be guaranteed within each optional programme, and that the ideal value of unity should be achieved in the mandatory science programme. They also resolved that the cumulative return coefficients of all States should be above 0.95 by the end of 1990, and that, for the following three-year period, the lower limit beyond which special compensatory measures be taken as provided for by the ESA Convention, be a return coefficient of 0.96.[211]

It is not our intention here to explore the subsequent development of the long-term space plan; that is dealt with briefly in the epilogue to this volume. By way of conclusion we should just like to remark on the strong programmatic continuity between the package deal adopted at the end of the 1980s and that adopted in the early 1970s. European autonomy was again the keynote, with an emphasis on launchers, and participation in the manned space programme. The heritage of Ariane 1 and Spacelab lived on in Ariane-5 and Columbus, while Hermes became the independent means of access to the space station. Science, through the Horizon 2000 programme, was given a new lease of life, notwithstanding the unhappiness that many delegations felt about the poor support given to new space science disciplines. Applications, by contrast, lost some of their weight inside the collaborative programme compared to the early 1970s when they were the driving force for a reorientation of ESRO's activities.

These programmatic continuities should not be allowed to conceal some important changes, however. Two are particularly noticeable. Firstly, the self-confidence, born of bitter past experiences, with which Europe now negotiated its agreements with the United States. Gone was the inferiority complex of the 1970s, the feeling that one should be grateful for what one could get from one's all-powerful partner. Secondly, the strength of the space industry in some of the larger countries, a strength which enabled them to take on with assurance the huge, complex and costly programmes like those adopted at The Hague. Space policy was now more or less synonymous with industrial and technology policy, one of the avenues through which European governments made long-term investments in R and D. Many European firms owed their in-house capability to the opportunities created for them by ESA. Many of them now wanted to be free of the constraints which that very framework now imposed on them. It was a tension whose signs were evident at Rome and in The Hague and which was brought under control through an appeal to European unity and an even tighter imposition of the just-return rule. Such appeals were imperative if ESA was not to become a victim of its own success, torn apart by the centrifugal pull of national interests now better pursued, for some, through national programmes or multi-lateral ventures with partners of one's choice who had equal standing and complementary capabilities.

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209 ESA/C-M/LXXX/Res. 1 (final), adopted on 10 November 1987, chapter IIIC.2.

210 ESA/C-M(87)2, 1 November 1987.

211 ESA/C-M/LXXX/Res. 1 (final), adopted on 10 November 1987, chapter IV. Art. IV.6 of Annex V to the ESA Convention dealing with industrial policy states that "The distribution of contracts between formal reviews of the situation should be such that, at the time of each formal review, the cumulative overall return coefficient of each Member State does not substantially deviate from the ideal value. For the first three-year period, the lower limit for the cumulative return coefficient is fixed at 0.8. At the time of each formal review the Council may revise the value of this lower limit for the subsequent three-year period provided that it shall never be lower than 0.8."

Chapter 3:
The Scientific Programme between ESRO and ESA (1973-1977)

A. Russo

Scientific research is difficult. It is hard to do it alone; it is even harder to do it together.
H. van de Hulst [212]

3.1 Introduction

We analysed in Volume 1 the development of the scientific satellite programme of the European Space Research Organisation (ESRO) in the first decade of its life. Conceived in the early 1960s by a group of European physicists and astronomers, ESRO officially came into being in March 1964, when its Convention entered into force after ratification by the governments of its ten member states. The programme of the new Organisation was written in a document, known as the Blue Book, prepared in 1961 by a Scientific and Technical Working Group and approved in October that year by the European Preparatory Commission for Space Research (COPERS, from its French initials).

In the following ten years, this programme was implemented amidst many difficulties of a technical, financial and institutional character, which led to a drastic retrenchment of the founding fathers' early ambitions and expectations. By 1972 only seven small and medium-size satellites had been launched, roughly half the number planned, and no large satellite project had been realised. In spite of these difficulties and setbacks, however, ESRO could claim a very important role at the beginning of the new decade. Firstly, its satellites were working successfully and providing useful scientific data. For the European space science community, the most active, experienced and influential group of people involved in space activities in the Old Continent (at least in its western part), ESRO represented an irreplaceable instrument for carrying on important research programmes in the various scientific fields that the advent of space technologies had opened up to experimental investigation.

Secondly, in the new framework of space activities, characterised by the growing importance of application satellites, ESRO provided Western European countries with a convenient institutional framework capable of guaranteeing their governments and industry an adequate presence in the new economic and commercial dimension of space. The Organisation's managerial capability and technical expertise indeed represented a very firm basis for any joint European effort in such fields as satellite telecommunications, meteorology and Earth resources surveying. The importance of this aspect is particularly evident when considered in the light of the failure of ESRO's sister organisation ELDO (European Launcher Development Organisation) and the inefficiency of the European Conference for Satellite Telecommunications (CETS, from its French initials).

Finally, among the diverging economic interests and hard political conflicts which characterised the activity of the European Space Conference (ESC) in its effort to agree on a definite space policy at continental level, ESRO represented the only solid example of a possible cooperation. In December 1971, ESRO member states agreed on a "package deal" that defined the conditions for the Organisation to continue its activity beyond the 8-year period covered by its Convention, not only in the field of space research but also in the new fields of application satellites. This agreement paved the way for a second package deal, agreed on by the ESC in July 1973, which laid down the institutional framework for a coherent European effort in all sectors of space, including the development of a European launcher (Ariane), a programme for a manned space laboratory in the framework of the NASA space shuttle programme (Spacelab) and the coordination of national space programmes. This

212 Van de Hulst (1961), p. 233.

second package deal was the cornerstone for the eventual creation in 1975 of the European Space Agency (ESA), whose organisation was essentially based on ESRO's.

The ESA Convention was approved by a Ministerial Conference held in Brussels on 15 April 1975 and the new Agency came into *de facto* operation on 31 May. A few months later, on 9 August, the first ESA spacecraft was successfully launched and started providing a regular flow of important scientific data. This was the COS-B satellite, carrying a sophisticated instrument to study celestial gamma rays, whose mission had been approved by ESRO's decision-making bodies in 1969. At that time, only one of ESRO's spacecraft was still in operation, the satellite HEOS-1 devoted to magnetospheric and solar wind studies. It re-entered the atmosphere two months later, on 18 October, after having completed 542 highly eccentric orbits in nearly seven years of successful operation. While COS-B was starting its orbital life, the ESA technical staff as well as a large fraction of the European space science community were implementing four scientific satellite projects approved in the days of ESRO. These were: (i) the geostationary satellite GEOS, approved with COS-B in 1969 and scheduled for launch in 1976 (later postponed to 1977), whose aim was the study of magnetospheric phenomena from the favourable position of the geostationary orbit; (ii) the space telescope IUE (International Ultraviolet Explorer), originally a joint undertaking by NASA and the UK Science Research Council in which ESRO had agreed to participate in 1971, whose launch was also scheduled for 1977; (iii) the ISEE-B satellite, ESA's contribution to the three-satellite International Sun-Earth Explorer programme developed in collaboration with NASA; and (iv) the X-ray space observatory Exosat. Both ISEE-B and Exosat had been approved in 1973 and were originally scheduled for launch in 1977 and 1979, respectively. Owing to budgetary revisions during the course of 1975, however, the Exosat project had been delayed and launch was now scheduled for 1980.[213]

The transformation of ESRO into ESA found the Organisation's bodies involved in a new round of the decision-making process to select future scientific satellite projects. After the 1973 decision on ISEE-B and Exosat, a new decision was expected by 1976, when one or more projects would be approved for missions to be flown in the early 1980s. In preparation of this decision, the European space science community was called upon to submit ideas and proposals, and several mission definition and feasibility studies were performed by ESA, in consultation with the Agency's scientific advisory bodies. In the event, the decision was taken in two steps: in October 1976, the ESA Science Programme Committee (SPC) decided that ESA should participate in the NASA Space Telescope project; then, one year later, the SPC approved the Out-of-Ecliptic mission (later re-named the International Solar Polar Mission), a joint ESA/NASA project consisting of two spacecraft flying over the North and South poles of the Sun, respectively, with the help of the gravitational pull during a Jupiter swing-by.

In this chapter, we will discuss this decision-making process, which can be divided into three main phases. In the first, from June 1973 to April 1974, the European scientific community and their representatives in ESA's advisory committee structure were invited to agree on a set of space missions for which a definition study was recommended. The aim of this kind of study (mission definition or pre-Phase-A studies, in ESA language) was to design a preliminary outline of the mission, to identify the various concepts and approaches for realising it, and to assess the scientific importance of the results that could be achieved. At the end of this phase, thirteen missions were selected for such a definition study by ESRO's Scientific Programme Board (SPB).

The second phase covers the period from that decision up to March 1975, when a much more important decision was required, namely to select a restricted number of missions for which a feasibility (Phase-A) study was to be performed. The aims of such feasibility studies were to establish the technical and financial feasibility of each project, to propose a well-defined project concept, to identify the research and technology effort required to support it, and to state a preliminary cost estimate to completion. We shall see that, on the basis of the results of the definition studies, five

[213] In the event, Exosat could only be launched in May 1983.

missions were selected for feasibility study by the SPB, following the recommendations of the scientific advisory bodies. Such a decision was one of ESRO's last legacies to the incoming ESA.

The third phase covers the first two years of the new Agency's life, and concluded with the selection of the projects to be adopted in ESA's Scientific Programme. As we have anticipated, two projects were pointed out by the scientific community as the most interesting, the Space Telescope and the Out-of-Ecliptic mission. In October 1976, the SPC approved European participation in the former but reserved a decision on the latter because of uncertainties regarding the financial aspects of the programme. The decision was expected by May 1977, but it had to be postponed until November because of the crisis originated by the launch failure of the GEOS satellite in April that year.

The development of this decision-making process occurred in a transition period of which the transformation of ESRO into ESA was only one aspect. Three others should also be mentioned: (a) the new role of scientific research in the general framework of civilian space activities, which were more and more driven by economic rather than scientific interests; (b) the prospects opened up by the new space technologies under study in the post-Apollo era, i.e. re-usable transportation systems and manned space stations; (c) the new dimension of international cooperation in space, with the establishment of closer links both across the Atlantic and across the Iron Curtain. All these aspects will be dealt with, with more or less emphasis, in the following pages, making up the general background of the story we are about to analyse. We should stress, however, that the decision-making process we shall discuss in detail here is not the only relevant element in the history of ESRO's and ESA's Scientific Programme in the period from 1973 to 1977. Two others, at least, must be mentioned. Firstly, alongside the discussions on future scientific projects, ESA's decision-making bodies were also engaged in discussing the European contribution to the first Spacelab mission. The principal aim of this mission was the verification of the performance of Spacelab and its subsystems. However, taking into account the constraints imposed on the first payload by these system-test objectives, approximately half of the Spacelab resources were available for the accomplishment of scientific, application and technology objectives. These experimental objectives were planned jointly by ESRO and NASA, each agency taking about half of the available resources for European and US experiments, respectively. The discussions on the selection and financing of the European complement to the first Spacelab payload developed in parallel with those we are analysing below. They will be the object of Chapter 14.

The second parallel story regards the problems and difficulties which affected the development of the GEOS and Exosat projects. The former suffered from a severe financial crisis in 1975, when it became evident that the accumulation of technical changes together with cost inflation would bring about a significant over-run of the budget allocation. After many negotiations with the industrial contractor, British Aircraft Corporation leading the STAR industrial consortium, a new cost-to-completion was agreed on and the launch date was postponed from August 1976 to April 1977. In order to meet this time schedule, however, it was necessary to forgo the qualification of the second flight model, a decision much to be regretted after the launch failure of the satellite.[214]

As to Exosat, it is important to recall that this was the first ESRO/ESA satellite for which the Organisation was financing and managing the scientific payload. This was a consequence of the observatory nature of the mission and implied that its data should be made available to European observers outside the groups involved in the payload development programme. The design of the spacecraft passed through many modifications in the course of project development, both regarding the satellite and its scientific payload. The scientific objectives of Exosat also evolved, following the rapid evolution of X-ray astronomy, and in particular the lunar occultation mission no longer had the primary importance which it had when the project was first approved. The most important change was due to the controversial decision to launch the satellite by Ariane instead of the originally foreseen Delta 2914. This implied a substantial increase in the cost of the project. Moreover, the ups and downs of the Ariane development and qualification programme resulted in delays which added to those

[214] ESRO/PB-S(75)10, add. 1, 22 May 1975.

imposed by budgetary restrictions. In the event, it was decided to revert to Delta and Exosat was finally launched by the American rocket in May 1983.[215]

3.2 The Scientific Programme in the new ESRO framework

When, in the spring of 1973, discussions started on ESRO's future Scientific Programme, a few important elements had to be taken into account. First was a strong financial constraint. The 1971 package deal had fixed at 27 MAU (in 1971 prices) the annual level of resources for the Scientific Programme as from 1975. Excluding adjustments for inflation, this figure was confirmed at the time of the second package deal, despite the dramatic increase in the financial resources made available to ESRO by its member states (from 75 in 1971 to 178 MAU in 1974). It remained unchanged after the birth of ESA, whose total budget reached 462.4 MAU in 1976. Indeed, while giving a level of stability to the Scientific Programme, the budget fixed by the 1971 package deal was rapidly becoming critically low when compared to the increasing size of the scientific community calling on ESA and to the demands for more ambitious research projects following the successes of the previous decade.[216]

The second element was the new relationship between ESRO/ESA and NASA. The participation of ESRO in the IUE project and the joint ISEE mission had already established good bases for effective collaboration in scientific projects of mutual interest. Moreover, the two agencies were jointly developing the Spacelab programme whose aims also included scientific objectives. Two reasons suggested fostering such a collaboration towards more ambitious goals. The first was a financial reason: ESRO/ESA could not hope to undertake important scientific projects without joining its meagre resources with those of its powerful American counterpart. The second was the lure of the new space technologies which would become available in the 1980s as a result of NASA's post-Apollo programmes. European scientists could not miss the opportunities offered by space shuttles, large space telescopes and manned space stations. NASA, for its part, had similar reasons. The American agency was struggling with the restrictions which followed the bonanza of the Apollo era and was keen to associate Europe into its Scientific Programmes. On the one hand, this helped from the financial point of view; on the other, the existence of international obligations partly eased the way towards approval of programmes and budgets from the Federal Government and Congress.

A third element affecting science policy discussions after 1973 was that future scientific missions could be carried out both by payloads on board spacecraft and by instrumentation on board Spacelab. The ultimate aim of the Spacelab programme was to develop an Earth orbiting, re-usable manned laboratory that could be used by a wide community for scientific, application and technological objectives. European space scientists were thus confronted with a new facility that not only opened up new possibilities in the traditional space science disciplines, but also involved fields not covered by ESRO activities (e.g. medical and biological sciences, and material sciences). In January 1973, a meeting of 250 scientists and technologists was convened by ESRO in Frascati, Italy, to discuss Spacelab utilisation. Following the meeting, ESRO set up a number of "Spacelab payload groups" to study the possible utilisation of this facility in the different scientific and application fields. In the United States, the National Academy of Sciences' Space Science Board organised in July at Woods

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215 Altmann et al. (1983).

216 MAU stands for million accounting units, ESRO's Conventional monetary unit. The Accounting Unit (AU) was originally defined in the ESRO Convention as 0.88867088 grams of fine gold and its value was roughly equivalent to one US$. Following the 1971 crisis of the international monetary system based on the Bretton Woods agreement of 1944, a new concept had to be defined. After many discussions, in 1975 it was agreed to adopt the European Accounting Unit (EAU, later known as ECU) as the Accounting Unit for ESA. The EAU was made up of a "standard basket" of the nine European Community currencies weighted according to the average over five years of the gross national product and the intra-European trade of each state. In 1975 (1976) the value of the AU in terms of the main currencies was 1.27 (1.30) US$; 3.22 (3.05) DM; 6.21 (5.22) FF; 822 (815) LIT; 0.53 (0.57) GBP. See Frank (1976) and ESA Annual Report 1975, pp. 139-140.

Hole, Massachusetts, two study weeks devoted to the scientific utilisation of the Space Shuttle and Spacelab.[217]

Finally, we must recall the changing institutional framework in which future Scientific Programmes were being discussed. Since the December 1971 package deal the very definition of "space research organisation" no longer answered the programmes that ESRO was called to develop. Science, in fact, hardly provided the main rationale for the existence and functioning of ESRO in this new phase of its life, and covered only a small fraction of its total budget. Practical objectives such as commercial telecommunications, air traffic control and weather forecasting had replaced scientific research as the principal aim of ESRO's undertaking. With the second package deal of 1973 and the eventual creation of ESA in 1975, science would become even less important within the overall programme of the new Agency. Economic and commercial interests, technological innovation and industrial policy were more and more the driving forces which shaped its activity, rather than the scientists' thirst for new knowledge on physical phenomena in outer space.

However marginal science might appear in ESRO's new charter, it nevertheless represented a key element in its overall programme. Firstly, it was the only part of the programme which was mandatory for all member states, and the one which for ten years had provided a successful ground for European cooperation in space. In the framework of the *à-la-carte* system that was to characterise the programme structure of the new Agency, the "special nature of the Scientific Programme" was explicitly recognised "as the common factor through which the whole Organisation was held together".[218]

Secondly, the definition of the actual content of the Scientific Programme, i.e. the feasibility studies of possible missions, the adoption of specific projects and the selection of experimental payloads, always involved political issues of a different quality from that of application programmes. The latter, in fact, were characterised by well-defined objectives, these being the development of a commercially viable communication satellite system, a reliable meteorological satellite or any other technical device designed to operate in space for a specific application. Once the programme had been approved with its associate budget, users' specifications, technical options and industrial policy considerations were the important elements of all subsequent discussions and decisions. It was a different case for the Scientific Programme. As ESRO's Director of Programmes and Planning put it, "the scope of the Scientific Programme was decided by the financial envelope, within which the scientific committees endeavoured to follow a coherent scientific policy".[219] The definition of such a "coherent scientific policy" required continuous negotiations between the various sectors of a peculiar and very diverse community of users. It called into question the plans and expectations of research groups active in the many fields of space science, the relation between ESRO's Scientific Programme and its member states' national programmes, and the relation between these programmes and those of NASA and other non Western European space agencies (USSR, Canada, Japan).

A third element to point out is that scientists did in fact play an important role in the life of the Organisation. Indeed, ESRO was born out of an initiative of the European space science community and its growth and success owed much to the perseverance and far-sightedness of this community. After a decade of active work in rocket and satellite experiments, physicists and astronomers involved in space research composed the most united, experienced and open-minded group of space users in Europe, who could adequately cope with the international dimension of the space effort and had the culture and intellectual authority to stand comparison with their American counterparts. Some influential scientists, like the former Director General Hermann Bondi and the Council Chairman

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217 Information on the scientific sessions at the Frascati meeting is in LPAC(73)4, 31 January 1973. For ESRO's Spacelab payload groups, see ESRO/PB-S(73)14, 10 September 1973. The NAS study weeks, held from 2 to 14 July 1973, were attended by a few European scientists and by the LPAC chairman who reported at the 49th meeting (4 October 1973), LPAC(73)23, 26 October 1973.

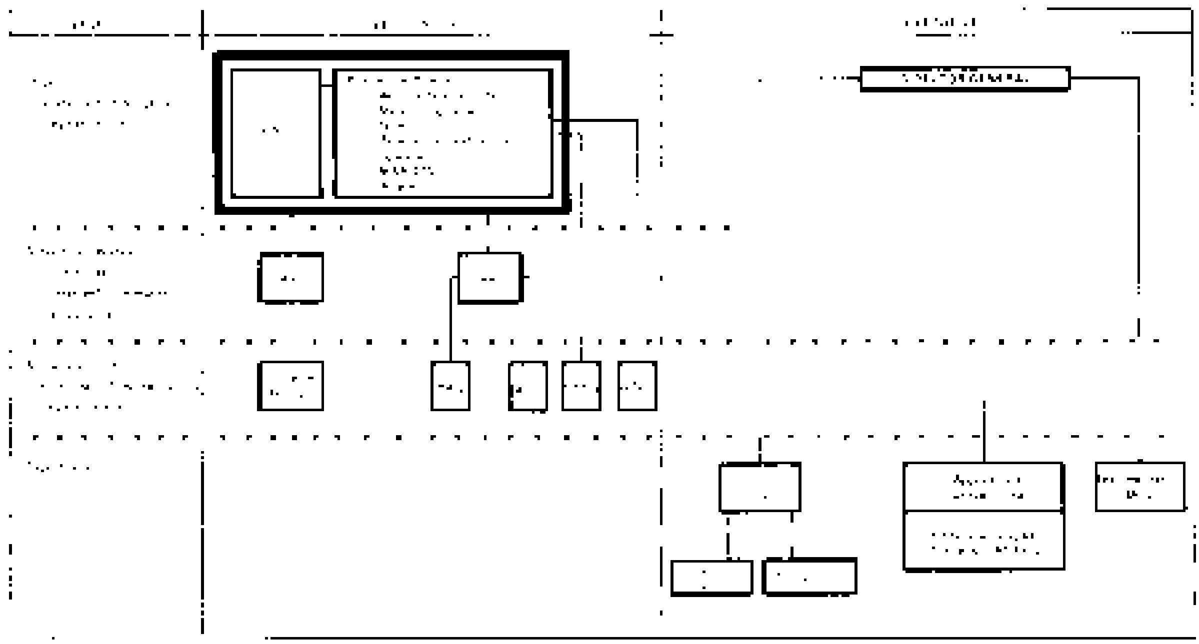
218 SPB, 9th meeting (23 October 1974), ESRO/PB-S/MIN/9, p. 10.

219 J.A. Dinkespiler at the 1st SPB meeting, (17 October 1972), ESRO/PB-S/MIN/1, 8 November 1972, p. 12. See also Council, 46th meeting (9 May 1972), ESRO/C/MIN/46, 23 May 1972, p. 4.

Giampiero Puppi, played a decisive role in the most delicate passages of ESRO's political life; many others held important advisory positions in national governments as regards space policy, and served in ESRO's legislative bodies.[220]

3.3 The question of scientific advice and the role of the LPAC

The peculiar political character of the Scientific Programme is displayed in the discussions about the status and role of the new Scientific Programme Board (SPB) and, above all, of the long-standing Launching Programme Advisory Committee (LPAC). With the approval of the December 1971 package deal, it became necessary to change the ESRO Convention in order to take into account the Organisation's new involvement in the application fields and the requirements of the optional programme system. This issue absorbed much of the Council's time during 1972, the main question being how to reconcile the need for a unitary management, represented by the Council and the Executive, with the necessity of running several different programmes, with different groups of participating states and separate budgets. We shall not go into the detail of these discussions. It suffices to recall that for each programme approved by the Council a Programme Board was established, composed of delegates from the participating states, fully responsible for executing that programme (Figure 3-1). The legal status of the Programme Boards was the same as that of the



Note:
The AFC (Administrative and Finance Committee) and JPPC (Joint Programmes and Policy Committee) were subordinate bodies of the Council. The JPPC was advised on technical matters by the Technology Advisory Group (TAG, formerly ARAC) and the Space Components Co-ordination Group (SCCG). The STAG (Science and Technology Advisory Group) and the ATAG (Aeronautical Technical Advisory Group) advised the Meteorological and the Aeronautical Programme Boards, respectively.

Figure 3-1: ESRO's committee structure in 1973

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[220] The term "legislative" is used here to indicate the Council, the Programme Boards and all subordinate bodies composed of national delegates. The latter could either have decision-making authority or function as advisory bodies. The term Executive is used to indicate the ESRO/ESA Directorate and its staff. Advisory groups of experts (non-delegates) were also set up to report to legislative bodies or to the Executive (see Figures 3-1 and 3-3).

Council, its powers and functioning being defined by the special Arrangements between ESRO and the governments of participating states for the execution of each specific programme.

The Scientific Programme Board had been set up in order to place the various programmes on the same level. It thus replaced the Scientific and Technical Committee (STC) which, like the Administrative and Finance Committee (AFC), was a subordinate body of the Council. In this case, however, the role of the Board was not defined by any special arrangement between a group of member states. The activities referred to it, in fact, were merely those covered by the ESRO Convention and its functions were those that the Convention explicitly assigned to the Council. In other words, it was up to the Council to institute the SPB and delegate the necessary powers to it. Such considerations had caused some controversy when it came to decide whether to extend the programme board concept to the Scientific Programme too. In the event, the Council agreed to set up a Programme Board for the Scientific Programme alongside those for the application programmes, but reserved the right to examine the scientific budget after approval by the Board.[221]

Within its terms of reference, the SPB was also given competence for the selection and adoption of specific scientific projects within the overall programme and the ceiling approved by the Council. This was the most important element of the complex process which ultimately led to the launch of an ESRO satellite. It was not, however, the one that defined the Organisation's scientific policy. While politically relevant, the adoption of a satellite project in the ESRO programme represented only the culminating point of a decision-making process which was largely driven by forces and interests outside the control of the legislative arm of ESRO. As we have described in Volume 1, it was the scientific community that liberally suggested space missions and experiments. These were discussed and refined by two groups of experts, the Astrophysics Working Group (AWG) and the Solar System Working Group (SSWG), and by the LPAC. Following these discussions, a few of them became the object of feasibility studies performed in ESTEC or in industry under ESTEC guidance. Finally it was the task of the LPAC to discuss the results of these studies and recommend one or more projects for final approval.

In the whole process, the LPAC played by far the most important role in shaping the Organisation's scientific policy. It advised the ESRO Director General on the planning of future activities and defined scientific guidelines to orient the space science community in the making of their proposals; elected the members of the two Working Groups and nominated their chairmen and vice-chairmen (to be endorsed by the STC); instructed the ESRO Directorate of Programmes and Planning about mission definition and feasibility studies to be performed; discussed the scientific merit of the most interesting projects, assessing their technical and financial feasibility as well as the capability and competence of the groups called on to build the payload and analyse the data; and, finally, it selected the project to be recommended to the STC (later to the SPB) and the Council for adoption in the ESRO programme. At this final stage, of course, these projects had already passed through a severe process of progressive definition and refinement, and a strong scientific constituency had already committed itself to their eventual realisation. The legislative bodies had a mere rubber stamping function.

In the ESRO framework, the LPAC consisted of a body of five independent experts whose task was to advise the Director General on all scientific matters, both regarding ongoing projects and the planning of future activities. Its members were appointed by the STC (later by the SPB) from a list of candidates submitted by the Director General after consultation with the scientific community, and they served for a period of three years. The chairman was elected by his colleagues. The LPAC was assisted in its work by the Director of Programmes and Planning and by the Director of ESTEC, as

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221 Council, 52nd meeting (13-14 December 1972), ESRO/C/MIN/52, 10 January 1973. The SPB's terms of reference are reported in ESRO/PB-S(73)5, 12 March 1973. Preliminary discussions were held at the first two meetings of the (provisional) SPB, on 17 October and 19 November 1972, respectively: ESRO/PB-S/MIN/1, 8 November 1972, and ESRO/PB-S/MIN/2, 10 January 1973.
See also ESRO/PB-S(72)12, 28 September 1972; ESRO/C(72)58, 6 November 1972, and rev. 1, 20 November 1972.

Table 3-1: The Launching Programme Advisory Committee (1973 - 1975)

	February 1973 - October 1974	November 1974 – May 1975
Restricted membership	H. van de Hulst, Leiden (chair) H. Elliot, London (up to May 1974) G. Haerendel, Garching G. Pizzella, Frascati J. Steinberg, Meudon	H. van de Hulst, Leiden (chair) L. Houziaux, Mons (since Feb. 1975) G. Pizzella, Lecce M. Rees, Cambridge J. Steinberg, Meudon
Astrophysics W. G.	C. de Jager, Utrecht (chair) L. Scarsi, Palermo (deputy)	C. de Jager, Utrecht (chair) L. Scarsi, Palermo (deputy)
Solar System W. G.	A. Dollfus, Meudon (chair) C. Fälthammar, Stockholm (deputy)	A. Dollfus, Meudon (chair) C. Fälthammar, Stockholm (deputy)
Life Science W. G.		H. Bjurstedt, Stockholm (chair) H. Bücker, Frankfurt (deputy)

well as by the chairmen of the scientific working groups. By statute, its recommendations had to be based on purely scientific and technical considerations (Table 3-1).[222]

The special position of the LPAC as the key actor in the definition of ESRO's scientific policy and the fundamental link between the Executive and the European space science community reflected the peculiar *raison d'être* of the Organisation in the 1960s, i.e. that of pursuing scientific research on behalf of the community itself. After the 1973 package deal, in the framework of discussions around the forthcoming new Space Agency, the status and role of the LPAC came to be reconsidered. In particular, it was felt that the SPB, which represented the interests of all member states, should have complete control over the definition of the Organisation's only mandatory programme. A discussion on this question was prompted by the French delegation in the Council and developed in the second half of 1973, in the aftermath of the controversial decision to adopt ISEE-B and Exosat in the programme against the Venus orbiter. The French scientific community, in fact, had supported the planetary mission, but had been defeated by the strong scientific constituency that had grown up around Exosat in the course of more than two years of studies on this project.[223]

Three arguments were pointed out in particular. Firstly, the new Agency was supposed to integrate in its programme a number of ongoing programmes in member states. This called for a more substantial participation of national scientific groups and space agencies in future planning, and the SPB delegations were certainly more appropriate than independent experts in designing ESRO/ESA's scientific policy. Secondly, budgetary restrictions limited the number of mission definition and feasibility studies that could be performed. Therefore the selection of such studies could actually become something of a policy decision which should be reserved to the SPB. Finally, expert advice could never be and should not be completely independent and solely based on scientific arguments. "It was an illusion to think that scientists debated purely on scientific grounds," the French delegates claimed, "political elements were bound to cover their decisions, and this should be recognised in the composition of [the] working groups". And the Belgians argued that "the experts [...] had to be entirely familiar with the problems arising at the level of their national delegations. [...] The appointment of the

222 The status and functions of the LPAC as described above, in particular its becoming an advisory body to the Director General and no longer to the STC, were approved at the 20th Council meeting (29-30 November 1967), after the conclusion of the Bannier report: ESRO/C/MIN/20, 14 December 1967. See ESRO/C/306, add. 4, rev. 1, 14 December 1967.

223 ESRO/C(72)70, 1 December 1972; ESRO/C(73)19, 30 March 1973, with add. 1 (30 May 1973) and 2 (18 June 1973); and ESRO/C(73)26, 10 April 1973.

experts should therefore be a matter for the governments, through the Organisation's legislative bodies". In the light of these considerations, and following the example of the other Programme Boards, it was argued that the SPB should control all stages of the decision-making process and that scientific advice should be conveyed directly to Board, either from an LPAC with enlarged membership, in order to include wider national representation, or from its own advisory body consisting of experts nominated by national scientific authorities.[224]

Facing this challenge, the LPAC and the Executive reacted by stressing the importance that the former kept its role as an advisory body of independent experts. In the words of the LPAC chairman, the Dutch astrophysicist Hendrik van de Hulst:

> *An LPAC of the kind that already existed remained necessary and [...] the creation of another advisory body, namely a group with scientific experts from each member state to report to the SPB, would constitute an unnecessary further step in the Organisation's committee structure.*[225]

ESRO's Director of Programmes and Planning J. Dinkespiler, for his part, stressed that the advice of high-level scientists, "wise men" as he called them, was crucial for finding compromises between conflicting scientific interests:

> *Experience had shown that, with regard to the Scientific Programme, it was extremely difficult to arrive at a decision unless the Director General was in a position to submit to the delegate bodies a programme proposal involving his responsibility; hence his need to have access to expert advice to help him to assume this responsibility.*[226]

As a consequence of these discussions, a compromise was reached according to which the LPAC remained an advisory body to the Director General, but should also provide advice to the SPB when requested, and keep the latter continuously informed of its activity. Moreover, it was decided that its membership should be enlarged to include one expert in life sciences, concurrently with the envisaged establishment of a Life Science Working Group. While approving this compromise, however, the SPB reaffirmed its willingness to keep a firm control of the various stages of the selection process of future projects, stressing in particular that it would keep "a very close watch" over the selection and execution of feasibility studies. This was not the end of the story, however, as the forthcoming

224 The two quotations are from SPB, 4th meeting (18 September 1973), ESRO/PB-S/MIN/4, 22 October 1973, p. 9; and from Council, 57th meeting (1 June 1973), ESRO/C/MIN/57, 20 June 1973, p. 13, respectively.

225 LPAC, 48th meeting (21 June 1973), LPAC(73)17, 17 July 1973, p. 2.

226 ESRO/C/MIN/57, *cit.*, p. 14.

discussions about ESRO's scientific policy and future programmes would re-open the whole question of the LPAC and the other scientific advisory bodies.[227]

3.4 Discussing future Scientific Programmes

The LPAC started to discuss ESRO's future Scientific Programmes in early February 1973. Introducing the discussion, Dinkespiler reviewed the evolution of the Organisation in the light of the reform started in December 1971, pointing out two aspects in particular. Firstly, the fact that the scientific budget would remain unchanged against the dramatic increase of ESRO's total financial resources; secondly, that the development of the Shuttle/Spacelab system would offer space research new and interesting opportunities. In this light, Dinkespiler advised, it was necessary to adapt ESRO's advisory bodies to this broader field of possibilities and to revise the LPAC policy statement of June 1970. The latter, we should recall, had given priority to magnetospheric studies and high energy (i.e. X- and gamma-ray) astrophysics, and this had oriented the ESRO mission studies and, eventually, the LPAC recommendation of ISEE-2 and Exosat. Optical (including ultraviolet) astronomy, solar physics and planetary missions had been excluded from the programme, both for financial reasons and because of NASA's strong effort in these fields. In the new situation created by the forthcoming availability of the Shuttle/Spacelab system, and by the prospects of collaborative ventures with NASA, a new scientific policy was called for and new guidelines had to be established for scientific missions in the 1980s.[228]

The discussion was resumed in June, after the definitive approval of ISEE B and Exosat, and the LPAC agreed that the European space science community should be invited to submit ideas and proposals. It asked the SSWG and AWG to prepare a report on the current trends in the research areas falling within their terms of reference. A special LPAC meeting was planned in January 1974 to discuss these reports and to define guidelines for ESRO scientific mission studies, in time for the ESRO/NASA programme review meeting scheduled in February 1974.[229]

The two Working Groups duly performed their task and by the end of 1973 their reports were submitted to the LPAC.[230] The SSWG identified eight priority research areas, with no explicit preference assigned to any of them (Table 3-2). Specific missions were also suggested for four of these areas: (a) a four-telescope cluster on board Spacelab to investigate solar physics phenomena; (b) a space probe to be launched into an out-of-ecliptic trajectory associated to an Earth orbiting spacecraft for solar wind investigation and stereoscopic observations of the sun; (c) a space telescope for observing bodies of the solar system; and (d) an astrometry mission for precise measurements of

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227 ESRO/PB-S(73)15, 17 October 1973; SPB, 5*th* meeting (9 November 1973), ESRO/PB-S/MIN/5, 12 December 1973; 6th meeting (8 February 1974), ESRO/PB-S/MIN/6, 25 March 1974, p. 6. Preliminary activity for the creation of the Life Science Working Group (LSWG) developed in Spring 1974 by a 4-member "Nucleus" nominated by the ESRO Director General after a recommendation of the LPAC. This nucleus proposed names of specialists in the different areas and the LSWG members were eventually appointed by the ESRO Director General. The Working Group held its first meeting on 27 September 1974, and elected the Swede H. Bjurstedt as its chairman. A life science expert in the LPAC was never nominated but there was one in the ESA Science Advisory Committee (SAC), which replaced the LPAC in 1975. For detailed information, see: LPAC, 50th meeting (5 November 1973), LPAC(73)27, 2 January 1974; 51st meeting (LPAC, 14-16 January 1974) LPAC(74)5, 14 February 1974; 53rd meeting (29 March 1974), LPAC(74)11, 7 May 1974; and 55th meeting (13 September 1974), LPAC(74)17, 15 November 1974. See also LPAC(74)6, 14 February 1974; ESRO/PB-S(74)16, 17 April 1974; ESRO/PB-S(74)32, 4 October 1974; and LSWG, 1st meeting (27 September 1974), LIF(74)3, 1 October 1974.

228 LPAC, 45th meeting (1 February 1973), LPAC(73)9, 19 February 1973. The LPAC policy statement of 1970 and its consequences were discussed in Volume 1, chapter 8.

229 LPAC, 48th meeting (21 June 1973), LPAC(73)17, 17 July 1973; 49th meeting (4 October 1973), LPAC(73)23, 26 October 1973.

230 The two reports are SOL(73)16, December 1973, and ASTRO(73)15, 18 January 1974. See also SOL(73)7, 24 September 1973.

the position and motion of stars. The first two involved cooperation with NASA, while the last two could be independent European projects, the latter in particular being already studied in France by the Centre National d'Etudes Spatiales (CNES). A second group of research areas included magnetospheric, ionospheric and atmospheric studies. It was recommended that ESRO should ensure that European scientists had opportunities to fly experiments in these fields on board Spacelab when available. Finally, the SSWG recommended that ESRO should enter the field of solar system exploration by collaborating with NASA in developing deep space probes. Besides recalling the possibility of taking part in new missions to Mercury, Venus, and Jupiter, the SSWG also stressed its strong interest in the NASA plans for a Mars surface rover, and in a mission to comet Encke currently under study in Germany as a follow-up of the US/German Helios programme.[231]

Table 3-2: Priority areas selected by the Solar System Working Group (December 1973)

Research fields	Proposed missions	Remarks
Solar physics	Cluster of 4 telescopes on board Spacelab, with broad spectral resolution (visible to X-rays) and high resolution	ESRO should build one of the 4 telescopes
Solar / Interplanetary physics	Out-of-ecliptic spacecraft plus near Earth spacecraft for solar wind studies and stereoscopic observations of the sun	Deep space tracking network required. High launch cost
Solar system astronomy	Telescope on shuttle-visited spacecraft dedicated to observations of planets, comets and asteroids	Could be independent European project
Astrometry	Astrometry instruments carried in Spacelab or satellite	Could be independent European project
Solar system exploration	Spacecraft missions to Mercury, Venus or Jupiter; cometary missions (Encke, Halley); Mars surface rover	Collaboration necessary
Magnetospheric research	Plasma physics experiments in Spacelab	Possible coordination of magnetospheric, ionospheric and atmospheric experiments in Spacelab
Ionospheric research	Experimental ionospheric physics in Spacelab	
Atmospheric research	Active sounding (in particular by laser), passive remote sensing and mass spectrometry in Spacelab	

The AWG presented 13 proposals for future missions, equally distributed between free-flyer spacecraft and Spacelab missions (Table 3-3). No priority was explicitly assigned between them, but the Group provided the LPAC with an indication of the level of support that these missions had from its members. These were asked to select three preferred satellite missions and three preferred Spacelab missions and the result of this voting procedure was reported on a marking scale. The ensuing table showed that a strong interest existed in infrared astronomy, with two missions recommended for immediate consideration: a small satellite-borne telescope mainly devoted to the study of the cosmic

231 The joint ESRO/NASA comet Encke mission was officially proposed by the German Ministry of Scientific Research and Technology in a letter dated 12 December 1973 and reported in ESRO/PB-S(74)9, 24 January 1974. For the Mars Rover, see SOL(73)8, 2 October 1973.

background radiation, and a large infrared telescope on board Spacelab.[232] Other preferred missions were: a Spacelab payload for X-ray spectroscopy and polarimetric studies in the 0.5-8 keV energy range; a satellite for low-energy gamma-ray astronomy; and a Spacelab telescope associated with a photon-counting system for ultraviolet stellar spectrophotometry.

Table 3-3: Mission proposals recommended by the Astrophysics Working Group (December 1973)

Research fields	Proposed missions or payloads	Marking	Remarks
Infrared astronomy	Satellite-borne telescope for IR background and sky survey	12/14	
	Large IR telescope in Spacelab	13/14	
	IR interferometer for high-resolution studies on board Spacelab	-	At a later date
Ultraviolet astronomy	1-metre stellar spectrophotometer on board Spacelab	9/14	
X-ray astronomy	Low energy (< 0.3 keV) sky survey satellite	8/14	
	Spacelab instrument for spectroscopy and polarimetry in the 0.5-8 keV energy range	11/14	Early SL mission to correlate with Exosat
Gamma-ray astronomy	Low-energy gamma-ray satellite	11/14	
Cosmic rays	Isotopic composition at energies between 2 and 15 GeV/n	-	Requiring further studies
Solar physics	European Space Solar Observatory	7/14	
	High-resolution telescope on board Spacelab	5/14	
	X-ray telescope on board Spacelab	3/14	
Fundamental physics	SOREL satellite project to test gravitation theories	3/14	Requiring further studies
	Mercury orbiter to test gravitation theories	-	Requiring further studies

The LPAC discussed the Working Groups' reports in a three-day meeting held from 14 to 16 January 1974 in a "quiet and secured place" in Argentières, at the foot of Mont Blanc. It then finalised its own report on 28 January. We have no record of these discussions and therefore we must limit ourselves to

232 An infrared astronomy Spacelab payload had been studied by an ESRO mission definition group for a few months: ESRO/PB-S(73)19, 31 October 1973.

presenting their conclusions.[233] Two aspects must be pointed out. The first is that the LPAC did not formulate guidelines for future scientific policy, as it had done in 1970: it did not suggest priorities between the various research fields nor did it recommend specific kinds of mission (e.g. satellite or Spacelab mission, small or large spacecraft, purely European or co-operative projects). It rather suggested a procedure to arrive at a "responsible decision" on the selection of new scientific projects. This meant, in the words of the LPAC, a decision taken by the SPB on the basis of "factual information about the scientific aims to be achieved, the technical problems to be solved, and the legal arrangements to be made if the project involves interagency cooperation".

The LPAC suggested that the process for arriving at such a decision should be divided into two successive phases. The first should be devoted to definition studies of a rather large number of missions, singled out on the basis of the suggestions from the scientific community.

During a mission definition study the type of instrumentation to be carried has to be specified in a preliminary fashion, but in sufficient detail to assess the scientific importance of the mission and the interest it may command in the European scientific community. However, many technological problems that may be involved must be left open and, consequently, the cost of the project can at this stage be guessed only very roughly.[234]

At the end of the first phase, and as a result of the definition studies, a small number of missions had to be singled out for more accurate feasibility studies, the aim of which was to collect the "factual information" referred to above, in order to eventually provide the SPB with all the important elements for making the final choice.

The second aspect of interest is, of course, the list of missions recommended by the LPAC for immediate definition studies (Table 3-4). This included 11 missions, essentially accepting most of the working groups' preferred projects with two important exceptions: the astrometry project and the cometary mission. The former, in the opinion of the LPAC, required preliminary discussions in order to assess "whether such a project would have sufficient scientific interest and support in the scientific community to compete with the projects recommended for further studies". As to the cometary mission, the LPAC considered that current injection techniques only allowed a simple fly-by mission with high relative velocities and this "appear[ed] to be a very expensive way of collecting about an hour's worth of data".

As a matter of fact, only the Jupiter orbiter survived in the LPAC list of the SSWG's ambitious plans in the field of planetary studies. Such a mission, however, was intended to study radiation belt and plasma physics rather than planetary physics. The Committee had discarded the solar system telescope as well as proposals for a visit to and sampling of one of the Mars satellites, and for participating in the American Mars landing programme. In the opinion of the LPAC, "any mission in this area, if at all financially feasible for Europe, would remain too much of an isolated and belated effort within ESRO's programme".[235]

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233 The LPAC report is LPAC(74)4, January 1974. See also LPAC, 51st meeting (14-16 January 1974), LPAC(74)5, 14 February 1974, and 52nd meeting (28 January 1974), LPAC(74)12, 12 April 1974. The search for a "quiet and secured place" for this meeting was put forward to the ESRO Executive by the LPAC members at their 50th meeting (5 November 1973), LPAC(73)27, 2 January 1974, p. 9.

234 LPAC(74)4, *cit.*, p. 9.

235 LPAC(74)4, *cit.*, pp. 23 and 25. The poor consideration given to planetary studies by the LPAC was regretfully noted at the 9th meeting of the SSWG, (24-25 April 1974), SOL(74)3, 3 September 1974, pp. 2-3.

Table 3-4: Missions recommended for immediate studies by the LPAC (January 1974)

Mission	Primary scientific objectives	Spacelab/free flyer
Infrared background and sky survey	Spectrum and polarisation of IR radiation between 100 µm and 2 mm and sky survey of sources between 50 and 500 µm	free flyer
Large infrared telescope	Infrared exploration of stars, sun, planets and interstellar medium	Spacelab
Stellar ultraviolet spectrophotometry	Exploration of stellar evolution and interstellar medium	Spacelab
X-ray spectropolarimetry	Investigation of X-ray sources in the 0.5 - 8 keV energy range	Spacelab
Low energy gamma-ray	Study of gamma-ray emissions from supernovae and galactic plane survey in the energy range below 10 MeV	free flyer
Solar telescope cluster	Simultaneous high-resolution study of the sun in all wavelength regions	Spacelab
Solar observatory	Study of the solar atmosphere with high spectral, spatial and time resolution	free flyer
Solar stereoscopic mission	Stereoscopic study of solar features	free flyer
Out-of-Ecliptic mission	Study of the solar wind, interplanetary magnetic field and the cosmic radiation	free flyer
Jupiter orbiter	Study of the plasma physics regime in the Jupiter environment	free flyer
Magnetospheric, ionospheric and atmospheric research	Dedicated Spacelab payload to study plasma physics and the coupling between the magnetosphere, ionosphere and atmosphere	Spacelab

The LPAC proposals were revised by the Executive after a joint ESRO/NASA meeting, held in ESTEC on 11 February 1974, where the two organisations' Scientific Programmes and plans were reviewed in order to highlight common interests and discuss possible cooperation. Eventually, after further discussion by the LPAC, the ESRO Executive identified 12 missions worthy of definition studies, eight of which in cooperation with NASA (Table 3-5). Three main changes must be pointed out. Firstly, the cancellation of the solar observatory, probably because NASA was not interested in such a project and ESRO could not afford to develop it alone. Secondly, the envisaged participation of ESRO in NASA's most ambitious scientific project, the Large Space Telescope (LST). ESRO, in particular, would contribute one of the instruments to be mounted on the focal plane of the telescope. Finally, the astrometry project was now included among the missions to be studied. This was a compromise negotiated with the French delegation in the SPB. ESRO, in fact, was not expected to perform any mission definition study on space astrometry projects, as they were actively being studied

Table 3-5: Missions recommended for immediate studies by the ESRO Executive (April 1974)

Spacelab payloads in collaboration with NASA	Large infrared telescope for IR study of stars, sun, planets and interstellar medium
	1-metre ultraviolet telescope for UV stellar spectroscopy
	Solar telescope cluster for high-resolution study of the Sun at all wavelengths
	Payload for the study of the atmosphere, magnetosphere and plasmas in space (AMPS)
Automatic satellites and space probes in collaboration with NASA	Infrared satellite for the study of the infrared background and sky survey of IR sources
	Out-of-Ecliptic mission for the study of the solar wind, interplanetary fields and cosmic rays
	Jupiter orbiter for the study of fields and plasmas in the Jupiter environment
NASA Large Space Telescope	ESRO instrument at the focal plane of the LST
ESRO payload for Spacelab	X-ray spectropolarimeter for the study of sources in the 0.5- 8 keV energy range
ESRO projects involving automatic satellites and space probes	Solar probe for stereoscopic study of the Sun (in association with NASA spacecraft)
	Low-energy gamma-ray satellite
	Astrometry mission (automatic satellite or Spacelab)

in France. Its activity would be limited to the organisation of an international symposium to discuss proposals in this field and to appraise the degree of interest of the scientific community.[236]

The Executive also suggested a time schedule for the decision-making process. Following the SPB's endorsement, all mission definition studies would be prepared during 1974 under the responsibility of the Directorate of Programmes and Planning's Space Mission Division. For each study a mission definition group would be set up, "comprising enough scientists to represent European interests properly".[237] The results of these studies would be discussed by the SSWG and AWG and then, on the basis of these discussions, the LPAC would indicate which projects it recommended for feasibility (Phase-A) studies. The SPB would eventually take the final decision on such a recommendation by January 1975. It was expected that five feasibility studies would be approved and executed during 1975 by industrial contracts. Their results would eventually be discussed at a scientific symposium to be organised in early 1976. Finally, after examination of the two Working Groups, the LPAC would indicate the project(s) that it recommended for adoption in the ESA programme and the SPB would decide by March 1976.

[236] PB-S(74)15, 18 April 1974. The conclusions of the ESRO/NASA programme review meeting are reported in ESRO/PB-S(74)12, 11 April 1974. See also LPAC, 53rd meeting (29 March 1974), LPAC(74)11, 7 May 1974.

[237] PB-S(74)15, *cit.*, p. 2.

3.5 The SPB decision on the study programme for 1974

According to the framework emerging from the discussions on the prerogatives of the SPB, the mission definition studies had to be endorsed by the Board itself, on the basis of the LPAC report, the results of the ESRO/NASA programme review and the proposal of the ESRO Executive. The discussion was particularly lively and sometimes paradoxical, all contradictions about the Scientific Programme in the delicate transition period coming into dramatic evidence. These contradictions regarded in particular: the legitimisation of the LPAC and its working groups as the bodies entitled to define ESRO's scientific policy; the poverty of the scientific budget *vis-à-vis* the expectations of scientists; the question of the scientific use of Spacelab; and the ever-present tension between the various disciplinary and national sectors of the space science community.[238]

The discussion was opened with a long and provocative statement by the SPB chairman, the influential French scientist and scientific policymaker Maurice Lévy, who was also the chairman of the ESRO Council as well as Director of the CNES. Two aspects were pointed out in his statement: firstly, the way in which scientific opinions reached the Organisation and a scientific policy was defined; secondly, the problem of funding. According to Lévy, there was "a need to transform the scientific space programme after its first ten years devoted to the exploration of the Earth's near environment by sounding rockets and satellites". The new missions, he argued, should be much more ambitious, should require large instruments and be oriented towards astronomy and the study of planets. The whole machinery for selecting ESRO's Scientific Programme was put into question:

> *Over the last ten years a large number of laboratories had built up both staff and equipment covering a number of areas and, at the same time, both for the selection of and performance of experiments, certain structures had emerged. Unfortunately, in some respect, these structures had features in common with the 'mandarin' system – young scientists were not consulted and they were unable to make their voices heard among the decision-makers. The fact that space projects were costly and that their development extended over a number of years at a time when science budgets were being cut back meant that there was keen competition between laboratories whose survival often depended on participation in a particular programme. Hence a certain blinkered view and lack of objectivity in the assessment of projects.*[239]

The ESRO Executive, Lévy continued, was "subjected to constant pressure both from the delegations themselves and from various scientific groups [...] Therefore, it was all too frequently inclined to make the necessary political compromises instead of developing an ambitious and truly forward-looking programme". As a consequence, the LPAC and the Executive were now suggesting a programme which had "the semblance of a series of highly cautious compromises" as compared to the "new impetus" of the American Scientific Programme, characterised by "a bold and energetic approach to large-scale planetary exploration programmes and wide usage of the Space Shuttle".

Having agreed to expend 300 MAU or so on the development of Spacelab, in spite of the generous offer of American co-operation, Europe was unable to come up with any major programme for using the equipment.

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238 SPB, 7th meeting (30 April 1974), ESRO/PB-S/MIN/7, 30 May 1974. At this meeting a few delegations presented their comments to the LPAC report in written documents: ESRO/PB-S(74)17, 11 April 1974 (UK); ESRO/PB-S(74)18, 19 April 1974 (Switzerland); ESRO/PB-S(74)19, 26 April 1974 (Germany); ESRO/PB-S(74)20, 29 April 1974 (Sweden); ESRO/PB-S(74)22, 30 April 1974 (Italy). The issue had been preliminarily discussed by the SPB at its 6th meeting (8 February 1974), ESRO/PB-S/MIN/6, 25 March 1974.

239 ESRO/PB-S/MIN/7, *cit.*, p. 3. All quotations from Lévy's statement are from this and the following two pages.

Both in the member states and within ESRO itself, Levy concluded, there was "a fundamental need for renewal of the structures controlling the scientific space programmes". Only in this way, would it be possible to define a scientific policy based on a few ambitious projects, taking advantage of the co-operation with NASA and meeting the challenge of space research in the 1980s.

Where should the money for such ambitious plans come from? This was Lévy's second argument. Given the constraint of the scientific budget, only two or three out of the dozen projects on which the SPB was about to launch definition studies could be included in ESRO's programme. Moreover, there was a major financial problem related to Spacelab. When, in fact, the 1971 package deal had established the financial envelope for the Scientific Programme, Spacelab was not yet in sight. And when the project was approved in the 1973 package deal, no provision had been foreseen for financing any Spacelab payload agreed on in the framework of ESRO's Scientific Programme. It would be utopian, argued Lévy, to expect any increase in the mandatory Scientific Programme: firstly, because most member states had now reached a plateau as regards their contributions to ESRO; secondly, because of plain national pride. In Lévy's blunt words:

> *The diverging views among the states as to the content of this programme were such that some states, particularly some of the biggest, would in fact refuse to support an increase in the budget of the mandatory programme if in doing so they ran the risk of having projects imposed on them which none of their laboratories was interested in.*
>
> *The only possibility of fostering ambitious scientific projects was the adoption of the* à la carte *policy for the Scientific Programme too, thus providing means for supporting optional programmes complementing the mandatory one. These optional programmes would bring together those member states that were interested, possibly in close liaison with NASA.*

Lévy's statement caused no little discomfiture among those present. The LPAC chairman, H. van de Hulst, asked whether the Committee's report was really "useful or desired by the Scientific Programme Board in view of the very fundamental issues that had been raised by its chairman". The Belgian delegation concurred with Lévy's statement, arguing that "the criticism it contained applied almost directly to the manner in which the LPAC had carried out its work [...] The distribution by subjects of the missions recommended by the Committee reflected too closely the composition of this body, which constantly tended to direct ESRO's policy along the same lines". The German delegation, on the contrary, "queried whether young scientists had in fact complained about the decision-making process with regard to the selection of new scientific projects". The Italian delegation, in Giuseppe Occhialini's characteristic tone, said that the chairman's remarks at the meeting would be given the same diffusion in the Italian scientific community as the LPAC report, "and for this it would be useful if there could be an unequivocal translation of the meaning the chairman gives to the term 'mandarinat' for which the interpretation in French dictionaries is varied".[240]

In the event, it was agreed to postpone the discussion on Lévy's statement to the following meeting and to deal now with the proposed missions. The SPB, in other words, chose the easiest path: it de-coupled the problem of ESRO's scientific policy from that of selecting mission definition studies. The former was temporarily removed and confined to the sphere of "general discussions", thus allowing the SPB to deal with the latter in the ecumenical way suggested by the LPAC's report. This course of action eased the way in this very preliminary phase of the decision-making process: why, in fact, should the SPB do what the LPAC had refrained from doing, i.e. set guidelines or establish priorities? why not approve as many mission definition studies as requested by the scientific community? On the other hand, everybody knew that studying such a large number of missions would raise expectations in the space science community, which ultimately could not be fulfilled for financial reasons.

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[240] ESRO/PB-S/MIN/7, *cit.*, pp. 5-7.

The outcome of the discussion made the paradox quite evident. The SPB, in fact, with the exception of Belgium, agreed with the LPAC proposals, supplemented by those of ESRO's Director General. At the same time, most delegations expressed their preference for one or the other project, or suggested new ones, according to national scientific interests. The German delegation, as was to be expected, requested the Executive and the LPAC to reconsider the cometary mission, arguing that "the short duration of the encounter with the comet cannot be taken as a measure of its scientific value".[241] The Swiss delegation, led by the planetologist Johannes Geiss, whose instruments had been included in the Apollo lunar missions, deplored the rejection of the planetary study projects and advocated a coordinated European effort in the field of planetary exploration in collaboration with NASA and the USSR Academy of Sciences. The cosmic-ray physicist Bernard Peters, in his capacity as spokesman of the Danish delegation, regretted that the LPAC had been unable to recommend any experiment in the field of high-energy cosmic-ray astrophysics and requested that mission studies in this field be undertaken, "in view of the remarkably high level achieved by certain laboratories specialising in this area in Europe". Peters himself was proposing an improved design for an experiment on cosmic-ray isotopic composition which had been rejected by the AWG.[242]

The French delegation expressed its satisfaction that the astrometric project, originally rejected, was now recommended. It also supported the planetology studies, while manifesting doubts about the real interest of the proposed atmospheric, ionospheric and magnetospheric studies. The Swedes did not concur, which is hardly surprising given the long-standing tradition of ionospheric and magnetospheric research in that country. One of the Swedish delegates, the scientist Bengt Hultqvist, was an influential spokesman of this tradition as well as an ESRO pioneer. The delegation emphasised that a major fraction of the groups involved in ESRO's Scientific Programme were involved in these research fields. Europe should not follow NASA's attitude, they argued, but continue the work already undertaken and extend its knowledge of the cosmic plasma in the magnetosphere. Finally, the Italian delegation, among whom Occhialini did not like Spacelab, argued that, contrary to the LPAC decision, the X-ray survey satellite originally included in the AWG list should be preferred to the Spacelab X-ray instrument. A definition study of such an X-ray mission was also requested by the British delegation, which also supported Peters' cosmic-ray mission and suggested two new missions: an entry probe to Saturn's satellite Titan and a high-energy gamma-ray astronomy mission.

To sum up the discussion, five new projects were put forward for immediate definition studies besides the twelve already selected, and the Director General warned that the available staff and finance would not permit the carrying out of 17 mission definition studies concurrently. It was eventually agreed that the cosmic-ray mission and the cometary mission should be added to the LPAC proposals; that the two British proposals could not lead to a project to be selected in early 1976 and therefore an immediate study was not necessary; that the out-of-ecliptic mission and the solar stereoscopic mission might be studied together as they could conceivably be combined; and, finally, that the AWG would be called to discuss the two X-ray missions again in order to eliminate one of them. In this way, there would be 12 missions remaining for ESRO definition studies, a 13th mission on astrometry being already under study by the CNES. Two days later, by a majority vote, the AWG confirmed the choice of the Spacelab X-ray spectropolarimeter (Table 3-6).[243]

[241] ESRO/PB-S(74)19, *cit.*, annex.
[242] ESRO/PB-S/MIN/7, *cit.*, p. 6-7.
[243] AWG, 10th meeting (2 May 1974), ASTRO(74)5, 15 July 1974. See also ASTRO(74)4, 2 May 1974.

Table 3-6: Mission definition studies carried out in 1974

Large Infrared Telescope for Spacelab (LIRTS)

The telescope would permit observation of the planets and other celestial objects with large spatial and spectral resolution. It consisted of an ambient-temperature telescope with a diameter of 2-3 m mounted on a stabilised platform on board Spacelab. Fitted with different focal-plane instruments (photometer, polarimeter, interferometer, heterodyne receiver), it would operate in the 30 to 1000 μm range and would have a pointing accuracy of 2 arcsec (for 1000 seconds).

Cryogenic Infrared European Telescope (CIRES)

This satellite would serve two scientific objectives: (a) to undertake a systematic exploration of the sky in the 10 to 1000 μm range; (b) to measure the spectrum and anisotropy of the diffuse background radiation. The instrument consisted of a 50 cm aperture telescope cooled to a temperature below 20 K by means of liquid helium. The satellite, weighing approximately 300 kg, would be three-axis stabilised with a precision of about one arcmin.

Low Energy Gamma-Ray Observatory (LOGOS)

The scientific aim of this space observatory was to measure the celestial diffuse background and to detect sources of line and continuum emission. The proposed payload consisted of four germanium/lithium detectors, with a total sensitive area of 120 cm^2, cooled to a temperature below 90 K. The payload was expected to weigh 220 kg and the whole satellite 450 kg. It would be placed in either a highly eccentric or a geostationary orbit.

Focal Plane Instrumentation for the Large Space Telescope (LST)

The LST to be developed by NASA was a wide-aperture telescope (2 to 3 m) with an angular resolution of better than 0.1 arcsec. It would be placed in low orbit and periodically visited by the Shuttle. Its lifetime would be not less than 15 years. The envisaged ESRO contribution to the project was the supply of scientific instruments mounted on the focal plane of the telescope, such as a spectrograph for faint objects and/or a high-resolution camera as well as a photon counting detector. In addition, the supply of the solar array was also envisaged.

One-Metre Ultraviolet Spacelab Telescope (MUST)

The scientific objectives of this telescope were complementary to those of the LST. It would have a very high spectral resolution and its angular resolution was about 0.5 arcmin. The telescope would be mounted on a stabilised platform on board Spacelab and several instruments could be accommodated on the focal plane: e.g. a high- or low-resolution spectrograph, a photometer grating and a high-resolution camera.

Cosmic-ray Astrophysics Projects

Three projects were studied in this field:

a. A Spacelab instrument including a superconducting magnet. This would permit measurement of the isotopic composition in a wide range charge composition (20 to 50 GeV per nucleon) as a function of energy and electron/positron spectra.

b. A satellite experiment designed to study the isotopic composition from nickel to neon at energies between 1 and 2 GeV per nucleon. The satellite, three-axis stabilised and weighing about 900 kg, would be placed in low orbit.

c. A satellite experiment designed to measure the charge spectrum as a function of energy, particularly at energies in excess of 100 GeV per nucleon. The satellite, spin stabilised and weighing about 350 kg, would be placed in either a highly eccentric orbit or a geostationary orbit.

X-ray Spectropolarimetry on board Spacelab (EXSPOS)

The experiment was intended for studies of the spectra of cosmic X-ray sources and for the detection of polarised X-ray emission. It consisted of a number of Bragg crystal spectrometers operating in the 2 to 10 keV energy range, enabling the study of variable sources with good time resolution and high sensitivity.

Continued on next page

Following from previous page

Study of the Atmosphere, Magnetosphere and Plasmas in Space (AMPS)

NASA's AMPS programme foresaw the use of Spacelab to perform active or passive sounding of the atmosphere, to make *in situ* measurements and, with the aid of sub-satellites, to study plasma physics by means of ion and electron accelerators, plasma generators, radio transmitters and antennae. The envisaged ESRO contribution to such a programme was a laser facility for sounding the atmosphere in the relatively unknown region between 35 and 120 km altitude. Moreover, ESRO could also build certain sub-satellites.

Solar Telescope Cluster on board Spacelab (STC)

In the framework of a dedicated solar physics Spacelab payload, including a cluster of telescopes for co-ordinated and simultaneous measurements over a wide range of wavelengths, ESRO would provide a grazing-incidence telescope for use in the X-ray region.

Pioneer Jupiter Orbiter and Probe

In the framework of NASA's Pioneer programme, it was envisaged to develop a Jupiter orbiter and a probe penetrating the atmosphere of the planet. The defined mission's objectives were to investigate Jupiter's atmosphere and magnetosphere, to study Galilean satellites and to analyse the planet/satellite system from the point of view of celestial mechanics.

Out-of-Ecliptic and Solar Stereoscopic Mission (OOE)

This combined mission comprised two scientific objectives: (a) *in situ* measurement of the interplanetary environment outside the ecliptic plane; (b) observation of the Sun from a position away from the Earth/Sun line, in order to obtain a stereoscopic view of certain solar structures. Two completely different missions were studied for the achievement of these objectives:

a. A three-axis stabilised probe, injected into an orbit with a radius of one astronomic unit and bearing a set of electric thrusters powered by solar cells (solar electric propulsion, SEP) capable of gradually shifting the orbital inclination to approximately 60° with respect to the ecliptic by the end of three years. In this option ESRO would be responsible for the module containing the scientific instruments;

b. a set of two space probes, spin stabilised and launched towards Jupiter by a single launch vehicle. Taking advantage of the planet's gravitational pull, one of the probes would pass over the North Pole of the Sun at about 1.5 astronomical units and the other over the South Pole. In this option ESRO would be responsible for the provision of one of these spacecraft.

Interception of Comet Encke

This mission for a ballistic interception of the comet Encke in 1980 was intended to study the physical and chemical properties of the comet and its nucleus, the nature of the solar-wind/coma interactions, the dynamics of dust particles in the vicinity of the comet, and others. The fly-by velocity at the moment of meeting the comet would be around 7 km/s and the useful observation time was estimated at 30 hours at least.

Space Astrometry

Three projects for a space astrometry mission were discussed at an international symposium organised by ESRO: an automatic satellite, a telescope on board Spacelab and a focal-plane instrument for the LST. The foreseen performance would represent an improvement by a factor of 10 in the state of knowledge of positions, proper motions and trigonometric parallaxes of stars. This progress was considered of great scientific importance for a number of fields, such as astrophysics, astronomy of double stars, stellar kinematics, solar-system mechanics, geodynamics.

3.6 The Scientific Programme in transition

This conclusion of the first phase of the decision-making process calls for a few considerations. The first is that, unlike what had happened five years before, no clear scientific policy was defined in order to orient ESRO's forward-looking studies and the European space scientists' long-term plans. Neither the scientific working groups nor the LPAC, let alone the SPB, wanted to run the risk of discussing and establishing priorities between the various research fields (e.g. astronomy, planetary exploration, magnetospheric studies, etc.), between alternative technical options (e.g. Spacelab vs unmanned spacecraft, large telescopes vs multi-experiment satellites, etc.), and between different institutional frameworks (e.g. confining ESRO's scientific research to the mandatory programme or exploring the possibility of optional Scientific Programmes). This is in part justified by the rather uncertain perspectives of space research in the 1980s. On the one hand, the lure of new space technologies such as the space shuttle, cryogenic infrared telescopes, large optical telescopes, electric propulsion, etc., stimulated plans for ambitious, large-scale projects. On the other hand, there were persisting uncertainties regarding technical and financial feasibility, political approval, co-operative ESRO/NASA arrangements and so on. Given the limitation of budgets and the uncertainties of congressional approval, it appeared risky to commit oneself at such an early stage to one or two big projects which could eventually fail. Moreover, not all space research fields required "big science". Medium-sized satellites and proven technologies could successfully be used for magnetospheric studies or X- and gamma-ray astronomy. The eclecticism of the set of missions studied by ESRO in 1974 reflected the fact that all sectors of the European space science community were now strong and skilled enough to advocate their pet projects. A choice had to be made anyway, but only when all options had been given equal opportunities of being carefully studied.

A second consideration involves the role of the national scientific establishments *vis-à-vis* what Lévy had defined the "mandarin system" within the European space science community. We have seen how the French and German delegations succeeded in having their national projects – the astrometry satellite and the cometary missions, respectively – included in the list of missions to be studied for possible adoption in the ESRO programme. It is true that the second package deal had stipulated that the forthcoming European Space Agency would integrate national projects in its programme. But the fact is that the ESRO scientific advisory bodies had not recommended those particular projects. While a compromise could be accepted at the level of a mission definition study, the problem nevertheless remained: who was entitled to decide which national projects were worthy of consideration for inclusion in the ESRO/ESA programme, the national delegations in the SPB or the experts in the LPAC and its working groups?

This brings us to a third consideration, which is the still hot question of ESRO/ESA's scientific advisory system. The close association of the ESRO Directorate of Programmes and Planning and the LPAC, as well as the presence in the latter of some of the most influential European space scientists and ESRO pioneers, had strongly determined the course of ESRO's Scientific Programme in the 1960s and early 1970s. However provocative the term "mandarin system" might be, it reflected a situation in which a small group of leading scientists and important laboratories did have a major role in orienting and shaping ESRO's scientific policy. The advent of a new generation of scientists and the growing political importance of space activities now put the "old citadel" in a state of siege. Scientific merit could no longer be the only aspect to be considered when selecting new projects, and scientists could not be entirely independent of their governments, claimed most SPB delegations. The Italian delegation, advised by Occhialini, retorted:

> *Throughout its long association with the Organisation, and with the LPAC in particular, it could not recall one case where a scientist, called upon to give a recommendation on scientific grounds, had made this choice on a national basis. [...] It had never known of pressure being brought to bear on an LPAC member by his national authorities [...] most of the members were professors, who were in the course of their work, called upon to*

> *make very many important judgements, and who were well qualified to make recommendations concerning the Scientific Programme of ESRO.*[244]

When, one year later, the French delegation urged changes in the scientific advisory system with "the stated aims of permitting a renewal of ideas and providing better guarantees of impartial choices," the LPAC chairman van de Hulst curtly commented that "there were plenty of ideas in Europe for space experiments, what was missing was the money to carry them out".[245]

Finally, our last consideration involves the role of Spacelab in ESRO's Scientific Programme. We have already pointed out that no extra funding had been granted for financing ESRO payloads for Spacelab missions. Therefore, either Spacelab experiments had to be developed by groups of member states as special (optional) projects, or funds had to come out of ESRO's scientific budget. In the former case, the mandatory character of the Scientific Programme would be jeopardised; in the latter, new research fields and scientific groups would compete for funding with the traditional ones. The question was discussed by the LPAC and SPB in this period but no solution was agreed on, pending the definition work on Spacelab facilities and subsystems.[246] Underlying these discussions there was, however, a fundamental matter of controversy. The Spacelab programme was a very important political and technological enterprise – indeed it represented the start of a new era in US-European co-operation in space and Europe's ticket to manned spaceflight. However, most space scientists considered that such a facility was of very little scientific interest. Against the obvious advantages of return capability, large weight capability and the possibility of on-board adjustment of instruments, there were serious disadvantages such as the short duration of the experiments, restricted orbits, contamination caused by gases from the life-support equipment, and attitude instability caused by the crew. Scientists in the United States were very critical as regards the utilisation of Spacelab in the science disciplines, as was evident at the National Academy of Science Summer Study in Woods Hole. In the words of the NASA Director of the Spacelab programme:

> *The Sortie Lab [Spacelab's former name] was not the most popular programme presented to this group of scientists. With the exception of the life scientists present, most of the attendees felt their resources could be better placed on automated systems in the conventional space science disciplines. Once faced with the fact that a Sortie Lab would probably be provided by a European cooperative effort, they grudgingly conceded that there were some ways in which it could be useful to all disciplines.*[247]

European scientists did not have better esteem of the scientific potentialities of Spacelab. Reporting to the LPAC on the Frascati symposium, G. Haerendel said that "there was scepticism [among scientists] regarding the Spacelab". At the symposium, in fact, critical comments had been made by important scientists like C. de Jager, H. van de Hulst, J. Geiss, and G. Occhialini, rapporteurs for solar astronomy, IR and UV astronomy, space and plasma physics, and high-energy astrophysics, respectively.[248] Occhialini himself, retorting to Lévy's brutal statement about Europe being unable to propose any major programme for using Spacelab after "having agreed to expend 300 MAU or so on its development", was equally brutal:

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[244] SPB, 4th meeting (18 September 1973), ESRO/PB-S/MIN/4, 22 October 1973, pp. 9-10. At this meeting Occhialini participated as an adviser of the Italian delegation.

[245] SPB, 9th meeting (23 October 1974), ESRO/PB-S/MIN/9, 4 November 1974, p. 5. We shall discuss the French proposal shortly.

[246] LPAC, 45th meeting (1 February 1973), LPAC(73)9, 19 February 1973. SPB, 4th meeting (18 September 1973), ESRO/PB-S/MIN/4, 22 October 1973. See also ESRO/PB-S(73)14, 10 September 1973.

[247] Lord (1987), p. 11. Logsdon (1986) has pointed out that the American space science community in 1970 and 1971 congressional hearing had been vocal in its opposition to the shuttle programme.

[248] LPAC(73)9, *cit.*, p. 6. LPAC(73)4, 31 January 1973. More on this in chapter 14.

> *Who 'agreed'? Certainly not the scientists. They were not consulted (neither the younger ones nor the older ones) on policy matters. If they had been, they would have said that there were very few solid scientific arguments in favour of the Space Shuttle programme as currently envisaged.*[249]

To scientists it was clear that Spacelab should not significantly reduce, let alone exclude, other types of experimental activity in space. They were certainly not willing to subscribe to the French delegation's statement that "most of the funds for the Scientific Programme would be taken up by Spacelab for a long time to come, [therefore] it would be wiser to devote the funds for future studies to Spacelab experiments rather than automatic satellite experiments".[250] This was not the case, as we have seen, but the issue was only temporarily removed.

In conclusion, we can say that the decision on the 1974 study programme was typical of this transition period. The Old Guard of European space research was trying to keep its position under the impact of a new wave of political and technological novelties. They claimed skill and competence as well as the unique experience they had in Europe regarding space activities. Moreover they tried to resist the growing political influence over ESRO's scientific affairs, the marginalisation of science in the new framework of the European space effort, and the drift towards manned science missions. Their critics considered instead that the time was ripe to build a new European science policy in space, nurtured by transatlantic cooperation in the space shuttle programme and by strong national initiatives. In their opinion, the established leadership of the European space science community was not culturally prepared to design such a new policy; governments and science policymakers should do it. A compromise was agreed on in spring 1973 which left all options still open, but the real issues were still on the negotiating table: forthcoming discussions and decisions would hardly be peaceful.

Discussions, in fact, started soon, when the SPB was called to discuss the issues raised by its chairman, namely the opportunity of changing the scientific advisory system and the possibility of having special scientific projects outside the mandatory programme. We have already reported on Occhialini's arguing against Spacelab. In his long statement, Occhialini also opposed the idea of having optional Scientific Programmes. Here is an excerpt of his characteristic language:

> *It may be easy for the "big" member states of ESRO to bear such expenditure, but it is much more difficult for the "small" one to contemplate. [...] The chairman, who also represents the powerful CNES, cannot adopt the same attitude as the scientists of other delegations, who represent countries in which the economic and structural problems do not allow of a large-scale scientific research effort. This being the situation, extension to the scientific field of the policy of "à la carte" programmes (what a frightful expression!) already adopted for the application programmes would mean the "small" countries participating on an ever smaller scale in the Organisation's activity and the whole business becoming a nightmarish game of poker.*[251]

The discussion, however, did not produce any significant result. Some delegations recognised that, notwithstanding their drawbacks, the "à la carte" programmes could provide the only realistic solution for increasing the resources devoted to science. Europe was not lacking in ambitious ideas, argued the chairman of the LPAC, "it was for want of funds that most of these proposals got no farther". And the German delegation pointed out that the dEarth of new scientific ideas was due to the reduction of research activity in Europe:

> *One could not expect young scientists to go on showing the necessary enterprise to embark on projects if they knew that their activities had little chance of leading to*

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249 PBS, 8th meeting (13 June 1974), ESRO/PB-S/MIN/8, 31 July 1974, annex II, p. 1. Occhialini made this statement in his personal capacity, not on behalf of the Italian delegation.

250 ESRO/PB-S/MIN/4, *cit.*, p. 7.

251 ESRO/PB-S/MIN/8, *cit.*, annex, p. 2.

anything and that in any event they would have to pursue their research work for at least five years before they could carry out a space experiment.[252]

The discussion on the financial problem was concluded with the suggestion that the delegations should investigate at national level "how they might contribute financially to the new activities". As regards the delicate issue of the status of the LPAC and, more generally, of expert advice on future Scientific Programmes, the French delegation announced that it was preparing a document on this subject and it was agreed to discuss the question at a following meeting on the basis of this paper. Pending this document, which would bring up again for discussion the compromise agreed upon less than one year before, the relations between the SPB and the LPAC remained strained. This is reflected by the controversial replacement of two LPAC members, H. Elliot, whose term of office expired in March 1974, and G. Haerendel, who resigned in October for personal reasons. In both cases the SPB did not endorse the list of candidates the LPAC had suggested to the Director General and many negotiations were required before M. Rees and L. Houziaux were elected. The minutes do not make clear the reasons for this contrast, but it seems that the main objection regarded the inclusion among the candidates of W.I. Axford, a long-time advocate of the Out-of-Ecliptic and the cometary missions, who had just assumed the directorship of the Max-Planck-Institute für Aeronomie in Katlenburg-Lindau after working for many years in the United States. It is significant that the two newly-elected members were not active in space research, while the retiring members and Axford were.[253]

The French delegation's document was duly prepared and it prefigured a complete change in the system in force. The stated objective of the proposed new system was to comply with the SPB chairman's request that the present system of scientific advisory bodies be modified, "in order to encourage adequate consideration of new ideas and avoid that these were blocked because of conservatism originating from the required effort of reconversion they impose on European space laboratories".[254] The suggested way to reach this objective was to detach the scientific advisory bodies both from the laboratories involved in space research and from the ESRO Executive, and to put them directly under the aegis of the SPB. The proposal was articulated in three points. Firstly, the number of working groups should be increased in order to take into account the variety of space disciplines. Both the chairmen and the members of the groups would be appointed by the SPB after nomination from the national delegations, the ESRO Director General being called only to give his advice on the nomination of chairmen. Secondly, the LPAC should be replaced by a scientific committee whose membership would include the chairmen of the working groups and up to six scientific personalities outside the working groups, three of whom should be "généralistes". Finally, the establishment was foreseen of a higher authority ("Comité d'Orientation") called to advise once a year on the general outline of the programme in the framework of the whole of scientific research in Europe.

The counter-offensive against the French proposal came from ESRO's acting Director General, Roy Gibson, following a nervous discussion in the LPAC.[255] His argument rested on two main points. Firstly, he recalled that it was the role of the Director General to make proposals and recommendations about future programmes and he could only accomplish this task with the assistance of a highly qualified scientific advisory body. The same kind of expert advice was required during the implementation of approved projects, owing to the continuous evolution of scientific knowledge and

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252 ESRO/PB-S/MIN/8, *cit.*, p. 9. The LPAC chairman's quotation is from p. 11. The conclusive remark quoted below is from p. 14.

253 For the replacement of Elliot, the relevant meetings are: LPAC, 53rd meeting (29 March 1973), LPAC(74)11, 7 May 1974, and 55th meeting (13 September 1974), LPAC(74)17, 15 November 1974; SPB, 8th meeting (13 June 1974), ESRO/PB-S/MIN/8, 31 July 1974, and 9th meeting (23 October 1974), ESRO/PB-S/MIN/9, 4 November 1974. For the replacement of Haerendel, the relevant meetings are: LPAC, 57th meeting (7 November 1974), LPAC(74)20, 27 November 1974, and SPB, 10th meeting (20 November 1974), ESRO/PB-S/MIN/10, 20 January 1975. For the role of Axford in the OOE mission, see Hufbauer (1993).

254 ESRO/PB-S(74)35, 10 October 1974, p. 1 (our translation from the original French text).

255 LPAC, 57th meeting (7 November 1974), LPAC(74)20, 27 November 1974, pp. 3-5. Gibson's document is ESRO/PB-S(74)35, add. 1, 18 November 1974.

technical facilities. If the SPB established its own scientific advisory body there would be a risk of divergence and conflict which could jeopardise the very possibility of taking decisions. In this respect, Gibson recalled the agreement reached in November 1973, according to which there should not be in ESRO two possibly competing scientific advisory bodies, a wide circulation of information being however assured among the Executive, the LPAC and the SPB. The Director General did not tackle the delicate issue of impartiality, on which the LPAC had shown great sensitiveness: "Impartiality would certainly be no better guaranteed if the Scientific Committee members were nominated by delegations to the Scientific Programme Board," van de Hulst had commented in this respect, while the French LPAC member J. Steinberg had "very much regretted the implication in the French Delegation's proposals that the present LPAC was not impartial.[256]

Gibson's second point hit at the core of the argument of the French document, namely the role of the SPB. It was not the Board's task to plan future programmes, he argued, recalling that, according to its terms of reference, the SPB was a delegate body of the Council whose task included "the selection and adoption of *specific* scientific projects within *the overall programme* and the ceiling *approved* by the Council". Moreover, Gibson pointed out that the draft ESA Convention then under discussion stated that "the *Council* approves the *Scientific Programme* [...] and that a *Programme Board* is created to rule on the questions regarding the approved programme".[257] In other (and more brutal) words, you the SPB do your job of approving specific projects and controlling their execution, and leave to the Council, the ESRO Director General and the LPAC the task of defining a scientific policy and planning future programmes. In the event, pending the discussions in progress on the draft ESA Convention, the SPB agreed not to tackle the issue again and the whole matter was dropped.[258]

3.7 The selection of feasibility studies

The mission definition studies approved by the SPB were duly carried out from March to November 1974 by twelve groups of European scientists and ESRO staff members, under the supervision of the Directorate of Programmes and Planning's Space Missions Division (Table 3-6). Altogether, more than 50 external scientists were actively involved in different stages of the work, the LPAC and the SPB being called to discuss progress reports on ongoing studies. In addition, the Executive organised in October a symposium on Space Astrometry in order to ascertain the degree of interest and support in this field among the scientific community.[259] On 4 to 5 February 1975, the Executive discussed with NASA officials those projects which had already been identified as candidates for possible cooperation, in order to review the respective positions and identify future actions after the preliminary study phase. Finally, later in February, the Astrophysics and Solar Physics Working Groups were requested to discuss the results of the studies and the Executive's conclusions, in order to assess the candidate missions from the scientific point of view and make recommendations to the LPAC on those missions which should be subjected to Phase-A studies during 1975.[260]

Both Working Groups had closely followed the activity of the mission definition groups, discussing important issues about the scientific interest and technical feasibility of the various options emerging from the studies. Each Group discussed those missions that fell under its competence, the AWG also giving its advice about the astrometry project, the Out-of-Ecliptic and Stereoscopic mission, and the Solar Telescope Cluster, which fell within the competence of the SSWG. As financial constraints did

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256 LPAC(74)20, *cit.*, p.4.

257 ESRO/PB-S(74)35, add. 1, *cit.*, pp. 2-3. Our translation from the original French text. Emphasis in the original.

258 SPB, 10th meeting (20 November 1974), ESRO/PB-S/MIN/10, 20 January 1975, p. 7.

259 The symposium was held in Frascati on 22-23 October 1974, with the participation of about 40 astronomers and geophysicists: *ESRO Bulletin*, No. 26 (December 1974), p. 33.

260 ESRO/PB-S(75)2, 7 March 1975. See also LPAC(75)3, 18 February 1975. The reports on the 13 projects studied in 1974 are MS(74)24 to MS(74)36.

not allow more than five Phase-A studies to be performed in 1975, each Working Group was expected to recommend no more than three projects.[261]

3.7.1 The recommendations of the Solar System Working Group

The easy task for the SSWG was to recommend a Phase-A study on the AMPS (Atmosphere, Magnetosphere and Plasmas in Space) programme; the difficult one was to successfully advocate missions in two fields alien to ESRO's tradition, namely solar physics and planetary studies. ESRO's participation in the Spacelab AMPS programme was definitely in line with the Organisation's record of atmospheric and magnetospheric studies, and enjoyed the support of a well-established sector of the European space science community. The AMPS programme aimed at exploring the Earth's neutral and plasma environment by the use of sophisticated instrumentation on board Spacelab over a 5 to 10 year programme of flights. Besides the "core" devices or general-purpose instruments to be provided by NASA and ESRO, it was foreseen that the AMPS payload might also include instruments provided by independent scientific groups. The interest of European space scientists in such a programme was strong, as revealed by the fact that, in response to a NASA Announcement of Planning Opportunities, about 20% of the proposals came from ESRO member states. Eleven European scientists were members of the AMPS Science Definition Working Group.[262] At the ESRO/NASA review meeting it was recognised that the technical and managerial interfaces were good and NASA stated that they hoped to effect a rapid build-up to a full AMPS payload in the early 1980s. Therefore, despite some opposition from its chairman, the French astronomer A. Dollfus, the SSWG recommended that ESRO should participate in the AMPS programme, starting immediate feasibility studies on a laser facility for sounding the atmosphere in the region around 100 km altitude (LIDAR) and on purpose-built subsatellites and launching devices. The possibility was also discussed that the LIDAR might be included in the payload of the first Spacelab mission.

More controversial was the ESRO contribution to the Solar Telescope Cluster (STC) envisaged by NASA for a dedicated solar physics Spacelab flight. In a first phase, the European solar physics community and the SSWG had been unable to reach unanimous agreement on the choice of what kind of telescope should be contributed by ESRO. It was then suggested that the Executive should study the technical, managerial and cost aspects of the different options. In the event, following the results of this study, the SSWG had endorsed the Executive's proposal to build an X-ray grazing incidence telescope, but emphasised the desirability of designing the STC mission as a truly collaborative venture in solar physics, the scientific programming of all instruments being performed by the interested scientists on both sides of the Atlantic.

When the time came to decide on feasibility studies, however, no definite plans had been prepared by NASA for the build-up to a full STC payload. The Executive concluded therefore that "it was not clear what ESRO would be contributing to in 1980," and proposed that no Phase-A studies should be performed in 1975. The Working Group did not endorse this position. Two of its members, C. Jordan from the Culham Laboratory and M. Pick from the Paris-Meudon Observatory, strongly advocated the project, arguing that "the consequences [...] of a delay in the project of 2 to 5 years [...] would imply the loss of a healthy solar physics community in Europe". The discussion eventually led the Working Group to conclude that a Phase-A study of the grazing incidence telescope should be performed

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261 The AWG discussed the ongoing mission studies at its 11th meeting (7 September 1974), ASTRO(74)9, 23 October 1974, and 13th meeting (6 December 1974), ASTRO(74)13, 21 January 1975. The final recommendations were discussed at the 14th meeting (20-21 February 1975), ASTRO(75)6, 27 May 1975, and reported in ASTRO(75)3, 25 February 1975. The SSWG discussed the ongoing mission studies at its 9th meeting (24-25 April 1974), SOL(74)3, 3 September 1974, and 10th meeting (19-20 September 1974), SOL(74)9, 27 November 1974. The final recommendations were discussed at the 12th meeting (17-18 February 1975), SOL(75)4, 23 May 1975, and reported in SOL(75)3, 20 February 1975. The two Working Groups' recommendations are also reported in ESRO/PB-S(75)2, *cit.*, annexes 3 and 4, respectively.

262 SOL(74)3, *cit.*, p. 3. The NASA announcement was circulated in November 1973, as reported in ESRO/PB-S(74)8, 29 January 1974.

anyway, in consideration of the fact that "this telescope would yield excellent scientific results, even in the most pessimistic case that NASA's contribution [to the STC] was very modest".[263]

The other important project for which a Phase-A study was recommended by the SSWG was the Out-of-Ecliptic and Solar Stereoscopic Mission (OOE). The history of this project dated back to a suggestion made in 1965 by the leading German astrophysicist L. Biermann. A good scientific constituency had grown up since, both in Europe and the United States, and a dual-purpose mission was eventually envisaged: (a) the *in situ* observation of the interplanetary environment outside the very thin disc close to the ecliptic within which all measurements had so far been confined; (b) the stereoscopic observation of the Sun by coordinated measurements from the out-of-ecliptic spacecraft and from the Earth or near-Earth orbit.[264] The study performed in 1974 by a joint ESRO/NASA team discussed two alternative OOE missions. The first foresaw a single spacecraft travelling out of the ecliptic up to approximately 60°, under the thrust of a Solar Electric Motor currently being studied at the Jet Propulsion Laboratory (JPL). In this so-called "Solar Electric Propulsion" (SEP) mission ESRO would provide the science module. The second mission foresaw the simultaneous launch of two spacecraft from the Shuttle towards Jupiter. The two probes would pass close to the planet and be diverted by its gravitational field in such a way that one would pass over the North Pole of the Sun and the other over the South Pole. In this so-called "Jupiter Swing-By" (JSB) mission each space agency would provide one spacecraft. In both options, NASA would provide the launcher and ground support, while the scientific experiments would be shared by European and American scientists.

In this case too, however, the ESRO decision makers had to cope with the uncertainties regarding NASA's plans. In November 1974 the American space agency terminated JPL's programme to develop ion propulsion for the OOE mission. As a consequence, the SEP mission would not be possible in the early 1980s. This, according to the Executive, was a good reason for discarding this option, the other being that "ESRO did not wish to become involved in a project which was closely tied to a major development such as SEP, which was beyond its control".[265] By the time the SSWG was called to issue its recommendation, the dual spacecraft JSB mission was also jeopardised because of NASA's budgetary constraints. A possible fall-back JSB mission had been suggested during the ESRO/NASA programme review, namely that only the ESRO spacecraft be launched, NASA still providing the launcher and ground support. The SSWG discussed at length whether the one-spacecraft OOE mission was still attractive enough to pursue within the foreseen timescale, some of its members arguing that a new mission definition study was required in order to assess its real scientific interest. In the event, the Working Group recommended by a majority vote that a Phase-A study on the ESRO spacecraft for the OOE mission should be performed anyway, even considering the possibility that it might fly alone if NASA decided not to proceed with the dual-spacecraft version.

Besides the three projects described above, for which a feasibility study was recommended, three others fell within the competence of the SSWG: the Jupiter orbiter and probe, the astrometry mission and the cometary mission. The first foresaw sending a NASA Pioneer spacecraft carrying American and European experiments to study the atmosphere and magnetosphere of the Solar System's biggest planet as well as the properties of some of the Jovian satellites. By February 1975, however, it was evident that such a mission could hardly be recommended. Firstly, as the ESRO Executive pointed out, "the proposed hardware contribution was of less interest to the Organisation than in other projects under study, [...] ESRO would prefer to offer more challenging work to European industry".[266] Secondly, the Pioneer Jupiter Orbiter (PJO) was in competition with other missions to Jupiter and Uranus that NASA was planning for the period 1979 to 1981. Therefore, the SSWG regretfully concluded that studies on the PJO mission should be interrupted and recommended that a real strategy for European planetary science be studied by ESRO in view of possible cooperation with NASA in other planetary missions beyond 1980.

263 SOL(75)4, *cit.*, pp. 6-7; SOL(75)3, *cit.*, p. 2.
264 Hufbauer (1993).
265 SOL(75)4, *cit.*, p. 11. See also Hufbauer (1993), p. 180.
266 SOL(75)4, *cit.*, p. 9.

As to the astrometry project, its objective was to measure stellar positions, proper motions and trigonometric parallaxes, with an accuracy at least 10 times better than that of present observations. The project, as we have anticipated, was discussed at a symposium organised by ESRO in October 1974 and three options were studied: an automatic satellite of the Thor-Delta (TD) class, a telescope to be mounted on Spacelab and an astrometry instrument in the focal plane of the Large Space Telescope. While not being particularly interested in such a mission, the SSWG recommended that a mission definition study should be initiated "in order to bring the definition of astrometry projects to the same level as the other 12 missions proposed". The Spacelab telescope, in particular, was considered worthy of such a study.[267]

Finally, the SSWG took into consideration the probe to comet Encke, based on the German Helios spacecraft technology. Cooperation with NASA in this project proved impossible in view of the latter's plans to proceed independently with a study of a Mariner spacecraft mission to Encke. This was the first reason for the ESRO Executive's proposal not to proceed with further studies of such a project, the second being the high cost *vis-à-vis* the limited data return (approximately 30 hours observation time). The latter argument was strongly opposed by the German members of the Working Group, who argued that "it was not quite fair to judge a mission in terms of the volume of data provided," and that "the value of the mission should [not] be judged by the bit rate per accounting unit that would accrue".[268] In the event, the Working Group agreed on a proposal by J. Blamont to explore the possibility of a special project with the German authorities or, alternatively, to re-consider the cometary mission in cooperation with NASA, in the context of the envisaged strategy for planetary science.

3.7.2 The recommendations of the Astrophysics Working Group

The missions falling within the competence of the AWG had been thoroughly discussed by interested scientists at seminars held in ESTEC on 3 to 5 December 1974. The Working Group's task was essentially to make a choice between complementary projects in four research areas. Firstly, there were the two infrared astronomy projects LIRTS and CIRES. The AWG discussed at length these two options for entering this new and fascinating field of astronomy. Many doubts had been expressed both in the US and in Europe about the feasibility of useful IR astronomy measurements from Spacelab, both because of possible contamination problems and because of the short duration of Spacelab flights, and these doubts were echoed in the AWG discussions. Doubts were also expressed about the satellite project CIRES. This was intended to serve two scientific objectives, i.e. a complete and systematic exploration of the IR sky and a measurement of the spectrum and anisotropy of the diffuse background radiation. Opinions were divided about which of these objectives should be privileged, some preferring a dedicated survey satellite, others advocating a ground-based instrument or a Spacelab-borne specialised experiment to measure the diffuse background.

In the event, the AWG endorsed the Executive's proposal to perform a Phase-A study of the LIRTS, defined as an infrared telescope of 2 to 3 metre diameter, operating at ambient temperature and mounted on a stabilised platform on board Spacelab. Two important qualifications, however, were attached to the AWG recommendation. First, that the size of the telescope should not be reduced below 2 metres; secondly, that a viable programme required a flight frequency of one 7-day mission per year. Four such missions or, equivalently, two 30-day missions were required to provide coverage of the whole celestial sphere. Should one of these conditions not be fulfilled, the AWG stressed, a reconsideration of the project and of its desirability would be necessary. As to the CIRES, the AWG acknowledged that NASA was studying an infrared satellite to be launched before 1980. As ESRO's financial constraints and Europe's technical expertise in the field of cryogenics did not allow for a timely launch of CIRES, the survey aspect of the mission was not worth pursuing. The AWG suggested studying a small Spacelab instrument for measurement of the background microwave

[267] SOL(75)3, *cit.*, p. 4.

[268] SOL(75)4, *cit.*, p. 17. The first quotation is from W.I. Axford, the director of the Max-Planck-Institut für Aeronomie in Lindau, the second from D. Offermann, of Bonn University.

radiation and stressed the importance of Europe developing expertise in the field of cryogenics for infrared and cosmic-ray missions.

The second research area was that of optical and ultraviolet astronomy. Here little doubt existed about the great opportunity offered by the NASA Large Space Telescope (LST) project. In the AWG's opinion, "if [the LST] is realised in about its presently foreseen form, it will dominate astronomical progress in the 1980's". It was essential that such a facility should be accessible for European astronomers, and that all necessary steps should be taken to ensure a reasonable participation in the LST programme. The AWG acknowledged, however, "the uncertainty of NASA's plans regarding the mission and its latest ideas regarding the possible form an ESRO contribution could take".[269]

Following preliminary contacts between the two space agencies and after discussions within the AWG, ESRO had studied two focal-plane instruments for the LST, a High Resolution Camera (HRC) and a Faint Object Spectrograph (FOS), together with a photon counting system which could be applied to both. NASA had indicated its preference for ESRO to produce the HRC as it felt that the FOS should be assigned as a result of a competitive call for proposals. The reward for ESRO providing an instrument would be a certain guaranteed amount of observing time for European astronomers. This possible arrangement drew some criticism from US astronomers, who felt that all LST instruments should be assigned on a competitive basis and did not like a fraction of the observing time being blocked off from their community. In Europe, too, some questioned why ESA should invest so much in the LST development programme in order to have access to what European astronomers could get anyway through normal competition, since NASA intended to open its Announcements of Opportunity to the entire scientific community. By early 1975 the LST Science Working Group in the US had accepted the principle of the non-competitive selection of one focal-plane instrument to be provided by ESRO/ESA. This opened the way to real negotiations between the two agencies, the outcome of which was however still unpredictable owing to the complex scientific, technical and institutional problems involved.[270]

Equally unpredictable was whether the LST project could pass the formidable obstacle of Congressional approval, and if so in what form. In June 1974 the House had denied funds for continuing planning studies on the telescope in 1975. Only after strong lobbying and a joint House-Senate conference were $3 million appropriated of the $6.2 million originally requested by NASA. A new start in 1976 was out of the question, and no guarantee existed that the building of the LST in 1977 might eventually be approved. European participation in the LST programme was one element of NASA's strategy to win this approval; the other was to redesign the telescope in order to reduce its costs, and performance as well. By the end of 1974, the Science Working Group had reluctantly accepted a reduction of the telescope mirror to 2.4 metres from the planned 3 metres. NASA, however, was also studying the possibility of a further reduction to 1.8 metres, with only two scientific instruments, something that astronomers considered a real betrayal of their expectations from a "large" space telescope. Eventually, the 2.4-metre telescope was approved by the NASA Administrator and the struggle to win federal funding started again. It was expected that the situation on the LST and the ESRO-NASA collaboration would be clarified in June 1975.[271]

The relative uneasiness of the AWG *vis-à-vis* the uncertain LST situation is reflected by the discussion on the second UV astronomy project, the One-Metre Ultraviolet Spacelab Telescope (MUST). Should the LST go ahead there were good reasons for discontinuing studies on the MUST. In the event, however, that the NASA project should be jeopardised or the ESRO cooperation should not be pursued, Europe could not miss the opportunity to develop its own project. The AWG, in fact, recommended that the MUST should be kept under study anyway, noting that the photon counting detector being studied for the LST could be successfully used on the European telescope.

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269 ASTRO(75)3, *cit.*, p. 2; ASTRO(75)6, *cit.*, p. 11.

270 Smith (1989), pp. 135-140. See also Bonnet & Manno (1994).

271 Smith (1989), pp. 121-135 and 143-154.

The third important choice was between the two high-energy astrophysics projects, i.e. the Spacelab-borne X-ray spectropolarimeter EXSPOS and the gamma-ray astronomy satellite LOGOS. The Working Group endorsed the Executive's proposal that the former should be studied at Phase-A level, as this mission was better defined as regards both the scientific objectives and the proper instruments to achieve these objectives. According to the AWG, EXSPOS was "a typical Spacelab payload representative of a whole class of high-energy astrophysics Spacelab payloads". It was assumed that one flight per year represented a reasonable time scale and that seven or eight flights would be required to cover all known X-ray sources.[272]

Finally, the AWG had to advise on the three proposals on cosmic rays. The mission definition group had concluded that a superconducting magnet on board Spacelab was the facility required to meet all important scientific objectives. This, however, could hardly be available in the 1980s and therefore two satellite payloads were proposed as possible alternatives: one for studies on the isotopic composition and another for investigating elemental abundances at high atomic weight. The AWG, however, did not recommend any of these satellite missions for a Phase-A study, but stressed the importance of keeping the superconducting magnet facility for Spacelab under study.

In conclusion, among the mission proposals falling under its competence, the AWG recommended the participation in the LST (with the MUST a subordinate option), the Spacelab infrared telescope LIRTS and the Spacelab X-ray facility EXSPOS as scientific projects to be studied in 1975 at Phase-A level. The Working Group also endorsed the SSWG's recommendations on the OOE and the astrometry missions, but not that regarding the Solar Telescope Cluster. The AWG proposed, in fact, that a new mission definition study be carried out to re-define the project as a Spacelab "lone-flyer" independent of other STC elements.[273]

3.7.3 The LPAC makes its recommendation and the SPB endorses it

The results of the mission studies, together with the ESRO Executive's conclusions and the Working Groups' recommendations, were presented to the LPAC on 27 to 28 February 1975.[274] Introducing the discussion on behalf of the Executive, the acting Director of Planning and Future Programmes, A. Dattner, stated that the resources available in 1975 would only permit the execution of 5 Phase-A studies out of the 6 recommended by the SSWG and AWG. The ensuing discussion hardly added any new elements to what had been extensively discussed within the Working Groups. Their conclusions were essentially endorsed by the Committee, whose main task was now to decide which of the 6 recommended Phase-A studies should be discarded. In the event, this was the X-ray telescope designed for the Solar Telescope Cluster, as was to be expected in the light of the Executive's position. The LPAC recognised that the uncertainty of the NASA planning was the main reason for not pursuing further studies of the envisaged ESRO instrument. It endorsed, however, the AWG's recommendation that the Spacelab grazing incidence telescope should be studied as a "lone-flyer" and stressed that such a study should be given "first priority" among the category of lower level studies to be performed in 1975. As regards the LST/MUST question, the Committee stated that ESRO should carry out further definition studies on the LST instruments until the end of June, pending a clarification of the LST situation. If at that time a decision to go ahead on LST were not reached in the US or a suitable form of ESRO participation were not yet defined, Phase-A studies on the MUST should be initiated. Moreover, it was agreed that a reconsideration of a possible cooperation on the LST would be called for if a mirror diameter of 2.4 m could not be achieved.[275]

Following the LPAC meeting, the ESRO Executive proposed that the SPB should endorse a study programme for 1975 which included the 5 Phase-A studies recommended by the LPAC as well as some additional lower level (i.e. mission definition or technological) studies on projects which were

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272 ASTRO(75)3, *cit.*, p. 2; ASTRO(75)6, *cit.*, p. 13.

273 ASTRO(75)2, *cit.*, p. 2.

274 LPAC, 58th meeting (27-28 February 1975), LPAC(75)5, 14 April 1975.

275 LPAC(75)5, *cit.*, p. 5-6. The LPAC recommendations are reported in annex 1. See also ESRO/PB-S(75)2, *cit.*, pp. 3-6.

not supposed to be candidates for ESRO's next scientific project, but which might become candidates for subsequent projects. Among the latter, first priority was given to the Grazing Incidence Solar Telescope (GRIST), as recommended by the LPAC.[276]

The discussion at the SPB meeting did not touch on major issues. The Chairman recalled the "somewhat critical attitude that he had come to adopt, in recent meetings, of the process leading up to the preparation of the Organisation's Scientific Programme," but now he wanted to state that "he was extremely satisfied with the way in which the work had gone ahead within the Executive, the Working Groups and the LPAC to achieve the definition of the proposals which were about to be submitted to the Programme Board".[277] Delegations generally supported the LPAC's and Executive's proposals, although the German delegation regretted that the studies on a cometary probe had to be abandoned. In conclusion, the SPB approved without any further comment the proposed study programme for 1975 (Table 3-7).

Table 3-7: ESA study programme for 1975 – 1976

	Projects	Remarks
Phase-A studies of candidate projects among which a selection would be made in 1976 of ESRO's next scientific project(s) following Exosat	LIRTS	An IR telescope with a 2 to 3 m mirror and pointing accuracy of about 2 arcsec.
	LST / MUST	Further studies of the LST focal plane instrument (Faint Object Camera and Photon Counting Detector). Depending on the LST status, either Phase-B studies would be initiated or Phase-A studies on MUST would be carried out.
	EXSPOS	A Spacelab instrument to study spectra and polarisation of X-ray sources in the 2 to 10 keV energy range.
	AMPS	NASA's Spacelab programme for atmospheric, magnetospheric and plasma studies
	LIDAR	A laser facility for active atmospheric sounding in AMPS missions
	Subsatellite	Subsatellites for use with AMPS missions
	OOE / Stereo	A medium-cost spacecraft as contribution to co-operative dual-spacecraft project. Study of the implications of launching ESRO spacecraft alone.
Mission definition studies (including studies on Shuttle-independent contingency missions)	GRIST	A grazing-incidence X-ray solar telescope for Spacelab.
	Others	Astrometry mission, Infrared Diffuse Background Satellite (IRSAT), Solar Probe, Extreme UV and X-ray Satellite (EXUV), Dumb-bell mission, Sun-Earth Observatory and Climatology Satellite (SEOCS), Transient X-ray Sources Satellite.

[276] ESRO/PB-S(75)2, *cit.*, pp. 7-8.
[277] SPB, 11th meeting (26 March 1975), ESRO/PB-S/MIN/11, 24 April 1975, p. 2.

3.8 Outlines for European space research in the 1980s

What comments can a historian make on the conclusion of this phase of the selection process of ESRO's next scientific project? The first concerns the process itself, i.e. its peculiarity *vis-à-vis* that in use in the United States. Here NASA controlled the whole process of selecting both the missions to be developed and the scientists for a particular mission. In order to cope with the intense competition among scientists for access to space, "NASA created a strong Headquarters organisation with a scientific and technical staff to establish policy, formulate the research programme, establish scientific missions, and select the scientists for those missions".[278] This was hardly the case for ESRO for which, as we have seen, it was the continuous negotiation within the European space science community that led to the progressive definition of the Organisation's Scientific Programme. Out of the two dozen missions suggested by the scientific Working Groups in December 1973, five had survived by March 1975, after intensive study and discussions at various levels of the ESRO advisory system. Hardly more than one or two could eventually be adopted at the end of the process, by mid-1976. ESRO of course played an important role, by directing mission definition and feasibility studies, by keeping technical and institutional contacts with NASA, and by assuring circulation of ideas among scientific groups in Europe. Nevertheless, it was up to the scientific leadership in the various disciplines and national scientific communities to approve the studies, to endorse cooperative projects and to orient the circulation of ideas. This was what ESA's present Director of Science Roger Bonnet called "a bottom-to-top approach whereby the community is the only source of the ideas and of the concepts of missions, the Agency being there only to transform these ideas and concepts into reality".[279]

Our second comment covers the five projects selected for feasibility studies. How do they relate to ESRO's established scientific tradition? Firstly, we can point out that European solar physicists and planetary scientists had again failed to obtain proper consideration for a mission in their respective fields. The "low level" study of an X-ray solar telescope could hardly satisfy the hopes and expectations raised by the envisaged Spacelab STC mission. As a matter of fact, the lure of such a mission proved doubly fallacious, as it also prevented the European solar physics community from designing an independent satellite project capable of competing successfully with the other proposals. As to planetary science, it confirmed itself as the weakest element in European space science. The high cost of launchers and of deep space tracking and telemetry stations made planetary missions only feasible in cooperation with NASA, but the latter's vigorous programme in the field (the Pioneers and Mariners, and the forthcoming Voyagers) could only place Europe in a subordinate role that ESRO policymakers could hardly accept.

Secondly, we can underline the great importance of astronomical projects, certainly a novelty after the previous disappointments of the LAS and UVAS projects in the 1960s and the LPAC policy statement of 1970.[280] The envisaged participation in the Space Telescope appeared as one of the central elements in the Organisation's scientific planning for the 1980s while, with the LIRTS, European astronomers were given a chance to enter the field of infrared observations of celestial objects. Just as X-ray astronomy had marked in the 1970s a dramatic revolution in the scientific knowledge of the skies, so infrared astronomy promised to do in the 1980s. The Dutch IR-astronomy satellite IRAS, under development in collaboration with NASA, and the envisaged ESRO LIRTS promised to give Europe a forefront position in this new field (Figure 3-2).[281]

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278 Naugle (1991), p. 116.

279 Bonnet (1993), p. 2.

280 See chapters 6-8 in Volume 1.

281 Beckman (1977). The important role of Spacelab for infrared astronomy was very soon recognised. ESRO set up a study group to design a possible infrared astronomy payload for Spacelab in late summer 1973, i.e. soon after the approval of the Spacelab programme by the ESRO Council and before the first discussions in the AWG and the LPAC: ESRO/PB-S(73)19, 31 October 1973. About IRAS, see ESRO/PB-S(75)6, 11 March 1975.

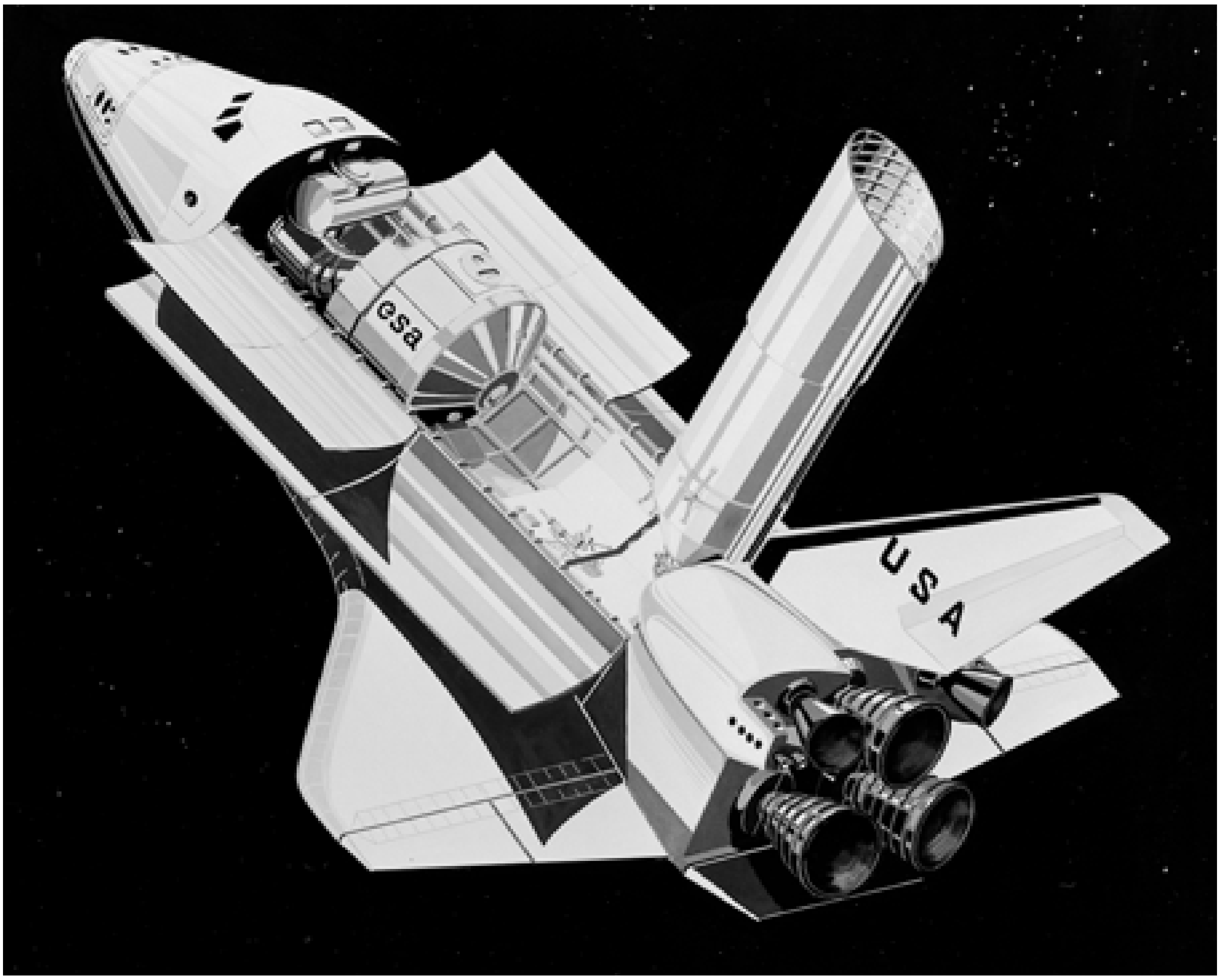

Figure 3-2: Artist's impression of the Large Infrared Telescope for Spacelab (LIRTS), in operational mode aboard the Shuttle (Beckman, 1977)

Alongside the novelty of ambitious astronomical projects there was the confirmation of the important role of atmospheric and magnetospheric studies in the ESRO programme. The AMPS programme was in fact perfectly in line with previous (sounding rockets and ESRO-I) and ongoing (GEOS and ISEE-B) ESRO activities in this field. The same can be said of EXSPOS, which met ESRO's ongoing effort in X-ray astronomy (Exosat), even though some scientists would have preferred the gamma-ray satellite LOGOS as a representative project in the field of high energy astrophysics.

Finally, we should underline the originality of the OOE project. For the first time in the history of astronautics, a spacecraft would be flung out of the ecliptic plane, i.e. the flat region around the Sun where all solar system bodies revolve, fulfilling scientific objectives which ran from solar physics to cosmic-ray studies and from solar wind measurements to studies of the interplanetary environment.[282] Science historian K. Hufbauer (1993) has told in detail how the idea of such a mission was born and eventually developed, first in Europe and then in the USA. As a matter of fact, this was a rather controversial project, whose scientific rationale was continuously negotiated because of the several changes in its concept (SEP vs JSB, single- vs dual-spacecraft, solar physics vs interplanetary medium studies, ESA/NASA collaboration vs pure ESA mission, etc.). The progressive definition and refinement of the project and its successful passing through ESRO/ESA's decision-making system, well represented, in our opinion, the characteristic "bottom-to-top" approach we discussed above.

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282 Page (1975).

Our third comment relates to the importance of the Shuttle/Spacelab system in ESRO's scientific planning in the mid-1970s. Three projects – AMPS, EXSPOS and LIRTS – were designed for use with Spacelab, and indeed the fulfilment of their scientific objectives required many flights of the Shuttle-borne laboratory spread over several years. The LST and the OOE mission required the Shuttle as launcher, except for the fall-back version of the latter, which required an Atlas-Centaur launcher for the one European spacecraft. We should recall that, in the case of EXSPOS and LIRTS, alternative satellite projects had been discarded, i.e. LOGOS and CIRES. Both of these had been defined as "high cost" projects by the Executive, as compared to the "low cost" and "medium cost" labels assigned to EXSPOS and LIRTS, respectively. This assessment, however, did not include recurring costs typical of Spacelab missions (e.g. maintenance, refurbishment and repeated launches and operations). Whatever good scientific reasons existed for preferring EXSPOS and LIRTS to LOGOS and CIRES, respectively, the preference was also based upon highly optimistic expectations about the performance of the Shuttle/Spacelab system. Indeed, in the ESRO/ESA planning for Spacelab utilisation, it was envisaged that more than 20 NASA missions with European participation and seven fully European missions should be performed in the period 1980 to 1985.[283]

By the autumn of 1975, the Executive became well aware of the fact that this dependence on the Shuttle/Spacelab system was an "undesirable situation to be in because [...] the Shuttle could be subject to delays and modifications".[284] Sound planning demanded that alternative, Shuttle-independent scientific missions should be available to the Agency. The Director General addressed a letter to the space science community, urging proposals for "scientific missions which do not have to be launched with the Shuttle".[285] Following this consultation, it was decided that four new definition studies should be carried out in 1976 on Shuttle-independent contingency missions: a Sun-Earth Observatory and Climatology Satellite (SEOCS); a "Dumb-bell" mission, foreseeing two spacecraft linked by a wire or tether for magnetospheric studies; an Extreme Ultraviolet and X-ray Survey Satellite (EXUV); and a Transient X-ray Sources Satellite.[286]

Finally, our last comment concerns the cooperation with NASA, which was to become more and more imperative because of the imposed ceiling on the scientific budget against the increasing sophistication and cost of space projects.[287] The two most important projects in ESRO/ESA planning, the LST and OOE missions, could be possible only with NASA, the former by definition and the latter, in either the twin- or the single-spacecraft version, because of the launching vehicle and deep space facilities. Of the three others, AMPS was essentially a NASA programme with European participation, and EXSPOS and LIRTS were designed as pure ESRO/ESA ventures. These, however, required full availability of Spacelab facilities for several Shuttle missions, thus depending on some kind of agreement and/or cooperation with NASA. More generally, the foreseen use of the Space Shuttle in the 1980s as a unique means for carrying scientific experiments into space gave NASA great control over ESRO/ESA's Scientific Programme, as the use of Ariane would probably be too costly for the scientific budget. This circumstance was a cause of concern within the European space science community, which found an echo in the discussions of ESA's advisory bodies.[288]

In conclusion, in one way or another, in the 1970s a large part of ESRO/ESA's scientific planning depended on that of its American counterpart. The relations between the two space agencies became closer and closer at both the technical and institutional level during the decade. Scientific contacts intensified, both for discussing ongoing joint projects and for future planning. European scientists were invited to participate in the NASA scientific advisory bodies and, conversely, representatives of NASA's scientific staff joined the Astrophysics and Solar Physics Working Groups. As ESRO pioneer

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283 ESA Annual Report 1975, p. 71. We should also recall that first priority among mission definition studies had been given to the GRIST, also a Spacelab payload. Regarding NASA's optimistic claims about the Shuttle performance and cost-effectiveness, see Logsdon (1986).

284 ESTEC's G. Haskell at the 15th SSWG meeting (6-7 October 1975), SOL(75)12, 1 February 1976, p. 12.

285 ESA/SPC(75)19, 5 December 1975.

286 ESA/SPC(76)6, 11 February 1976, and Add. 1, 27 February 1976.

287 Manno (1980).

288 SAC, 1st meeting (24 February 1976), SAC(76)4, 7 April 1976, p. 12.

Reimar Lüst would later state, the relationship between Europe and the United States in space cooperation was leaving the period of tutorship to enter that of junior partnership.[289] Although there were obvious advantages to be gained from cooperation with NASA, this also implied being subject yearly to the uncertainties of Congressional decisions which could strongly affect ongoing or future programmes and could result in unilateral postponement or cancellation of joint projects. The experience, in fact, often proved frustrating.[290]

3.9 From ESRO to ESA

The approval of feasibility studies of possible future projects was one of ESRO's last legacies to ESA. In June 1975 the new Agency came into *de facto* operation and a new committee structure was set up. The SPB was replaced by a Science Programme Committee (SPC), whose formal status as a subordinate body of the Council was lower than that of a Programme Board (Figure 3-3). In this period, as was to be expected, the question of scientific advice again came under discussion. In September the Director General proposed to replace the old-standing LPAC with a new Science Advisory Committee (SAC), reporting to him and responsible for providing advice on the whole of the Agency's Scientific Programme. According to his proposal, the members of the SAC and its chairman would be chosen by the Director General and the Committee would work in close contact with the Directorate of Planning and Future Programmes. Moreover, a number of scientific Working Groups would be set up, of which the chairmen and half the members would be nominated by the Director General, the other half being co-opted by their colleagues. A main change in the status of these Working Groups was that they would henceforth report to the Director General and not to the SAC. Four Working Groups were eventually set up: Astronomy (AWG), Solar System (SSWG), Life Sciences (LSWG) and Material Sciences (MSWG).[291]

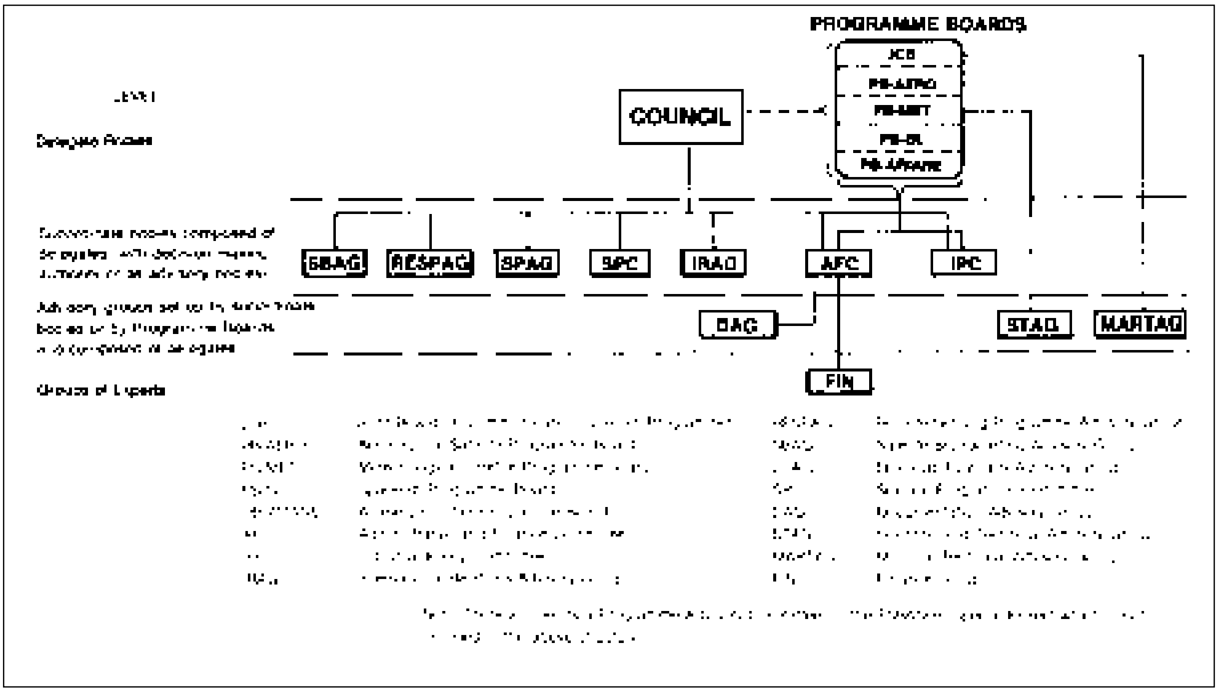

Figure 3-3: The Agency's Committee Structure in 1976.
(Source: ESA Annual Report, 1976)

[289] Lüst (1987). The evolution of ESRO/NASA relations is dealt with in detail in chapters 13 and 14 of Volume 1.

[290] Bonnet & Manno (1994), chapters 4 and 5.

[291] ESA/SPC(75)8, 16 September 1975; ESA/SPC(75)17, 27 November 1975.

When called on to comment on this proposal, which aimed at integrating the scientific advisory system within the Executive's activity, most SPC delegations expressed strong reservations. "The Science Programme Committee must be careful that it was not confronted with a ready-made programme which it was only requested to 'rubber-stamp'," the German delegation warned. The SPC should obtain direct advice from its own subordinate bodies, argued the Belgian delegation, adding: "The Director General [has] the right to consult whom he pleases, but he should not ask the SPC to consecrate his choice". Other delegations supported the view that the SPC should set up its own advisory body as other Programme Boards did, or at least appoint part of the SAC membership.[292] Reservations on the Director General's proposal were also expressed by the AWG, whose members felt that the new structure would not be representative of the European scientific community. They argued that part of the membership of the Working Groups and the SAC should be appointed by external scientific bodies such as the European Science Foundation or the European Physical Society.[293] In the event, however, the Director General's position prevailed. The SPC agreed not to set up its own advisory body after being assured that all information resulting from the activity of the SAC and the advisory groups would be made available to it. The first membership of the SAC is reported in Table 3-8.

Table 3-8: The Science Advisory Committee (1975-1977)

Restricted membership	M. Rees, Cambridge (chair) W. Axford, Lindau R. Bonnet, Verrières-le-Buisson G. Colombo, Padova L. Houziaux, Mons H. Wolff, Harrow
AWG chair	L. Scarsi, Palermo (up to February 1976) H. Habing, Leiden (Feb. - Sept. 1976) G. Setti, Bologna (since October 1976)
SSWG chair	J. Geiss, Bern
LSWG chair	H. Bjurstedt, Stockholm

Summarising, to the benefit of the new SPC, the schedule of main steps and decisions regarding future scientific projects, the Executive explained that five Phase-A studies were being conducted, the results of which would be available by spring 1976 (Table 3-7). As usual, these results would be discussed in a scientific symposium, presumably at the end of June, then the scientific working groups and the SAC would be requested to issue their recommendations. By the end of July, the Director General would submit his proposals to the SPC, called to decide on the new project(s) to be adopted in the ESA Scientific Programme. Eventually, because of the limited funds available in 1976 and 1977, it was necessary to postpone the decision to early October.[294]

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292 SPC, 1st meeting (9 October 1975), 12 November 1975, pp. 8-9.

293 WG, 16th meeting (28 October 1975), ASTRO(75)13, 4 December 1975. The AWG's criticism was reported by its chairman to the first SAC meeting (24 February 1976), SAC(76)4, 7 April 1976, pp. 2-5.

294 ESA/SPC(75)15, 1 December 1975; ESA/SPC(76)10, 18 February 1976; ESA/SPC(76)19, 17 May 1976. Status reports on the various studies of scientific missions are ESA/SPC/(75)5, 19 September 1975, and ESA/SPC/(76)5, 17 February 1976.

3.10 Discussing the new projects

Both Working Groups had being discussing ongoing feasibility studies, providing continuous advice on the best way to achieve the scientific goals assigned to the mission studied. The main concern regarded the status of the LST project, whose official name was now Space Telescope (ST), after the reduction of its diameter to 2.4 m. Following NASA's intimation that the Faint Object Spectrograph (FOS) would be assigned as a result of a competitive call for tenders, the Executive had decided not to enter into competition on the FOS but to concentrate study on a Faint Object Camera (FOC) with associated Imaging Photon Counting System, i.e. the former High Resolution Camera (HRC) with the accent now on faint objects. Provision of this instrument was ESA's main contribution to the ST and the ticket for obtaining a fraction of observing time for European astronomers. It was envisaged that ESA should also provide the solar arrays and contribute to the ST operations. Negotiations between ESA and NASA were being pursued by a joint Working Group set up in June 1975.[295]

The situation remained, however, very uncertain at the political level. Early in October 1975, the US President G. Ford announced cuts in the forthcoming federal budget and NASA had to shoulder its portion of the burden. The start of the ST project in 1977 was thus under serious threat and doubts were expressed within the AWG about "whether the LST would indeed fly".[296] The US President was to present the federal budget to Congress at the end of January 1976, and only then would it be known whether the ST was included as a "new start" in the 1977 NASA budget. If it was not, one had to assume at least a one-year delay in the start of the ST. This was a rather embarrassing situation for the AWG, which had to decide whether to start feasibility studies on the MUST or to keep supporting the Space Telescope. In early December 1975, it agreed to stick to the ST, but reaffirmed that the MUST should be considered as a fall-back project should the former not be pursued.[297]

In January 1976 it appeared that the ST was not in the NASA budget for the fiscal year 1977, and funds were not even provided for further Phase-B studies. This was bad news for ST supporters in the US astronomical community as well as a matter of great concern for the AWG, whose members wondered "at what point a decision should be made to continue the study on the MUST".[298] A dramatic discussion on the ST programme and other ESA studies in ultraviolet astronomy developed at an AWG meeting in April, which exposed all the drawbacks of ESA's being so closely tied to the NASA programme. On the one hand, there was uncertainty about the future of the ST project. NASA had made it clear that the ST would have top priority in the 1978 budget, to be approved by Congress in 1977. ESA, however, had to make a decision in 1976, i.e. prior to this hoped-for approval. On the other hand, despite the strong support given by the AWG to the MUST, the latter had the great disadvantage that, in order to achieve important results, it had to fly on many Spacelab missions. In fact, ten 30-day flights of the MUST would be required to achieve the equivalent observing time eventually available to ESA on the ST. While no cut-back had been made on the Shuttle main development programme, one could hardly be confident that budgetary constraints would not in the future negatively affect the Spacelab mission schedule. Moreover, the question of the cost of Shuttle/Spacelab missions was still open. Not surprisingly, some AWG members regretted that ESA had not considered a free flyer configuration for an ultraviolet telescope! In the event, the AWG had little choice but to reaffirm its support for the NASA project, and unanimously it did so.[299]

Late in June 1976, ESA's advisory bodies were called to recommend which project(s) should be adopted in the Scientific Programme. Apart from the uncerta*in situ*ation of the ST project, two new elements had to be considered. Firstly, the AMPS programme was under critical review within NASA and it looked as if European scientists would not gain admittance to it for some years. Consequently, such a programme could no longer be proposed as a realistic context for use of the LIDAR and the subsatellites. These facilities had now to be considered as independent projects within the framework

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295 ESA/SPC(75)6, 17 September 1975.

296 Smith (1989), pp. 160-163; AWG, 16th meeting (28 October 1976), ASTRO(75)13, p. 11.

297 AWG, 17th meeting (1-2 December 1975); ASTRO(75)15, 23 February 1976.

298 AWG, 18th meeting (28 January 1976), ASTRO(76)4, 5 May 1976, p. 5.

299 AWG, 19th meeting (13 April 1976), ASTRO(76)6, 14 June 1976, pp. 5-8.

of a possible European future programme of multidisciplinary Spacelab missions. Secondly, in addition to the projects for which a feasibility study had been prepared (Table 3-7), three others of minor importance were to be considered for possible adoption in the Scientific Programme. These were:

- The ESA contribution to the experimental payload of the first Spacelab mission, in particular those instruments to be funded out of the scientific budget. Two facilities had been considered for possible inclusion in the first Spacelab payload (FSLP): the LIDAR and a Sled device for studying the behaviour of the vestibular system of astronauts under weightless conditions.[300]

- The extension of the COS-B mission beyond its planned lifetime of two years, as requested by the experimenters after the brilliant performance of the satellite.[301]

- The passenger experiment for the Ariane qualification flight L02 (APEX-L02). Three options had been proposed: the COS-B second flight model (COS-B2), the GEOS second flight model (GEOSARI) and the COS-B spacecraft with a variety of experiments (COSARI).[302]

The results of all feasibility studies were presented to the scientific community during a symposium held on 28 to 30 June 1976. On 1 July the SSWG and AWG discussed the projects and issued their recommendations. The following day it was the turn of the SAC to do its job.[303]

3.10.1 The Working Groups' recommendations

Three projects fell within the field of interest of the SSWG: the LIDAR, the sub-satellites, and the Out-of-Ecliptic mission. The first, as we have anticipated, was to be considered both with regard to its possible inclusion in the FSLP and in the framework of a possible future programme of Spacelab missions for atmospheric studies (four 7-day missions in one year had been recommended by the consultant group in order to gain significant scientific results). At a previous meeting, in April, the SSWG had accepted the principle of including the LIDAR in the FSLP. This decision, which had been urged by the Executive because of the constraints of the Spacelab programme timetable, was taken with many reservations, both because the results of the Phase-A study were not yet available and because it had to be taken outside the competitive framework scheduled for late June. Similar reservations were expressed by the SAC when called to endorse the SSWG's recommendation. Both the SSWG and the SAC had underlined that the decision to fund the LIDAR for the FSLP from the mandatory scientific budget should not in any way prejudice the chances of other missions or set *a priori*ty over any of them. Further development and re-flights of the LIDAR had to be considered in the same way as other competitive projects.[304] When, in early July, the SSWG discussed again the possible inclusion of the LIDAR in the FSLP, new information was available from the responses to the Call for Preliminary Proposals and from the discussions at the scientific symposium. The SSWG then reversed its April decision and concluded that a greater scientific return from the FSLP would be

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300 ESA/FSLP(75)3, 9 September 1975; ESA/SPC(76)17, 18 May 1976, and Add. 1, 16 July 1976. The Sled fell within the province of life sciences and does not concern us here. Its inclusion in the FSLP was approved by the SPC after a positive recommendation of the SAC. For a general description of this facility, see Steinz (1980). We will deal with the whole story of the FSLP in chapter 14.

301 ESA/SPC(76)29, 19 July 1976.

302 ESA/SPC(76)34, 22 September 1976. For the Apex (Ariane Passenger Experiments) programme see Pfeiffer (1976).

303 SSWG, 19th meeting (1 July 1976), SOL(76)14; AWG 21st meeting (1 July 1976), ASTRO(76)10, 30 September 1976; SAC 13rd meeting (2 July 1976), SAC(76)11, 27 August 1976. The recommendations of the working groups and the SAC are attached to ESA/SPC(76)25, 3 September 1976.

304 SSWG, 18th meeting (27-28 April 1976), SOL(76)8, 2 July 1976. SAC, 2nd meeting (28 April 1976), SAC(76)8, 4 June 1976. The final recommendations are reported in ESA/SPC(76)13, 18 May 1976. For the scientific use of the LIDAR, see SSWG, 16th meeting (16-17 December 1975), SOL(76)1, 16 February 1976.

obtained by a passive sounding package than by the LIDAR. The latter was not recommended for the FSLP, and its possible use in future Spacelab missions was not even discussed.[305]

The other project studied in the framework of the ill-fated AMPS programme was the development of sub-satellites to support Spacelab instruments. Several types of sub-satellites had been investigated, including the interesting class of tethered satellites. The SSWG recognised the interest of such sub-satellites, but decided not to recommend the immediate adoption of this project in the ESA programme. In conclusion, failing the possibility of cooperating with NASA in the AMPS programme, ESA's plans in atmospheric and magnetospheric studies with Spacelab were definitely jeopardised.[306]

The OOE mission remained the only important project available to the space science community involved in Solar System research, and it was strongly supported by the SSWG. The Group considered it a "multi-disciplinary [and] truly exploratory mission", whose scientific interest involved many fields, from interplanetary science to solar physics, and from Jovian studies to astrophysics. The Group insisted that the dual-spacecraft mission was definitely to be preferred both to the single-spacecraft mission and to a new proposal advanced by the Italian physicist Giuseppe Colombo, namely to combine one out-of-ecliptic spacecraft with a solar probe.[307]

The three other projects pertained to the AWG, i.e. the 2.4 metre Space Telescope (ST), the infrared telescope LIRTS and the X-ray spectropolarimeter EXSPOS. The AWG reaffirmed its strong interest in the ST, "the most important development for astronomy in the 1980s". It was the unanimous opinion of the Working Group that "ESA should obtain guaranteed observing time for European astronomers so that they do not have to rely on 'hitch hikes'". Current negotiations with NASA foresaw that ESA would provide the Faint Object Camera with the associated Image Photon Counting System, the Solar Array and a contribution to the activities of the Space Telescope Science Institute. The European contribution was envisaged as 15% of the total cost and, in return for this contribution, 15% observing time would be allocated to European astronomers.[308]

The LIRTS was considered by the AWG no less important than the ST. "An instrument such as the LIRTS," the Group claimed, "will be mandatory for the progress of infrared astronomy once the [Dutch satellite] IRAS has flown (circa 1981) [...] The instrument appears to be technically feasible, flexible and fast". The Group also stressed that the LIRTS was a totally European instrument, and this gave "a certain degree of independence *vis-à-vis* the United States space programme [to be balanced] with the strong dependence of the Space Telescope programme on approval by NASA and Congress".[309] The main problem with the LIRTS was the great uncertainty regarding the cost of reflights, since no official charging rates for Spacelab missions were as yet available from NASA. After the first 7-day mission, 28-day missions were recommended for economic reasons. The cost of each such mission was estimated by the Executive at about 23 MAU, as compared to the total cost of the project (including the first 7-day flight) of 40.3 MAU. That figure, the Executive warned, was not under ESA's control and might be inaccurate by rather large amounts.[310]

The third project within the AWG's field of interest was EXSPOS. This was less expensive than the LIRTS (25.4 MAU, including the first 7-day mission), but again its operation would be more costly than its development (an estimated 11 MAU for each subsequent 28-day mission). The Working Group considered this instrument "of high scientific value and of great importance to X-ray astronomy

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305 SOL(76)14, *cit.* See also ESA/SPC(76)13, Add. 1, 15 July 1976.
306 SOL (76)12, 1 July 1976. Also attached to ESA/SPC(76)25, *cit.*
307 SOL(76)12, *cit.*, p. 1. About Colombo's proposal, see SSWG, 13th meeting (17-18 April 1975), SOL(75)6, 13 June 1975.
308 ASTRO(76)11, 13 July 1976, p. 1. Also attached to ESA/SPC(76)25, *cit.* The principles for ESA/NASA collaboration on the ST project are presented in ESA/SPC(76)36, 7 September 1976. It should be noted that the SSWG had also expressed interest in the ST because of its profitable use in solar system science.
309 ASTRO(76)11, *cit.*, pp. 1-2.
310 ESA/SPC(76)33, 1 September 1976, p. 14.

[...] the logical step to aim at in the Shuttle era, because it will allow experimentation with various techniques designed to achieve high spectral resolution".[311]

Concluding the discussion on the three candidate projects, the AWG had to recommend priorities among them. Some advocated the ST, arguing that cooperation was the only "entrance ticket" to obtain a reasonable amount of observing time, and that its approval was urgent because of NASA's schedule. Others insisted that higher priority should be given to the LIRTS, while observing time on the ST should be negotiated through the guest observing programme or by granting the US astronomers observing time on the LIRTS. The EXSPOS was finally supported by those AWG members who were directly involved in high energy astrophysics: this discipline, they claimed, was entirely dependent upon space resources, while optical and infrared astronomy could also take advantage from existing ground-based facilities. Finally, it was pointed out that "EXSPOS, and to a minor degree LIRTS, were the two projects which were independent of the aleas of cooperation".[312]

In the event, a vote was taken. The outcome was that the ST and the LIRTS were both of prime importance for European astronomy and no relative priority could be assigned on scientific grounds. In case priorities had to be made in the financing schedule, the AWG agreed that the ST should take priority. It stated, however, that studies of focal plane instrumentation for the LIRTS should be pursued in any case and its mirror should be ordered as soon as possible. As to EXSPOS, the AWG decided by a majority vote that it should be given lower priority.[313]

3.10.2 The SAC recommendation

On 2 July 1976, the SAC was called to discuss the recommendations of the SSWG and AWG and to issue the final recommendation on ESA's future Scientific Programme.[314] Two main questions were on the table. Firstly, the Committee had to assess the scientific merit of the projects which had been recommended by the Working Groups, namely the OOE, ST and LIRTS. Secondly, it had to assign a relative priority among them. On the former, the conclusions of the SSWG and AWG were fully endorsed by the SAC. On the latter, it could only agree that no priority could be assigned on scientific grounds. The SAC considered the OOE, LIRTS and ST as "three outstanding projects", each of which could be submitted to ESA's decision-making bodies for possible adoption in the Agency's programme. Regarding the OOE mission, the SAC recognised that the two-spacecraft version offered "distinct scientific advantages". It recommended that the mission be approved and that ESA enter immediately into negotiations with NASA "with a view to determining a basis for collaboration so that an Announcement of Opportunity can be issued early in 1977". The SAC also endorsed the AWG's conclusion regarding the LIRTS, recommending that Phase-B studies be started immediately and that the mirror be ordered as soon as possible even if (for financial or other reasons) developments had to be slowed down.[315]

As to the ST, the SAC stressed that "all members of the SAC and Working Groups seem convinced that the ST is indeed the most outstanding and important project in space astronomy planned for the next decade; and we have no doubt that this view is widely echoed in the European scientific community". Against those who argued that personal contacts with American astronomers might be sufficient to ensure access to the ST, the Committee claimed that ESA should have a formal stake in the project.

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311 ASTRO(76)11, *cit.*, p. 2.
312 ASTRO(76)10, *cit.*, p. 5.
313 ASTRO(76)9 and ASTRO(76)11, *cit.*
314 SAC, 3rd meeting (2 July 1976), SAC(76)11, 27 August 1976. The minutes do not report on the discussions on this item of the agenda. A summary of the final recommendations is reported in SAC(76)10, 27 July 1976, and a fuller report is in SAC(76)12, 1 September 1976. Both documents are attached to SPC(76)25, *cit.*
315 SAC(76)12, *cit.*, pp. 1 and 4; SAC(76)10, *cit.*, p. 1.

Guest-observer status may indeed prove adequate and satisfactory for some favoured individuals whose links with United States groups are unusually close. But the SAC does not believe that the broad European astronomical community (with whose interest it should primarily concern itself) will have any real chance of fair and adequate access, particularly during the early years of the ST's operation, unless ESA formally participates and, in return, gets a guaranteed share of observing time and participation in the proposed "ST Institute". Moreover, European groups certainly cannot, by mere "hitch-hiking", participate seriously in the definition and provision of ST instruments. We therefore regard the case for formal participation as a very strong one.[316]

The SAC supported the draft Memorandum of Understanding under discussion between ESA and NASA and, incidentally, recalled that even 15% of the observing time would be invaluable to Europe, this amount exceeding, in terms of hours per year, "the entire clear dark time on a ground-based telescope".

Alongside the support to the three major projects, the SAC also expressed its opinion on the others whose Phase-A studies were available. It concurred with the AWG in considering EXSPOS "an instrument of high scientific value for X-ray astronomy, [...] the logical step to aim at in the Shuttle era". Two elements, however, spoke against such a Spacelab facility when compared to the LIRTS. Firstly, the likelihood that the latter would obtain more data during Spacelab flights of limited duration; secondly, "the desirability of ensuring opportunities within ESA for infrared astronomers". As a consequence, the SAC recommended that only a minor effort should be devoted to study instrumentation for spectropolarimetry suitable for use on Spacelab. Regarding the sub-satellites for AMPS studies, the SAC recognised that interesting experiments could be performed by such facilities. The feasibility study, however, had revealed a much higher cost for the various options than had been hoped for. Moreover, several technical aspects deserved more study, in particular regarding tethered satellites and the operational aspects of sub-satellite retrieval.[317]

Finally, the SAC discussed the controversial question of the LIDAR. This facility was strongly supported by SAC member G. Colombo, who emphasised the measurement accuracy which could be reached by laser techniques for geophysical studies. The other members did not concur, however. When assessed in comparison with other Spacelab facilities, such as the LIRTS and EXSPOS, the scientific case for the LIDAR appeared much less definite, W. Axford argued, while R. Bonnet stated that the discussions at the recent scientific symposium had shown that better science could be done with passive techniques on board Spacelab. Concluding the discussion, chairman M. Rees stated that, in previous meetings, the SAC had assessed the LIDAR outside of a competitive framework. Now the Committee had more information, both about the other opportunities that could be provided on Spacelab and about the kind of science that could be done on the FSLP. The conclusion, expressed in a diplomatic tone, definitely reversed the SAC's previous opinion.

From this and from the scientific presentations made at the June symposium on the LIDAR and the passive sounding techniques, the LIDAR seemed to have a more negative position than it had at the last meeting when the SAC had recommended the funding of the LIDAR for the FSLP from the mandatory scientific budget.[318]

Later in July, the SPC agreed to cancel the LIDAR from the FSLP and asked the Executive to study in place of it the feasibility of a stabilised platform for passive sounding experiments (CAPS, Common Attitude Pointing System).[319]

In conclusion, the ESA scientific advisory bodies identified three outstanding projects (OOE, ST and LIRTS) among which they did not attempt to assign a relative priority on scientific grounds. Financial

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316 SAC(76)12, *cit.*, pp. 1-2 (emphasis in the original).

317 SAC(76)12, *cit.*, p. 6.

318 SAC(76)10, *cit.*, p. 6.

319 SPC, 5th meeting (30 July 1976), ESA/SPC/MIN/5, 30 August 1976. This decision was taken against the strong opposition of the Italian delegation which supported the LIDAR.

considerations, technical aspects, schedule constraints, and questions related to the collaboration with NASA would orient the Director General's proposals and the eventual decisions of the SPC. Before discussing these developments, however, we shall pause for a brief interlude.

3.10.3 G. Colombo's dissenting opinion and the Spacelab question

The SAC's statement was not unanimous. A strong dissenting opinion was expressed by G. Colombo, an advocate of the LIDAR and of tethered satellite projects. Colombo did not limit himself to conveying his ideas to the Italian delegation in the SPC but, after the latter had definitely cancelled the LIDAR, he decided to circulate a written statement with a severe criticism of the whole of SAC's policy (and also ESA's). We will take advantage of this document in order to present a few thoughts about the political aspects of the decisions ESA's policy-makers were about to take.[320]

Colombo's arguments started from a rather usual criticism (the "mandarin" argument), i.e. that a large number of young scientists felt "frustrated, totally neglected and unnecessarily deluded" because of ESA's scientific policy. Three main reasons were listed. Firstly, the poverty of the budget allocated to the Scientific Programmes, "even if it is clearly recognised that it is in these programmes that resides the most advanced technology". Secondly, the belief that more resources should be devoted to "the solution of problems more directly linked to the human environment". Finally, "the obvious fact that the programme is in reality under the control of a well established conservative group which has dictated the past ESRO activity and continues to do so with ESA". In Colombo's opinion, the negative decision on the LIDAR was but "a further manifestation of the traditional conservative policy of ESRO, a further proof of the little imagination and the little courage that have characterised in the past the activity of our organisation".

The core of the argument was the role of the Space Shuttle. The Shuttle, Colombo claimed, "is not an astronomical observatory but an element of the Space Transportation System". Its rationale was not to provide a platform for space telescopes, but to make possible the construction of space stations where such telescopes could be installed in the future. The obvious implication was that ESA should drop all plans to develop telescope facilities for Spacelab (LIRTS, GRIST, EXSPOS) as well as its planned contribution to the Space Telescope. In the long-term, the only economic solution for astronomical observations from space was the Astronomical Space Station exploiting the Shuttle servicing capability. ESA, Colombo concluded, should concentrate on studying telescope facilities suitable for such foreseeable developments. As regards the ST, he recommended a strong European participation in the ground support facilities and in the operation of the ST Science Institute. An obvious corollary, not explicitly stated here, was that the best use of Spacelab was for Earth-oriented missions (i.e. looking at the "human environment"), such as those based on the LIDAR facility or specialised sub-satellites.

Colombo's dissenting opinion also involved the OOE mission, which he had always opposed as a member of the SSWG. He criticised the proposed dual spacecraft mission to the Sun's poles and reiterated his proposal that one out-of-ecliptic spacecraft should be combined with a solar probe. The SSWG had discarded this option, as we have seen, expressing its preference for the dual spacecraft version. Colombo, on the contrary, recalled that several scientists participating in the June symposium had supported his proposal and argued that "such a solar probe would yield unique '*in situ*' information on the origin of the solar wind and on the solar corona, would provide fundamental tests of general relativity, and would also provide a unique opportunity to obtain direct information on the Sun's interior structure".

How shall we appraise Colombo's arguments? What do they say about the policy choices the ESA decision-makers were about to make? Our answer will be based on three considerations. Firstly, we can safely dismiss the argument about the alleged conservatism and self-interest of ESA's scientific advisers. On the one hand, a certain degree of conservatism is unavoidable in all established

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320 Colombo's document is reported in ESA/SPC(76)25, Add. 1, 13 September 1976. The following quotations are from pp. 1-2.

communities, and it can also be convenient when important technical and financial aspects are at stake. On the other hand, it is usual for those whose expectations are not fulfilled to blame the "old generation" for frustrating and neglecting fresh new ideas coming from "young people". As a matter of fact, we have shown how the decision-making process for defining ESRO's and ESA's Scientific Programme was highly competitive and, at the same time, absolutely open. It involved the laborious development of scientific discussions at various levels (national communities, working groups, advisory committees, delegate bodies, etc.); mission definition and feasibility studies involving ESRO/ESA staff, outside scientists and industry; meetings and symposia whose proceedings were often edited and circulated; and continuous negotiations at high political level. In this process, strong interest groups and lobbies emerged and fought for success, whether for a general policy decision or the approval of a pet project. Success might be the outcome of good scientific arguments as well as of strong political influence. One can hardly claim, however, that all possible options were not carefully assessed, all opinions discussed, all controversies negotiated. The fact is that, at the end of this highly competitive process, there could only be winners and losers (sometimes by a strict majority vote); and since ESRO/ESA could only afford one major project every three or four years, the frustration of the losers was as deep as the satisfaction of the winners.

Our second consideration regards the actual result of the decision-making at this stage, with reference to the scientific fields involved. One can indeed hardly speak of conservatism. In the preceding eight years, the ESRO/ESA Scientific Programme had been dominated by high energy astrophysics (COS-B and Exosat) and magnetospheric physics (GEOS and ISEE-2). This tradition had been established mainly at the expense of optical astronomy (LAS and UVAS), solar physics (TD-2) and planetary science (Venus orbiter). Now, the Agency was driven to direct its efforts towards infrared astronomy, a brand new discipline in astronomical space research; optical astronomy, in order to take advantage of the most ambitious space telescope ever conceived; and solar/interplanetary science, by a quite original space mission. Colombo could certainly claim that the dismissal of the solar probe as well as the earlier abandonment of planetary and cometary projects confirmed the poor status of solar physics and planetary science in ESRO/ESA's tradition. One can hardly claim, however, that following that path would have been less conservative.

Our third consideration touches what is, in our opinion, the most important of Colombo's arguments, namely the role of the Shuttle/Spacelab system in future space science activities. In Colombo's view, the future of space astronomy lay in manned space stations, while automatic satellites and Spacelab facilities would mainly be directed towards the Earth and its near environment. The Shuttle was the transportation system for the new era: it would be a low-cost device to put satellites in near Earth orbits, it would make the building of space stations possible, and it would enable experimenters to work in space in a shirt-sleeve environment. With hindsight, one can consider this view as highly optimistic; no less optimistic however was the idea of flying the LIRTS once or twice a year for several years on 28-day long Shuttle/Spacelab missions, or planning a 5 to 10-year programme of flights of the AMPS payload. In other words, in order to be an effective research facility as was hoped for, Spacelab would have to perform as a space station, the difference being that the former would re-fly every one or two months with different configurations and payload, while the latter could continuously orbit the Earth.

Here is the deep ambiguity of the Spacelab programme. ESRO/ESA's policy-makers had embarked on the undertaking for essentially political reasons. On the one hand, Spacelab was a key element of the second package deal which had made the birth of the new European Space Agency actually possible. On the other, it was Europe's only ticket to enter the American Space Shuttle programme. Alongside its political importance, the Spacelab programme was also of great technological interest, as for the first time it posed to ESRO/ESA and the European industry the challenge of manned space flight. The perspective, however, was much hazier when considered from the point of view of the utilisation of Spacelab. Most scientists, as we know, did not like it and did not miss the opportunity to stress that manned flights should not jeopardise the use of automatic spacecraft in space research. Regarding applications, the use of Spacelab could only make sense in the perspective of future large space stations, a very uncertain future indeed. With the obvious exception of Germany and in part France, ESRO member states were very reluctant to commit themselves to invest resources in Spacelab utilisation. In a sense, however optimistic some ESRO planners were regarding the Shuttle/Spacelab system, Spacelab appeared similar to the original ELDO rocket: a technical facility in search of meaningful use and adequate funding.

The optimistic vision of Spacelab performance had driven ESRO's scientific advisory bodies to discard CIRES and LOGOS in favour of LIRTS and EXSPOS, and the astrometry and cometary missions in favour of AMPS and GRIST. In conclusion, it was not a conservative approach which affected the choices of ESRO's and ESA's scientific advisory bodies in 1974-76 but, on the one hand, the American vision that the Shuttle/Spacelab system would be the main and most profitable facility available for every space research discipline in the 1980s and, on the other hand, the European vision that they would have a high status in the ESA/NASA relationship as regards the exploitation of the facility. Some doubts existed in the scientific community regarding both visions. The political importance of Spacelab, and the hopes that the Shuttle and Spacelab would be in the 1980s what the Saturn launcher and the Apollo spaceship had been in the 1960s, overcame these doubts and shaped ESA's scientific planning by the mid 1970s.

3.11 The approval of the ESA participation in the Space Telescope programme

In September 1976 the Director General submitted his proposal on new scientific projects to the SPC.[321] This proposal, covering the period 1977 to 1983, was supported by a detailed presentation of the financial aspects, which we have summarised in Table 3-9. Taking into consideration a fixed ceiling for the Scientific Programme of 59.7 MAU (at mid-1976 price levels, corresponding to the 1971 package deal ceiling of 27.0 MAU), and the financial requirements of ongoing programmes and in-house scientific activity, the availability of funds for new programmes increased from 3 MAU in 1977 to 53.3 MAU in 1983. The total availability in the 1977-1983 period was 221.5 MAU.

In order to elaborate his proposal, the Director General took into consideration only the three major projects recommended by the scientific advisory groups, namely ST, OOE and LIRTS. This resulted in a list of six possible combinations, each consisting of a different set of (1 to 3) projects approved. We should note that of the seven mathematically possible combinations, one was not taken into consideration, namely that including the ST and LIRTS. No explanation was explicitly given for this exclusion which, however, can easily be understood. Approving the ST and LIRTS at the expense of the OOE mission, in fact, would have strongly unbalanced the ESA Scientific Programme towards astronomy, unduly mortifying solar system science. In other words, if two projects were to be approved, one had to be the OOE mission. In addition to these six combinations, a seventh was included which foresaw all three projects approved, but with the development phase (Phase-C/D) of the LIRTS delayed at least two years after the completion of the Phase-B study.

For each of these seven combinations of the three major projects, four variants were considered, each consisting of incorporating from all to none of the three minor projects, namely the CAPS facility for the FSLP, the passenger experiment for the L02 Ariane test flight and the prolongation of COS-B.[322] The estimated development costs of each of the resulting 28 combinations were then compared with the available resources in order to ascertain which combinations were feasible from the financial point of view. The Director General's proposal eventually stemmed from the results of this exercise, supplemented by considerations on the schedule constraints and the prospects of ESA/NASA co-operative projects ST and OOE. The proposal was articulated in the following points:

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321 ESA/SPC(76)33, 1 September 1976; ESA/SPC(76)34, 22 September 1976.

322 To be precise, the first variant foresaw all minor projects approved, the second only APEX-L02, the third the CAPS and the COS-B prolongation, and the fourth none.

Table 3-9: Summary table of financial aspects of new projects (1977-1983) (in MAU at mid-1976 price levels and 1977 exchange rates) *

Project	Total cost	Remarks
Space Telescope	60.1	ESA contribution until 1983. Post-1983 costs estimated at about 20 MAU.
OOE	71.0	Complete ESA contribution until launch (1983).
LIRTS	40.3	Including launch and costs for a first 7-day mission. Following missions estimated at about 23 MAU each.
EXSPOS	25.4	Including launch and costs for a first 7-day mission in 1981. Following missions estimated at about 11 MAU.
LIDAR	11.7	Including launch and costs for a first 7-day mission in 1981. Following missions estimated at about 3 MAU.
Sub-satellites	39.3	Series of 5 sub-satellites with orbit and attitude control up to 1984.
CAPS	4.0	Development costs in the period 1977-1980.
APEX-L02	8.5 - 9.3	Development and operation costs (1977-1981) depending on option chosen.
COS-B prolongation	1.3	Operation costs (1977-1978).

Note:
* ESA/SPC(76)33, 1 September 1976. The figures for APEX-02 are from ESA/SPC(76)34, 22 September 1976

The SPC was invited to approve at once the ESA participation in the ST project. Phase-B studies would start immediately, but further developments would be subject to the final approval of the project by the US authorities and to the favourable conclusion of the negotiations with NASA.

A decision on the OOE mission could be delayed to Spring 1977, when more information would be available on the status of the project in the USA as well as on a number of financial uncertainties regarding ongoing programmes (in particular Exosat). The launch window of January 1983 could still be met provided that an Announcement of Opportunity be released soon in order to allow a quick start of Phase-B, should the mission be approved.

The LIRTS project could not be approved at this stage. A Phase-B study of the project was recommended, however, because the results of this study were needed in case neither the ST nor the OOE were approved by the US authorities.

The SPC was finally invited to approve the APEX-L02 project, endorsing the SAC recommendation that the GEOSARI mission should be selected. A decision on the CAPS and the COS-B prolongation could be reserved for early 1977.[323]

Before going to the SPC, the Executive's proposal was discussed by the SAC.[324] The main issue was whether the SAC endorsed its implied priorities (ST, OOE and LIRTS in sequence), in consideration of the fact that it had not assigned any relative priorities to the three major projects. In fact, the SAC reaffirmed that the ST and OOE should be assigned equal priority and "both projects [should] have equal opportunity for realisation". Such a statement was urged in particular by W.I. Axford, a long-time advocate of the OOE mission, and by the SSWG chairman, J. Geiss. In response to this concern, the Director General stated that "it was his intention to proceed with obtaining approval for both projects", and that different schedules had been suggested for the two projects only because of constraints depending on NASA's plans. As regards the LIRTS, the SAC recalled that the AWG had recommended the ST and LIRTS with equal priority. It acknowledged, however, that ESA could not commit itself beyond Phase-B in view of the uncertainties about the flight costs of Spacelab and the duration and frequency of flights. Finally, the Committee stressed that the inclusion of GEOSARI on the APEX-L02 should not jeopardise the 1983 launch of the OOE mission or delay a Phase-B study of the LIRTS.

In conclusion, the proposal that the Director General submitted to the SPC for approval definitely committed the Agency to the Space Telescope and the Out-of-Ecliptic mission, provided that the ESA/NASA collaboration could be successfully implemented. Its rationale essentially derived from three main elements. Firstly, financial considerations prevented the approval of all three major projects. Secondly, in spite of the uncertainties of cooperation, the realisation of the ST project seemed less problematic than that of an ambitious Spacelab facility like the LIRTS (indeed, none of the many Spacelab projects originally proposed survived the screening process). Thirdly, as we have already pointed out, it was hardly possible to propose two astronomy projects, while the Space Telescope and the Out-of-Ecliptic mission would satisfy two different sectors of the space science community. The contextual approval of GEOSARI, a mission devoted to magnetospheric research, consolidated the balanced equilibrium in the Scientific Programme: the Earth's space environment with GEOSARI, the sun and interplanetary medium with OOE, and the stars and possibly the planets with ST, were open to investigation to European space scientists in the 1980s.

The SPC was called to take its decision on 4 and 5 October 1976, three years after the decision-making process had started. The Director General's proposal was generally well received, even though some delegations expressed doubts about the financial feasibility of the three projects. It was generally agreed that the ST should have priority over the OOE mission for the time being, and all endorsed the GEOSARI mission, with the exception of the UK delegation, which feared that this might compromise a favourable decision on the OOE the following spring. Only two delegations expressed open criticism towards the proposal. One was the Italian delegation, as to be expected. They recalled Colombo's reservations on the OOE mission and his plea for environmental research, and argued that the Space Telescope did not present as much interest for Europe from the technological point of view. The other was the German delegation, which recognised the very great scientific value of the ST project, but considered it relatively too costly. The German scientific community, in fact, had opted in favour of the OOE and LIRTS projects, a choice which also had the advantage of leaving some budget resources available for smaller missions to be undertaken alongside major projects.

In spite of these reservations, the Executive's proposal was eventually unanimously approved. ESA participation in the ST project was thus officially endorsed by the legislative arm of the Organisation and the Director General was invited to start Phase-B studies and continue negotiations with NASA in order to arrive at a Memorandum of Understanding. The funding of the GEOSARI project for the

[323] The recommendation of the SAC, SSWG and AWG on APEX-L02 are attached to ESA/SPC(76)34, *cit.* On GEOSARI, see Knott (1977).

[324] SAC, 4th meeting (15 September 1976), SAC(76)15, 4 November 1976. Following quotation from p. 6.

Ariane L02 test flight on the ESA Scientific Programme was also approved. A decision on the OOE mission was reserved for spring 1977, after consideration of an updated statement of the financial situation. Meanwhile, the Executive was authorised to continue negotiations with NASA on this mission, and eventually to issue an Announcement of Opportunity if judged necessary. A decision on the Phase-B study of the LIRTS and the prolongation of the COS-B mission was also reserved to spring 1977.[325]

Before concluding this section, a word must be said about the CAPS, for which a decision was reserved pending the conclusion of the feasibility study. The results of the study showed that its cost would be of the order of 8 MAU, i.e. twice as much as estimated. Moreover, in order to develop the CAPS in time for the FSLP, an exceptionally fast procurement procedure had to be authorised and the delivery date had to postponed by 4 to 6 months.[326] On this basis, the SSWG and the SAC recommended that the CAPS should not be included in the FSLP and the SPC eventually cancelled it.[327]

3.12 The approval of the Out-of-Ecliptic mission

The decision on the OOE mission was the last to be taken in the selection process started in 1973. By spring 1977 the Executive had performed a thorough reassessment of the OOE and ST programme costs, concluding that it might be possible to accommodate the OOE project within the science ceiling. The Director General then proposed to approve the project, the SSWG and SAC having re-affirmed their previous positive recommendation. At the same time, he also proposed to approve the extension of the COS-B mission, while studies of the LIRTS should be continued at Phase-A level.[328]

When, late in May, the SPC was called to discuss the Executive's proposal, the situation had dramatically changed because of the failure of the GEOS mission. The satellite had been launched on 20 April from Cape Canaveral, Florida, by a Delta 2914 launcher but, because of malfunctioning of the launcher, it was impossible to put the satellite into the foreseen geostationary position. After three days of intensive mission analysis, it was decided to use GEOS' apogee motor to place the satellite into a rescue orbit with an apogee of about 38,000 km and a perigee of about 2100 km. Having achieved this complex orbital manoeuvre, the experiments were switched on and some useful data could be obtained.[329] In spite of this partial rescue, however, it was clear that the original scientific objectives of the mission could not be met. The idea then emerged that the qualification model of GEOS, intended for the GEOSARI mission with Ariane in 1979, could be brought to flight standard as soon as possible, so that it could be launched around February 1978 on a Delta vehicle (GEOS-2). The idea was warmly supported by the GEOS experimenters and eventually endorsed by the SAC.[330] The main problem regarding the GEOS-2 mission was the cost of the launcher, which could not be borne by the scientific budget without jeopardising the programme. The SPC, in the event, agreed to the accelerated refurbishment of the second GEOS flight model but excluded any provision for the launch costs. In the words of the Swiss delegation, "the effect of the accident to the GEOS launcher should be the responsibility of the Agency as a whole, and not merely of the Scientific Programme".[331]

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325 SPC, 6th meeting (4-5 October 1976), ESA/SPC/MIN/6, 17 November 1976. The final resolution is reported in Annex II.

326 ESA/SPC(76)46, 6 December 1976.

327 SPC, 9th meeting (14 December 1976), ESA/SPC/MIN/9, 24 January 1976, pp. 12-13. The SSWG and SAC recommendations are in SOL(76)20, 9 December 1976, and SAC(76)23, 13 December 1976, respectively. Both documents are attached to ESA/SPC(76)50, 13 December 1976.

328 ESA/SPC(77)12, 29 April 1977. SSWG, 22nd meeting (2 March 1977), SSWG(77)2, 10 May 1977; SAC, 7th meeting (2 May 1977), SAC(77)8, 7 July 1977. At the SAC meeting, G. Colombo re-affirmed his opposition to the OOE project and his statement is reported in the Annex to SAC(77)8.

329 ESA/SPC(7)13, 16 May 1977; GEOS(1977).

330 SAC, 7th meeting (2 May 1977), SAC(77)8, 7 July 1977.

331 SPC, 11th meeting (27 May 1977), ESA/SPC/MIN/11, 18 July 1977, p. 4.

In the aftermath of the failure of the GEOS launch, pending a decision on the financial aspects of the envisaged GEOS-2 mission, the SPC could not discuss the proposal the Director General had prepared for concluding the decision-making process on new scientific projects. A decision on the OOE had to be reserved for a later time, when a complete reassessment of the financial situation would be available. The SPC, however, was now requested to approve the COS-B prolongation up to end 1978, the start of experiment selection for the OOE mission, and some Phase-A studies on LIRTS instruments. The SPC agreed to these decisions, that on the LIRTS being approved by a majority vote.[332]

An updated version of the Director General's proposal was prepared in October, to be submitted to the SPC meeting of 8 November. This document presented an exercise similar to that performed one year earlier, i.e. the estimated costs of the approved programmes and in-house scientific activity in the period 1977-1983 were compared with the available budgets, in order to demonstrate the financial feasibility of both the GEOS-2 and OOE missions. The former would be launched in 1978 by a Delta rocket, the latter in 1983 as foreseen. The feasibility of this programme rested on two important conditions regarding the funding of the GEOS-2 mission, namely: (a) that the Council agreed that the 3 MAU savings in the 1977 budget might be used as a contribution to the cost of the launcher, and (b) that NASA accepted an ad hoc payment schedule which would deviate substantially from that normally used for reimbursable launches. Under these conditions, the cost of the GEOS-2 mission could be covered by the Science Programme budget.[333]

The discussion in the SPC on the Director General's proposal was animated by the opposition of the Belgian and French delegations, both arguing that the combination of OOE and GEOS-2 would lead to severe budgetary difficulties. The former claimed that GEOS-2 was a new programme whose scientific merit still had to be assessed in the light of the limited resources of the scientific budget. Arguing that most of the groups involved in GEOS would also participate in OOE, the Belgian delegation proposed that the SPC should take an immediate decision in favour of OOE, "which seemed to be a well constituted and appealing new mission," and ask the scientific advisory groups and the Executive to put forward a list of other new projects instead of GEOS-2. The French, on the contrary, suggested that only the latter should be approved while a decision on OOE should be delayed until new information was available in mid-1978. These arguments were strongly opposed by other delegations. The German delegation was particularly sanguine in defending the OOE, any delay in which would be, in its opinion, "absolutely unacceptable". The Swedish and Swiss delegations, for their part, strongly contested the idea that GEOS-2 should be regarded as a new programme, the former arguing that its cost should be considered as an insurance matter, the latter recalling that "the general scientific community in the member states had sacrificed important funds for developing the experiments in GEOS".[334] Scientific and financial aspects as well as personal interests were at stake in this discussion. Several national delegates, in fact, were scientists directly involved, or whose institutes were involved, in GEOS experiments: Denmark's B. Peters, Germany's K. Pinkau, Sweden's B. Hultqvist and Switzerland's J. Geiss, the latter also being the chairman of the SSWG. And the Belgians were not wrong when foreseeing that they would presumably be involved in the OOE mission as well.

The real reason for this nervous discussion was the controversial issue of the launcher for Exosat. Let us step back one year. In late 1976, the Executive had suggested that Exosat might be launched by Ariane instead of the foreseen Delta 2914 rocket. The Council accepted this suggestion and the

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332 ESA/SPC/MIN/11, *cit.*, pp. 7-8. The proposal on the LIRTS was approved by 5 votes in favour (B, F, S, CH, UK), to 2 votes against (I, SP) and 4 abstentions (DK, FRG, IRL, NL). The case for the COS-B mission extension was presented in ESA/SPC(77)12, Add. 2, 6 May 1977.

333 ESA/SPC(77)30, 18 October 1977, with add. 1, 7 November 1977. See also ESA/C(77)66, 19 July 1977. The cost of the launcher was estimated at \$17.4 million, equivalent to 15.4 MAU.

334 SPC, 14th meeting (8 November 1977), ESA/SPC/MIN/14, 6 December 1977, p. 6, and Add. 1, 11 January 1978.

Executive had eventually studied the technical and financial implications of the Ariane option.[335] When, in June 1977, the SPC was called to give its advice, several delegations criticised the Executive's proposal, both on technical grounds and because it required an 11 MAU increase in the Exosat programme. In the event, "as a gesture of solidarity" in consideration of the political importance of promoting the use of Ariane for launching European scientific satellites, the SPC approved a resolution, with the German, Italian and UK delegations voting against, which stated that the Ariane solution could be accepted, provided that no more than 4 MAU should be debited to the Scientific Programme. This figure corresponded to the cost of adaptation of the spacecraft and its payload to the new launcher, the remaining 7 MAU being the cost difference between Ariane and Delta launching.[336] In early July, the Council finally approved the Ariane solution, the Italian and UK delegations reiterating their negative vote, but it could not find an agreement on the attribution of the additional cost. Opinions were divided, in fact, about whether this should be covered with a GNP-based contributions scale, as advocated by a majority of delegations including France, Belgium and the Netherlands, or in accordance with the contribution scale of the Ariane production programme, as proposed in particular by Germany and Italy. As a consequence, the question of funding the GEOS-2 mission also remained pending, as France opposed the allocation of the 3 MAU 1977 savings as a contribution to this mission. The whole matter then re-emerged at the SPC meeting we were discussing above.[337]

According to the French delegation, both the cost of the GEOS-2 launcher, and the extra costs incurred for adaptation of Exosat to Ariane, should be imputed to the scientific budget. The German delegation strongly disagreed, recalling that "the Scientific programme had made a sacrifice by making available 4 MAU for adaptation of the Exosat satellite for launch on Ariane [...] If this contribution of 4 MAU was insufficient, then the decision to adapt Exosat should be reconsidered, but the decision on GEOS-2 and OOE should not be subjected to uncertainties resulting from the Exosat/Ariane situation". No less sanguine was the Swedish delegation: "It did not oppose the use of Ariane, it was opposed to these costs, which were associated with the developments of a launcher for future commercial projects, being an extra burden for the Scientific Programme". In the event, a vote was called on a resolution which endorsed the Executive's proposal to approve the GEOS 2 and OOE and, at the same time, reaffirmed that the scientific budget would not contribute more than 4 MAU towards the costs related to launching Exosat on Ariane. The resolution was adopted by 5 votes in favour (Denmark, Germany, Netherlands, Sweden and Switzerland), 2 votes ad referendum (Italy and United Kingdom) and 3 abstentions (Belgium, France and Spain).[338] One month later, and after many negotiations, the Council finally agreed to de-couple the question of Exosat/Ariane funding from the GEOS-2 mission and approved the financial arrangements for the launch of the latter as suggested in the Director General's proposal. The OOE and GEOS-2 missions were thus finally adopted in the ESA programme alongside the Space Telescope. The Exosat/Ariane funding remained pending but the Council agreed that the Scientific Programme should not contribute more than 4 MAU for the adaptation of Exosat for launch on Ariane.[339]

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335 ESA/C(76)88, 20 September 1976; ESA/C(76)129, 9 December 1976. Council, 13th meeting (16-17 December 1976), ESA/C/MIN/13, 8 February 1977. The Executive's study is reported in ESA/C(77)49, 15 June 1977, also attached to ESA/SPC(77)20, 15 June 1977.

336 SPC, 12th (extraordinary) meeting (28 June 1977), ESA/SPC/MIN/12, 8 August 1977, and ESA/SPC/XII/Res. 1, 29 June 1977. The German delegation said it would be able to accept the Ariane launcher provided that no charge was made to the science programme budget. The Italian and UK delegations said that they would only be able to accept it if this resulted in a payment to the science programme budget.

337 Council, 18th meeting (30/6-1 July 1977), ESA/C/MIN/18, 18 July 1977, and add. 3, 19 September 1977; 19th meeting (26-27 July 1977), ESA/C/MIN/19, 3 August 1977; 20th meeting (3-4 October 1977), ESA/C/MIN/20, 17 October 1977. See also ESA/C/(77)79, 19 August 1977.

338 ESA/SPC/MIN/14, *cit.*, pp. 5 and 7, and ESA/SPC/XIV/Res. 1, 8 November 1977.

339 Council, 22 meeting (12-14 December 1977), ESA/C/MIN/22, 4 January 1978, with attached ESA/C/XXII/Res. 6, and Res. 7. See also ESA/C(77)103, 17 November 1977, and add. 1, 24 November 1977.

3.13 Epilogue

By the end of 1977 the decision-making process for the choice of ESA's new scientific projects came to a conclusion. This process had started in June 1973, its final goal being to select one or two space missions from which interesting results could be obtained in the first half of the 1980s. ESRO's and ESA's scientific advisory bodies had to guide this process taking into account, on the one hand, the rigid financial constraints imposed on the scientific budget and, on the other, the expectations of their large, mixed and often quarrelsome scientific constituency. Their discussions were affected by ESRO's scientific heritage, as well as by the lure of new research fields and revolutionary technical facilities; their planning also reflected a characteristic ambivalent feeling *vis-à-vis* NASA, the need for cooperation always being balanced by the determination to remain independent.

More than four years after the LPAC's first discussion, the process ended with the final adoption of the Space Telescope project and the Out-of-Ecliptic mission, the former eventually called the Hubble Space Telescope, in honour of the great American astronomer Edwin P. Hubble, and the latter being renamed, after a suggestion from NASA, the International Solar Polar Mission (ISPM). ESA's participation in both projects was subject to their approval by the United States authorities and to a favourable outcome of negotiations with NASA. Both missions depended on the successful development of the Space Shuttle programme. In fact, as regards the political conditions, things soon turned out favourably. The Space Telescope was finally approved by the US Congress in July 1977 and the Memorandum of Understanding (MOU) between ESA and NASA was signed in October that year.[340] In the course of 1978 the political framework of the ISPM mission was also settled: in February, following a joint ESA/NASA selection process, the scientific payloads were selected for the two spacecraft; in September, after harsh congressional debates and an intense lobbying effort, the mission was finally approved by the US authorities. The MOU between the two agencies was formally signed by ESA's Director General and the NASA Administrator in March 1979.[341]

This was not the end of the story, however, at either the technical or the political level. In 1980, in fact, as a result of difficulties with the development of the Space Shuttle, NASA announced a delay of two years in the ISPM launch. At the same time, also because of budgetary limitations, it became evident that NASA would not be able to maintain the first launch date for the Space Telescope in December 1983. This was bad news, in particular for ISPM whose scientific objectives could be best achieved if the two spacecraft were launched, as planned, during the very restricted window in early February 1983. As work on the ESA spacecraft was already well advanced, it was agreed to continue with its development and integration up to completion and then to store the spacecraft until the new launch date.[342]

The following year was much more frustrating. NASA announced that it would not continue with development of its ISPM spacecraft and delayed the launch of the ESA spacecraft by another year. The announcement was completely unexpected and was strongly contested by ESA. In fact, as a result of NASA's unilateral decision, the concept of a two-spacecraft mission was destroyed and the fulfilment of the mission's scientific objectives severely impaired. Apart from the impossibility of performing stereoscopic and imaging observations, only possible from the NASA spacecraft, about one half of the instruments to be flown on the mission would not be used, and about 80 US and European investigators were eliminated right away from the project.[343]

Strong political and diplomatic actions were undertaken by the ESA Executive as well as by member state representatives, in order to reverse the NASA decision. These, however, came to nothing and therefore, partly in view of the large expenditure already incurred on ISPM in Europe, it was agreed that ESA should proceed with a single spacecraft mission, eventually renamed Ulysses. A "build-and-store" philosophy was adopted, i.e. the project would be developed according to the previously defined

340 Smith (1989), pp.175-186; Laurance (1990).
341 Hufbauer (1993); Wenzel & Eaton (1980).
342 Wenzel & Eaton (1990).
343 Bonnet & Manno (1994).

schedule until the completion of the flight acceptance testing by mid-1983. The flight spacecraft would then be placed into storage until late 1985, when it would be recommissioned for launch on the Space Shuttle Challenger in May 1986. The tragic disaster of 28 January that year, when Challenger exploded soon after lift-off killing its crew, abruptly terminated the final testing and preparation for launch that Ulysses was undergoing at Kennedy Space Center, Florida. Pending the re-establishing of the Space Shuttle programme, the spacecraft was brought back to Europe and placed into storage for the second time. It was finally launched by the Shuttle Discovery on 6 October 1990.[344]

The Challenger disaster also affected the launch schedule of the Hubble Space Telescope. Owing to a series of financial and technical difficulties, the original launch date of December 1983 had been put back several times, resulting in a three-year delay overall. Finally, Hubble was being prepared for a launch in October 1986 when the Challenger disaster occurred. This caused a further delay of about three and half years. The Telescope was finally launched by the Shuttle Discovery on 24 April 1990 and successfully deployed from the Orbiter cargo bay the following day.[345]

In the light of the history we have been analysing here, it is extremely significant that when Ulysses and Hubble started their challenging scientific missions, two other ESA spacecraft were already performing their task in the sky: the cometary probe Giotto and the astrometry satellite Hipparcos. Our patient reader will certainly recall that both a cometary and an astrometry mission had been discussed by the SSWG in 1973 and discarded by the LPAC. Both missions survived, however, at study level and were eventually selected in 1980, at the end of a new round of feasibility studies and decision-making which we will discuss in the following chapter. Giotto and Hipparcos were pure ESA projects and both were launched by the ESA launcher Ariane, the former in 1985 and the latter in 1989. In March 1986, while Ulysses was being placed into storage after the Challenger disaster, Giotto heralded its successful historic encounter with the comet Halley. Most instruments survived the dramatic impact with the comet's atmosphere and the spacecraft was then targeted to a new encounter with the comet Grigg-Skjellerup in July 1992. It is worth recalling that Giotto, like Ulysses, had originally been conceived as the ESA contribution to a joint ESA/NASA cometary mission to be launched on the Space Shuttle. At the end of 1979, however, with the cost of the Shuttle programme soaring, the American cometary project was cancelled. Annoyed by this betrayal of their expectations, the European scientists already involved in the joint project proposed that ESA should adopt the Halley mission in its own programme. They also suggested that the spacecraft could be launched by Ariane, which in December of that year had successfully performed its first test launch. Their lobbying succeeded in having the project approved and accommodated in the budget together with Hipparcos.[346]

As we see, very little survived in the early 1990s of the ambitious plans for scientific cooperation which ESA and NASA had been discussing about fifteen years earlier. Nor had the expectations regarding Spacelab been met. The first launch of the European-built laboratory took place on 28 November 1983 with the Shuttle Columbia on the 9th Shuttle flight. This 10-day mission was mainly devoted to verification test objectives, but it also carried many experiment facilities from both European and US scientists.[347] By this time, the ambitious flight schedule planned three years before was being drastically retrenched. In September 1980, in fact, the Space Transportation Systems Operations Office had forecast two Spacelab missions in 1983, three in 1984, and two each year beyond that time, with occasional isolated pallet opportunities in between. By June 1984, only one mission had been performed and nine were scheduled: four in 1985, one in 1986 and 1987, and three in 1988. Moreover, several discipline-oriented Shuttle missions carrying Spacelab pallet elements were planned in the same period.[348] In the event, after the 1983 mission only three other Spacelab missions were launched, all in 1985, the last one being the all-German project D-1, sponsored by the

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344 Wenzel & Eaton (1990).
345 Laurance (1980).
346 Calder (1992); Logsdon (1989). See also Russo (1994).
347 Bolton et al. (1984); Knott (1984); Shapland & Rycroft (1984), pp. 117-152; Lord (1987), pp. 343-364. The development of the Spacelab programme and the preparation of its first flight are discussed in detail in chapters 13 and 14, respectively.
348 Lord (1987), pp. 364-365; Shapland & Rycroft (1984), pp. 153-165.

German Ministry of Research and Technology. The Spacelab-2 mission carried the 1265 kg Instrument Pointing System (IPS), developed in Europe as part of the Spacelab Programme and provided as a service for Spacelab users.[349] None of these missions carried a joint ESA/NASA payload, and barely a handful of European principal investigators could hitch-hike on the two NASA missions. Indeed, as anticipated by many scientists, Spacelab was a very poor deal for European space science. Spacelab was not a good deal for European space industry either. NASA, in fact, purchased only one additional facility, barely complying with the requirements of the MOU. Indeed the Spacelab programme was criticised in Europe as being a 1 billion dollar gift to the US Space Shuttle programme, "Europe's most expensive gift to the people of the United States since the statue of Liberty," the head of the German delegation in the ESA Council remarked.[350]

In conclusion, looking back with hindsight, one can hardly avoid noting the error of perspective which affected the discussions that ESA scientific advisors and decision makers held in mid-1970s on the future of space science. We shall recall here the two factors which in our opinion, contributed to this erroneous vision. The first was the highly optimistic consideration of the scientific potentialities of the Shuttle/Spacelab system. The optimism we should point out, was less harboured by the scientific community than by the political decision-makers. Nevertheless, in the wake of the spectacular Apollo moon landings, it was genuinely felt that a new era of big science in space was opening up in the 1980s. The great versatility of the Space Shuttle and the large capacity of its cargo bay made many dreams feasible. As a matter of fact, well before the Challenger accident it became evident, firstly, that the financial and technical difficulties of the Shuttle development programme would severely harm NASA's science programmes and, secondly, that the Shuttle operation was much too expensive for this facility to be used in scientific missions, the commercial and military interests being a better trade off.[351]

The second factor was the lure of ESA/NASA scientific cooperation. Both space agencies needed this cooperation, as a consequence of the budgetary limitations of the 1970s. In 1974, the US Congress stated that collaboration with ESA was a *sine qua non* for it eventually to approve NASA's Space Telescope. Similarly, ESA's scientific advisory bodies could hardly design ambitious scientific missions which could dispense with NASA participation. However, in spite of the good scientific and technical relations established in that period, too many differences existed between the two agencies as regards their institutional and political framework. The difference in the budget procedures was the most striking one. Decision-making could be very long for ESA, as we have seen, because of its multinational constituency, but once a project had been approved its financial allocations were also approved in terms of a certain cost-to-completion. In a way, provided no cost escalation occurred, the project became legally binding for member states and there was no threat of cancellation. NASA, on the contrary, was a national agency whose overall programme and budget had to be negotiated annually with the Federal Government and Congress. Funds could always be shifted from one programme to another on the basis of political considerations, congressional lobbying or national security priorities.

The case of the joint ISPM (former OOE) mission is particularly revealing. The ESA/NASA Memorandum of Understanding, in fact, included the (obvious) statement that its applicability was always subject to the availability of funds for both parties, according to their "respective funding procedures". This condition applied with near certainty to ESA, after the mission had been approved in November 1977. It was different on the US side, however. Here the final go-ahead was given by Congress in early 1978 with the inclusion of ISPM in the fiscal year 1979 budget. Two years later, as a consequence of President J. Carter's budget cuts, NASA's research budget was dramatically reduced in order to protect the escalating Space Shuttle programme, and the mission had to be delayed two years. The election of R. Reagan as Carter's successor brought about fundamental changes in the budget process, which led to a further decrease in the space science budget and, ultimately, to the unilateral

349 Sahm & Jansen (1985); Heusmann & Wolf (1985); Lord (1987), pp. 374-388.

350 W. Finke, quoted in McCurdy (1990), p. 102. See also Lord (1987), p. 396; Gibson (1992), p. 42.

351 *Nature* (1979) and (1982). See also Logsdon (1986).

cancellation of the ISPM spacecraft. Here is the comment of two protagonists of ESA's scientific history:

The outrage and incredulity in Europe were great [...] incredulity that an international agreement would be cancelled at all. This reflected ESA's stunned realisation of the fundamental difference in attitude between the two organisations about the sanctity of a Memorandum of Understanding. In Europe [...] the MOU was considered as legally binding on its Member States, while it became painfully clear that this was not the case for the US Administration.[352]

This was a severe lessons for ESA policymakers, which deeply affected future relations with their American counterparts: "Europe would no longer accept being considered a subordinate participant".[353]

352 Bonnet & Manno (1994), p. 102.
353 *Ibid*, p. 106.

Chapter 4:
The Definition of ESA's Scientific Programme for the 1980s

A. Russo

Introducing the European Space Agency's Annual Report for 1975, the Chairman of the ESA Council, Wolfgang Finke, did not hide the difficulties that the newly created Agency had to face up to in the future: "If the eleven-year marriage of Europe and space under ESRO was occasionally stormy, the lusty cry of its progeny ESA after a long-anticipated and difficult birth did not signify the end of the problems". One of ESA's biggest problems, Finke wrote, was its very size – more precisely, the size of its programme and the budgetary consequences:

Deciding what to put into the greatly enlarged programme of space activities to be undertaken by the new Agency had itself been difficult, given the different priorities of the ten Member States. Working out how these activities were to be financed in the mid-1970s – a period of peak expenditure for several of the biggest programmes which had been started virtually simultaneously – was bound to be intractable.[354]

The dramatic increase of the volume of financial resources to be managed was the first aspect of the budgetary problems the new Agency had to cope with. The funds managed by ESA in 1975 amounted to 342.4 MAU, with an increase of 73.6% and 180% over ESRO's funds in 1974 (197.2 MAU) and 1973 (122.1 MAU), respectively.[355] A second aspect derived from the complexity of the optional programme structure of ESA's activities. The Agency had to manage several independent budgets, each corresponding to a different programme, supported by a specific set of Member States, with a specific contribution scale. Only two budgets were mandatory, i.e. supported by all Member States according to a gross national product (GNP) contribution scale. These were the General Budget, covering the basic and support activities, and the Science Budget, covering all scientific satellite projects and the research activities of ESTEC's Space Science Department (SSD). The other budgets covered the various optional programmes approved by the ESA Council, each of them being financed by the participating Member States according to a contribution scale mutually agreed upon. In the first phase of its life, the Agency ran six optional programmes: Telecommunications, Spacelab, Ariane, Marots, Aerosat and Meteosat.

Besides the contribution scales, another important difference existed between the science programme, on the one hand, and the optional programmes, on the other. The former consisted of a succession of individual projects within an overall financial envelope, the various projects being selected by a competitive procedure mainly based on scientific merit. Each optional programme, on the contrary, comprised one clearly specified project, mainly defined on political grounds and to be completed within an agreed fixed cost. The management of this complex budgetary structure was made more difficult by the need to comply with the so-called "fair return" principle, requiring that, for each programme, the participating Member States should receive a share of industrial contracts as far as possible equal to their financial contribution.

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354 W. Finke's "Foreword" to ESA *Annual Report 1975*, p. 4. The new Agency began to function "de facto" on 31 May 1975 but, pending formal ratification and entry into force of its Convention, the ESRO Convention remained the legal basis of its activities and programmes. ESA's first Member States were the same as ESRO's, namely Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom. By the end of 1975, Ireland had also signed the ESA Convention, but it formally became a Member State in 1980, when the Convention came into force. Meanwhile, that country was associated in the Agency's activities under the terms of a special Agreement of Cooperation and Association.

355 ESA, *Annual Report 1975*, p. 137; ESRO, *Annual Report 1974*, p. 197; ESRO, *General Report 1973*, p. 169. A further increase of 35.8% was realised in 1976, when the funds managed by ESA amounted to 465 MAU: ESA, *Annual Report 1976*, p. 164.

A complicating factor in the administration of ESA's various budgets was the peculiar economic climate in Europe in the 1970s, characterised by a high rate of inflation and large monetary fluctuations. The weighted average price increase within the Member States was 14.6% over the period mid-1974 to mid-1975, but the inflation rates were very different in the various countries, ranging from 7.1% in Germany to 24.8% in the United Kingdom.[356] The different inflation rates and the large fluctuations in the exchange rates between national currencies and ESA's Accounting Unit called for a serious revision of the Agency's financial regulations, in particular regarding the procedures for calculating financial contributions and industrial returns. Failing to reach a general agreement on this matter, in December 1977 the Council called on the International Monetary Fund (IMF) for an expert analysis of the economic and monetary situation, and asked it to provide recommendations on how to change ESA's financial system accordingly. The IMF duly prepared its report by June 1978, but the diverging interests of those Member States with strong currencies and low inflation rates and those Member States with weak currencies and high inflation rates made any substantive agreement impossible. As a consequence, the triennial level of resources for 1978-1980 could not be approved, and the mandatory budgets for 1978 and 1979 were not adopted because the required unanimous agreement was not achieved. As a consequence, mandatory activities, including the Scientific Programme, were developed by the recurrent application of the system of *provisional twelfths* approved by the Council on a provisional basis.

Return to normality was realised in 1980, when the Council decided to maintain unchanged the existing financial system, but to provide for some ad hoc compensation to take into account the most negative effects of inflation and exchange-rate variations. This compromise eased the way to the formal entry into force of the ESA Convention, which occurred after the French government deposited its instrument of ratification on 30 October that year. In February 1984, after ten years of discussions, the Council finally approved the new Financial Regulations, thus replacing a financial system whose substance went back to the first ESRO Financial Rules of November 1964.

It is against this historical background that we will discuss in this chapter the evolution of ESA's Scientific Programme in the late 1970s and early 1980s, dealing in particular with two main topics: (a) the definition of a general strategy for European space science in the 1980s; (b) the decision-making process that led to the selection of the Agency's next scientific projects: the cometary mission Giotto and the astrometry satellite Hipparcos.

4.1 Discussing a long-term strategy for ESA's scientific activities

In early 1977, the ESA Director of Planning and Future Programmes, André Lebeau, asked the Science Advisory Committee (SAC) to undertake a discussion on a long-range strategy for ESA's scientific activities.[357] At that time, the Agency's first scientific satellite, the gamma-ray observatory COS-B, was in the second year of its orbital life, providing a continuous flux of valuable data; two other satellites, GEOS and ISEE-2, both devoted to magnetospheric studies, were scheduled for launch later that year and a third one, the X-ray satellite Exosat, was under development; finally, a new run of the decision-making process had just been concluded with the decision to undertake two new projects in collaboration with NASA, the Hubble Space Telescope and the International Solar Polar Mission (ISPM).[358]

The main reason for the SAC to undertake the new long-term planning exercise, which followed that made in 1970 by the SAC's forerunner of the ESRO period, the Launching Programme Advisory

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356 ESA, *Annual Report 1975*, p. 138.

357 "Medium-term orientation of the activities of the European Space Agency (1977-1983)", ESA/EXEC(76)1; SAC, 6th meeting (28 January 1977), SAC(77)3, 22 March 1977.

358 In the event, the launch of GEOSin April 1977 failed because of malfunctioning of the Delta launcher. The second GEOSflight model was successfully launched in July 1978. The ISEE-2 satellite, launched in October 1977, was the European contribution to the ESRO/NASA International Sun-Earth Explorers mission.

Committee (LPAC), was to make a case for a substantial increase in the level of resources for the science programme, established with the 1971 "first package deal".[359] That agreement had fixed the target annual level of the mandatory science budget at 28 MAU (including 1 MAU for contingency) at mid-1971 prices, corresponding to 69 MAU at mid-1976 prices.[360] The available funds for scientific activities were lower in ESA than in NASA by a factor of ten, the SAC noted, while the number of active research groups at European universities and research institutions had kept growing steadily since the beginning of the space age. Moreover, the technical complexity and financial cost of scientific space projects had significantly increased in this period, evolving from small multidisciplinary spacecraft with an exploratory character to large dedicated missions, and new research fields had added to the traditional space sciences, in particular those related to Earth observation from space platforms.

Finally, important developments had occurred since 1971, notably the decision of ESRO/ESA Member States to build the Spacelab facility within the framework of the US Space Shuttle programme, and to undertake the construction of the heavy satellite launcher Ariane. The advent of Spacelab, on the one hand, opened up the "microgravity" space environment to experimental activity in the fields of materials science (crystal growth, tribology, fluid dynamics, surface phenomena, materials processing, etc.) and life sciences (human physiology, cellular biology, plant growth, vaccine research, etc.). On the other hand, the availability of Ariane would have the consequence that European space missions will preferably be launched by this launcher, and therefore "the ESA Scientific Programme would require a higher level of funding in order to satisfy the potential claims that would be made for its use".[361]

After some preliminary discussions, the SAC decided to hold an extraordinary meeting exclusively devoted to long-range planning of ESA's Scientific Programme. This meeting was to be carefully prepared by the SAC members, the Working Groups and the ESA Executive, in consultation with national delegations in the Science Programme Committee (SPC) and the scientific community at large.[362] The chairman of the SAC, the British astronomer Martin J. Rees, set the agenda for the discussions in an informal document he circulated in early October, following a meeting of the Committee on Space Science of the European Science Foundation (ESF) in which he had been invited to participate.[363]

Rees identified two broad classes of issues. The first included topics of specific interest of the SAC, such as the question of scientific priorities, the role of free flyers vs Spacelabs, the equilibrium between "classical" and "new" space science disciplines, the relationship between scientific and application programmes, the ways to reduce the costs of spacecraft and launches. The second regarded areas "where the ESF could usefully take the lead", i.e. the optimum feasible level of activity in European space science and the relation between the ESA programme and the national programmes. The problem, according to Rees, was to define a scientific policy tailored to Europe's needs and resources:

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359 The LPAC policy statement of June 1970 is discussed in chapter 8 of Volume 1.

360 ESA/C(76)33, rev. 3, 17 November 1976, Annex. Besides the effects of inflation, the new figure also took into account the changes in the budget structure introduced after the second package deal and the setting up of ESA. Eventually, the science budget for 1977 was approved by the Science Programme Committee (SPC) at the level of 67.3 MAU: SPC, 9th meeting (14 December 1976), ESA/SPC/MIN/9, 24 January 1977, pp. 11-12.

361 SAC(77)3, *cit.*, p. 8.

362 SAC, 7th meeting (2 May 1977), SAC(77)8, 7 July 1977.

363 M.J. Rees, "Long range planning studies. Some preliminary ideas on what the SAC might do", SAC(77)12 [10 October 1977]. The following quotation is from p. 2. The ESF Space Science Committee was chaired by H. Massey, a pioneer of space research in Europe, and included other eminent space scientists (and ESRO founding fathers), such as R. Boyd, H. Elliot, H. van de Hulst, C. de Jager, R. Lüst, B. Peters. The ESA Director General, R. Gibson, and A. Lebeau were also members of the Committee. The meeting attended by Rees was held on 5 October 1977, and a copy of the minutes is available in *D/Sci archives*.

> *There is little point in discussing scientific priorities in a completely "abstract" way [...] We ought instead to focus on what Europe should do, taking full cognisance of what has already been achieved, the existing expertise (and limitations), and the wishes and plans of the major established European institutes. In the light of such considerations, we can maybe suggest some hypothetical launching programmes for major projects in the 1980s which, taken as a whole, could [...] provide a balanced scientific return, and give each member country a fair share of the action. This cannot be done without making a careful choice of subfields within each discipline, and accepting that some fields must be left entirely to NASA and the USSR.*

Rees also suggested a procedure to proceed with a thorough study of the European space policy for the 1980s. An extraordinary meeting of the SAC should be organised in early 1978, to be attended by incoming and outgoing SAC members, the chairmen of the Working Groups, top ESA officials and some invited experts and ESF members, "to discuss priorities in general and to decide what individual scientists or institutions might be invited to contribute opinions, papers on scientific topics, or information about plans and preferences". A further extended meeting would be held some months later "to digest the material and prepare a report".[364]

The extraordinary SAC meeting was duly held on 25 February 1978, chaired by the newly elected SAC chairman Roger Bonnet (Table 4-1).[365] The key question discussed at the meeting was the definition of a proper framework for ESA's Scientific Programme, i.e. the content of the activities to be supported by the Agency's mandatory science budget. This essentially meant a distinction between those disciplines, research fields and technologies that could be accommodated within the programme and those that could not, for either financial reasons or lack of relevant interest and experience in Europe. The LPAC's policy statement of 1970 had excluded from the ESRO programme such important fields as optical astronomy, solar physics and planetary exploration; at the same time, it had given priority to high energy astrophysics and magnetospheric studies. It was likely that a similar list of "negative and positive priorities" would be necessary in the new phase too.

This exercise involved two different aspects. The first was a careful appreciation of the long-term scientific potential of the various research fields, and the role Europe could play *vis-à-vis* the parallel efforts in the USA and the Soviet Union. As was pointed out at the meeting, "[one] should be cautious about giving priorities for missions to be carried out ten years hence [and] it would be a mistake to close off areas of science at this stage".[366] The second involved the question of the kind and size of projects to be done by ESA. On the one hand, large, observatory-type missions seemed most appropriate for cooperative undertakings, but, owing to the necessarily limited number of such projects, there would have been large fluctuations in the activity of any individual research group, with young scientists having a chance to carry out experiments only every six to eight years and being otherwise left with routine work. On the other hand, small projects and multi-experiment satellites could more easily cater for the scientific community at large and facilitate a balance among disciplines, but many felt that confining ESA to small-size projects would betray the ambitions of European space scientists and the very meaning of their collaborative effort.

4.1.1 "Classical" and "new" space science disciplines

The balance between the various disciplines and between large and small projects was only part of the problem, however. The SAC had to establish also what criteria allowed a "new" discipline to be included in ESA's mandatory Scientific Programme. Since the early ESRO period, this had traditionally included two broad research areas, covered by the Solar System Working Group (SSWG)

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364 SAC, 8th meeting (18 November 1977), SAC(77)15, 15 December 1977, p. 10. This procedure as well as the agenda for discussions were eventually detailed by the Executive in SAC(78)1, 8 February 1978, and SAC(78)4, 17 February 1978.

365 SAC, "Extraordinary meeting on long-term planning" (25 February 1978), SAC/78)6, 11 April 1978.

366 SAC(78)6, *cit.*, p. 6.

Table 4-1: Participants in the SAC extraordinary meetings on long-term planning (25 February and 26-27 September 1978)

Members of the SAC:	R. Bonnet (chairman)
	W. Axford
	G. Colombo *
	K. Pinkau
	A. Wiin-Nielsen
	H. Wolff
Outgoing members of the SAC:	M. Rees *
	L. Houziaux **
Chairmen of Working Groups:	
Astronomy	G. Setti
Solar System	M. Petit
Solar Telescope	F. Pacini
Life Sciences	(H. Wolff)
Material Sciences	H. Weiss
Outgoing Chairmen of Working Groups:	
Solar System	J. Geiss*
Life Sciences	H. Bjurstedt
Chairman of the SPC:	H. Curien
European Science Foundation:	
Chairman, Space Science Committee	H. Massey (R. Boyd) ***
Chairman, Astronomy Committee	R. Lüst
Invited Expert	H. van de Hulst
ESA:	
Director General	R. Gibson
Dir. of Planning and Future Programmes	A. Lebeau
Dir. of Scientific and Meteorological Progrs.	E. Trendelenburg
Deputy Director of Planning	A. Dattner
Head of Future Scientific Programmes Dept.	E. Peytremann
Head of Space Science Dept.	D. Page
	V. Manno

and the Astronomy Working Group (AWG), respectively. The former included solar physics, planetary science, solar-terrestrial relations, ionospheric and magnetospheric studies; the latter included astronomy and astrophysics, and cosmic-ray physics. All these fields had been covered to some extent by ESRO's first satellites, while in the late 1960s and early 1970s priority had been given to magnetospheric research (ISEE-2 and GEOS) and high-energy astrophysics (COS-B and Exosat). In the new decade, Spacelab would open up interesting opportunities for "science in space" in a variety of disciplines outside the traditional domain of "space science". Microgravity research in life sciences and material sciences was only possible on Spacelab missions, and could extend the European space expertise in a domain of great importance in view of future manned space stations. In fact, two new

* Only attending the February meeting.
** Only attending the September meeting.
*** Massey was unable to attend the September meeting but was represented by Boyd.

working groups had been set up by ESA in order to deal with the new scientific prospects, the Life Sciences Working Group (LSWG) and the Material Sciences Working Group (MSWG).

Should biomedical research on Spacelab be considered as space science in the ESA framework, and then supported by the mandatory science budget? The answer tended to be positive, and in fact the SAC had recommended (and the SPC approved) the funding of a Sled facility for vestibular studies in the payload of the first Spacelab flight out of the science programme budget.[367] If, however, this programme should cater for the further development of life sciences in space, a revision of the "package deal" level of resources could hardly be avoided.

The situation was different in the case of materials science, also represented in the first Spacelab payload by a general experimental facility under development with national funding. There was an evident potential economic interest in this research field on the borderline between science and applications, and it was expected that governments and industry would support its development in the framework of an envisaged optional programme on Spacelab utilisation. The problem remained, however, about the role of the SAC and the SPC in the definition of a scientific policy for this field. In the words of the chairman of the MSWG, H. Weiss:

> *The distinction between science and applications was academic. All our techniques were derived from scientific studies. In the field of material sciences, the physical and chemical behaviour of fluids and gases in space was still a mystery to a large extent and many years of exploration of materials in space would be required before the setting up of a space factory would be feasible. This field was indeed a scientific one and belonged to the science programme.*[368]

If there was a scientific content as well as an economic interest in materials science, and if this field was to share Spacelab facilities with "traditional" space science disciplines, how could the European scientific community represented in ESA's advisory and decision-making bodies be involved in the selection of experiments? How could the principle of scientific merit, adopted within the framework of the mandatory science programme, be safeguarded within the framework of an optional programme funded according to national economic interests? If, on the contrary, material sciences were included in the science programme (and the budget increased accordingly), how could one prevent the new application-oriented disciplines from being unduly privileged against "classical" research fields?

Alongside the new Spacelab sciences, a similar problem arose regarding Earth-oriented research, a field which was coming to the forefront of space research in the wave of the new interest for environmental sciences in the 1970s, but was not covered by ESA activities. Earth sciences included a wide spectrum of disciplines on the borderline between science and applications, from oceanography to climatology, from geodynamics to atmospheric physics, from geodesy to remote sensing. Lebeau, was a convinced advocate of the Agency's involvement in this field:

> *This complex of disciplines forms a single whole, with a unity of its own, and one must not seek to divide it up artificially. It is founded on a set of homogeneous space techniques and means. It relates to a clearly identified, homogeneous scientific community and one which, moreover, as things stand at present is virtually excluded from the European programme.*[369]

According to the Director of Planning and Future Programmes, an optional science programme should be set up for the study of the Earth and its atmosphere. Such a programme, he said, "would constitute, alongside the mandatory Scientific Programme and the [optional] application programmes, a new category of activities".

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[367] See chapter 14 in this volume.

[368] SAC(78)6, *cit.*, p. 4.

[369] SAC(78)3, 16 February 1978, p. 4. The following quotation is from p. 1.

The proposal was not well received by the spokesmen of the European space science community. All recognised that a way was needed of including new branches of science in the ESA programme, either by enlarging the mandatory programme or establishing optional Scientific Programmes, but they did not like that any area of science should be granted a preferential position on the basis of its potential value for applications. The founding fathers of European space science were particularly resolute in this respect. "The study of the Earth and its atmosphere [is] also of a scientific nature", Reimar Lüst argued: "While a programme such as proposed might be more applications oriented than others and therefore more easily accepted politically, this would be at the expense of recognising the significance of the science to be done by ESA". Supporting Lüst's arguments, Hendrik van de Hulst, Martin Rees and Johannes Geiss recalled that the field of atmospheric research was covered by the SSWG and had not been neglected either in the past or in future planning. The latter added: "While new programmes might understandably be introduced into the Agency's structure, if these were imposed there might be criticism from other disciplines. Therefore care should be taken to select only first rate scientific objectives".[370]

Behind principles there were, of course, financial considerations and disciplinary allegiances. As the total funds that national governments allocated to space would presumably not increase in the future, all money going to application-oriented projects would be lost for pure-science projects, both within the ESA framework and in national space programmes. Facing the pressure of new disciplines and new research fields which claimed access to space, Lüst and his peers wanted to protect the "traditional" fields by preserving the original character of ESRO's Scientific Programme, i.e. one driven by the established European space science community. They advocated more resources for space science, either by increasing the mandatory budget or in the form of optional programmes, but insisted that all research fields should be dealt with on equal footing, and that ESA's scientific policy should be defined on purely scientific grounds.

The discussion about the role of the new disciplines in the ESA programmes was complicated by two factors. Firstly, the SAC was split on this issue, with one of its members, Giuseppe Colombo, strongly arguing that priorities should also be based on "possible economic return", and that ESA should preferably undertake projects aimed at geophysical problems.[371] Secondly, a dramatic difference of opinion existed within the ESA Directorate, setting Lebeau, on the one hand, in opposition to the Director of Scientific Programmes, Ernst Trendelenburg, on the other. The former advocated an important European effort in Spacelab utilisation and Earth-oriented research within the framework of ESA's activities. The latter shared his fellow space scientists' distrust of Spacelab and was resolutely against the inclusion of application-oriented disciplines in the mandatory Scientific Programme. The present level of the scientific budget was highly unsatisfactory, he argued, and one could hardly expect that it could be significantly raised in the near future: "In this situation, the inclusion in the Scientific Programme of 'new' disciplines [...] would be inadvisable, in that it would no doubt alienate our traditional customers without necessarily generating any 'new' friends".[372] The contrast between the two men led in this period to an important modification in ESA's directorate structure, essentially complying with Trendelenburg's vision: responsibility for studies of future scientific projects, with the significant exception of studies related to life sciences and material sciences, was transferred from Lebeau's Directorate of Planning and Future Programmes to Trendelenburg's Directorate of Scientific Programmes. Moreover, the latter ceased to be responsible for the meteorological programmes, which were placed under the responsibility of the newly created Directorate of Applications Programmes (en enlargement of the former Directorate of Communications Satellites Programmes).This change enabled Trendelenburg to guide ESA's scientific policy more efficiently according to his own orientations.

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370 SAC/78)6, *cit.*, pp. 3-4.

371 SAC(78)6, add. 1, 20 April 1978. Colombo's strong criticism of SAC's scientific policy is discussed in the previous chapter. cf. also Bonnet (1985).

372 SAC(78)4, 17 February 1978. cf. also Lebeau (1997).

Coming back to the extraordinary SAC meeting, two other important questions discussed by the participants were the role of the Ariane launcher and the aims of technological research within ESA. Ariane was much too big and expensive for the launch requirements of most scientific missions. Therefore, either scientific satellites had to go into orbit on shared launches, which would imply technical and schedule restrictions for the Scientific Programme, or a reduced version of Ariane had to be studied in order to meet the launch requirements of the programme itself. The issue of ESA's technological research touched a recurring controversial theme, i.e. the diverging interests of larger countries with important national space programmes and technological capability, on the one hand, and smaller countries which were dependent on ESA for supporting their research groups and training their engineers, on the other. The former, notably France and Germany, argued that the technological research programme at ESTEC should be kept at a minimum and mainly developed in relation to specific projects. This position was spelled out at the meeting by Klaus Pinkau and supported by Lüst. The interests of smaller Member States, which obviously converged with ESA's, were defended by Lebeau who insisted that "the technological research programme [should be] oriented towards basic space technology rather than specific projects".[373]

Concluding the meeting, a list of activities and task assignments was identified, and a Steering and Editorial Board (STEB) was set up, comprising R.M. Bonnet, K. Pinkau, H. Wolff and A. Wiin-Nielsen, with the task of preparing the final report. The on-going work was discussed at the ordinary SAC meeting of 9-10 May and a draft report was then discussed on 26-27 September at a new extraordinary meeting with essentially the same attendance as the previous one (Table 4-1).[374] The final version of the report was eventually approved by the SAC on 19 December and then printed and circulated by ESA.[375] We will review its content in the following section.

4.2 The SAC's vision of European space science in the 1980s

"In the SAC's view, a case can – and should be made – to recover the support for space science which was lost in 1972": this sentence we find in the introduction of the report.[376] That year, we should recall, the provisions of the first package deal started to be implemented, rapidly transforming the former "space research organisation" into an organisation mainly devoted to application satellites (Figure 4-1). The budget for scientific projects was dramatically reduced from about 60 MAU to the target figure of 27 MAU plus 1 MAU contingency per year (at 1971 price levels).[377] At that time, this was meant to be a minimal funding level required for maintaining a viable Scientific Programme; in fact, it became a maximum level as Member States refused to increase their mandatory contributions to the science budget above the required minimum. After price level adjustments and new budgetary procedures, the annual level for science amounted to 76 MAU in 1978, to which one could add a *pro-rata* share of the general budget and a small amount for the scientific part of the first Spacelab mission, thus bringing the total to approximately 85 MAU. This figure, the SAC commented, "is about

373 SAC(78)6, *cit.*, p. 10.

374 SAC, 11th meeting (9-10 May 1978), SAC(78)11, 9 June 1978; SAC, Extraordinary meeting on long-term planning (26-27 September 1978), SAC(78)20, 20 November 1978.

375 SAC, *Recommendations on the development of space science in the 1980s*, ESA SP-1015, December 1978. The report was also referenced as SAC(78)17 and circulated under cover SA/SPC(79)12, 3 January 1979.

376 ESA SP-1015, *cit.*, p. 11.

377 It is worth recalling that in 1971 the LPAC had estimated that "the minimum level of funding required for a truly viable scientific satellite programme lies between 45 and 47 MAU": LPAC, 36th meeting (28-29 April 1971), LPAC/110, p. 3 (restricted session). A recommendation for an increase of the science budget had been made by the LPAC in its 1974 guidelines for new mission studies: LPAC(74)4, January 1974. cf. chapter 8 in Volume 1 and chapter 3 in this volume.

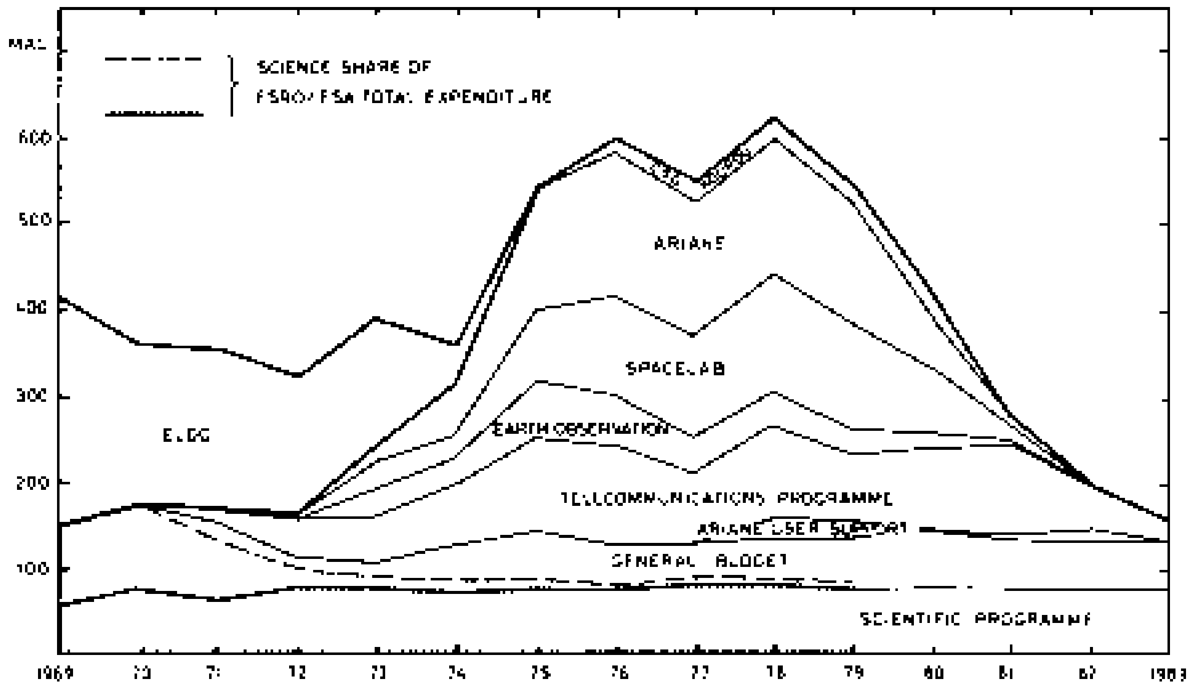

Figure 4-1: Expenditure of ESRO, ELDO and ESA, normalised to mid-1978 price levels (ESA SP-1015, p. 9)

three times smaller than CERN's 1978 budget (approximately 260 MAU) [and] very low compared to the space-science effort in the USA".[378]

The second package deal (1973) and the ensuing creation of ESA (1975) had brought an important new element into the framework of the European space effort, i.e. the decision to build the Ariane launcher and Spacelab. This had two particular consequences: firstly, that future European space missions were preferably to rely on Ariane and the Shuttle/Spacelab system for launch, at a cost presumably higher than "traditional" launch vehicles; secondly, that new scientific disciplines wished to be included into ESA's science programme in addition to the "classical" space sciences.

This situation justified the SAC's claim for a significant increase in the science budget in the coming decade, and a quick analysis of the graph reported in Figure 4-1 showed that this was indeed possible and even necessary. It indicated in fact that, owing to the completion of the Ariane and Spacelab programmes, the ESA funding requirements were undergoing a dramatic reduction in the near future. Supplementary support for space activities was then required, in order to "avoid Europe falling further behind the United States in terms of level of effort, and to enable European scientists to play a role compatible with Europe's historical and political importance in the World".[379] An increasing support to space research, in other words, was to be considered as a key element of a sound space policy for Europe *vis-à-vis* the United States, and also Japan, whose space effort was already comparable to that of ESA Member States as a whole. It was the SAC's task to show that the new resources made available for space activities in Europe could profitably be spent within the framework of ESA's Scientific Programme.

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[378] ESA SP-1015, *cit.*, p. 9. The comparison between space science and high energy physics was suggested by Trendelenburg on the basis of the CERN report *Resources given to high energy physics in 1976 in the CERN Member States*, prepared by C. Roche, DIR/CPO/153/Rev., January 1978. cf. Trendelenburg's letter to STEB members, 27 July 1978, in *D/Sci archives*.

[379] ESA SP-1015, *cit.*, p. 15.

4.2.1 "Has ESA been good for science?"

This was the first question, or rather, as the authors of the report, with some rhetorical lengthiness, put it:

> *Has ESA been good for science and is it necessary for Europeans to cooperate within the framework of a European organisation or agency rather than undertake projects as bilateral or multilateral cooperative ventures, in particular with the USA where, due to the volume of NASA's activities, the cost efficiency of space science could more easily be improved? Furthermore, to what extent should we rely on US generosity and goodwill? In other words, should we have our own kitchen and cook our own dinners, or should we await possible invitations to dinner from outside?*[380]

After a review of past scientific achievements, and a complex cost-effectiveness analysis of ESRO's and ESA's scientific satellites in comparison with national projects, the SAC concluded that "ESRO/ESA appears to have been less expensive than several national agencies". The Committee recognised that one important element against the wish of lowering costs was the industrial policy that forced ESA to place contracts according to the "just return" principle, and it strongly recommended that "the fair geographical distribution of contracts should be averaged over more than one project at a time, and over periods longer than those necessary for the completion of a project". As an example of such a relaxed policy, the SAC presented the case of hardware experiments contributed by national scientific groups to the various ESRO/ESA satellites, where a fair geographical distribution had been achieved over a ten-year period, "without the imposition of a forced policy towards this end".[381]

In conclusion, answering the foregoing question, the spokesmen of the European space science community insisted that Europe should keep a cooperative effort "on a European scale", in addition to any possible bilateral or multilateral undertakings. Three main reasons were given. Firstly, in a context in which the increasing complexity of spacecraft and experiments reduced the number of flight opportunities, and made the competition between scientists fiercer, the European programme increased the possibilities for the space science community to fly experiments, and offered more "security, stability and continuity" than cooperative ventures with a "one-off character". Secondly, the spectrum of scientific interests in Europe differed in many areas from that of American scientists, "and the European community at large feels the need for an independent programme in which its particular interests can be safeguarded and represented". In this respect, a clear guideline for future European programmes could be identified, i.e. "to exploit those fields of science of which the originality is well recognised, and which can be undertaken earlier in Europe than in the USA or USSR". Finally, the concept of free cooperation between European nations was an ideal that extended beyond the scope of space research alone: "The furtherance of this ideal may in itself be worth some small cost penalty", the SAC argued.[382]

4.2.2 The content and dimension of ESA's Scientific Programme

The next step was to discuss an overall programme for the development of space sciences within ESA in the 1980s, including both the "classical" disciplines (astronomy and solar system science), and the new fields of microgravity research and Earth sciences. In Table 4-2, we present the plans elaborated between 1976 and 1978 by ESA's four Working Groups, which the SAC laid at the foundation of its

380 ESA SP-1015, *cit.*, p. 26.
381 ESA SP-1015, *cit.*, pp. 24-25.
382 ESA SP-1015, *cit.*, p. 26.

Table 4-2: Development of space science within ESA in the 1980s according to the Working Groups' long-term programmes

Disciplinary field	Programme elements
Astronomy and astrophysics	Exploitation of the Space Telescope The UV and X-ray survey satellite EXUV The astrometry satellite Hipparcos One Spacelab pallet per year for small experiments A large observatory for IR astronomy (LIRTS concept) A large observatory for X-ray astronomy (EXSPOS concept)
Solar System sciences	Two missions in the areas of planets or comets An X-ray solar telescope on Spacelab (GRIST) A satellite or Spacelab facilities for space plasma studies A standard platform for atmospheric sciences A standard platform for geodynamics
Earth sciences	Participation in the GARP programme (SEOCS satellite) An ocean and ice programme A solid-Earth physics satellite
Material sciences	Participation in one Spacelab mission per year
Life sciences	Studies of the human vestibular system by the Sled facility Biorack facility for the study of plants, cells and bacteria

analysis.[383] Two aspects were to be discussed: firstly, the size and content of the ESA Scientific Programme; secondly, the institutional framework in which the programme itself could be implemented. The first aspect was related to the place of the new disciplines *vis-à-vis* the classical ones and to the financial resources required to develop a viable programme in the various research fields. The second was related to the various mechanisms that the ESA Convention provided for the implementation of the Scientific Programme, namely the mandatory programme, the optional programmes and the internationalisation of national programmes (either within the mandatory programme framework or as an optional programme).

As regards the first aspect, the SAC refrained from establishing negative priorities, and recommended that "Europe [should] follow a policy in which all the fields of European scientific excellence in space are developed and supported, and in which the space science budget is not so small that entire fields must vanish". Three considerations supported this statement: firstly, the potential of the various research fields in Europe, as resulted from the Working Groups' discussions with the scientific community at large; secondly, the need to have a fair balance between the various (old and new) disciplines; thirdly, the role of space science in the political environment within which Europe would develop its overall space effort. As the SAC put it:

383 AWG, *Report on long-term planning, 1980-1990*, ASTRO(76)13, August 1976; *Summary and conclusions of astronomy long-term planning*, ASTRO(78)12, August 1978. SSG, *An approach to long range planning 1980-1990*, vol. I, SOL(76)9, September 1976, and vol. II, SOL(78)12, June 1978. SSWG, *Report of the Ad Hoc Panel on Earth Sciences*, SOL(78)16, August 1978. MSWG, *Long-term planning in material science*, MAT(78)10, March 1979. LSWG, *Long-term planning in life sciences*, LIFE(79)1, 1979.

In space science, Europe should accept and be equal to the position that it has economically and politically in the World. Europe should move into the next decade attempting to meet the challenge deriving from its scientific and cultural heritage.[384]

This ecumenical space policy implied the achievement of an event rate of about one satellite launch per year and about half a Spacelab every two years, so that existing groups would be granted a minimum level of continuity in hardware-building activity and an evenly spaced event rate of experiments in microgravity research. The obvious implication was a strong plea for a significant increase in the resources devoted to science in the ESA budget: "If such an increase is not achieved, it will not be possible to continue supporting the different branches of science in a reasonable way and it will be necessary to kill entire fields. [...] The reductions occurring in the 1970 to 1972 time frame have cut too deeply into the possibilities of space science, and [...] an upward correction must now occur".[385]

As regards the institutional framework, the SAC agreed to take "a pragmatic approach", recognising that in order to meet the demands of the classical and new disciplines, a combination of all three funding mechanisms should be used, "while at the same time maintaining the scientific standard irrespective of the way in which a particular programme is funded".[386] The case of Earth sciences was exemplary in this respect. Earth-oriented space projects were justified both for their purely scientific value (e.g. the understanding of the relations between the atmosphere, the oceans and the polar ices, or the study of the global motion of the Earth's crust) and because of their potential for easily identified applications (e.g., the description and prediction of the climatic system, or the possibility of Earthquake predictions). After a discussion in a restricted meeting which is not reported in the minutes, the SAC "unanimously agreed that Earth Sciences should be recognised as a discipline within ESA and be treated on an equal footing with the other scientific disciplines".[387] It, however, recommended that Earth-oriented missions should be supported within the framework of an optional programme, and that an Earth-Oriented Research Working Group be established "within the ESA's advisory structure, in order to guarantee a competitive selection procedure similar in every respect to that used in the field of 'classical' space disciplines".[388]

According to the SAC, the mandatory programme should continue to provide the backbone of ESA's scientific activity, but it was too small to support the long-term plans in the classical disciplines, and certainly it had no margin to provide for the new microgravity sciences. The Committee noted that, as a result of the tight financial constraints, both the AWG and the SSWG had undertaken a frustrating procedure of killing mission proposals and reducing the programme to the minimum level required to maintain the scientific community in the disciplines within their purview. Despite this exercise, the long-term programmes elaborated by the working groups required expenditures in the range of 120 MAU per year in the 1980s, i.e. about 30% of ESA's total expenditure, "assuming a constant annual expenditure of 400 MAU (Figure 4-1)". The SAC, however, agreed to refrain from identifying particular fields for which support should be stopped in the future should the level of the science budget not be increased. On the contrary, it recalled that ESRO/ESA had never undertaken a pure solar physics or planetary mission, and considered that this situation had to be rectified.[389]

A cautious attitude was adopted as regards life and material sciences:

The basic question is whether the microgravity research [...] will prove important or not. The SAC believes that there is need for a cautious but adequate investment here, much of which will have to be used to fund an exploration phase [...] This phase may last until the

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384 ESA SP-1015, *cit.*, p. 33.
385 ESA SP-1015, *cit.*, p. 38.
386 ESA SP-1015, *cit.*, p. 39.
387 SAC, 14th meeting (28 September 1978), SAC(78)21, 20 November 1978, p. 2.
388 ESA SP-1015, *cit.*, p. 34.
389 ESA SP-1015, *cit.*, p. 32.

> *middle of the next decade, when it will be possible to review the situation and decide which of the investigations are ripe for in-depth study and scientific evaluation.*[390]

The Committee recommended that the exploration phase be supported by "a modest but continuous supply of Spacelab flight facilities", but insisted that additional funding had to be found and that the missions had to be "of high scientific value". The level of resources required during the exploration phase was estimated at 120 MAU for ten years, which could be accommodated within the framework of the mandatory Scientific Programme, "if its present very low level were increased".

4.3 The role of Spacelab (and Ariane)

Two considerations can be made regarding the role of microgravity sciences in the SAC's report. Firstly, it reflects the long-standing distrust of space scientists towards man-in-space programmes. Since the glamorous times of the Apollo programme, they knew that scientific objectives were hardly the main motivation for sending human beings into orbit, while political, military and ideological considerations were the real driving force for manned space missions. As the former NASA director for the space science programme put it:

> *Underlying the prevailing discontent in the scientific community regarding the [manned spaceflight] programme was a rather general conviction that virtually everything that men could do in the investigation of space, including the moon and planets, automated spacecraft could also do and at a much lower cost.*[391]

European space scientists, for their part, did not like being obliged to follow their American colleagues in the trap of manned spaceflight: i.e. being obliged to search for a scientific rationale for an essentially political decision such as the "second package deal" decision to build Spacelab in Europe.[392] The SAC then insisted that the new disciplines should be developed within ESA "according to the same scientific principles" as the classical ones; that a competitive selection procedure should be introduced, "making use also of advice that is not *a priori* space-oriented"; and that the new Working Groups for life, material and Earth-oriented sciences "should include scientists of high repute not committed to space investigations".[393]

The second consideration concerns the actual prospects of Spacelab utilisation. When the SAC was preparing its report, the Spacelab programme was suffering a dramatic crisis, with development costs estimated to be about 50% higher than the approved budget; the first mission delayed from spring 1980 to mid-1981, and then again to spring 1982; the cost of the European contribution to the first Spacelab payload estimated at about twice the level approved two years earlier; and the two envisaged ESA demonstration missions almost definitely jeopardised. It was becoming more and more clear that it was not only scientists who did not like Spacelab, but ESA Member State governments as well were reluctant in committing resources in the future utilisation of Spacelab, with the obvious exception of Germany.[394]

Within this framework, the SAC felt it should make clear its opinion about the role of the Scientific Programme in the future exploitation of Spacelab and Ariane, being aware that a strong pressure would be exerted on the European space science community in the future to design ESA scientific missions in such a way as to make fullest possible use of these made-in-Europe space transportation

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390 ESA SP-1015, *cit.*, p. 35.

391 Newell (1980), p. 290. Cf. also pp. 389-392, about the negative attitude of American space scientists towards the Space Shuttle programme. Logsdon (1970), Lord (1987) and McCurdy (1990) devote several pages to the lukewarm (say often negative) attitude of American scientists to the Apollo, Spacelab and Space Station programmes, respectively.

392 See chapters 11-14 in Volume 1. cf. also Schwarz (1979).

393 ESA SP-1015, *cit.*, p. 47.

394 See chapter 14 in this volume.

systems. This could not be accepted. Spacelab was not competitive with conventional satellites for classical sciences on a cost/observation-day basis, and the high cost of the launch would gravely endanger the development of microgravity sciences for which Spacelab was the only opportunity for experiments. Here is the SAC's conclusion,

> *The scientific community should consider itself as a potential user of this means of transportation, and not a promoter of it. In no way should the community and the Working Groups themselves undertake the task of programming the utilisation of Spacelab.*

A similar argument was made for Ariane. This rocket had been conceived and developed mainly for launching heavy telecommunications satellites into geostationary orbit, and it was oversized for most scientific missions. Double launches could not offer a general solution because of the constraints in terms of interface, orbits and launch windows. In conclusion:

> *The SAC wishes to express clearly its concern that neither Spacelab nor Ariane is adapted to the financial state of the Scientific Programme and to the majority of its needs. If ESA wishes to promote the use of Ariane or Spacelab for science, then the mandatory programme must be put in a position to buy the launches by an increase in the funds available to the programme; alternatively, "free" launches could be provided in the form of an optional programme (which would allow the participating Member States to choose their respective contributions).*[395]

In a later statement, the SAC clarified that, in its recommendation to increase the mandatory budget to the level of 120 MAU/year, it was not intended that this should cover increased launch costs: "If the Member States agreed to grant 120 MAU/year as recommended, but stipulated that exaggerated launch costs (Ariane and Spacelab) should be charged to the mandatory programme, this would not improve the current situation for science".[396]

A new occasion for the SAC to express its opinion about the issue of Spacelab utilisation occurred in May 1979, when the rising costs of the programme and the diverging interests between Member States made the prospects of European use of this facility appear more and more uncertain. No firm commitment had been made from Member States, apart from Germany, for supporting the proposed experiments on the two demonstration missions planned by ESA; no long-term plan for Spacelab use in the microgravity field had been worked out; and all the important Spacelab instruments studied in depth within the science programme (the infrared telescope LIRTS, the X-ray solar telescope GRIST and the laser instrument for atmospheric studies LIDAR) had had to be abandoned because of their poor scientific profitability.[397] In this situation, the SAC was called to put the question of Spacelab utilisation and the plans for its follow-on development on its agenda. "The SAC is well aware that the future of space programmes depends to a large extent on the results of these discussions [...], as Spacelab is one the major components of the Agency's transportation systems development programme", Bonnet wrote to the Director General.[398]

In view of the SAC meeting, the Executive (i.e. Lebeau's Directorate in this case) prepared a report on the costs of the utilisation of Spacelab for scientific investigations, whose aim it was to answer the criticism which had often been made with respect to the high costs of Spacelab missions and the high cost to develop Spacelab experiments and equipment. The key argument was the comparison of launch costs per kg of experiment for Shuttle/Spacelab and conventional launchers/spacecraft, respectively

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395 ESA SP-1015, *cit.*, pp. 48-49. The possiblity of optional programmes for launching scientific missions on Ariane or Spacelab referred to the obvious interest of France and Germany to support their utilisation after the development phase.

396 SAC, 17th meeting (16 March 1979), SAC(79)10, 3 May 1979, p. 4.

397 See chapters 3 and 14 in this volume.

398 R. Bonnet, letter to R. Gibson, 30 Mars 1979, *D/Sci archives*.

(Tables 4-3 to 4-5). These cost figures, the Executive argued, were "strongly favourable for Spacelab when compared to conventional satellite payloads". While recognising that Spacelab was not a vehicle tailored for traditional space disciplines, in particular those fields of astronomy and space physics requiring long-term observations or measurements, the document insisted that "the large mass and volume capabilities of Spacelab offer better possibilities for some areas of traditional space sciences like infrared astronomy (cryogenic cooling) and multi-spectral solar observations, large instruments for astrophysical observations, etc".[399]

Table 4-3: Comparison of launch costs per kg of experiment for Shuttle/Spacelab, conventional launchers and sounding rockets [SAC(79)12]

Project	**Experiment Mass**	**Mission implementation costs (excl. experiment costs)**	**Cost/ kg of experiment (kAU/ kg)**
13 ESRO/ESA scientific satellites	672.5 kg (51.7 average)	1111 MAU	1650
First Spacelab Mission (FSLP)	1392 kg (European share)	21.7 MAU (excl. Shuttle launch costs)	15.6
Spacelab mission DM2 (5 pallets)	5960 kg	60 MAU (incl. 25 MAU for launch services)	10
Spacelab mission DM1 (Module-only)	3900 kg	54.6 MAU (incl. 25.6 MAU for launch services)	14
Sounding rockets (e.g. Texus II)	240 kg	1.7 MAU	7

The SAC definitely disagreed with these arguments. The comparison of launch costs per kg of experiment for the Shuttle/Spacelab system and conventional launchers was not the most significant way of reviewing the matter, as the total cost of Spacelab experiments was as high as those of comparable experiments on unmanned satellites. Given the present situation of the Scientific Programme, they argued, there is no way of planning Spacelab utilisation, let alone endorsing any follow-on development, until the costs of Spacelab missions are significantly reduced. The first priority was to increase the funding of European space science rather than to make further expenditure on transportation systems.[400] The latter argument was made more explicit by K. Pinkau in a letter to Bonnet just after the meeting:

Table 4-4: Specific launch costs of various launch vehicles [SAC(79)12]

Launch vehicle		**Costs per kg of bare experiment mass (only launcher costs involved)**
Spacelab	(4000-6000 kg experiment, 25 MAU for NASA Shuttle/Spacelab services)	4.2 - 6.3 kAU/ kg
Thor Delta (2914)	(low orbit, 15 MAU, 25% experiments of 1950 kg payload)	30.8 kAU/ kg
Ariane	(low orbit, 32 MAU, 25% experiments of 4500 kg payload)	28.4 kAU/ kg
Scout	(UK 6, 625 km orbit, 62 kg experiments)	64.8 kAU/ kg

399 SAC(79)12, 26 April 1979, p. 9.

400 SAC, 18th meeting (9-10 May 1979), SAC(79)16, 25 June 1979. The SAC's views were supported by the ESF Space Science Committee, represented at the meeting by its chairman J. Geiss. See also 19th meeting (26 September 1979), SAC(79)25, 8 November 1979.

Table 4-5: Comparison of experiment development costs for some free-flyers and the FSLP [SAC(79)12]

Free-flyers	**Experiment original cost/ kg (kAU/ kg)**	**Cost/ kg (1978 price level) (kAU/ kg)**
Meteosat (experiment only, 1973)	273	382
Several small (5 kg) experiments on ESRO I and ESRO II	200	279
COS-B (experiment only, 1971)	165	264
HEOS A2 (experiment only, 1968)	250	488
ESRO IV (experiment only, 1969)	193	354
Spacelab experiments (FSLP)	**Mass (kg)**	**Cost/ kg (1978 price level) (kAU/ kg)**
Charged particle beams (ES020)	41.5	27.9
Solar constant (ES021)	5.5	18.6
X-ray astronomy (ES023)	20.5	29.0
Sled (ES200)	165.0	26.5
Material science double rack (ES300)	467.0	33.8
Grille spectrometer (ES013)	137.0	42.7
Microwave remote sensing exp.	153.0	38.9

If you look at the German expenditures, [...] you see that expenditure between 1971 and 1976 rose by only 10% (which is less than inflation) although they accepted the entire Spacelab plus applications programme plus Ariane and Kourou into their funding. [...] They achieved this by killing the national scientific space programme. In our view it is entirely fair to say that the Spacelab development in the past has been paid essentially from within the Scientific Programme in Germany.[401]

The SAC could not endorse any follow-on programme, Pinkau continued, without having previously received a firm assurance that the mandatory Scientific Programme will be increased, and that it will not be charged for the launch costs of Spacelab and Ariane. In a following letter, Pinkau, who was to succeed Bonnet to SAC chairmanship, directly challenged the Executive's argument with an irreverent metaphor:

The considerations on the cost of any approach cannot be restricted to comparison, [...] an absolute yardstick exists. It is the size of the financial envelope available for that part of the activity which is to be served by this system. In our case, it is the size of the mandatory programme. [...] Systems have to come in practical sizes to be used. It may be much cheaper for me, per roll of toilet paper, to buy it by the truck-load, but I may not be able to afford to invest so much money in this venture and it may be not practical. Thus I may still decide to buy single rolls (Thor Deltas, for example) although they may be more expensive per roll, since this is compatible with my income and with a practical solution.[402]

401 Pinkau, letter to Bonnet, 19 June 1979, *D/Sci archives*.

402 Pinkau, letter to Bonnet, 28 September 1979, *D/Sci archives*. Lebeau's comments, attached to a letter to Bonnet of 17 October 1979, are *ibid*.

Pinkau made a similar argument regarding Ariane. "Scientists are led to believe that their proposals are doomed to failure from the outset if they do not propose Ariane missions", he wrote to Bonnet, and then continued:

> *It thus appears that we are victims of a feedback cycle which from the outset is reducing the scientific usefulness of our limited mandatory budget, because we are being presented with mammoth missions only. The mortality rate of these mammoth missions must be very high due to the financial situation, [...] and the time and enthusiasm of the proposing scientists, and much money, is being wasted.*[403]

More money for science is needed, this was again the general conclusion, not only for the sake of space science, but for making the rate of usage of Ariane and Spacelab proportionate to the level of resources Europe had invested in these new space transportation systems. The SAC, for its part, made it clear that it "would assess proposals on their scientific interest and associated costs irrespective of the launching and space transportation systems that might be used".[404]

4.4 More money for science?

The report on the development of space science in Europe in the 1980s was definitely approved by the SAC at its meeting of 19 December 1978, and eventually published by ESA. It was also agreed that a summary of the report should be prepared for the Council, listing the SAC's main recommendations and the actions required for their implementation.[405] The first and most urgent set of recommendations, on which all other arguments about the future development of space science in Europe depended, regarded of course the increase in the level of resources. These recommendations are summarised in the following three statements:

> *The support for space science which was lost at the time of the 1971 first package deal should be recovered as soon as possible through an increase in the level of the mandatory programme and the creation of optional programmes (in particular for Earth sciences).;*
>
> *The level of the mandatory programme should be increased to 120 MAU/year for astronomy and solar-system sciences, plus 12 MAU/year for microgravity sciences, i.e. about 33% of an assumed 400 MAU total level of resources for ESA in the 1980s.*
>
> *The launch costs with Ariane and Spacelab (or part of them) should not be charged to the mandatory budget.*

There was nothing the SPC could do regarding the problem of funding, but to discuss the SAC's report and advise the Council, the only body entitled to decide on this crucial question, to give "its urgent attention" to the fact that:

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403 Pinkau, letter to Bonnet, 18 October 1979, *D/Sci archives*. cf. also Trendelenburg to Bonnet, 25 October 1979, and Bonnet to Trendelenburg, 6 November 1979.

404 SAC, 20th meeting (5-6 December 1979), SAC(79)35, p. 2. It must be noted that this meeting was held after a SAC mission to the USA, on 23-25 October, where they visited the NASA Johnson and Kennedy Space Centers. Following this visit, concern about the lack of any firm plan for Spacelab utilisation in Europe was expressed by Bonnet in a letter to Gibson, 26 October 1979, *D/Sci archives*.

405 SAC, 15th meeting (19 December 1978, SAC(78)23, 8 January 1979; 16th meeting (22-23 January 1979), SAC(79)4, 9 March 1979. The summary report for the Council is ESA/C(79)14, 11 June 1979. Preliminary versions of this document, for discussion in the SPC, are attached to ESA/SPC(79)7, rev. 1, 8 May 1979, and ESA/SPC(79)7, rev. 1, corr. 1, 15 May 1979.

The present level of the mandatory programme, if not increased or complemented by optional programmes or otherwise, leads to a serious situation for European space science, in which groups that have gained world renown by their present work may face the problem of survival and where work in the new fields of space science may not get a fair chance of development.[406]

A few aspects of the SPC discussions, however, are worth mentioning as they are evidence of the attitudes of Member States towards the main questions. Most delegations were in favour of a general increase in the funds devoted to space sciences, but opinions diverged about how this could be achieved. The French delegation opposed the idea of increasing the mandatory budget, and stated that their authorities would anyway not approve participation in new optional programmes in the near future. Additional French money, in other words, would eventually go to the national programme. Moreover, the delegation could not agree with the SAC's arguments regarding the launcher question. France being the main sponsor of Ariane, its position is easily understood:

It was up to scientists to adapt their missions to the launchers which existed. [...] The primordial [political] question was whether ESA considered its Scientific Programme as a separate entity, in which case there would be no need for it to accept the imposed launcher, or whether it represented an essential part of a coherent whole. In the latter case, every attempt should be made to make the maximum use of the investments already made, and the use of Ariane was not a constraint but an objective.[407]

Contrary to France, Germany was in favour of increasing the science programme budget, in consideration of its political importance as ESA's only mandatory programme. The German delegation argued that, "in order to avoid a decomposition of the fundamental activity of the Agency", the scientific mandatory programme should be restored to the level it enjoyed before the 1971 package deal, and insisted that the transfer of individual scientific projects to optional programmes should be resisted. Only the new Earth-oriented sciences and material sciences could be regrouped as optional programmes, each with their own budgets.[408] The delegation also believed that the Scientific Programme should use as far as possible the Shuttle/Spacelab system and Ariane, but the Council should find ways of subsidising their use.

Similar concern about the high costs of the new space transportation system was also expressed by the Swiss, Swedish and British delegations. The latter, however, was adamantly against any increase in the mandatory budget which, in its opinion, should anyway provide for the classical disciplines only. Equally against any increase in the mandatory budget was Spain, which, however, argued that new disciplines should be considered within the Scientific Programme. Italy and the smaller Member States were in general in favour of a global increase in expenditure on space sciences, but they could not give any firm information about the rate of increase (if any) their authorities would eventually agree to, or their financial participation (if any) in new optional programmes.

In view of the important Council discussion on the SAC report and the future of the Scientific Programme, the Executive prepared a document to present its own case for an increase in the level of the mandatory budget and a proposal for the practical implementation of the SAC's recommendations.[409] The starting point was again the crucial divide of the 1971 package deal. In the period between 1967 and 1971, the ESRO annual budget showed an overall increase of about 20% for

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406 SPC, 19th meeting (22-23 March 1979), ESA/SPC/MIN/19, 26 April 1979. The quotation is from the attached resolution ESA/SPC/XIX/Res. 1, 23 March 1979.

407 SPC, 18th meeting (23-24 January 1979), ESA/SPC/MIN/18, 22 February 1979, p. 4.

408 The quotation is from a draft resolution presented by the German delegation which, however, was not put to the vote: ESA/SPC(79)15, 26 April 1979. Cf. ESA/SPC/MIN/19, *cit.*, p. 7, and SPC, 20th meeting (22-23 May 1979), ESA/SPC/MIN/20, 25 June 1979, p. 6.

409 ESA/C/Bur.(79) 3, 29 May 1979, attached to ESA/SPC(79)27, 12 September 1979. Following quotations from pp. 4- 6

satellites and sounding rockets and of about 50% for satellites alone, the Executive recalled, while in the following period, the envelope for space science in ESRO/ESA was dramatically reduced and strictly maintained at the level established with the first package deal. As a consequence, the Executive concluded, "there has been no evolution in the European scientific activity in space but, at best, stagnation". Four main arguments were then given for an increase in the scientific budget. Firstly, the intellectual challenge presented by advanced space missions which required international collaborations: "a simple return to purely national programmes would represent scientifically a step backwards". Secondly, the high scientific interest of the European space science community in ESA's programme, as demonstrated by the number and quality of proposals addressed to the Agency: "ideas and proposals abound, only money is scarce". Thirdly, the low level of the ESA science budget in comparison with other international scientific activities, in particular particle physics at CERN. Finally, the non-competitive position of the ESA science programme in relation to NASA: "the NASA science budget is about 9 times as high as that of ESA [while] the GNP of the US is about equal to that of the ESA Member States". In conclusion, the Executive fully endorsed the SAC's main recommendation that, from 1982 onwards, "the pure science programme of ESA should receive a substantial boost and recover the momentum that was severely reduced in 1971".

The Executive (i.e. Trendelenburg's Directorate in this case) went even further, however. It presented its own estimate of the financial requirements for space science within ESA and suggested a possible scenario to implement the proposed new budget level. In fact, the 120 MAU/year level recommended by the SAC for astronomy and solar system sciences could only be assumed as a baseline of the science budget, as it allowed the launch of a medium-size satellite per year.[410] These disciplines had now evolved from an exploratory phase to a phase which required larger systems of higher performance and higher cost. In the astronomy field, projects such as a large infrared telescope or an X-ray facility fell into the 250-300 MAU class. In the solar system area, where single spacecraft were cheaper, the new scientific objectives required groups of spacecraft simultaneously operating at different sites, therefore "the global costs of such programmes again falls into the above brackets". Finally, if the European scientific community wanted ESA to get involved in planetary missions in cooperation with another agency, the European contribution was again estimated at about 250 MAU. Assuming that at least three such large projects were developed during a decade, the Executive concluded, then the total annual budget for space science should be set at the level of 200 MAU/year, which would also include a fixed provision (of the order of 5%) for microgravity sciences. The new level could be achieved at the beginning of the 1990s by progressive increases of around 10% per year as from 1982 (Figure 4-2).

4.4.1 The Council's answer is no

The Council discussed the "deplorable status of the science budget" at its meeting of 28-29 June 1979.[411] Most delegations accepted in principle the possibility of an increase in the mandatory science budget, but the required majority could not be achieved and the Executive was then invited to make its plans on the basis of the package deal funding level. We are not surprised by this result. At that time, in fact, the Member States had not yet settled the financial questions related to the bad economic conditions in some of them, as well as the questions related to ESA's complex budgetary structure. The mandatory budget for 1979 had not been approved in due time and the meeting itself was still unable to find an agreement; consequently, the Council had to authorise continuation of the *provisional twelfths* system with regard to the general budget and the Scientific Programme budget beyond 30 June.[412] In this situation, it was hardly conceivable to secure the requested unanimous agreement to an increase in the mandatory budget.

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410 This figure, the Executive noted, corresponded to that recommended by the LPAC in 1971, when actualised to 1979 price levels (see fn. 177).

411 ESA/SPC(79)27, *cit.*, p. 1. Council, 32nd meeting (28-29 June 1979), ESA/C/MIN/32, 19 July 1979.

412 ESA/C/XXXII/Res. 7., 28 June 1979.

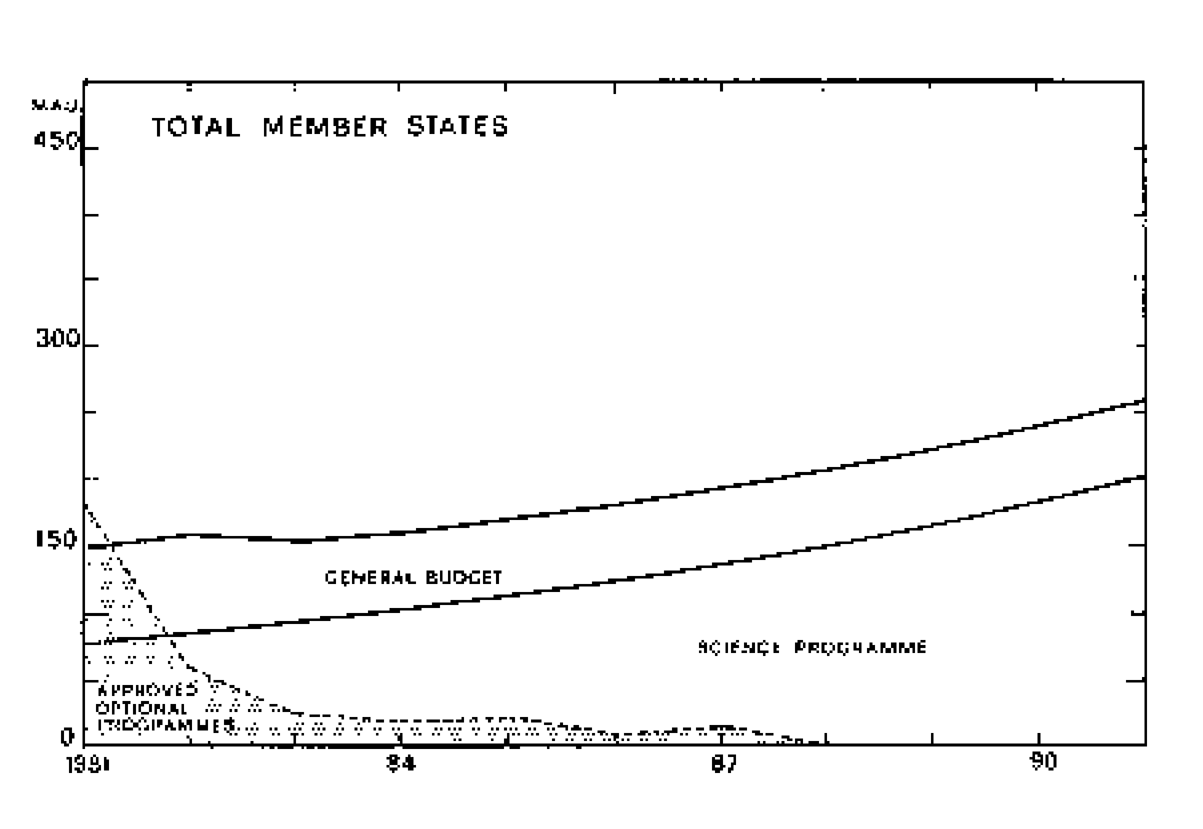

Figure 4-2: Contribution of Member States to the Mandatory Budgets, assuming an increase of 10% in the Science Budget from 1982 onwards: (ESA/SPC(79)27)

The strongest opposition against the idea of reinforcing and extending the Scientific Programme came from France and the UK. The former had always been very luke-warm towards ESA's mandatory Scientific Programme. As early as during the discussions on the first package deal, in 1971, the French delegation had insisted that the Scientific Programme should be made optional like the application programmes, and only with a drastic reduction of funds had it been finally agreed to keep it mandatory. The French space science community had never been a big user of the ESRO/ESA Scientific Programme, its efforts being developed rather within the framework of France's strong national space programme and by co-operative ventures with scientific groups in Europe, the USA and the Soviet Union.

Contrary to France, the UK had always been in favour of a cooperative European Scientific Programme funded according to a GNP contribution scale. It considered, however, that the level of the science budget could not be increased, both because of the difficult economic situation in Europe and in order to prevent its national programme from being reduced accordingly. The high inflation rate in Britain had resulted in a dramatic increase in the contributions to ESA in national currency, and all pounds given to ESA meant less funds available for national scientific activities.[413] Moreover, the British delegation argued that the cost-effectiveness ratio of ESA's science programme was unduly low compared to national programmes, and insisted that measures had to be taken to improve this ratio before speaking of increasing the budget level. Finally, the delegation opposed the funding of microgravity sciences from the envelope of the Scientific Programme.

413 Long negotiations had been developed in 1976-1978 among ESA Member States in order to find ways to compensate the negative effects of high inflation rates in the contributions of the UK and Italy: Council, 14th meeting (28 January 19789), ESA/C/MIN/14, 17 February 1977, with attached resolution ESA/C/XIV/Res.; 23rd meeting (Part II, 6-7 April 1978), ESA/C/MIN/23(II), 20 April 1978, with attached resolution ESA/C/XXIII/Res. 5.

The two other big Member States, Germany and Italy, were generally in favour of an increase in the mandatory budget, but while the former "wanted the Scientific Programme to be effectively reinforced and extended in the medium-term", the latter stated that "in view of the financial situation it was unable to enter into any new commitments".[414] The difference is easily understood. Germany's economic strength, low inflation rate and ambitious space programme (including Spacelab utilisation) allowed its political authorities to commit themselves to support ESA activities, being aware that the country's industrial system would certainly take advantage of the Agency's contracts. Italy, on the contrary, suffered from severe economic problems and a high inflation rate; its contributions to ESA were escalating because of the changes in the conversion rates. and its industrial system was not able to keep pace with the "just return" principle.[415]

The most convinced advocates of the SAC arguments for an increase in the mandatory science budget were the smaller Member States whose scientific groups had benefited most from the ESRO/ESA programmes, i.e. Belgium, Denmark, the Netherlands, Sweden and Switzerland. "The Agency [should] remain faithful to its first calling, which was that of a scientific organisation", the Dutch argued, suggesting that ESA's overall funding should be split into three equal parts, one third going to science, one third to applications and one third to space transportation systems. The Swiss and Danes concurred, while the Belgians and the Swedes qualified their statements: the former arguing that it would be difficult to secure approval of national authorities, "if the Belgian scientific community could not be directly associated with the work done under the programme, from which during recent years it had been excluded by circumstances"; the latter observing that "financial considerations currently militated against an increase in the programme's budget envelope".[416] Finally, the Irish and Spanish delegations stated there was no way for their governments to approve additional resources to the mandatory budget.

While frustrating the SAC's and Executive's plea for a reinforcement of the mandatory Scientific Programme (and *a fortiori* rejecting the proposal that Ariane and Spacelab launches of scientific payloads be financed from outside the science budget), the Council agreed to the principle of setting up optional programmes in scientific areas connected with future applications, in particular in the field of Earth sciences. It also invited the Executive to produce a programme proposal with respect to microgravity sciences, to be eventually implemented within the framework of a Spacelab utilisation programme.

The outcome of the Council meeting was bad news for the space science community. The SAC chairman advised the SPC that during the presentation of candidate projects for ESA's future Scientific Programme, scheduled for November 1979 (see next section), "the scientific community should be informed of the fact that certain disciplines will have to be eliminated from the Agency's activities".[417] The SAC itself could only endorse the initiative of the Life Sciences and Material Sciences Working Groups to elaborate a joint research programme in microgravity sciences to be submitted to the Council outside the framework of the mandatory Scientific Programme, and put on the record that "one of its main tasks in the coming years, together with the Executive, would be to maintain efforts to convince the national delegations of the need to increase the mandatory budget".[418] These efforts, as we shall discuss in the following chapter, will be crowned with success in January 1985, when the ESA Council meeting at ministerial level in Rome endorsed the *Horizon 2000* long-term Scientific Programme, worked out by the European space science community during the previous year, and agreed that the Agency's mandatory Space Science Programme should be increased by 5% a year until 1989.

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414 ESA/C/MIN/32, *cit.*, p. 5.

415 Italy's poor position with regard to the geographical distribution of ESRO/ESA industrial contracts between 1972 and 1989 is reported in *ESA Annual Report 1979*, p. 164.

416 ESA/C/MIN/32, *cit.*, pp. 5-6.

417 SPC, 21st meeting (8-9 October 1979), ESA/SPC/MIN/21, 25 October 1979, p. 7.

418 SAC, 12th meeting (5-6 December 1979), SAC(79)35, 3 March 1980, p. 9.

While failing in its aim of increasing the mandatory science budget, the SAC planning exercise of 1978 had however important consequences in shaping the future development of ESA scientific activities. The most important was the Council decision to exclude the new space science disciplines, i.e. Earth sciences and microgravity research, from the mandatory programme as well as from the terms of reference of the Science Directorate. An Earth Observation Programme and a Microgravity Programme were eventually set up to support activities in these fields, funded on an optional basis and managed by other Directorates. This did not help the case for an increase in the mandatory budget but, on the other hand, kept the ESA scientific programme well under the control of the established European space science community. By preserving the "traditional" pure-science character of the mandatory Scientific Programme in a phase of financial difficulties, the SAC and the Science Directorate wanted in fact to protect those research fields in which most of its constituency was actively involved at that time. If the support for space science of the ESRO period could not be recovered, and the SAC could not have many hopes in this respect, the ESRO spirit could however be safeguarded within the stronghold of a mandatory Scientific Programme including only the "classical" space science disciplines.

4.5 Studying future scientific projects

While discussing the long-term strategy for European space science, the ESA scientific advisory bodies were also involved in the selection process for the new project(s) to be adopted in the Agency's programme for launch in the mid-1980s. Taking into account the financial constraints imposed by the ongoing projects, the Executive estimated that a new project could be started in 1980 and a second one in 1981, and the SPC would be called on to take decisions by the end of 1979 and 1980, respectively.[419] As usual, the decision-making process had started a few years earlier, back in the ESRO times. In March 1975, in fact, ESRO's Scientific Programme Board had approved a few mission definition studies to be performed during that year.[420] First priority was given to the Grazing Incidence Solar Telescope (GRIST), a facility originally designed as the European contribution to a dedicated solar physics Spacelab mission in collaboration with NASA. After NASA had failed to confirm its commitment to this cooperative project, the LPAC had recommended that the possibility of flying the GRIST alone should be studied, in order to fill a long-standing European gap in the field of solar physics.[421] In addition, the Executive was requested to undertake preliminary studies on three topics: i.e. an astrometry mission for accurate measurements of positions and proper motions of stars; small "throw away" satellites for infrared astronomy to be launched from Spacelab; and the development in Europe of cryogenic technology for infrared astronomy missions and of superconducting magnets for cosmic-ray missions. Two other studies were undertaken in the following months, after recommendations from the SSWG and the AWG, respectively. The first was of a solar probe to be directed towards the centre of the Sun after a Jupiter fly-by; the mission objectives included the determination of the gravitational quadrupole moment of the Sun, tests of the relativity theory, and *in situ* measurements of the interplanetary medium. The second study was of an exploratory astronomy mission in the extreme ultraviolet and soft X-ray spectral region.[422]

A further extension of the Executive's study programme was agreed on in early 1976, after the Director General had urged the European space science community to suggest proposals for "scientific missions which do not have to be launched with the Shuttle". At that time, in fact, all five candidates for the next scientific project(s) to be selected in October that year depended on the availability of the

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419 ESA/SPC(78)5, 16 May 1978.

420 SPB, 11th meeting (26 March 1975), ESRO/PB-S/MIN/11, 24 April 1975. See also ESRO/PB-S(75)2, 7 March 1975.

421 See previous chapter. The GRIST was to be one of a cluster of four telescopes for simultaneous measurements of the solar radiation over a wide range of wavelengths.

422 ESA/SPC(75)5, 19 September 1975. cf. SSWG, 14th meeting (21-22 May 1975), SOL(75)9, 1 September 1975, and SOL(75)8, 28 May 1975; AWG, 15th meeting (10-11 June 1975), ASTRO(75)10, 18 September 1975. The solar probe had been originally suggested by G. Colombo (cf. SOL(75)6, 13 June 1975, annex 1).

Shuttle, either as launcher or as Spacelab's carrier. "Although we have no grounds to believe that the Shuttle might not be available at the required time", the Director General advised, "sound planning demands that alternate, Shuttle-independent scientific missions be available to the Agency".[423] In other words, the Executive wanted establish a set of contingency scientific missions in order to fill a possible gap of one or two years in the Scientific Programme, should the Shuttle be delayed. Many mission proposals were discussed by the SSWG and AWG, and four new studies were eventually approved by the SAC: a Sun-Earth Observatory and Climatology Satellite (SEOCS); a "Dumb-bell" mission, foreseeing two spacecraft linked by a wire for geophysical and magnetospheric studies; a satellite for studying variable X-ray sources; and the Extreme Ultraviolet and X-ray Survey satellite (EXUV), already recommended by the AWG and now endorsed with first priority.[424]

The complete list of the eight mission definition studies undertaken by ESA in 1975-1976 is provided in Table 4-6. According to the usual ESA procedure, it was foreseen that, following these preliminary (mission definition) studies, four missions would have been selected in Autumn 1976 for feasibility (Phase-A) studies, whose results would be the foundation for the final selection of the Agency's next scientific project(s).

Table 4-6: ESA mission definition studies in 1975-1976

Mission	**Scientific objectives**
Space Astrometry	Accurate measurements of positions, proper motions and parallaxes of celestial objects.
Sun-Earth Observatory and Climatology Satellite (SEOCS)	Measurement, monitoring and mapping of the Earth's radiation budget (incoming solar flux and radiation fluxes leaving the Earth to space).
Grazing Incidence Solar Telescope (GRIST)	An X-ray telescope carried by Spacelab, using the Instrument Pointing System, to observe the Sun in the 10-170 nm wavelength range, with high spatial and spectral resolution.
Extreme Ultraviolet and soft X-ray Survey Satellite (EXUV)	Astronomical observations in the 1-100 nm spectral band to study the interstellar medium, stellar atmospheres and stellar evolution.
Solar Probe	A spacecraft directed to "graze" the Sun (at a few solar radii) using a swing-by around Jupiter, to study the solar quadrupole moment, parameters related to gravitational theory (general relativity tests), and the Sun's immediate surroundings.
Infrared Satellite (IRSAT)	A satellite carrying a telescope cooled to the temperature of liquid helium to measure, in the far infrared, the spectrum and spatial distribution of the infrared diffuse flux.
Dumb-bell	Two spacecraft linked by a wire to measure the Earth's gravitational field in order to get information on plate tectonics and convective motions in the Earth's interior. Also magnetospheric and plasma studies
Transient X-ray Sources Satellite	Sky survey in order to detect, observe and monitor variable X-ray sources.

423 ESA/SPC(75)19, 5 December 1975. The candidate Spacelab projects were a laser facility for atmospheric studies (LIDAR), an infrared telescope (LIRTS) and an X-ray instrument (EXSPOS); the two other candidate projects, designed to be launched on the Shuttle, were the Out-of-Ecliptic (OOE) mission and the Hubble Space Telescope. See previous chapter.

424 SSWG, 17th meeting (29 January 1976), SOL(76)5, 1 March 1976; AWG, 18th meeting (28 January 1976), ASTRO(76)4, 5 May 1976; SAC, 1st meeting (24 February 1976), SAC(76)4, 7 April 1976. The SPC endorsed the SAC recommendations at its 3rd meeting (11 March 1976), ESA/SPC/MIN/3, 13 April 1976. The Executive's reference document, with a list of all mission proposals received, is SAC(76)1, 15 January 1976. The working groups' and SAC's recommendations are reported in SOL(76)4, 9 February 1976; ASTRO(76)3, 5 February 1976, and SAC(76)3, 27 February 1976, respectively. All of these documents are also attached to ESA/SPC(76)6, 11 February 1976, and Add. 1, 27 February 1976.

The reports on the eight mission definition studies were discussed during a symposium held in Paris on 28 to 30 June 1976. Following the symposium, on 1 July, the AWG and SSWG discussed those projects which fell within their respective competencies and issued their recommendations about which projects should be studied at Phase-A level. The following day it was the turn of the SAC to do its job.[425]

Four projects were in the field of interest of the AWG, i.e. the astrometry mission and the three projects dedicated to astronomical observations in three different regions of theelectromagnetic spectrum, respectively: the infrared (IRSAT), the extreme ultraviolet (EXUV) and the X-rays (variable sources). The first had originated within the French scientific community (the very first proposal was presented by P. Lacroute as early as March 1966), and preliminary studies had been performed during 1974 by the Centre National d'Etudes Spatiales (CNES).[426] The AWG recognised that the astrometry satellite would have "a very fundamental impact on astronomy [as] it will overcome basic problems in the fundamental system of stellar positions that have plagued astronomy for more than a century, and that have stopped developments in possibly very fruitful fields such as galactic dynamics". The Group then highly recommended a Phase-A study, whose main objective should be the technical feasibility of the required accuracy. As regards the three astronomical satellites, the AWG recommended a Phase-A study on the EXUV project: "This satellite will [...] make a survey in a spectral region that hitherto has been largely unknown [and], as in all new surveys, completely unexpected results may be obtained".[427] Two main reasons were given for discarding the IRSAT project as presently designed. Firstly, it was felt that its objectives should be redirected towards measurements of the fluctuations of the microwave background; secondly, some of its scientific goals would be resolved by the Dutch infrared satellite IRAS under development. Finally, the X-ray satellite was not regarded as being extremely fundamental.

The four other projects listed in Table 4-6 fell within the aegis of the SSWG, i.e. the Spacelab solar telescope GRIST, the climatology satellite SEOCS, the solar probe and the "dumb-bell". GRIST, if eventually adopted in the ESA programme, would have met the long-standing expectations of European solar physicists to have a dedicated European mission in their field of interest. Therefore the group advocated the scientific interest of the X-ray solar telescope and recommended the start of a Phase-A study on this instrument. The SEOCS was the second project recommended by the SSWG for a feasibility study. This satellite, the Group argued, "responds to the urgent need to obtain a better understanding of the Earth's atmosphere-surface-ocean system", a need which was recognised by the international Global Atmospheric Research Programme (GARP). The SSWG also underlined that the proposed SEOCS mission was "basically a *scientific* mission", indeed the first ESA spacecraft devoted to atmospheric science, but it recognised that, in the long run, "practical climatology and meteorology will benefit from the results".[428] While recommending these two projects for immediate Phase-A study, the SSWG did not discard the other two. Both the solar probe and the dumb-bell were considered scientifically very interesting projects, and the Group recommended that some complementary studies should be undertaken on a few critical aspects, in preparation for eventual Phase-A studies to be undertaken in the future.

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425 SSWG, 19th meeting (1 July 1976), SOL(76)14, 15 September 1976; AWG, 21st meeting (1 July 1976), ASTRO(76)10), 30 September 1976; SAC, 13th meeting (2 July 1976), SAC(76)11, 27 August 1976. The SSWG's recommendations are reported in SOL(76)12, 1 July 1976, and SOL(76)13, 5 August 1976; the AWG's recommendations are reported in ASTRO(76)9, 1 July 1976, and ASTRO(76)11, 13 July 1976; The SAC's recommendations are reported in SAC(76)10, 2 July 1976, and SAC(76)12, 1 September 1976. All of these documents are attached to ESA/SPC(76)25, 3 September 1976. These were the same meetings where the LIRTS, the Space Telescope project and the OOE mission were recommended for adoption in the ESA Scientific Programme at the end of the previous selection process (previous chapter).

426 Perryman & Hassan (1989).

427 ASTRO(76)11, *cit.*, p. 3.

428 SOL(76)13, *cit.*, p. 4, emphasis in the original.

The SAC endorsed the Working Groups' recommendations. The endorsement of GRIST, as recalled above, was a kind of a moral obligation towards the solar physics community which had strongly advocated keeping the project alive after the abandonment of the joint ESA/NASA Solar Telescope Cluster. Moreover, it was also the only important scientific project on Spacelab, after financial considerations had forced the abandonment of the infrared telescope LIRTS and the X-ray facility EXSPOS. The SAC then recognised the scientific importance of the exploratory mission to be accomplished by the EXUV satellite in a new field of astronomy, which bridged the gap between the "traditional" UV band and the medium-energy X-ray region already studied in some detail from space. Observations in the 10-1000 Å band, they stressed, would provide information on the interstellar medium, stellar atmospheres and stellar evolution. As regards SEOCS and the astrometry mission, both these projects were a novelty within the ESA scientific tradition, the former reflecting the new interest of atmospheric scientists and geophysicists in the complex phenomena which affect the Earth's climatic system, the latter involving a sector of the astronomy community hitherto alien to space technologies. The Committee, in particular, recognised the great scientific value of the SEOCS project ("an outstanding opportunity [...] to study the interactions between the Sun and the Earth up to the level of the upper atmosphere", in the words of R. Bonnet), as well as its interest in the future meteorology programme. As to the astrometry mission, the SAC considered that its technical feasibility deserved careful investigation and that the astrometry community should be encouraged to address the problems related to the required instrumentation.[429]

The feasibility studies on these four candidate projects were carried out during 1977 and early 1978 by four different teams of scientists, who defined in detail the scientific objectives and justifications, as well as the instrumental and mission requirements, while the technical, operational and managerial aspects were taken care of by ESA staff and by study contracts with industry.[430] They were reviewed by the AWG and SSWG, which confirmed their interest in these projects and suggested complementary studies in view of the final decision scheduled for the end of 1979.[431]

Two important aspects can be pointed out. Firstly, the fact that the three satellite missions (astrometry, SEOCS and EXUV) were designed for launch with Ariane, a consequence of the decision to use the European launcher for future ESA missions. This, in particular, caused an important change in the design of the astrometry mission, now renamed Hipparcos after the name of the Greek astronomer of the second century B.C. who discovered the precession of the equinoxes and prepared the first stellar catalogue based on accurate observations of star positions. The previous concept of a near-Earth spacecraft in polar Sun-synchronous orbit was abandoned and the spacecraft was designed for being operated in geostationary orbit, thus improving the chance of sharing an Ariane launch with another (presumably application) satellite. The main change regarded the attitude control system: in fact the original idea of passive stabilisation by the Earth's gravity field had to be abandoned because the gravitational stabilising force is too small at the geostationary distance from Earth, and an active attitude control was adopted, based on the use of reaction wheels in the spacecraft. This system, however, posed severe technical problems because the small disturbances from the mechanical bearings (the so-called "attitude jitters") might have jeopardised the astrometric goal of achieving angular measurements in the range of 2 milliarcsec. It was only in 1982, two years after the mission had definitely been adopted in the ESA programme, that the problem of "attitude jitters" could be solved via the introduction of the attitude control by cold-gas jets by the satellite prime contractors.[432]

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429 SAC(76)11, *cit.*, p. 8.

430 ESA/SPC(78)4, 12 May 1978.

431 AWG, 31st meeting (9 May 1978), ASTRO(78)7, 2 August 1978; SSWG, 27th meeting (8-9 May 1978), SOL(78)6, 13 June 1978. Also ASTRO(78)8, 31 May 1978, and SOL(78)8, 8 June 1978, both attached to SAC(78)12, 8 June 1978.

432 Perryman & Hassan (1989), p. 81. The EXUV spacecraft, whose planned orbit was highly eccentric (apogee about 120,000 km), was also originally designed for a tandem launch on Ariane with an application spacecraft aimed at geostationary orbit, but eventually a dedicated Ariane launch was envisaged and the spacecraft design parameters were established accordingly.

The second aspect is the recognised high operational costs for GRIST. It was evident that the development costs of the instrument plus the costs for a minimum programme of three Spacelab flights would be disastrously high, and it became necessary for the SAC to reappraise the mission, unless an agreement could be reached with NASA for a free flight in exchange for data, "which was however not considered likely". Following a suggestion from W. Axford, the SAC recommended that the possibility of a "descoped" GRIST be studied, "in view of the importance of including solar physics in the ESA programme and the fact that NASA still considered GRIST to be part of the Solar Telescope Cluster".[433] The study was eventually undertaken, but after NASA had confirmed that it was not interested in a cooperative mission, it was definitely removed from the list of candidate missions.[434]

4.5.1 The comets and the Moon

In the second half of 1978, an important new element was introduced into the decision-making process. Within the framework of a general re-organisation of the planning and selection procedures for scientific projects, the Executive informed the Working Groups and the SAC that it was possible to undertake Phase-A studies for two new projects to be added to the list of candidate missions for the end-1979 selection.[435] The AWG and the SSWG were then requested to make their recommendations for potential new candidates, on the basis of the pool of mission proposals already discussed within the framework of their long-term planning. The former decided to maintain its emphasis on the two projects within its competence already under study, i.e. Hipparcos and EXUV, and recommended that the Executive should perform complementary studies on these rather than study any further project at Phase-A level.[436] The SSWG, on the contrary, found itself in the embarrassing situation of setting *a priori*ty among three mission proposals which it had already considered equally interesting: a cometary mission, an orbiting lunar observatory and an oceanography satellite.

The idea of a cometary mission had been discussed in the early days of ESRO as the second large project after the ill-fated Large Astronomical Satellite (LAS). Subsequently, the SSWG had recommended such a mission in its 1973 report to the LPAC on long-term priorities in the areas within its competence. The Working Group, in particular, expressed at that time its interest in a mission to comet Encke currently under study in Germany as a follow-up the US/German HELIOS programme. At the insistence of the German delegation in the Scientific Programme Board, the cometary mission to Encke was submitted to a mission definition study during 1974, but it was eventually abandoned because of its high cost.[437] After the creation of ESA, the SSWG made a case for Europe to undertake deep space missions in its 1976 report on long-term scientific strategy. In this framework, two possibilities for a cometary mission were suggested: firstly, a cooperative mission with NASA, e.g. a dual spacecraft mission in which ESA would provide a simpler daughter spacecraft; secondly, a purely ESA mission to several comets, using the Earth or Venus to make the required trajectory changes.[438] By mid-1978 the first possibility became a concrete option when NASA proposed to Europe to

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433 SAC, 12th meeting, 19 June 1978, SAC(78)15, 21 July 1978, p. 6.

434 ESA/SPC(78)25, 27 October 1978; SPC, 18th meeting (23-24 January 1979), ESA/SPC/MIN/18, 22 February 1979, p. 6. As a matter of fact, new hope of including GRIST again in the selection process arose during the SAC mission to NASA in October 1979 (fn. 52), when the American space agency informed that there was a possibility of flying in the same Spacelab payload (without charge to ESA) the GRIST and an American Solar Optical Telescope (SOT). This possibility, however, did not materialise. Cf. SAC(79)24, 11 September 1979, SAC(79)32, 29 November 1979, and SAC(79)34, 7 December 1979.

435 The new procedures, which aimed at shortening the period between conception and approval of new projects, are described in ESA/SPC(78)17, 9 October 1978, reproduced with two minor changes in ESA/SPC(78)17, rev. 1, 16 November 1978. They reflected the change in the ESA Directorate structure which gave responsibility for studying future scientific projects to the Directorate of Scientific Programmes, as discussed above.

436 AWG, 32nd meeting (13 June 1978), ASTRO(78)11, 5 July 1978. Cf. also ESA/SPC(78)24, 18 October 1978.

437 See previous chapter. Cf. SSWG, *Priorities for the Eighties*, SOL(73)16, December 1973. The possibility of a special project mainly funded by Germany was also discussed but could not be realised.

438 SSWG, *An approach to long range planning 1980-1990*, Vol. I, SOL(76)9, September 1976.

cooperate in a mission to comet Tempel-2 to be launched in 1985. The NASA project foresaw a large spacecraft driven by a solar-electric propulsion system (SEPS) to a rendezvous with the comet during its 1988 apparition; a passive probe provided by ESA would be released from the main spacecraft to meet comet Halley at the end of 1985.

A workshop on cometary missions was held in April 1978 in Darmstadt, which was attended by more than 60 European scientists and whose results were summarised as follows:

> *From this meeting, it was clear that the European cometary community is growing very fast, because space scientists not previously involved in cometary studies realised that they could exercise their expertise in one of the many aspects of a cometary mission. [...] It was clear that a good deal of instrumental expertise does exist in Europe, in all domains addressed [...] It was concluded that a cometary mission is mature enough to drive in Europe a tremendous interest among many scientists of various fields.*[439]

The advocates of the cometary mission insisted that, in the event that the NASA rendezvous mission should be postponed, ESA should anyway undertake a purely European ballistic mission, using Ariane to launch a space probe aiming at flying-by two comets (or a comet and an asteroid) with the help of an Earth-gravity assist.

Their plans, however, were opposed by those scientists who argued that Europe should enter the field of planetary exploration via a mission to the Moon, more precisely a Polar Orbiting Lunar Observatory (POLO) aimed at "geochemical and geophysical mapping of the whole surface of the Moon, including the far-side and the polar regions". The report of a meeting held in Paris in April 1978 goes on as follows:

> *There exists a broad well-defined scientific community in Europe which has already been involved in NASA lunar programs and therefore is acquainted with problems of lunar research. About 30 laboratories in Europe have been involved in lunar sample analysis, lunar data interpretation and synthesis, or even directly participating as investigators in various missions to the Moon. [...] Thinking of future planetary missions, a POLO could be the ideal precursor [as] its instrumentation could be adapted to other planetary orbiters, like a Mars or Mercury polar orbiter and precursor for future lunar exploration and utilisation. [...] It is a mission that can be done within the budgetary constraints of ESA in the next decade as a fully European enterprise but not excluding co-operation with NASA.*[440]

The third mission had been recommended by the SSWG's Panel on Earth Sciences, following a workshop on Space Oceanography, Navigation and Geodynamics (SONG) organised at Schloss Elmau in January 1978. This was a three-axis-stabilised Long-Life Oceanographic and Ice Dynamics Satellite (LLOIDS), to be launched by the end of 1985 into a near-polar orbit with an altitude of about 1000 km. The general objectives of this mission were to provide global information on ocean surface phenomena (general dynamics of the oceans, tidal dissipation, interaction between the oceans and the atmosphere) and to measure the bulk change of ice caps.[441]

As we have anticipated, the SSWG did not award any priority among these three projects, all being considered of comparable scientific value and each of them being supported by an important constituency. In June 1978, however, the Group was requested to indicate which of the three project studies should be started first, and performed at an accelerated pace (Phase-A level) in order that it might be included as a candidate in the decision cycle for selecting ESA's next scientific project at end-1979. The two other studies would normally be performed at mission definition level, on a time

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439 SOL(78)8, 8 June 1978, annex 5, p. 3.
440 SOL(78)8, *cit.*, annex 6, p. 2.
441 SOL(78)8, *cit.*, annex 7.

schedule compatible with the following decision point at the end of 1980.[442] The real contest, actually, was between the POLO project and the cometary mission, as the LLOIDS was not presented as a candidate for such a quick study. While, in fact, the Earth sciences were already covered by the SEOCS in the list of candidate projects, an exploratory mission to a solar system body, either the Moon or a comet, was a real first in the history of Europe in space. Here is a summary of the main arguments presented by the supporters of the two options, as recorded in the final resolution.[443] The first two are from the comet supporters, the following three are from the moon-lovers:

> *The exploration of the comets is an entirely new and very appealing scientific subject and, moreover, a cometary mission would look attractive for the general public.*
>
> *A decision in favour of POLO would automatically exclude the possibility of participating in the Halley/Tempel-2 mission because of the tight time schedule imposed by the launch window in 1985; on the contrary, giving priority to the cometary mission would not exclude the lunar mission for which a decision would be delayed by one year and that, in any case, was not constrained by a launch window.*
>
> *The foregoing argument is hardly convincing; in fact, owing to the overall constraints of the ESA programme, it is very unlikely that a second project in planetary exploration would be selected one year after the selection of the cometary mission.*
>
> *The lunar polar orbiter is scientifically very good, it can easily be launched by Ariane, and the technical risks are very limited; on the contrary, several managerial problems are to be expected for the joint ESA/NASA cometary mission, while a purely European fly-by mission would have a poor scientific return because of the short duration of the encounter.*
>
> *A cooperative venture with NASA would have a twofold disadvantage: firstly, coming after the Space Telescope and the Out of Ecliptic mission, the joint cometary mission would make the ESA Scientific Programme dangerously dependent on the US space policy; secondly, because of the limited contribution of ESA to a common project (estimated at 20 to 25%), the participation of European scientists to the mission's scientific harvest would be limited as well.*

After two days of lively discussion, a general consensus could not be reached and a vote had to be taken. The result showed dramatically the discord within the Working Group, reflecting the existence of substantial communities supporting both planetary missions: six votes were in favour of the lunar polar orbiter, four in favour of the cometary mission, two members abstained. As a consequence, this was the obvious conclusion — if only one mission could regretfully be studied within the time frame of the decision cycle ending in late 1979, then the POLO mission should have priority. Halley's comet was definitely lost.

The minutes do not inform us about the votes expressed by the twelve SSWG members participating in the meeting, but J.-L. Bertaux, from the French CNRS' Service d'Aéronomie in Verrière-le-Buisson, and U. Fahleson, from the Royal Institute of Technology in Stockholm, asked that their dissent from the majority opinion be explicitly reported. A third vote in favour of the cometary mission can be ascribed to H. Fechtig, from the Max-Planck-Institut für Kernphysik in Heidelberg, a

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442 SSWG, 28th meeting (21-22 June 1978), SOL(78)11, 10 August 1978.
443 SOL(78)10, 22 June 1978.

specialist in mass spectrometry of meteoritic material and interplanetary dust, and an ardent advocate of cometary studies.[444]

This was not the end of the story, however. The supporters of the comets, in fact, had a powerful ally in ESA, namely E. Trendelenburg, and an influential advocate in the SAC, namely W. Ian Axford, the Director of the Max-Planck-Institut für Aeronomie in Lindau, where several research groups were already designing instruments for the envisaged cometary mission. They succeeded in convincing the SAC chairman R. Bonnet that the matter deserved further discussion, and thus the issue of priorities for future studies was put on the agenda of the SAC meeting scheduled for 28 September. The timing was quite appropriate: NASA had confirmed its plans for its 1985 cometary rendezvous mission, and a European team was expected in Washington on 11-12 October to discuss the technical and managerial aspects of the envisaged Tempel-2/Halley dual-spacecraft mission.[445]

At the SAC meeting, Trendelenburg pointed out that "letters had been received from European scientists expressing disappointment at the outcome of the study priority set up by the SSWG", and invited the Committee to "act as an arbitrator in this case and to express a view as to whether the priority set by the SSWG should be maintained". After extensive discussion, the SAC reversed the SSWG priority and recommended that a study on the joint ESA/NASA cometary mission be started immediately, "with the goal of being ready for a decision by the end of 1979". At the same time, it definitely excluded the possibility of studying a purely European fly-by mission.[446]

In the following days the protests of the supporters of the lunar mission could not prevent Trendelenburg's Directorate from undertaking intensive studies in-house and with the Americans on the Halley probe to be carried on NASA's mother spacecraft to Tempel-2, for what was now called the International Cometary Mission (ICM). Several members of the SSWG blamed the SAC for acting "in an undemocratic manner", some explicitly challenging its right to give advice "independent of and even in contradiction of Working Groups' recommendations". These arguments, however, could not change the situation. Bonnet claimed that the SAC had in fact acted in accordance with its procedures in making its recommendation to the Executive, "which the Executive had thought it correct to pursue". Trendelenburg, for his part, stated that "the Executive could if it deemed it necessary, or had any grounds for disagreement with the Working Groups' views, seek the advice of the SAC, as the senior scientific advisory body".[447]

4.6 The selection of ESA's next scientific mission

The decision on ESA's next scientific mission was eventually postponed to February 1980 in order to fit within the American policy-making. In the USA, in fact, the cometary mission was in competition with a Venus Orbiter mission, both of them being launch-window dependent, and the probability of the former being approved by NASA and the Congress was hardly higher than 50%. A first indication as to whether the ICM would receive a positive response was expected by January 1980, if in the NASA budget presented by the President to the Congress there would have been a request for the development of the SEPS technique required to drive the spacecraft towards its rendezvous with Tempel-2. At the same time, in order to comply with the NASA selection procedures for the instruments to be included in the payload of scientific satellites, the SAC agreed to deviate from the

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444 Calder (1992), p. 21-22. Calder's lively book is essentially based on personal interviews with the main protagonists of the history of the Giotto mission. He informs us that the main lobbying for POLO came from the British scientists.

445 The ESA/NASA October meeting is reported on in ESA/SPC(78)25, *cit.*, p. 3. cf. also Calder (1992), p. 20.

446 SAC, 14th meeting (28 September 1978), SAC(78)21, 20 November 1978, pp. 3-4. Only four members of the SAC attended the meeting, namely Bonnet, Axford, Pinkau and Wiin-Nielsen, together with the chairmen of the AWG (Setti), SSWG (Petit) and MSWG (Weiss). The two other members, Colombo and Wolff, were unable to attend.

447 SAC, 15th meeting (19 December 1978), SAC(78)23, 8 January 1979, pp. 2-3.

usual ESA policy of issuing an Announcement of Opportunity (AO) to the scientific community only after project approval. NASA, in fact, planned to release an AO for the ICM in late Spring 1979; therefore, either ESA would have to issue a joint AO with NASA at that time, or the European scientific community would be unduly penalised in the final definition of the payload. There was no choice but to accept the first option, even though "experimenters wishing to bid for space on other candidate ESA satellites might feel themselves being at a disadvantage".[448] The SPC endorsed the SAC decision but made it clear that "[this] did not imply that the SPC accorded priority to the cometary mission, [and] the issuing of the AO should not be invoked as a reason for giving the cometary mission priority over other candidates".[449] This was quite fair; nevertheless the preparation of experiment proposals in view of the forthcoming AO (eventually issued in October) did reinforce the cometary scientific constituency already established in Europe.

After the dismissal of GRIST and the addition of the ICM, three other changes occurred in the list of candidate projects for the February-1980 selection. Firstly, the elimination of SEOCS from the list, as it was agreed that this project should be considered as part of the optional Earth-observation programme, and then funded from outside the mandatory science budget. Secondly, the addition of a general Spacelab facility for life-sciences experiments, called Biorack. This was a set of holding units and incubators for plants, cells and tissues, and lower vertebrates, similar to those widely used in standard laboratory research. The Biorack, whose cost was estimated at less than 5 MAU, had been strongly recommended by the LSWG and endorsed by the SAC, and the SPC had eventually agreed that it be included in the list of candidate projects for the mandatory programme.[450] Finally, the SAC and the SPC endorsed the Executive's proposal to consider for inclusion in the programme the utilisation of the GEOS spacecraft for a bold scientific mission to be launched at no or very low cost on one of the Ariane test flight. This so-called GEOS-3 mission would aim at exploring the Earth's magnetospheric tail (i.e. the magnetospheric region in opposition to the Sun) beyond the orbit of the Moon, at about 230 to 260 Earth radii from the Earth.[451]

The list of candidate projects at end-1979 is reported in Table 4-7.[452] According to the usual ESA procedure for the selection of new scientific project(s), the results of the Phase-A studies were to be presented to the scientific community and discussed at a symposium scheduled for 22 January 1980 in ESTEC. Following this presentation, the Working Groups would be called to discuss the projects within their competence and issue their recommendations. Subsequently, it was up to the SAC to make its recommendation to the SPC, whose final decision was scheduled for 4-5 March.

4.6.1 The comet and the stars: telex lobbying

When the ESTEC symposium was being prepared, it was announced in the USA that the required funding for the SEPS had not been included the President's budget. As solar electric propulsion was an essential element of the Tempel-2/Halley mission, it had to be acknowledged that the basis for the cooperative cometary mission no longer existed.[453] Facing the new situation, the Executive decided to resume a proposal, originally made in early 1979 by G. Colombo, which combined the GEOS-3 project and a mission to Halley. This mission, called HAPPEN (Halley Post-Perihelion Encounter), foresaw that the GEOS-3 spacecraft, instrumented for Earth-magnetotail research but suitably

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448 SAC, 16th meeting (22-23 January 1979), SAC(79)4, 9 March 1979, p. 6.

449 SPC, 18th meeting (23-24 January 1979), ESA/SPC/MIN/18, 22 February 1979, p. 6.

450 SAC, 14th meeting (28 September 1978), SAC(78)21, 20 November 1978; SPC, 17th meeting (14 November 1978), ESA/SPC/MIN/17, 5 December 1978. Cf. ESA/SPC(78)19, 16 October 1978.

451 The GEOS-3 concept was first presented in ESA/SPC(78)26, 6 November 1978, and add. 1, 10 November 1978. Several mission profiles were studied in the following months in consultation with the SSWG. Cf. SAC, 6th meeting (22-23 January 1979), SAC(79)1, 9 March 1979, pp. 6-7; SSWG, 31st meeting (3-4 May 1979), SOL(79)10, 25 June 1979.

452 The reports on the Phase-A studies for the classical science projects, all dated December 1979 and coded SCI(79)9 to 12, are available in *D/Sci archives*. The report on the Phase-A study for Biorack, prepared under the responsibility of the Directorate of Future Programmes, is coded DP/ST(80)1.

453 The history of US plans for a cometary mission are discussed by Logsdon (1989).

Table 4-7: Candidate projects for adoption in the ESA Science Programme (February 1980)

Mission	Scientific objectives and technical characteristics
Space Astrometry (Hipparcos)	Accurate measurements of parallaxes, proper motions and positions of about 100,000 selected stars. The scientific payload, including a 25 cm Baker-Schmidt telescope, would be mounted on a three-axis-stabilised spacecraft launched by Ariane into a circular geosynchronous orbit.
Extreme Ultraviolet and Soft X-ray Survey Satellite (EXUV)	Search for extreme UV points and nebular sources in the band 100-1000 Å, and mapping of the diffuse emission in the band 10-250 Å. Two telescopes mounted on a three-axis-stabilised spacecraft launched by Ariane into a highly eccentric (apogee 120,000 km), low inclination orbit.
International Cometary Mission (ICM)	A joint NASA/ESA mission to rendezvous with comet Tempel-2 in 1988 and to fly-by comet Halley in 1985. A main spacecraft provided by NASA and a Halley probe provided by ESA launched together from the Shuttle, using an Inertial Upper Stage, and driven by an SEP system. At Halley encounter, the probe is released from the spacecraft and targeted to approach to within a few hundred kilometres of the comet's nucleus.
Earth's Magnetospheric Tail Explorer (EMTEX, formerly GEOS-3)	Exploration of the Earth's magnetotail beyond the orbit of the Moon, perhaps as far as 260 Earth radii from the Earth. A spacecraft based on the GEOS-1 and -2 design, and using a certain amount of hardware remaining from the GEOS programme, would be launched by Ariane into the geomagnetic tail. Two orbit options were foreseen.
Biorack	A Spacelab multi-user facility for research in the areas of developmental and genetics studies in biology, with accommodation for cells, tissue, micro-organisms, small insects, etc., and enabling these specimens to be exposed to weightlessness and cosmic radiation.

reconfigured, could be targeted to intercept the tail of comet Halley at the end of its magnetotail mission. The encounter with Halley would occur in March 1986, after it had rounded the Sun, instead of the pre-perihelion encounter in November 1985 foreseen in the ESA/NASA mission.[454]

The GEOS-3/Happen mission proposal was discussed at the ESTEC symposium in January, and it was supported by the GEOS experimenters: "The HAPPEN proposal would, after the likely cancellation of the ESA/NASA comet mission, present a unique opportunity for cometary plasma research", they recommended to the SSWG.[455] The Working Group, however, did not agree. At their meeting of 24 January, the SSWG strongly recommended GEOS-3 for selection for the new ESA scientific project, but rejected the HAPPEN extension: "Opinions were somewhat divided", the SSWG concluded, "but, on balance, [...] the probable science to be achieved by this mission did not justify the estimated [additional] expenditure of 30 MAU".[456] The comet was thus lost again. The minutes of the meeting do not give details of the discussion, but several members regretted that, after the loss of

454 The HAPPEN mission had been discussed by the SSWG at its 31st meeting (3-4 May 1979), SOL(79)10, 25 June 1979, but it had been discarded in view of the on-going planning for the ESA/NASA (Tempel-2/Halley) cometary mission. Cf. the SSWG's recommendation reported in SOL(79)9, 4 May 1979. The GEOS-3/HAPPEN mission as proposed by the Executive is described in SCI(80)2, January 1980.

455 Copy of this recommendation, dated 24 January 1980, typewritten and signed by nine GEOS experimenters, is in *D/Sci archives*.

456 SOL(80)3, 29 January 1980.

POLO, the crisis of the cometary mission had caused again a situation in which no planetary mission was left for decision, and the Working Group had to continue to recommend only projects in the same discipline of magnetospheric research.[457]

Opinions were also divided within the AWG, whose task it was to award priority to one of the two projects under its competence, the astrometry satellite Hipparcos and the EXUV mission. Of the 13 members attending the meeting, 8 voted in favour of Hipparcos and 5 in favour of its competitor. While both missions were considered as promising good scientific return, two main arguments were raised against EXUV. Firstly, the controversial combination of two experiments in the same payload; secondly, the fact that the scientific objectives of this mission were being covered by two different missions planned by NASA and Germany, respectively. In support of Hipparcos there was a large constituency, including both the astronomer community (a resolution supporting the astrometry mission had been adopted in August 1979 by the International Astronomical Union's General Assembly) and the scientific community interested in geodesy (precise astrometric data are required for measuring the Earth's rotation and the shape of its surface).[458]

Given the results of this formal consultation, the task for the SAC was now to decide on two main questions. Firstly, whether to recommend GEOS-3 or Hipparcos for immediate adoption in the ESA Scientific Programme; both projects, in fact, could not be accommodated in the 1980 budget, but the loser would anyway remain in the list of candidate projects for the next selection in early 1981. Secondly, whether to recommend Biorack for funding out of the science budget. The latter had been strongly recommended by the LSWG, and its scientific interest was not questioned, but its inclusion in the mandatory budget was not politically innocent *vis-à-vis* the on-going debates about Spacelab utilisation.[459]

The SAC meeting was scheduled for 6-7 February, with the German physicist Klaus Pinkau replacing Bonnet in the chair (Table 4-8).[460] There were ten days for the supporters of the cometary mission to rescue their project. Insisting on the GEOS-3/HAPPEN concept was out of the question, after the SSWG resolution. In fact, the combination of two different objectives within one mission could be criticised both from the scientific and the technical points of view: The GEOS-3 spacecraft could not be instrumented appropriately for studying the comet without detracting substantially from the effectiveness of the magnetotail mission, and important instruments for cometary studies such as a camera, a neutral mass spectrometer and an instrument for measuring dust composition could not be included in the payload. Moreover, the cometary mission had a definite launch window in 1985, which could only be achieved if it was adopted now. As a consequence, the adoption of Hipparcos would definitely have killed GEOS-3/HAPPEN, while, on the contrary, GEOS-3 alone could still remain in the list of candidate projects for the early-1981 selection, which the magnetospheric scientists certainly preferred. In conclusion, a new proposal for a cometary mission was required.

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457 SSWG, 33rd meeting (24 January 1980), SOL(80)4, 7 May 1980. An explicit criticism to the Executive for introducing GEOS-3 in the decision process instead of concentrating its efforts on assessment studies of POLO in order to have this project ready for a decision at the same time as the cometary mission was made by G. Neukum in a letter to G. Haskell (SSWG Secretary), 20 February 1980, *D/Sci archives*.

458 ASTRO(80)2, 30 January 1980. Cf. AWG, 39th meeting (24 January 1980), ASTRO(80)3, 21 March 1980.

459 The various financial implications arising from the selection of any of the candidate projects (including EXUV) were described by the Executive in SAC(80)5, 31 January 1980. The LSWG recommendation on Biorack is reported in LIFE(80)1, 30 January 1980.

460 SAC, 21st meeting (6-7 February 1980), ESA/SAC/MIN/21, 17 April 1980.

Table 4-8: SAC membership and Working Group Chairmen in 1980

Members of the SAC:	K. Pinkau (chairman)
	A. Egidi
	H. Elliot
	J. Kovalevsky
	G. Tammann
	H. Weiss
Chairmen of Working Groups:	
Astronomy	C. de Jager
Solar System	A. Gabriel
Life Sciences	H. Wolff
Material Sciences	Y. Malmejac
Earth Observation	E. Raschke
Space Telescope	F. Pacini

The proposal came in a telex to Trendelenburg from an impressive group of German physicists, many of whom were already involved in designing experiments for the ill-fated ESA/NASA mission. "Comet Halley will be the only comet in this century that is active enough to make it an outstanding target for a flyby mission", they wrote, and then made their proposal as follows:

> *A separate spacecraft, such as of GEOS type, solely dedicated to cometary science is much more adequate. This spacecraft could be launched together with GEOS-3 in its original version. The production of two similar spacecraft and their simultaneous launch will probably be only slightly more expensive than the figure (60 + 30 MAU) quoted for the HAPPEN mission. The extra cost over GEOS-3 should be comparable to that of the probe (50 MAU) for the NASA/ESA mission.*[461]

There were several advantages in launching a pure comet probe jointly with GEOS-3, they argued. Firstly, the use of two similar (existing) spacecraft for the magnetotail and the comet reduced the cost of each spacecraft; secondly, a dual launch would use the full capability of Ariane, help optimising mission planning, and cause no extra launch costs for the cometary mission; last but not least, ESA would fly its first interplanetary mission, a purely European cometary mission, for the extra cost of an inexpensive satellite.

Trendelenburg was delighted to receive this telex, but his staff had just one week to work out a credible technical proposal to be presented at the forthcoming SAC meeting. Only a rough outline could be prepared, which could hardly win approval against Hipparcos. The latter had a convinced advocate in the SAC, the French scientist J. Kovalevsky, who had contributed to the Phase-A study. The crucial question was whether the scientific appeal of the cometary mission was sufficient to justify a delay in taking a decision on the next project, i.e. until the technical and scientific feasibility

461 The telex, dated 29 January 1980, was signed by 19 physicists, including H.U. Keller, W.I. Axford, L. Biermann, H. Fechtig, R. Lüst, F. Neubauer and U. von Zahn. A copy of this telex, as well as a few others sent by other scientists to protest against the SSWG negative decision on the GEOS-3/HAPPEN proposal, are in *D/Sci archives*. cf. Calder (1992), pp. 32-34.

of this new proposal could be established beyond doubt. Another three-month study was required, Trendelenburg told the SAC.[462]

After presentations of all candidate projects (including EXUV) and some general discussion, it took two restricted sessions for the SAC to reach agreement on the final resolution, ... and the comet mission was rescued. The SAC, in fact, unanimously recommended that the proposed Comet/GEOS-3 dual mission be selected as the next scientific project, provided that, within a period of three months, the scientific value of the project could be confirmed, its technical feasibility demonstrated, and the estimated cost not be higher than 120 MAU.[463] The engineers hurried to work, and the cometary mission acquired a charming name: Giotto. This was motivated by the fact that the earliest realistic portrait of Halley's comet was painted by the great Italian artist in one of the beautiful frescoes in the chapel of the Scrovegni family in Padua. The star of Bethlehem in the painting of the Adoration of the Magi, in fact, is but a faithful representation of the famous comet, as Giotto saw it during its sensational appearance in 1301.

There are three main reasons for the SAC decision. The first is obviously the firm commitment of Trendelenburg's Scientific Directorate to undertake the cometary mission. While the SAC was formally independent in making its recommendations, nevertheless it was the Directorate which provided the necessary inputs in terms of technical assessments and financial estimates of mission proposals. Had Trendelenburg not decided to hurry studies on the GEOS-3/Happen project and then on the purely cometary mission, and had he not insisted on submitting both projects to the SSWG and the SAC, the Halley comet mission would definitely have been lost to ESA. Public relations considerations seem to have had a major role in Trendelenburg's efforts in supporting the cometary mission. Visiting a famous comet and sending close-up images of its nucleus to TV screens on Earth was certainly more appealing to popular eyes than accurately measuring star positions, and would add glamour to the European space effort which lacked space walks and footsteps on the Moon. If, after all, the ESA programme depended on taxpayers' money, why not offer them a colourful vision of the wonders of nature in addition to esoteric papers in scientific journals?[464]

The second reason was the strong interest of the magnetospheric physics community, in particular the GEOS-3 experimenters, in linking their pet project to an independent cometary mission. From the scientific standpoint, during Giotto's long journey to its encounter with Halley, important data on the interplanetary medium could be obtained that would enhance the scientific value of GEOS-3. This was not the only element, however. The GEOS-3 constituency, in fact, could hardly win a competition against the powerful astronomy community supporting Hipparcos, but their chances would certainly be higher if the magnetospheric mission could be coupled to such a stimulating objective as studying a comet *in situ*,. Facing the challenge of a technically sophisticated astronomical mission, the old tradition of ESA magnetospheric studies would be dramatically reinforced by its association with Europe's first interplanetary mission.

Last but not least, there was some weakness in the Hipparcos project itself. Some technical uncertainties regarding its feasibility had been expressed in the Phase-A report; the question of the complex data handling had not yet been settled; and the high costs of the project had been recognised, in particular because it was suggested that the payload should be financed by ESA. No unanimous consensus, as we know, had been expressed by the AWG on awarding priority to Hipparcos against EXUV, and an influential SAC member, the British physicist H. Elliot, argued that "a definite decision

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462 SAC, 21st meeting (6-7 February 1980), ESA/SAC/MIN/21, 17 April 1980.

463 SAC(80)7, 11 February 1980. No minutes of the restricted sessions are available, but Kovalevsky asked that its doubts that in-depth studies on the combined Comet/Geos-3 mission could be done in a three-month period be recorded.

464 Calder (1992), p. 23. It is worth recalling here that the public relations aspect of the Giotto mission was very badly managed by ESA and the scientists involved in the experiments. On "the night of the comet", while everybody was expecting to see beautiful colour pictures of the comet nucleus, what was shown on several hundred million television screens was a series of coded isophotes totally incomprehensible to the public.

to go ahead with Hipparcos could not yet be taken because of the absence of complete confidence in the technology".[465] These doubts were reflected in the SAC resolution, which requested that the three-months period should also be used for further technical studies on the astrometry mission, and to find ways and means whereby the payload could be funded nationally. The SAC clearly stated that, in case the comet mission should not be feasible, Hipparcos should then be the first choice (against EXUV and GEOS-3 alone) only provided that the payload was funded outside the mandatory budget. The resolution then concluded:

> *In the event that the Hipparcos payload would need to be funded within the mandatory programme, the SAC was divided as to whether Hipparcos should then remain the Agency's choice or if EXUV should be carried out because this mission was considered by some members to be just as interesting.*[466]

A last word must be said regarding Biorack. The SAC did not endorse this project at this stage but requested the Executive to undertake a further study to firm up the estimated cost of the facility, and to issue an Announcement of Opportunity in order to establish a possible payload for the first Biorack mission: "The recommendation whether to go ahead with the funding of Biorack and its ancillary equipment would be made following evaluation of the science proposed".[467] In the event, Biorack was included in the optional Microgravity Programme, established in February 1982.

The SAC decision came as a bombshell in the scientific community. Pinkau and Trendelenburg, as well as the SPC chairman and the ESA Director General, were flooded by telexes and letters from all over Europe, blaming, on the one hand, the unusual and "arbitrary" procedure of recommending a project not supported by technical studies and not previously discussed by the SSWG, and claiming, on the other, the great support that Hipparcos enjoyed within the scientific community. The chairman of the Hipparcos Consortium, P.L. Bernacca, wrote that 170 research proposals for the astrometry mission had been presented by 125 astronomers from 12 countries, recalling that 24 institutes from 8 countries were available to put manpower into hardware and software activities, and 5 were already working on aspects of hardware and software using their own funds. The cometary lobby was just as active, however, and many telexes arrived expressing satisfaction with the SAC decision and whole-hearted support for Giotto, "which is a once in a lifetime opportunity".[468]

4.6.2 The SPC decision

It was up to the Science Programme Committee, whose meeting was scheduled for 4-5 March under the chairmanship of the Italian physicist Edoardo Amaldi, to say the last word on the selection of ESA's next scientific project. In this political body, made up of national delegations and where senior scientists and space policymakers sat side by side, even an appealing scientific idea could not do without sound technical and financial credentials, all the more so as the idea was so controversial. Pending the results of the on-going study, the information Trendelenburg could provide in support of the Director General's formal proposal to select the combined Giotto/GEOS-3 mission was rather poor.[469] In fact, the lack of information and the hurried decision which the SPC had to confront was

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465 ESA/SAC/MIN/21, *cit.*, p. 4.

466 SAC(80)7, 11 February 1980, p. 2.

467 *Ibid*.

468 All telexes are in *D/Sci archives*. The last quotation is from one signed by a group of physicists of the M.P.I. für Kernphysik in Heidelberg and the universities of Bochum and Bonn. The "arbitrariness" of the SAC action was blamed by SSWG members A. Brahic and A. Cazenave, from Toulouse. "Great enthusiasm" was expressed, on the contrary, by the original proponents of the dual Comet/GEOS-3 mission. The rationale for the SAC decision is expressed in a letter sent by Pinkau to the AWG chairman C. de Jager, dated 17 March 1980, a copy of which is in *D/Sci archives*.

469 The Working Groups and the SAC acted as advisory bodies to the DG, and it was the latter who formally made proposals to the policymaking SPC. The terms of reference of the ESA scientific advisory structure are described in ESA/ADMIN(79)10, 22 May 1979. The DG's proposal to the SPC is in ESA/SPC(80)4, 13 February 1980.

regretted by most SPC delegations, and the French explicitly questioned the Executive for presenting a proposal which was not "politically advisable since it had not met with a general consensus in the scientific community and could possibly lead to a complete split in the Committee".[470] Only Germany and Sweden advocated the dual Giotto/GEOS-3 mission, as was to be expected given the involvement of German and Swedish scientists in the former NASA/ESA cometary project and magnetospheric studies, respectively. France (of course), Belgium, the Netherlands, Denmark, Italy, Switzerland and Spain supported Hipparcos. The British delegation requested that the decision be deferred until more information was available on both Hipparcos and the combined Giotto/GEOS-3 mission; and the Irish said that among Irish scientists there was an equal interest in both projects.

The long discussion in the SPC brought into evidence two elements: firstly, that if a vote had been taken, then Hipparcos would have been chosen as ESA's next scientific project; secondly, that such a decision would anyway have left several delegations and a large fraction of the scientific community deeply dissatisfied. Apart from Germany and Sweden, Italy did not want to abandon GEOS-3, as only "a slight preference" had been expressed for Hipparcos within its scientific community; Switzerland anyway wanted GEOS-3 or Giotto (both being impossible) in addition to the astrometry mission; an "important minority" of the Belgian scientific community had expressed interest in the cometary mission; and even France suggested exploring the possibility of undertaking a mission to comet Halley in cooperation with NASA.

In the event, a compromise agreement was reached: Hipparcos was reinstated as the next scientific project, with the provision that ESA should also take responsibility for the payload development, but the Executive was instructed to pursue the study of the Halley mission until the end of June, definitely discarding GEOS-3. If Giotto proved to be scientifically interesting and technically feasible within a cost envelope of 80 MAU, then it would be included in the ESA programme, "on the understanding that the Hipparcos project could be stretched to accommodate the cometary mission". The stars could wait, while the comet could not be stopped in its journey through the solar system, and the two-week launch window of July 1985 could not be missed.[471]

The compromise did not make the SAC happy, at least not its chairman who went as far as offering his resignation to Trendelenburg. "It apparently is true that comets are a bad omen", Pinkau wrote to his fellow SAC members.[472] Firstly, facing the grim financial situation of the science programme, he did not like the SPC decision to finance the Hipparcos payload out of the mandatory budget. It was customary for ESA scientific satellites that the payloads be financed nationally, but Hipparcos was now the third astronomy project, after Exosat and the Space Telescope, for which the SPC had voted in favour of paying also for the payload: "Thus [it] is beginning to establish a policy", Pinkau remarked, and such a policy implied of course that less funds would be available for new projects. Secondly, according to the SAC chairman. the ESA decision-making process favoured "big science" projects, the main determining factors being financial feasibility and Ariane launch, rather than the "value for money" of the proposed missions. The dual Giotto/GEOS-3 mission would have supported "a very large community with very good science at low cost", Pinkau argued, but the SPC had not considered the magnetotail mission worth the price difference between the financial frame of the cometary mission (80 MAU) and the combined Giotto/GEOS-3 mission (120 MAU). This difference was roughly equal to the price of the Hipparcos payload. Finally, Pinkau remarked on the unfair distribution of resources between astronomy and solar system science, the former taking by far a larger fraction of the available funds for the 1980s.

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470 SPC, 23rd meeting (4-5 March 1980), ESA/SPC/MIN/23, 3 April 1980, p. 3.

471 ESA/SPC/XXIII/Res. 1, 7 March 1980. The resolution was approved with the only abstension by the Netherlands delegation.

472 Pinkau, letter to the SAC members, 14 March 1980, copy in *D/Sci archives*. cf. also Pinkau’s letter to M. Rees, also dated 14 March 1980, and Bonnet’s letter to Pinkau, 21 April 1980, *ibid*.

4.6.3 Giotto and Hipparcos adopted

The Giotto study was duly prepared by mid-May and the final report discussed at a meeting of the interested scientific community on 30 May. It foresaw a flyby mission launched in July 1985 either by Ariane in association with an application satellite or by a Thor-Delta rocket, a significant involvement of American scientists in the scientific investigations being foreseen in the latter case in exchange for a free ride. The Halley encounter was scheduled for March 1986 (four weeks after perihelion) with a flyby velocity of 68 km/sec, active trajectory control and adequate shielding guaranteeing spacecraft operations up to a few hundred km from the comet's nucleus. The model payload, with a total mass of 53 kg, included: an imaging camera; neutral, ion and dust mass spectrometers; a dust impact detector; a plasma analyser; a magnetometer; and a UV-spectrometer. The estimated cost was 85 MAU, plus 2 MAU for the use of the large antenna at the Parkes Radio Observatory in Australia for tracking and data acquisition during the short encounter phase. The inclusion of Giotto in the programme implied a delay in the Hipparcos project by about 6 months and a delay in the selection of the next scientific project by about one year. An immediate decision had to be taken in order to respect the 1985 launch date.[473]

On the basis of the results of the study, the SSWG unanimously expressed its enthusiastic support for the Giotto project, which it considered "an exciting and cost-effective scientific opportunity", and recommended its inclusion in the ESA programme as a purely European mission launched by Ariane.[474] Two weeks later, the SAC fully endorsed this recommendation.[475]

When, however, the matter came up for discussion, and final decision, at the SPC, two clouds hindered the conclusion of the selection process. Firstly, there was the request byf Germany to re-discuss the issue of the ESA funding of the Hipparcos payload. If Giotto and Hipparcos (payload included) were approved, the German Minister for Research and Technology warned, the science budget would be blocked for a long period, making it impossible to support other areas of space science. The suggestion was that the Hipparcos payload should be funded in the form of an optional programme by the Member States interested in the astrometry mission.[476] The second cloud derived from the French request that the cometary mission should anyway be open to American investigators, even if the mission was launched by Ariane. The collaboration with the USA was considered indispensable, "both from the point of view of the scientific results to be obtained and from the point of view of the security of the mission itself". This was an important policy question which could only

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473 The report, coded SCI(80)4, 14 May 1980, is in *D/Sci archives*. Cf. also ESA/SPC(80)13, 6 June 1980. Negotiations with NASA about the possible use of a Thor-Delta launcher were still ongoing. The possibility of using the Parkes facility at such a good price compared to NASA's Deep Space Network (4 to 10 MAU) materialised only after the completion of the report, but, to Trendelenburg's relief, before the SPC meeting (*infra*). Calder (1992), p. 37, writes that Parkes' request was 200,000 dollars (about 0.14 MAU), which is obviously incorrect.

474 SOL(80)6, 30 May 1980. Cf. SOL, 34th meeting (30 May 1980), SOL(80)7, 30 June 1980.

475 SAC, 22nd meeting (16-17 June 1980), ESA/SAC/MIN/22, 5 September 1980. The SAC resolution is reported in SAC(80)15, 17 June 1980.

476 W. Finke's letter to the Director General, dated 25 March 1980, was circulated under cover ESA/SPC(80)10, 9 April 1980. Finke's arguments echoed Pinkau's and one can reasonably guess that the latter, who was an influential scientific adviser to the German government on space matters and a former SPC delegate, exerted some influence.

be decided upon by the Council, but the French delegation insisted that the SPC resolution should include a statement to this effect and be referred to the Council in the form of a recommendation.[477]

After a long discussion, the German delegation agreed to withdraw its request regarding the funding of the Hipparcos payload, in order to remove "a major obstacle for the approval by some delegations of the Giotto mission". France, on the contrary, formally stated that, unless the resolution explicitly indicated that the call for experiment proposals would be open to US experimenters, it would vote against it, which it eventually did. Giotto was thus adopted in the ESA programme with ten votes in favour and one against. The last word was Trendelenburg's:

> *The Director of the Scientific Programme underlined the importance of the decision taken; he stressed that the Giotto project was certainly more risky than any other project undertaken by the Agency to date, but believed that ESA had demonstrated that it was technically able to undertake such a project and hoped delegations would fully support the Executive in its endeavours to carry out the mission successfully.*[478]

4.7 Epilogue

The Giotto spacecraft was successfully launched by an Ariane 1 vehicle on 2 July 1985, carrying on board a 59 kg scientific payload including ten experiments. The following day, its solid-propellant Transfer Propulsion System was fired as planned and put the spacecraft right on course for its rendezvous with Halley's comet.[479] Giotto was to act as a sort of *kamikaze* mission, approaching the comet at about 600 km in order to get a close-up view of the nucleus and its atmosphere. Passing at a speed of about 70 km per second through the thick cloud of dust and gas surrounding the cometary nucleus, there was very little chance of survival for the spacecraft and its scientific instruments. The Giotto mission, which had required two years for decision-making (including the preparation of the ill-fated NASA/ESA mission), five years for building the spacecraft, and eight months of cruising in space, was to collect all its relevant data in the very last hour of its lifetime.[480]

The encounter phase started at about 6 p.m. GMT on 13 March 1986 and Giotto's closest approach to the comet occurred at 00:11:0.5 GMT on 14 March, at a distance of about 596 km from the comet's nucleus and 144 million km from the Earth. Although the encounter was formally over 15 minutes after that moment, payload operations continued until 02:40 GMT on 15 March when the scientific mission was terminated and the payload switched off.[481] As the spacecraft and several instruments survived the dramatic encounter with Halley, it was eventually decided to extend the mission and to redirect Giotto to encounter comet Grigg-Skjellerup by means of an Earth-swing-by manoeuvre. The latter encounter took place on 10 July 1992, with the spacecraft passing within approximately 200 km of the cometary nucleus, 214 million km from the Earth.[482]

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477 SPC, 24th meeting (8-9 July 1980), ESA/SPC/MIN/24, rev. 1, 13 August 1980, p. 3. There is no explicit reason given for the French insistence on having the Giotto payload open to US investigators. Most probably this was due to the fact that the French space policymakers did not believe that the most important Giotto instrument, the imaging camera, could be built in Europe and wanted to secure the experience of the Jet Propulsion Laboratory's group which had built the camera for the Voyager spacecraft. At that time, in fact, one of the most influential French advisers for space policy matters, Jacques Blamont, was visiting JPL, trying to convince them to devise a camera for Giotto. cf. Calder (1992), p. 40.

478 ESA/SPC/MIN/24, *cit.*, p. 5. The final resolution is reported in ESA/SPC/XXIV/Res. 1, 9 July 1980.

479 Wilkins (1985).

480 Russo (1994).

481 "Giotto special issue", *ESA Bulletin*, No. 46 (May 1986). A lively account of the "night of the comet" is in Calder (1992).

482 Schwehm (1992).

Hipparcos was launched on 8 August 1989 by an Ariane-4 vehicle, one year later than originally scheduled because of various delays in the Ariane launch schedule. The launch was successful and the spacecraft was injected into the elliptical transfer orbit (210 km perigee and 36,000 km apogee) with high precision. About 36 hours after launch, the apogee boost motor was due to be fired to put the satellite into its final geostationary orbit. However, the firing attempt failed, as did several subsequent attempts to ignite the motor, and it became clear that an irrecoverable on board hardware failure had occurred. A recovery mission was then designed for Hipparcos, with the satellite remaining in a highly eccentric orbit (500 km perigee and 36,000 km apogee) and orbital coverage being carried out by ground stations in Odenwald (Germany), Perth (Australia) and Kourou (French Guiana). The implementation of the recovery mission was completed in early November and then the satellite was commissioned for scientific use. Targeted for an operational lifetime of three years, Hipparcos lived one year longer, performing accurate astrometric measurements of about 120,000 stars until 15 August 1993, when the mission was terminated.

A discussion of the important scientific results obtained by these two ESA missions is outside the scope of this chapter. It is worth recalling, however, that both represented a striking novelty in space science, Giotto offering for the first time the possibility of studying cometary phenomena by close-up imaging and *in situ* measurements, and Hipparcos providing a space platform for the most ancient branch of astronomy. Moreover, Giotto's glamorous encounter with Halley's comet, broadcast to television viewers all over the world, finally gave the European Space Agency a place in the public's imagination regarding space exploration. From the historical point of view, however, the great scientific interest of Giotto and Hipparcos, as well as their successful performances, should not make one forget the political factors which led to their adoption into the ESA programme against POLO and EXUV, respectively. Had Germany and France not strongly supported the cometary mission and the astrometry mission, respectively, these would probably not have passed the selection process, perhaps not even started it.[483] In the event, it was a compromise between ESA's two biggest Member States which ended the decision-making process: Germany agreed that ESA funded the Hipparcos payload, and France accepted a delay in the astrometry mission in order to have Giotto launched on time.

Both missions were purely European projects, launched by Ariane: this prompts our second historical consideration. In the early 1980s, in fact, all ambitious plans for scientific cooperation between ESA and NASA fell apart. We have discussed above the end of the envisaged joint cometary mission in January 1980. Later that year, as a result of technical and financial difficulties with the Space Shuttle development programme, NASA announced a two-year delay in the launch of the ESA/NASA dual-spacecraft International Solar Polar Mission (ISPM). This meant, firstly, that the launch window of February 1983 could not be met, thus jeopardising the mission's main scientific objectives, and, secondly, that the ESA spacecraft, whose development was near completion, had to be stored until the new launch date. Things went even worse the following year, as NASA unilaterally announced that it would not continue with development of its ISPM spacecraft, and that the launch of the ESA spacecraft would be further delayed. All efforts to reverse the American decision were frustrated, and ESA Member States eventually agreed to proceed with a single spacecraft mission, named *Ulysses*.[484] The spacecraft was scheduled for launch on the Shuttle Challenger in May 1986, but the tragic accident of 28 January that year, when Challenger exploded soon after lift-off killing its crew, put a brake on the Shuttle programme. Thus, when Giotto was heralding its historic encounter with Halley, Ulysses was sadly being placed into storage for a long period. It was eventually launched by the Shuttle Discovery on 6 October 1990, as much as seven years after the construction of the spacecraft had been completed.

After the Tempel-2/Halley cometary project was aborted, the joint ISPM mission abandoned, and the plans for cooperative utilisation of the Shuttle/Spacelab system frustrated, the Hubble Space Telescope remained the only ESA/NASA cooperative project, with ESA acting as a junior partner. Hubble was originally scheduled for launch on the Space Shuttle in December 1983 but the launch date had been

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483 See previous chapter.

484 Bonnet & Manno (1994), pp. 98-108. Cf. also Johnson-Freese (1990), pp. 35-44.

put back several times, resulting in a three-year delay overall. Its launch was eventually scheduled for October 1986 but the Challenger accident caused a further delay. The telescope was finally launched by the Shuttle Discovery on 24 April 1990, thus joining Hipparcos to the benefit of the astronomy community at large. By this time, Europe could rightly claim to have overcome a period of junior partnership with the United States and entered a new period of equal partnership and competition in many areas of space activities: strong competition in the launcher domain, with Ariane taking up a larger and larger share of the market, and "real partnership" claimed as the necessary foundation for cooperating in the future development of the Space Station.[485]

The dramatic problems of the science budget could not be solved in the period covered here. In spite of the many arguments put forward by the SAC in its 1978 report, the bad economic conditions of the 1970s prevented the ESA Member States from approving an increase in the mandatory budget, as requested by the spokesmen of the space science community. The consequences were rather severe, as demonstrated by the evolution of the launch rate of scientific satellites. Seven satellites were launched by ESRO in the 1968-72 period, i.e. before the impact of the first package deal. A three-year standstill followed, then three satellites were successfully launched by ESA between 1975 and 1978 (COS-B, ISEE-2 and GEOS). The next ESA satellite, EXOSAT, originally scheduled for launch in 1979, suffered from many delays because of budgetary problems and was eventually launched four years later, in 1983. Then Giotto came in 1985 and Hipparcos in 1989, certainly a far cry from the event rate of about one satellite launch per year that the SAC had considered necessary in order to keep a viable space science activity in Europe in the 1980s.

Facing this situation, which was the cause of much frustration and disappointment within the European space science community, ESA's scientific policymakers could no longer avoid the difficult task of establishing a general framework for a long-term programme in which a proper balance could be maintained between large and smaller projects, between purely European and cooperative projects, and between the various research fields. ESA’s scientific missions could no longer be selected on an ad hoc basis, through a competitive procedure driven by incidental power relations within the advisory bodies, as and when funds became available in Europe or the United States. The future space science programme had to be put into perspective, so that hundreds of scientists in Europe who were making use of space investigations could feel confident that a flight opportunity would be provided in a definite time framework, and plan their work accordingly. The battle for more money in the 1980s had been lost; the next effort was to work out a plan to the year 2000.

[485] Lüst (1987). This is the text of an address the ESA Director General presented in Washington on 4 April 1987. For Europe's "hard negotiating line" regarding future cooperation in the Space Station programme, cf. Bonnet & Manno (1994), pp. 108-119. A detailed discussion can be found in Chapter 15 of this volume. See also Johnson-Freese (1990).

Chapter 5: Towards the Turn of the Century

A. Russo

This chapter concludes the history of ESRO's and ESA's Scientific Programme, covering the events that occurred during the first half of the 1980s, i.e. between the selection of Giotto and Hipparcos as ESA's new scientific projects (July 1980), and the approval of the Horizon 2000 long-term scientific plan by the ESA Council meeting at ministerial level in Rome in January 1985. The latter event marked an important turning point in the history of the European space science effort, dramatically reversing the negative consequences of the package deals of 1971 and 1973 as regards the budget level and planning opportunities.

This period was also critical for ESA's history from a more general point of view. It saw the conclusion of the package deal programmes, those which had substantiated the setting up of the Agency in 1975: the maiden flight of Ariane took place successfully on Christmas Eve 1979 and it was qualified for commercial activity two years later; Spacelab was duly developed and delivered to NASA for its first Shuttle flight in November 1983; the Marecs (formerly Marots) satellite was successfully launched by an Ariane vehicle in December 1981, becoming ESA's first satellite to be used for commercial services. The time was then ripe for discussing Europe's new policy in space and eventually embarking ESA on a new set of long-term programmes. Following many discussions and negotiations in the ESA Council and its delegate bodies, a ministerial meeting was convened in Rome in January 1985, the second such meeting since the creation of ESA, the first having been held eight years earlier. An ambitious Long-Term European Space Plan was approved on this occasion and confirmed at a new ministerial meeting in November 1987 in The Hague. It included in particular the development of a new heavy satellite launcher (Ariane-5); a complex manned space infrastructure as a contribution to the international Space Station programme (the *Columbus* programme); and the *Hermes* spaceplane. Horizon 2000 was also an important element of this Long-Term Space Plan, indeed it was the only important element which survived as such after the dramatic political events which changed European history at the turn of the decade and forced a drastic reshaping of ESA's programmes.

Within the historical background outlined above, our narrative will essentially deal with two main topics. The first is the selection process which led, in March 1983, to the adoption of the Infrared Space Observatory (ISO) as ESA's new scientific project, following Giotto and Hipparcos. The second is the preparation, approval and early implementation of the Horizon 2000 programme, with the selection of the SOHO and Cluster missions as the first "Cornerstone" project. An important institutional change occurred in the Agency in this period, which affected the events we will discuss in the following pages. This was the decision, taken in 1981, that each Directorate should have authority for its own future projects, while previously studies of all future projects were entrusted to the Directorate of Planning and Future Programmes, now abolished. This gave the Directorate of Scientific Programmes full control not only of ongoing satellite programmes, but also of the Agency's overall scientific policy, including the selection process for new projects. An important consequence of this change was that each Director would have his own Advisory Committee reporting directly to him (there was no woman among the ESA Directors at that time, nor is there one now). In particular, the Science Advisory Committee (SAC), which formerly advised the Director General on all scientific matters, became the Space Science Advisory Committee (SSAC), restricting its activity to advising the Director of Scientific Programmes on matters falling within his responsibilities, i.e. the "traditional" research fields in astronomy and Solar System science. Life sciences, material sciences and Earth observation went to other Directorates.

Two main effects stemmed from the implementation of this new institutional framework. On the one hand, the space science community involved in European space programmes since the early days of ESRO went a step further in protecting its institutional and financial domain from the challenge of the new space disciplines which had emerged in the 1970s. On the other hand, those sectors of the scientific community working on borderline research fields (e.g. atmospheric science) found themselves in a somewhat uneasy situation *vis-à-vis* the mainstream of ESA's scientific activities. Their pleas for having a fair share of the overall scientific budget were generally frustrated, notwithstanding the formal support expressed in a few SSAC resolutions. Member states were divided on this issue: some of them argued that the exclusion of the new disciplines from the mandatory Scientific Programme left them in a continuous state of uncertainty, pending Council decisions on the start of dedicated optional programmes; others insisted that the mandatory budget should only cover "pure science", while funding of "application-oriented" research fields should be provided for by interested nations on an optional basis. We will not discuss this issue further in this chapter, which is devoted specifically to the development of the mandatory Scientific Programme, but we want to stress that the Horizon 2000 plan definitely legitimised this institutional separation between these two broad areas of scientific research in space.

5.1 Studying new scientific projects

After the decision, in July 1980, to adopt the Giotto and Hipparcos missions into ESA's Scientific Programme, a new project selection was expected by the end of the following year, at the conclusion of a planning cycle which had started in November 1978. At that time, ESA had circulated among the European space science community a call for mission proposals and, after evaluation by the Astronomy and Solar System Working Groups, seven missions had been subjected to an assessment study. Moreover, two former mission proposals were reintroduced into the planning cycle: the lunar mission POLO, which had been discarded in September 1978 in favour of the cometary mission; and the solar X-ray telescope GRIST, because NASA had said that there was the possibility of including this instrument in a Spacelab payload together with an American Solar Optical Telescope (SOT).[486] Table 5-1 is a list of the eight missions under consideration.

Table 5-1
Missions proposals studied in 1979

Mission	Scientific objectives	Cost (MAU)
Asterex	Asteroid exploration.	160/170
Eiscat-Sat	Study of high-latitude magnetospheric phenomena	100
X-ray astronomy	Spectroscopy study of ariable sources	110
X-ray astronomy	Study of transient X-ray phenomena	110
Schmidt telescope for UV astronomy	Fast, wide-angle Schmidt telescope on Spacelab	55 + 12 per reflight
Infrared Space Observatory (ISO)	Infrared telescope cooled to liquid helium temperature	135
Polar Orbiting Lunar Observatory (POLO)	Survey of the Moon's physical and chemical properties	190
GRIST	Grazing Incidence X-ray Solar Telescope on Spacelab	75 + 20 per reflight *

* The cost of the first flight (20 MAU) is included in the development cost figure. In the case of a collaborative venture with NASA, the first flight would be free of charge to ESA

[486] SAC(79)32, 29 November 1979. The results of the new assessment studies are reported in SCI(79) 1 to 7.

The results of the assessment studies were presented to the scientific community and the ESA advisory bodies on 22 and 23 November 1979 at ESTEC. Subsequent to the presentations, the Working Groups considered the projects within their terms of reference and issued their recommendations regarding which of these missions should be submitted to Phase-A (feasibility) studies.[487] Four missions were within the province of the AWG, i.e. the two X-ray missions, the infrared mission ISO, and the Schmidt telescope. All of them were considered of very high scientific value and qualified in principle for Phase-A studies. The Working Group recognised, however, that the infrared mission could not be ready for a decision in 1981 because of lack of definition of the cryostat. It therefore recommended that an in-depth study of this critical element should be performed before initiating the Phase-A study. Moreover, it supported the concept combining the two X-ray missions into one and recommended a study on this possibility. As regards the Schmidt mission, the AWG recognised its potentially useful scientific return, but considered that it should be given a lower priority.

Among the four Solar System missions, the SSWG expressed its interest in having Phase-A studies performed on the GRIST, POLO and Asterex missions. The first, however, was subject to a positive indication by NASA about its willingness to implement a cooperative SOT/GRIST Spacelab programme. The other two were well outside the financial capabilities of ESA's mandatory science programme and therefore they could only be realised as a collaborative venture with NASA or within the framework of a special (optional) project. As both possibilities appeared weaker for the asteroid mission than for the lunar mission, Asterex was given a lower priority. As to the Eiscat-Sat project, the SSWG recognised that good scientific results could be obtained at much lower cost by using a GEOS spacecraft, and recommended that a further assessment study should be carried out of this possibility.

The final decision about which missions should be submitted to Phase-A study, thus becoming candidates for the 1981 selection of new ESA project(s), rested with the SAC. A financial constraint was however associated with this decision, since the Executive warned that available resources were adequate to accomplish only three, perhaps four, fully-fledged Phase-A studies in 1980. Therefore it proposed to definitely discontinue further work on the Schmidt telescope and the Asterex mission and to start immediately studies on the combined X-ray mission, the ISO cryogenic system and the GEOS option for Eiscat-Sat. The Executive also stated that it was ready to start a Phase-A study on GRIST, subject however to receiving from NASA "a note containing favourable terms for a joint utilisation of GRIST and indicating NASA's availability to conduct jointly with ESA in-depth accommodation studies of GRIST with SOT". As regards POLO, the SAC was invited to advise whether a Phase-A study should be initiated immediately or "only at a time when more substantiated information on the realism of either of these two theoretical possibilities was available [i.e. collaboration with NASA or optional project]".[488]

The POLO project was a somewhat delicate issue within the European space science community. As we have discussed in the previous chapter, the lunar mission had been proposed alongside the cometary mission during the previous selection cycle and, after lively and passionate discussions, the SSWG had decided to recommend the former. This decision was eventually reversed by the SAC, which awarded priority to the cometary mission, thus opening the way to the final adoption of the Giotto project, but also to bitter reproaches from several SSWG members for such an "undemocratic" behaviour. Eventually, the SSWG insisted that POLO should anyway be maintained in the next planning cycle alongside the newly proposed Asterex project, both being considered as important contributions to the Agency's planetary programme.[489] The abandonment of Asterex, which had already been decided, made a decision on POLO particularly delicate.

The SAC discussed the Executive's proposal in the aftermath of the Council's recent refusal to agree an increase in the mandatory scientific budget, as requested in the SAC's Long-Term Planning Report

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487 ASTRO(79)18, 23 November 1979; SOL (79)15, 23 November 1979.

488 SAC(79)32, *cit.*, p. 2.

489 SSWG, 31st meeting (3-4 May 1979), SOL(79)10, 25 June 1979; SOL(79)9, 4 May 1979.

of December 1978.[490] In this situation, new scientific projects had still to be realised within the strict limits imposed on the budget level of the Scientific Programme by the 1971 Package Deal (i.e. 85.1 MAU per year at 1979 prices). The SAC expressed deep concern about the high costs of the proposed missions, and agreed that a "design-to-cost" approach should be adopted for the new study phase. This meant that Phase-A studies of the selected projects should ascertain their feasibility within financial limits established *a priori* for each of them. As a general rule, it was assumed that no single scientific mission should be considered for which the cost to ESA exceeded 1.5 times the annual budget. Consistent with this approach, the SAC recommended to study the possibility of combining the two X-ray proposals into one mission within a total cost ceiling of 100 MAU, and approved a Phase-A study on GRIST, subject to a positive response from NASA and with the proviso that the project be maintained within a cost limit of 55 MAU (i.e. the currently estimated development cost without the first launch). Moreover, the SAC agreed that a Phase-A study be carried out on POLO within an expenditure ceiling of 140 MAU from ESA's mandatory Scientific Programme: any amount in excess of this value was to be financed by other means (i.e. cooperation with NASA or an optional programme). Finally, the SAC endorsed the proposals to carry out a further assessment study on Eiscat-Sat, with a view to accommodating the proposed payload in a copy of the GEOS spacecraft, and to study the cryogenic system necessary for the ISO project.[491] The former, however, was eventually discarded after the decision to use a GEOS-type spacecraft for the Giotto mission.

5.1.1 Feasibility studies

The study programme on future candidate projects was started in the first half of 1980. In the field of X-ray astronomy, a new assessment study demonstrated the feasibility of a combined payload fulfilling the scientific aims of both the originally proposed missions. The new mission, named X-80, foresaw a spacecraft compatible with a dual Ariane launch, carrying a payload consisting of four wide-field cameras, two large area proportional counters, one phoswich detector, a Bragg spectrometer and a gamma-burst detector. A contract for a Phase-A study was awarded to Dornier, whose results were expected by April 1981.

Progress was also achieved on ISO. Two different conceptual designs of the cryostat were studied at industrial level by Linde and Dornier, respectively, and preliminary studies of the model payload instruments were also initiated. The results of these studies were discussed during a workshop at ESTEC on 28-29 May 1980, where preference was expressed for a liquid-helium/liquid-hydrogen concept. Studies for such a hybrid system were then initiated with Linde, as well as two conceptual studies of the cooled telescope, one with Carl Zeiss and the other with Matra.

Important steps were also realised regarding GRIST and POLO, but both of these missions suffered from the uncertainties related to the need for setting up a cooperative effort. In January, NASA positively indicated their interest in performing a joint GRIST/SOT Spacelab mission, and an agreement was then reached between the ESA Director of Scientific Programmes and the NASA Associate Administrator for Space Science to conduct coordinated technical and operational studies with a view to establishing interface definitions and responsibilities for this mission. A first technical meeting was held in March and preliminary studies indicated that joint accommodation appeared feasible, even though, the Executive noted, "progress on the joint ESA/NASA activities has not been as good as expected".

As regards POLO, in January the Executive issued an invitation to all ESA Member States and NASA, asking for an expression of interest for contribution to this mission. One firm answer was received from NASA, which expressed strong interest in cooperating with ESA on the lunar mission and offered to provide Shuttle launch services and spacecraft tracking facilities by their Deep Sspace Network (DSN). On this basis, an open invitation to tender was issued in July to industry for a Phase-A study contract on the POLO mission, including two spacecraft to be injected into lunar

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490 SAC, Recommendations on the Development of Space Science in the 1980s, ESA SP-1015, December 1978. See previous chapter.

491 SAC, 20th meeting (5-6 December 1979), SAC(79)35, 3 March 1980; SAC(79)34, 7 December 1979.

transfer orbit from the Shuttle by means of a built-in motor. The first spacecraft, a three-axis-stabilised Orbiter, would carry large scientific instruments in low polar orbit about the Moon. The second, the so-called Relay satellite, would be placed in high-altitude lunar orbit, thus enabling it to maintain radio contact between the Orbiter and the Earth when the former was over the far side of the Moon and not visible from the Earth.[492]

In July 1980, the SPC confirmed the adoption of both Hipparcos and Giotto into ESA's Scientific Programme. Owing to the financial constraints this simultaneous approval imposed on the mandatory budget, it was necessary to introduce a delay of approximately one year in the planning cycle for the next project, whose selection was now scheduled for late 1982 or early 1983. This delay had two important consequences. First there was the possibility to include ISO in the list of candidate missions, together with POLO, GRIST and X-80. In fact, the Executive intended to carry out a full Phase-A study of both the cryostat, including the telescope and focal plane instruments, and the spacecraft in 1981. Second there was the possibility to perform Phase-A studies of two additional projects to be included in the candidate list. A new call for mission proposals was thus addressed to the scientific community, which resulted in seven proposals.[493] After consultation with the Astronomy and Solar System Working Groups, the Executive initiated assessment studies on four of them, and the results were presented to the scientific community on 10 June 1981 at ESTEC (Table 5-2).[494]

Table 5-2: Missions proposals studied in 1981

Missions	Scientific objectives
Magellan	High resolution spectrography in the far ultraviolet region
DISCO	Solar seismology, irradiance variations and imaging in the far ultraviolet, and studies of the interplanetary medium
Asterex *	Close fly-by of several asteroids for comparative studies
Kepler	Mars geophysical orbiter for studies of the Mars atmosphere, topography and magnetic field

* Resubmission of the former proposal

As anticipated, the available resources allowed two of these missions to be submitted to Phase-A studies and the selection, as usual, fell to the SAC, based upon recommendations from the Working Groups. The AWG recommended a Phase-A study of Magellan, the only mission within its terms of reference, but it also expressed its interest in the solar seismology studies envisaged by the DISCO mission. The SSWG, for its part, awarded priority to Kepler but it also expressed its interest in having a Phase-A study carried out on Asterex: "a mission of great discovery value [which] would put European scientists in the lead in this field".[495] In the event, the SAC endorsed the Working Groups' recommendations that Phase-A studies on Kepler and Magellan should be carried out in order to prepare these missions as candidates for the next selection. The Committee also stated that no further studies should be carried out on the Asterex mission because the expected scientific return was considered inadequate in relation to the high costs, but it recommended that a mission derived from the DISCO proposal should be prepared for a possible Phase-A study in view of the possibility that the POLO mission might not be implemented in time for the 1982/83 selection. According to the SAC, the

492 ESA/SPC(80)5, 15 February 1980; ESA/SPC(80)18, 11 June 1980 (quote p. 2); ESA/SPC(80)29, 3 November 1980.

493 ESA/SPC(80)33, 5 November 1980; ESA/SPC(80)34, 11 November 1980.

494 ESA/SPC(81)8, 1 June 1981. For the Working Groups' discussions and recommendations, see AWG, 41st meeting (2-3 December 1980), ASTRO(81)12, 20 January 1981, and ASTRO(80)11, 3 December 1980; SSWG, 37th meeting (22-23 January 1981), SOL(81)7, 2 April 1981, and SOL (81)6, 23 January 1981. The results of the assessment studies are reported in SCI(81) 1 to 4.

495 AWG, 43rd meeting (11 June 1981), ASTRO(81)8, 1 October 1981, and ASTRO(81)7, 11 June 1981; SSWG, 38th meeting (12 June 1981), SOL(81)19, 15 September 1981, and SOL(81)9, 11 June 1981 (quote).

revised DISCO mission should mainly address solar seismology and interplanetary medium measurements in support of the ISPM (later *Ulysses*) mission, and its cost should not exceed the current estimate of 114 MAU.[496]

5.1.2 GRIST and POLO abandoned

By the end of 1981, prospects for cooperative ventures with NASA on the GRIST and POLO missions were definitely jeopardised. In fact, the difficulty of carrying out the joint SOT/GRIST Spacelab mission was already evident after the second ESA/NASA technical meeting in September 1980. While the scientific interest in combining simultaneous observations in the optical and X-ray spectral region by these two complementary facilities was recognised, the technical and operational feasibility of the joint mission was far from being demonstrated. Critical problems existed in the areas of mechanical accommodation, sun pointing with co-alignment of one arcsecond, operation of two Instrument Pointing Systems, sharing of Spacelab resources, etc. In spite of the need to discuss all of these aspects in depth, NASA was already planning the start of the industrial development of the SOT facility and it was unable, for contractual reasons, to give technical information on the instrument while the tender action was under way. The situation was aggravated by the fact that the specifications and related documentation released to potential bidders did not mention the possibility of a joint flight with GRIST. In this framework, no studies on the technical definition and joint accommodation of the European instrument could be carried out before the award of the SOT contract, originally expected in June 1981 but eventually delayed. Study work on GRIST progressed at low level on the telescope and the focal plane instruments, but when discussions with NASA were resumed, the latter informed ESA that, because of the financial situation, it could not make any commitment with regard to cooperative projects. Consequently, study activities on GRIST were stopped.[497]

A different story developed for POLO, the responsibility for which was essentially European, with NASA contributing Shuttle launch services and tracking operations in return for participation in the scientific payload. While the Executive was expecting offers from industry for the Phase-A study contract, the French delegation asked the Director General to consider the possibility of a purely European mission, using Ariane as the launch vehicle. As the available resources did not allow the study of both launch options (i.e. Ariane or the Shuttle), the Executive decided to suspend the tender action and invited the SPC to recommend which option should be followed up.[498]

Two important questions were involved in this delicate issue. The first was whether Europe should carry out the lunar mission alone or in collaboration with NASA. In spite of the letter of intent, there was, in fact, no guarantee that the American space agency would finally be in a position to collaborate in the project. Secondly, if Europe opted for carrying it out on its own, there was the question of the high costs of this mission, estimated at about 200 MAU. For France it was a matter of policy: "It would be most inappropriate if the choice of a launcher for all scientific missions were based on purely economic considerations", the French delegation argued, stressing "the importance of making the most of the European investment in Ariane". The SAC, on the other hand, considered it inadvisable to invest 200 MAU in a single mission for planetary science, and resolved that there was no reason to depart from its own rule that no single scientific mission should be recommended for which the cost to ESA would exceed 1.5 times the annual scientific budget. It therefore confirmed that a Phase-A study on POLO should be undertaken on the assumption that the mission would be carried

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496 SAC, 25th meeting (11-12 June 1981), SAC/MIN/25, 30 September 1981; SAC(81)8, 23 June 1981; ESA/SPC(81)8, add. 1, 20 June 1981. The SAC recommendations were eventually endorsed by the SPC at its 27th meeting (25-26 June 1981), ESA/SPC/MIN/27, 15 September 1981.

497 ESA/SPC(80)29, 3 November 1980; ESA/SPC(81)13, 1 June 1981; ESA/SPC(81)24, 19 November 1981. The SOT project was eventually abandoned by NASA in the aftermath of the Challenger disaster: Hufbauer (1991), 196.

498 SAC(80)20, 7 October 1980, also attached to ESA/SPC(80)30, 31 October 1980; ESA/SPC(80)29, 3 November 1980.

out in collaboration with NASA, with an expenditure ceiling of 140 MAU from ESA's scientific budget.[499]

In order to find a way to reduce the costs of the mission, the Executive considered the possibility of suppressing the Relay satellite. The main objective of this spacecraft was to provide accurate information about the trajectory of the Orbiter, in order to determine the Moon's gravity field. An alternative was to accommodate within the Orbiter an instrument measuring the gravity gradient, thus eliminating the need for a relay satellite and therefore reducing the cost of the mission by some 50 MAU. No instrument of this type had yet been flown, however, and it was soon realised that there was no chance of having an operational gravity-gradient meter in time for the POLO mission. The SAC then confirmed its recommendation, which was finally approved by the SPC, with France and Belgium abstaining.[500]

The Phase-A study on POLO was to start in industry in early March 1981. In February, however, the new US president, Ronald Reagan, announced his budget revisions, which included a dramatic reduction in the funds for space science. As a consequence, NASA announced its intention to cancel the American spacecraft in the joint ESA/NASA International Solar Polar Mission (ISPM).[501] Strong political and diplomatic actions were undertaken both by the Executive and by ESA member state governments in order to reverse this decision, with negotiations developing during most of 1981. "It is clear [...] that this is a very inopportune moment at which to expect a confirmation or redefinition of the basis for cooperation [on POLO]", the Executive noted in early June, informing the SPC that it had decided not to initiate the Phase-A study on the lunar mission. All activity on POLO would be delayed "until the technical options are clarified and a realistic basis for cooperation with NASA has been re-established".[502] All hopes of reversing the US decision on ISPM were definitely lost on 4 September, when the NASA Administrator officially informed the ESA Director General that he would not include the American ISPM spacecraft in the 1983 budget submission to the White House. At the same time, "it became plain that, because of the financial situation, NASA would not be able in the foreseeable future to re-confirm its interest in pursuing studies of [the POLO mission] or other potential cooperative missions". The Executive therefore concluded that the envisaged joint lunar mission had to be abandoned.[503]

The possibility that cooperation with NASA would collapse had been well known to the interested scientific community during this period and a number of alternative mission concepts had been put forward by several scientists, in order to rescue the lunar mission after the seemingly inevitable abandonment of the cooperative project. Among these, the most interesting was that the Relay satellite be funded nationally, a possibility which became concrete when the German Ministry for Research and Technology (BMFT) transmitted to ESA a proposal to build the Relay satellite made jointly by the Max-Planck Institutes in Garching and Lindau, and by the AMSAT-Deutschland company.[504] The Executive, however, made it clear that, owing to the need to reassess the new mission concept and to obtain a firm commitment from the German authorities, a Phase-A study on POLO could not be completed in time for the next project selection in 1982. The majority of SSWG members, however,

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499 SPC, 25th meeting (18 November 1980), ESA/SPC/MIN/25, 5 January 1981, p. 11; SAC, 24th meeting (17-18 December 1980), SAC/MIN/24, 5 March 1981; SAC(80)28, 18 December 1980; ESA/SPC(80)37, 22 December 1980. Only one of the SAC members, the French astronomer J. Kovalesky, expressed a preference for the Ariane launch option.

500 SPC, 26th meeting (15-16 January 1981), ESA/SPC/MIN/26, 5 May 1981.

501 This dramatic event in the history of ESA/NASA relations is discussed in Bonnet & Manno (1994), 98-108. The origin of the ISPM mission is discussed in chapter 3 in this volume.

502 ESA/SPC(81)13, 1 June 1981, p. 1. On ISPM negotiations, see ESA/SPC(81)11, 4 June 1981.

503 ESA/SPC(81)15, 25 September 1981; ESA/SPC(81)19, 19 September 1981, p. 1.

504 ESA/SPC(81)19, 19 November 1981.

did not like this conclusion, and insisted that an effort should be made to enable POLO to catch up with the selection schedule.[505]

The real issue facing the ESA scientific advisory bodies was the choice between POLO and DISCO, i.e. which of these two missions should finally be prepared as a candidate project for the next selection. The emphasis given to solar seismology experiments had moved the DISCO mission towards the astrophysics interest area, therefore the AWG urged that this mission should be studied at Phase-A level. The SSWG, for its part, "felt unable to make a positive recommendation either way with regard to a Phase-A study [on DISCO]", but reaffirmed, as noted above, its support for POLO.[506] In the event, the SSAC agreed with the Executive that a Phase-A study of POLO could not be completed in time for the next project selection and recommended to definitely proceed with DISCO. It also recommended that an assessment study on the ESA/Germany POLO mission should be carried out, "as soon as resources permit", but stressed that a full Phase-A study should be undertaken only after a firm commitment was obtained from the German authorities. This course of action was endorsed by the SPC.[507]

Three main reasons can be given for this decision. Firstly, after the loss of the American ISPM spacecraft, the DISCO mission could provide a new opportunity for the ISPM science team to complete its experiments by accommodating in the DISCO payload some instruments for interplanetary measurements related to the new fully European *Ulysses* mission. In other words, DISCO was considered interesting by a large fraction of the space science community, represented in both ESA's Working Groups: astrophysicists for the solar seismology experiments, space plasma physicists for interplanetary measurements, ISPM scientists for the possibility of rescuing some experiments formerly planned for the American spacecraft. Secondly, the European space science community lacked a clear strategy on planetary research. "There was […] a certain amount of competition and disagreement between scientists who promoted the study of different planets", a former SSWG chairman recalled later.[508] An important part of the European planetary community was already involved in the preparation of the Giotto cometary mission; another part was concentrating on the study of the Kepler mission to Mars, with the aim of having it selected in 1982, and did not have an interest in supporting a possible competitor in the planetary field. Thirdly, after the disappointing experience with NASA, both the Executive and the scientific advisory bodies did not want to proceed with projects whose cost was beyond the Agency's financial capabilities before having a firm guarantee that a cooperative venture could actually be set up. As the Director of the Scientific Programme put it:

> *As much as the Executive welcomed cooperative projects, it could not, as a question of principle, commit some 500 kAU on a Phase-A study until it had a more formal commitment than was represented in a cover letter from the German authorities to the Director General as had been so far the case.*[509]

The BMFT, for its part, argued that it was not possible at this stage for Germany to give a binding guarantee that it would fund the Relay satellite, "since it will first be necessary for the Phase-A study to investigate whether this concept is technically feasible and can be implemented (largely in-house) in

505 SSWG, 39th meeting (12 November 1981), SOL(81)14, 8 February 1982, and SOL(81)13, 12 November 1981. A vote was taken on this issue, resulting in a majority of 10 votes in favour of proceeding with a Phase-A study of the joint ESA/German mission, with 3 against and 1 abstaining.
506 AWG, 44th meeting (12 November 1981), ASTRO(81)12, 20 January 1981, and ASTRO(81)10, 12 November 1981; SOL(81)12, 12 November 1981 (quote).
507 SSAC, 27th meeting (13 November 1981), SSAC/MIN/27, 1 December 1981 (quote on p. 4), and SSAC(81)11, 13 November 1981 (quote); SPC, 29th meeting (7-8 December 1981), ESA/SPC/MIN/29, 22 January 1982. The proposal for a Phase-A study on DISCO is in ESA/SPC(81)22, 19 November 1981.
508 Huber (1993), p. 194. See also ESA/SPC/MIN/27, *cit.*, p. 11.
509 ESA/SPC/MIN/29, *cit.*, p. 10.

the way proposed by the [Max-Planck] institutes".[510] It was a sort of *impasse*. On the one hand, the Executive did not want to embark in a costly Phase-A study without a guarantee that the project was financially feasible; the BMFT, on the other hand, did not want to commit itself to funding the project before its technical feasibility was demonstrated.

The results of the assessment study on a fully European POLO mission were available in May 1982. Besides the so-called "German relay option", two other options had been considered: first was a free-flying sub-satellite in the same orbit as the main orbiter but separated by about 100 km; second was the orbiter connected by a 50-100 km tether to a sub-satellite, which would fly vertically below in a gravity-gradient stabilised configuration.[511] The three options were discussed by the SSWG on 28th May, in the presence of representatives of the SPC, the SSAC and a number of experts. In the event, the Working Group recommended proceeding immediately with a Phase-A study of the Orbiter plus Relay satellite option, in cooperation with the German institutes to be involved in the project. It also recommended, however, that "the ESA Phase-A study should be carried out in such a way as to allow for the option of flying the orbiter satellite alone, […] since the SSWG believes that its science alone would comprise an important mission".[512] This last statement deserves some explanation. The Working Group, in fact, was aware that, if the mission were based entirely on the use of the Relay satellite and this was then refused by the German authorities, there would automatically be no more mission. No commitment had yet been received from Germany to pay for the Relay satellite, however, and it appeared that the German offer was contingent on POLO being available for selection at the next round. This, however, implied a delay in the decision on the next ESA project up to October 1983, whereas the other five projects under consideration would have been ready for selection by February that year.

The SSAC frustrated the SSWG's expectations. Firstly, it did not endorse the judgement that the Orbiter alone would bring an adequate scientific return, and recommended that a Phase-A study on POLO should be carried out on the basis of a dual spacecraft, "on the assumption that the Relay would be built and financed under the responsibilities of the German authorities". Secondly, the SSAC made it clear that "a prerequisite for ESA's commitment of effort to the Phase-A study should be a guarantee that a parallel and coordinated Phase-A study of the Relay will be carried out in Germany". Finally, the Committee could not accept a delay in the selection of the next project: firstly, in order to have enough time for payload selection and technical development prior to major industrial commitment; secondly, because "the scientific communities associated with the remaining five projects need an early decision on selection for their forward planning".[513]

The last word on the future of POLO pertained to the SPC. Here, the German delegation stated that "it would have to oppose any procedure that did not permit POLO to be included among the candidates for selection as the Agency's next project". In fact, the two Max-Planck Institutes that were to fund the scientific instruments for this mission considered that, "if it was not included in the next selection, there would necessarily be an unacceptable delay in the development of the satellite and they would therefore cease their studies". The delegation insisted that the selection of the new scientific project should be postponed until the autumn 1983, but only three other delegations (Italy, Sweden and Switzerland) supported this proposal, which was finally rejected. The SPC agreed that POLO might still be taken into consideration for a possible new project selection in 1984, but in fact it was eventually abandoned.[514]

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510 Letter to the ESA Director of the Scientific Programme from the BMFT, 5 February 1982, circulated as Annex 1 to ESA/SPC(82)9, 19 May 1982.

511 SOL(82)2, 19 May 1982, also attached to ESA/SPC(82)9, 19 May 1982.

512 SOL(82)3, 28 May 1982, reporting the recommendation approved at the 40th SSWG meeting (28 May 1982), SOL(82)5, 30 July 1982.

513 SSAC(82)5, 8 June 1982, reporting the recommendation approved at the 29th SSAC meeting (3 June 1982), SSAC/MIN/29, 14 June 1982.

514 SPC, 31st meeting (17-18 June 1982), ESA/SPC/MIN/31, 30 August 1982, p. 6.

Table 5-3: Candidate projects for the 1983 selection

Project/Science	Payload	Spacecraft/Orbit	Cost (MAU)
ISO Infrared astronomy in the 2-150 μ band	A telescope with a 60-cm diameter mirror and a 9-m focal length. A liquid hydrogen-liquid helium cryostat would be used to cool the focal plane instrument to 3 K and the primary mirror tot 10 K	3-axis stabilised, 1800 kg spacecraft in a 12-hour period elliptic orbit	258
DISCO Solar and heliospheric studies	12 instruments for measuring solar surface oscillations, solar irradiance variations, solar imaging in the far-ultraviolet, and studies of the interplanetary medium	Spin-stabilised, 900 kg spacecraft placed at the L1 libration point (point of neutral gravity between the Sun and the Earth) at a distance of 1.5 million km from the Earth	159
Magellan Far ultraviolet (less than 1400 Å) spectroscopy	An efficient optical grating system using a single reflecting surface together with a highly efficient detector assembly	3-axis stabilised, 850 kg spacecraft in a 48-hour period elliptic orbit	181
X-80 X-ray astronomy: spectroscopy, timing and transients	5 complementary instruments covering the energy range 0.5-200 keV	3-axis stabilised, 1100 kg spacecraft in 500 km circular orbit close to the equatorial plane	184
Kepler Mars geophysical studies: atmospheric science, planetary interior and surfaces, interaction with the solar wind	Proposed model payload: neutral gas and ion mass spectrometers, IR and UV spectrometers, retarding potential analyser, Langmuir probe, magnetometer, plasma wave analyser, plasma particle detector, radar altimeter	Spin-stabilised, 800 kg spacecraft (350 kg around Mars) in a 48-hour period elliptic (150 km x 7000 km) orbit around Mars	188

5.2 ISO selected as new scientific project

Table 5-3 lists the five candidate projects on which a Phase-A study had been carried out during 1981-82, in view of the selection scheduled for early 1983. Following the usual ESA procedure, these projects were presented and discussed at an open scientific meeting held in Scheveningen, The Netherlands, on 31 January and 1 February 1983. Subsequent to the presentations, the Solar System and Astronomy Working Groups met in order to formulate recommendations on the projects which fell within their respective terms of reference, and the SSAC made its own recommendation to the Executive. On the basis of these recommendations, the latter would formulate a proposal to the SPC for a final decision during its March meeting, it being understood that, for financial reasons, only one project could be adopted.[515]

For the SSWG, the choice was between the Sun and Mars. The DISCO mission, on the one hand, combined experiments in the field of solar seismology with studies of the interaction between the sun and the interplanetary medium. It brought together in a constructive way the expertise of communities working in three distinct areas: stellar evolution, solar physics and interplanetary medium. In the opinion of the SSWG:

515 ESA/SPC(82)26, 15 November 1982; *ESA Annual Report 1982*, 20-22.

DISCO aims to determine the internal density, temperature, rotational velocity and convection within the sun. This will proved a crucial test for theories of stellar evolution. [...] The complement of heliospheric experiments provides in situ measurements of solar wind streams together with optical and spectroscopic studies of the solar atmosphere giving valuable support for the ISPM mission.[516]

The Kepler Mars Orbiter, on the other hand, finally gave the European space science community the possibility to enter the important field of planetary exploration. According to the SSWG, this mission might allow a wide community of European scientists to address various problems of comparative planetology: structure, dynamics, composition and evolution of the atmosphere; climatology; topography and geochemistry of the surface; behaviour of dust and condensate; magnetic field; internal structure of the solid body; interplanetary boundary. "The objectives of Kepler have not been covered by the previous US and USSR missions to Mars", the SSWG remarked, "and this represents an opportunity for the European scientists to face planetological problems by means of a relatively low-cost space mission".[517]

In the event, after a "lengthy discussion" on both these projects and following a round-the-table voting, the SSWG decided in favour of DISCO as its first choice and recommended, therefore, to proceed with the DISCO project for the next mission.

The three other projects fell within the terms of reference of the AWG. After an in-depth discussion of each individual proposal, "a clear majority in favour of the ISO mission emerged (10 out of 13 of the members present)". Finally, "further discussions led to unanimous support from the AWG for the selection of ISO".[518] It is not difficult to understand the reasons for the Working Group awarding priority to the infrared mission. The field of X-ray astronomy, in fact, was already covered in the ESA programme by the Exosat mission, scheduled for launch in May 1983, while the orbiting IUE spacecraft still provided the European astronomical community with an important facility for ultraviolet spectrometry. Infrared astronomy, on the contrary, represented an expanding new field in which Europe could play an important role. As early as 1974, the ESA scientific advisory bodies had recommended studies on two infrared missions: a cryogenic telescope on board a free-flying satellite (CIRES) and a large telescope on board Spacelab (LIRTS). The latter had also been studied at Phase-A level and included in the list of candidate projects for the 1976 selection, but regretfully it had to be discarded because of the financial uncertainties regarding the cost of Spacelab launches.[519] The ISO mission, if approved, would provide the next major step in infrared astronomy after the first survey being made by the recently launched Dutch IRAS satellite.

The SSAC agreed with the Working Groups that the DISCO and ISO missions deserved the highest priority within their respective terms of reference; the question was which of them should finally be selected. The Committee (Table 5-4) was chaired at that time by E. Amaldi, the Italian physicist and scientific statesman who had been one of the founding fathers of CERN and ESRO. The SPC chairman, the Dutch astrophysicist C. de Jager, also attended the meeting, as well as important members of the Executive, including the outgoing Director of Scientific Programmes E. Trendelenburg and his successor R. Bonnet.[520]

516 SOL (83)2, 2 February 1983, reporting the resolution approved at the 42nd SSWG meeting (2 February 1983), SOL(83)3, 31 March 1983.

517 *Ibid*.

518 ASTRO(83)2, 2 February 1983, reporting the resolution approved at the 47th AWG meeting (2 February 1983), ASTRO(83)3, 31 March 1983.

519 See chapter 3 in this volume.

520 SSAC, 31st meeting (2-3 February 1983), SSAC/MIN/31, 19 April 1983. The following quotations are from pp. 2-5.

Table 5-4: SSAC membership in 1983

E. Amaldi (chair)	Rome
K. Fredga	Solna
M. Huber	Zurich
J. Lequeux	Marseille
H. Völk	Heidelberg
J. Bleeker (AWG chair)	Utrecht
A. Gabriel (SSWG chair)	Chilton

After the presentations of the Working Groups' recommendations, Amaldi initiated the discussions by noting that ISO represented "a typical example of an observatory of general use to the astronomical community but which had high costs, while DISCO and Kepler fell into the category of multi-experiment satellites with lower costs, typical of past ESA missions". Five members of the SSAC, including Amaldi himself and (of course) the AWG chairman Bleeker, expressed their preference for ISO, which they considered as having the most potential for scientific discovery and catering for a very large community of astrophysicists and planetary scientists. The infrared mission "would be of interest to, and used by, the whole astronomical community", Lequeux argued, "[while] DISCO was of interest to a more limited community and [its] objectives could be obtained in future through improved ground measurements". According to Völk, "the project presented a technological challenge which would give Europe the lead in the field of cryogenic development on this scale". Fredga stressed that "ISO would bring infrared astronomy to the same level as astronomy in other wavebands". Amaldi, for his part, said that he was impressed by the helioseismology objective of DISCO, which he considered as "completely new, very difficult and of great interest not only from the solar point of view", but concluded that "ISO appealed to him more".

The two other members of the SSAC advocated DISCO. Gabriel's support was automatic, given his capacity as SSWG chairman. While considering both projects of high scientific merit, he gave two good reasons in favour of DISCO and three against ISO. The former had two important objectives. The first, helioseismology, involved a novel field of astrophysics in which European scientists had a leading position both regarding theoretical expertise and experimental activity from the ground; the second, optical observations of the sun and solar wind measurements, would be of great value in support of the Ulysses mission, but it was also interesting by itself as it would combine direct observations of the solar disc and *in situ* plasma measurements, thus providing important new information on the solar wind acceleration and transport. The reasons against ISO were: (a) its timing, as its specifications would be frozen before all the results of the survey mission IRAS became available; (b) its technological content, involving the many problems associated with packaging the whole payload within the cryostat; and (c) its costs, well above the 1.5 annual budget limit recommended by the SSAC. The need to maintain Europe's lead in helioseismology was also stressed by Huber in his statement in favour of DISCO, "a smaller project which would fit better into the present science envelope".

In the resolution approved at the end of these discussions, the SSAC carefully listed the scientific merits of both projects, concluding however with a strong recommendation that ISO be selected as the new scientific project for ESA. It added the following comment:

The SSAC finds this mission technologically challenging. The Committee realises that the development costs are beyond the customary limits. However, due to the present advancement of science, Europe is confronted with the need to develop such facilities in certain fields of space science and, in the interest of European scientists, the SSAC recommends such undertakings to ESA. The SSAC recognises that the optimisation of the development schedule and the resulting cost profile make it necessary for more adaptable financial methods to be applied within the science programme and recommends that, if necessary and in the best interests of the programme, the appropriate measures be granted by the SPC and Council.[521]

In order to understand this comment, two important aspects must be considered. Firstly, as it is evident in the last column of Table 5-3, the cost of ISO was much higher than the "customary limit" of 1.5 times the annual budget (116 MAU in 1982 prices). The SSAC, in other words, was recommending for ISO what it had previously refused to accept for POLO. Secondly, as the Executive's financial forecasts clearly showed, the choice of ISO led to a difficult financial situation in the years 1990-91, when the funding profile resulted in an important overspend. This situation, the Director General noted, "can only be smoothed out if the possibility of effecting yearly compensations is given, albeit within the fixed five yearly level of resources". We shall deal with this aspect later.

In the event, the Director General accepted the SSAC recommendation and proposed to the SPC the selection of ISO as the new project in the Agency's Scientific Programme. Here is his comment:

The Director General fully realises that ISO exceeds the customary financial limits of 1.5 yearly budgets. However, he also recognises, based on the results of the recent call for mission proposals, that the progress of space science now makes it necessary that, in certain areas at least, large and complex facilities be put at the disposal of the European scientists. [...] If such truly international facilities as ISO have to be realised in a European context, then they must be developed by ESA.[522]

The ESA mission is to implement large projects, the argument went, and this required long-term planning and financial flexibility.

The SSAC decision did not go unnoticed among the scientific community, and several DISCO supporters tried to make a case in order to have the SPC reverse this decision. In a letter addressed to the SPC chairman in the aftermath of the SSAC meeting, Gabriel raised again, with some added bitterness, the financial aspect:

A previous recommendation of the SPC remains on the table, that missions should in general cost not more than 1½ annual budgets, in order to have a reasonable launch rate. Of course it is understood that there can be exceptions possible, but to approve ISO at 2½ annual budgets, following on Hipparcos, another large mission with a cost over-run, is going to mean a period of 5 or more years with only two launches. Furthermore, both of these are in the field of astronomy. I am worried about the impact of this on Solar System scientists, who have followed the guidelines, and produced two excellent missions [DISCO and Kepler] within these constraints.[523]

It must be noted that previously it had been customary to maintain a balance between solar-system and astrophysical sciences in the ESA programme by making a simultaneous or near-simultaneous selection of one mission for each field (COS-B and GEOS in 1969; Exosat and ISEE in 1973; Space

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521 SSAC(83)2, 3 February 1983, reporting the recommendation approved at the 31st SSAC meeting (2-3 February 1983), SSAC/MIN/31, 19 April 1983.

522 ESA/SPC(83)8, 14 March 1983, pp. 3-4.

523 A.H. Gabriel, letter to C. de Jager, 7 February 1983, *D/Sci Archives*. About the uneasiness among the solar-system community after the SSAC decision in favour of ISO, see Huber (1993), p. 194.

Telescope and ISPM/Ulysses in 1976-77; Hipparcos and Giotto in 1980). The selection of such a costly project as ISO against the much less expensive DISCO mission definitely prevented the possibility of approving a new project before the end of the next selection cycle, scheduled for 1985 or 1986, and no guarantee existed, of course, that a solar-system mission would have been selected on that occasion.

A strong initiative aimed at driving national authorities represented in the SPC in favour of DISCO was also undertaken by some Ulysses scientists, who underlined the twofold importance of such a mission: firstly, it would provide simultaneous in-ecliptic (baseline) measurements with out-of-ecliptic Ulysses observations; secondly, it would restore the optical observations lost from the original ISPM mission concept with the deletion of the American spacecraft.[524] The German physicist U. von Zahn, for his part, addressed himself directly to SPC members, blaming the SSAC for not considering, on the one hand, the ongoing development of a German Infrared Laboratory (GIRL), scheduled to fly on Spacelab in 1986-87, whose science capabilities were "almost equal to the proposed ISO satellite, and for some aspects even superior", and, on the other hand, the "severe consequences" that the high costs of ISO would have for "all fields of space science except IR astronomy". Would it not be wiser for ESA to study the possibility of eventually renting the GIRL facility for dedicated ESA missions after its first successful flight, von Zahn concluded.[525]

Finally, a general argument against ESA's scientific advisory system was raised by the Belgian delegate in the SPC, M. Ackerman, from the Institut d'Aéronomie Spatiale de Belgique, who contested the inclusion of solar physics within the terms of reference of the SSWG despite its obvious pertinence to astrophysics. This, for Ackerman, resulted in a unavoidable decline of geophysics and planetology in the ESA programme, and the failure of Kepler against four astrophysics projects (DISCO being also included in this category) was the regretful but obvious consequence of this unfair situation. "The dice are loaded towards astronomy and away from Solar System geophysics", Ackerman concluded.[526]

These arguments and objections notwithstanding, the SSAC's and Director General's recommendation was not seriously challenged at the SPC meeting called to approve the next scientific project. All delegations recognised that DISCO and ISO were the best two missions under consideration and agreed that the latter had to be preferred, with the exception of the Swiss delegation which expressed its preference for DISCO but said that it would not oppose the choice of the infrared mission. The Committee, therefore, unanimously approved the Director General's proposal to select ISO as the next scientific project, but many delegations insisted that DISCO should be kept under consideration for the next selection cycle.[527]

No doubt, the appeal of infrared astronomy played an important role in driving ESA and its scientific advisory bodies towards the selection of the ISO mission, both from the point of view of the expected scientific harvest (IRAS was paving the way towards a definite European leadership in this new field) and from the point of view of the technical challenge related to the project implementation (cryogenics and infrared detector technology). While DISCO, with its multi-experiment payload covering various disciplinary fields, remained "well within the scientific, technical and budgetary resources available for the science programme", ISO appeared to the SSAC to be "an observatory [which] has a supranational character, i.e. is beyond the scope of any national space programme, and can therefore

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524 Letter of A. Balogh to ISPM investigators, 10 February 1983; circular letter of A. Balogh, C.C. Harvey and J.L. Steinberg to the scientific community, 15 February 1983; both in *D/Sci Archives*.

525 U. v. Zahn, letter to SPC members, 9 March 1983, *D/Sci Archives* (underlined in the original). Eventually, the GIRL project was never realised.

526 "Bias claim" (by P. Campbell), *Nature*, 301, 24 February 1983, 647-648, on 648. This comment was the object of a nervous exchange of letters between Ackerman and Gabriel: *D/Sci Archives*.

527 SPC, 33rd meeting (29-30 March 1983), ESA/SPC/MIN/33, 6 June 1983.

only be undertaken by an organisation such as ESA".[528] It was the right project for taking the Agency's Scientific Programme into the next decade.[529]

5.3 The start of a new planning cycle

With the approval of ISO, it was agreed that the other projects (DISCO, Kepler, Magellan and X-80) should be kept under consideration for eventual inclusion as candidate missions for the next selection. According to the usual ESA procedure, the planning cycle was initiated while the previous one had not yet reached conclusion. It started in early July 1982, when the Director of Scientific Programmes issued a call for mission proposals. A total of 20 proposals were received, eight in the field of Solar System science and twelve in the astronomy field.[530] All proposals were discussed by the Working Groups and the SSAC in December and, following their recommendations, five of them were finally selected for an assessment study phase in the first half of 1983 (Table 5-5).[531] A preliminary cost analysis of these mission proposals indicated that their average cost was about 250 MAU, i.e. 2.5 times the annual scientific budget: "This is clear evidence – the SSAC noted – that the present level of the scientific budget, corresponding to the 1971 package deal, is totally inadequate to maintain the competitive position of European space science".[532] Two other proposals, Cassini and Quasat, were kept under consideration in view of potential collaborative ventures with NASA. The former was a

Table 5-5: Mission proposals studied in 1983

Missions	Scientific objectives
XMM	X-ray multi-mirror spectroscopy
First	Far-infrared and submillimetre spectroscopy
Agora	Asteroid rendezvous
Cluster	Four-spacecraft mission for magnetospheric research
SOHO	Solar and heliospheric studies
Cassini	Study of the atmosphere of Saturn's moon Titan
Quasat	Very-long-baseline-radio-interferometry

European probe to be released into the atmosphere of Titan after being carried by an American Saturn orbiter; the latter was a spacecraft carrying a large antenna to be used in conjunction with a network of ground-based radio telescopes for very-long-baseline-interferometry (VLBI) at 21 GHz.

The results of the assessment studies were presented to the scientific community, SPC delegates and ESA scientific advisory bodies in Frascati, Italy, on 10-11 October 1983. Some 130 scientists attended the presentations. In the following two days, the Astronomy and Solar System Working Groups and the SSAC met to make recommendations on the future study programme. As usual, their task was to select those missions which should be subjected to a Phase-A study and hence become candidates for next project selection in mid-1985. Moreover, they were called to recommend which of the previous projects should be kept in the selection process.[533]

528 SSAC(83)2, *cit.*, p. 2.

529 The launch of ISO was planned for 1992, four years after Hipparcos, ESA's last scientific satellite launch in the 1980s. Hipparcos was eventually launched in 1989, followed by Ulysses one year later. The launch of ISO occurred on 17th November 1995.

530 The complete list is in ESA/SPC(82)28, 30 November 1982. See also ASTRO(82)5 / SOL(82)6, 12 November 1982.

531 AWG, 46th meeting (13-15 December 1982), ASTRO(82)8, 31 March 1983, and ASTRO(82)7, 15 December 1982; SSWG, 41st meeting (13-15 December 1982), SOL(82)9, 7 February 1983, and SOL(82)8, 15 December 1982; SSAC, 30th meeting (15-16 December 1982), SSAC/MIN/30, 21 February 1983, and SSAC(83)1, 7 January 1983.

532 SSAC(83)1, *cit.*, p. 2.

533 ESA/SPC(83)10, 13 June 1983; ESA/SPC(83)16, 25 October 1983.

Two projects fell within the terms of reference of the AWG, the X-ray space telescope XMM and the far infrared astronomy mission FIRST (Far InfraRed and Submillimetre space Telescope). Both missions were extremely ambitious, involving sophisticated technology. The former foresaw a large, observatory type spacecraft (about 4000 kg mass, 10 m length) carrying some 20 independent but closely aligned telescopes, each telescope consisting of a number of grazing incidence X-ray mirrors and associated focal-plane instruments. According to the Executive, "the realisation of such a mission would present a major challenge to institutes and industry as the scale of production and the scale of spacecraft assembly, integration and testing were beyond European experience".[534] The latter was designed to carry out heterodyne spectroscopy in the 200 μm to 1 mm wavelength range by cryogenic cooled instruments on board a spacecraft equipped with a large deployable antenna.

The AWG considered XMM and FIRST as "scientifically very exciting", but recognised that "within the present ESA Science Programme both missions could not be conducted simultaneously or in succession within one decade". For the Working Group, however, it was "imperative that missions of this magnitude be developed and flown within the foreseeable future", and it insisted that the necessary technology should be developed in Europe in order to "ensure that a leading role be taken in missions of this calibre".[535] The AWG, in other words, adopted a long-term perspective: neither XMM nor FIRST could be prepared as candidate projects for the next selection, and even in the longer term only one of these missions could reasonably be implemented by ESA, but the Agency and the interested sectors of the scientific community were called to look further ahead, i.e. to accept the principle that both missions should eventually be realised in a 20-year timeframe and to make future plans accordingly. For the shorter term, the AWG recommended that the X-80 mission, already studied in the previous planning cycle but discarded in favour of ISO, should remain in the list of candidate projects for the next selection. Magellan, on the contrary, was definitely discarded in view of ongoing ESA/NASA discussions on a possible joint UV astronomy mission initially called Columbus, but later renamed Lyman.

The three other projects fell within the domain of the SSWG, each of them representing one of the major Solar System disciplines, i.e. planetary science, space plasma physics and solar physics. The AGORA (Asteroid Gravity, Optical and Radar Analysis) concept foresaw a 2500 kg deep space probe driven by an ionic propulsion system, which made it possible to make up to three rendezvous with large asteroids and two fly-bys at a few km/s. The Cluster mission was designed to study in three dimensions the small-scale structure of plasma phenomena by four appropriately spaced small spacecraft. Finally, SOHO (SOlar and Heliospheric Observatory) was aimed at investigating the Sun and its sphere of influence, in particular plasma phenomena in the outer layers, the acceleration of the solar wind and solar seismology. The inclusion of a heliospheric seismology instrument in the SOHO model payload had made the DISCO project obsolete and it was in fact withdrawn from the competition.[536] Both Cluster and SOHO had been considered as a possible European contribution to the International Solar-Terrestrial Physics (ISTP) programme, which was being discussed by ESA, NASA and the Japanese Institute for Space and Astronautical Science (ISAS). Within this framework, which included the launch of three NASA spacecraft and one Japanese, the possibility of NASA contributing launchers for both ESA missions and/or tracking support by their Deep Space Network was actively considered. The SSWG in fact recommended that Cluster and SOHO should enter Phase-A study immediately, with a view to preparing them for the next project selection. As regards the AGORA mission, the Working Group recognised that "at the beginning of the next decade, asteroids will remain the only major family of unexplored Solar System objects. A first mission to study these extremely varied bodies is therefore one of the first priorities of planetary exploration". However, as the cost of the asteroid rendezvous mission was beyond ESA capabilities, the SSWG suggested that this mission, as well as the Saturn/Titan mission, should be considered in the framework of possible

534 *ESA Annual Report* 1984, p. 27.

535 ASTRO(83)9, 12 October 1983, p. 1, reporting the resolution approved at the 49th AWG meeting (12 October 1983), ASTRO(83)11, 10 February 1984.

536 The origin of the SOHO mission concept and its relation with the former GRIST and DISCO projects is discussed in detail in Huber et al. (1996).

ESA/NASA collaboration, and recommended that the former Kepler mission to Mars be included again for the next project selection.[537]

The SSAC endorsed the Working Groups' recommendations. It requested that SOHO and Cluster be immediately subjected to a Phase-A study and that the studies already completed on Kepler and X-80 be updated, with the aim of including all four projects in the list of candidates for selection in mid-1985. Moreover, following the suggestions of the Working Groups, the SSAC recommended that joint assessment studies with NASA should be performed on the Saturn/Titan and AGORA missions in the Solar System area, and on Columbus (Lyman) and Quasat in the astronomy area. These studies could lead to more detailed Phase-A studies in 1985-86, and eventually to a selection in 1987. Finally, the SSAC endorsed the long-term perspective suggested by the AWG, recommending that preparatory technological studies should be initiated on XMM and FIRST, in order "to identify in depth the critical development areas to be further verified before the start of Phase-A proper." It added a remark that addressed a critical issue:

> *During these preliminary studies in 1984, discussions should be held and proposals made as to the source of funding of the subsequent preparatory technology development. The latter will, in fact, require funds well in excess of those available from within the general studies budget.*[538]

This statement can be better appreciated in the framework of the long-term planning exercise which ESA was initiating in that period, whose final outcome would be the Horizon 2000 programme. ESA's traditional approach to project selection, based on a point decision at the end of each planning cycle, had resulted in the unavoidable abandonment of the most ambitious mission proposals, either because of financial constraints or for lack of sufficient technical and industrial competence in Europe. The Horizon 2000 philosophy, on the contrary, aimed at defining a comprehensive space science programme spread over a 20-year period, including a mission sequence arranged within an appropriate time schedule, and the necessary technological research programme and industrial preparation. It was only in this new framework, which implied of course a significant increase in the financial level of the science budget, that such missions as XMM, FIRST or AGORA could eventually be adopted in the ESA programme.

5.4 Planning the future

In January 1981, the Director General presented to the Council the case for a long-term plan for ESA activities in the new decade:

> *We must recognise that ESA has come to the end of its first phase of development, and that we must now establish the goals for the next decade. We have to develop a programme for the coming ten years that can at the end of the period create the same or even better benefits for Europe than the past ten years have provided.*[539]

During these years, the DG argued, ESA had been highly successful in pursuing the goals which were set by the two package deals of 1971 and 1973. In the scientific field, "many exciting discoveries were made thanks to such scientific satellites as TD-1, HEOS, COS-B, ISEE, and IUE". In the application

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537 SOL(83)8, 12 October 1983, reporting the resolution approved at the 44th SSWG meeting (12 October 1983), SOL(83)9, 3 January 1984. Plans for ESA/NASA collaboration in solar-terrestrial physics had been discussed at a joint meeting in June 1983 in Paris, whose conclusions are reported in Annex I to SOL(83)9. Annex II shows a figure, also reproduced in Huber et al. (1996), with a possible sequence of missions (including SOHO and Cluster) in the envisaged ISTP programme. The latter was then defined at a joint meeting of ESA, NASA and ISAS in December 1983.

538 SSAC, 32nd meeting (12-13 October 1983), SSAC/MIN/32, 1 December 1983, p. 5.

539 ESA/C(81)8, 24 January 1981, p. 2. This document followed a previous one, coded ESA/C(80)80, 5 November 1980, which had been discussed with member state delegations.

satellite field, the Agency could boast the success of Meteosat, the very good performance of the experimental telecommunications satellite OTS, the sale of the operational ECS satellite to Eutelsat for its European communications satellite system, and the contract with Inmarsat for the lease of the Marecs maritime communications satellite. The Ariane launcher had been successfully launched for the first time in December 1979 and was due to be fully qualified during 1981. Finally, the engineering model of Spacelab had been delivered to Cape Kennedy.

> *With approximately ten thousand people in Europe employed in the space industry, and the technological spin-off that has created further employment within advanced industry, it is fair to say that the European space effort is now on a sound footing. Had it not been for the central role played by the joint space effort, all of this would have been lost to Europe.*[540]

With the near completion of the package deal programmes, he continued, the ESA expenditures were expected to fall dramatically from the level of about 500 MAU in 1981 (at 1979 prices) to less than 200 MAU as from 1984. New goals had to be established, and new resources had to be channelled into research and development activities, in order to allow Europe "to have a voice in the world-wide forum on space matters, [...] to play a role in future global space developments, and [...] to attain a competitive position in space technology". The Director General recognised that "it would be unrealistic to expect anything substantially more than the [present level of resources], and therefore one cannot become fully competitive. The aim must therefore be to reach the competitive level in at least a selected number of areas and be a qualified partner for major international ventures." In his proposal for a long-term plan, he outlined a baseline programme, based on GNP-based contributions from member states, which could be accommodated within about 450 MAU per year. This was considered as "the minimum critical programme to allow Europe a viable opportunity to remain a reckonable space force in the 1980s". In addition, the possibility of developing a "supplementary programme" was also contemplated for some programme elements which offered attractive possibilities to users and industry, but which could not be included within the financial constraints.[541]

Three main aspects must be noted in the Director General's proposal. First was the emphasis on the Scientific Programme, whose weight in the overall ESA effort was due to increase from 17.6% in 1981 to 28% in 1990. The Scientific Programme is the principal mandatory activity of the Agency, the Director General argued, "a legacy of the recognition of founding fathers of ESRO of the unifying character of scientific research". The 1971 package deal level had provided the Scientific Programme with a level of stability for ten years, but that level was now dramatically low compared to the increasing size of the space science community and to the demands for larger and more sophisticated systems. Some one hundred space science groups were active in member states whose work affected or was directly affected by ESA's Scientific Programme, and the objective for the Agency was to provide, on average, one flight opportunity a year by the 1990s. According to the Executive, the annual expenditure for scientific projects during that decade should be stable at the level of about 130 MAU (i.e. about 50% higher than the package deal level), to be reached through a steady progression starting in 1984.[542]

The second aspect was the great importance given to the new Earth observation field, essentially covering climatology and Earth resources. The former was basically a scientific discipline, "but in the future it may also offer public service and considerable economic benefits". The commercial exploitation of Earth resources satellites was nearer, but there was much exploratory and experimental work to be done first. There was general agreement among member states that an Earth observation

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540 *Ibid*., pp. 1-2.

541 *Ibid*., pp. 4-5. The document noted that the total European effort in space (including ESA and national programmes) was about 1000 MAU per year, to be compared to about 8000 MAU for the total US effort (NASA, military and private), an estimated 8000 MAU for the total USSR effort, and about 3000 MAU for the total effort in Japan, Canada, India, Brazil, Arabia, Indonesia and Australia.

542 *Ibid*, p. 12. The package deal level in 1979 financial conditions was 86.1 MAU, including contingency.

programme was needed, starting with a satellite for ocean and ice monitoring, and for climatology studies. The Director General's proposal included both this project and a land surveillance project, with a total expenditure of 772.5 MAU in the 1981-1990 period, i.e. about 16% of the total expenditure in the decade, with a peak in 1985-1987.[543]

Finally, the third aspect was the uncertainty regarding space transportation systems (STS). "It is in [this] field that the future is most unpredictable for Europe", the Director General stated, arguing that he could not, at this stage, "put before [delegations] definite proposals for the second half of the decade". In fact, it was hardly possible to identify the balance between further development of launch vehicles and manned flight activities until the results of the early Ariane series and the early Spacelab flights became available:

> *At that time, [...] we will have a more objective view from users and potential users of the STS to help us decide which developments should be taken up in the baseline programme. For that reason, most of the funding allocated to STS from 1985 onwards is not tied to either Ariane or Spacelab. It does, however, represent either the launcher development beyond Ariane-4 or a significant continuation of the collaboration in manned flight effort.*[544]

The Director General's document was discussed by the Council Bureau's Working Group during two sessions, on 12 February and 6 March 1981 respectively, and then at the Council meeting of 29 April.[545] Here it was impossible to secure a consensus on the proposal, for several reasons. Firstly, while the majority of delegations were in favour of the proposed increase in the funding level of the mandatory Scientific Programme from 1984 onwards, the necessary unanimous agreement could not be reached. Britain and France, in particular, opposed such an increase while Germany, on the contrary, supported the idea of "an appreciable increase in the Scientific Programme". Secondly, opinions diverged regarding the overall level of the proposed baseline programme. For Germany, 450 MAU per year was definitely too much, and its delegation proposed an overall level of about 400 MAU as a maximum GNP-based annual envelope for ESA's activities. Other delegations agreed on the 450 MAU/year level for the overall baseline programme, but considered it difficult to achieve this level by GNP-based contributions or did not want to contribute on a GNP basis to all individual programmes. Finally, important new programmes for which a decision was originally expected by mid-1981 were still under discussion, and all delegations considered that it was at least premature to discuss a long-term plan before agreeing on medium-term programmes. In particular there were significant differences of opinion about the payload and mission objectives of the Earth resources satellite ERS-1; a decision on the Ariane-4 programme was not yet on the agenda, nor that on the Spacelab follow-on development (FOD) programme; the approval of the development phase (Phase-C/D) of the L-Sat (Olympus) communications satellite was still pending, while the split on direct broadcast satellite (DBS) projects between France and Germany on the one hand, and the other member states, on the other, made the very future of ESA's Telecommunications Programme highly unpredictable.[546]

Facing the impossibility of reaching a consensus on a 10-year plan, the Executive made do with a less ambitious approach, submitting a proposal for a medium-term plan, covering the following five years and essentially based on approved programmes, new programmes for which a decision was about to be

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543 *Ibid*, p. 6.

544 *Ibid*, p. 7.

545 ESA/C(81)35), 3 April 1981; Council, 47th meeting (29 April 1981), ESA/C/MIN/47, 11 June 1981, pp. 2-10, and add. 1, 29 June 1981. See also ESA/C(81)27, 3 April 1981.

546 The detailed definition phase (Phase-B study) of the ERS-1 programme was approved in May 1982, and the development phase (Phase-C/D) was subscribed in 1984; the Ariane-4 programme and the Spacelab FOD programme were both approved in 1982; the L-Sat Phase-C/D was subscribed in late 1981.
The development of the ESA telecommunications programme in the second half of the 1970s is discussed in chapter 6 in this volume.

taken, and study activity on possible future programmes. Within this framework, the budget for the mandatory Scientific Programme was confirmed at the package deal level, i.e. 93.5 MAU/year at 1980 economic conditions, but the Executive stressed that this might have to be reviewed later on, "in the light of the discussions with member states on the increase in the mandatory Science Programme".[547] This statement was substantiated by the Council resolution concerning the level of resources for mandatory activities in the 1982-1986 period, approved at the 52nd meeting in February 1982. In this resolution, in fact, the Council agreed to increase the science budget in 1984-1986 by 3 MAU and confirmed "its intention to initiate discussions between member states, in time for the review of the level of resources in 1984, with the aim of achieving a more significant increase of the financial level of the Scientific Programme".[548]

The discussions on the medium-term programme continued during 1982 and 1983, on the basis of subsequent updates of approved projects and the financial forecast.[549] Within the framework of these discussions, in September 1983, the Executive again presented a case for long-term planning, based on four main arguments. First was "the question of paramount importance" of redefining the 1971 budgetary level of the mandatory Scientific Programme. Second was the need for planning future programmes in the field of Earth observation, in order to address both the scientific and application objectives ("today's experimental missions become tomorrow's operational missions"). Third was the need for Europe to clarify its position in relation to "the still vague concept of the US Space Station", a key element for all future planning, particularly regarding Ariane's successor. Finally, there was the dramatic decrease of the total yearly expenditures for ongoing programmes foreseen in 1986-88 (some 400 MAU in 1988 compared with about 1000 MAU in 1984-85), which underlined the importance of the 1985-86 timeframe for taking major decisions on future European space programmes.[550]

The Executive's proposal was discussed at length during the 60th Council meeting, on 19 October, and all delegations agreed that, owing to the importance of policy decisions to be taken, it was appropriate to convene a Council Meeting at Ministerial Level in 1984. The ministerial meeting was actually organised in Rome on 30 and 31 January 1985. It established guidelines for the Long-Term European Space Plan whose main elements were the Horizon 2000 space science programme, the Columbus programme as Europe's contribution to the International Space Station, and the Ariane-5 launcher programme. Moreover, ministers agreed to expand the Earth observation programme and the microgravity programme, and to decrease spending on telecommunications. With these commitments, ESA's expenditure was due to level off at about 1700 MAU in the 1990s (at 1984 prices).[551] The guidelines adopted in Rome were confirmed at the subsequent ministerial meeting, held in The Hague on 9 and 10 November 1987, in which the Ariane-5 and Columbus development programmes were approved at an estimated cost of 3496 MAU and 3713 MAU, respectively. Moreover, the *Hermes* spaceplane programme was approved at an estimated cost of 4429 MAU.[552] It is not the aim of this report to discuss in detail the preparation of the Rome and The Hague meetings and the implications of all decisions taken on those occasions. It is, however, within the framework of the planning effort we have just described that we will discuss the preparation of the Horizon 2000 programme and its eventual approval.

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547 ESA/C(81)71, 8 October 1981, and rev. 1, 2 December 1981, pp. 5 and 6, respectively.

548 ESA/C/LII/res. 1 (final), 11 February 1982, approved at the 52nd Council meeting (10-11 February 1982), ESA/C/MIN/52, 25 March 1982, after discussion of ESA/C(82)5, 19 January 1982. The 3 MAU increase in the scientific budget was not to be realised by a corresponding increase in contributions, but via an expected increase in "other income". See also Council, 51st meeting (9-10 December 1981), ESA/C/MIN/51, 18 January 1982, and ESA/C(81)87, 30 November 1981.

549 ESA/C(82)53, 22 April 1982; ESA/C(82)79, 8 October 1982; ESA/C(83)26, 28 March 1983.

550 ESA/(83)71, 19 September 1983, pp. 8-10.

551 *ESA Bulletin*, No. 41 (February 1985), 4-11. Preparatory documents are ESA/C(84)30, 21 March 1984; ESA/C(84)46, 12 June 1984, and rev. 1, 21 November 1984.

552 *ESA Bulletin*, No. 53 (February 1988), 8-30; Reuter (1988). On the Rome and The Hague meetings and subsequent events, see Madders (1997), 290-351.

5.5 Towards Horizon 2000

We can identify two main elements that led the European space science community to prepare a long-term plan, and which created the conditions for it to be approved by ESA member state ministers meeting in Rome. The first is the dramatic financial situation of the Scientific Programme, which showed up strongly in 1981; the second is the determination of the new ESA Director of Scientific Programmes, Roger Bonnet, who succeeded Ernst Trendelenburg in May 1983, to thoroughly review the selection procedures of the Agency's scientific projects. As he recalled later:

> *In 1983, it became clear that ESA could no longer continue with its existing method of selecting project after project, without a long-term perspective and some kind of commitment that would allow the scientific community to prepare itself better for the future. ESA too needed a long-term programme in space science.*[553]

5.5.1 The financial outlook for the Scientific Programme

The first evidence of some major problems in the financial situation of the Scientific Programme appeared in a document prepared by the Executive in January 1981 for submission to the SPC.[554] In 1980, we should recall, Giotto and Hipparcos had been approved on the basis of a financial situation which made possible their smooth development during the first half of the decade and the start of a new project by 1983. A series of events occurred in the second half of 1980, however, which produced substantial modifications in the financial outlook. The most important were: (a) the two-year delay in the ISPM development schedule imposed by NASA decisions, implying a cost increase of about 16 MAU; (b) the increase of 9 MAU in the estimated cost to completion of the Space Telescope; and (c) the increase of about 6 MAU in the estimated cost to completion of Exosat. As a result, the new financial outlook showed that a new programme could only be started in 1984, which however implied an overrun of some 6 MAU on the science level that year. Moreover, no funds were available for the development of the Biorack facility for microgravity life science experiments on Spacelab. If Biorack was to be developed within the framework of the Scientific Programme, important overruns were foreseen in 1982-1984, and the start of a new project would only have been possible in 1985.

In May 1981, the Council approved the new (optional) Microgravity Programme, which included Biorack as one of its first elements. This, however, did not ease the financial situation of the mandatory Scientific Programme which, by the end of the year, appeared dramatic.[555] The funds available for new projects up to 1986 had decreased from 88.9 MAU to 60.6 MAU (in 1981 prices), with an overrun of 13.3 MAU foreseen in 1983. This was without taking into account the expected increases in the cost of the Ariane launchers for Giotto and Hipparcos, and the potential cost increases in the development contracts of both projects. Two main reasons were given for this situation. First was the decision to further extend the in-orbit operations of COS-B, GEOS, ISEE and IUE beyond their nominal lifetimes; second was the cost increases in Exosat, ISPM and the Space Telescope owing to technical problems and launch delays.

The situation worsened in 1982, when funds available for new projects further decreased to 20.6 MAU (1982 prices) with important overruns foreseen in 1983 and 1984.[556] Three possibilities existed to cope with this situation. First was the recourse to the so-called "flexibility margin", i.e. an increase in the science budget for the period 1983-1986, followed by an equivalent decrease in the following years. This option, however, required explicit Council approval and, in any case, simply shifted the problem in time and made the start of future projects difficult. The second possibility was to negotiate appropriate industrial arrangements with prime contractors and Arianespace, in order to define a different expenditure profile. This meant, in fact, that industry would be requested to pre-finance

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553 Bonnet (1995), p. 10.
554 ESA/SPC(81)4, 5 January 1981.
555 ESA/SPC(81)31, 2 December 1981.
556 The evolution of the financial outlook in 1982 is presented in ESA/SPC(82)11, 7 June 1982, and ESA/SPC(82)24, 17 November 1982.

certain items, with the result of an overall cost increase because of the loan charges. Thirdly, it was possible to delay the development phase of Hipparcos by some six months. This last option, as to be expected, was harshly opposed by the SSAC, which insisted that the planning schedule should be maintained:

> *The SSAC does not wish that a delay of Hipparcos be used as the easy way out of a financial difficulty largely due to facts beyond its control. It, therefore, requests that the present financial difficulties be overcome by the use of flexibility of the annual budget and by specific industrial arrangements. [...] The SSAC also recommends that the selection of the next scientific project be made as foreseen in early 1983 and that a new call for proposals be made to the scientific community for new additional projects to be included in the next planning cycle, leading to a further decision in the 1984/85 timeframe.*[557]

The SSAC had good reasons for its criticism. Firstly, all its efforts to have the science budget raised above the level imposed ten years earlier had been frustrated, even though that level was only half that existing in the earlier ESRO period, while space science was becoming more and more demanding in terms of resources. Secondly, the new budgetary system, approved by the Council in October 1981, resulted in the mandatory Scientific Programme, based on permanent use of the Agency's facilities, having to pay about 24.6% of the support costs and capital investments while the science budget covered only about 12.6% of the total ESA budget. "Application programmes such as for example Marecs were subsidised by the Scientific Programme as far as support costs were concerned", Trendelenburg reported to the SSAC. The SSAC chairman, for his part, noted that there was a difference between what formally appeared in the ESA budget and what was really the expenditure of the Scientific Programme: "The Scientific Programme does not receive in cash the amount it expected to receive in accordance with the 1971 [package deal] level".[558] Finally, the push of member states towards the use of Ariane for ESA's scientific satellites resulted in higher launching costs having to be borne by the science budget.

In the event, after the ESA Administrative and Finance Committee (AFC) expressed its concern about the budgetary situation of the Scientific Programme, the Council could not reach the required two-thirds majority for unblocking the flexibility margin which had been provisionally included in the 1983 budget.[559] The Council then agreed to delegate authority to the AFC to take a decision on this issue, following a detailed examination of the financial situation of the Scientific Programme. The situation appeared more and more depressing, despite the successful launch of Exosat on 20 May 1983 (six years later than originally planned). In fact, preliminary results of Phase-B studies on Hipparcos showed that its cost to completion would be much higher than originally foreseen, and the SPC went as far as discussing the possibility of finally cancelling the project. The cost of the Giotto programme was also increasing, which led four delegations (Ireland, Italy, Netherlands and UK) to propose that a ceiling should be imposed on its cost-to-completion. After the Director of Scientific Programmes had urged the SPC "not to jeopardise this programme which had already encountered many difficulties", this proposal was not endorsed by the majority of delegations.[560]

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557 SSAC(82)7, 8 June 1982: resolution approved at the 29th SSAC meeting (3 June 1982), SSAC/MIN/29, 14 June 1982.

558 SSAC/MIN/29, *cit.*, p. 4. See also ESA/SPC(82)17, 8 June 1982. The issue was also discussed at the 31st SPC meeting (17-18 June 1982), ESA/SPC/MIN/31, 30 August 1982.

559 ESA/C(82)107, 20 October 1982; ESA/C(83)49, 31 May 1983; Council, 56th meeting (8-9 December 1982), ESA/C/MIN/56, 14 January 1983, pp. 15-18; 59th meeting (8-9 June 1983), ESA/C/MIN/59, 26 July 1983, pp. 10-12. See also SPC, 32nd meeting (1-2 December 1982), ESA/SPC/MIN/32, 21 January 1983, pp. 2-3, 6-7; and 33rd meeting (29-30 March 1983), ESA/SPC/MIN/33, pp. 6-7.

560 ESA/SPC/MIN/33, *cit.*, p. 4. The financial situation of the Scientific Programme is reported in ESA/SPC(83)6, 15 March 1983.

In view of the important AFC meeting where a decision had to be taken on the use of the flexibility margin for 1983, the Executive prepared a general document on the financial situation of the Scientific Programme, discussing both the reasons for its difficulties and the means for overcoming them.[561] Two main elements were identified which contributed to the cost increases in the programme after 1977. First were unplanned programmatic decisions, such as the extension of satellite operations beyond the originally budgeted lifetime or the launch of GEOS-2 to replace the first GEOS spacecraft, which had been placed in an incorrect orbit. These decisions had resulted in a cost increase of about 55 MAU. Second were increases in the cost-to-completion of the various projects compared to the estimates at the end of Phase-A studies. The contribution of this element to the cost increases was about 153 MAU, essentially due to unforeseen development problems (59%), consequences of NASA decisions and/or decisions concerning the European launcher policy (21%), changes related to the distribution of ESA support costs (14%) and improvements to the scientific missions (2%).

Several short- and long-term measures were discussed which could in future permit a more efficient financial management of the Scientific Programme. The first short-term measure was, of course, the unblocking of the flexibility fund of 5 MAU included in the 1983 budget. Another measure was the delay of the Hipparcos and ISO programmes. Such a decision had to be examined very critically, the Executive warned, "as both cases affect the integrity of the Scientific Programme". In the case of Hipparcos, Phase-B had already been stretched to the maximum consistent with coherent development, and a delay in the start of the (development) Phase-C/D would adversely affect both the industrial consortium and the scientific groups which were preparing the observatory programme and the final reduction of data. In the case of ISO, "a delay may very seriously affect European competitivity in the field of infrared astronomy, which is being demonstrated by [the Dutch infrared satellite] IRAS to be of exceedingly high scientific value". ISO, in fact, was entering into direct competition with a Shuttle infrared telescope facility (SIRTF) planned by NASA.

Four long-term measures were then proposed. First was an operations budget line, outside the science budget, to cover satellite operations beyond their planned lifetime (this element, in fact, accounted for some 16% of the increase experienced). Second was the introduction of a preparatory programme for science, in order to base the scientific projects, in particular in new domains of research, on a more solid technical foundation. The Executive noted in this respect:

> *In the past, at the time of ESRO, the whole Organisation was set up around scientific projects and hence such preparatory activity was conducted by the technological programme of ESRO. Nowadays, the technological programme's resources are spread widely among the various areas of interest in the Agency.*

The third measure was the introduction of competitive Phase-A studies, in order to allow cross-checks between industrial proposals, and to more easily detect artificial compression of costs, intended to improve the chances of project approval. Finally, a modification of the Agency's support cost recharging policy was proposed. Admittedly, the Scientific Programme was an important user of the Agency's support, the Executive acknowledged, but "there is clearly an anomaly", in the fact that this programme was charged 35% of the total ESA overheads, while it represented only about 11% of the Agency's total volume of activity.

Concluding its report to the AFC, the Executive pointed out the real problem which made the situation of the Scientific Programme so unsatisfactory, i.e. the increase in sophistication and cost of scientific missions compared to "the persistent limitation of the science budget to a level established in 1971 in a totally different scientific environment". Projects like Hipparcos and ISO, the Executive argued, had costs of between two and three scientific annual budgets, which implied, on the one hand, the reduction of the frequency of flights to "an unacceptably low level" and, on the other the need for

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[561] ESA/AF(83)48, 26 August 1983, attached to ESA/SPC(83)13, 29 August 1983. Following quotations are from pp. 5-8.

more flexible financial tools in order to carry them out: "To constrain expenditure of these projects to remain strictly within the annual level, on a year by year basis, is in itself an impossible feat".

In the event, the AFC agreed to unblock the flexibility margin in the 1983 budget. It also recommended a few measures to remedy the financial situation of the Scientific Programme. These included, in particular, the introduction in future budgets of an allocated contingency allowance of some 5%, and the introduction of competitive and more detailed Phase-A studies, with possible extension of competitivity in the project definition phase (Phase-B). These measures were eventually approved by the Council, but most delegations recognised that the time was now ripe to discuss the increase in the annual budget allocated to this programme. "It was inconsistent to provide for a contingency margin in a budget whose level had not been increased", the Swiss delegation argued, and the Italian delegation added that, "as long as this contingency margin was provided for within the approved level of resources, the AFC's recommendation concerned budgetary technique".[562]

We should recall that, in its 1982 resolution on the level of resources for the mandatory activities in the 1982-1986 timeframe, the Council had explicitly expressed the intention to discuss the increase of the financial level of the Scientific Programme in 1984, within the framework of discussions on the new level of resources. In fact, in its medium-term plan for 1985-90, presented in May 1984, and in its parallel proposal on the level of resources for the mandatory activities in the period 1985-89, the Executive proposed that the financial level of the Scientific Programme should be increased from 1985 onwards by 7% per year, up to the target level of 212 MAU (1984 prices, or 200 MAU at 1983 prices), to be reached in 1991.[563] This proposal, which was substantiated by the objectives of the Horizon 2000 programme, was included in the long-term space plan which the Executive presented in June 1984 as a basis for Council discussions in view of the Rome ministerial meeting.[564]

5.5.2 A new approach to ESA's space science

On 30 March 1983, at the conclusion of the 33rd meeting of the SPC, a moved Cornelis de Jager, one of the founding fathers of European space science and the then chairman of the SPC, said his farewells to Ernst Trendelenburg who was leaving ESA, of which he had been "one of its most faithful servants" since the earliest ESRO times. The minutes of the meeting inform us that de Jager "spoke humorously of the exceptional personality of this genuine European who had defended tooth and nail the interests of the Scientific Programme, whose budget was always too small". With as much emotion, Trendelenburg acknowledged the "cooperative spirit of the SPC delegates, with some of whom he had worked for nearly 20 years". He claimed satisfaction at having maintained "the integrity of the ESA Scientific Programme, which was the tangible proof of the existence of the European spirit", but expressed his regret for "not [having] been able to obtain a substantial increase in the scientific budget".[565]

Beyond the understandable emotion experienced by the participants in the meeting, this exchange of views reported in the minutes points out the turning point marked by Trendelenburg's departure. Trendelenburg had been the Director of Scientific Programmes since the creation of ESA, in 1975, after having spent most of his scientific career in ESRO, first as the director of ESLAB and then as the head of ESTEC's Space Science Department. Raised in the "old" ESRO/ESTEC purely space science

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562 Council, 61st meeting (7-8 December 1983), ESA/C/MIN/61, 10 January 1984, p. 20. See also ESA/C(83)93, 30 September 1983; ESA/C(83)124, 17 November 1983, and add. 1, 25 November 1983. The AFC's report was discussed a the 35th SPC meeting (9-10 November 1983), ESA/SPC/MIN/35, 27 January 1984.

563 ESA/C(84)29, 2 May 1984; ESA/C(84)67, 20 September 1974. See also ESA/C(84)68, 20/984; ESA/SPC(84)8, 21 May 1984; ESA/SPC(84)15, 2 November 1984. The financial level of the Scientific Programme in 1983 prices was about 130 MAU.

564 ESA/C(84)46, 12 June 1984, and rev. 1, 21 November 1984.

565 SPC, 33rd meeting (29-30 March 1983), ESA/SPC/MIN/33, 6 June 1983, pp. 13-14. In a letter addressed to the European scientific community on 26 April 1983 (*D/Sci Archives*), Trendelenburg explicity expressed his satisfaction at having protected "the integrity of the Scientific Programme from the many attempts to introduce application-oriented sciences to make it 'more useful to mankind'".

culture, he opposed resolutely the inclusion in the Agency's mandatory Scientific Programme of the new application-oriented space disciplines which emerged in the 1970s, i.e. Earth observation and microgravity, and shared his fellow space scientists' distrust of Spacelab. This opposition did not make it easier for member states to agree on an increase in ESA's mandatory budget, in particular because of the strong opposition of France, whose delegation in the SPC did not appreciate what it considered a conservative approach to space science. Moreover, the French had not appreciated Trendelenburg's very direct management in forcing through the decision to approve the Giotto mission to the detriment of Hipparcos, a project which was strongly pushed and supported by France.[566] In the event, the Council decided in 1982 that Trendelenburg's contract should not be renewed, and in January 1983 it unanimously approved the appointment of the French physicist Roger Bonnet to the post of Director of Scientific Programmes, with effect from 1 May.

Bonnet had been raised in the cradle of French space science, i.e. Jacques Blamont's Service d'Aéronomie at Verrières-le-Buisson. He obtained his PhD in 1968, in the midst of the student revolt which swept through French universities and institutions, and one year later he became the first director of the newly created Laboratoire de Physique Stellaire et Planetaire, also located in Verrières-le-Buisson in direct competition with Blamont's laboratory.[567] Bonnet knew well the functioning of ESA's Scientific Programme, both from his direct involvement in some of ESRO's and ESA's projects, and because he had been the chairman of the SAC from 1978 to 1980. In this capacity, he was responsible for the important SAC report of December 1978 on the development of space science in the 1980s.[568]

Taking up his duties, Bonnet was well aware of "the gravity of the crisis through which the Agency's Scientific Programme was passing".[569] His approach to the crisis was to take advantage of the planning effort under development within ESA in order to work out a long-term programme in space science to be submitted to the forthcoming Council meeting at ministerial level. There were a number of good reasons for the establishment of such a programme. First there was the need to define some kind of commitment on the part of the Agency that would allow the scientific community to prepare itself better for the future. As Bonnet recalled later, "the need for scientific institutes involved in the development of the payloads and for industry in charge of realising the missions to prepare themselves sufficiently early, created a quasi natural rationale for the formulation of Horizon 2000".[570] Second there was the need for more advanced long-lead technological developments, in order to introduce into the programme those ambitious missions that had been proposed by the scientific community, but which could not be approved because their feasibility could not be established. Within the framework of a long-term perspective, Bonnet argued, such missions could be accepted into the programme and adequately prepared by a suitable technological research effort. Thirdly, a clear definition of medium- and long-term objectives was required in order to match available resources to scientific requirements. This implied establishing a fixed envelope for the cost of each planned mission, thus forcing, on the one hand, the scientific community to limit its ultimate ambitions and, on the other, the ESA management to ensure more efficient control over the development of the programme. Last but not least, "the only possibility for Council changing [the 1971] level rested on the assessment of a substantive plan and a reference framework for future space science activities".[571]

Bonnet's new approach to scientific planning within ESA had probably been the subject of some discussions within the European space science community. As early as 1 June 1982, the need for a long term mission plan in ESA's Scientific Programme had been advocated in two parallel letters addressed to the Scientific Programme Directorate by M. Grewing and K. Pounds, SPC scientific

566 See previous chapter.
567 Bonnet (1992).
568 SAC, *Recommendations on the development of space science in the 1980s*, ESA SP-1015, December 1978. See previous chapter.
569 Council, 60th meeting (19-20 October 1983), ESA/C/MIN/60, 25 November 1983, p. 19. See also SPC, 34th meeting (21 June 1983), ESA/SPC/MIN/34, 31 August 1983, pp. 1-2.
570 Bonnet (1993), p. 6.
571 Bonnet (1995), p. 10. See also Bonnet & Manno (1994), p. 37.

delegates for Germany and the United Kingdom, respectively.[572] According to Grewing, "instead of selecting a single mission every year (or every second or third year), ESA should consider to establish a mission sequence for a period of 10 to 12 years, comprising 3 or 4 major scientific missions, i.e. leaving some room for 3 to 4 smaller missions to be added in on a shorter notice in much the same way as missions are currently selected and implemented". The major missions were to be selected on the basis of two main criteria, i.e. the scientific merit and perspective of a particular scientific field (e.g. infrared astronomy), and the broad technical feasibility of a mission in that particular field. Grewing then continued:

> *This means that neither all of the focal plane instrumentation nor all technical details must be known at the point of selection, but it should be clear that within Europe there is a broad scientific potential in that particular field, and it must be possible to identify the technically difficult areas in order to initiate a timely study of these problems.*

Several benefits of this approach were listed by Grewing and Pounds. Firstly, by establishing its own long-term mission plan, ESA could enter the international scenario in a way more compatible with that adopted by other organisations like NASA or the Japanese space agency. In this way, Grewing argued, "it would be much less subject to long term policy announcements made by other agencies, having to find 'white spots' for its own programme, but ESA could instead make its own claims (and - if desirable - go into international negotiations about joint projects or complementary missions)". Secondly, within Europe, space science groups and national planners would have a European strategy within which they could operate, "acknowledging some (generally larger) projects for ESA and making additional activities supportive or complementary" (Pounds). Thirdly, a proper continuity of scientific and technical development would be assured, thus allowing useful savings in the development of common facilities, spacecraft or subsystems.

These and other similar arguments were echoed in Bonnet's presentation of the objectives and procedures of the long-term planning exercise to the SPC in October 1983.[573] The objectives were defined as follows:

a. To identify the long term goals and concepts of future missions that are likely to be requested for the science programme of ESA by the European scientific community.

b. To establish a model long term programme of high scientific value which will ensure continuity of efforts to scientific institutes and industry and which will be the subject of discussions with Member States.

The reference frame thus established, the document continued, would provide a basis for the financial requirements to be submitted to the Council and for the identification of the main areas of technological development. Moreover, it would provide a reference around which the various sectors of the space science community could eventually organise themselves in order to take the best possible share of the missions. Finally, it would help in planning future collaborative efforts with NASA and other national space agencies.

The approach to the preparation of the long-term programme would essentially follow the same pattern adopted for the introduction of new scientific projects into the ESA programme. A "call for mission concepts" was to be addressed to the scientific community at large, in order to ensure that "the study output is firmly based on its wishes and capabilities". These mission concepts would be assessed

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572 M. Grewing, telex to V. Manno and H. Olthof, 1 June 1982; K. Pounds, telex to H. Olthof, 1 June 1982. *D/Sci Archives*.

573 ESA/SPC(83)17, 25 October 1983, with attached D.SCI/LTP/WP(83)1, 5 October 1983. The following quotations are from the latter document. A preliminary version, dated 7 September 1983 with reference code D.Sci/WP(83)1, is in *D/Sci Archives*.

by ESA from a technical and financial point of view, and then submitted to six Topical Teams covering the various disciplines in astronomy and Solar System sciences (Table 5-6). The task of the Topical Teams was to evaluate the capability of the proposed missions to contribute to the achievement of the scientific goals identified in the various scientific areas and to establish priorities. The results of the Topical Teams would be discussed by a Survey Committee, "which will assess their relative scientific importance and technological status". This Committee would finally formulate a recommendation on a global model programme for the 20-year period 1985-2004.

Table 5-6: Proposed Topical Teams for the long-term plan

Relativity and gravitation
Cosmology and extra-galactic astronomy
Galactic astronomy
Solar and heliospheric physics
Planetary science
Space plasma physics

The Survey Committee, chaired by the chairman of the SSAC, comprised the SSAC members, the chairman of the SPC, and a number of invited scientists representing important European scientific organisations, such as the European Science Foundation (ESF), the European Centre for Nuclear Research (CERN) and the European Southern Observatory (ESO). Its first meeting, on 30 September 1983, was chaired by the outgoing SSAC chairman, Edoardo Amaldi. Subsequently, Johan Bleeker, the outgoing chairman of the AWG, took over the chairmanship of the SSAC (Table 5-7).

Table 5-7: Survey Committee for Horizon 2000

SSAC members	J. Bleeker (Chair)	Utrecht
	K. Fredga	Solna
	H. Fechtig	Heidelberg
	A. H. Gabriel	Chilton
	J. Lequeux	Marseille
	H. Völk	Heidelberg
	M. Huber (SSWG Chair)	Zurich
	F. Pacini (AWG Chair)	Florence
SPC Chair	C. de Jager	Utrecht
EOAC *	M. Lefebvre	Toulouse
ESF	J. Geiss	Bern
	B. Hultqvist	Kiruna
CERN	L. van Hove	Geneva
ESO	G. Setti	Munich
IAU **	R. West	Munich
(Secretary: V. Manno, ESA)		

* Earth Observation Advisory Committee
** International Astronomical Union

5.6 The Horizon 2000 long-term plan

The preparation of the Horizon 2000 plan proceeded as planned, the only departure being that the three Topical Teams in the astronomy field were replaced by an Astronomy Survey Panel, composed of a three-member Core Team, each member reporting on one of the topics originally foreseen, and a Technical Support Team consisting of four experts reporting on the observing instruments in the various spectral domains (optical and UV instrumentation; X- and gamma-ray astronomy; infrared, submillimetre and radio astronomy; interferometry missions) (Table 5-8).

Table 5-8: Rapporteurs for the long-term plan

Solar System Topical Teams	
Solar and heliospheric physics	P. Delache (Nice), chair to 20 February 1984
	P. Hoyng (Utrecht), chair from 20 February 1984
Space plasma physics	G. Haerendel (Munich), chair
Planetary science	S. Bauer (Graz), chair
Astronomy Survey Panel	
Core team	
Extra-galactic astronomy	A. Fabian (Cambridge)
Galactic astronomy	E. van den Heuvel (Amsterdam)
Relativity and gravitation	I. Roxburg (London)
Technical support team	
UV and optical	J. Deharveng (Marseille)
X- and gamma-ray astronomy	H. Schnopper (Lyngby)
IR, sub-mm and radio	G. Winnewisser (Cologne)
Interferometry	R. Schilizzi (Dwingeloo)

A "call for mission concepts" was addressed by the Director of Scientific Programmes to the European scientific community on 2 November 1983, explaining the rationale and procedure for undertaking such an exercise. It insisted on the need "to make an effort of prospection into the future and to identify the way space science will move in Europe in the 15 years ahead of us", and stressed that "only conceptual descriptions of missions are requested to help us identify the type and general technological features of the future missions which could conceivably be realised within a coherent European programme in space research".[574]

Table 5-9: Response to the call for mission concepts

Solar System sciences	*35*
Solar and heliospheric physics	9
Magnetospheric and plasma physics	8
Planetology	8
Comets and small bodies	5
Atmospheric studies	4
Solid Earth	1
Astronomy	*33*
Gamma-ray astronomy	3
X-ray astronomy	12
UV	8
Optical astronomy	2
IR and submillimetre astronomy	2
Interferometry	4
Others	2

By the end of 1983, some 77 responses were received, including 68 mission concepts as given in Table 5-9.[575] The level of detail of the individual proposals varied widely, ranging from ideas expressed on a single sheet of paper to detailed instrument proposals including engineering drawings. All proposals were analysed by the ESA engineers, and the technical implications for each potential mission assessed, but the mission concepts addressing Earth sciences (atmospheric physics, climate

574 R.M. Bonnet, letter to the "Space science community", 2 September 1983, *D/Sci Archives*, with attached D.Sci/LTP/WP(83)1, *cit.*

575 Survey(84)3, rev. 1, 7 February 1984, *D/Sci Archives*.

research and solid Earth physics) did not receive further consideration as they did not fall within the terms of reference of the space science programme. Furthermore, the scientific objectives and mission concepts were analysed by the Solar System Topical Teams and the Astronomy Survey Panel within the framework of the past achievements and current trends of the various disciplines, taking into account the interests and capabilities of the European scientific community and the missions already planned by national space agencies in Europe, the USA (NASA) and Japan (ISAS). The Survey Committee, together with the Topical Teams and Panel chairmen discussed their reports and finally, during a three-day meeting in Venice, on 30 May to 1 June 1984, built up an overall programme for European space science in the next 20 years, which received the evocative title *Horizon 2000*.

Some 50 European scientists were involved in the study: "The whole exercise was conducted by the scientific community for the scientific community", in Bonnet's words.[576] The report of the Survey Committee was issued in July 1984 and circulated within the scientific community and member state delegations.[577] A more extended publication followed in December, including the detailed reports of the Solar Science Topical Teams, the contributions of the members of the Astronomy Survey Panel, and a chapter on industrial benefits derived from the European space science programme, prepared by the Executive on the basis of responses to a questionnaire sent to industrial companies. In this form, it was available to the ministerial delegations preparing the forthcoming meeting in Rome.[578]

The long-term mission programme designed in the Horizon 2000 plan is represented pictorially in Figure 5-1.[579] It was based on three classes of missions to be carried out in the time-frame extending up to 2004, each including projects feasible within a cost envelope corresponding to 2, 1 and 0.5 annual budgets, respectively. Its implementation, the Survey Committee stressed, required a budget envelope of about 200 MAU per year (1983 price level) to be reached progressively between 1985 and 1991, i.e. about a 7% yearly increase starting from the 1984 budget level of about 130 MAU.[580] The four major projects constituted the so-called "Cornerstones", satisfying the highest priorities identified in the domains of astronomy and Solar System sciences, and involving long-lead technical preparation. Within the Cornerstone framework were medium-class projects, i.e. the kind of missions which entered ESA's usual selection process. The mission programme included in this class projects already approved (Giotto, Ulysses, Hipparcos, ISO and the European contribution to the Space Telescope) and some five more projects to be selected in the future. Finally, the circle in the middle included small size projects, i.e. low-cost missions, participation in international programmes, and experiments onboard the future European retrievable Eureca platform.

The two Cornerstones in the astronomy domain (X-ray spectroscopy and heterodyne spectroscopy) reflected the well established position of the European space science community in the field of high energy astrophysics and its new interests and capabilities in the field of infrared and submillimetre astronomy. The former was demonstrated by the success of ESA's COS-B and Exosat missions as well as by three national projects then under development: the German soft X-ray mission Rosat, the Italian hard X-ray mission SAX and the French gamma-ray mission Sigma. About 50 per cent of the total number of mission concepts received in the astronomy domain were in fact related to high energy astrophysics. In the words of the Survey Committee report:

> *The scientific achievements and technical developments in high energy astrophysics now fully justify the development of third generation observatory class satellites which are*

576 Bonnet (1995), p. 10.
577 *European Space Science Horizon 2000*, Report of the Survey Committee, July 1984.
578 ESA, *European Space Science: Horizon 2000*, ESA SP-1070, December 1984. Annex I in this report lists the responses to the Call for Mission Concepts; annex II reports the list of the participants in the study.
579 Survey Committee Report, p. 16; ESA SP-1070, p. 13; Bonnet (1985), p. 10.
580 The ESA Accounting Unit was roughly equal to 0.8 US$ in 1985.

expected to provide an improvement of a factor of 10 to 100 in sensitivity, spatial and spectral resolution, or number of objects studied.[581]

The choice of the soft X-ray region as a Cornerstone project was motivated, on the one hand, by the responses to the call for mission concepts and, on the other, by the fact that NASA was already developing a mission in the hard X-ray and gamma-ray region (GRO, an acronym for Gamma-Ray Observatory). The XMM project discussed within the framework of the ongoing planning cycle was the obvious candidate to eventually match this Cornerstone concept.[582]

As regards the other Cornerstone in the astronomy domain, the Survey Committee noted that, after the European ISO and the American SIRTF infrared missions (the approval of the latter was however highly uncertain), the sub-millimetre wavelength region became "the last major unexplored part of the electromagnetic spectrum". A Cosmic Background Explorer (COBE) was to be launched by NASA towards the end of the 1980s, aimed at mapping the large scale distribution of the cosmic background at sub-mm wavelength. On a much longer timescale, NASA was studying a Large Deployable Reflector (LDR) which, however, required "presently undeveloped technologies [and] human assistance for antenna deployment in space". The conclusion:

Present European developments in submillimetre antenna technology allow for the development of a timely mission in submillimetre heterodyne spectroscopy as an intermediate step, which would provide the European scientific community with a unique opportunity to take the lead in studies of star and planetary system formation, origin and evolution of galaxies and small scale granularity of the cosmic background radiation.[583]

Here again, the European space community had provided a mission concept, the FIRST project, which appeared scientifically appropriate and technically feasible in the Horizon 2000 timescale.[584]

Before discussing the two Cornerstones in the domain of Solar System sciences, a comment must be made regarding the astronomy fields which were excluded from the Cornerstone frame, i.e. the optical and UV region and the interferometry missions. The former had benefited from the long-standing International Ultraviolet Explorer (IUE) mission, a joint NASA/ESA/UK space observatory launched in 1983 and still operating very successfully, while, in the visual part of the electromagnetic spectrum, the Space Telescope (ST) was expected to provide an important scientific harvest in the future. The Survey Committee acknowledged that an important hole would remain in the 900-1200 Å (far ultraviolet) wavelength region, "and therefore as a follow-up to IUE and as a complementary mission to ST, there is a need for a space observatory in [this] region which will be able to study the morphology of molecular hydrogen and deuterium". This was essentially the former Magellan mission concept, now included in the framework of the joint ESA/NASA study on the Lyman mission.[585] As regards very long baseline interferometry (VLBI) programmes, involving the use of in-orbit telescopes linked to ground-based telescope networks for high spatial resolution in the visible, infrared and millimetre range, this could not be accommodated within the 20-year timescale of Horizon 2000, for both technological and financial reasons. An interferometry box was however included in the picture, outside the baseline programme defined by the Cornerstone framework, as a reminder, either in case additional funds could be made available or for post-Horizon 2000 planning.

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581 Survey Committee Report, p. 11; ESA SP-1070, p. 63.

582 H.W. Schnopper, "Technical comments - X- and gamma-ray astronomy", in ESA SP-1070, 97-103.

583 Survey Committee Report, p. 13; ESA SP-1070, p. 65.

584 G. Winnewisser, "Technical comments – infrared, submillimetre and radio astronomy", in ESA SP-1070, 105-107.

585 Survey Committee Report, p. 12; ESA SP-1070, p. 64.

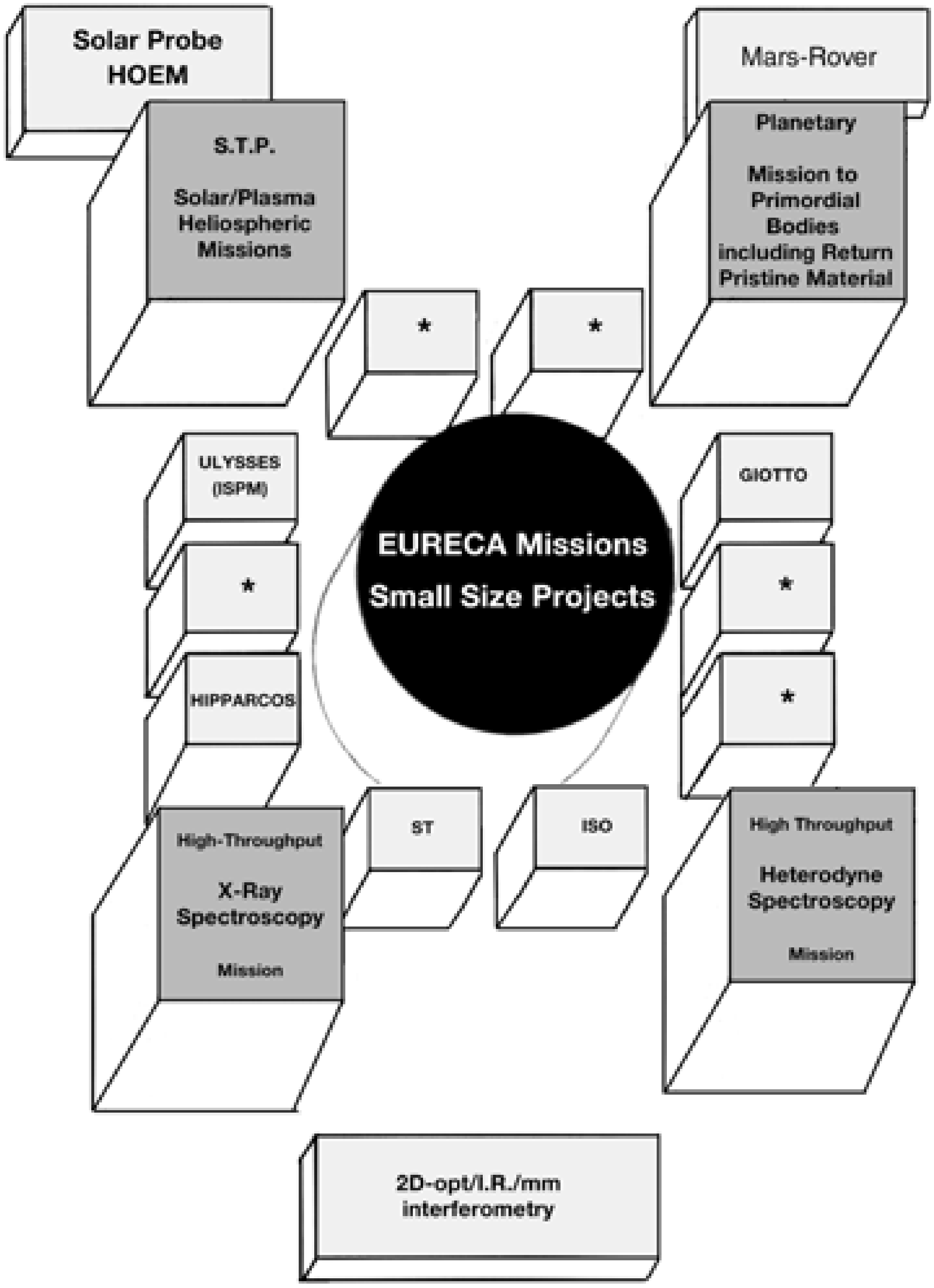

Figure 5-1: Horizon 2000 Programme Content

The choice of Cornerstones in the Solar System areas involved some delicate issues. Firstly, planetary research and solar physics had never been the object of a dedicated ESRO or ESA mission, but European scientists had gained wide expertise in both fields thanks to their participation in American and Russian missions. The Giotto mission then under development partly filled the gap in the planetary field, but the various bodies in the Solar System (Moon, comets and asteroids, planets) all had their own supporters within the space science community, each claiming a major (Cornerstone) mission booked for himself. Secondly, in the current planning cycle, as we know, there were three competing candidate projects in the Solar System domain (SOHO, Cluster and Kepler). These missions were medium-class projects but their respective scientific constituencies advocated their inclusion in the long-term programme framework, just as the major astronomical projects FIRST and XMM had found a place in the Cornerstones.[586] Thus, instead of suggesting one definite Cornerstone project, the Topical Team on Solar and Heliospheric Physics argued that "the strategy for achieving the solar and heliospheric science objectives outlined in [their report]" implied the implementation of the SOHO mission, and recommended that feasibility studies should be initiated on more ambitious projects such as a heliosynchronous out-of-ecliptic mission and a solar probe.[587] Similarly, the Topical Team on Planetary Science insisted that "the most important task is to concentrate on the ongoing activities, for example the preparation of the Kepler mission to Mars", while suggesting as "suitable candidates for future new initiatives" medium-class projects such as a lunar polar orbiter (Selene) derived from the POLO project and a project (Venture) involving multiple Venus orbiters. For the longer term, the proposed major projects were comet and asteroid rendezvous missions and a Mercury orbiter (Hermes). The report thus satisfied all sectors of the European planetary science community as revealed by the responses to the call for mission concepts.[588] Finally, the Topical Team on Space Plasma Physics argued that, "when we are looking beyond the time covered by the present mission planning cycle, we should not forget that the latter deals with several proposals of great importance for the development of space plasma physics. In particular SOHO and Cluster represent important steps in the formulation of a continuous and well-balanced policy". A list of potential programme elements was then suggested, but with a clear specification that they were to be intended "after SOHO and Cluster".[589]

When the participants in the Venice meeting convened in the splendid premises of the Fondazione Cini, on San Giorgio Island, they had already agreed on the Cornerstone concept. Only three Cornerstones were foreseen, however, two of them being definitely assigned to submillimetre and soft X-ray missions (eventually the FIRST and XMM projects). The third was reserved for planetary science, but no particular body in the Solar System had been given priority yet. It was taken for granted, however, that the meeting would eventually agree on a mission to primordial bodies (comets and asteroids) with return of pristine materials, a logical follow-up of the Giotto mission and the most important objective in future planetary science. It was during the meeting that a new Cornerstone for solar and plasma physics was proposed and won approval. Lacking written records of the meeting, here is how some of the protagonists later recalled the event:

> *It was a surprise when a fourth Cornerstone, consisting of the SOHO and Cluster missions, originally called the "Solar-Terrestrial Physics (STP) Cornerstone", was introduced by M. Huber – then chairman of the Solar System Working Group – following a comment by CERN's L. van Hove regarding the bias towards astronomy (to the*

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586 The fourth candidate project in the current planning cycle, the X-ray mission X-80, had been removed from the competition because of the new strategy emerging in this discipline during the preparation of Horizon 2000 (i.e. repeated flights of instruments on retrievable platforms such as Eureca), and because it partially overlapped with the forthcoming Italian SAX mission: SSAC, 36th meeting (25 October 1984), SSAC/MIN/36, undated, and SSAC(84)7, 26 October 1984.

587 P. Hoyng et al., "Report of ESA's Topical team on solar and heliospheric physics", in ESA SP-1070, 27-36, on p. 35.

588 S.J. Bauer et al., "Report of ESA's Topical team on planetary science", in ESA SP-1070, 51-58, on p. 58.

589 G. Haerendel et al., "Report of ESA's Topical team on space plasma physics", in ESA SP-1070, 39-48 and on p. 47-48.

detriment of the solar-system sciences) that was inherent in the original plan with just three Cornerstones. It may well be that it was not immediately clear to all meeting participants what the STP Cornerstone was actually to be, in particular that it took G. Haerendel's idea to combine SOHO and Cluster in one programme. In any case, the Executive returned next morning still with the original plan of three Cornerstones. This immediately attracted criticism from K. Fredga, B. Hultqvist (who had already given strong support to the idea of the STP Cornerstone the day before) and others. The ensuing discussions produced an admission of the feasibility of the STP proposal from the cost and schedule viewpoints and it was therefore reinstated. [...] The inclusion of this Cornerstone balanced the Horizon 2000 programme between the disciplines represented by active researchers at that time.[590]

In fact, this was a twofold victory for this sector of the space science community: not only did they obtain a fourth Cornerstone, eventually renamed the "Solar-Terrestrial Science Programme" (STSP), but also secured the slot for both their pet projects, namely SOHO and Cluster, which could thus escape the risks of the selection process. Finally, we should mention that two reminders for very ambitious Solar System missions in the post-Horizon 2000 timescale were included in the framework, a Mars rover and a solar probe.

5.6.1 Scientists' lobbying

"The meeting in Venice [...] was the crowning event of our long term planning effort, [...] certainly going beyond our highest expectations when we started the exercise", Bonnet wrote to all those who had contributed to Horizon 2000. He then addressed the crucial question of having the programme approved and the scientific budget increased accordingly:

One obvious outcome of our exercise is the great momentum given to our future programme and several delegations in the SPC considered that it may help to obtain an increased level of finance for space science in Europe. I did not in fact expect to have such an immediate and positive reaction, but the facts are there and we must capitalise on this situation. [...] Armed with this important result, we will then make a determined effort to have the proposed programme and the new budget level approved.[591]

Bonnet himself undertook a series of visits to national delegations to advocate the endorsement of the programme recommended by the Survey Committee while, as noted above, the Executive started planning future activities under the assumption of the 7% yearly increase in the scientific budget foreseen in Horizon 2000.[592] The approval of such an increase, however, was far from being secured, despite the enthusiastic support for the programme expressed from all sides of the European space science community. As the Netherlands delegation to the SPC put it: "The strong impression made by the excellent work of the teams which had contributed to this Report [...] should not be interpreted as a definite sign that the Netherlands authorities were prepared to endorse an increase in the science budget". The delegation itself, however, considered that the programme described in the Horizon 2000 report was "really a strict minimum that ensured a balance between the various scientific disciplines", and expressed its intention to try to convince its national authorities to approve it.[593] Similar statements were made by the German, Italian and Irish delegations, while Sweden and Switzerland endorsed the 7% increase.

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590 Huber et al. (1996), p. 32. See also Huber (1993).

591 R. Bonnet, letter to the members of the Survey Committee, Topical Teams, Astronomy Survey Panel, 19 June 1984, *D/Sci Archives*. A preliminary discussion on the Survey Committee report was introduced at the 37th SPC meeting (6-7 June 1984), ESA/SPC/MIN/37, 10 October 1984, pp. 6-7.

592 SSAC, 36th meeting (25 October 1984), SSAC/MIN/36, undated; ESA/C(84)29 and ESA/C(84)67, *cit.*

593 SPC, 38th meeting (19-20/1184), ESA/SPC/MIN/38, 20 February 1984, pp. 5 and 11. Most of this meeting was devoted to a discussion of the Survey Committee report. Similar discussions occurred at the 65th Council meeting (17-18 October 1984), ESA/C/MIN/65, 23 November 1984. See also ESA/SPC(84)21, 5 November 1984.

A much more cautious attitude was expressed by the British delegation, which said that it hoped that "it would be able to convince the relevant UK authorities to find the additional funds necessary to carry out the plan", but also stressed that, "in the current state of its financial planning, it could not accommodate an increase in the science budget without this affecting other activities".[594] Belgium and France, on the contrary, definitely opposed the 7% increase in the scientific budget. A more modest increase, say 3 or 4%, could be envisaged, "perhaps by giving up one of the major [Cornerstone] projects", the French delegation said. Such a suggestion was strongly opposed by Bonnet and Bleeker, who pointed out that the Cornerstones were already the outcome of a careful selection procedure and the programme thus conceived had achieved a balance between the various scientific areas. "Unless this balance was respected, the Scientific Programme as a whole could be jeopardised", the Director of the Scientific Programme argued. The chairman of the SSAC added: "If this minimum threshold was not reached, Europe would lapse back into 'a posteriori' planning, since the effect of removing one Cornerstone would be to break up the coherence of the plan and destroy all the others".[595]

During the two months preceding the Rome ministerial meeting the whole European space science community undertook a strong initiative in support of Horizon 2000, urging ministers and scientific statesmen to endorse a substantial increase in ESA's Scientific Programme according to the objectives described in the Survey Committee's report.[596] France, as we know, was one of the major stumbling blocks for the approval of such an increase, and it was directly to the French Ministre de la Recherche et de la Technologie, Hubert Curien, a former chairman of the ESA Council, that the Director of the Marseille Observatory, Jacques Lequeux, addressed his plea on 22 November:

> *En tant que membre du Space Science Advisory Committee de l'ASE, Président du Groupe Spécialisé "Astronomie" du Conseil Scientific de l'INAG [Institut National d'Astronomie et de Geophysique] et membre du Groupe de Travail "Astronomie" du Comité des Programmes Scientifiques du CNES, je pense pouvoir me faire l'interprète de l'ensemble de la Communauté astronomique et géophysique française en soutenant vigoureusement l'augmentation proposée du budget du Programme Scientifique de l'ASE.*

Three weeks later, on 13 December, it was the turn of a senior cosmic ray physicist from Saclay, Lydie Koch-Miramond, to address herself to Curien:

> *Au moment où une décision capitale pour l'avenir de la science spatiale européenne se prépare, je voudrais, en tant que membre du Comité des Sciences Spatiales de la Fondation Européenne de la Science, insister sur l'importance des programmes scientifiques européens pour les communautés scientifiques et industrielles spatiales.*

The President of the Comité National d'Etudes Spatiales (CNES), for his part, received a letter, dated 26 December, from F. Praderie, an astronomer from the Paris Observatory and a member of CNES' Astronomy Working Groups. After declaring his surprise at the fact that CNES had not organised any consultation of the French scientific community in order to discuss the Horizon 2000 report, nor had it scheduled any hearing of ESA's Director of the Scientific Programme before the CNES Council, Praderie wrote:

> *Il me paraît très grave que notre pays soit celui ou l'un de ceux qui envisagent de bloquer le plan proposé par la Direction Scientifique de l'ASE. S'il devait le faire, il empêcherait ou ralentirait excessivement la réalisation d'un programme de recherche spatiale à la mesure des forces intellectuelles, des ressources des laboratoires et des capacités des industries existant dans les pays européens.*

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594 ESA/SPC/MIN/38, *cit.*, p. 6.

595 *Ibid*, pp. 9-10.

596 Unless otherwise specified, all documents cited in the following paragraphs are in *D/Sci archives*.

In a wider European context, a letter was addressed on 12 November to about 50 scientists all over Europe by three important Swiss space scientists: Johannes Geiss, a professor at the University of Bern, a former member of ESRO's Launching Programme Advisory Committee and the President of the European Science Foundation; the chairman of the SSWG, Martin Huber, from the Federal Institute of Technology in Zurich; and Andreas Tamman, from the University of Basle. After warning their colleagues that "a real danger emerges now that once again the Science Programme will become the victim in the process of making compromises that customarily precedes European agreements", they wrote:

> *It is in this situation that we take the liberty of writing to you and propose that we all contact the decision-makers in our respective countries and try to convince them that the programme Horizon 2000 has to be an essential component of the future programme of ESA. [...] The most appropriate form of consultation or intervention with government officials will be different from one country to the other. It is important, however, that we take action immediately, because the system will be frozen in the next few weeks.*

They insisted on three main points: firstly, that the 7% yearly increase should be introduced to the ministers "on equal footing with Ariane-5 and the Space Station participation"; secondly, that the increase to the level of 200 MAU should be "explicitly included in the agreement of the ministers"; thirdly, that the joining of the Scientific Programme with other programmes such as microgravity would be "a diversionary manoeuvre [whose] result would be insufficiency of funds for achieving the goals of the long-term science programme".

Switzerland, as we know, was the only member state, together with Sweden, that was already a convinced supporter of the 7% annual increase assumed in Horizon 2000. In fact, the initiative of its scientific spokesmen was followed one month later by a letter from the Director of the Office Fédéral de l'Education et de la Science to the ministers for research in all ESA member states. The following is a passage from this letter:

> *Vu la qualité du programme scientifique et son attractivité [...] je me permets de vous demander, Monsieur le Ministre, de bien vouloir soutenir la proposition de l'Exécutive et du Directeur du programme scientifique et de faire tout votre possible auprès des autorités financières de votre pays, pour que l'augmentation de 7% soit acceptée. Du point de vue scientifique, il serait très regrettable de devoir étaler ou même amputer, par un décision négative, ce programme important, pour réaliser un gain d'une disaine de MUC représentant à peine 1.5% du budget total de l'ESA! Pour une économie aussi modeste, l'Europe courrait le risque de perdre sa position scientifique d'avant garde, acquise qu cours de ces dernières années.*

The political situation regarding the status of Horizon 2000 in the preparation of the ministerial meeting was reviewed by the SSAC at its meeting of 18 December 1984, which was also attended by ESA's new Director General, the German physicist Reimar Lüst, one of ESRO's founding fathers. Here it appeared that the majority of member states seemed able to accept a 5% increase, but the UK was the only country in which such a compromise did not seem possible. According to Lüst, if the UK authorities could be persuaded, then the other countries that are still reluctant would probably be ready to follow. However, as explained by Gabriel, despite the great interest of the British scientific community in the Horizon 2000 programme, the situation in the UK was highly critical. The astronomy budget, which included the contribution to ESA's Scientific Programme, had been greatly reduced and only if funded by additional money coming from other government departments, could the required increase in ESA's scientific budget be feasible.[597] Given this situation, the wording of the

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[597] Bonnet, in fact, tried to convince the British Department of Trade and Industry to contribute directly a fraction of the 5% increase: copy of an exchange of letters between Bonnet and DTI's J. Leeming (21 December 1984 and 10 January 1985) is in the *D/Sci archives*.

draft resolution prepared by the Executive for the ministerial meeting indicated that the level of funding of the Scientific Programme should be progressively increased to reach 147 or 162 MAU by 1989, the two figures corresponding to yearly increases of 3 and 5%, respectively. In any case, Lüst explained, "no Member State would commit itself officially to an increase beyond 1989".[598]

The SSAC reaction was one of great concern. For its members, it was clear the Horizon 2000 programme was contingent on achieving the new level of 200 MAU in the early 1990s, corresponding to a 5 to 7% yearly rate of increase. A 5% increase represented a threshold, "the very minimum level required". If a lower level were adopted, they argued, "Horizon 2000 was out of reach". They were aware that the long-term programme had raised great enthusiasm and many expectations in the space science community, just because of its integrated approach and internal coherence: "There had been a change of heart in the UK scientific community after the appearance of Horizon 2000 as guarantees were now included. If the 5% increase were not obtained, this enthusiasm would disappear", Gabriel said. Bleeker, for his part, remarked that if Horizon 2000 were reduced due to insufficient funding, support from the Netherlands might not be forthcoming: "The whole programme would backfire and people would no longer believe in ESA".[599]

Concluding the discussion, the SSAC approved a resolution in which it reiterated the importance of the 5% rate of increase as a threshold:

> *Above this threshold, a balanced programme with established priorities, supported by the European space science community, can be carried out. With a lower rate of increase, such a programme is out of reach. The absence of a long term plan would have serious consequences for the science programme since it will inevitably lead to a piecemeal approach with no consensus in the broad scientific community.*[600]

In a less formal setting, during the dinner which followed the SAC meeting, Bleeker and his colleagues insisted with Lüst that he should refrain from including in the proposed resolution the 3% increase option, but should rather advocate his fellow scientists' interests *vis-à-vis* ministers.[601] Bonnet, for his part, three days after the meeting, addressed a letter directly to the UK Prime Minister, Margaret Thatcher, recalling the visit she had made to ESTEC in September 1983 and her interest in the planned Giotto mission to Halley's comet. "I remember your amusement when I compared the size of the Universe with the size of the ESA budget", Bonnet wrote. He then added:

> *It was thus all the more disappointing for me [...] to see that the United Kingdom Delegation could not commit itself to support the requested increase of the Scientific Programme Budget. [...] It would be extremely regrettable for a country with the scientific standing of the United Kingdom to find itself isolated on this essential issue.*

5.6.2 Horizon 2000 approved

In the event, the scientists' lobbying activity achieved success. The ministers meeting in Rome finally agreed on the 5% rate of increase over the 1985-1989 period, with the level of funding of the mandatory Scientific Programme reaching 162 MAU (1984 prices) in 1989. In the draft resolution submitted to the ministers, the Director General had also included a reference to the fact that "the [Horizon 2000] long-term plan proposed for space science requires a level of about 200 MAU per year by the mid-1990s", but this sentence was eventually cancelled in the version approved in Rome, in

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598 SSAC, 37th meeting (18 December 1984), SSAC/MIN/37, 15 January 1985, p. 2.
599 *Ibid*, pp. 2-3.
600 SSAC(84)8, 19 December 1984.
601 Bonnet, personal communication to A. Russo.

spite of it being supported by Sweden and Switzerland.[602] This setback did not cause much concern, however. As Bonnet explained to the SSAC: "In three years' time, there would be a review of the level of resources, by which time [...] ESA's capability to implement the long term plan would be well-proven and good arguments could be advanced for making available further resources for the Scientific Programme".[603] In fact, the Executive started planning the implementation of the Horizon 2000 programme assuming that the annual budget would continue to increase beyond 1989 until reaching the 200 MAU level.[604] This planning assumption was well founded. In fact, at the ministerial meeting in The Hague, in 1987, it was agreed that the 5% yearly increase in the Scientific Programme budget should be carried on to reach a level of 216.7 MAU in 1992 (1985 prices, or 198.3 MAU at 1984 prices).[605] However, the formal decision to continue the annual 5% increase in the Scientific Programme budget until 1994 was taken by the Council only in December 1990, overcoming strong opposition from the UK delegation.

One can hardly overestimate the importance of such decisions. This was the first time in 15 years that the ESA scientific budget had been increased; in fact it was granted an annual increase of 5% above inflation, to be implemented over ten years. As a mandatory activity, any decision to increase the level of resources of the Scientific Programme required unanimous approval, a result which had not been possible since the time of the first package deal in 1971. The difficult financial situation of the programme in the early 1980s made it essential for space ministers of ESA member states to adjust its financial level to the new demands of space science. This is only part of the story, however. Another element to be considered is the general optimism regarding the future of Europe in space at the time of the Rome and The Hague meetings. Ten years after the approval of the ESA Convention, space cooperation in Europe had reached a level of maturity where member states could talk confidently of full autonomy in space research and technology in the opening new phase of the space era. In the words of Reimar Lüst, the ESA Director General at the time of these meetings:

> *It is clear that Europe cannot allow itself to be reduced to a subordinate or subsidiary role in space ventures if it is to maintain its current hard-won position. [...] The need for international collaboration on major space undertakings is not disputed, but Europe wishes to enter such undertakings on an 'equal partnership' basis, this concept applying at all levels.*[606]

While the Ariane-5 launcher would strengthen Europe's market position in the field, the Hermes spaceplane and the Columbus in-orbit infrastructure were the winning cards which Europe could put on the table at future negotiations on international collaboration in the space station project. With member states committing themselves to almost double the yearly ESA expenditure in seven years, reaching about 2600 MAU by 1993 (1986 prices), it was not an outrageous idea to spend less than 8% of this money for pure science.

Finally, ministers called to approve the increase in the scientific budget were faced not only with a general plea for "more money for science", as had been the case with the SAC Report of 1978, but with a coherent and comprehensive development plan for European space science activities in the following 20 years, including a balanced programme of large and medium-sized missions, an appropriate balance among the various disciplines, a suitable development schedule, and a definite financial framework. Moreover, they were confronted with the determination of the whole of a scientific community which still had an important influence in orienting government space policies, which claimed its pioneering role in starting Europe's space effort and which stressed the importance

602 Council, 67th meeting at ministerial level (30-31 January 1985), ESA/C-M(85)MIN/1, rev. 1, 25 September 1985, with attached ESA/C-M/LXVII/Res. 1 (Final), 4 February 1985. The Director General's proposal is ESA/C-M(85)2, 19 December 1985, with attached ESA/C-M(85)Res. 1 (Draft).

603 SSAC, 38th meeting (13 February 1985), SSAC/MIN/38, 20 March 1985, p. 1.

604 ESA/SPC(85)11, 28 October 1985.

605 *ESA Bulletin*, No. 53 (February 1988), p. 25.

606 Lüst (1988), p. 9.

of the mandatory Scientific Programme as the backbone of ESA's overall activities. As a rightly happy Bonnet put it, in a letter addressed to the "wide scientific community" just after the Rome meeting:

> *This successful outcome of the Conference would probably not have been possible without the existence of the programme as described in Horizon 2000, nor without your efforts of persuasion with your authorities at national level. May I express here my sincere congratulations on the success of these efforts, to which I would also like to add my thanks for your enthusiastic contributions to this common endeavour.*[607]

5.7 First implementation of Horizon 2000

The SSAC started discussing the general framework for the implementation of the Horizon 2000 programme at its March 1985 meeting.[608] Three main questions were involved in this discussion. First was the definition of a proper sequence between the four Cornerstones and of the framework for their eventual development, on the basis of scientific, technical and political considerations. It was felt that the first two Cornerstones would be indicative of the resolution and methods by which ESA would implement Horizon 2000, therefore their timely and efficient preparation was a key element for maintaining the support of the scientific community and securing the continuation of the 5% yearly increase by the time the new level of resources was to be decided by the Council. The second question was related to the need to introduce smaller projects between the Cornerstones, to be selected competitively according to the standard ESA procedures. In particular, it was necessary to fit the start of the first Cornerstone within the ongoing selection process, for which a decision was scheduled for February 1986. Finally, the third question regarded the budget. A pillar of the Horizon 2000 concept was that the costs of each Cornerstone had to be strictly maintained within a ceiling of 400 MAU and the smaller projects should cost less than 200 MAU, which implied a strict *design-to-cost* approach in the definition of the scientific objectives, and the utmost rigour in project management.

There was no doubt that the first Cornerstone to be implemented was the STSP.[609] In fact, the two projects forming the Solar Terrestrial Programme, SOHO and Cluster, were both under Phase-A study and the related technologies were within the reach. The second in line appeared to be the High Throughput X-ray Spectroscopy mission, whose related technologies were well linked to the developments already carried out on Exosat and were being further studied within the framework of the assessment study of the XMM mission. Beyond the first two Cornerstones, the situation became blurred. The Planetary Cornerstone had by and large not been defined, except for its paramount goal, i.e. the return of pristine material from a comet nucleus.[610] The contours of the mission and the intermediate steps necessary to achieve this goal were still unknown, the potential for international cooperation was to be explored in order to remain within the 400 MAU cost limit. The enabling technologies (solar electric propulsion, landing and sample acquisition, sample return) were far from ready. Finally, the Heterodyne mission, for which the FIRST project was a possible candidate, was technologically within the reach of Europe, thanks to the expertise which would be gained by the development of the ISO mission. However, this Cornerstone was the one that would benefit most from the space station facilities, both for assembly in space and for servicing its cryogenic system. Its more precise definition would therefore only be possible when a more realistic and practical appraisal of the space station capabilities and characteristics was available.

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607 R. Bonnet, letter to "wide scientific community", 6 February 1985, *D/Sci Archive*s.

608 SSAC, 39th meeting (14-15 March 1985), SSAC/MIN/39, 10 June 1985.

609 This paragraph is based on a draft document, coded SSAC(85).... and dated 8 March 1985, which was prepared by the Directorate of Scientific Programmes in view of the SSAC discussion. It was to be issued as SSAC(85)1 but was eventually withdrawn: *D/Sci Archives*.

610 The objective of returning a comet nucleus sample was confirmed by the SSWG in May 1985, after a meeting of the European members of the ESA/NASA Primitive bodies Science Study Group: SSWG, 48th meeting (21-22 May 1985), SOL(85)4, 23 September 1985 and SOL(85)2, 22 May 1985.

After this preliminary discussion, the SSAC agreed in principle that the STSP Cornerstone, including the development and launch of both SOHO and Cluster, should be recommended to the SPC for approval in February 1986. This, of course, implied the abandonment of Kepler, formally still in competition with these two missions, and the rescheduling of a new selection for a small/medium class project in 1987-88. The decision was not however taken without some conflict. One of the new SSAC members, M. Ackerman, did not like the "inferiority situation" in which Kepler had found itself as a consequence of the introduction of the STSP Cornerstone and insisted that the Mars mission should be maintained in the selection cycle. "There had been a failure on the side of ESRO not to go into the planetary field. The same thing was now happening with Kepler", Ackerman argued. To this, Bonnet replied that the Executive would offer the SPC the choice between implementing the STSP as a whole or selecting one of the three projects in competition (SOHO, Cluster and Kepler), but stressed that "if the Executive could implement the STSP Cornerstone within 400 MAU, it would do so unless the SSAC expressed a strong negative opinion on this approach".[611]

The scientific communities interested in solar and space plasma physics reacted very favourably to this course of action: about 200 scientists participated in a Workshop on Future Missions in Solar, Heliospheric and Space Plasma Physics organised by ESA in Garmisch Partenkirchen, Germany, from 30 April to 3 May 1985.[612] The supporters of Kepler had a good card in their hands, however, i.e. the high cost of the twin SOHO/Cluster mission, well above the 400 MAU ceiling. The STSP concept, in fact, implied that these two existing major projects had to be fitted into the financial envelope allotted to a Cornerstone. In its implementation plan for Horizon 2000, presented to the SSAC and the SPC in October 1985 and endorsed in principle by both committees, the Executive had assumed that, in the case of the STSP Cornerstone, a 10 to 15% contingency margin should be allocated above the "canonical" 400 MAU envelope, but the cost to completion estimated at the end of the Phase-A study turned out to be significantly higher that the allocation outlined in the plan, up to more than 550 MAU, not including the launch vehicles as it was assumed that free launches would be obtained from NASA in the framework of the ISTP programme.[613] A drastic reduction of costs was a *sine qua non* for having the STSP Cornerstone approved, which implied a severe descoping of the mission, i.e. a reduction of the SOHO payload and/or the number of Cluster spacecraft.

The SSAC found itself in a very difficult situation. On the one hand, it was doubtful whether such a descoped mission would be worthwhile from the scientific point of view (the alternative of flying only one fully-fledged mission was considered but discarded). On the other hand, the NASA contribution was not yet confirmed and depended on the approval of the ISTP programme. If the launcher were to be purchased at full cost, the additional funds required could amount to approximately 200 MAU (a free ride on an Ariane-5 qualification flight was also considered, but this possibility could not be taken for granted at this stage). After a dramatic discussion on the various options, the SSAC agreed that an STSP mission consisting of a descoped SOHO and a three-spacecraft Cluster should eventually be pursued, which still implied an estimated cost of 460 MAU, not including launches. Assuming that the scientific value of this option would be confirmed (with a three-spacecraft Cluster mission, three-dimensional structures of the plasma environment could no longer be obtained), this option had two main advantages. Firstly, it would not lead to any delay and the scheduled decision in February could be maintained. Secondly, this approach would give a further two-year period before substantial expenditure would be entered into, during which, if the USA came to a positive decision on the ISTP programme, the financial burden on ESA could be reduced and the SOHO/Cluster mission could be brought back to the original concept. "A very difficult situation was being faced", Bonnet recognised,

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611 SSAC/MIN/39, *cit.*, p. 6. The SSAC membership had been partially renewed in 1985, with J.L. Culhane (UK) replacing F. Pacini (I) as AWG chairman, and M. Ackerman (B) and M. Dobrowolny (I) replacing Fredga, Völk and Gabriel.

612 *Future missions in solar, heliospheric & space plasma physics*, ESA SP-235, June 1985.

613 The Executive's implementation plan for Horizon 2000 was presented in ESA/SPC(85)11, 28 October 1985. It was discussed by the SSAC at its 41st meeting (25 October 1985), SSAC/MIN/41, 20 November 1985, and SSAC(85)5, 25 October 1985; and by the SPC at its 40th meeting (1-19 November 1985), ESA/SPC/MIN/40, 23 December 1985, and ESA/SPC(85)18, 20 November 1985. See also Huber et al. (1996), p. 32.

stressing how essential it was that "the scientists and governments who had approved Horizon 2000 and who had confidence in it should not lose faith. Extreme care should be taken not to jeopardise their decision". That same day, defending the Executive's implementation plan in front of the SPC, he confirmed that the 400 MAU ceiling (including contingency) remained a key element of the Cornerstone concept, but an exception had to be made for the STSP in view of its double mission nature and for which an additional contingency margin was in fact provided.[614]

In view of the February 1986 decision, the scientific community, together with ESA's scientific advisory bodies and the SPC delegates, were called to participate in a conference in Darmstadt, on 7-8 January, to discuss the three missions for which a Phase-A study had been completed and were ready for selection (SOHO, Cluster and Kepler), and the new mission proposals to possibly be submitted to Phase-A study for the next selection in 1988. In the first case, the real issue was the choice between the double SOHO/Cluster mission as the STSP Cornerstone project or the Kepler Mars orbiter as a medium-class project. In the second case, three proposals were on the table: the contribution of a European Titan probe to the NASA Cassini mission to Saturn, the far UV mission Lyman (in collaboration with NASA) and the VLBI mission Quasat (for which international collaboration was still to be defined). Following the conference, the Solar System and Astronomy Working Groups made their recommendations on the projects, within their terms of reference, and the SSAC its own recommendation to the Director of the Scientific Programme. The latter would eventually present his proposal to the SPC for the final decision.

The SSWG unanimously agreed to recommend the STSP programme as the first step in the implementation of Horizon 2000:

> *SOHO and Cluster as a joint programme will represent a major breakthrough in the study of solar-terrestrial physics. This programme offers new opportunities for cross-fertilisation among disciplines which have reached maturity, and are ready to undertake a multi-disciplinary approach to this complex subject.*[615]

The Working Group regretfully recognised that the Kepler mission could not be given preference over the STSP Cornerstone, but acknowledged that a large part of the Mars science that could be accomplished by Kepler would be done by two approved US and USSR missions (Mars Observer and Mars Phobos).

In the SSWG resolution's annex which outlined the STSP programme, Cluster was described as a four-spacecraft mission, according to the specifications given in the Phase-A study report, whose main objective was "to study quantitatively and in three dimensions the small-scale structure of the plasma phenomena in the Earth's environment". This was, at that time, more wishful thinking than a concrete possibility. In fact, the Working Group recommended that ESA should set up a special STSP Advisory Group (STPAG), including a small group of senior scientists, with the task of advising the Executive on the necessary cost reduction exercise while maintaining, at the same time, the scientific value of the mission. The SSAC, for their part, fully endorsed the SSWG recommendation, emphasising that "the start of the STSP is crucial to the initiation of the science long-term programme Horizon 2000, which is part of the ESA Long-Term Programme and which has the support of the scientific community". The Committee recognised that this programme needed to be reduced further in order to reach a value compatible with the constraints of the Horizon 2000 implementation plan, and urged the Executive "to pursue vigorously the cost reduction exercise along the lines the it [had] identified".[616] As a matter of

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614 SSAC, 42nd meeting (19 November 1985), SSAC/MIN/42, 26 November 1985, p. 6. SPC, 40th meeting (18-19 November 1985), ESA/SPC/MIN/40, 23 December 1985, and ESA/SPC(85)18, 20 November 1985.

615 SSWG, 50th meeting (9 January 1986), SOL(86)3, 30 April 1986, and SOL(86)2, 9 January 1986, annex 1, p. 2.

616 SSAC, 43rd meeting (10 January 1986), SSAC/MIN/43, 3 February 1986, and SSAC(86)1, rev. 1, 10 January 1986.

fact, the SOHO/Cluster mission which the Executive submitted to the SPC for approval still remained undefined as regards its actual configuration and costs: pending NASA decisions on the ISTP programme it was presented as a purely European version, "which relies on European launch systems [i.e. Ariane-5 demonstration flights] and data networks".[617]

The SPC met on 6 February 1986, in the aftermath of the dramatic accident which had destroyed the Challenger Shuttle, killing its crew (28 January). This event threw a new shadow on the STSP programme: firstly, because SOHO was assumed to be eventually launched on the Space Shuttle, whose immediate future was now unpredictable; secondly, because of the consequences the accident would have on NASA's budget and then on the American contribution to the ISTP programme. This situation notwithstanding, all SPC delegations finally approved the adoption of the STSP double mission into ESA's Scientific Programme, with the understanding that every effort should be made in order to keep its costs within the limits of the Cornerstone established envelope, i.e. 460 MAU plus contingency in this special case, and that the SPC should be regularly informed of the progress of ESA/NASA negotiations. In this perspective, the SPC reserved the right to confirm its approval after discussing the result of the cost reduction exercise from both the financial and the scientific point of view.[618]

In the event, a tentative agreement was reached with NASA in October that year, by which ESA would develop four identical Cluster spacecraft, one of which would be launched by NASA in 1993 into an equatorial orbit, thereby replacing NASA's "Equator" ISTP satellite now cancelled, and the three others would be launched in 1994 (free of charge) on an Ariane-5 demonstration flight. The first spacecraft would then be moved to join the others, thus completing the planned Cluster fleet. ESA would also develop the SOHO spacecraft (including payload integration) for which NASA would provide testing, launch services and operations. European and US experiments would be included in SOHO and the first Cluster spacecraft.[619] This scenario, the SSAC remarked, would fulfil the scientific goals of the STSP Cornerstone, while remaining within the established financial envelope. The SSAC members were aware that no full guarantee on the part of the American space agency was yet available; indeed the negative experience of the ISPM mission was still too fresh in the memory. Hence their conclusion:

> *The SSAC underlines that with this scenario ESA assumes a pivotal role in the establishment of the international collaboration on ISTP. The SSAC stresses that [this scenario] is contingent on a firm commitment by NASA before October 1987 [by the signature of a Memorandum of Understanding]. Failure to obtain this would lead ESA to opt for a purely European project. This may eventually entail a choice between the two components of the STSP Cornerstone.*[620]

This approach was approved by the SPC.[621] Later on, however, it became clear that combining the scientific mission of the Equator satellite with that of Cluster introduced a high element of technical risk into the programme, consequently it was agreed to drop this option. All four Cluster spacecraft were then accommodated in one Ariane-5 vehicle. The cost aspect was however still open, as by November 1987 the estimated cost to ESA of the STSP programme was still 500 MAU. It was then decided that the best approach for achieving further economies would be a joint effort by the ESA project team and the scientific community, represented by a small committee chaired by H. Balsiger, from the University of Bern.

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617 ESA/SPC(86)1, 20 January 1986.

618 SPC, 41st meeting (6-7 February 1986), ESA/SPC/MIN/41, 17 March 1986.

619 ESA/SPC(86)21, 31 October 1986. This scenario also included the possible contribution of one or two additional Cluster spacecraft from the USSR Space Research Institute IKI.

620 SSAC(86)4, 20 October 1986, resolution adopted at the 45th SSAC meeting (8 October 1986), SSAC/MIN/45, 18 November 1986.

621 SPC, 43rd meeting (17-18 November 1986), ESA/SPC/MIN/43, 10 January 1987.

A very detailed and careful joint review of all project costs and cost-estimating history was conducted, and several economies were introduced into the project team. This resulted in a total STSP estimate of 484 MAU (1984 economic conditions), compared with the SPC's revised limit of 460 MAU. After further cost surgery, the final cost presented to the SPC amounted to 474 MAU, a figure that it found acceptable.[622]

During this period, ESA and NASA issued a joint Announcement of Opportunity to the European and US scientific communities (March 1987). About 40 experiment proposals were received and then evaluated by a Joint Evaluation Committee. The payloads for both missions were eventually announced by ESA and NASA in March 1988: eleven instruments were selected for Cluster and twelve for SOHO.[623] The two agencies also worked out a Memorandum of Understanding (MOU) whose final version was signed in November 1989. It foresaw the launch of SOHO by an American Atlas-II vehicle in March 1995 and the launch of all Cluster spacecraft by an Ariane-5 qualification flight in December 1995. A Scientific Programme was also defined in the MOU, with equitable shares of the scientific investigations and mission elements.[624]

Before concluding this section, a word must be said regarding the proposals for future missions discussed in Darmstadt. All three missions under consideration were recommended by the Working Groups for Phase-A study, the Titan probe for the Cassini mission by the SSWG and Lyman and Quasat by the AWG.[625] The SSAC agreed that the two astronomy projects, Lyman and Quasat, should be the subject of Phase-A studies during 1986, while the study on Cassini should be deferred until 1987, pending a clarification of NASA's planning for planetary missions.[626] Later on, however, NASA informed ESA that because of budgets cuts, in the wake of the Challenger accident, they could no longer consider the Lyman and Quasat projects for the present. On the contrary, Cassini was receiving full support by the American scientific community and high priority had been given to this mission for launch in the 1995-96 launch window. The SSAC then recommended that a Phase-A study should immediately be initiated on Cassini, which therefore remained the main candidate project for the 1988 selection. A descoped configuration of Lyman and Quasat was also kept under study, while discussions were initiated with the Australian and Canadian space organisations for possible cooperation.[627]

5.8 Epilogue

It is not the historian's task to follow further on events that belong to this decade's story and to present future planning. It is, however, worth recalling that the Infrared Space Observatory (ISO) was successfully launched by a dedicated Ariane vehicle on 17 November 1995, more than two years later than the original schedule.[628] The main reason for the delay was the emergence in 1992 of major technical problems in the telescope and the liquid helium valves for the cryostat. On the one hand, the first flight model telescope had to be rejected due to excessive contamination and blemishes on its primary mirror, and a new one had to be built using the spare mirror. On the other hand, three different types of cryogenic valves were produced and then submitted to parallel evaluation and testing in order to select the type to be used inside the cryostat. This constituted the bulk of the payload module, its function being that of keeping the 60 cm-diameter telescope and the four scientific instruments at very

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622 Huber et al. (1996), p. 34.

623 V. Domingo et al. (1988).

624 ESA, *Annual Report*: 1989, 18-22. Both missions are described in detail in several articles in *ESA Bulletin*, No. 84 (November 1995), 81-149.

625 SOL(86)2, cit; AWG, 57th meeting (9 January 198), ASTRO(86)4, 27 January 1986, and ASTRO(86)2, 9 January 1986.

626 SSAC(86)2, 10 January 1986.

627 SSAC, 45th meeting (8 October 1986), SSAC/MIN/45, 18 November 1986, and SSAC(86)6, 20 October 1986; 46th meeting (5 February 1987), SSAC/MIN/46, 27 March 1987, and SSAC(87)2, 5 February 1987. See also ESA/SPC(86)24, 28 October 1986, and ESA/SPC(87)5, 18 February 1987.

628 A detailed description of the ISO mission appears in *ESA Bulletin*, No. 84 (November 1985), 43-80.

low temperature (2 – 4 K). The satellite was injected into a 24-hour period, nearly equatorial, highly eccentric elliptic orbit and was operated from ESA's Villafranca ground station, near Madrid. It provided useful scientific data until the end of its planned lifetime, in May 1988.

The development phase of SOHO and Cluster started in 1991, both contracts being signed in July that year with Matra and Dornier, respectively. At the same time, the Ariane Programme Board formally selected Cluster as a passenger on the second qualification flight of Ariane-5 (flight V502), scheduled at that time for late 1995 and then in accord with the scheduled Atlas flight due to carry SOHO into orbit in July. Delays in the Ariane-5 programme development, however, made this launch window only available for the first qualification flight (V501). In the event, SOHO was successfully launched on 2 December 1995 and, after a good insertion into the requisite transfer trajectory towards the L1 Lagrangian point, the spacecraft successfully began its mission. SOHO, in fact, operates in a "halo" orbit around L1, the point where the gravitational forces of the Sun and the Earth balance each other, at a distance of 1.5 million km from Earth (i.e. one hundredth of the Sun-Earth distance). In this orbit, the spacecraft remains almost stationary with respect to both bodies, thus providing a perfect vantage point for solar investigations.[629]

The Cluster launch was rescheduled for mid-1996 but, on 4 June that year, the four spacecraft were lost in the explosion which destroyed the first Ariane-5 vehicle soon after lift-off. In the aftermath of this painful event, the SPC approved the procurement of a fifth Cluster spacecraft, named *Phoenix*, based largely on spare units from the original Cluster programme, to be launched as a passenger on an Ariane-4 vehicle in December 1997. Subsequently, however, the SPC agreed that three new Cluster spacecraft should be built and all four should be launched in two pairs on separate Soyuz vehicles in mid-2000 (Cluster-II programme). The total cost of this programme was to be maintained within a financial envelope of 214 MAU, including a contribution to member state institutes to support the development of new payloads.[630]

In November 1988, the SPC selected the European participation in the NASA Cassini mission to Saturn as ESA's new scientific project and the first medium-size mission in the Horizon 2000 plan. This foresaw the development in Europe of a probe, named *Huygens*, to be carried by the Cassini Saturn Orbiter and released towards Saturn's Titan moon. Huygens was then to descend in the atmosphere of Titan by the use of a system of parachutes, conducting experiments both in the atmosphere and on the surface. The Cassini/Huygens mission wonthe competition against four other projects, i.e. the Quasat and Lyman missions already under study since 1983 and now foreseen as collaborative projects with NASA and Canada, a joint CNES/USSR/ESA mission to asteroids and comets (*Vesta*), and a gamma-ray astronomy mission (GRASP).[631] The Cassini/Huygens composite spacecraft was successfully launched by an Atlas vehicle on 15 October 1997, thus starting a long journey that will take it to Saturn and its moons in 2004.[632]

During this period, progress was also realised in the implementation of the other Horizon 2000 Cornerstones. The X-ray spectroscopy mission XMM was confirmed in 1991 as the second Cornerstone to be implemented, its launch being foreseen for late 1999.[633] This decision probably affected the choice in 1993 of the second medium-class project, the large gamma-ray observatory *Integral*, based on a service module common to XMM and conceived as a joint project between ESA,

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629 Vandenbussche (1996).

630 Credland & Schmidt (1997).

631 All these projects are described in detail in *ESA Bulletin*, No. 55 (August 988), 8-40.

632 A dscription of the Huygens/Cassini mission is in *ESA Bulletin*, No. 92 (November 1997), 17-68.

633 De Chambure et al. (1997)

the Russian Academy of Sciences (a Proton launch vehicle) and NASA (ground segment support). XMM is now scheduled for launch in early 2000, Integral in 2001.[634]

The two mission proposals for the other Cornerstones had to be reduced in scope because their projected costs were outside the allocated budget. For the cometary mission, named *Rosetta*, the concept of returning a sample from a comet to Earth was abandoned after the NASA decision not to support the envisaged cooperation. A purely European venture was then approved by the SPC in 1993 as the third Cornerstone of Horizon 2000, foreseeing a rendezvous mission to comet Wirtanen including the release of a Lander for surface science investigations. The launch is scheduled for January 2003 on board an Ariane-5 vehicle, with rendezvous with the comet in 2011 up to the perihelion passage in 2013. [635] The fourth Cornerstone project, the sub-millimetre astronomy mission FIRST, whose very advanced technologies required a long preparatory work (with a planned launch in 2007), suffered from the Cluster accident and the ensuing decision to embark on the Cluster-II programme. Present study activity is devoted to a possible cost-saving combination of FIRST with the "Planck" mission, a medium-class project selected in 1996 and aimed at measuring the Universe's microwave background radiation with great accuracy.

5.9 Concluding remarks

During the last forty years, science has been a pivotal element of Europe's effort in space, despite the minor weight the Scientific Programme has in the overall ESA budget (less than 13% in 1997). The appeal of space research was the main rationale for Western European governments agreeing to set up ESRO in the early 1960s, and the success of this "Space Research Organisation" compared to the failure of ELDO to achieve its goals has been the basis for the eventual establishment of the European Space Agency's technical and institutional infrastructure. ESA's Scientific Programme, the only mandatory activity for all member states, has been, according to many participants in the history of Europe in space, the real glue which kept together so many different nations (small and big countries, with unequal industrial capabilities, with and without national space programmes, embedded in different systems of international relations) in such a demanding collaborative undertaking, against the centrifugal pull of diverging and often conflicting interests. In the words of the Swiss scientists advocating government approval of Horizon 2000:

> *It is largely due to the Scientific Programme and the active support of the science community that ESA has developed, at least to some degree, into a truly European organisation.*[636]

Two main turning points can be recognised in the historical development of European space research in the ESRO/ESA framework. The first was the transition from ESRO to ESA, marked by the two "package deals" of December 1971 and July 1973, when science definitely lost its linchpin position within the joint European space effort, in favour of application satellite programmes, manned platforms and launcher development. Funds devoted to space science programmes dropped dramatically compared to the previous ESRO period, remaining essentially at a constant level during the following twelve years. Scientists managed to cope with the ensuing budgetary difficulties by carefully selecting the new projects after severe competitive procedures, by protecting their traditional domain of "pure science" disciplines (i.e. astronomy and Solar System sciences) from the intrusion of the new "application oriented" research fields (i.e. microgravity science and Earth observation) and by seeking collaborative ventures with NASA, the latter often resulting in disappointing experiences.

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634 Competing projects with Integral were a stellar observatory (Prisma), a spacecraft (STEP) to test the "equivalence principle", in cooperation with NASA, and a contribution to a large network of surface stations on Mars planned by NASA (Marsnet). These are described in Bonnet (1991). The scientific mission of Integral is presented in Clausen & Winkler (1994).

635 SSAC(93)7, 24 September 1993. For the evolution of the Rosetta mission concept, see Atzei et al. (1989), Schwehm & Hechler (1994), Verdant & Schwehm (1998).

636 Geiss, Huber and Tamman's letter of 12 November 1984 to fellow space scientists, *cit.*

The second turning point was the preparation and eventual approval of the Horizon 2000 long-term plan which we have discussed in this paper. While finally winning more funds for ESA's Scientific Programme from reluctant member state governments, Horizon 2000 introduced an element of stability in its development, against the unavoidable casualness implied in the former selection procedure.[637] Prior to the existence of this plan, the selection procedure consisted of periodically calling for mission proposals from the wide European scientific community, which were then analysed by the Agency's various advisory bodies and eventually submitted to feasibility studies in industry. The final selection was the result of generally fierce competition, whose outcome could hardly be envisaged. This method was very successful in providing a continuous injection of new ideas into ESA's Scientific Programme and in keeping up with the rapid evolution in the various areas of space science. Moreover, the competition usually led to a good end product, in terms of originality and scientific worth of the winning projects. It also had two disadvantages which became apparent in the early 1980s. The first was that ESA and the scientific community were not in the position to know what their programme would be before the competitive selection had been accomplished. Consequently, no long-term planning was possible, both regarding the necessary preparatory technological development and in the discussions with NASA on possible cooperative ventures. The second disadvantage, dramatically coming into evidence with the result of the 1982 call for mission proposals, was that ESA was prevented from undertaking those very ambitious missions, in terms of scientific interest and technical challenge, that the scientific community considered as pivotal for the last decade of the century. Whence the rationale for undertaking the long-term planning exercise that led to Horizon 2000, an exercise which was also very timely in view of the preparation of the overall European Long-Term Space Plan.

Two main elements can be recognised in the new framework which emerged from the Horizon 2000 plan. The first is the important role now assumed by ESA's Directorate of Scientific Programmes *vis-à-vis* the European space science community. "This was the first time that the SSAC was talking of an implementation plan", Bleeker remarked when his Committee started discussing the Executive's plan for Horizon 2000.[638] The main guidelines for the next 20 years were now firmly established and no doubt the element of rigidity introduced by the Cornerstone projects, whose development was essentially controlled by Bonnet's Directorate, were due to prevail over the flexibility inherent in the usual selection procedure for the smaller projects, in which the scientific community and SPC delegations had the major role. In fact, the "essential tension" between these two elements of Horizon 2000 was evident in many SPC discussions, with delegations stressing the plan's balance between Cornerstones and small/medium-class projects and insisting that the share of expenditure devoted to the latter should not be swallowed by the financial requirements of Cornerstone development.[639]

The second element is the stronger position of ESA *vis-à-vis* its American counterpart. The establishment of a solid programme framework extending over two decades changed the shape of international cooperation, as it was clear that the Cornerstones had to remain under ESA leadership and be consistent with ESA's own technical and financial means, with cooperation bringing new, added capabilities to these European missions. Some risks could still be taken at the level of small- and medium-sized projects (such as the Huygens/Cassini probe), but European space scientists did not want to suffer again from such "outrages" as the ISPM story. ESA wanted to be "master of its own future and not be dependent upon decisions taken outside its own control".[640]

We can now conclude our story with one last consideration. The optimism of the Rome and The Hague ministerial meetings proved illusory, not because of planning mistakes but because of the impact of great historical events. The end of the Cold War and the reunification of Germany changed dramatically the political and financial framework in which the Long-Term European Space Plan had

637 Bonnet (1985).
638 SSAC/MIN/39, *cit.*, p. 6.
639 See for example ESA/SPC/MIN/40, *cit.*, pp. 3-7; SPC, 44th meeting (9-10 March 1987), ESA/SPC/MIN/44, 30 March 1987, pp. 5-8. These meeting were devoted to discussions of the Executive's first and updated implementation plan, respectively.
640 Bonnet (1995), p. 10. See also Lüst (1987).

been worked out and approved. The Plan's most ambitious projects had to be drastically retrenched or even abandoned, while member state governments embarked on difficult discussions on a new mission for ESA in a political world marked by severe budgetary constraints in Europe and the USA, by the emergence of possible larger collaborative ventures with Russia, and by a new *involvement* of the European Union in space matters. Within this complex new framework, the intrinsic merit and the successful development of the Scientific Programme again represented, as during past difficulties, the strongest element of stability and confidence.

Chapter 6: The Third Phase of the Telecommunications Programme: ECS, Marecs and Olympus

A. Russo

International space cooperation is not a charitable enterprise; countries cooperate because they judge it in their interest to do so.
K. Pedersen
Former NASA Director of International Affairs [641]

The origin and early development of ESRO/ESA's telecommunications satellite programme have been discussed in Chapters 9 and 10 of Volume 1. The programme was approved in principle by the ESRO Council in December 1971, after five years of preliminary studies, within the framework of the first "package deal". Its overall aim was to develop a communications satellite meeting the needs of the European Conference of PTT administrations (CEPT) and the European Broadcasting Union (EBU). This included the routing by satellite of a sizeable portion of the total amount of intra-European telephone traffic managed by the PTTs, and the total replacement of the terrestrial circuits for the EBU Eurovision system. In September 1973 the so-called "Telecom Arrangement" entered into force, i.e. a formal agreement between ESRO and the governments of the nine participating member states, defining the institutional and financial aspects of programme implementation. In fact, all ESRO member states but Spain agreed to participate, their delegates sitting on the Communications Satellite Programme Board.

According to the Telecom Arrangement, the programme was split into two phases. The first phase, called Phase-2 as it followed the study phase developed in the period 1971-1973 (labelled Phase-1), was essentially devoted to the development of an experimental satellite, called OTS (Orbital Test Satellite), whose launch was planned for the end of 1976. The participating states agreed to finance this phase on the basis of a firm financial envelope of 115.1 MAU (at 1972 prices), the scale of contributions being essentially based on their gross national products (GNP), but with two important limitations. Firstly, no country was to contribute more than 25% to the programme; secondly, the Netherlands contribution was fixed at 2.5%, i.e. about half the amount resulting from the GNP formula.[642]

The following phase (Phase-3) was to be devoted to the development of two flight units of the operational European Communications Satellite (ECS) to be delivered to the users; one in orbit, the launch being foreseen for 1980, the other on the ground. The financial envelope of this phase was estimated at 160 to 283 MAU, depending on the configuration of the satellite and on the possible additional launching of a prototype. Decisions on the start, precise content and financial envelope of this phase were to be taken in 1975 or 1976 by a *double two-thirds majority*, i.e. a two-thirds majority of participating states representing at least two-thirds of contributions.

With the approval of the second "package deal", in 1973, a new element was added to ESRO's (eventually ESA's) telecommunications satellite programme, namely the Marots project. This was an experimental satellite for maritime communications based on the OTS platform, to be launched by end 1977. Eight member states (Belgium, France, Germany, Italy, Netherlands, Spain, Sweden and the United Kingdom) plus Norway supported the Marots programme, whose financial envelope was established at 75 MAU (1973 prices). The United Kingdom provided by far the largest contribution

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641 Quoted in Logsdon (1984), p. 16.

642 The initially agreed on contribution scale is reported in Table 8 of chapter 10 in Volume 1. This was slightly revised subsequently, as reported in ESRO/PB-TEL/XIV/Res. 1 [28 February 1975] and ESA/JCB(77)38, 2 November 1977.

(about 56%). A Maritime Satellite Programme Board was initially set up as the body responsible for directing the Marots programme, but in June 1975 the ESA Council decided that a Joint Board on Communication Satellite Programmes (JCB) should be set up, responsible for directing both the OTS/ECS and Marots programmes.[643]

Although Marots was originally conceived as an experimental satellite, its design had, from the very beginning, taken full account of the guidelines for operational satellites evolved by the Intergovernmental Maritime Consultative Organisation (IMCO), under whose aegis discussions on a global maritime satellite system had been proceeding for some years. In particular, it was envisaged that a new international organisation, named Inmarsat, should be created to implement and manage such a system. At an Intergovernmental Conference on Maritime Satellites, held in London in February 1976, Marots was offered by the states participating in the programme as part of an embryo maritime satellite system prior to the establishment of the Inmarsat system. This system would include Marots, positioned over the Indian Ocean and operated by a newly created organisation of the European PTT administrations called Eutelsat, together with two American Marisat satellites, positioned over the Atlantic and Pacific Oceans and operated by Comsat General Company.[644]

In this chapter we shall discuss the development of ESA's communication satellite programmes in the period 1976-1981, i.e. from the first discussions on the content of the Telecom Programme Phase-3 until the approval of the Olympus programme. Three parallel stories are to be analysed in this framework. First is the ECS project itself, i.e. the logical follow-up of the OTS programme and the basic space segment element of the envisaged European communications satellite system. The approval of the ECS development programme by ESA member states depended on a clear commitment from the PTT authorities represented in the CEPT to eventually use the system, i.e. to procure, operate and maintain the whole space segment (four to five satellites), as well as to implement the necessary Earth segment elements (20 to 25 ground stations and associated network). While interested in the research and development programme conducted by ESA in the framework of the OTS programme, the future users of the ECS system were not at all convinced of the economic viability of satellite communications in Europe, and insisted that governments should subsidise the use of the system in the first phase of operation.

The second story concerns the development of the Marots programme, eventually renamed Marecs. In this case, an interested user community did exist, which in fact drove the programme towards the development of an operational satellite which could be offered on the world-wide market of maritime communications satellites. Several players were active in this market, however, including American industry, telecommunications authorities from all over the world, and non-member-state governments. In the event, Marecs was the first European satellite which won a place in the international market for commercial satellites, but the harsh opposition of the US Inmarsat signatory made the end of the story less successful than had been expected.

Finally, we shall follow the story of the H-Sat (Heavy Satellite) project, a proposal for a new communications satellite programme aimed at qualifying European industry in the future market for direct television broadcast satellites. This was hardly a success story, as we shall see. In fact, diverging opinions and interests among ESA member states, regarding both the satellite's mission and ESA's industrial policy, led eventually not only to the abandonment of the H-Sat project, but also to the end of the joint European approach to communications satellite programmes. In fact, ESA's new Olympus programme was not supported by France and Germany, which instead decided on a bilateral programme to develop an operational direct broadcast satellite.

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643 ESA/JCB-C(75)6, 4 August 1975. It was also envisaged that the JCB should eventually take responsibility for the aeronautical satellite programme (Aerosat).

644 ESA Annual report 1976, 35-38; ESA/JCB(76)33, 29 October 1976, annex II. See also Dumesnil (1981), Galligan (1981). Three Marisat satellites had been developed by Hughes Aircraft Company for Comsat and were scheduled for launch in 1976, their main user in the first period of operation being the US Navy.

The unifying theme which underpins these three stories is the critical passage from research and development activity to commercially oriented programmes. As an R&D organisation, ESA was essentially driven by the need to provide the technology push for qualifying the European space industry. As a multinational organisation, the Agency was bound to comply with the fair-return industrial policy which formed the core of the solidarity link between its member states. However, in order to transform a good technology into a successful commercial product (such as a communications satellite, the Ariane launcher, or Spacelab), two conditions must be fulfilled: firstly a strong market pull capable of supporting a viable work level in industry; secondly, a competitive price *vis-à-vis* similar products available on the market. Both conditions were far from being realised in Europe in the late 1970s and early 1980s, as regards satellite telecommunications. Satellite links for telephony services were not considered economically attractive by European operators, as the heavy investments required in the Earth segment substantially exceeded the savings in the terrestrial network. Direct broadcast had a still uncertain future and one could hardly foresee at that time the dramatic growth of direct-to-home and cable television prompted by the success of the Astra system. Even where a demand did exist, as in the case of global maritime communications, the market was rather limited (only few satellites were required) and highly competitive. This situation implied that, as in the case of Ariane and Spacelab, ESA member states needed to make a vigorous promotion effort in order to have the new space technology, developed in the framework of the Agency's programmes, moved to the commercial sector. This promotion effort was successful in the case of Ariane; it was not even implemented in the case of Spacelab; it was painfully accepted in the case of ECS (by subsidising satellite procurement and operation) and Marecs (by accepting marginal cost payments for ESA services); it was a nonsense in the case of Olympus.

As regards industrial policy, it was soon evident that the strict enforcement of the fair-return principle ran against the general objective of reducing costs. On the other hand, all Member States insisted that their industry should contribute as much as possible to the new development programmes, in order not to be left out of the future market. Interests diverged, of course. Those countries which had a more advanced industry argued that ESA's commercially-oriented projects should be based on the optimisation of industrial capabilities in Europe, avoiding interface costs and preventing the selection of "second best" companies in order to comply with the fair-return requirements. The others, on the contrary, insisted that the solidarity link embedded in the collaborative effort should not be relaxed in such a crucial passage as moving from research and development to commercialisation. A compromise was possible in the case of ECS, as it was to be implemented within the framework of the existing Telecom Programme, with a definite mission of Europe wide service. It was not possible in the case of H-Sat, where divergences emerged regarding the satellite mission (experimental vs operational) and only national services were envisaged.

6.1 Discussing Phase-3 of the Telecom Programme

In May 1976, the Executive presented to the JCB its proposal for Phase-3 of the Telecom Programme, covering the period January 1977 to end 1980. Its main objective, according to the 1973 Arrangement, was to develop the operational ECS spacecraft and to deliver two flight units to the CEPT, one in orbit and one on the ground. Alongside this objective, two other important lines of activity were suggested: a technology research programme in the area of communications systems, spacecraft subsystems and microwave technologies (eventually known as ASTP: Advanced Systems and Technology Programme); and the development of a spacecraft platform of the 800 kg class, compatible with the Ariane launcher, to be used in support of a wide spectrum of future communications missions such as a direct television broadcast satellite or a second generation ECS. It was foreseen that the first version of the heavy platform should be launched in December 1980 on the last qualification flight of Ariane, labelled L04, in association with a typical communications payload developed outside the framework of the Telecom Programme. A further and somewhat separate component of the programme was the procurement at low marginal price of an additional OTS platform, to be launched on a no-cost basis by the L03 Ariane qualification launch. This platform would be identical to that provided for the OTS and Marots spacecraft (a third platform was already under development as a back-up), but suitably modified for making it compatible with Ariane launch. It would support a communications payload funded from outside the Telecom programme.[645]

The feasibility of such a programme, the Executive explained, derived from three main reasons. Firstly, following the decision (taken in 1974) to use the more powerful Delta 3914 rocket for launching the OTS instead of the standard 2914 model, the OTS design had been upgraded, thus making the satellite much closer to an operational vehicle than initially expected. As a consequence, the development of the ECS could be carried out at substantially less cost than the guiding financial envelope planned in 1973. Secondly, the original estimates for Phase-3 had been rather conservative, while increased efficiency could now be assumed both within industry and within ESA. Finally, full advantage could be taken of the L03 and L04 Ariane qualification launches. All this made it possible to keep the overall cost estimate of the programme within the limit of the minimum figure of 203 MAU (at 1975 prices) originally envisaged in the Telecom Arrangement for Phase-3 (Table 6-1).

Table 6-1: First proposal for Phase-3 of the Telecom Programme

Programme elements	MAU (1975 prices)
ECS	85.65
Heavy platform	68.46
ASTP	36.20
L03 satellite	8.97
Contingency	3.72
Total	203.00

The Executive's proposal envisaged this phase as a necessary step in a long-term European R&D effort in space telecommunications, whose rationale was derived from three main considerations. Firstly, it was to be expected that by the second half of the 1980s, new applications would become economically and operationally attractive, in particular regarding direct television broadcasting to end users and specialised communications services (communications to offshore oil pumping facilities, data transmission and computer communication networks, remote printing, teleconference service, electronic mail, etc.). While the OTS/ECS programme was aiming at providing traditional services such as fixed-point telephony and television distribution, larger and more sophisticated satellites would be required by the end of the decade to meet the new demands.[646]

The second consideration regarded the future market for satellite communications. In addition to the established market of trans-oceanic communication services, institutionally covered by the Intelsat system, national and regional systems were also being set up, representing a new, rapidly expanding market for communications satellites and associated technologies. The first domestic systems in Canada and the United States had been operating since 1972 and 1974, respectively (Anik A and Westar satellites), while the first Indonesian communications satellite (Palapa A) was scheduled for launch in July 1976. Moreover, Japan, India, Australia, Brazil and the Arab countries had embarked on plans to establish national or regional systems. Thanks to the European OTS/ECS programme and the Franco-German Symphonie Programme, European space industry was reaching maturity, bridging the technology gap with the USA (ECS in fact would be comparable with the forthcoming Intelsat V satellite), and it could compete with American manufacturers in the new international market for satellite communications. In fact, the MESH industrial consortium, responsible for the OTS development, was tendering for the Brazilian communications satellite (Brasilsat) with a proposal based on a vehicle derived from the OTS platform. At the same time, the core industrial companies of the Symphonie programme, Germany's MBB and France's SNIAS (Aérospatiale), had succeeded in

[645] ESA/JCB(76)7(C), 20 April 1976, and ESA/JCB(76)7(C), corr., 11 May 1976. The financial and legal background of the Telecom Arrangement for Phase-3 is discussed in ESA/JCB(76)10(C), 3 May 1976.

[646] Howell & Hånell (1976); Rosetti (1976).

securing a substantial share of the Intelsat V development contract.[647] In the Executive's view, a continuing effort in research and development activities was required in order to ensure that the technology gap did not reopen, and to guarantee European industry a competitive position in the future fields of commercial applications.

Finally, the third consideration regarded the availability after 1980 of the Ariane vehicle, which would provide Europe with an independent launch capability into geostationary orbit. With unrestricted access to Ariane, the Executive argued, it was desirable to plan future satellite programmes around the capability of this European launcher, and according to the schedule of its production programme. The heavy platform programme was proposed in this light, its aim being the development of a multi-purpose spacecraft platform compatible with Ariane, to which a variety of different communication payloads could be attached. The parallel effort in spacecraft sub-systems, communication technologies and space transportation systems would lead the European aerospace industry to an early operational availability of large geostationary systems for the future world-wide market.

The JCB did not endorse the Executive's plan, three main arguments being raised by delegations.[648] The first concerned the still uncerta*in situ*ation regarding the future utilisation of the ECS system. While most PTT administrations had expressed themselves in favour of the implementation of the system, the economic aspects of its eventual operation were far from being settled.[649] A study prepared by CEPT's Comité de Coordination des Télécommunications par Satellite (CCTS) had shown that the costs of the satellite system would be significantly higher than the equivalent terrestrial circuits, even taking into account the ESA subsidies covering the cost of two satellites and one launch. The PTTs, in fact, were to provide for the construction and operation of the Earth stations, as well as for the replenishment satellites and launches needed to provide adequate transmission capacity over the period 1980-1990 (4 or 5 satellites were considered necessary to fulfil the CEPT communications needs in the decade).[650] For the CEPT to agree to use the ECS system, it was necessary that ESA (i.e. the space budgets in its member states) undertake to subsidise adequately the establishment of the system beyond the provision of the Telecom Programme and to guarantee that a given maximum cost for maintaining the space segment over a certain number of years would not be exceeded. Negotiations on these issues, whose economic implications were still to be assessed, were continuing between ESA and the CCTS (we shall deal with this aspect later).

The strongest opposition to the ECS project came from Germany, based on the Deutsche Bundespost's refusal to participate in the operational use of the ECS system. As a similar refusal had been expressed by the British Post Office, the German delegation argued, the expected volume of the international telephony traffic within Europe to be routed via the satellite system would amount to only 50%t of the total originally envisaged. For this requirement, the capacity of OTS would be wholly adequate until at least the mid-1980s and, therefore, ESA should simply undertake to plan the operational use of the OTS spacecraft, and to build two additional flight units (one in orbit and one on the ground) to cover the operational needs of the interested CEPT members over the whole decade. Much more interesting, according to the German delegation, were the prospects for maritime communications. It in fact proposed to extend the Marots programme by the construction of two additional satellites (one in orbit and one spare), in order to ensure the service continuity necessary for an operational maritime service.[651] The other delegations did not share this negative attitude and were generally in favour of undertaking the ECS programme as proposed by the Executive, but the majority of them considered that it was not possible to take a decision at such an early stage, pending the negotiations with the CEPT on the operational use of the system.

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647 ESA/JCB(76)21(C), 26 July 1976; Müller (1990), p. 250.

648 JCB, 5th meeting (13 May 1976), ESA/JCB/MIN/5, 4 June 1976.

649 ESA/JCB(76)8(C), 12 April 1976.

650 The results of the CCTS' economic analysis are summarised in the appendix of document ESA/JCB(76)18(C), 21 July 1976. The document itself presents the Executive's criticism of this study.

651 ESA/JCB(76)20(C), 20 July 1976. The Executive's commentary to the German proposal is in ESA/JCB(76)20(C), add. 1, undated (a hand-written note on this draft document specifies that it was not published).

The second argument regarded the further development of the telecommunications programme and the heavy platform proposal. According to the German delegation, the development of a multi-purpose platform suited to the Ariane launcher should be the main object of a forward-looking Phase-3 of the Telecom Programme, and it agreed with the Executive that this platform should undergo its first flight testing on the L04 launch, with payload elements provided by the member states. Most of the other delegations, on the contrary, felt it was premature to develop the heavy platform in time for the L04 Ariane launch. The French delegation, in particular, argued that only in 1980 would it have been reasonable to begin development of a new satellite platform, "with a view to having available a heavy experimental satellite in 1985 and an operational satellite in 1990".[652]

The third argument regarded the industrial policy aspects of the Telecom Programme, i.e. the implementation of the fair return concept in the geographical distribution of industrial contracts. The delegations of the smaller Member States were particularly sensitive to this issue. Switzerland, in particular, whose industrial return figure during Phase-2 had remained extremely low and would probably become even lower in Phase-3, noted that Swiss industry had been entirely left out of the MESH tender for developing the Brasilsat satellite: "The commercial benefits of the Agency's programmes [should] not be reserved to only some of the participants in the programmes", the delegation argued, insisting that the Executive should make every effort to remedy any imbalance in the geographical distribution.[653]

In conclusion, the JCB chairman summarised the discussion by stating that the Board had expressed little interest in supporting the OTS derivative platform and the heavy platform for the L03 and L04 Ariane launches, respectively, while no decision could be taken regarding the ECS project and the ASTP before September that year.

6.2 The H-Sat proposal and the telecommunications package deal concept

While the Executive was preparing its revised proposal for Phase-3, a new element had to be considered. On 10 July 1976, the Director General received a letter signed jointly by three important European aerospace companies, France's SNIAS, Germany's MBB and Belgium's ETCA, proposing to develop a multi-purpose satellite platform of the Ariane class, called Phebus X, preliminary studies of which were already under way with their own funding. More specifically, they wanted to involve the Agency in the implementation of this project, regarding both the technical specification of the platform and the realisation of an experimental payload for its first test flight on L04. The financial contribution required from ESA was estimated at a maximum of 30 MAU, not including the costs of adapting the platform to a specific payload or of developing and qualifying such a payload.

The three companies' proposal originated from their previous experience in the space field as core members of the COSMOS industrial consortium. Moreover, SNIAS and MBB had been the main contractors for the development of the Symphonie spacecraft, and the former was the industrial architect of the Ariane launcher programme. Phebus X was thus considered as the first step towards the future development and commercialisation of heavy communications satellites of the Ariane class. In order to pool the industrial property and to better coordinate the efforts, they envisaged setting up a new joint legal entity, eventually called Eurosatellite, which would supersede the COSMOS consortium. The Eurosatellite group was to be organised as a "Groupement d'Intérêt Economique" (GIE), seen under French law as a type of international association and already experimented with in the Airbus programme. Whereas the traditional consortia system was characterised by the prime

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652 ESA/JCB/MIN/5, *cit.* p. 7.

653 *Ibid*, p. 5. Industrial return figures for Phase-2 are reported in ESA/JCB(76)22(C), 28 July 1976.

contractor/subcontractor relationship, the GIE arrangement provided for joint sharing of management responsibility, risks and profits.[654]

Following the Eurosatellite proposal, the Executive worked out a new plan for Phase-3 of the Telecom Programme. It again included four lines of activities, two of which were the ECS programme and the ASTP as in the former proposal. A third line of activity consisted of the operational extension of the Marots programme, as suggested by the German delegation, foreseeing the construction of one or two additional satellites. Finally, there was a detailed proposal for a large experimental satellite, to be launched on L04 and intended as a forerunner of the operational broadcast satellites of the 1980s. This satellite, eventually called H-Sat, was based on the use of the Phebus X platform, supporting a payload for experimental tests in direct television broadcasting and high-power telecommunications. The cost of this project was estimated at 50 MAU, including 30 MAU to Eurosatellite for developing the platform and 15 MAU for the payload (Table 6-2).[655]

Table 6-2: New proposal for Phase-3 of the Telecom Programme

Programme elements	MAU (1975 prices)
ECS	85.65
Marots extension	40.40
ASTP	36.20
H-Sat	50.00
Contingency	8.00
Total	220.25

An important aspect of the envisaged H-Sat programme was that a major part of ESA's responsibility for its implementation would be transferred to industry, which implied, on the one hand, a reduction in the non-fixed common costs relating to the programme, but, on the other, that the Agency would not be in a position to impose any *a priori* geographical distribution on industrial contracts for the Phebus X platform. It was still possible to achieve a fair geographical distribution of contracts relating to the payload, the Executive explained, but it also insisted on two main points: firstly, "each advanced equipment should, if possible, be procured from the supplier or Agency whose development programme is the most advanced or whose relevant technology base is the soundest"; secondly, "a geographical distribution of work must be achieved that matches the interest and ability of the relevant countries to pay for the work given to their particular industry". In order to avoid any imbalance in the industrial return, it was proposed that each participating country should contribute to the costs of H-Sat in proportion to the amounts of the contracts received by its own industry (the "fair contribution" concept).[656]

The Executive's plan required a new legal framework for implementation. According to the 1973 Telecom Arrangement, in fact, the aim of Phase-3 was the development of the ECS satellite within an overall financial envelope to be agreed by the participating states by a double two-thirds majority. While the principle of flying a heavy platform for communications satellites on the L04 test launch had been accepted by the Ariane Programme Board and the Council in the framework of the APEX (Ariane passenger experiment) programme, the development of such a platform within the framework of the Telecom Programme could only be realised if all participants agreed on a liberal interpretation of the Arrangement, otherwise an additional protocol had to be negotiated. This was only part of the problem, however. Another legal arrangement covered the Marots Programme, which did not foresee

654 Müller (1990), p. 250. The letter from the three industrial companies is reported as annex I to ESA/JCB(76)23, 31 August 1976. A comprehensive survey of the European space industry in the late 1970s and early 1980s is in Dondi (1981). The evolution of the consortium concept is also discussed in Dondi (1980).

655 ESA/JCB(76)23, 31 August 1976.

656 *Ibid*, annex II, pp. 4-5.

any operational phase following the development and launch of the satellite, and whose participating states were not the same as in the Telecom Programme. The latter, in fact, did not include Spain and Norway, which however participated in Marots, and it included Switzerland and Denmark, which did not participate in the maritime satellite programme. New legal arrangements or protocols had therefore to be negotiated in order to cover both the extension of the Marots programme and its eventual inclusion in a comprehensive telecommunications programme. In conclusion, the Executive's proposal envisaged a kind of "package deal" in the communications satellite field, which required a general agreement between all ESA member states and a new legal framework, defining for each programme element the participating states, the technical content, the financial envelope and the contribution scale.[657]

The telecommunications package was discussed by the JCB at its September 1976 meeting and endorsed in principle, but with some reservations regarding three main topics. First was the opportunity to speed up the H-Sat project in order to comply with the time schedule of the L04 launch. Some delegations, notably Italy and the Netherlands, noted that "the main point seemed to have been not so much to work out a valid programme as to take advantage of the L04 flight, thus imposing very severe constraints on the timetable", and wondered whether the development of a heavy platform could be justified on the grounds of foreseeable requirements up to 1985. Second was the "revolutionary" nature of the proposed management method in relation to the critical issue of the Agency's industrial policy, which caused some concern among the smaller country delegations. Belgium, Denmark, Sweden and Switzerland expressed their support to the H-Sat project, but insisted that a satisfactory solution should be found in respect of the geographical distribution of industrial work. Italy stated that "the action proposed by the Executive would be unacceptable unless the Agency continued to exercise control in management and industrial policy matters as usual". Third was the question of the economic aspects of the operational use of the ECS system: no delegation was prepared to approve this part of the programme "unless the users undertook to use the system operationally on acceptable terms". The quotation is from the statement of the French delegation, the most convinced supporter of the ECS programme. Germany, for its part, repeated its arguments against the economic viability of the envisaged system, insisting that even if the PTT administrations in all member states were to participate in the programme, "the ratio between the cost of the space system and that of the Earth system during the ten-year period 1980-1990 would remain of the order of 2 to 3 to 1", and in Germany it would be even higher.[658]

In conclusion, the Board invited the Executive to prepare detailed proposals for each element of the programme, taking into account the legal aspects and the geographical distribution considerations. The Executive was also invited to place feasibility studies of H-Sat with interested industrial groups, "with a view of giving the programme an adequate European basis [i.e. acceptable geographical distribution of work], and so that the detailed content of this particular programme element may be approved by delegations in February 1977".[659]

The first ESA Council Meeting at Ministerial Level was scheduled for 14-15 February and in view of this important event, the Executive, in consultation with the JCB, undertook three main lines of action. Firstly, it placed feasibility (Phase-A) studies on the H-Sat project with three industrial groups: SNIAS and Matra were awarded study contracts for the platform, on behalf of the Eurosatellite and MESH groups, respectively; AEG was put in charge of studying the payload. In addition, Eurosatellite and MESH were also invited to tender for the development contract forf H-Sat, assuming that both offers should include AEG as a co-contractor for payload development. It was foreseen that, following Council approval in February, the final decision on the prime contractor could be taken in mid-June,

657 ESA/JCB(76)25, 9 September 1976.
658 JCB, 8th meeting (16 September 1976), ESA/JCB/MIN/8, 5 October 1976, pp. 3, 5, 6.
659 ESA/JCB/VIII/Res. 1, 16 September 1976, annex to ESA/JCB/MIN/8, *cit.*

thus enabling the immediate starting of the programme in order to comply with the L04 launch schedule.[660]

The second line of action was the working out of a revised package deal proposal, on the basis of three new assumptions: firstly, the need to provide for commercial insurance for the ECS and Marots launches; secondly, a reduction in the hardware required to implement an operational Marots space segment, assuming that only one additional satellite would be launched (Marots B); thirdly, a significant reduction of the ASTP, by eliminating payments previously envisaged in 1981 and 1982. The overall cost of the programme was thus brought back to 203 MAU in 1975 price terms, corresponding to 235 MAU at 1976 prices (Table 6-3). A tentative scale of contributions for each programme element was also worked out, essentially based on the contribution scales for Phase-2 and the Marots programme for the ECS and the Marots extension elements respectively; on GNP percentages for the ASTP element and on a preliminary assessment of industrial interest and capability in the various member states for H-Sat.[661]

Table 6-3: Package deal proposal for the telecommunications programme

Programme elements	MAU (1975 prices)	MAU (1976 prices)
ECS	88.65	102.8
Marots extension	25.77	29.4
ASTP	25.00	28.4
H-Sat	50.00	55.1
Indirect H-Sat costs	13.58	18.3
Total	**203.00**	**235.0**

The third line of action was the definition of a suitable arrangement with the CEPT regarding the operational use of the ECS system during the decade 1980-1990. On the one hand, such an arrangement was a *sine qua non* condition for the member states to approve this core element of the programme: in fact there was no point in developing the ECS satellite if the PTT administrations did not undertake to implement the whole ECS system, i.e. to build the necessary Earth stations and to procure the other satellites required to maintain the space segment. On the other hand, the PTTs wanted a commitment for an ESA contribution towards the total investment in the space segment and its operation for a ten-year period. This contribution should include the provision of additional satellites and launches besides those foreseen in Phase-3 of the Telecom Programme; the operation and in-orbit control of the ECS satellites; and the continuation of technological and experimental activities preparing for second-generation satellites. ESA's eventual activity related to the setting up and operational use of the ECS system in the 1980-1990 period could not be included in Phase-3 of the Telecom Programme, but would form the content of a new optional programme, called Phase-3 bis. The Council was not requested, at this stage, to take a decision on this programme, but its definition and eventual implementation of course represented an intrinsic element in the overall discussion on the proposed telecommunications package deal. We shall address this aspect in more detail in the following section.

6.3 ECS operations in the 1980s and Phase-3 bis of the Telecom Programme

In March 1976, a large majority of the European PTT administrations, with the notable exception of the Deutsche Bundespost and the British Post Office, had expressed their intention to participate in the setting up and utilisation of a regional system of satellite telecommunications based on the future ECS spacecraft, and undertook to build the necessary Earth stations and other terrestrial infrastructure. These administrations, however, made their participation conditional "on the costs chargeable to them

[660] ESA/JCB(76)38, 13 December 1976; ESA/JCB(77)1 (Part B), 12 January 1977.

[661] ESA/JCB(76)33, 29 October 1976; ESA/C-M(77)11, 27 December 1976; add. 1, 12 January 1977; add. 2, 27 January 1977; ESA/JCB(77)4, 8 February 1977.

for such participation remaining within acceptable limits".[662] Following this preliminary position, negotiations started between the ESA Executive and a group of CEPT representatives in order to define the conditions on which the PTTs would agree to use the ECS system.

As a preliminary conclusion of these negotiations, it was agreed that the national PTT administrations would set up and maintain some 20 to 25 Earth stations required to receive satellite signals to be channelled in the telephone and the Eurovision networks. The management of the space segment of the ECS system would be delegated to a new international organisation, called Eutelsat, which the PTTs would create. During an initial period of ten years (1980-1990), Eutelsat would entrust ESA with the procurement and launches of the satellites necessary to maintain the planned space segment over the decade, i.e. two satellites in orbit and in working order at all times, and with the required control operations (telemetry, telecommand and tracking). ESA, in other words, would act as a technical manager of the space segment on behalf of Eutelsat. For these services, Eutelsat would pay a fixed price each year, eventually adjusted to take into account inflation effects, but not to be modified in the event of a launch failure, or an in-orbit satellite failure before the end of its design lifetime, or an increase in satellite and launcher costs. Moreover, ESA was requested to undertake a technology research programme aimed at developing a second generation ECS spacecraft. A legal agreement between ESA and Eutelsat would provide for the technical and financial aspects of the cooperation between the two organisations.[663]

On the basis of these principles, and taking into account the considerable investments for setting up the Earth stations, the PTTs assumed that Eutelsat should pay, for the ESA services, no more than 55 MAU (at 1975 prices) in the ten-year period 1980-1990.[664] It was up to the space authorities in ESA member states to cover any shortfall between this amount and the actual costs to be borne by the Agency in order to fulfil its obligations. Assuming that at least four successful launches were necessary in order to maintain the space segment over the decade, the programme content and cost estimate for Phase-3 bis was presented by the Executive as follows (1975 prices):

a) procurement of two additional satellites (two already planned under Phase-3), at a cost of 30 MAU, plus 1 MAU for storage;

b) three launchers (one already planned under Phase-3), at a cost of 36 MAU (based on the cost of a Delta vehicle);

c) technical management, acceptance trials, launch and in-orbit control operations during the decade, at a cost of 20.8 MAU;

d) launch insurance, at an estimated cost of 7.5 to 9 MAU;

e) construction of a back-up satellite, at a cost of 15 MAU, which would however be repaid either by the insurance, in the event of a launch failure, or by the users after the initial ten-year period;

f) a technology research programme, worth some 4.8 MAU per year.[665]

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662 Letter of the chairman of the CCTS, F. Locher, to the ESA Director General, dated 2 April 1976, annex to ESA/JCB(76)8(C), 12 April 1976.

663 ESA/JCB(76)15(C), 15 July 1976, and add. 1, 26 July 1976.

664 The total investments of Eutelsat PTT administrations for building, maintaining and operating the required Earth stations over a ten-year period was estimated at about 250 MAU: ESA/JCB(78)57, add. 1, p. 2.

665 ESA/JCB(77)33, 29 October 1976, annex I; ESA/JCB(76)34, 3 December 1976, annex III. Revised figures taking into account January1977 price levels are in ESA/JCB(77)4, 8 February 1977. A first draft of the envisaged ESA/Eutelsat legal arrangement is in ESA/JCB(77)2, 14 January 1977, annex I.

Taking into account the Eutelsat contribution of 55 MAU, ESA Member States were thus requested to contribute 12 MAU of capital investments (satellites and launchers) and the whole of operating costs for establishing and maintaining the ECS space segment during the first decade of operations; in addition, they had to pay for the insurance premiums and the R&D activity, and to advance the money for the fifth satellite. In other words, while approving the ECS programme within the framework of the telecommunications package, ESA Member States had to accept that a further financial commitment would be required in the near future in order to grant this satellite a viable operational future.

6.4 The first Council Meeting at Ministerial Level

The first ESA Council meeting at ministerial level convened in Paris on 14 and 15 February 1977, its agenda covering all of the outstanding financial and programme problems of the Agency in the second year of its lifetime. In particular, it was asked to take decisions on the continuation of current programmes and the start of new projects, on the role of ESA in the operational fields, on the relations with non-member states and other international organisations, and on the next three-year level of resources. A major item on the agenda was the telecommunications package-deal proposal. No commitment was requested yet for the support of the ECS system in the 1980s (Phase-3 bis), but delegations were advised that a further financial guarantee would be necessary later in order to meet the CEPT conditions.

The discussions during the meeting involved three important issues. First, the question relating to the future operational use of the space systems developed within the framework of the Agency's programmes: Spacelab, Ariane and ECS were all expected to be available by the early 1980s, but it was evident that a promotional effort was required in order to persuade potential users of their merits and to initiate a real commercial space activity in Europe. What role should ESA play in this promotional effort? How long and how much should member state space budgets (i.e. R&D money) subsidise operational systems meant for commercialisation? At which point should the space agency withdraw from applications programmes, leaving all responsibility for future development to industry? How should suitable contribution scales be defined for promotional programmes whose benefits would eventually go to industries in one or another country? These problems underlay discussions on such issues as the Ariane production phase, for which it was proposed that ESA should undertake a promotion programme of six operational launchers; the Spacelab utilisation programme, with at least two demonstration missions to be funded by ESA; the operational use of Meteosat, for which ESA was to act as an operating agency in the absence of an international entity representing European meteorological authorities; and Phase-3 bis of the telecommunications programme which we have already discussed.

Member states had different views on these questions, representing their different political priorities and economic interests. For France, as was to be expected, support to the Ariane production programme was an absolute priority: "Our activity in the telecommunications field is pointless unless a launch capability is freely available to us – the French delegation argued – and we therefore consider that the decisions to be taken on the extension of the telecommunications programme are inseparable from these on the production of Ariane".[666] On condition that ECS and H-Sat would be launched by Ariane, France was in favour of the overall telecommunications programme and agreed that the Agency should also provide guaranteed ECS service for 10 years under an arrangement between ESA and Eutelsat. For France, it was a matter of long-term industrial policy:

> *For the time being, traffic was obviously not such as to warrant a communications satellite; it was likewise certain that once the satellite was operational, traffic routed via space would be light during the first year and increase progressively, becoming economically viable after ten years, while at the same time promoting the development of*

[666] Council meeting at ministerial level (14-15 February 1977), ESA/C-M(77)19, 3 March 1977, annex VIII, p. 1.

European space industry. [...] Whatever the system was called, whether OTS, ECS or something else, the main thing was that it should be operational, and that the PTT administrations should make the necessary investments in respect to the ground equipment and then derive sufficient profit to finance the space segment in its entirety. [...] Europe should not leave its space industry to face a situation that might become catastrophic.[667]

Other delegations did not share the same views. The Netherlands, for example, "found it surprising" that, under the terms of the draft ESA/CEPT agreement, "all the risks were to be borne by ESA while any profit would go to the national administrations". The quotation is from a statement at a JCB meeting; at the ministerial meeting, the Netherlands representative insisted that any reference to a further financial guarantee following the completion of Phase-3 should be deleted.[668]

The German Minister, for his part, argued that ESA should not be involved in any operational activity or commercial undertaking:

Where application satellites are concerned, ESA should be considered primarily as a typical development organisation. It should in future only undertake the development and testing of new systems when the users demand them and when requirement studies guarantee their use. The marketing of space systems, however, is not one of ESA's tasks.[669]

For Germany, it was up to national governments and national agencies to support commercially oriented space systems developed within the ESA framework. They opposed the concept of ESA supporting an Ariane production programme while, in the case of Spacelab, insisted that ESA's role should be limited to providing reimbursable services to outside users. As regards the ECS project, the German delegation reiterated its opposition to the Executive's plan, insisting that ESA should rather develop a satellite deriving directly from OTS, at a cost of about 75 MAU. Germany, of course, was not prepared to participate in the Phase-3 bis programme, considering that the users should cover the costs of the operational system. Priority was to be given to the H-Sat project, whose costs were estimated by the German authorities at 60 MAU, while the whole telecommunications programme could be carried out within a ceiling of 200 MAU. The delegation concluded with a warning note:

Should the Executive consider that it was impossible to contain the overall communications programme within an envelope of 200 MAU*, Germany would take part exclusively in the extension of the Marots programme and would invite all the countries that so wished to take part in its national heavy platform programme.*[670]

The second issue was the question of ESA's industrial policy and the fair-return principle, particularly regarding the H-Sat project. According to the preliminary contribution scales suggested by the Executive, the industrial participation of the smaller countries in this programme element would have been well below that foreseen in the programme as a whole, as a consequence of the fact that the H-Sat programme was to make use of the various national capabilities in the most effective way. This approach towards a commercially oriented industrial policy was a necessary condition for Europe to compete successfully in the world market of communications satellites, and it was obviously supported by those countries whose space industries were already well advanced, notably France and Germany. The German minister was quite explicit in this respect:

Linked to the need for the cost-effective and economical use of ESA's resources is the question of Member States' "fair return" on industrial contracts. This return is a

667 JCB, 9th meeting (12 November 1976), ESA/JCB/MIN/9, 3 December 1976, p. 7.
668 ESA/JCB/MIN/9, cit, p. 6; ESA/C-M(77)19, *cit.*, p. 9.
669 ESA/C-M(77)19, *cit.*, annex VII, p. 2.
670 ESA/C-M(77)19, *cit.*, p. 10.

regulator rightly recognised by the Convention with a view to the uniform increase of competitivity all round. In this connection, some Member States are justifiably concerned about their unsatisfactory returns. On the other hand, a too timid approach to this important principle, with the emphasis on short-term goals, is also fraught with risks: risks of fragmenting projects and making them more costly, which should not be underestimated, in view of the keen competition for the limited world market. The ESA Council will shortly be faced with the hard task of finding satisfactory solutions to the problems of how our collaboration may become more cost-effective and economic.[671]

France too advocated a market-oriented approach to ESA's industrial policy in the coming decade. In particular, it insisted that the H-Sat project should not be implemented as part of an overall telecommunications programme, where it would hardly be possible to diverge significantly from a contribution scale based on the OTS and Marots programmes, but as a real new independent programme, solely devoted to direct television broadcasting, in which France was prepared to participate to the extent of 35%.[672]

This approach, however, was opposed by those member states which had not managed to establish a competitive industrial capability and therefore risked being left out of the most promising technical developments. For them, a strict enforcement of the fair return concept in all future ESA programmes should remain the linchpin of the European joint effort in space. As the Dutch minister put it:

In respect of the heavy platform, [...] the industrial return [must] be based on a formula in which the industrial distribution of work was adapted to the financial contributions of the member states, and not the other way round.[673]

The Italian delegation, for its part, stated that Italy would support the extension of ESA's telecommunications programme on condition that its scientific and industrial capacity could be fully used within this framework and that its national activities in the space communications field could be integrated within the Agency's programme. The delegation insisted that the H-Sat programme should not be confined to direct television broadcasting, as requested by France and Germany, but should also include experiments in the 20/30 GHz band which were being planned in Italy, the participation of Italy being dependent on the inclusion of the 20/30 GHz experimental package.[674]

The divergences relating to industrial policy emerged also in the third issue under discussion, i.e. the research activities to be performed within the framework of the telecommunications programme (ASTP). This programme element was supported by those member states which did not have national space programmes, and therefore depended on ESA for advancing their industrial competence and training their engineers. France and Germany, on the contrary, which supported strong R&D activities in the framework of their national programmes, did not like devoting so many resources to this part of ESA's activities which, in their opinion, resulted in a duplication of effort and a waste of money. Why not use national capacity for common programmes, they argued, rather than undertaking expensive technology research projects within ESA? France, in fact, announced that it would not participate in the ASTP, at least until the specifications of the direct television broadcasting project were known and the ECS project frozen. Germany, for its part, expressed its willingness to participate in the programme, "in order to meet the smaller nations half-way", but insisted that its budget should be set around 15 MAU, which "would already allow a considerable amount of work to be done" and in any case not exceed 20 MAU.[675]

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671 ESA/C-M(77)19, *cit.*, annex VII, pp. 1-2.

672 JCB, 10th meeting (15 December 1976), ESA/JCB/MIN/10, 12 January 1977, p. 7; 11th meeting (24-25 January 1977), ESA/JCB/MIN/11, 22 February 1977, pp. 3, 6.

673 ESA/C-M(77)19, *cit.*, p. 9.

674 ESA/C-M(77)19, *cit.*, p. 8; ESA/JCB/MIN/9, *cit.*, p. 5; ESA/JCB/MIN/11, *cit.*, p. 11.

675 ESA/JCB/MIN/11, *cit.*, p. 4; ESA/C-M(77)19, *cit.*, p. 9.

The only programme element which was not controversial, receiving in fact unanimous support, was the operational extension of Marots. In order to understand this position, we need a short digression. In January 1977, just before the ministerial meeting, Comsat contacted both ESA and the European PTT administrations, in order to investigate the possibility of using Marots satellites to provide service continuity to their users after the end of life of their Marisat satellites, whose design life was five years. A total of four Marots spacecraft were required to provide reliable service continuity, and Comsat was prepared to pay 40 to 50% of the costs of the third and fourth flight units, provided that it would have access to the two launched under the ongoing Marots programme (Marots A) and the proposed extension under approval by ESA Member States (Marots B).

The Comsat proposal was extremely interesting, the Executive explained, as it implied the setting up, in the early 1980s, of a world-wide maritime system entirely based on the Marots spacecraft, which would be used not only by Europe but also by the United States and probably Japan: "Such a major extension of the Marots programme would place European space industry in an extremely competitive position prior to the procurement of the satellites for a definitive Inmarsat world-wide maritime system, which may be foreseen for the middle of the 1980 decade". A great deal of urgency was, however, attached to the examination of this possibility:

> *Comsat General have clearly indicated the need for a firm position from Europe by April [1997]; if this is not forthcoming, then the pressure for them to provide follow-on Marisat space segment is such that Comsat General would be forced to consider other solutions, both in terms of spacecraft hardware and in terms of prospective partners.*[676]

Without approval by the Ministerial Council of the Marots B extension proposed in the framework of the telecommunications package deal, further discussions with Comsat would not be possible and this opportunity would definitely be lost.

All delegations agreed that positive action should be taken on this part of the telecommunications package. "On no account must we miss this opportunity of making one of our systems operational", the German minister argued; and the British added:

> *"The American offer represents an opportunity for Europe to get its satellites into a world system within five years from now and I am sure delegates will agree we must not let this opportunity slip".*[677]

In the event, the divergence of views that had emerged on the other elements of the package prevented the ministers from adopting a formal resolution. Only a declaration of intent was approved, in which they expressed their interest in ESA to undertake the overall telecommunications programme including the four elements proposed by the Executive, and instructed the Director General to submit to the next meeting of the JCB "his proposals for the next measures to be taken regarding all elements of the overall programme, including such interim measures as he may feel necessary". The DG was however authorised to proceed forthwith with the initial steps for the industrial development of the additional hardware envisaged for the Marots programme extension. The final decision on the telecommunications package deal was deferred to the next Council meeting, scheduled for 30 June and 1 July 1977.[678]

6.5 Negotiations on all fronts

Discussions about the telecommunications package deal continued throughout the year in the JCB, the June meeting of the Council having been unable to take a decision. Four main areas of controversy

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676 ESA/JCB(77)1, 12 January 1977, part A. See also ESA/JCB(77)4, 8 February 1977, pp. 3-4.

677 ESA/C-M(77)19, *cit.*, annex VII, p. 3; annex IX, p. 1.

678 ESA/C-M(February 77)Dec. 1, 15 February 1977, attached to ESA/C-M(77)19, *cit.*

remained, i.e. the financial commitments relating to the use of the ECS system in the first decade of operations (Phase-3 bis); the compatibility of the Marots satellite with the Marisat system; the adjustment of industrial return and the contributions of participating states; and the mission specifications of H-Sat. We shall discuss these issues in turn.

6.5.1 ESA-Eutelsat negotiations for funding ECS operations

In May 1977, the European PTT administrations set up, on an interim basis, the Eutelsat organisation, responsible for the management of the space segment of European communications satellite systems, including in a first phase the ECS and the Marots satellites.[679] Later that year, those Eutelsat members interested in the ECS system started negotiations for the definition of the legal and financial framework for their participation in the establishment, operation, maintenance and utilisation of the ECS space segment. This depended, in turn, on the successful outcome of negotiations with ESA regarding the commitment from the Agency to contribute to the procurement and operation of the required space segment for the first ten-year period. The total cost of this effort was estimated by the Executive at about 44 MAU, in 1976 prices (Table 6-4). This figure, however, was calculated on the basis of the cost of a shared Ariane launcher and did not include the sum (28.5 MAU) to be advanced for the procurement and launch of a fifth (back-up) satellite.[680] The ESA member states, with the important exception of Germany, were generally willing to accept the principle of subsidising the ECS operational use in its initial phase (they had no other choice, in fact!), but urged the Executive to negotiate more favourable conditions before approving this part of the telecommunications package.[681] The German authorities, for their part, considered that only a few PTT authorities were actually going to use the system in the years 1981 to 1985; therefore Eutelsat would probably not be in a position to pay the annual utilisation cost of 6.5 MAU until the mid-1980s. Thus they made it clear that Germany's participation in the ECS development was conditional upon Eutelsat's undertaking to bear the utilisation costs from the time the first satellite became operational in 1981. Otherwise, they stated, "the starting-up date must be put back".[682]

Table 6-4: Estimated costs of the ECS system space segment in the 1980s

Cost elements	**MAU (1976 prices)**
Investments	*78.4*
- 2 satellites	33.5
- 3 launchers	43.5
- storage	1.4
Insurance	7.5
Operations	23.2
Total	**109.1**
Eutelsat contribution	65.0
ESA contribution (Phase-3 bis)	44.1

The situation was on the edge of an impasse: on the one hand, the PTTs would not undertake to use the ECS system, and make the necessary investments in the Earth segment, unless the governments accepted to heavily subsidise the space segment operations; on the other hand, many governments would not accept to support the ECS development programme within ESA unless the PTTs accepted to commit themselves on the use of the system. As a matter of fact, the CEPT and Eutelsat held a

679 ESA/JCB(77)15, 5 April 1977; ESA/JCB(77)18, 31 May 1977. The formal Agreement on the constitution of Interim Eutelsat entered into force on 30 June 1977. Eutelsat's initial member states were Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxemburg, Monaco, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

680 ESA/JCB(77)43, 17 November 1977. A preliminary version is ESA/JCB(77)8, 7 April 1977.

681 JCB, 17th meeting (16-17 November 1977), ESA/JCB/MIN/17, 5 December 1977.

682 ESA/C(77)93, 4 October 1977, p. 1, *Text of a letter from the German Federal Ministry of Science and Technology to the Director General of ESA, dated 24 August 1977*.

strong negotiating position, since the European communications satellite system was not emerging from a real demand from potential users, but rather from the governments' interest in supporting advanced space technologies. Now, for ESA's research and development programmes giving rise to an operational system, they had to sell the satellites to lukewarm users holding a monopolistic position, and it was the latter who fixed the price.

6.5.2 Changes in the Marots specifications

The negotiations between ESA, Interim Eutelsat and Comsat (on behalf of the Marisat consortium) led to the concept of the so-called Joint Venture, i.e. a formal agreement between Eutelsat and other parties interested in the procurement of a global maritime system before the establishment of Inmarsat. The space segment of such a system would comprise two Marots spacecraft made available by ESA to Eutelsat under the proviso of the on-going Marots programme and its eventual extension, plus two other spacecraft procured by the Joint Venture. During the year, the discussions broadened to include not only the USA. but also Canada, Japan and other countries.

A major technical problem arose in this context, relating to the frequencies used for the links between the satellites and the shore stations. At the start of the Marots programme, frequencies in the 11/14 GHz bands (Ku-band) had been selected, as for the OTS and ECS fixed service systems. On the contrary, the Marisat satellites used frequencies in the conventional 4/6 GHz bands (C-band), and the Marisat consortium would not accept shore-to-satellite links at the higher frequency bands for this implied expensive conversion of the existing ground station equipment. Moreover, during discussions in preparation for Inmarsat, it became clear that most countries had a clear preference for the 4/6 GHz bands, which were therefore likely to become the international standard. "The prospects of using the 11/14 GHz bands for maritime purposes [are] nil, at least during the lifetime of the present generation of satellites", the chairman of Eutelsat's Marots Council explained to JCB delegations, pointing out that Eutelsat had no choice but to request ESA to modify Marots A and B to the 4/6 GHz bands.[683]

The consequences for the Marots programme of a change to C-band frequencies were rather severe. This change, in fact, implied an extensive redesign of the payload, a minimum two-year delay in the launch of Marots A (from December 1978 to December 1980 if work in industry on the new design was initiated immediately), and an extra cost of 18 MAU (1976 prices). Moreover it meant that the two Delta launchers procured under the programme could no longer be used at reasonable cost, since NASA was contemplating closing their launch pads at Cape Kennedy by early 1980, and therefore another launch vehicle would have to be used. Both Ariane and the Shuttle could be considered in principle, but the Marisat consortium insisted that the allegedly less expensive Shuttle should anyway be used for Marots C and D, whose procurement it was due to support.

In September 1977, the Executive requested the JCB to endorse its plans for reorienting the Marots programme. Firstly, Marots A and B would be modified as requested by Eutelsat, by changing from Ku- to C-band frequencies. Secondly, steps would immediately be taken to recover as much as possible of the already incurred cost for the procurement of the two Delta launchers. Finally, the Marots A prime contractor (Hawker Siddeley Dynamics) would be invited to make a competitive offer for a total of four spacecraft, which would form the basis for ESA to make a firm proposal to Eutelsat and the Marisat Consortium. The Executive believed that, "notwithstanding the fundamental reorientation required to the programme, and the consequent losses which would inevitably result from it", it was possible to limit the financing by ESA to the 120% ceiling of the on-going Marots A programme (approximately 120 MAU at 1976 prices) plus the 30 MAU foreseen for the Marots B extension. It underlined, however, that industry had been asked to make its offer on the basis of four Shuttle launches: "It will be for the European side to decide whether and how Ariane launches may be

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683 JCB, 16th meeting (22-23 September 1977), ESA/JCB/MIN/16, 2 November 1977, p. 7. Cf. ESA/JCB(77)19(M), 7 July 1977.

financed, since these will inevitably be more expensive than Shuttle launches in the time-frame being considered".[684]

There was no choice for the JCB but to endorse this course of action: "If the Board did not take the decisions recommended by the Executive, [...] ESA and the whole of European industry would lose all credibility", the chairman warned, insisting that "to refuse the change of frequencies would be to abandon all hope of dealing with the Marisat consortium and would not even permit European PTT administrations' requirements to be satisfied". Two important qualifications were associated to this decision, however. Firstly, the French delegation insisted that the Marots spacecraft had to be launched by Ariane, the launches being eventually subsidised by ESA. The Agency is pursuing and expanding a technological programme, they argued, "therefore the criteria of the research and development programmes should be applied, and not purely commercial ones". Secondly, the German delegation considered that if the tender for four satellites was not successful, the Marots programme would be devoid of any commercial interest and should therefore be abandoned.[685]

By the end of the year, HSD submitted its proposal for the provision of four maritime communications spacecraft, the first two of which would be funded by ESA and then put at the disposal of Eutelsat, whilst the third and fourth would be procured, via ESA, by the partners of the Joint Venture. The first spacecraft would be based on the OTS platform while the three others would use the upgraded ECS platform. In order to comply with the French request regarding the launch vehicle and to keep the costs within previously indicated estimates, it was assumed that Marots A would be launched by the Ariane L04 test flight and Marots B by means of an operational Ariane, shared with another spacecraft. The launch costs for both spacecraft, in this case, would not exceed 7.25 MAU. The third and fourth spacecraft could be launched by either Ariane or the Shuttle.[686]

Eutelsat confirmed its interest in a two-satellite programme covering the Atlantic and Indian oceans, but the implementation of the global four-satellite system depended on a successful outcome to the negotiations for setting up the envisaged Joint Venture. A major problem in this context was that the Marisat consortium insisted that the third and fourth spacecraft should use a Hughes-developed communications payload derived from the Marisat payload instead of the payload under development by the European Marconi company for Marots A and B. The JCB then authorised the Executive to pursue the Marots A/B programme with the Marconi payload anyway while, at the same time, continuing negotiations with the Marisat consortium for the procurement of the two additional spacecraft with the Hughes payload.

The legal framework of the envisaged Joint Venture and the conditions of an ESA offer for the space segment of a pre-Inmarsat world-wide maritime satellite system were discussed at a meeting in London on 20 and 21 December 1977. Present at the meeting, in addition to representatives of ESA, Eutelsat and the Marisat consortium (Comsat and Western Union), were delegates from Canada, Greece, Japan, Bulgaria and the Soviet Union, together with the chairman of the Inmarsat Preparatory Committee. Messages aPOLOgising for their absence, but expressing interest in the proposals under discussion at the meeting, were received from Australia, New Zealand and Kuwait. After discussions on a number of technical and financial aspects, ESA undertook to provide, by end of March 1978, a formal proposal for participation in the third and fourth satellite procurement, based on a firm fixed-price offer from industry. A number of working meetings would be arranged meanwhile to discuss problems and queries relating to this proposal and to consider the necessary formal agreements between the Joint Venture participants on the one hand, and between the Joint Venture and ESA on the other.[687]

684 ESA/JCB/(77)30(M), 2 September 1977, pp. 3-4.
685 ESA/JCB/MIN/16, *cit.*, pp. 8-9.
686 ESA/JCB(77)39(M), 14 November 1977; JCB, 17th meeting (16-17 November 1977), ESA/JCB/MIN/17, 5 December 1977.
687 ESA/JCB(78)4, 12 January 1978.

The link between the evolution of the Joint Venture and the ESA Marots programme was a major issue in the discussions over the possible extension of the latter. The Executive insisted that a positive decision on Marots B should be taken as soon as possible in order to strengthen the European position in the negotiations with the Joint Venture partners, but opinions diverged among member ESA states. France and Britain, on the one hand, argued that the European maritime programme should be dissociated from these negotiations; Germany, however, insisted that it should be implemented only on the condition that four European maritime satellites would eventually be incorporated into a world-wide operational system.

6.5.3 The MESH offer for the ECS development contract

Pending final approval of the telecommunications package deal by the JCB and the Council, the Executive undertook to get preliminary approval from the Industrial Policy Committee (IPC) of the prime contractorship for the development of ECS and H-Sat. This made it possible, on the one hand, to establish a definite baseline for the geographical distribution of industrial work, and on the other to maintain the industrial capability which had developed in the previous years around the OTS and *Symphonie* programmes. Many companies in Europe had already performed preliminary studies of next-generation communications satellites on behalf of ESA, and now they needed a more definite prospect of future work. Pending formal approval of the ESA programme, the choice of the prime contractor and associated industrial group would keep project teams in place and allow a limited release of funds to cover procurement of long-lead hardware parts and the initiation of some critical developments. In this and the following sections, we shall discuss the events leading, in the summer of 1977, to the choice of the industrial groups responsible, respectively, for the development of ECS and H-Sat.

In July 1976, the JCB had approved the principle that the ECS spacecraft should be procured directly through Hawker Siddeley Dynamics (HSD), prime contractor for OTS on behalf of the MESH industrial consortium.[688] It was assumed, in fact, that ECS should draw heavily on the OTS project so as to eliminate unnecessary risks in this initial operational system and to minimise recurring costs. Preliminary studies up to system design level (Phase-B) had been performed during that year, firstly assuming a Delta vehicle for the initial launch, but subsequently making Ariane the baseline launch vehicle for the whole production run. The Phase-B study was completed in March 1977, defining a configuration essentially compliant with the requirements of the CEPT, i.e. a 7-year lifetime satellite carrying 12 communications channels and with the power capability of running 9 channels in sunlight and 5 in eclipse.[689]

In parallel with these study activities, HSD prepared a preliminary offer for the production of the first two satellites, which was the subject of an exhaustive review by the Executive. As a result of negotiations, mostly regarding the geographical distribution of industrial work, MESH submitted a revised offer for the development and construction of the first flight unit at the price of 59.9 MAU (1976 prices), with an option for three additional flight units at a total price of 44.9 MAU. The proposed geographical distribution of industrial work is shown in Table 6-5.[690]

An important aspect of the MESH offer was that this distribution did not match the contribution scale of Phase-2. If the latter was to be confirmed for this programme element in the telecommunications package, as had generally been assumed, all countries but France, Germany and the United Kingdom would have had an unacceptably poor industrial return. As it was hardly possible to modify the geographical distribution proposed by the contractor, there was no choice but to agree on a modification of the contribution scale, e.g. by extending to the ECS project the method envisaged for H-Sat, that is a contribution scale proportionate to the work obtained by industry in the participating

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688 JCB, 7th meeting (27 July 1976), ESA/JCB/MIN/7, 3 September 1976, with attached ESA/JCB/VII/Res. 1, 27 July 1976. The reference document is ESA/JCB(76)16(C), 13 July 1976.

689 Bartholomé (1978).

690 ESA/IPC(77)70, 21 June 1977 (also attached to ESA/JCB(77)22, 21 June 1977); add. 2, 12 July 1977.

Table 6-5: Proposed distribution of industrial work for ECS (%)

Belgium	2.09	**Prime contractor:**	HSD (UK)
Denmark	0.40	**Co-contractors:**	Matra (F)
France	20.80		ERNO (D)
Germany	26.90		Saab (S)
Italy	11.40		AEG (D)
Netherlands	1.75		Selenia (I)
Spain	0.40		Aeritalia (I)
Sweden	3.63		
Switzerland	1.99		
United Kingdom	16.80		
USA/others	9.20		
Unallocated	4.64		

states. This, of course, did not please those countries which wanted to maintain their industrial capability in the communications satellite field. Italy, in particular, expressed its dissatisfaction, for its participation in ECS was much lower than in the OTS programme, and explicitly requested that it should be improved, "in view of the interest Italy had always shown in the telecommunications programme".[691]

Notwithstanding these reservations, the IPC unanimously approved the award, in July 1977, of the ECS development contract to the MESH consortium, subject to the approval of the overall telecommunications package. Since such approval was not expected in the near future, the JCB and the IPC authorised the support of interim MESH work on ECS until the end of September, at the level of 6.5 MAU.[692]

6.5.4 Selection of the H-Sat Contractor

Much more controversial was the award of the development contract for H-Sat. As we have anticipated, two industrial groups had been requested to tender and in April 1977 SNIAS and Matra, on behalf of Eurosatellite and MESH respectively, submitted their offers. These were subsequently revised as a result of some changes in the specifications, primarily in the area of the payload, and new tenders were finally submitted on 13 June. The main features of both bids are shown in Table 6-6, together with the evaluation results.[693]

The MESH and Eurosatellite groups, the Executive pointed out, "taken together, represent the essential part of European capacity in the matter of communications satellites, [...] but neither group, taken separately, represents that capacity in a satisfactory way".[694] The former was one of the three consortia traditionally involved in ESA programmes (together with COSMOS and Star), and it had acquired its capability in communications satellite technology through its involvement in the OTS programme.

691 IPC, 16th meeting (25-26 July 1977), ESA/IPC/MIN/16, 28 July 1977, p. 5. Cf. also Council, 18th meeting (30/6-1 July 1977), ESA/C/MIN/18, 18 July 1977, p. 5.

692 ESA/IPC/MIN/16, cit, p. 10. JCB, 15th meeting (26 July 1977), ESA/JCB/MIN/15, 17 August 1977, pp. 3-4. The content of this preliminary contract is presented in ESA/IPC/70, add. 1, 13 July 1977 (also attached to ESA/JCB(77)26, 13 July 1977). The payments concerned were to be provisionally paid from the Phase-2 budget for 1977, being subject to repayment from the Phase-3 budget once the latter was formally approved.

693 ESA/IPC(77)68, 16 June 1977 (also attached to ESA/JCB(77)21, 17 June 1977); add. 1, 13 July 1977; add. 2, 19 July 1977 (also attached to ESA/JCB(77)25, 19 July 1977); add. 2, corr. 1, 21 July 1977.

694 ESA/IPC(77)68, add. 1, *cit.*, p. 4.

Table 6-6: H-Sat tenders

	Eurosatellite	**MESH**
Price in MAU	59.73	65.73
Overall mark (%)	54.75	54.81
Geographical distribution (%)		
Belgium	4.87	0.45
Denmark	0.86	1.36
France	26.00	28.81
Germany	35.17	29.02
Italy	17.92	18.60
Netherlands	0.15	1.39
Spain	0.38	0.30
Sweden	6.21	8.16
Switzerland	1.70	0.00
United Kingdom	3.77	5.82
United States	2.82	3.96
Canada	0.15	0.13
Other or to be allocated	0.00	2.00
Industrial structure		
Prime contractor:	SNIAS (F)	Matra (F)
Co-contractors:	SNIAS (F)	Matra (F)
	MBB (D)	ERNO (D)
	ETCA (B)	HSD (UK)
	Dornier (D)	Saab (S)
	AEG-Telefunken (D)	Aeritalia (I)
	Selenia (I)	MBB (D)
	Ericsson (S)	Fokker (NL)
		BTM (B)
		AEG-Telefunken (D)
		Selenia (I)
		Ericsson (S)

The latter had emerged from the experience of MBB and SNIAS (the core members of the COSMOS consortium) with Symphonie and Intelsat V. According to the Executive, the qualitative and quantitative evaluation of the two offers had not revealed any significant preference if one did not take into account price and geographical distribution, both proposals being judged acceptable and compatible with the mission and project requirements. In the area of costs, the Eurosatellite offer had a significant advantage (about 6 MAU), while the difference in the proposed geographical distribution of work was not supposed to constitute a determining factor in the choice of the contractor, since it was assumed that contributions would be linked to the share of industrial work. Neither of the two tenders was wholly satisfactory as regards geographical distribution, the Executive concluded, but both groups had declared their intention of improving their proposal in this respect, on the basis of further negotiations.

In view of these considerations, the Director General recommended that Eurosatellite should be selected for the H-Sat contract. This recommendation, he added, was also consistent with a sound industrial policy. In fact, in view of the intention to award the ECS programme to MESH by direct negotiation, a satisfactory balance in the use of existing European capability would be achieved by awarding the H-Sat programme to Eurosatellite. On the contrary, "the award of this contract to MESH would have put this group in a monopolistic position in Europe, even beyond the telecommunications programmes, as there are no other programmes of comparable dimensions to counterbalance this and to give sufficient work to the companies of the losing group".[695]

When the matter came to be discussed in the IPC, however, the Swedish delegation contested this approach: the market potential was not great enough to maintain two consortia in the space telecommunications field, they argued, and therefore ESA had to foster the creation of a monopoly situation by placing the H-Sat contract with MESH (of which, it should be remembered, the Swedish Saab company was a core member). The Danish delegation, for its part, pointed out that the geographical distribution of the MESH offer was better for smaller member states and that, even if the contract were awarded to Eurosatellite, the Executive had to impose on this group "an obligation to increase the industrial return to smaller countries such as Denmark".[696] Other delegations, both in the IPC and the JCB, expressed their dissatisfaction with the geographical distribution proposed in the Eurosatellite offer. The United Kingdom, the Netherlands, Sweden, Italy and Switzerland recalled that they were prepared to contribute with a higher percentage to the H-Sat programme, in consideration of its importance for the future of the European space industry. The Swiss delegation, in particular, called into question the industrial policy approach adopted by the Executive, whereby the contribution scale had to be aligned to the geographical distribution resulting from the tender offers:

> *The result was that some countries (for example Denmark, the Netherlands and Switzerland) were "bought out" of the telecommunications programmes because the overall contributions came down to less than half of what they intended to contribute. The Executive had not accepted the Swiss proposal to pay up to 3% of the Heavy Satellite programme; this was an important point which went beyond the programme itself since the Heavy Satellite was the programme which had the greatest chance of having a commercial follow-up.*[697]

In the event, by a majority of 6 votes in favour and four against (Italy, the Netherlands, Sweden and United Kingdom), the IPC approved the choice of Eurosatellite as prime contractor for the H-Sat project, but only on the condition that it undertook to improve the geographical distribution of work, "particularly in respect to Denmark, the Netherlands, Switzerland and the United Kingdom". The revised contractual baseline would be submitted again to the IPC in September 1977 and, should it not constitute a satisfactory solution to the majority of delegations, the choice of the prime contractor would have to be reconsidered.[698]

In the following two months, negotiations were developed between ESA and Eurosatellite, aiming at modifying the geographical distribution of work in compliance with the IPC resolution. The new offer was presented on 15 September and eventually submitted to the Committee (Table 6-7).[699] The new baseline contract price was slightly higher than the original offer, owing to the re-allocation of some tasks in order to improve the geographical distribution and to changes in the payload specifications. In addition to the baseline contract, the Executive recommended the approval of two other items, namely the electric propulsion experiment, already included in the original Eurosatellite offer, and the magnetic bearing momentum wheels, a new type of attitude control system whose testing in the space environment was worth doing. Finally, the IPC was requested to decide whether to replace the MAGE 3 solid propellant apogee boost motor assumed in the baseline satellite configuration with a liquid propellant motor under development in MBB. The cost increase implied by this option was estimated at 1.16 MAU.

695 ESA/IPC(77)68, *cit.*, annex, p. 33.
696 ESA/IPC/MIN/16, *cit.*, p. 6.
697 JCB, 14th meeting (21 June 1977), ESA/JCB/MIN/14, 5 July 1977, p. 4.
698 ESA/IPC/MIN/16, *cit.*, annex I.
699 ESA/IPC(77)88, 19 September 1977.

Table 6-7: Revised Eurosatellite offer (1976 price level)

Baseline contract price		60.03	MAU
Electric propulsion option		1.15	MAU
Magnetic wheel option		1.20	MAU
Total		62.38	MAU
Liquid ABM option (if selected)		1.16	MAU
Total		63.54	MAU
Geographical distribution (%)			
	Baseline	***Including recommended options***	
		Solid ABM	*Liquid ABM*
Belgium	5.50	5.22	5.12
Denmark	0.94	0.89	0.87
France	26.39	26.92	26.91
Germany	30.28	30.61	31.54
Italy	17.00	16.14	15.65
The Netherlands	0.15	0.14	0.14
Spain	1.81	1.72	1.69
Sweden	8.57	8.14	7.98
Switzerland	1.71	1.61	1.58
United Kingdom	3.77	3.58	3.51
USA	3.88	3.68	3.61
Unallocated	—	1.35	1.40
Industrial structure			
Prime contractor:		SNIAS (F)	
Co-contractors:		SNIAS (F)	
		MBB (D)	
		Saab (S)	
		Marconi (UK)	
		CASA (E)	
		ETCA (B)	
		SEP (F) (solid ABM option)	
		MBB (D) (liquid ABM option)	
		AEG-Telefunken (D)	
		Selenia (I)	
		Ericsson (S)	

This latter point deserves a few comments. The MAGE (Moteur d'Apogée Géostationnaire Européen) programme had been under development since 1974, under contract to ESA, by the French Société Européenne de Propulsion (SEP), in collaboration with the Italian SNIA-Viscosa and the German Maschinenfabrik Augsburg Nürnburg (MAN). Its aim was to provide a European apogee boost motor (ABM) capable of supporting ESA's geostationary missions. Performance specifications were initially centred on the needs of Delta-launched satellites (MAGE 1), but the development of the Ariane launcher and the evolution of ESA's programmes in the applications satellite field subsequently led to the development of a "family" of MAGE motors.[700] The MAGE 3 version, in particular, was planned at that time for eventual use on H-Sat missions. At the July meeting of the IPC, however, the German delegation insisted that H-Sat should integrate the liquid propellant ABM under development at MBB as an upgraded version of the motor used in the *Symphonie* satellite. The delegation also stated that it would ensure that the costs would not be greater than those of the solid propellant MAGE system. The Committee took note of this offer and instructed the Executive to examine the introduction of this proposal as an alternative in the contractual baseline with Eurosatellite. The results of this study, as

[700] Asad (1983). On the early history of the MAGE programme, in relation to the OTS/ECS and Marots/Marecs programmes, cf. ESA/JCB(80), 14 May 1980.

reported by the Executive, showed that both solutions were technically acceptable, the integration of the MBB motor implying, however, a cost increase due to design development and qualification, and a modification of the geographical distribution, mainly to the advantage of Germany and disadvantage of Italy (Table 6-7). A political constraint had meanwhile been added, however: in a letter to the ESA Director General, the German Federal Ministry of Science and Technology stated that the integration of the liquid-propellant ABM was a *sine qua non* condition for Germany to participate in the H-Sat programme. A further compelling condition was that the payload should carry two supplementary 200 W travelling wave tube amplifiers (TWTAs), in addition to the baseline 450 W and 150 W TWTAs, in order to flight test this technology extensively developed by AEG in the framework of the German national space programme. The letter specified that "the Federal Republic [was] prepared to bear any additional costs involved by providing equipment developed under its national programme

The reaction of the IPC to Eurosatellite's revised offer was negative, with most smaller member state delegations expressing their persisting dissatisfaction with the geographical distribution of work. Criticism went as far as blaming the Executive or the prime contractor for not taking into consideration offers from some companies to work on specific pieces of hardware. The various cases made at the meeting for changing the baseline work distribution often involved little money, at the level of a few hundreds of kAU. They demonstrate both the importance attached to the H-Sat contract for the future of space industry in Europe and the lobbying activities of many companies with IPC delegations.[701] "It was very regrettable that the discussions had barely improved the overall position for Denmark", the Danish delegation said. It argued that improvements could be achieved, firstly, by increasing the part relating to the ground support equipment to be contracted with Christian Rovsing by about 100 kAU; secondly, by requesting Saab to provide the same company with a sub-contract for certain TTC sub-systems; and thirdly, by re-awarding to Danneborg the 300 kAU sub-contract for instrumentation existing in the original offer, but deleted in the new one. The Netherlands delegation, recalled that it had formally proposed that its country should participate in the H-Sat programme with a percentage identical to the one received in Phase-2 (2.5%) and "very strongly deplored the unsatisfactory result of negotiations for the improvement of the share of work entrusted to its industry". The offer by Fokker to work in the area of thermal control had not been taken into consideration by SNIAS, the delegation noted with regret. The Swiss delegation explicitly blamed the Executive for not taking into consideration options which would improve the industrial return to its country, warning that "a condition for the choice of Eurosatellite was that its authorities must imperatively obtain a return of at least 2% of the contract". Finally, not surprisingly, Italy opposed reconsidering the choice of the apogee motor and stated that the new proposal was unacceptable as the percentage of work to be entrusted to Italian industry had been reduced.

No decision could be agreed on at the meeting, not only because of the need to reopen negotiations for the improvement of the geographical distribution, but also because the conditions indicated by the German government for their participation in the programme required a political decision at JCB or even Council level. The Committee thus agreed that a new proposal should be worked out by the Executive, after further negotiations with Eurosatellite.

We have reasons to believe that the new round of negotiations sometimes had the character of horse-trading, with the Executive having to assume more responsibility in driving the bargain than had been the case within the consortia framework, where the firms themselves agreed on a certain distribution of work. In order to improve the situation for Switzerland and the Netherlands, responsibility for the structure sub-system was transferred from Dornier to Contraves, and a major sub-contract to Fokker was introduced for the service module structure design and manufacture. These measures, however, called for a compensation to Dornier, which was given responsibility for the orientation and power transfer mechanism (the British HSD was also a candidate for this sub-system), for the complete antenna structure (part of this work being previously being offered to Contraves) and for a Dornier-developed antenna pointing system originally suppressed by Eurosatellite as a cost-reduction measure.

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[701] IPC, 17th meeting (19-20 September 1977), ESA/IPC/MIN/17, 5 October 1977. Following quotations are from pp. 12-14.

"Dornier no doubt considers it has suffered in this affair", the Executive commented, but it was confident that "this would be an acceptable situation". The housekeeping electronics was transferred from CASA to Danneborg, as a measure to improve the Danish share, the harness remaining however with the Spanish company. Other proposals for changing the geographical distribution were also discussed, particularly regarding the possibility of improving the situation for the UK, but could not be implemented either for technical reasons or because they would have been to the detriment of the shares of Italy and Belgium.[702]

The outcome of this horse-trading (Table 6-8) was a 1 MAU increase in the baseline contract price and a new geographical distribution, which the Executive now wisely calculated after excluding the contract share going to non-member states and the unallocated work (about 6 MAU in total). The adoption of all of the recommended options implied a cost increase of 5.09 MAU, mostly to the advantage of German and French industry. As regards the controversial liquid propellant ABM option, this was not included in the new proposal for it would have to be resolved in the Council.

Presenting the new proposal to the IPC, the Executive insisted that "significant improvements in geographical distribution" had been achieved, with the notable exception of the UK and that "there [was] no chance of going any further". As regards the unsatisfactory position of the UK, the Executive recalled that this situation stemmed from the fact the British authorities had originally underestimated their participation in the H-Sat programme, and that the large industrial return in the Marots programme largely made up for the overall geographical distribution of work in the telecommunications field. Only at a later stage had the UK communicated its intention to participate in the programme at a higher contribution level. The conclusions were in the form of an ultimatum:

> *Either all the changes described should be implemented as a whole, or, if they are not found to be acceptable by the delegations, the original distribution of work [...] should be retained. An "in-between position" is not considered tenable since the changes are the result of a complex "package deal" negotiated with Eurosatellite and its sub-contractors and any change may invalidate the deal.*[703]

During its October 1977 meeting, the IPC was requested to approve the revised offer, thereby confirming the selection of Eurosatellite as the contractor for the H-Sat project. While most delegations found the proposal acceptable, this was criticised by the Italian and UK delegations. The former keenly regretted that certain Italian firms had not been awarded the share of the work they had expected, and protested against "Eurosatellite's attempt to impose a price reduction on the Selenia offer, in what the delegation considered to be an arbitrary manner". The latter insisted that the contract share envisaged for British industry was appreciably lower than the envisaged percentage contribution and regretted that "the enthusiasm aroused by the programme at the beginning had somewhat abated". Referring to the rejection of those measures intended to increase the industrial return to Britain, the delegation blamed "the attitude of certain industrial firms that appeared to seek to impose their viewpoint, while the Agency was unable to win acceptance for that of the delegations". It was regrettable, it concluded, that "the Executive did not, as in other cases, accept a certain cost increase where such cost increase made it possible to achieve more satisfactory geographical distribution of work".[704]

A different position was taken at the meeting by the German delegation, which recalled the conditions its authorities had laid down for them to participate in the programme, particularly regarding the ABM, and stated that no further decision should be taken on H-Sat until the overall telecommunications package had been approved by the Council. This attitude was harshly criticised by other delegations. Italy and France argued that the solid propellant apogee motor was technically preferable for H-Sat, and that the use of this technology for Ariane launched satellites was consistent

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702 ESA/IPC(77)88, add. 1, 13 October 1977; the foregoing quotation is from p. 2.

703 *Ibid*, pp. 3 and 5.

704 JCB, 18th meeting (18-19 October 1977), ESA/JCB/MIN/18, 11 November 1977, pp. 3-4.

Table 6-8: Eurosatellite offer for H-Sat development (second adjustment)

Baseline contract price	61.05	MAU
Electric Propulsion option	1.15	MAU
Magnetic Wheel option	1.10	MAU
Supplementary 200 W TWTAs	2.84	MAU
Total	66.14	MAU

Baseline geographical distribution in Europe (%)

	Before adjustment	After adjustment
Belgium	5.53	5.44
Denmark	0.98	1.42
France	27.45	27.10
Germany	31.69	30.43
Italy	17.69	17.34
Netherlands	0.16	1.78
Spain	1.88	1.37
Sweden	8.92	8.77
Switzerland	1.78	2.43
United Kingdom	3.92	3.92

with the decision to develop the MAGE 3 motor.[705] Sweden, supported by the Netherlands, expressed its disapproval as follows:

> *While [the delegation] readily accepted that a country like Germany should exercise a profound influence on the orientation of the European space programme, it would regret it if that country was to forgo assuming its responsibilities; the delegation was indeed extremely surprised that the German delegation, after urging the Committee to vote in favour of Eurosatellite, was not prepared to confirm this attitude.*[706]

In the event, with Italy, Germany and the UK voting against, the IPC confirmed the selection of Eurosatellite as contractor for the H-Sat programme, and authorised the Executive to award the contract to this industrial group, subject to a positive decision on the execution of this programme in the framework of the overall telecommunications package deal.

6.6 Which mission for H-Sat?

The crisis of the H-Sat project put into evidence by the German attitude had its origin in a meeting of the World Administrative Radio Conference (WARC) held in Geneva in February 1977. This Conference established the basic regulations and technical parameters for future direct broadcasting satellite (DBS) systems for all European, African and Asian countries, with a plan for utilisation of the geostationary orbit and of frequency bands allocated to the transmissions from satellites to Earth (11.7 to 12.5 GHz). The WARC plan envisaged that each country would manage its own national DBS service, based on the use of high-power (about 200 W) transponders on board geostationary satellites, capable of transmitting signals that could be received by small "household" dishes in an area with the dimensions of a typical European state. The frequency spectrum was split into 40 adjacent channels all

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705 The Italian position was subsequently spelled out in a note reported in ESA/C(77)100, 15 November 1977, also attached to ESA/JCB(77)41, 15 November 1977.

706 ESA/JCB/MIN/18, *cit.*, p. 5.

used twice (with opposite polarisations), and each European country was assigned a number of channels (typically 5), as well as an orbital position, beam shape and transmission power. This assignment assured each country of the ability to deploy a DBS system and limited inter-system interference to an acceptable level. This approach was quite different from the typically international set-up of a telecommunications system such as ECS, whose signals were received by large PTT-owned antennas and distributed to end users via terrestrial networks. In fact, subsequent to the WARC meeting, a few European nations, notably Germany, France, Italy and the Scandinavian countries (Nordsat concept), started planning operational DBS systems, while all others expressed an interest in DBS experiments and demonstrations with a view to the future introduction of a national system. The need for adequate experimentation in this new field was particularly important, as it involved both technical aspects (development by industry of low cost, mass-produced home receivers) and "sociological" aspects (creation of new programmes and market promotion among the public at large).[707]

How did H-Sat fit into the new framework? This question involved two different aspects. Firstly, the WARC plan was based on the concept of strictly national systems, while the H-Sat system had been designed to permit direct TV broadcasting experiments and demonstrations in all parts of Europe, and was in consequence not specifically tailored to the needs of any particular country. The satellite's antenna pattern (beam width and orientation) did not coincide with the WARC pattern for any country; transmissions were restricted to a single sense of circular polarisation, whereas this varied from country to country in the plan; only two channels were available on the satellite, which were to serve all experimenters but could only be selected from those assigned to one or two specific countries. All this made it difficult to define an experimental mission serving several countries, for the technical characteristics of the satellite could comply with the WARC plan specifications for only one or two countries.

Secondly, we should recall that broadcast experimentation was not the only mission of H-Sat. In fact, the main objective of the H-Sat programme was the development and in-orbit demonstration of a multi-purpose heavy platform, able to make maximum use of the Ariane launcher capabilities and to support a range of future communications payloads. The satellite's mission, as originally conceived, included the in-orbit testing of various repeater and antenna technologies relevant to future communications satellites and a specific payload element for experimentation in the 20/30 GHz bands. H-Sat, in other words, had been designed as a large experimental satellite covering a wide spectrum of future broadcast and telecommunication systems. As a consequence of the results of the Geneva WARC meeting, however, the requirements for operational broadcast missions had been well defined, and the need for an experimental mission was less stringent for those countries that aimed at early development of a national system. The link between the H-Sat concept and future operational DBS satellites was called into question.

Following the WARC meeting, the Executive, in consultation with the European Broadcasting Union (EBU) and ESA's Satellite Broadcasting Advisory Group (SBAG), identified a number of solutions for the choice of the frequency channels, orbital position and pointing parameters for H-Sat.[708] The H-Sat channels could only be selected among those assigned to one or the other Western European countries in the WARC plan, it being assumed that the national authorities concerned agreed that these channels be made available for the experimental activity in other countries. The solution envisaged was one channel among those assigned to Scandinavia and the other among those assigned to Germany or France. The suggested orbital position was 19° West, i.e. the one assigned by WARC to most European nations (Germany, France, Italy, etc., but not the British Isles nor the Scandinavian countries). By in-orbit pointing of the satellite body, it was possible to illuminate different areas in Europe or Northern Africa, so that a large-scale experimental programme could be carried out, on the

707 ESA/JCB(77)6, 4 March 1977; ESA/SBAG(77)1, 28 March 1977.

708 ESA/SBAG(77)3, 5 April 1977; ESA/JCB(77)24, 13 July 1977. The SBAG included national delegates from all ESA member states except Switzerland and Denmark, plus the observers of Austria, Norway and the EBU.

basis of an utilisation plan to be defined by the 25 EBU member authorities interested in performing broadcast experiments by H-Sat.

This planning effort, however, could not conceal the weakness of the H-Sat concept *vis-à-vis* the new situation determined by the establishment of the WARC plan. Most EBU members did not envisage the introduction of an operational system in the short term and were therefore interested in an extensive experimental phase being carried on by H-Sat. Others, on the contrary, wanted to pursue early development of national DBS systems and insisted that H-Sat should definitely be given a clear pre-operational character. The group of Scandinavian countries envisaged the introduction of a dual satellite operational system (Nordsat) in the short term; France envisaged a national mission providing five-channel operation in accordance with the WARC plan; Germany, for its part, announced at the June meeting of the Council that their national space organisation was studying a national DBS satellite, and adumbrated the possibility of withdrawing from participation in the H-Sat programme.[709] The majority of the other delegations expressed concern about the new situation and the prospects that Germany might not participate in the H-Sat programme. Recalling that the heavy platform had been envisaged at the outset as the basis of a new family of satellites, the Italian delegation stressed that it would be impossible to reach agreement on the overall telecommunications package deal if one of its components was called into question. The French delegation remembered that it was partly at the instigation of the German authorities that it had been agreed to prepare "a rather ambitious satellite, with an experimental role, that would enable Europe to demonstrate its competence". The ESA Director of Planning and Future Programmes invited the German authorities "to state whether, and if so to what extent, the new concept it wished to promote was capable of leading to a European programme to be undertaken by the Agency".[710]

The German reservations notwithstanding, the Council invited the IPC to examine the MESH and Eurosatellite offers for the H-Sat development contract, and the latter, as we have seen, managed to select Eurosatellite. Pending a decision on the overall programme, the Executive requested the JCB to unblock the interim funding of 1 MAU in order to start some immediate work in industry and keep the project teams in place. The divergences on the technical options, however, prevented the Board from approving this request and it eventually decided to wait for Council decisions.[711]

6.7 The New Package Deal Proposal

In parallel with these developments, the Executive had, during most of 1977, been re-drafting new versions of its package deal proposal for an overall telecommunications programme.[712] These were discussed during several JCB meetings, but no final decision could be taken, the outstanding difficulty being the critical question of financial contributions and industrial return. The Executive was faced with irreconcilable restrictions. On the one hand, there was the obligation to keep within the ceiling of 200 MAU for the overall programme, which the German government considered a *sine qua non* condition for its participation. On the other hand, there were the wishes of the member states concerning their degree of participation in the Heavy Satellite programme: "If all wishes were to be satisfied then the ceiling would have to be lifted", the Executive argued.[713] The industrial offers for the ECS and H-Sat added a further restriction since, contrary to the fair-return concept, one had to adjust contributions to industrial return rather than the other way around. This approach was strongly opposed by the smaller member states, the Netherlands delegation being particularly sanguine in this

709 Council, 18th meeting (30/6-1 July 1977), ESA/C/MIN/18, 18 July 1977.
710 *Ibid*, pp. 7-8.
711 JCB, 17th meeting (16-17 November 1977), ESA/JCB/MIN/17, 5 December 1977. The reference document is ESA/JCB(77)35, 4 November 1977.
712 ESA/JCB(77)17, 20 June 1977; rev. 1, 13 July 1977; rev. 2, 20 September 1977; ESA/JCB(77)34, 4 November 1977.
713 JCB, 14th meeting (21 June 1977), ESA/JCB/MIN/14, p. 6.

regard.[714] Moreover, those member states whose industrial return had been unsatisfactory in the Agency's past programmes insisted that the balance should be recovered in the future. This principle had been agreed on by the ministerial meeting in February, but it was up to the Executive to work out a formula whereby the more favoured nations, i.e. France, Germany and the UK, accepted an industrial return of less than 100% (80 to 95% being proposed) in order to redress past imbalances of less favoured countries, notably Italy, the Netherlands, Sweden and Switzerland.[715]

Finally, there was the problem of the launcher. Due to the delay in the start of the H-Sat programme, the use of L04 for launching this satellite was no longer feasible, and a commercial Ariane launch had to be considered, for which the full price would have to be paid. However, the Marots A development schedule was compatible with an L04 launch; indeed it was the only satellite within the telecommunications package which could take advantage of this opportunity. The question was whether L04 should definitely be awarded to the Marots programme, the other satellites within the telecommunications package (ECS, Marots B and H-Sat) then paying full price for their launches, or a free ride on the last Ariane test launch should be considered a 'gift' for the whole of the telecommunications programme, thus allowing a reduction in the launch costs for the other parts of the programme. “It would be paradoxical for the Marots programme to benefit from the L04 launch”, the Belgian delegation pointed out, "since the largest contributor and consequently beneficiary, was the United Kingdom, which did not participate in the Ariane programme".[716]

By the end of 1977, the JCB had taken the discussions as far as was practicable, on the basis of the resolution of the February Council meeting at ministerial level. The time was ripe to go back to Council for taking major decisions on such important issues as the starting of new major projects, launcher utilisation principles and industrial policy. "There remained only a very little time in which to take these decisions, which were essential for the future of the telecommunications programme", the Director General warned. "If this telecommunications programme was not approved at the next [December 1977] Council session, then the Agency might as well abandon it".[717] The Board having been unable to approve a definite proposal to be recommended to the Council, it was agreed that the chairman should present a document summarising the Executive's latest proposal, together with the positions of the various member states regarding the various elements of the telecommunications package. The Council was requested to approve a guideline resolution which would enable the JCB to implement the various package deal elements.

The main financial aspects of the proposal presented to the Council by the JCB chairman are summarised in Table 6-9.[718] The total cost of the telecommunications package was now estimated at 282.5 MAU in 1977 prices (corresponding to 243.6 MAU in 1976 prices), covering the period from 1977 to 1982. The launch of Marots B was foreseen in 1981 or 1982, ECS in the second half of 1981 and H-Sat in late 1981 or early 1982. It was assumed that all satellites would be launched by operational Ariane vehicles, the L04 test launch being definitely assigned to Marots A. The estimated costs for the commercial Ariane launches were 18 MAU for ECS and Marots B, assuming a double launch for each of them, and 31 MAU for the single launch of the 800 kg H-Sat. The figures shown in Table 6-9 take account of the fact that the savings resulting from the use of the L04 launch were distributed equitably among the various programme elements. It was also assumed that, over the whole programme, each participating state would receive a minimum of 92% in industrial return, with the exception of the ASTP element where a return of 100% was guaranteed. The remainder would be

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714 Cf. the Netherlands delegation's statement at the 16th JCB meeting (22-23 September 1977), ESA/JCB/MIN/16, 2 November 1977, annex IV.

715 During the ministerial council a consensus had been reached over the principle of an 80% minimum industrial return, the remaining 20% remaining available for compensating past imbalance. The Executive then proposed a 90 to 95% minimum industrial return for the three larger countries.

716 JCB, 18th meeting (6-7 December 1977), ESA/JCB/MIN/18, 3 January 1978, p. 7.

717 *Ibid*, p. 3.

718 ESA/C(77)127, 12 December 1977; ESA/JCB(78)2, 12 January 1978. The figure corresponding to 1976 prices is given in ESA/JCB(77)34, 4 November 1977.

Table 6-9: Package deal proposal (December 1977)

Programme elements	Programme cost	Launch cost	Total
ECS	98.0	14.5	112.5
H-Sat	89.0	24.9	113.9
Marots B	33.6	14.5	48.1
ASTP	8.0	—	8.0
Total	228.6	53.9	282.5

used to help restore the balance in the overall distribution of industrial contracts. The geographical distribution of the main industrial contracts was presented as in Table 6-10.[719]

After extensive discussions, the Council adopted by 10 votes to 1 (Germany) a resolution which finally approved the principle that the four-element telecommunications programme be performed within the framework of the Agency. All delegations except those of Germany and Ireland subscribed to a declaration by which they undertook to participate in one or more elements of the overall programme, under certain conditions associated with total contributions, yearly contributions and industrial return. The JCB was requested to pursue matters further at its first meeting of 1978, taking into account the declarations and reservations made by the participants during the meeting. Italy, in particular, insisted that the value of the minimum return coefficient should be 90%, in order to have more money to restore past imbalances and that H-Sat should incorporate the MAGE 3 apogee motor. Final approval of the four programme elements was foreseen for the following Council meeting in February 1978.[720]

Germany was the only member state which voted against the resolution, a negative position which indeed jeopardised the actual possibility of starting the programme. Several reasons were listed by the German delegation for it refusing to join its ESA partners, the most important being that the cost of the overall programme had greatly exceeded the limit of 200 MAU. Moreover, the delegation regretted that H-Sat could no longer be launched on L04, thus missing the opportunity to enter the future market

Table 6-10: Geographical distribution of main industrial contracts in Europe (%)

Country	ECS	H-Sat	Marots	Total
Belgium	2.07	5.20	0.19	3.37
Denmark	0.42	1.27	0.60	0.84
France	24.02	26.48	7.18	23.54
Germany	32.76	32.80	11.75	30.74
Italy	14.42	16.90	4.12	14.59
The Netherlands	2.08	2.33	2.53	2.24
Spain	0.44	1.28	0.63	0.86
Sweden	3.87	7.83	8.44	6.18
Switzerland	1.69	2.29	2.34	2.04
United Kingdom	18.23	3.62	62.14	15.60
Norway	—	—	0.10	0.01
Total	**100.0**	**100.0**	**100.0**	**100.0**

[719] ESA/C(77)127, add. 1, 12 December 1977.

[720] Council, 22nd meeting (12-14 December 1977), ESA/C/MIN/22, 4 January 1978, with attached ESA/C/XXII/Res. 1, 14 December 1977. A summary of the Council meeting, prepared by the JCB chairman, is in ESA/JCB(78)1, 3 January 1978. In addition to ESA member states, Norway declared its intention to participate in the Marots extension programme, and Austria and Canada expressed their interest in participating in the ASTP to levels of 0.5 MAU and 1.0 MAU, respectively.

of DBS technology at an early stage and pointed out the still confused situation on Marots. Finally, Germany was unable to consider participation in Phase-3 bis (ECS operation) and insisted that contractual agreements with the users should ensure the full funding of the utilisation phase of the ECS system.

As a matter of fact, Germany was increasingly doubtful about the capability of ESA to manage commercially-oriented application satellite programmes. The cumbersome procedures of a large multinational organisation, the strict enforcement of the fair- return concept, and the orientation towards experimental projects rather than operational systems contrasted dramatically with the requirements of efficiency and frugality peculiar to market-oriented undertakings. Germany was now able to run successful application satellite programmes, alone or in collaboration with a few other spacefaring nations; why get involved in lengthy negotiations on how to re-allocate a few MAU or even less in order to fit a complex fair-return formula? As a senior German official in the Ministry of Research and Technology put it:

> *All our practical space applications which worked were national, bi-national or tri-national. In a wider framework, with many nations, only Scientific Programmes work.*[721]

With hindsight this statement may appear unfair, considering the eventual successes of Ariane and Meteosat, but it nonetheless reflects the feelings of many German space policy makers at that time.

6.8 The End of the Package Deal Concept

In the view of the ESA Director General, Roy Gibson, the February 1978 meeting of the Council was truly to be regarded as "the last opportunity" to launch the new telecommunications programme:

> *Quite apart from the damage - both material and psychological - that such prolonged uncertainty causes to the Agency, one cannot expect industry endlessly to remain suspended in the starting blocks.*[722]

Subsequent events fell short of Gibson's expectations. On 2 February, in fact, the German delegation informed the Council Bureau that Germany did not, in principle, intend to participate in the H-Sat programme, adding that the German government was funding studies in German industry on a pre- or semi-operational DBS project which they envisaged to offer, around the end of the year, for limited Europeanisation. No further expenditure for H-Sat or related activity would therefore be accepted by the German authorities until then.[723] In the light of the stance taken by the German delegation at the December meeting, this decision did not come as a surprise, but it implied a complete re-assessment of the H-Sat project, from both the technical and industrial points of view. A possible course of action was suggested by the French delegation, whereby the other member states should re-affirm their commitment to undertake the H-Sat programme but, in the first instance, financing should be limited to a six-month period during which preliminary Phase-B studies and some limited industrial work could be performed. A new geographical distribution of industrial work was also to be defined in this period, taking into account the withdrawal of Germany.[724]

With Germany's decision to withdraw from the H-Sat programme, the telecommunications package deal concept was definitely jeopardised. It was evident that each element of the overall programme had to proceed at its own speed, within a specific legal and institutional framework.[725] The decision to

721 Quoted in Müller (1990), p. 277.
722 R. Gibson, "Introduction", *ESA Annual Report 1977*, 7-15, p. 11.
723 ESA/C(78)14, 7 February 1978.
724 ESA/JCB(78)10, 7 February 1978; ESA/C(78)14, *cit.*, annex III.
725 The various legal instruments required to implement the different elements of the telecommunications package, as worked out at this stage, were presented in ESA/JCB(77)12, rev. 3, 25 November 1977.

start the ECS programme, in particular, could, according to the 1973 Telecom Arrangement, be taken by the JCB on a *double two-thirds* majority, subject however to unanimous agreement that the scale of contributions should be different from that of Phase-2 in order to make it proportional to the geographical distribution of work. Moreover, participating states had to subscribe to a declaration bearing on Phase-3 bis, which would provide the basis for the exploitation of the ECS system in the first ten years. The ESA/Eutelsat negotiations were not yet concluded, but a successful outcome seemed possible in the near future, and in any case the PTTs were adamant in requesting preliminary ESA guarantees for them to undertake to use the ECS system. The other elements of the telecommunications package could be implemented as optional programmes, on the basis of the resolution of the ministerial Council meeting. The member states wishing to participate in each of them should adopt a declaration defining the programme content, its financial envelope and the corresponding contributions.

At the February 1978 meeting of the JCB, the Executive proposed that the Board approve the immediate start up of ECS, and that the states participating in the Marots programme take those decisions regarding its extension (Marots B) which would facilitate final approval of this element by the Council. In both cases a provision was foreseen whereby the industrial contracts would be cancelled if the relevant agreement between ESA and Eutelsat were not approved by the end of 1978. As regards H-Sat, only preliminary studies worth some 6.1 MAU were foreseen for a period of six months from 1 April, in order to enable the Council to decide in September on whether and how to proceed with this programme on the basis of their results. Finally, a review of the cost and scope of the technology programme (ASTP) would be carried out, taking into account the absence of contributions from France and Germany.

This approach was approved in principle by most JCB delegations, but the Italian delegation took a very strong negative stance:

> *This situation has arisen partly because of the conflicting interests of the larger countries and partly because the Executive cannot be relied upon to support the views of the countries whose contributions are smaller. It is clear that, whereas near unanimity has been reached on the ECS and Marots B programmes, thus giving the go-ahead to the maritime programme and providing payloads for a number of Ariane launches, Germany's position vis-à-vis H-Sat has provoked a crisis in this latter project, and, with regard to the ASTP, the negative stances of two delegations have nullified the initiative of the others.*

The delegation regretted that Italy was suffering the greatest damage for this situation, as it had "always made its participation in the H-Sat payload and the ASTP a major condition", and warned that "if a vote was taken on Phase-3 of the Telecom Arrangement, our vote would be negative".[726]

The delegations of the smaller member states also expressed their concern about the limitation in the ASTP *vis-à-vis* ESA's overall industrial policy, regretting that past development efforts in the space telecommunications field seemed to have favoured the major contributors. In the words of the Swiss delegation:

> *The Agency's previous policy had in fact led the "small countries" to contribute towards the development of certain specialisations in the industry of the major contributors without themselves being in a position to gain a capability in interesting areas.*[727]

After a long discussion, the conditions required for a two-thirds majority vote on transition to Phase-3 of the Telecom Programme could not be met. The delegations acknowledged that, following the

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726 JCB, 19th meeting (8-9 February 1978), ESA/JCB/MIN/19, 10 March 1978, annex II.
727 ESA/JCB/MIN/19, *cit.*, p. 5.

German withdrawal from H-Sat, the original package deal concept endorsed at the ministerial meeting did not hold any longer and a fresh consideration from the Council was required, prior to which a decision of the JCB on the ECS programme was premature. The chairman was then requested to report to the Council and to suggest those actions and resolutions that would finally give the green light to the new phase of the European effort in space telecommunications. Here is the conclusion of his report:

> *The structure of this European Satellite Communications Programme is fragile and it is probably possible for any single Member State to make it collapse. It is, however, based on the assumption that all want the programme to go ahead, reserving their right to tailor their participation to each part to suit their specific wishes by means of their vote on the [various] items.*[728]

The 23rd meeting of the Council and the 20th meeting of the JCB were both held on 28 February and 1 March, in order to make possible the adoption of all the necessary documents enabling the start of the various programme elements. After many discussions, bouncing from one body to the other, and from one draft document to the other, the ECS development programme, the Marots extension (Marots B) and the interim Phase-B studies of H-Sat were finally approved. The ASTP programme, in which France and Germany confirmed that they would not take part, was deferred to a later meeting, pending a definition of its content and means of execution.[729]

The German delegation reserved its position on ECS and Marots B, however, arguing that "a pre-condition for a programme decision is a binding utilisation commitment on the part of Eutelsat". This in fact was not yet at hand, at least in the case of ECS, as several PTTs, including the Deutsche Bundespost, still opposed such an early commitment.[730] Germany's hard line on the telecommunications programme also aimed at urging the other member states to positively resolve outstanding problems in other areas of ESA activities. These were the Spacelab programme, whose cost was escalating beyond 120% of the established ceiling; the financial problems stemming from the different inflation and exchange rates of ESA member states; and the Ariane production programme.

The other delegations having accepted that the vote of the German delegation would be valid if presented before the next JCB meeting on 20 March, a second session of the 23rd Council meeting was scheduled for 6 and 7 April in order to finally endorse the relevant documents. In the event, Germany lifted its reservations and agreed to both the resolution on the ECS development programme and the declaration on the Marots extension. It also accepted to participate in the H-Sat interim studies at the ceiling level of 1 MAU.[731] A compromise was also reached on the ASTP, the early start-up of which was a condition for Italy to lift its own reservation on the other elements of the programme. As most delegations were still unable to take a decision on the content, financial envelope and work distribution of the ASTP, it was accepted that those participating states which so wished could subscribe to the relevant declaration and provide the necessary funding, in order to enable the programme to be started up. It was understood that the declaration remained open to later subscription by other Member States. Italy, Switzerland and Denmark subscribed to the declaration, the first

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728 ESA/C(78)14, add. 1, 16 February 1978, p. 3.

729 Council, 23rd meeting, part I (28/2-1 March 1978), ESA/C/MIN/23(I), 7 March 1978; JCB, 20th meeting (28/2-1 March 1978), ESA/JCB/MIN/20, 13 March 1978. Reference documents are ESA/C(78)14, add. 1 to 5, with several revisions and corrections. From the formal point of view, the ECS programme (Phase 3 of the Telecom Programme, covered by the 1973 Arrangement) was approved by a JCB resolution (ESA/JCB/XX/Res. 1 (Final), rev. 1, 1 March 1978); The Marots extension (Marots B) and H-Sat interim studies were approved by Council declarations (ESA/C/XXIII/Dec. 1 and 2, 1 March 1978).

730 ESA/C/MIN/23(I), *cit.*, annex II, p. 1.

731 ESA/JCB(78)18, 20 March 1978; ESA/C(78)39, 6 April 1978. JCB, 21st meeting (21 March 1978), ESA/JCB/MIN/21, 7 April 1978; Council, 23rd meeting, part II (6-7 April 1978), ESA/C/MIN/23(II), 20 April 1978, with attached ESA/C/XXIII/Res. 9. Austria was also associated in the H-Sat preliminary study: ESA/C(78)37, 3 April 1978.

Table 6-11: Financial envelope of the ECS programme (MAU at 1977 prices)

Space segment	69.7
Tests	8.2
Ground operations	10.9
Management	12.2
Launch insurance	3.5
Launch (single Ariane launch)	24.4
Total	128.9

undertaking to contribute 4 MAU, the others 0.5 MAU each. It was also agreed that Austria might participate in the programme from the very beginning, at the level of 0.5 MAU.[732]

6.9 The ECS Programme and the Approval of Phase-3 bis

The total cost of the ECS programme, as approved by the JCB on 1 March 1978, was 128.9 MAU (Table 6-11). The programme included the development of two ECS spacecraft, one Ariane launch, ground support equipment and the first six months of in-orbit control. Both satellites would eventually be made available to Eutelsat for regular operational use within the framework of a European communications satellite system. The Board also accepted that Spain be included in the programme with a contribution of 0.17% (this country did not participate in Phase-2).[733] The contributions to the ECS project and the geographical distribution of the industrial work to be performed in Europe are presented in Table 6-12. It shows the effect of the so-called "92% rule", i.e. the proviso that "those participants which in the overall industrial return statistics have a return exceeding the factor 'one', shall receive a 92% industrial return and that the remainder shall be used to redress the imbalance of the overall industrial return of the other member states".[734]

Table 6-12: ECS programme contributions and work distribution (%)

	Contributions	**Work distribution**	
		initial	*revised*
Belgium	3.27	3.01	3.18
Denmark	0.33	0.40	0.41
France	25.93	23.92	23.12
Germany	30.68	28.40	29.21
Italy	14.78	17.07	16.52
The Netherlands	0.94	2.04	1.98
Spain	0.17	0.42	0.41
Sweden	1.62	3.76	3.77
Switzerland	2.13	1.61	1.62
United Kingdom	20.15	19.37	19.78
Total	**100.00**	**100.00**	**100.00**

When the JCB adopted the resolution enabling the ECS programme to be started, the agreement between ESA and Eutelsat on the operational use of the ECS system had not yet been concluded. The resolution, in fact, foresaw that in the event that a satisfactory agreement had not been concluded by

[732] ESA/JCB(78)21, 10 April 1978. The programme content and work distribution proposed by the Executive is presented in ESA/JCB(78)11, 14 March 1978.

[733] ESA/JCB(78)13, 10 March 1978; ESA/JCB/MIN/21, *cit.* p. 5.

[734] ESA/JCB/XX/Res. 1 (Final), rev. 1, 1 March 1978, p. 2. The figures on the geographical distribution reported in this document were later revised, following negotiations with British Aerospace: ESA/JCB/MIN/25, 23 August 1978, Annex III, p. 1.

1 October 1978 (this date was eventually postponed until 31 December), it should cease to have effect, and provided for a cancellation clause to be included in the industrial contract should this situation occur. A few days after the JCB meeting, most Eutelsat member PTT administrations finally signed the Agreement relating to the ECS system. By this agreement, the signatories agreed "to participate in the establishment, operation, maintenance and utilisation of the ECS space segment, and to undertake all the obligations and responsibilities relating thereto".[735] The Deutsche Bundespost was among the signatories, this being the basis for Germany's positive vote on the resolution, as we have discussed above. At the same time, however, the PTTs informed ESA that, owing to the difficulties that most administrations had in putting their Earth stations into service, the operational use of the ECS system could not start before 1983, and therefore Eutelsat could not foresee any payment to ESA before that year. In order to cope with this delay, it was agreed that the launch date of the first ECS spacecraft should remain unchanged (end of 1981) and that the satellite should be made available to Eutelsat in 1982. Full operational use would start only in January 1983, after the launch of the second ECS spacecraft, but Eutelsat would pay an additional 2.5 MAU to cover partial utilisation in 1982. Subsequently, Eutelsat would pay for ESA services: 7.2 MAU per year during the first five years and 8.3 MAU in the following five-year period, thus making the total amount to be paid by Eutelsat for the operation of the ECS system space segment over the ten-year period 1983-1992 equal to 80 MAU (all figures at 1977 price levels).[736]

In order to arrive at a final approval of the ESA/Eutelsat arrangement and of Phase-3 bis of the ECS programme, three outstanding problems had to be resolved. The first regarded the pricing policy of Ariane launches for the ECS satellites. The production cost of an Ariane vehicle was estimated at about 32 MAU, but a "market" price of 24.44 MAU had been decided by the Council for launching the ECS 1 spacecraft (assuming single launch). The extension of this price to the three others ECS launches, which was considered unavoidable in the prevailing situation, required of course that those states which participated in the Ariane programme undertake forthwith to guarantee cover of any eventual difference between the production cost and the selling price of the launcher.[737] As this issue was still under discussion at national level in various countries, the French delegation announced that, in order to promote a speedy solution, its authorities were prepared to guarantee such a cover for those states which were not yet in a position to take an immediate decision. On this basis, the Council finally approved a resolution whereby the ceiling price for each of the ECS 2, ECS 3 and ECS 4 (single) Ariane launches was definitely fixed at 24.44 MAU. At the same time, the delegations of France, Germany, the Netherlands, Sweden and Switzerland subscribed to a declaration whereby they agreed that the corresponding additional funds should be shared in proportion to their industrial return on the manufacture of these three launchers. The other participating states, whose industry would also carry out work on the provision of these launchers, were invited to subscribe to the declaration as soon as possible. The financial envelope of Phase-3 bis was thus definitely set at 121.8 MAU (Table 6-13).[738]

The second problem was of course that of the scale of contributions. According to the Executive, this should be proportional to the distribution of industrial work for the procurement of the three satellites, the highest contributions coming from Germany (33.4%), France (23.4%), Italy (16.9%) and the United Kingdom (14%).[739] This proposal, however, met with strong opposition on the part of the Italian and Swiss delegations, which argued that the "92% rule" should be applied to Phase-3 bis as in the case of the ECS programme. It took many negotiations between the Executive and the national

735 ESA/JCB(78)15, 17 March 1978, annex, p. 16.

736 ESA/JCB(78)42, 17 July 1978.

737 ESA/JCB(78)46, 11 September 1978; ESA/JCB(78)57, 9 October 1978, with add. 1, 20 November 1978.

738 Council, 28th meeting (12-13 December 1978), ESA/C/MIN/28, 26 January 1979, with attached ESA/C/XXVIII/Res. 9 and
ESA/C/XXVIII/Dec. 3. Reference documents are ESA/C(78)161, 8 December 1978, and ESA/C(78)166, 11 December 1978.

739 ESA/JCB(78)57, 9 October 1978.

Table 6-13: Financial envelope of Phase-3 bis (MAU 1977 prices)

Satellite procurement (ECS 3, 4, 5)	68.9
Launchers (ECS 2, 3, 4)	73.5
Management and in-orbit control	27.4
Insurance	32.0
Total	201.8
Eutelsat contribution	80.0
ESA contribution	121.8

Table 6-14: Work distribution and contribution scale for Phase-3 bis

	Work distribution (%)		**Contributions**
	Europe	*Overall*	*%*
Belgium	3.33	2.75	3.19
Denmark	0.92	0.75	0.74
France	26.84	22.10	26.52
Germany	31.95	26.35	30.42
Italy	15.59	12.86	13.85
TheNetherlands	1.93	1.60	1.77
Spain	0.55	0.45	0.53
Sweden	3.99	3.30	3.97
Switzerland	0.68	0.56	0.55
United Kingdom	14.22	11.75	18.46
USA/Others	—	13.13	—
Reserve	—	4.40	—
Total	**100.00**	**100.00**	**100.00**

delegations as well as many discussions during two JCB meetings and three Council meetings in order to find an acceptable compromise, which was finally approved in April 1979 (Table 6-14).[740]

Finally, the third problem regarded the guarantee, requested by Eutelsat, of ten years of satellite continuity of service, i.e. two working satellites in orbit. In order to protect themselves against the apparently unlimited financial risk deriving from this obligation, ESA member states had accepted that the financial provisions of Phase-3 bis should include an insurance cover for both the launch and in-orbit operations during the whole design life (5 years) of the four ECS satellites. However, the terms by which in-orbit insurance could be procured left a residual risk since, owing to customary practice in aeronautical insurance matters, it was possible to insure a fourth and fifth year of in-orbit performance of the ECS satellites only two years after launch. At the urging of the German delegation, the Council considered that Eutelsat should recognise this residual risk and accept that ESA's unconditional guarantee of service continuity could be assured only when this additional insurance cover was obtained. In order to avoid amending the text of the Arrangement between ESA and Eutelsat, it was suggested that this issue should be settled by means of an official exchange of letters between the ESA

740 JCB, 28th meeting (5-6 December 1978), ESA/JCB/MIN/28, 17 January 1979; 30th meeting (1-2 February 1979), ESA/JCB/MIN/30, 12 March 1979. Council, 28th meeting (12-13 December 1978), ESA/C/MIN/28, 26 January 1979; 29th meeting (27-28 February 1979), ESA/C/MIN/29, 4 April 1979; 30th meeting (3-4 April 1979), ESA/C/MIN/30, 5 April 1979, with attached ESA/C/XXX/Dec. 1. The various contribution scales discussed during these meetings are reported in ESA/JCB(79)1, 16 January 1979; ESA/C(79)25, 9 February 1979; with add. 1 and 2, 27 February 1979; add. 3, 26 March 1979; add. 4, 3 April 1979. The work distribution is reported in ESA/JCB(79)2, 16 January 1979.

Director General and the Secretary General of Eutelsat. The Director General was authorised to sign the Arrangement as soon as this exchange of letters had occurred.[741]

Eutelsat did not concur. Firstly, they did not like it that a complementary letter was handed over at the time of signature of an Arrangement that had taken almost three years of negotiations. Secondly, in consideration of their heavy investments in the Earth segment, the Eutelsat member administrations could not accept that ESA might not be able to provide and maintain the space segment, and guarantee continuity of service. Again, the strong negotiating position of the PTT administrations became evident: "ESA was created to develop European space industry", Eutelsat's Secretary General wrote to the Director General, adding: "After years of work in this area, it would seem likely that ESA together with European space industry are capable of guaranteeing the life of a space system for telecommunications". In any case, he concluded, Eutelsat was not prepared to accept the suggested exchange of letters and would proceed to sign the Arrangement as it stood.[742]

After several negotiations, which involved not only ESA and Eutelsat, but also "space" and "postal" authorities at national level, an agreement was finally reached, whereby the Director General, on behalf of the member states participating in the programme, officially informed Eutelsat of the risks of premature termination of the Arrangement in the unlikely, but unfortunately not to be excluded, case that three satellites supplied for launching "either do not attain their planned orbit, cannot be brought into operation or can only be kept in operation for a period of less than 5 years". ESA would use its best endeavours to obtain adequate insurance covering the events causing the failure, he continued, but, "should, against all present reasonable expectations, such insurance not be possible, ESA will inform Eutelsat of this forthwith, without the other obligations of the Agency under the Arrangement being affected".[743] On this basis, the ESA/Eutelsat Arrangement was finally approved by the Council in April 1979.[744]

6.10 The ASTP Programme

The Declaration on the ASTP programme was adopted at the April 1978 Council meeting by the delegations of Denmark, Italy, the Netherlands, Sweden, Switzerland, the United Kingdom, and Austria (a non-member state). Only four countries, however, declared their readiness to embark on the programme and formally subscribed to the Declaration, namely Austria, Denmark, Switzerland and Italy, the latter with a contribution of 4 MAU and the other three with contributions of 0.5 MAU.[745] Subsequently, Belgium and Spain decided to participate in the programme, while France and Germany confirmed their intention not to take part in it.

The general objectives of the programme, extending over the four-year period 1978-81, were defined as follows:

- to keep the European state of the art in line with general progress, in terms of both system configuration and actual technologies;
- to define and promote new activities relating to advanced missions in the field of communications satellites (data transmission, mobile communications, direct satellite-to-satellite transmissions, new public services such as electronic mail, evolution to higher frequency bands, etc.);

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741 ESA/C/XXVIII/Res. 10, 12 December 1978, attached to ESA/C/MIN/28, *cit.*; ESA/JCB(79)3, 17 January 1979. The German position is reported in ESA/JCB(78)57, add. 2, 29 November 1978, annex I. The various draft versions of the ESA/Eutelsat Arrangement are reported in ESA/JCB(77)2, with rev. 1 to 6. The final text, as approved by Eutelsat and the ESA Council, is attached to ESA/C(78)90, rev. 1, 22 November 1978.

742 ESA/JCB(79)3, *cit.*, annex III, p. 1.

743 ESA/C(79)25, add. 3, annex II, p. 2.

744 Council, 30th meeting (3-4 April 1979), ESA/C/MIN/30, 5 April 1979.

745 ESA/JCB(78)21, 10 April 1978.

- to improve the competitiveness of European industry in the international market by studying, preparing and funding the technical activities that should be undertaken in anticipation of the most promising satellite procurement actions foreseen in the world;

- to introduce technological improvements in later flight models resulting from the ECS, Marots and H-Sat projects.

More specifically, three lines of activities were identified, i.e. communications systems and associated spacecraft configurations; communications equipment technology (satellite payloads and ground stations) and spacecraft subsystem technology (platforms).

While being a logical follow-up of the Supporting Technology Programme (STP) developed within the framework of Phase-2 of the Telecom Programme, the ASTP presented two important differences. Firstly, in comparison with the STP, whose aim was specifically the support of the OTS project (e.g. three-axis stabilisation, 11/14 GHz communications payloads), the ASTP was conceived as a coherent R&D programme relating to the short- and medium-term development of space telecommunication technologies. It involved both the modernisation of existing communications satellite systems and the preparation of new missions. Moreover, it made provision for supporting export-promotion activities in the non-European market. Secondly, the ASTP was adopted as an independent optional programme within the framework of ESA's overall telecommunications programme, funded on an *à la carte* basis by the participating member states. It was based on the concept that contributions from each participating country should be used to support activities to be developed in its own territory, the technical orientation of these activities being established in agreement with the national authorities. Concluding a presentation of the ASTP in the ESA Bulletin, an ESA officer involved in the programme defined it as "an *à la carte* technology research programme in a particular field":

> *For most participating countries, it is a substitute for activities which could have been developed at national level, and one would be inclined, in the case of the ASTP, to consider the Agency as the manager of national programmes. Nevertheless, it is a real programme of the Agency that must be conceived and managed as such, though complying with the objectives established by each participant.*[746]

Table 6-15: Contribution scale for the ASTP (MAU 1977)

Belgium	0.8
Denmark	0.5
Italy	4.0
The Netherlands	1.0
Spain	1.0
Sweden	1.0
Switzerland	0.5
United Kingdom	4.0
Austria	0.5
Total	**13.3**

Following the adoption of the Declaration, the Executive organised bilateral discussions with the delegations of participating countries, with the aim of determining their financial contributions and the corresponding activities to be carried out in their respective countries. As a result of these discussions, the Executive submitted to the JCB a list of activities that could be undertaken in the first phase (1978-79) of the programme in each participating state, as well as a proposal for the scale of contributions

[746] Imbert (1978), p. 39. The STP programme is described in Blondin & Dickinson (1978). Cf. also Müller (1990), pp. 170-181.

(Table 6-15).[747] This proposal was generally accepted by the delegations of the participating states, but some of them stated that they were unable to enter into a financial commitment for the programme as a whole and could therefore not subscribe officially to the Declaration. The JCB, however, approved the rules for the implementation of the ASTP and the budget for 1978, thus enabling the Executive to make a start with the programme in 1978.[748]

The overall ASTP work-plan for the period 1979-1981 was subsequently worked out by the Executive and approved by the JCB, within whose framework a few dozens of specific studies were undertaken in the participating countries. Some of them eventually decided to increase their contribution to the programme in order to maintain the work in their national industry. Italy, in particular, approximately doubled the level already approved, as an important effort was devoted in this period to satellite communications in the 20/30 GHz bands, in which Italy had a strong interest.[749] Another important area covered by ASTP activities was the study of second-generation maritime communications systems, which received support from the other main contributor to the programme, the United Kingdom.

During 1981, discussions took place on the extension of the programme for a further four years. In the event, a new four-year programme (ASTP-2) was approved in July 1982, in which all ESA member states except Ireland participated, plus Austria and Norway. In 1984, the ASTP-2 budget stood at 55 MAU. A further extension, called ASTP-3, was adopted by the participating states in 1986, with a programme envelope of 130 MAU.[750]

6.11 From Marots to Marecs

The Declaration adopted by the participants in the Marots programme at the March 1978 Council meeting made provision for an extension of the programme aimed at procuring and launching a second flight unit of the Marots spacecraft. Both Marots A, scheduled for launch for October 1980 by the Ariane L04 test launch, and Marots B, to be launched in mid-1981 by an Ariane operational vehicle, would eventually have been made available to Eutelsat for use as the space segment of its maritime communications satellite system. The two satellites were to be placed in geostationary orbit over the Atlantic Ocean and the Indian Ocean, respectively. The extension of the Marots programme was to be carried out within a firm financial envelope of 34 MAU (1977 prices), plus 24.4 MAU for Ariane launch services. The latter figure could be reduced to 18 MAU in case a double launch was arranged. The initial scale of contributions and industrial work allocation (taking into account the "92% rule") was approved as in Table 6-16.[751]

Following Council approval of the dual-satellite maritime programme, it was decided to modify the satellite design in order to meet the new operational requirements, in particular by switching from the OTS platform to the more capable ECS platform. The programme's name was accordingly changed from Marots to Marecs. A contract for the development of Marecs A and B was then placed with British Aerospace Dynamics (formerly Hawker Siddeley Dynamics), leading the MESH consortium.

The development of the Marecs A/B programme in this phase was strongly affected by the Joint Venture negotiations for the envisaged pre-Inmarsat world-wide maritime services. At the beginning of these negotiations, as discussed above, it was hoped that the Joint Venture (including PTT

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747 ESA/JCB(78)25, 16 May 1978.

748 JCB, 23rd meeting (30-31 May 1978), ESA/JCB/MIN/23, 27 June 1978, pp. 7-10.

749 ESA/JCB(79)10, 30 March 1979; add. 1, 21 June 1979; add. 2, 11 September 1979.

750 *ESA Annual Report*, 1982, p. 42; 1984, p. 55; 1986, p. 61.

751 ESA/C/XXIII/Dec. 1, 1 March 1978, approved at the 23rd Council meeting, part I (28 February 1978-1 March 1978), ESA/C/MIN/23(I), 7 March 1978. Cf. also ESA/C(78)14, add. 2, rev. 1, 1 March 1978. The Declaration was slightly amended by the JCB, 21st meeting (21 March 1978), ESA/JCB/MIN/21, 7 April 1978, and the new version (ESA/C/XXIII/Dec. 1, rev. 1) finally endorsed at the 23rd Council meeting, part II (6-7 April 1978), ESA/C/MIN/23(II), 20 April 1978.

Table 6-16: Contribution and work distribution for the Marots extension programme

Participating states	Contribution (%)	Work share (%)
Belgium	0.14	0.14
Denmark	—	0.55
France	5.74	5.09
Germany	13.29	11.75
Italy	1.28	3.95
The Netherlands	1.49	2.73
Spain	0.34	0.62
Sweden	6.61	8.83
Switzerland	—	3.33
UK	69.89	61.78
Norway	1.22	1.23
Total	100.00	100.00

authorities from both European and non-European countries) would implement the space segment of such a system by using the Marecs A and B satellites made available by Eutelsat and by procuring two further Marecs spacecraft from ESA. In spring 1978, however, when ESA presented its offer for Marecs C and D to the Joint Venture, Intelsat entered the game, offering the lease of a maritime communication payload fitted into the forthcoming Intelsat V spacecraft, whose first launch was scheduled for 1980. More specifically, Intelsat suggested that a low-cost space segment for a world-wide maritime network could be realised by using the dedicated Marecs A and B satellites (provided free of charge by ESA through Eutelsat) plus four Intelsat V maritime payloads. In this case, both European satellites were to be positioned over the Pacific Ocean, contrary to their original mission which was to cover maritime traffic off the European and African coasts.

ESA and the JCB national delegations obviously did not like this proposal which, however, attracted several PTT administrations of ESA Member States, whose delegates sat on Intelsat governing bodies. In other words, space and postal authorities in various European governments again had diverging interests in the critical field of satellite telecommunications. Introducing a nervous discussion on these new developments, the JCB Chairman emphasised "the fragility of the European position, in which the solidarity of Member States could easily be upset by the diversity of the various interests involved". The Director General, for his part, concluded the discussion urging the delegations "to keep close contact with their own national authorities responsible for dealing with the various aspects of the matter, in particular so as to ensure that they were informed of the 'space' elements of the problem".[752] All decisions, in fact, were well beyond the capacity of the Agency and the Board.

The pre-Inmarsat Joint Venture was established at a Constitutive Conference held in Bergen, Norway, from 25 September to 5 October 1978. Seventeen countries approved the Constitutive Agreement, i.e. all ESA member states except Switzerland, plus Australia, Canada, Greece, India, Japan, Kuwait, Norway and the USSR. The United States, which had participated in the preparatory meetings, was not present at the Bergen conference and did not join the new organisation. An important outcome of the conference was the definition of a procurement policy. Three alternative options were considered: the first foresaw a space segment consisting of four Marecs satellites, as in the original European proposal; the second foresaw two dedicated maritime satellites provided by Intelsat and three Intelsat V maritime payloads leased from Intelsat; the third foresaw three Marecs and three Intelsat V maritime payloads. Of these options, the second was definitely rejected, while a preference was expressed for the third one compared to the first. It was assumed that Marecs A and B would be made

752 JCB, 23rd meeting (30-31 May 1978). ESA/JCB/MIN/23, 27 June 1978, pp. 4-5. The reference document is ESA/JCB(78)WP/4, 30 May 1978 (originally issued as ESA/JCB(78)WP/2).

available through Eutelsat, and Marecs C (plus Marecs D in case option one was selected) would be procured under contract with ESA.[753]

The Constitutive Agreement adopted at the Bergen conference was opened for signature until 16 February 1979, and only after that date would the Joint Venture become a legal entity, having the appropriate power to decide on procurement contracts. Pending this decision, the Executive requested the participants in the Marecs programme to finance the procurement of long-lead items on Marecs C (and D), in order to avoid a price increase due to delays in contract initiation and to maintain the competitivity of the European proposal. Interim funding of 3 MAU was requested for this activity, which would eventually be reimbursed after contract signature. "It is only if the Joint Venture were not to be created that this interim funding would be at risk", the Executive argued, stressing however that such pre-financing of Marecs C/D hardware procurements was necessary, "in order further to improve the chances of the European proposals, particularly against possible last minute delaying tactics from certain potential members of Inmarsat who have not been represented at recent Joint Venture meetings".[754] Implicit reference is made here to the United States, whose interest was now to sabotage the Joint Venture and delay the establishment of a global maritime satellite system until Inmarsat was formally established and American industry became competitive. In fact, maritime satellite communications appeared as an important new market for space technologies, in which Europe could still legitimately claim a leading role, thanks to the Marots/Marecs programme.

The Executive's request was approved in principle by the JCB, with the German delegation taking a strong negative stance however, both because of its pessimistic vision about the future of the Joint Venture and because it considered that the bridging funding should be provided by industry. Belgium and Sweden, for formal reasons, could not take a stance at that meeting either, and therefore the British delegation, which was the main supporter of the Marecs programme, stated that its authorities would be prepared to underwrite temporarily the financial contributions of these three countries. It warned the German delegation, however, about the solidarity link which should hold together the major contributors to the 1973 package deal programmes:

> *The [British] delegation particularly invited the German delegation to adopt a positive stance, reminding it that the United Kingdom authorities were pursuing their efforts to lift the ad referendum which they had entered when the decision was taken on the overrun of the 100% cost-to-completion of Spacelab.*[755]

In the event, France, Italy, the Netherlands, Norway, Spain and the United Kingdom subscribed to a declaration whereby they authorised the Agency to place orders worth 3 MAU for long-lead Marecs C hardware items. The other participants in the programme, i.e. Belgium, Germany and Sweden, were invited to adhere to the declaration "at the earliest possible opportunity", the United Kingdom undertaking to make up any shortfall resulting from the eventual non-participation of these countries.

The German delegation's pessimism proved to be well founded. At the second Joint Venture conference, held in Brighton in January 1979, it was agreed to definitely confirm the commitment to procure three maritime packages on Intelsat V satellites, while only two Marecs satellites in orbit were considered necessary to complete the space segment of a global system at a realistic cost. The implementation of this concept meant in fact that ESA was to provide the Joint Venture (and later Inmarsat) with two satellites free-of-charge (Marecs A and B), the Agency being re-paid only for the services relating to the launches of the satellites, the procurement of Earth stations, and in-orbit operations. The Conference asked ESA to provide an offer for this dual-Marecs element of the space segment, but after the Director General warned the participants that he felt obliged to give the JCB a

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753 ESA/JCB(78)60, 10 October 1978. Cf. also ESA/JCB(78)45, 24 July 1978.

754 ESA/JCB(78)61, 10 October 1978, p. 2. Also ESA/JCB(78)50, 14 September 1978.

755 JCB, 27th meeting (23-24 October 1978), ESA/JCB/MIN/27, 22 November 1978, p. 9. The following quotation is from the attached ESA/JCB/XXVII/Dec. 1.

negative opinion on this solution, a second offer was also requested for an alternative solution, i.e. the provision of three Marecs spacecraft, one of which was to be a spare on the ground.[756]

The Brighton conference dramatically put into evidence the diverging interests existing between European governments. On the one hand, the space authorities of ESA member states advocated the promotion of the Marecs spacecraft in view of the future development of the maritime communications market. On the other, the state-owned PTT administrations insisted on the most economic solutions. "The national PTT authorities had not always shown as much cohesion as one might have wished", the Executive complained to the JCB. "Eutelsat [should] be invited to assume its responsibilities fully", argued the French delegation, adding that, "when an Ariane launch was sold to Intelsat, the national PTT authorities very effectively demonstrated their European solidarity". The delegation also stressed the political importance of the stakes, over and above the maritime programme:

> *Neither the technical quality of the offer nor even its price constituted fundamental criteria for choice. The essential was that Europe should give proof of its determination, but it was clear that the European PTTs had not always been fully aware of space problems. It was at government level that a consensus must be achieved. The principle of solidarity governing ESA's actions therefore required that the member states most directly interested in the programme should pursue their efforts vis-à-vis their partners in order to achieve this consensus.*[757]

The JCB finally agreed that ESA should not submit an offer limited to two satellites and decided to increase interim funding for the Marecs C procurement from 3 MAU to 5.7 MAU, as requested by the Executive, in order to maintain the validity of the new ESA offer for three satellites until the end of August, when the Joint Venture would finally make a decision. Belgium and Germany, however, stated they were still unable to adhere to the declaration, while Italy stated that it would contribute to the interim funding only in respect of the part of the work carried out in that country.[758]

ESA's offer for the provision of three Marecs spacecraft and the associated Earth segment was discussed at the third session of the Joint Venture Conference in The Hague in March. Here it was decided that it was no longer necessary to establish the Joint Venture since Inmarsat would soon come into being, and all decisions regarding the setting up of the first world-wide maritime system were thus delegated to the new organisation. At the close of the discussion, however, 16 out of the 18 delegations present, representing prospective Inmarsat members whose assessed contributions amounted to 72%, adopted a resolution whereby they confirmed their support for a space segment consisting of three Intelsat V maritime payloads and three Marecs satellites. Canada and the United States did not adhere to this resolution, the former arguing that the ESA offer still required further development on the aspects of price and contractual terms, the latter insisting that other possible alternatives (i.e. all-American) should continue to be given serious consideration.[759] The position of Canada came as a surprise, showing that divergences between PTT authorities and space authorities did not exist only in Europe. In fact, the Canadian delegation which participated in the JCB meetings with observer status stressed that "the Canadian authority present at The Hague [...] did not emanate from the Canadian government [and] had adopted an attitude that did not reflect its country's official position when the resolution was voted".[760]

Subsequently, it was agreed that ESA should present the three Marecs together as a package directly to Inmarsat, rather than presenting Marecs A and B to Eutelsat, which would in turn transfer them to

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756 ESA/JCB(89)7, 22 January 1979.

757 JCB, 30th meeting (1-2 February 1979), ESA/JCB/MIN/30, 12 March 1979, pp. 6-7.

758 ESA/JCB/XXX/Dec. 1, attached to ESA/JCB/MIN/30, *cit.*; ESA/JCB(79)9, 2 February 1979. Sweden eventually adhered to the interim funding of Marecs C: ESA/JCB(89)11, 7 February 1979.

759 ESA/JCB(79)13, 2 April 1979.

760 JCB, 31st meeting (9 April 1979), ESA/JCB/MIN/31, 14 June 1979, p. 4.

Inmarsat. This would in fact ease negotiations by eliminating an unnecessary step, the European PTTs being at one at the same time represented both in Eutelsat and in Inmarsat.[761]

Inmarsat came officially into being on 16 July 1979, and in August ESA submitted its offer for three Marecs spacecraft.[762] Assuming that the Joint Venture's decisions had set the basic principles for the procurement of the first space segment, the Executive expected that the offer would eventually be accepted and a contract signed between ESA and the new organisation. It, however, did not conceal the difficulties which were ahead, deriving from the fact that "this negotiation will, for the first time, be influenced by the basically hostile American (Comsat) participation".

> *One factor that Comsat will seek to exploit will be the credibility of the Agency in providing Inmarsat with a space segment on cost and on time [...] It may be argued that any delay in the programme will, apart from any resulting cost increase, tend to harm the chances of the sale of the third satellite (and a third launcher). Such delay will be (deliberately) misinterpreted by Comsat and would be presented as an inability of ESA to deliver any spacecraft or services in time.*[763]

Thanks to the effort developed in the Marecs A and B programmes, the Executive continued, the Agency had been able to present "a very competitive proposal" to Inmarsat, while interim funding allocations had also enabled the programme for Marecs C to remain on time. However, during the negotiations with Inmarsat it was necessary to keep the Agency in some position of strength, and the Executive recommended that, pending eventual reimbursement from Inmarsat on the basis of a contract presumably to be concluded in spring 1980, the JCB approve the financing of the Marecs C programme and of the Pacific Ocean control station. This would place the Agency on the same footing as Intelsat, whose Board of Governors had recently decided to purchase four maritime packages and to incorporate three of them in the last three Intelsat V satellites on order. Intelsat, the Executive advised, "has no more commitment from Inmarsat than has the Agency".[764]

Two main reasons were given for recommending such a course of action. Firstly, the Marecs C programme was entering an equipment manufacturing stage and should the continuity of this manufacture be interrupted, re-starting would be extremely costly, thereby destroying the price competitivity of the ESA offer. Secondly, by the time the Inmarsat Council would be called upon to take its final decision, "[it] would be faced with the inevitability of a Marecs C spacecraft being ready. Such psychological factors are not without their importance in a contract negotiation situation".[765] There was an element of risk involved, the Director General acknowledged, but "an 'act of faith' on the part of the Marecs participants would have a favourable psychological impact on Inmarsat".[766] The total funding requirement was estimated at 28.4 MAU, of which 3.2 MAU would have been required in 1979.

The JCB having been unable to reach general agreement on the "act of faith", the matter was discussed at a restricted session of the Council during its 33rd meeting in July 1979. Here, the German delegation confirmed it would not participate in the Marecs C programme, as "the risk of Inmarsat not accepting the European offer was too high for undertaking supplementary financial commitments". The British delegation declared that their authorities were prepared to make up for the German withdrawal, but this implied that they would not accept an increase in their contribution to the Scientific Programme.[767] Following these discussions, during a brief JCB meeting held on that same day, five participating

761 JCB, 32nd meeting (4-5 July 1979), ESA/JCB/MIN/32, 26 July 1979; Council, 33rd meeting (25-26 July 1979), restricted session, ESA/C(79)R/23, 12 September 1979.
762 Galligan (1981).
763 ESA/C(79)R/19, 12 July 1979, p. 2.
764 ESA/JCB(79)21, 20 June 1979, p. 1.
765 ESA/JCB(79)34, 12 July 1979, p. 1.
766 ESA/JCB/MIN/32, *cit.*, p. 3.
767 ESA/C(79)R/23, *cit.* p. 2 (our translation from French).

states in the Marecs programme (France, Italy, the Netherlands, Sweden and the United Kingdom) subscribed to a declaration whereby they agreed to support the Marecs C programme and the Pacific control station, pending reimbursement from Inmarsat on the basis of the contract to be concluded. Britain accepted to contribute as much as 72.2% of the expenditure required in 1979.[768] Subsequently, owing to delays in Inmarsat decisions, new funding was approved in order to support work in industry during 1980.[769] At the same time, in view of the important meeting of the Inmarsat Council scheduled for 6 February 1980, the ESA Director General wrote to the newly elected Director General of Inmarsat, Olof Lundberg, that "in the absence of a positive attitude to the use of Marecs", it would hardly be possible to maintain the validity of the ESA offer beyond May that year.[770]

The course of events frustrated ESA's expectations. The Inmarsat Council, in fact, decided not to procure a space segment for providing services in the 1980s, but rather to lease maritime communications capacity on existing satellites or those or under development. A second generation (Inmarsat II) space segment would be procured at a later stage, designed to provide services in the following decade. A call for tenders based on a leasing approach was then issued by Inmarsat in March.[771]

While, in principle, leasing could be very similar to the sale of satellites, ESA had to cope with three main problems in this respect. Firstly, the Agency was called to make a bid for a "sale of services". This kind of activity was contemplated indeed by the Convention (Article V.2), but its implementation required a decision by the Council. Moreover, it was specified in the Convention that "the cost of such operational activities shall be borne by the users concerned". The Executive warned however that an offer respecting the ESA internal charging policy would have "extremely negative consequences regarding price", therefore it proposed to adopt a marginal cost approach, i.e. to charge Inmarsat for only the additional costs arising directly out of such provision of services by ESOC and the Villafranca station.[772]

The second problem regarded the insurance policy, a crucial aspect in a situation where ESA was to make a proposal for providing service continuity over a period of 5 years. Adopting a leasing philosophy, in fact, meant that less payment or no payment at all would be forthcoming from Inmarsat in case of failure during launch or in orbit. The then recent loss of an RCA satellite insured for $78 million, together with the immediate prospect of only small amounts of premium income, had "destabilised" the insurance market, the Executive advised. Moreover, the Ariane vehicle would only have flown once (its maiden flight was scheduled for December 1979) before ESA’s bid would be submitted to Inmarsat in May 1980, and brokers could hardly offer attractive insurance premiums for an Ariane launch of Marecs. Two options existed for ESA: either to make an offer without insurance, thus assuming in full the risk of failure, or to negotiate with Inmarsat a possible equal sharing of insurance costs, tentatively determined at 17.5 MAU.[773]

Finally, there was the problem of recovering the investments already made in the Marecs C programme, its participants having agreed that it was no longer wise to go on constructing a third spacecraft. In this respect, the Executive proposed that ESA undertake to procure elements for such a third spacecraft, in particular a complete payload. This additional spare hardware would be included in the Inmarsat bid and reimbursed by Inmarsat over the five-year period. Pending such reimbursement, the expenditure incurred in the period 1979-1983 would be covered by the participants in the Marecs A and B programmes from the 20% margin of their financial envelope.

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768 JCB, 33rd meeting (26 July 1979), ESA/JCB/MIN/33, 25 September 1979, with the attached resolution ESA/JCB/XXXIII, Dec. 1.

769 JCB, 36th meeting (7-8 January 1980), ESA/JCB/MIN/36, 3 March 1980. Reference documents are ESA/JCB(79)58, 22 November 1979, and add. 1, 20 December 1979.

770 ESA/JCB(80)6, 5 February 1980.

771 ESA/JCB(80)9, 12 March 1980. cf. also Galligan (1981).

772 ESA/JCB(80)17, 14 April 1980, p. 3. The comparison between the full costs and marginal costs options is presented in ESA/JCB(89)32, 15 July 1980.

773 *Ibid*, p. 4. Also ESA/JCB(80)17, add. 1, 16 April 1980.

In the event, the Executive proposed to offer Inmarsat the leasing of the maritime communications capacity of two satellites (Marecs A and B) for five years (1982-1987), with spare hardware on the ground. The first satellite was to be placed in geostationary orbit above the Atlantic Ocean region and controlled by ESA's existing station at Villafranca, near Madrid; the second was to be placed above the Pacific Ocean region and controlled via a new station to be procured for that purpose by ESA, and eventually built in Ibaraki, Japan. The total cost to Inmarsat was fixed at $62.5 million, equivalent to 46.7 MAU (1980 prices).[774] This covered the provision of communication services over a five-year period, manpower and facilities supplied by the Agency on a marginal cost basis only, and a recovery of expenditure on the spare hardware over five years. In case only one satellite should achieve operational status, the quoted price was $35.0 million (26.2 MAU), while no payment could be claimed from Inmarsat if both satellites failed.

The JCB endorsed this proposal, but many delegations in the Council then complained about the marginal cost policy adopted in the Inmarsat bid, which in their opinion "was liable to have direct repercussions on the level of the Scientific Programme". In the event, there was no choice for the Council but to approve the offer, prepared by the Executive, which was formally submitted to Inmarsat on 2 May 1980.[775] At the same time, Inmarsat received proposals from Intelsat for the lease of maritime communications capacity on board its future Intelsat V spacecraft, as well as from the Marisat consortium for the lease of its in-orbit satellites. These offers were "highly comparable" with ESA's, the Executive warned, underlining that the charging of only marginal costs was "an essential condition of European competitivity". The JCB chairman, for his part, expressed his hope that "the Member States and Canada would be able to give the European offer their full support at the [forthcoming] Inmarsat meeting.[776] After many negotiations, both between ESA and Inmarsat (regarding technical and financial aspects of the leasing action) and between ESA member states (regarding pre-financing schemes of the programme), the lease contract was eventually signed in November 1980.[777]

Marecs A was successfully launched on 20 December 1981 by the Ariane L04 vehicle and two weeks later it reached its final position over the Atlantic. Following the commissioning and testing phase, the satellite started operational services for Inmarsat on 1 May 1982. Marecs B was lost in an Ariane launch failure on 10 September that year, resulting in a serious shortage of communications capacity over the Pacific region. The participating states agreed to procure and launch a replacement satellite (Marecs B2), taking advantage of the critical hardware for a third spacecraft already procured within the framework of the Marecs A/B programme. Marecs B2 was successfully launched by Ariane on 10 November 1984 and placed in its final orbital position over the Pacific. It went into operational service for Inmarsat by the end of the year, thus allowing ESA to fulfil its contractual obligations to the users.

The ESA/Inmarsat contract marked ESA's entry into the international commercial satellite market, confirming that government support to the Marecs programme had actually resulted in a product which was technologically and financially competitive with American products. The Marecs spacecraft, in fact, was specifically designed for maritime services in the 1980s, providing Inmarsat's first space segment with the largest communications capacity and a special search-and-rescue channel in ship-to-shore direction. Intelsat V, on the contrary, carried a maritime communications subsystem in addition to its basic fixed service communications payload. The experience with the Marecs programme was also very important in consolidating European capability in the maritime

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774 ESA/JCB(80)21, 13 May 1980; ESA/JCB(80)32, 15 July 1980. The corresponding figure at 1979 prices, given in ESA/JCB(80)17, *cit.*, is 40.68 MAU.

775 JCB, 38th meeting (15-16 April 1980), ESA/JCB/MIN/38, 14 May 1980; Council, 41st meeting (20 May 1980), ESA/C/MIN/41, 6 June 1980, with attached ESA/C/XLI/Res. (Final). ESA/JCB(80)21, 13 May 1980.

776 JCB, 39th meeting (28-29 May 1980), ESA/JCB/MIN/39, 10 July 1980, pp. 6, 9.

777 ESA/JCB(80)31, 16 July 1980; ESA/JCB(80)48, 26 September 1980; ESA/JCB(80)52, 26 October 1980. JCB, 40th meeting (30-31 July 1980), ESA/JCB/MIN/40, 22 September 1980; 41st meeting (16-17 October 1980), ESA/JCB/MIN/41, 28 November 1980; 42nd meeting (4-5 November 1980), ESA/JCB/MIN/42, 26 November 1980.

communications field. This was confirmed when, in 1985, an industrial consortium led by British Aerospace won the contract for developing the second generation Inmarsat 2 satellites. The Inmarsat 2 platform was essentially based on the ECS and Marecs design, while the payload was developed by Hughes Aircraft Company using a new design.

6.12 The End of the H-Sat Concept and the Start of Two DBS Programmes in Europe

On 1 March 1978, as discussed above, the Council and the JCB had approved a preliminary Phase-B study on H-Sat, pending a final decision on the start of the programme. The main objective of this six-month study was the improvement of the H-Sat design in view of its adaptability for future operational DBS missions, according to the WARC plan. This involved, in particular, the change from Ariane L04 to an operational Ariane launcher, the prolongation of the satellite lifetime to 7 years, and the modification of the antenna configuration to give two separately steerable single-beam antennas instead of a dual-beam single antenna.[778] It was moreover decided that two alternative satellite designs would be studied, corresponding to two possible schemes for participation of member states in the development phase, i.e. with or without the participation of Germany. First results of this study were available in early October, showing that, "the satellite design had proved to be fully compatible with the H-Sat mission objectives and – in particular – both platform and payload elements have been proved to match the stringent requirements for demonstrable growth potential and adaptability to the needs of future pre-operational and operational missions".[779]

On this basis, the Executive presented a proposal for "an integrated European approach to the development of operational broadcast systems". This represented a difficult compromise between the diverging interests of those countries which pursued an early development of an operational system, notably France, Germany and the Scandinavian countries, and those which advocated an initial mission mainly devoted to experimental activity. The plan envisaged a joint effort for the development of a common European platform designed to accommodate (with minor modifications) all foreseen operational missions. This effort had to be complemented by the continuing development of communications in the framework of both national and ESA programmes:

> *The future space segments for operational systems could then be readily furnished by the combination of the basic common platform with the relevant assembly of payload equipment adapted to specific mission requirements.*[780]

There were many important advantages in the concept of a European platform, the Executive argued. Firstly, from the technical point of view, the bulk of the necessary development would be done only once, minimum modifications being required to match the needs of each specific mission. The risk for individual users would also be reduced for any technical bug would be uncovered by a single development and test programme on the ground, and during in-orbit operations. Secondly, from the financial point of view, the development of a single common platform at European level would eliminate wasteful parallel development of similar products, and permit the initial development costs to be shared between a number of countries. Thirdly, from the industrial policy point of view, this approach would foster the creation of one industrial consortium in Europe able to produce platforms of this class in a cost-effective manner, thus helping European space industry to compete successfully on the world-wide market. On the contrary, parallel development of several platform concepts on a national or bilateral basis within Europe would lead to wasteful competition for external markets. Finally, the common platform would be developed and eventually upgraded in coherence with planned improvements in Ariane performance, so that the European launcher/platform combination could be successfully marketed externally.

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778 ESA/JCB(78)22, 28 April 1978.

779 ESA/JCB(78)55, 9 October 1978, p. 26.

780 ESA/JCB(78)67, 20 November 1978, p. 8. See also ESA/SBAG(78)10, 12 October 1978 (also attached to ESA/JCB(78)63, 23 October 1978).

A "logical sequence" for the development of an integrated European programme in the DBS field was then outlined, consisting of an initial satellite (H-Sat) with operational elements but limited capacity, closely followed by the procurement of one or more operational systems. More specifically, such a programme would consist of three phases. The first would be devoted to the prompt development (starting in early 1979) of H-Sat, suitably modified in order to provide for a limited pre-operational service for those countries that envisaged rapidly setting up an operational service. The satellite was to be launched in 1982, and its technical specifications were defined as far as possible according to the wishes of Germany as regards orbital position (19° W), frequency allocation (one channel), polarisation, and maximum conformity with the German coverage allocated at the WARC conference. The second phase, to be developed within a period of 18 months to 2 years, would be devoted to the manufacture of an operational satellite, to be launched in 1984, providing coverage of those European countries that wished to have a DBS system in the short term. Several options existed regarding the payload of this satellite, e.g. a French dedicated payload, a German dedicated payload, a payload matched to Nordsat requirements, and a mixed payload for a multinational mission. Finally, fully national systems based on the standard European platform would be developed in the third phase, whose content depended on national plans as well as on the achievements of the two preceding phases. In this plan, the Executive stressed, the Agency would be responsible for the definition and the procurement of the initial satellite, in close collaboration with future users, while during the subsequent procurement of operational satellites, the Agency's role would be limited to "that of coordination and technical support when requested by users".[781]

The Executive's plan was discussed at two SBAG meetings, on 13 October and 4 December 1978, respectively, after extensive consultations with the national broadcasting authorities represented in the EBU had showed that all were interested in using H-Sat for carrying out experiments in direct broadcasting. Here it was evident that all efforts to reconcile the experimental and operational requirements were doomed to failure. All ESA member states other than France and Germany supported the common European platform concept. The Swedish delegation, in particular, insisted that such a platform had to be developed as soon as possible in order to be used in the Nordsat project. France and Germany, on the contrary, stated that they were not interested in H-Sat and would eventually implement an operational satellite on a national or bilateral basis, outside the ESA framework.[782]

The French position came as a novelty, this country having been until then a convinced supporter of the H-Sat concept, both within ESA and within the EBU. The change of attitude, in fact, reflected ongoing bilateral consultations between the two major ESA member states on the possibility of developing a Franco-German system. By taking advantage of the experience that MBB and SNIAS had acquired in the Symphonie programme and in the development of the Intelsat V satellite, the two countries envisaged merging their industrial capabilities in the most efficient way, without being encumbered by geographical distribution constraints, in order to secure for their leading aerospace industries a competitive position in the future market of DBS systems.

As core members of Eurosatellite, MBB and SNIAS were thus in the embarrassing situation of being involved in the study of two potentially competing programmes, i.e. ESA's H-Sat and the envisaged Franco-German project. The embarrassment became evident when, at the conclusion of the interim study, the Executive requested a detailed financial offer for the development of H-Sat from Eurosatellite. The latter prepared a budgetary offer which the Executive considered of very little meaning, "since the prices submitted by certain contractors are artificial and without any supporting detail or any reference to the previous financial baseline". The lack of interest on the part of industry

781 ESA/JCB(78)67, *cit.* p. 10.

782 ESA/JCB(78)63, 23 October 1978); ESA/JCB(78)76, 5 December 1978. For the German position, see also ESA/SBAG(79)1, 2 February 1979.

could easily be explained: "The general political environment surrounding the programme and the fact that some industries have allowed themselves to be influenced by parallel national activities".[783]

In what appears to be a deliberate attempt to keep France linked to the ESA programme against Germany's centrifugal pull, the Executive suggested a possible modification in the H-Sat concept, i.e. the introduction of an alternative payload with one or two channels for French operational use, a channel for pre-operational services in Germany and other interested countries (Scandinavian countries and Italy), and the Italian 20/30 GHz experiment payload. This modification, however, was not accepted by the other member states, which confirmed their interest in the current H-Sat design and the experimental mission being studied by a joint ESA-EBU working group. France and Germany, on the other hand, rejected a possible compromise suggested by the EBU observer in the SBAG, which consisted of using H-Sat for two years for joint experimentation, and then making it available to countries with operational requirements.[784]

At the JCB meeting of 5 and 6 December 1978, the split between France and Germany, on the one hand, and the other member states, on the other, became dramatically evident. The Executive had proposed a complementary study programme (Phase-B2) at a cost of 4.5 MAU in order to ascertain whether the current H-Sat concept could be modified in order to meet the needs of all interested parties, but the French and German delegations stated that they would not approve any further funding of the H-Sat programme until the results of their on-going national studies were available. The other delegations, on the contrary, strongly supported the Executive's proposal, some of them harshly recalling that "the obligations imposed by the Convention for the harmonisation of national programmes with those of the Agency and for the Europeanisation of national activities also covered application satellites". France and Germany being unable to approve even a reduced (1 MAU budget) study programme proposed by the Executive during the meeting, the chairman concluded that "there was no point in continuing the discussion", and announced that a report would be submitted to the next Council meeting, scheduled for 12 and 13 December.[785]

The Council, however, was also unable to overcome the deadlock in the H-Sat programme. Despite the appeal to the French and German delegations "to reverse the stance they had taken and thus keep open the option for a European programme", these reaffirmed that they could not approve any commitments concerning H-Sat until the national studies had been finalised. In view of this situation, the Director General proposed to defer all decisions to February 1979, thus allowing the French and German authorities to arrive at a final decision. In order to keep the ESA H-Sat team together until then, the remaining delegations immediately approved an amount of 0.3 MAU to support additional studies.[786]

The new document which the Executive submitted to the JCB and the Council had the tone of an ultimatum, starting with "the three fundamental questions posed by the development of direct television broadcasting satellite systems in Europe":

> *Is it desirable for Europe to tackle this problem by means of collective actions? Should such action be determined by the ESA Council? What should be the role of the Agency, as an Executive entity, in the execution of this action?*[787]

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783 ESA/JCB(79)4, 11 January 1979, p. 3.

784 ESA/JCB(78)67, *cit.* ESA/JCB(78)76, *cit.* (fn. 782)

785 JCB, 28th meeting (5-6 December 1978), ESA/JCB/MIN/28, 17 January 1979, pp. 2-3. The Executive's proposal for a complementary study programme is described in ESA/JCB(78)68, 20 November 1978; ESA/JCB(78)71, 21 November 1978, and ESA/JCB(78)78, 5 December 1978. The JCB chairman's report to the Council is in ESA/C(78)162, 8 December 1978

786 Council, 28th meeting (12-13 December 1978), ESA/C/MIN/28, 26 January 1979, p. 19. The declaration relating to these additional studies was subscribed on 16th May and reported in ESA/C/XXXI/Dec. (Final).

787 ESA/JCB(79)6, 12 January 1979, p. 1. The following quotations are from pp. 9-10 and 12-13.

The document continued by presenting again the case for a coordinated European approach, against the adoption of "uncoordinated [national] lines which would [...] have adverse consequences both for the individual countries concerned and for Europe as a whole". A coordinated European industrial effort, leading to the efficient development and manufacture of the complete series of operational broadcast satellites required by the different user organisations, would be of benefit to all concerned in both technical and financial terms. As regards the H-Sat programme, it was recognised that "controversy exists over the nature of the payload and mission for the initial satellite", i.e. between those who believed that this should carry an operational payload and be immediately put into service, and others who insisted that the initial mission should be of an experimental character. Both viewpoints could be accepted, the Executive argued, stating that it could go along with either approach. It therefore proposed to leave open for the moment the question of the payload, in order to ensure that the platform development programme could be started immediately under ESA responsibility. Regarding the payload, the Agency's responsibility would depend on whether it was of an operational or an experimental nature. In the former case, one or two users could be entirely responsible for payload development and for the utilisation of the satellite, "while collaborating with ESA, EBU and other users in the execution of a minimal in-orbit test programme". In the other case, ESA would be responsible for payload development and procurement within the framework of the overall contract and all European users would be invited to participate in the experimental programme. The procurement of subsequent operational satellites would in any case be managed by the users, which could delegate certain technical and managerial tasks to national space authorities such as the French CNES or the German DFVLR, or to ESA. The latter should remain however responsible for certain coordination tasks in the domain of payload development as well as for launching, injection into geostationary orbit and in-orbit operations of future operational satellites.

Concluding its document, the Executive urged the JCB and the Council to answer the fundamental questions posed at the beginning. The urgency of these questions, it argued, was linked to the emergence of operational requirements and to the fact that national initiatives were being undertaken to meet them in competition with ESA's programme. Should Europe undertake a DBS development programme by means of collective action? Should such action be determined by the ESA Council? What should the role of ESA be? Delegations were strongly invited to adopt a clear position on these questions:

> *The Director General feels it his duty to state that any other course of action would constitute a violation of both the spirit and the letter of the ESA Convention. [...] In the absence of clear answers to these questions, ESA will be unable to progress in planning European collective action in this field.*

Neither the JCB nor the subsequent Council meeting were able to answer these questions, as France and Germany said that the studies undertaken at national level had not been completed and therefore no decision could be taken for the time being. In view of this attitude, the JCB chairman asked the Executive to study to what extent a European television broadcasting satellite could be developed without the participation of these two countries. The other delegations were upset, most of them feeling that it would be unrealistic to undertake such a programme without two major contributors. The Swiss delegation pointed out that the H-Sat programme had originally stemmed from the resolve to develop a platform using the capacity of Ariane, and from the very beginning it had been studied within a European framework. The competent European authorities should take their decision advisedly, it added for the benefit of the French delegation, "without forgetting either their obligations under the Convention or the acts of solidarity demanded of member states in connection with the Ariane follow-on development activities and the maintenance of the Guiana Space Centre".[788]

At the subsequent Council meeting of 28 February, seven member states (Denmark, Italy, Netherlands, Spain, Sweden, Switzerland and the United Kingdom) plus Austria approved a new study programme at a cost of 0.55 MAU to cover work during the period March-July 1979. The H-Sat

[788] JCB, 30th meeting (1-2 February 1979), ESA/JCB/MIN/30, 12 March 1979, p. 5.

concept being definitely jeopardised, the aim of the study was to investigate a wider range of future telecommunication missions, including fixed, broadcast and mobile services. These missions were to be studied *vis-à-vis* their compatibility with the large platform studied within the framework of the former H-Sat programme. A market survey was to proceed in parallel.[789]

While these studies were under development, the British delegation informed the Executive that from national studies and informal contacts with other member states it appeared that considerable interest remained in a European large communications satellite programme, based on the multi-purpose platform concept, even without the participation of France and Germany. It therefore urged the Executive to table a new programme proposal for at the next JCB meeting on 4 and 5 July.[790]

The failure to achieve a joint European approach to future space telecommunications programmes did not go unnoticed by the public or European political organisations. The chairman of the Committee on Science and Technology of the Council of Europe's Parliamentary Assembly commented on these events as follows:

> *The Committee heard with some concern [...] that a coherent multilateral approach within the framework of the European Space Agency might be endangered by a bilateral initiative on the part of France and Germany. This initiative, though highly commendable in substance, risks leading to other bilateral or trilateral initiatives by other countries — and thus to a general fragmentation of the European effort.*[791]

6.13 The L-Sat Concept and the Adoption of the Olympus Programme

The ESA study was duly completed by the end of June and reports of its conclusions were distributed to JCB and Council delegations.[792] The Executive had undertaken a market survey of several future telecommunications missions, including European broadcast services (DBS systems) and fixed services (regional trunk services, national inter-city trunk services, specialised services); global fixed services (Intelsat transponder leasing) and mobile services (maritime, aeronautical and land); and non-European regional and domestic services (mainly in Third World countries). The conclusion of this survey was that in every sector there was a clear potential market for large telecommunications satellites of European origin, the date for market materialisation for most of them falling in the 1984-87 period. As a consequence, in order for European industry to succeed in fulfilling the foreseen European domestic demand economically and to win orders for global and non-European regional or national systems:

> *it is considered essential that the necessary space segment elements be available "off-the-shelf" at the moment when each market manifests itself in the form of an invitation to tender from the national user authority, government, or international organisation. This means [...] that there should be developed in good time a suitable multipurpose platform of the appropriate class needed to fulfil most of the foreseen demands and the complete range of payload technologies and equipments matched with the predicted mission requirements* [underlined in the original text].[793]

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789 Council, 29th meeting (27-28 February 1979), ESA/C/MIN/29, 4 April 1979, with attached ESA/C/XXIX/Dec. 5 (Final). Cf also ESA/C(79)26, 9 February 1979. A detailed definition of the tasks of the study were subsequently described in ESA/JCB(79)14, 27 March 1979.

790 ESA/JCB(79)27, 8 June 1979.

791 ESA/JCB(79)29, 28 June 1979.

792 ESA(JCB(79)28, 19 June 1979. The full report is ESA/EXEC(79)3; July 1979, presented to Council under cover ESA/C(79)82, 27 June 1979. A summary report for the JCB is ESA/JCB(79)28, 19 June 1979.

793 ESA(JCB(79)28, *cit.*, p. 11.

According to the Executive, the number of large platforms European industry could reasonably hope to sell was in the range 20 to 30. It then proposed that ESA undertake a "multi-mission service demonstration satellite", based on the large platform studied in the framework of the H-Sat programme in association with a multi-element payload, each element demonstrating a particular future service type. The selection of the payload elements would be based on the strength of market predictions for each payload type, the interest in demonstrating certain new services, the benefit of in-orbit demonstration and qualification of the relevant technologies, and the willingness of participating member states (governments and/or user authorities) to finance both payloads and corresponding Earth segment elements. As an example of such a complex payload, the Executive suggested the following six elements:

a) a single channel direct broadcast payload with a steerable antenna for demonstration in all parts of Europe;

b) a payload dedicated to the pilot provision of special services primarily for business users over the whole European coverage area;

c) a payload for demonstration of future national inter-city telecommunications and special services in the 20/30 GHz bands;

d) a 20/30 GHz propagation beacon package;

e) a single channel UHF sound broadcast payload;

f) a C-band fixed service payload intended to test new techniques relevant to satellite applications in developing countries.

On this basis, the Executive proposed a new optional programme, called L-Sat, consisting of:

- the development of a multi-purpose large platform, compatible with both Ariane and the Space Shuttle;
- the development of a multi-element payload;
- the procurement and launch of a single flight model (supported by a flight spare);
- operations support for the satellite lifetime;
- supporting Earth segment equipment.

Assuming that the project definition phase would start in October 1979, and that the decision on the development phase would be taken in November 1980, the launch of L-Sat was scheduled for the end of 1983. The industrial cost of the platform was estimated at 40 to 50 MAU (including the procurement of the first flight model), while the average development cost of each payload element was estimated at 10 MAU.

The proposed implementation policy for this programme was strongly oriented towards preparing industry for future cost-competitive satellite production, in order to satisfy the market outlined in the survey. In particular, it was proposed to depart from the conventional consortium arrangements and select only the prime contractor. The latter would be encouraged to invest in the programme, to take maximum initiative and full responsibility for its actions, and to promote the future sale of the product. The prime contractor would select subcontractors by competition, with development and recurring price as main criteria, while ESA's role would be limited to general supervision. The participating Member States would contribute to the programme in proportion to their industrial return, "in turn reflecting relative industrial competitivity".[794]

At the JCB meeting of 4-5 July 1979, France and Germany confirmed that they did not intend to participate in the ESA project, their national authorities being in fact on the verge of agreeing to carry out a bi-lateral DBS development programme. The other delegations were generally positive towards L-Sat, but some of them expressed concern about the possibility of funding the programme if France and Germany did not participate. In the event, it was agreed that the proposal should go forward to the Council for consideration and eventual approval.[795] During the subsequent Council meeting, the L-Sat programme was finally approved and five member states (Denmark, Italy, the Netherlands, Switzerland and the United Kingdom) agreed to embark immediately on the project definition phase (Phase-B study).[796] They were joined by Belgium and Spain in October. One month later, British Aerospace was selected as prime contractor for the Phase-B study. Subsequently, Austria and Canada were also associated to the study programme.[797]

The project definition phase was completed in June 1981, when British Aerospace submitted its proposal for the development phase. Following some technical and financial negotiations between the prime contractor and ESA, and the submission of a new proposal, the L-Sat development programme was finally approved in December by all the countries which had participated in the study phase, except Switzerland. The financial envelope of the programme was established at 388.5 MAU (at 1980 prices); the initial scale of contribution, which corresponded to the estimated percentage shares of industrial work among the participants, is shown in Table 6-17, the unallocated amount reflecting the unforeseen withdrawal of Switzerland.[798]

Table 6-17: L-Sat contribution scale

Country	**%**
Austria	0.75
Belgium	3.7
Canada	9.0
Denmark	1.3
Italy	32.8
The Netherlands	11.8
Spain	2.6
United Kingdom	34.3
Unallocated	3.75
Total	**100.00**

The two objectives of the L-Sat programme were: (a) the development and launch of a multi-purpose large platform designed for a range of future telecommunications applications, and (b) the development, in conjunction with the space platform, of a series of telecommunications payloads and their in-orbit operations. The general aims were to advance European space industry in order to maximise its competitiveness in the world market and to stimulate users and promote new market applications. Several research laboratories as well as telecommunications and broadcast authorities

794 *Ibid*, p. 28.
795 JCB, 32nd meeting (4-5 July 1979), ESA/JCB/MIN/32, 26 July 1979.
796 Council, 33rd meeting (25 - 26 July 1979), ESA/C/MIN/33, 20 September 1979; ESA/C(79)92, 10 July 1979.
797 ESA/JCB(80)10, 12 March 1980; ESA/JCB(80)16, 31 March 1980.
798 ESA/JCB(81)33, rev. 1, 26 October 1981; ESA/JCB(81)34, rev. 1, 15 October 1981. JCB, 48th meeting (14-15 October 1981), ESA/JCB/MIN/48, 10 November 1981, with attached ESA/JCB/XLVIII/Dec. 1 (Final), rev. 2. Apparently, it was "for financial reasons" that Switzerland had to forgo participation in the L-Sat programme: Council, 51st meeting (9-10 December 1981), ESA/C/MIN/51, 18 January 1982, p. 37.

were to be involved in the experimental programme.[799] Four payloads were eventually approved for inclusion on the first L-Sat, which was eventually named *Olympus*. These were:

- A direct broadcast service (DBS) payload with two channels, one for pre-operational use in Italy (RAI), and the other for European use (EBU),
- A 12/14 GHz specialised services payload for communications experiments between small Earth terminals,
- A 20/30 GHz communications payload for experiments in new communications applications,
- A propagation package for gathering new information on the propagation of radio waves in the atmosphere at 12, 20 and 30 GHz.

Following the departure of France and Germany from the programme, the sharing of industrial work was reorganised. As the United Kingdom and Italy were now the main contributors, British Aerospace was selected as the prime contractor for Olympus development, while the Italian firm Selenia Spazio was responsible for coordination of the four communications payloads, including the design and development of the DBS and the 20/30 GHz Communications payloads. Marconi Space System (UK) and Bell Telephone Manufacturing (B) were responsible for the Specialised Services and the Propagation Package payloads, respectively, while the Canadian Company SPAR Aerospace had overall responsibility for the solar arrays. Originally scheduled for launch in early 1986, Olympus was eventually launched by an Ariane vehicle on 12 July 1989.[800]

Olympus' orbital life was unfortunate. In January 1991, the satellite lost the use of one of its solar arrays, but sufficient power was being delivered from the other array for the satellite to continue operations with all the payloads. It was however necessary to implement complex operating procedures which resulted eventually in a faulty operation and a loss of all attitude and orbit control of the satellite in May. The satellite began spinning and drifting along its orbit, internal temperatures dropped, and the batteries were completely discharged. A major recovery operation was developed in the following months, and the satellite was gradually brought back into operation by the end of the year.[801] It was expected to remain in operation until July 1994, but in August 1993 service from the satellite was interrupted for reasons which remain unclear (probably meteorite showers) and the satellite lost its Earth-pointing attitude and began spinning. All attempts to retrieve the satellite having failed, Olympus was finally turned off and its mission ended.

6.14 Epilogue

In May 1980, France and Germany signed a memorandum initiating their collaboration on the development of an operational DBS system. The programme began in 1981, and included development work and assembly of three five-channel satellites, one flight unit for each country and one spare. Later, it was expanded to four satellites, one flight unit and one spare for each country. The spacecraft serving Germany was called TV-Sat, that for France was called TDF (Télédiffusion de France, the name of the national broadcasting company). Both satellites were developed by the Eurosatellite consortium, MBB being the prime contractor for TV-Sat and SNIAS for TDF. In 1983, Eurosatellite (SNIAS prime contractor) was awarded a contract to develop Tele-X, a satellite derived from the former Nordsat project and sponsored by Sweden together with Norway and Finland. Tele-X was essentially identical to TV-Sat/TDF, but supporting a payload with three broadcasting channels and two channels for data transmission. TV-Sat was launched in November 1987, but it failed during initial deployment and was finally abandoned in the spring of 1988. The second flight unit was successfully launched in August 1989. Two TDF spacecraft were launched, in October 1988 and

799 Hughes & Bartholomé (1987).
800 Paul (1989).
801 Wilkins (1991).

July 1990, respectively, but each of them experienced two TWTA failures. Tele-X was launched in April 1989.

By the mid-1980s, two distinct DBS development programmes were thus under development in Europe, with two industrial groupings emerging in a potentially competitive position with each other in commercial markets. By the end of the decade, however, both programmes proved to be obsolete compared to the new technology adopted by a dynamic private company, Societé Européenne des Satellites (SES), set up in 1985 in Luxembourg with partial support from the government of the Grand-Duchy. In contrast to the high-powered Olympus and TV-Sat/TDF satellites, which were based on the use of 230 W TWTAs driving up to five DBS channels for national use, according to the WARC plan, the new concept took advantage of rapid advances in receiving technology to provide acceptable television broadcasting, at a much lower cost per channel and over a much larger geographical area, to domestic customers and cable-TV operators equipped with cheaper and smaller receivers than envisaged in the late 1970s. The DBS system set up by SES was based on the Astra satellite, developed by the American RCA company and used sixteen 45 W transponders capable of covering the whole of Western Europe. Astra 1 was launched in December 1988, its primary service area including England, France, Germany, Denmark, the Netherlands, Switzerland, Austria and northern Italy. A second, larger and more powerful Astra satellite was launched in March 1991.

The advent of the Astra system and its commercial success made the high-power DBS technology at the heart of both the Olympus and TV-Sat/TDF programmes obsolete prior to its introduction. As an informed observer remarked in 1990:

> *Advances in ground-based receiving technology have meant that there is no demand for a high-power satellite providing a small number of channels to cover a small area. Instead, future DBS markets are seen to be for medium-powered satellites with 100 Watt transponders, and to make TV-Sat/TDF and Olympus not much more than a fruitful, expensive effort.*[802]

As a matter of fact, both TDF and Tele-X had great difficulties in finding paying customers, and concerns about the viability of the TDF system almost led to its cancellation by the French government. After launch, the objectives of the project were redefined, the TDF satellites being no longer considered as an operational but as a pre-operational system assisting in the introduction of high-definition television. Initial plans for building a third TDF spacecraft were abandoned and the French government rather decided to participate in a new low-powered DBS project planned by Eutelsat, known as Europesat (eventually Hot Bird, developed by SNIAS and launched in March 1995).

Given its experimental and pre-operational character, Olympus was mainly used free of charge by a large number of PTT administrations, scientific laboratories and technical establishments for broadcast and communications experiments. One DBS channel was assigned to the Italian broadcasting authority (RAI) for pre-operational services under the terms of a special ESA/RAI Agreement; the other (EBU) channel was allocated to BBC Enterprises during prime time each day, the remaining daytime usage being allocated to the transmission of educational programmes from many organisations. The 20/30 GHz Communications payload and the Specialised-Services payload were used by some sixty organisations, including PTT administrations, private service providers, scientific and educational establishments. Applications with an international character were coordinated by Eutelsat within the terms of an ESA/Eutelsat agreement. Finally, an Olympus Propagation Experimenters (OPEX) group was set up, for coordinating the activity of approximately thirty scientific and technical establishments involved in propagation experiments.[803] In view of future commercialisation, a multinational marketing

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802 Müller (1990), p. 334. See also Müller (1991), pp. 291-292.

803 Paul (1989).

team was formed to promote Olympus throughout the world, but in fact no Olympus derivative was sold.[804]

As a result of the split between the two DBS programmes, two main industrial groups evolved further in Europe, sharing the communications satellite market. The first, called Satcom International, emerged from the experience of the MESH consortium in the OTS/ECS programmes, and included as its main members British Aerospace (BAe) and Matra. They jointly developed a standard platform for communications satellites called Eurostar. The second was the Eurosatellite group, including SNIAS and MBB as its core members, which took advantage of the two companies' experience in the Symphonie project and marketed their Spacebus platform. These two groups were in direct competition for a share of the international market for civilian communications satellites both with each other and with American industry. Besides developing the Marecs spacecraft, the first group was successful in securing contracts for the development of Inmarsat 2 (BAe prime contractor), the French satellite Telecom (Matra), the military communications satellites Skynet 4 and NATO IV (BAe), the Spanish satellite Hispasat (Matra) and the private transatlantic communications satellite Orion (BAe). Eurosatellite was able to secure contracts for the development of Eutelsat 2 and Arabsat (SNIAS), in addition to the bilateral TV-Sat/TDF. Moreover, we should remember the Kopernikus satellite, based on ECS and TV-Sat technology and developed by MBB/ERNO for Deutsche Bundespost; the Italsat satellite developed by Selenia for the Italian Space Agency and operated by Telespazio; and the important MBB and SNIAS participation in the Intelsat V contract.

While being successful in the European "protected" market, European industry was not equally successful in those markets where they had to cope with the strong competition of American companies. Indeed, in the period between 1991 and 1993, European companies participated as candidate prime contractors in 16 calls for tender on the international market for civilian communication satellites, but all contracts with the exception of Arabsat were won by American industry. Two main reasons for this rather disappointing performance were acknowledged in a report prepared for ESA by a Working Group on Satellite Telecommunications Policy.[805] First was the important US government-sponsored market (Department of Defence and NASA), which represented a major source of R&D funds and a powerful way of amortising development costs. This captive market was equivalent to some 14 times the European market. Second was the large dispersion of European industry and a captive market consisting of too many small series: "Hence it cannot realise economies of scale as can, for instance, Hughes Aircraft, which has so far succeeded in selling 39 satellites of the same type". A great concern was then expressed about the prospects of opening the European market to international competition, as envisaged at that time by the European Commission:

> *It is clear that, should the European market be totally opened to international competition, European space industry would have great difficulty in surviving and, if Eutelsat were to procure its next generation of satellites from US suppliers, the chances of survival would be next to nil.*[806]

ESA's fair-return industrial policy was blamed in this report as "counter-productive in the telecommunications programmes that have close links with commercial markets". It is practically impossible, the authors argued, to reconcile the objective of rendering the European space industry competitive on the world market, "whilst at the same time respecting the sacrosanct principle of the fair return". While recognising that this principle was deeply entrenched in the ESA tradition and

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804 Italy had initially planned to use a refurbished version of the Olympus satellite, known as Sarti, as a follow-up of its national communications satellite (Italsat), based on the ECS platform. The first Italsat was launched in January 1991, but delays in the procurement of the second spacecraft (eventually launched in August 1996) caused the abandonment of the Sarti project.

805 *Europe at the crossroads: the future of its satellite communications industry*, ESA SP-1166, November 1993.

806 *Ibid*, pp. 15-16.

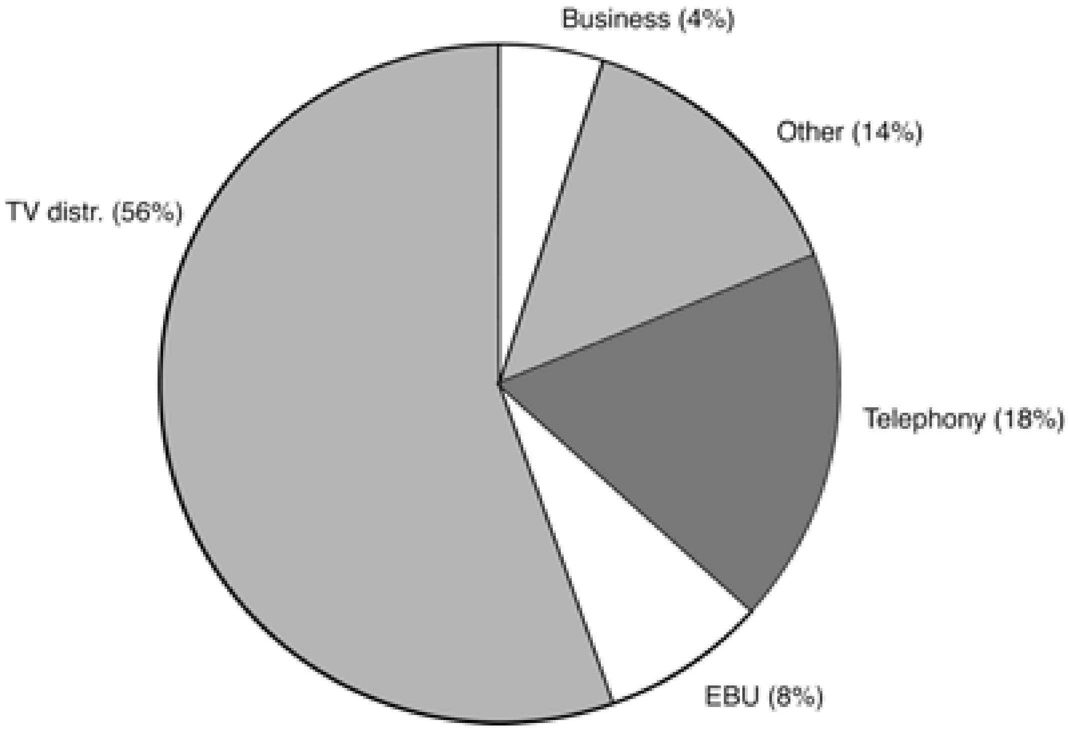

Figure 6-1: ECS Utilisation

strongly supported by the smaller countries concerned about the survival of their industry, the report insisted that "this survival depends much less on the application of ESA's rules than on the ability of the European industrial leaders to keep themselves competitive". The only way to reconcile competitiveness and fair-return objectives, in a spirit of European solidarity, was the adoption of the so-called principle of fair contribution, i.e. that each country's contribution should be consistent with its own industrial capability.[807]

It is far beyond the scope of this chapter to discuss the arguments and recommendations presented in the Working Group's report. In fact, this is not a matter of history, but rather of today's policy discussions about a general strategy for Europe in space. Several players are involved in these discussions, including ESA and its member state governments as well as the European Commission, telecommunications operators, industrial groups, financial institutions, international regulatory organisations, etc. It is, however, fair to conclude that ESA's telecommunications programme was an important element for qualifying the European space industry in this important world-wide market. In fact, the communications satellite output from Europe is largely dominated by the ECS family and Eurostar derivatives, with about 25 satellites successfully launched. According to a recent study conducted by a consultancy firm on behalf of ESA, the direct economic effect of the ECS/Marecs programme amounts to 3250 million ECU (1980 prices), this figure representing the business that would have been lost in the baseline scenario had the ESA programme not taken place. This must becompared with the total ESA expenditure on the programme itself, estimated at about 1060 million ECU (1980 prices).[808]

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807 *Ibid*, pp. 25-26.

808 Bramshill Consultancy Ltd., *Study on the direct economic effects of the ECS programme*, Basingstoke, Hants, April 1995. The baseline scenario assumed that France continued anyway its national programme with the development of a less advanced version of Telecom 1, which partly substituted for ECS. A "pessimistic scenario" was also considered, with France not proceeding with a national programme.

The satellite industry benefited from work to a value of 1900 MECU relative to the baseline scenario without the ESA Telecom Programme, while the launch services benefit was estimated at 210 MECU (a relatively low impact because substitution of US satellites for European satellites was assumed not to affect the use of Ariane). As regards the telecommunications services, the business activity resulting from the operation of ECS and Marecs was estimated at 1140 MECU relative to the baseline scenario. The PTT administrations, however, were right in their lukewarm attitude towards the use of satellites for intra-European telephony. Against all expectations, in fact, the ECS satellites were used mainly for television distribution rather than telephony and business data traffic (Figure 6-1). The use of ECS for telephony resulted in the PTTs spending about 90 MECU more than on an alternative terrestrial system; in other words, if ECS had not gone ahead, the PTTs would have saved money without losing services.

Alongside this consideration, one should also recall that the ECS satellites were remarkably successful and reliable from the technical point of view, and enabled Eutelsat to establish itself as an increasingly profitable organisation. The success of television distribution by satellite, pioneered by Astra, led to a dramatic expansion of media activity throughout Europe. This also made use of Eutelsat facilities, from the ECS system to the present Hot Bird satellites. Eutelsat would never have existed had the ECS programme not been carried out by ESA.

Chapter 7:
The European Meteorological Satellite Programme

J. Krige

A: The Europeanisation, Development and Launch of Meteosat

7.1 Introduction

On 23 November 1977 a Delta 2914 rocket lifted off from Cape Kennedy carrying aloft Meteosat-1, a meteorological satellite originally conceived at the French Centre des Etudes Spatiales in Toulouse, but 'Europeanised' in the early 1970s.'[809] The satellite was separated from the launcher about 25 minutes later, injected into near synchronous orbit at second apogee and reached its nominal position (0° longitude) on 7 December. Two days later images in three spectral bands, visible, infrared and water vapour were received at ESA's ground control station ESOC in Darmstadt, Germany. Meteosat thus became the first European satellite successfully placed in geostationary orbit – an honour it snatched from the grasp of the telecommunications satellite OTS, which had been unceremoniously dumped into the Atlantic only a couple of months before.

This launch proved to be the first of three using hardware prepared in the framework of the Meteosat pre-operational programme.[810] One back-up flight model was orbited successfully on 19 June 1981 as a free-riding passenger on the third Ariane launch, where it accompanied the Indian telecommunications satellite Apple. The second flight model of an even earlier vintage in the development plan was also refurbished and launched successfully on the first flight of Ariane-4 on 15 June 1988. This pre-operational programme laid the foundations for the so-called MOP series, which has seen the launch of four further European operational meteorological satellites, the most recent in September 1997.

A success story then, or so it seems. But we must be careful, for we must not forget that in the late 1970s and early 1980s the pre-operational programme lived precariously. When it got under way in the early 1970s, the plan was to hand over operational responsibility for the original system to the European meteorological community within the decade. In the event, the ministries of research and development which were funding Meteosat became increasingly frustrated at the reluctance of the meteorological community and their supporting ministries to take over organisational and financial responsibility for an operational meteorological activity. The MOP series which began in the late-1980s attests to the success of the pre-operational programme. But it started far later than was

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809 A description of the Meteosat system, including its interest to meteorology, its technical and managerial dimensions and its launch programme was published in a special number of the ESA Bulletin the month after the launch of Meteosat- 1, *ESA Bulletin*, No. 11, December 1977. See also Summary Report on Progress of Meteosat Programme since 10th ESA PB-MET Meeting, ESA/PB-METIMINII 1, Annex II, 16 January 1978 (ESA3537).

810 From a technical point of view a pre-operational satellite is one designed and developed to be one of a series of identical spacecraft. It is to be contrasted with an experimental satellite, where there is no such constraint on the design choices made.

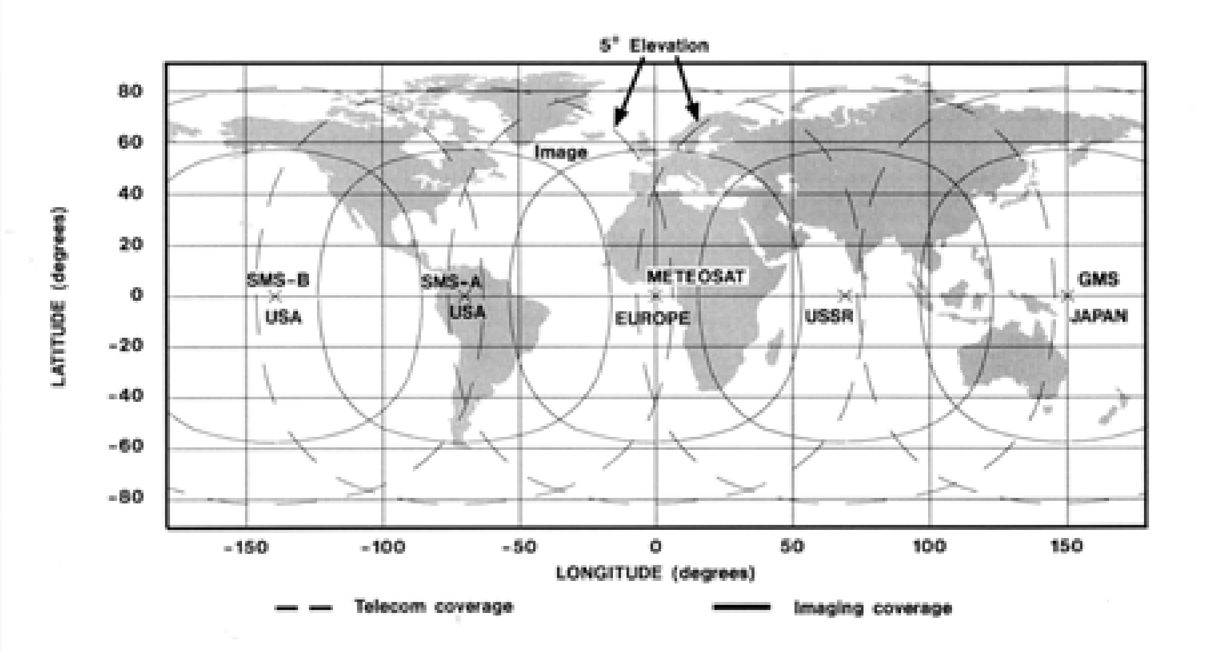

Figure 7-1: Coverage of the geostationary meteorological satellites participating in the GARP programme (Source: ESA Bulletin No 11, December 1977, p.11).

originally hoped, its delay reflecting the hesitations of the prime user community for which the satellite was originally intended, the meteorologists, to mobilise resources for a European operational meteorological system. The transition was slow in coming or, at least, far more tortuous than in the parallel case of telecommunication satellites. It was tortuous because, legal and administrative issues apart, the national services needed to be convinced that continuous coverage could be provided from space and that it required a European operational satellite system before they committed resources to space and ground segments which were far more complex and costly than their traditional technologies.

Several related considerations gave the first phase of the Meteosat programme its stability and continuity, the hesitations of the prime user community notwithstanding. Firstly, the pre-operational programme undoubtedly made optimal use of the resources originally allocated to it when it was agreed upon. Technological success, sound management and good economic house-keeping, along with a fair share of luck – all three pre-operational launches were successful – surely gave the programme some of its stability. Nothing succeeds like success.

Technological and managerial achievement apart, a number of institutional factors also kept the programme going. Firstly and crucially, this was not an isolated, stand-alone programme. Meteosat was integrated into an international programme sponsored by the World Meteorological Organization, the so-called Global Atmospheric Research Programme or GARP. This programme foresaw a joint effort by the USA, the USSR, Japan and Europe to improve computer forecasting and modelling by using data satellites in geostationary and polar orbits. Meteosat was one element of the so-called FGGE (First GARP Global Experiment), first scheduled for 1976, but delayed until 1979. Its key role in this programme (see Figure 7-1) provided much of its initial rationale and sealed the commitment of the participating states to it and to making provision for a backup launch in the event of its failure – an option subsequently exercised despite its initial success.

Meteosat was also protected by the interest that university researchers had in its data. The importance of accurate information about the weather for military and civilian uses, from agriculture to mass jet travel, as well as the availability of new technologies after the war, led to a surge of interest in meteorology and to fundamental changes in its practice. Meteorology in government and academia expanded enormously. To cite US figures, the only ones we have, from the mid-1940s to the mid-1980s there was a tenfold increase in the number of American universities awarding degrees in meteorology as well as in the number of articles published annually in US journals of meteorology. Civil and military funding for the field also increased enormously. A new style of research was put in place in which numerical modelling became the dominant methodology.[811] The situation in Europe was not dissimilar. In 1975 a European Centre for Medium Range Weather Forecasting was established at Bracknell in the UK within the framework of the European Economic Community' COST programme. It was dedicated to atmospheric modelling and in 1977 it took delivery of a Cray 1-A Supercomputer, "the first machine that was really adequate for operational global weather prediction".[812] ESA, for its part, organised two meetings of scientific users of Meteosat in June 1979 (in Darmstadt) and in March 1980 (in London). Both were attended by around 80 scientists from a dozen countries.[813]

Finally we cannot overlook the role of the ESA Executive, led by Programme Manager Dieter Lennertz, in promoting Meteosat. For much of the 1970s the ESA team was under constant pressure from the user communities and the participating states, not because of worries over the space segment – the manufacture and testing of Meteosat and its instruments went ahead without any major surprises – but over the inadequacies of the ground segment and the computing facilities in particular. Once this was more or less resolved in 1979, they found themselves with an installation that was working reasonably well, a team at ESOC which had accumulated the requisite expertise in the handling and interpretation of meteorological data, a growing interest from new regions (like Africa) in satellite-derived atmospheric data – and participating states which were increasingly hostile to continuation as the meteorological services dragged their feet over taking charge. Faced with the threat of termination and the disbanding of the teams, the Executive was tenacious and determined. It pushed ahead with organising the launch of the second flight model and the prototype, it drafted and redrafted the legal documents needed to extend the duration of the original arrangement and it did what it could to get the national meteorological services to set up an operating agency. This finally happened with the formal establishment of an organisation called Eumetsat in 1985.

This chapter is divided into two main parts. The first deals essentially with the history of the space and ground segments of Meteosat-1, taking the story up to the launch of the satellite. It focusses mainly on two issues: the process of Europeanisation of the French meteorological satellite and the difficulties surrounding the implantation of the data handling facilities at ESOC. The second part discusses two phases of the transition to the operational programme: the Programme Board's increasing frustration with the reluctance of the meteorologists to establish an operational system and the measures taken between 1981 and 1983 by the MOP Working Group to do just that, measures which led to the official birth of Eumetsat in 1985. Before getting under way we shall quickly situate the demand for satellite data by meteorologists in the more general framework of the post-war reconfiguration of their field.

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811 See F. Nebeker, Calculating the Weather. Meteorology in the 20th Century (New York: Academic Press, 1995), 173 and A. Dahan Dalmedico, "L'Essor des mathématiques appliquées aus Etats-Unis: L'Impact de la seconde guerre mondiale," Revue d'histoire des mathématiques, 2 (1996), 149-213.

812 L. Bengtsson, "Development in Atmospheric Modelling and Weather Prediction - The Role and Contribution of ECMWF", in A. Klose and I. Dusak (eds), Proceedings of the COST Forum on Transnational Cooperation in Science and Technology) with new European Partners, Vienna, 22 November J991 (Brussels: CEC DGXII/GlI, 1992), 59-73. The Convention establishing the ECMWF was signed in May 1973 by 17 countries and it entered into force on 1 October 1975. The centre is based in Reading (UK) and its main objectives are (1) the development of numerical models for medium range weather forecasting, i.e. up to 10 days ahead; (2) the preparation on a regular basis of medium-range weather forecasts for distribution to the meteorological services of the member states; (3) research directed to improving these forecasts and (4) collection and storage of appropriate meteorological data. The original plans for the Centre foresaw a staff of about 120 people, including 40 graduate scientists and an annual operating budget of some 7.6 MAU - Summary Report on the Informal Conference of Directors of European Meteorological Services held on 27 April 1972 (52023). See also (52014)).

813 See (ESA3631) and (ESA3656).

7.2 The changing field of meteorology in the 1960s and 1970s

The science of meteorology underwent fundamental changes during and after the second world war, both in terms of the sources of data available to meteorologists and in the practice of meteorology itself. Traditionally data derived from floating buoys, ships and aircraft were supplemented by upper air observations using instruments carried aloft by balloons. New observing techniques developed during the war, notably radar and then the development of Earth observation satellites by the superpowers in the 1960s, allowed not only for the systematic collection of far more information, but also for the inclusion in forecasts of data gathered from remote areas of the globe. To handle all this data, new and powerful techniques of real-time collection and manipulation were needed. The availability of increasingly powerful computers was coupled with the development of mathematical models from which it was hoped to forecast the future state of the atmosphere from a knowledge of its 'initial conditions' and the dynamics of the processes affecting climate. The practice of meteorology was changed completely. Previously, to quote two practitioners, "both the forecaster and the investigator were forced to content themselves with such highly oversimplified descriptions or models of the atmosphere that forecasting remained largely a matter of extrapolation and memory". Indeed "forecasting was essentially a rather simple extrapolation of weather developments over the past few days for another 24 or 48 hours into the future, essentially based on the experience of the forecaster".[814] Now a variety of disciplinary regimes: fluid dynamics, physics, mathematics etc., were mobilised to build Systems of differential equations representing the transfer of heat and moisture- in the atmosphere and the behaviour of gases. [815] Armed with values of parameters describing the vertical profile of such atmospheric properties as wind, temperature and moisture and the most powerful computers on the market, the meteorologist aimed to predict more reliably the evolution of the weather over anything from two days to two weeks. Figure 7-2 gives one an idea of the complexity of the problem; it illustrates the processes and their interactions, which were included in one European mathematical model in the mid-1970s.

During the 1960s, both the USA and the USSR embarked on satellite programmes intended to improve the quality of weather forecasts. These were used to supplement the data obtained using traditional means, by covering sections of the Earth (deserts, less developed countries) and of the ocean which were not accessible using existing techniques. The improved geographical coverage, the additional kinds of information (e.g. on wind velocity and direction by analysing cloud movements) and the systematic sampling in accordance with a predetermined time-space grid and real-time data dissemination, all gave satellites a unique role in forecasting. They had another advantage: the same satellite could be used for meteorological data transmission between different ground stations.

Two orbits provided complementary information to meteorologists. Satellites in polar orbits provided high-resolution coverage of the whole surface of the Earth, giving 'soundings' of the vertical distribution of temperature and humidity from which other weather-relevant parameters, like pressure, could be inferred. They had two disadvantages, however. Firstly, their coverage was only intermittent - they made observations of a particular area only once per day in the visible range, or twice if they were equipped with infrared sensors. This seriously limited their use for short term forecasting, when rapid local changes needed to be tracked at least once an hour. Secondly, they were ill suited to measuring air movements in the tropics, which played a vital role in the evolution of global weather. Geostationary satellites, on the other hand, were able to supply quasi-continuous coverage of the whole area within their field of view, which was what was needed for short-range forecasts. The kind of data of interest to meteorological agencies that these satellites could provide included cloud cover by day and by night, vertical profiles of temperature and water vapour, information on snow and ice cover, the brightness temperature of clouds over continental and oceanic surfaces, the distribution of

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814 The first quote is from Jule Charney, one of the leaders of numerical modelling of the atmosphere, cf. Neheker, note 3, p.178. The latter statement is by Bert Bolin, leading Swedish exponent of this approach, in The Global Atmospheric Research Programme. A Cooperative Effort to Explore the Weather and Climate of Our Planet (Geneva: WMO/ICSU, 197 1), 8. The emphasis is Bolin's. The document can be found in (52012).

815 See ESRO/PB-MET(72)7 and Annex, 1 June 1972 (ESRO8961) and L. Bengtsson (Footnote 812)

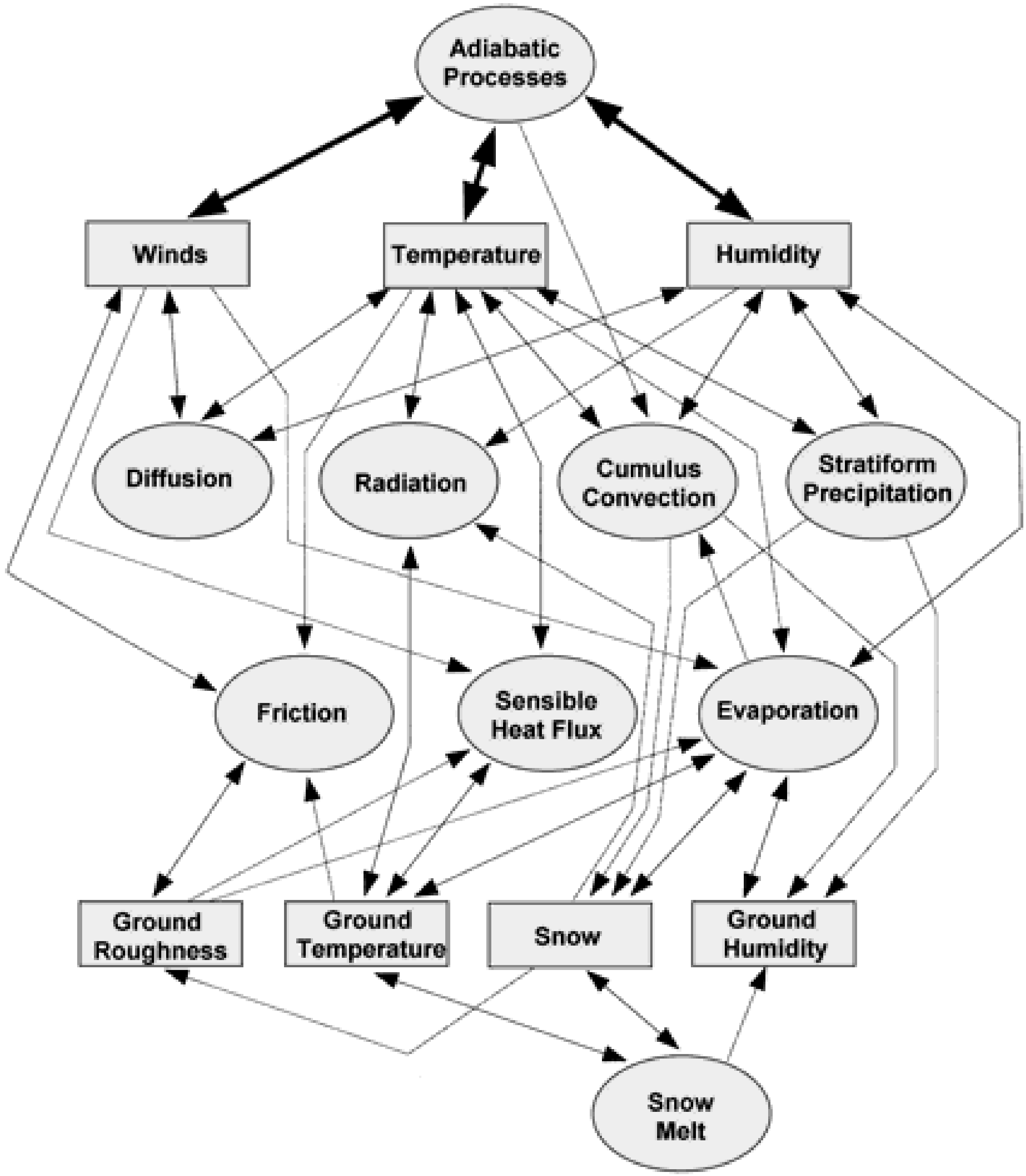

Figure 7-2: Schematic of the atmospheric processes and their interactions as in the ECMWF model.
The thick arrows identify the main interactions governing the weather.
[From Bengtsson, cited in Footnote 812].

the total reflected and scattered short-wave radiation and, finally, the distribution of the total long-wave radiation emitted by the Earth. Their limitation was that their image quality degenerated from about 60° latitude upwards. [816]

The implementation of global and regional systems to exploit these new possibilities was one of the tasks undertaken by the World Meteorological Organization (WMO) in the framework of its so-called World Weather Watch (WWW) programme. It also conducted, in collaboration with ICSU, a research programme called the GARP (Global Atmospheric Research Programme). This was an international collaborative project similar in concept to, though much larger than, the International Geophysical Year held in 1957. It was organised by twelve scientists under the chairmanship of Bert Bolin (from Sweden), who set about defining one of its elements, the so-called FGGE (First GARP Global Experiment). At a planning conference in Brussels in 1970 it was decided that this experiment should be held in 1976. Its main objective was to combine the resources of all the participating countries so as to provide "data on the basis of which the adequacy of numerical models of the atmospheric general circulation [could] be tested". To this end it was to make use of observations from existing or planned networks of surface and upper air stations (including buoys and commercial ships and aircraft) as well as satellites. From its very early planning, this group foresaw a European satellite as one element of this global system. Just which satellite that would be was not, however, obvious, as we shall see immediately. [817]

7.3 First steps towards a European meteorological satellite: From EARS to EMOS to Meteosat

The European Space Conference meeting in Bonn in November 1968 decided that Europe should develop an application satellite programme and authorised ESRO to extend its activities to include studies of, for example, air traffic control, communications and meteorology satellites. Thus mandated, a team at ESTEC began to look into the possibilities for weather satellites. It was led by J. Vandenkerckhove and included P. Blassel, R. Collette and D. Lennertz, to whom was soon added R. Tessier, who had had two years of experience with Earth resources satellites at CNES. The ESRO team decided to explore the costs and benefits of a small (170 kg) geostationary satellite and a low-altitude near-polar orbiter of either about 100 kg (to be launched by a British, French or US rocket) or of 300-600 kg (to be launched by Europa I or an American Delta rocket).

The large polar satellite seemed the best in their eyes. Weight limitations on the instrument payload of both the small geostationary satellite and the small near-polar orbiter would restrict their capability and undermine their reliability (since little redundancy could be provided). By contrast the combination of reliability and "growth potential" of a large polar orbiter enabled it to subsequently incorporate bigger and heavier experiments and gave it the flexibility needed to develop it into an operational system.

These first tentative thoughts on the EARS (European Atmospheric Research Satellite) were presented to a group of ESRO member states' representatives (in fact almost all of them the directors of national meteorological services) present in Geneva on 13 June 1969 to attend the XXIst meeting of the WMO's

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816 Undated paper prepared for meeting of Europeans with NASA and NOAA in February 1971(52004). See also K. Stewart, "The Significance of Meteosat for Meteorology", *ESA Bulletin*, No. 11, December 1977, 6 - 10.

817 See Annex 3 to the minutes of the *Premiere Reunion du Groupe 'Ad-Hoc' Meteorologie*, held in Geneva on 13 June 1969, which was written by Bolin (52002) as well Bolin's report for the WMO quoted in Footnote 814. The third component foreseen was a near-equatorial balloon tracking orbital satellite.

Executive Committee. This (non-ESRO) group of potentially interested users came to be known as the *Ad Hoc Group on Space Meteorology*. [818]

The Ad Hoc Group confirmed the ESRO team's choice. Their main reason was that the alternatives overlapped with national programmes then under way. Britain planned to launch a small satellite into polar orbit in 1973. It would carry an infrared radiometer and a small interrogation experiment. France was planning a geostationary satellite called Meteosat to carry a camera experiment in the visible and IR ranges for global cloud observation and an interrogation experiment for stationary buoys and platforms. The only doubt raised by those present concerned the cost of a large polar orbiter, though it was felt that if one planned for a pre-operational series of satellites rather than just a single spacecraft one could reduce the unit cost considerably.

A general framework for the further study of EARS was soon defined. A budget envelope of FF 250 million ($50 million) was laid down for the development and launch of the first satellite, ground segment costs included. The feasibility study was also to make provision for the launch of three follow-on satellites all carrying the same basic payload. This was to weigh between 45 and 60 kg. It was to comprise a number of measuring instruments whose interest was already proven. These were to be supplemented by experimental payloads intended to explore potential future operational techniques. In defining this package, ESRO was to be assisted by a team of experimental and operational meteorologists who would bear in mind the requirements of the national weather services. On the experimental side, the names of Drs. Bolle (FRG), Morel (F) and Houghton (UK) were invoked. The meteorological experts were to be nominated by the directors of the weather bureaux. Tessier was nominated as in-house mission manager to liaise with this group.

In January 1970, ESRO came up with its preliminary concept for a European Meteorological Operational Satellite. As conceived, EMOS was a 300-400 kg three-axis-stabilised Earth-oriented satellite in a circular, near-polar orbit of apogee and perigee about 1700 km and a period of two hours (i.e. 12 orbits per day) (see Figure 7-3). EMOS had two main missions: (a) day and night observation of the Earth's cloud cover for short-term weather forecasting, and (b) quantitative sounding of the troposphere and lower stratosphere for numerical weather predictions. For the first, a scanning radiometer in the visible and infrared ranges with automatic picture transmission and a low-light television camera for Earth and cloud photography were foreseen. For the second, an infrared temperature sounder was provided for. The possibility of including a system for data collection from fixed and mobile platforms was also considered. As for the cost, this was estimated at 73.5 MAU including the launch vehicle, but excluding the ground segment. [819]

Faced with an estimate far in excess of the 50 MAU originally foreseen, the Ad Hoc Group insisted that a less ambitious programme be developed, a view repeated during two unofficial meetings of the directors of European meteorological services gathered in Brussels in March 1970 to plan the GARP. They suggested that the payload should be cut back to contain only instruments for infrared imaging and for infrared temperature and water vapour sounding. The television system and the interrogation system were to be abandoned and the wisdom of including experimental instruments along with already proven operational instruments in the same payload was questioned. The cost envelope was cut to 40 MAU, excluding the launcher and launch services. [820]

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818 The debates at this meeting are summarised in the document just cited, in a draft of the minutes for part of the meeting sent by W. Nellessen to J. Vandenkerckhove on 17/6169 and an internal unsigned and undated report for A. Dattner entitled *Rapport sur les etudes d'ESRO dans le domaine des satellites meteorologiques*, all in (52002)

819 From the report cited in Footnote 821

820 For the information in this paragraph see the *Compte rendu des réunions officieuses tenues a Brussels les 18 et 20 mars 1970 a l'Institut Royal Météorologique de Belgique....* (52003), the ESRO interim report on a system study on EMOS dated May 1970 (52005) and the Summary Report produced in October 1970 (52006). Some of the cost data are from a paper by O. Carel (CNES) in his *Note sur la collaboration de la météorologie nationale et de l'ESRO* dated 10 June1970 (52003).

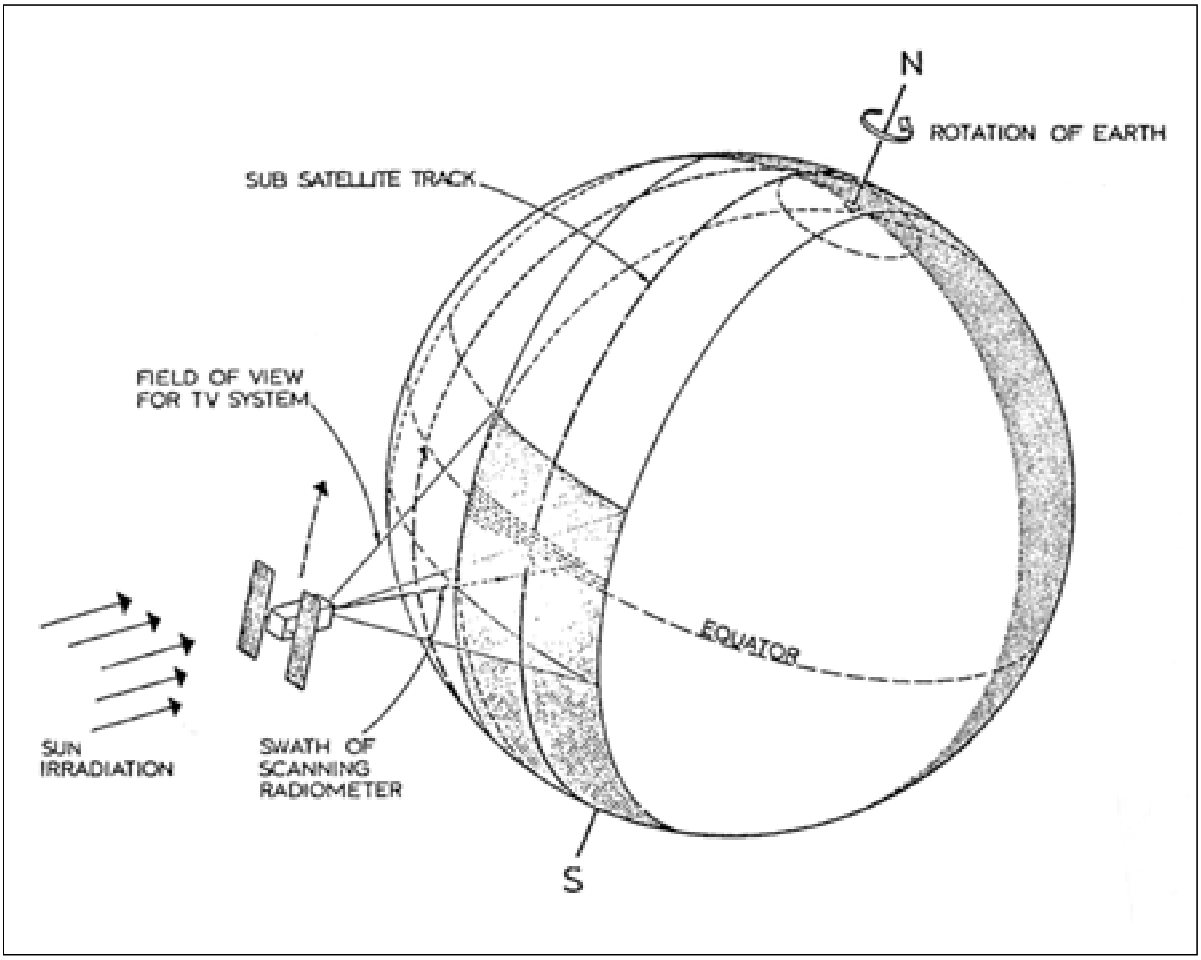

Figure 7-3: Schematic of orbit and coverage for EMOS.[821]

The hesitations in meteorological circles were reflected in the proposals on applications satellites made by the Committee of High Officials to the ministers meeting at the European Space Conference in Brussels in July 1970. They suggested that a meteorological satellite could be delayed for two or three years: Europe should initially concentrate on telecommunications and navigation satellites. Their argument was that Europe did not have the human, industrial and financial resources to start more than two programmes at once. Other concerns, of course, informed their reasoning. If meteorology was downgraded, said ESRO Director-General Bondi, it was because the proponents of the other two application satellites had "lobbied better". The meteorological experts, he went on, had yet to convince their respective governments that they had a programme which was "really European, really worthwhile and really interesting technologically."[822]

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[821] For this paragraph see the *Report on Studies Carried out in 1969 in the Field of Meteorological Activities*, ESRO/ST/344, 9 February 1970, presented to Scientific and Technical Committee at its meeting on 24 February 1970.

[822] See the minutes of the meeting of the Meteorology Ad Hoc Group on 11 June 1970 in Paris dated 23 June 1970. We have Tessier's handwritten notes on part of the proceedings, from which the quotations are taken (52003)

Table 7-1. US meteorological satellites covering the period 1960 - 1980

Operational (low Earth orbit)	
Tiros 1 - Tiros 10	April 1960/July 1965
Essa 1 -Essa 9	February 1966/February 1969
Itos (Tiros M)	January 1970
NOAA 1 (Itos A)	December 1970
Itos B, D, E, F, G (NOAA 2, 3, 4...)	To take over from Itos A when the need arose
Tiros N	To take over from NOAA satellites from 1965
Development (low Earth orbit)	
Nimbus 1, 2, 3, 4, E, F	[1964/1973
EOS	To follow on from Nimbus and ERTS from 1975
Geostationary satellites	
ATS 1, 3, F, G	from December 1966
SMS A, B	from 1972
GOES A	from 1975 (1 or 2 satellites over USA)

Here was the crux of the problem. Indeed the meteorologists interested in developing a satellite system were quite unable at this stage to come up with a project which was sufficiently convincing to unite and mobilise them. The low-Earth orbit was dominated by US satellites (see Table 7-1). What is more, the commitment to a large and ongoing meteorological satellite programme by various Federal agencies meant that American industry could provide satellites for other clients at prices far below those proposed by European industry: the US manufacturer of an Itos satellite offered to supply one to ESRO for $5 million, to be compared with the $40 million for a European-built EMOS (which was based on a similar concept). This meant that if ESRO wanted to enter the field, it should not preclude *a priori* the geostationary orbit – an option which had, however, been put aside by the Ad Hoc Group from its inception, to avoid duplicating the French Meteosat programme. [823]

Faced with a loss in priority of their polar orbit project, some (notably British) meteorologists believed that the best way to convince their governments of the interest of a European satellite was by collaborating with the Americans, either by taking a share of global coverage or by alternating launches. The idea that a joint venture with the United States would be preferable to an 'isolated' European satellite like EMOS was reinforced at an informal meeting of directors of meteorological organisations during a WMO Executive Meeting in mid-October. [824] When the Ad Hoc Group met later that month it began to reconsider its priorities: the possibility of including a European geostationary

[823] The data are from a memo by Tessier prepared for the ESRO mission to NOAA/NASA in February 1971. See also Carel's paper quoted in Footnote 820.

[824] See the minutes cited in Footnote 822.

satellite in the newly emerging and very ambitious American SMS (Synchronous Meteorological Satellite) programme seemed distinctly desirable. [825]

The American idea, which was still in the planning stage at the end of 1970, was to put in place a coordinated global system of weather satellites. Their scheme had two main components: two or three low-altitude, near-polar orbiting satellites (probably the US' Tiros-N and the Soviet Union's Meteor satellites) and four large (300 kg) geostationary satellites. Two of these were to be the new generation American SMS satellites. Japan was planning a third, while it was open to Europe to supply a fourth. Their main mission would be to photograph the Earth in both the infrared and visible channels, to retransmit these photographs, once processed on the ground, to interested users, to collect and redistribute data from ground platforms and to relay data from other meteorological satellites.

The directors of the European meteorological services saw several advantages in the joint geostationary system. Firstly, unlike the Itos system, this was still in the planning phase, leaving more scope to define a programme of direct interest to the Europeans. What is more, the Americans had foreseen a non-US component from the start. The programme also fitted perfectly into the plans of the WMO's World Weather Watch. Unlike EMOS, the data from a European satellite would be part of a co-ordinated programme providing systematic global coverage. The Europeans could include their own instruments in the scheme without difficulty, e.g. a Smith-Houghton temperature probe developed in the UK. The industrial interest in developing an orbiter of this size and complexity was patent. And the coverage provided of Africa would be useful both practically, for long-haul aircraft crossing the continent and politically, as a gesture of solidarity with developing countries who did not have the resources to mount a similar system. In short the only obvious problem – and this was of considerable concern – was that such a satellite might duplicate the French Meteosat programme, though the group felt that this was unlikely since CNES's satellite seemed to be less ambitious than those foreseen for the SMS system. [826]

The French thought otherwise. Appraised of the Ad Hoc Group's thinking, J. Bessemoulin, Director of the French National Meteorological Service and M. Bignier, on behalf of the President of CNES, immediately sent strongly-worded protests to ESRO DG Bondi. They pointed out that everyone knew that France was developing a geostationary meteorology satellite. Its importance had been confirmed in the VIth national plan then under consideration, which foresaw its extension into a European operational system. Since 1968 the French delegation to ESRO had believed that the Organisation should develop a satellite in low-Earth orbit, arguing that geostationary satellites gave poor photographic cover of Nordic Europe above 60° latitude. The suggestion that ESRO should now place a meteorological satellite in geostationary orbit would necessarily duplicate the French effort and upset the balance between the European and French space programmes. CNES and the French national meteorological service were therefore "at once shocked and disappointed to see the European collaborative effort, which they wanted to be effective, running counter to the development of a national project for which they had high hopes" (Bessemoulin). There was no place for two West European meteorological satellites in geostationary orbit and ESRO's plans to develop one risked upsetting the negotiations between France and NASA on the CNES programme, which were in their final phase. Before taking an irreversible decision, Bessemoulin concluded, ESRO would do well to "weigh all the consequences" of its actions. [827]

These threats were not to be taken lightly. Ministerial conferences in July and November 1970 had revealed the depths of the divisions between Belgium, France and Germany on the one hand, and Britain on the other. The former three were convinced that Europe should develop an autonomous launch capability and that the science programme in ESRO should be cut back, and were prepared to go it alone with any partners who shared their priorities. France had gone further and had denounced

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825 See the minutes of the third meeting of the Meteorology Ad Hoc Group held in Brussels on 26 October 1970 (52003).

826 Memo Tessier to Dinkespieler, 6 November 1970, *Informations sur le programme français Météosat* (52003)

827 Letters Bessemoulin to Bondi, 7 December 1970 and Bignier to Bondi, 10 December 1970 (52004).

the ESRO Convention with effect from the end of 1971 (though subsequently, with the idea of having 'a la carte' programmes to accommodate different national interests gaining weight, it began to take a more compromising line). [828] In this delicate political context it was essential that nothing be done to harm the French national programme. [829]

Thus forewarned, a European delegation of meteorologists visited NASA and NOAA (the National Oceanic and Atmospheric Administration) in February 1971 to discuss how best to proceed. It was headed by R. Schneider, the director of the Swiss Meteorological Institute and newly-elected chairman of the *ad hoc* Space Meteorology Group. He was accompanied by his counterparts from Britain, Germany and France (i.e. Bessemoulin) and a small ESRO contingent. The evolution of the US meteorological and Earth resources programmes were described to them and the possible areas in which Europe could make a contribution were identified. [830] A comprehensive report of the visit was presented to a meeting of the Ad Hoc Group in Noordwijk early in March 1971. Two main conclusions were drawn by the meteorologists. [831]

Firstly, they agreed that there was an 'overabundance" of polar-orbit satellites, as evidenced by the fact that the data-handling capacities on the ground were already saturated so that the existing US satellites in this orbit were not being operated at full capacity. Of course, Europe was not adequately covered by the US system. However, the Soviet Union was known to be planning to launch two satellites in polar orbit in its Meteor programme and there were also discussions under way in both Germany and Italy to develop national meteorological satellites of the same kind. (Britain, for its part, had decided to cancel its experimental polar satellite and to fly the instruments on American Nimbus and Tiros satellites.) The interest of a European geostationary satellite was thus confirmed.

The second point that struck the meteorologists was the cost and complexity of the ground stations, which they had underestimated and which would ultimately have to be borne to some extent by their budgets. The acquisition of information from space and its processing in real-time demanded sophisticated data-processing techniques and a large staff. Indeed their US hosts estimated that for a single geostationary meteorological satellite, a complete data acquisition and processing station would need about 150 staff plus the personnel needed to operate a computer equivalent to a CDC 6600. Just where the borderline lay between the space and ground segments in this complex was a matter for negotiation, but in any event it was clear that a major new financial burden for the meteorological services was in the offing.

The ground segment was not *a priori*ty at this stage however. What had to be decided first, in the light of the US visit, was the space segment of a European meteorological system. By 3 June 1971, when the meteorologists next gathered, they had specified their ideal package. It had two components. Firstly, there would be a geostationary satellite which complemented towards the east the cover provided by the US system and gathered data in the visible and IR ranges. This would be combined with a polar satellite taking vertical temperature soundings – a mission to which the geostationary satellite was less well adapted. The two spacecraft would be linked by a space-space-ground system transmitting the data from the polar satellite via its partner to Earth, so enabling a single ground station communicating with the latter to obtain sounding data on a global scale. Of course, if the twin system were not possible (even making use of a national polar satellite), the meteorologists were prepared to make do with the geostationary satellite only. To avoid duplication with Meteosat, it was made abundantly clear that this system would be put in place as a successor to the French programme. As

828 See J. Krige and A. Russo, *Europe in Space, 1960-1973,* ESA SP- 1172, 1994 and meeting of the ESRO Council in December 1970, ESRO/C/MIN/35, 12 January 1971.

829 Letters Bondi to Schneider, 4 December 1970 and Dinkespiler to Bessemoulin, 9 December 1970 (52004)

830 The material on the mission to NASA/NOAA, including presentations by Bandeen (on instrumentation), Naugle (on NASA's meteorological satellite programme) and Scull (on ERTS) are in (52010).

831 The minutes of the meeting are in (52012). The main conclusions were presented by Tessier to the IAPC at its meeting on 11 May 1971, ESRO/IAPC/MIN/2, 7 June 1971, Annex 11 (ESRO9329), in which he presented his paper ESRO/IAPC(7 1)2, 19 March 1971 (ESRO9339). These two reports by Tessier contain useful potted histories of the meteorologists' deliberations.

Schneider said emphatically to the second meeting of the IAPC on 11 May, "it is not our intention at all - and we realise that it is practically and technically impossible – to produce something at the European level for 1975-1976" –, the year when a European contribution to the FGGE would need to be launched. With a clear gesture towards the French delegation he added that "In this matter we rely completely on the extremely good cooperation that exists with the national services, who are thinking of launching geostationary satellites into orbit at that time".[832] In short, the European geostationary satellite was only foreseen for the second half of the decade, when it would take over from Meteosat, the latter playing a full role in the international collaborative programme scheduled at this time for 1977/8.

Schneider's fears of offending the French soon proved to be ill-founded. After hearing several statements on the users' requirements, the French delegation to the IAPC meeting in May remarked that they now seemed clearly focussed on a geostationary satellite. It went on to say that it "was convinced that it should let the European countries benefit from the work that had already been undertaken in France in respect of a meteorological satellite project". This conviction was substantiated six weeks later. In a letter to the chairman of the ESRO Council dated 25 June 1971, the French delegation proposed that "the ESRO Member States cooperate in the Meteosat project [which] would thus become an ESRO programme [...]". The letter was accompanied with detailed proposals on how to effect the 'Europeanisation' of the national project, which was now at a stage, it was said, when CNES was "ready to issue calls for tender to industry during the coming weeks" [833].

Several concerns inspired the French proposal. First and foremost it was a political gesture, a proposal explicitly made within the framework of the negotiations then under way between the Member States, which were being orchestrated by the new ESRO Council Chairman Puppi. As the letter of 25 June made clear, it appeared that "one of the main functions of the new Organisation [would] be to provide a forum for consultation which [would] enable duplication between the various programmes to be avoided on the one hand and permit the European community to benefit from developments and studies undertaken in each ESC [European Space Conference) Member State on the other". From this point of view, the letter went on, France hoped that the relationships established between CNES and ESRO around the Meteosat programme "might well serve as a model for other projects". France was thus at once signifying its willingness to collaborate with its partners in a new European space organisation, suggesting one way in which that collaboration could be achieved and by taking the initiative, acquiring considerable moral and political weight to impose its priorities on any eventual European space programme that might be put in place.

Material considerations also played a role of course. Firstly, the cost of the space segment had risen unexpectedly. During previous negotiations between CNES and NASA the French had hoped to persuade the American agency to subsidise their launch costs. However when NASA was appraised of the plans in Europe to launch two geostationary meteorological satellites, one by CNES and one by ESRO, it said that it preferred to support the latter financially - and estimates of the cost of France's national satellite therefore had to be adjusted upwards. [834] Then there was the ground segment. As we mentioned earlier the enormous costs of setting up and running an operational system were brought home to European meteorologists after their visit to the USA in February. All of their plans before then had concentrated on the satellite and its payload: now they appreciated that the ground segment was an essential part of any meaningful programme. Since this would come from their budgets, not from the space budget (meteorological services were typically funded by the Ministries of Transport), they quickly concluded that European collaboration was a must. Bessemoulin was a case in point. Furious in December 1970 that European meteorologists were considering developing a geostationary

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[832] The quotation is from Annex IV to the minutes, ESRO/IAPC/MINI2, 7 June 1971 (ESRO9329). For the minutes of the meeting of the Space Meteorology Group held in Zurich on 3 June see (52012). The European meteorologists' priorities are specified in ESRO/IAPC(71)12, 1 July 1971 (ESRO9349).

[833] The letter and supporting documentation were circulated as Annexes I and II to ESRO/C(71)36, file (ESRO578).

[834] Private communication, R. Tessier.

satellite through ESRO, he had no sooner visited America in February 1971 than he "insisted on the need for European co-operation as soon as possible" as far as data-handling was concerned. [835]

The engineers at CNES who were developing Meteosat were stunned by these developments. They had been working for several years on their national meteorological satellite. Its most sophisticated and technically 'noble' component, the radiometer, had been developed to the point where they were ready to place a contract for its fabrication, with Matra. Not party to the political debates which led to the decision to Europeanise Meteosat, they found themselves confronted with a *fait accompli* which they were powerless to change. Their programme, their device, their jobs, their careers were suddenly put at risk from one day to the next. The best that could be done to protect their (and CNES') interests was to suggest that the implementation of the project be entrusted to its Toulouse Space Centre and to demand that the French team continue to play a key role in the development of the project. [836] But would the ESRO engineers and member states accept that?

7.4 Meteosat: From French to European satellite

CNES engineers began designing a French meteorological satellite in March 1969, to be launched as part of the VIth national plan in the early 1970s. The main reasons for this political choice were three: the wish of France, "the third world space power", to affirm its presence in a field of applications in which it already had some considerable experience; secondly, the immediate interest for France to provide meteorological support in the European-Atlantic zone and along the Europe-Africa air routes; and, thirdly, in the longer term, to increase France's influence in the WMO, particularly the World Weather Watch Programme, as well as in the more limited framework of European collaboration. [837]

To achieve these objectives it was planned to place the satellite between longitudes 10°E and 30°E, so permitting coverage of southern Europe and Africa (see Figure 7-4). It was to take and transmit photographs of the globe, in the visible and infrared spectral ranges, to a station in France and to serve as a data relay for the retransmission of photographs or meteorological charts to dispersed meteorological stations. Meteosat was a pre-operational satellite which was intended to contribute to the first year of the GARP (foreseen for 1976). It was also intended to demonstrate to the weathermen the feasibility of the technology and the use of the instruments on board and to encourage the meteorological services to gain experience in the collection and diffusion of meteorological information garnered from satellites. [838]

The Meteosat system offered for Europeanisation made provision for the fabrication of two flight models of the satellite (one being a reserve) and one launch on a Thor-Delta rocket which, as we mentioned, was already the subject of NASA-CNES discussions. [839] It also made provision for the ground segment, which had four elements. Firstly, there was to be a central station equipped with a 12 metre diameter antenna: the ESRO Council would decide on its geographical location. This station would control the orbiter as well as receive raw data from it and would retransmit meteorological information to other stations after processing. The raw data would be acquired either from Meteosat's radiometer or from land and sea stations (ships, floating buoys) interrogated by it. This central station

835 The quotation is from the minutes of the meeting of the ad hoc Space Meteorology Group on 4-5 March 1971 (52012).

836 Annex II to ESRO/C(71)36, 5 July 1971, p.3 (ESRO578).

837 From Villevielle's *Note sur le projet de satellite météorologique français géostationnaire* dated June 1969 in file (52001). This file contains some useful early documentation about the French project.

838 See the previous document, the questionnaire drawn up by H. Felix, CNES paper N°7/METEOSAT, 22 April 1960 (52001), O. Carel's *Specifications des utilisateurs de Météosat*, CNES/PR/AM-ME/N°70T. 124, 2 July 1970 (52003) and *Le systeme Météosat*, prepared by H. Felix, March 1971(52011).

839 The description that follows is based on Annex II to ESRO/C(7 1)6 of 24 June 1971, (French) Proposal for Europeanising the Meteosat Project (ESRO578) and the debate at the 7th meeting of the IAPC held on 30 September 1971, minutes ESRO/IAPC/MIN/7, 13 October 1971 (ESRO9334). All quotations are from this latter document.

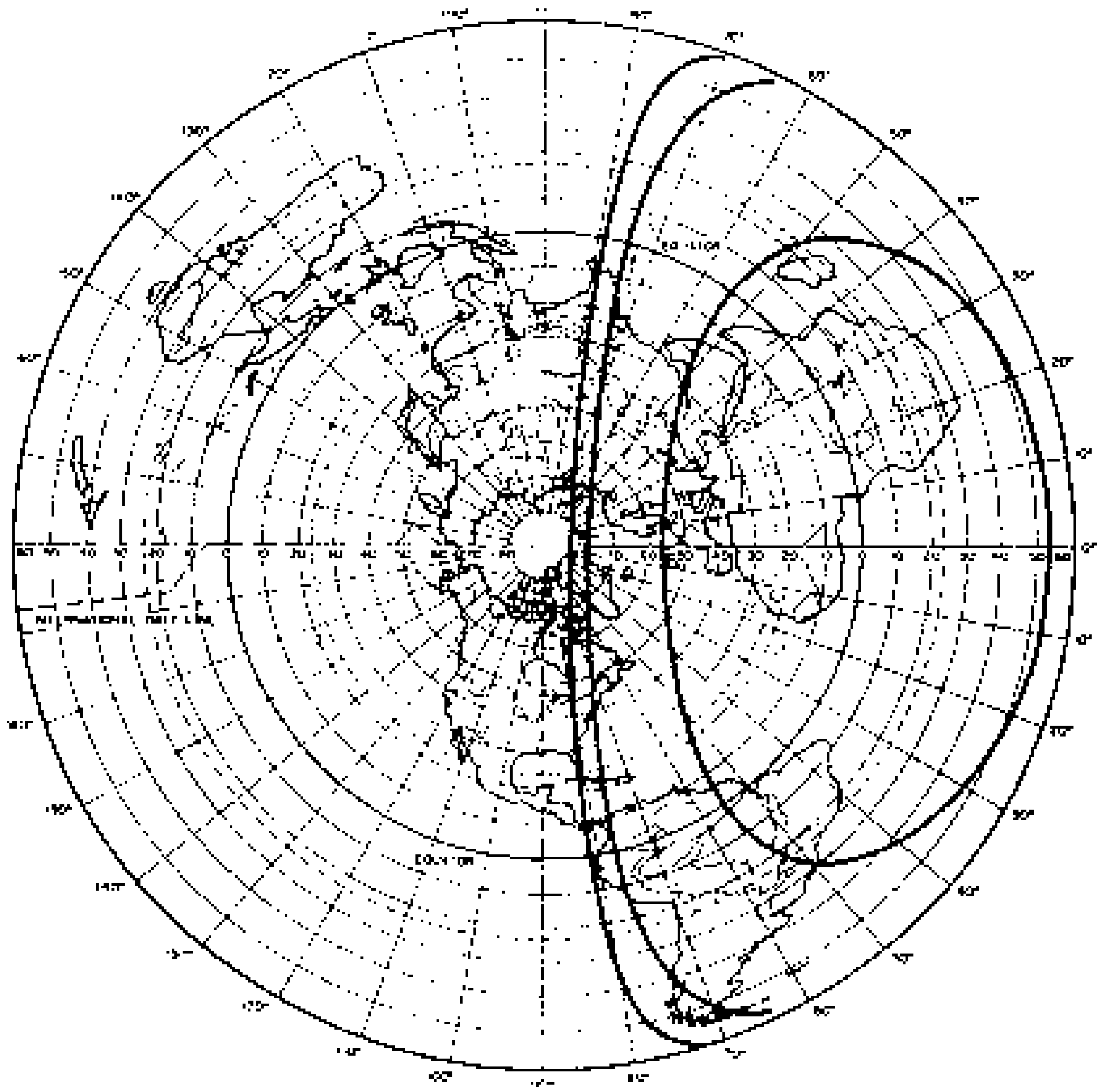

Figure 7-4: Coverage of a geostationary meteorological satellite placed at 0° longitude. [840]

would be linked to a pre-processing centre, possibly though not necessarily located at the same place. The pre-processing centre was to convert the raw data from the satellite into a signal that could be exploited by the users, e.g. it was to add a coordinate grid to the image, or to transcribe it into a given cartographic projection. These images could then be distributed to 'main' (4 - 5 m diameter antenna) or 'local' (2 - 3 m diameter antenna) stations via the satellite. The precise nature of the interface with the national meteorological services was not specified: as regards the ground segment the French system costed only the central station, a prototype main station and some ten prototype non-manned stations.

ESTEC engineers and the Ad Hoc Group on Space Meteorology both assessed the French offer from a technical point of view. They confirmed that the basic spacecraft concept proposed, a spinning satellite

840 Figure 1.2 from *Le système Météosat*, prepared by H. Felix, March 1971(52011). For the version of the satellite made available after the French offer see the *Rapport de Synthèse* of August 1971(50015).

with a mechanical tilt of the radiometer for scanning the Earth, was valid and that the overall performance of the instrument payload met the requirements of the European meteorologists, at least as far as a geostationary satellite was concerned: "most reasonable requirements will be well met by Meteosat", they confirmed. ESTEC noted however the uneven development of various parts of the system. More attention had been paid to critical components, like the radiometer, and further work was required to homogenise the preliminary studies at sub-system level and to bring the definition of the complete Meteosat satellite to the level of detail corresponding to a typical ESRO Phase-B study. Only then could reliable cost estimates be provided – the French estimate of 35 MAU seemed far too low – and contracts placed with industry. [841] The meteorologists also called for modifications and extensions to the basic system to meet their needs. They wanted minor changes in the visible imaging system of the radiometer and felt that a second high-power data-transmission channel should be added to the spacecraft. They also called for changes to the ground segment. The meteorologists suggested that the tasks foreseen by CNES for the data handling centre be extended to allow the extraction of wind data and more elaborate processing of cloud images and that the number and complexity of the 'principal' ground stations be increased. [842] In short, from a technical point of view, the Europeanisation of Meteosat did not seem to pose any major difficulties.

These lay elsewhere. In the year that it took to formally transform the French satellite into a European project, two main issues had to be resolved. Firstly, there was the organisation and management of the space segment of the project itself. The initial French proposal was seen by ESRO and the other Member States as leaving far too much control over the project in CNES's hands: long and difficult negotiations were required to shift the balance of power to the 'European' level. There were also ongoing uncertainties about the functions to be performed by the ground segment and by association about the precise technical (and financial) location of the interface between the national meteorological services and ESRO. This issue was of course tied up with the role and responsibilities of the prime users of the system and the transfer to them of responsibility for operating the satellite.

7.4.1 The space segment: interfacing with CNES. The management and control of the Europeanised Meteosat

The organisational structure foreseen in the initial French proposal left the execution of the project more or less entirely in the hands of CNES' Toulouse Space Centre (CST). The project would be based there and the project manager would be a member of the CNES staff and responsible to the Director of the CST. More than 50% of the project team would be from CST, the remainder being ESRO staff "together perhaps with specialists directly detached from the Member States". These participants, the French delegation assured the IAPC, "would be integrated in the team: they would thus have an active status, carrying responsibility and would not be mere observers". CNES would not charge internal costs in respect of its project team personnel or support laboratories, but would charge external costs and overheads relating to system integration and environmental testing. Tendering and the award of contracts for both the space and ground segments would also be handled by Toulouse which would privilege European industry, the spacecraft itself (60% of the total cost) being offered to the three European consortia COSMOS, MESH and STAR.

CNES's relationship to ESRO, the French suggested, would be analogous to that of an industrial prime contractor with the Organisation, although they insisted that "the overall responsibility of the CNES would however be much greater than that of an ordinary contractor" – a feature, said the French delegation, "which was part of the Meteosat proposal and as such was not negotiable". The precise terms of the arrangement would be specified in a contract between the ESRO Director General, acting on behalf of the participating states and the Toulouse Space Centre. The programme would be carried out under his responsibility and it would be up to him to ensure that it was executed within the

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841 For a report on the project see Tessier's first *Réflexions preliminaires sur la proposition d'européanisation de Météosat* dated 13 September 1971(52014) and the Summary Report concerning the technical evaluation of the Meteosat system, ESRO/IAPC(71)33, 12 November 1971 (ESRO9370).

842 The meteorologists' report is document ESRO/IAPC(71)3 I, 7 December 1971 (ESRO 368). A preliminary version dated 29 October 1971 is in (52014).

deadlines and financial envelope fixed by the Council. The programme would be optional and the participating states would be represented on a programme board which would monitor its progress and keep an eye on the geographical distribution of the industrial contracts. An international user group of scientists and national meteorological services, along with members of ESRO's and CNES's Directorates of Programmes and Planning would be set up and would advise, through the ESRO Secretariat, on the "maintenance of the project mission" and on how the system was to be operated once commissioned.

The French proposals were the subject of ongoing negotiations between ESRO and CNES and a number of lively exchanges at meetings of the IAPC, the AFC and the Council during the following months. By the end of November 1971, the basis for a compromise had been reached, though not without difficulty: indeed the management framework of the project had been completely revised. The guiding principle was that, if Meteosat was to be funded at a European level, the technical and financial management of the project had to be entrusted to ESRO. This meant that the project should "remain firmly under international control, the Director General [of ESRO and not the Director of CNES, as the French had originally suggested] assuming responsibility for its management". Furthermore, "the award and management of the contracts should be in accordance with the rules and procedures of the Organisation". ESRO, not CNES, would therefore be responsible for preparing the tender action, evaluating the offers, selecting the industrial prime contractor and the sub-contractors and administering the awarded contract. To execute the project, the DG suggested, and the French agreed, that an integrated management team, responsible for the entire programme, including spacecraft, payload, ground facilities and operation be set up. The project manager and at least half the staff of some 35 people were to be from ESTEC and not from CST as CNES had originally proposed. At the same time, to make best use of the experience and expertise already acquired at Toulouse, it was suggested that the remainder of the staff should be engineers then engaged on Meteosat, who would be seconded from CST and fully integrated into the ESRO project team (in the final agreement with CNES provision was made for up to 14 staff from CST to be put at the disposal of ESRO). [843]

The French, of course, wanted something in return for these concessions. The first thing that they insisted on was that the project team be based at Toulouse on the premises of CST. This had certain financial advantages for ESRO: the CNES contribution to functional support (see below) represented an estimated saving to the organisation of about 100 man-years and CST test facilities would be made available at marginal cost. In addition it had, to quote the Director General of ESRO, "the intangible advantage of situating the project in the technical atmosphere in which it was born." [844] Not everyone was convinced. The British, in particular, felt that the European character of the project would be compromised and that one participating state would gain an unfair advantage by having the project team based in a national institute. The French, however, were adamant: "should it be decided not to locate the project team at CST in Toulouse, then the whole basis of the project would have to be reconsidered", they warned. [845]

The second key issue on which they dug in their heels was the division of functional support between ESRO and CNES. Formally 'functional support' meant activities normally carried out by ESRO rather than in industry. Concretely, functional support came down to the allocation of responsibility to individuals inside the project team for various parts of the programme, including subsystems. It was here that the engineering skills and experience in the design and construction by industry of the meteorological system would be acquired and it was here that France wanted to ensure that it retained its competitive advantage over its partners, building on the foundation already laid in the national programme.

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843 This material is drawn primarily from the internal memo *Management of the Meteosat programme*, dated 20 October 1971(52014), ESRO/AF(71)96, 26 October 1971 (ESRO2282) and ESRO/C(71)63, 2 December 1971 (ESRO6O4). The final agreement with CNES is ESRO/C(72)14, rev. 3, 17 May 1972.

844 ESRO/C(71)63, 2 December 1971 (ESRO6O4).

845 ESRO/PB-MET/MIN/1, first meeting of the Meteorological Satellite Programme Board held on 21 March 1972, document (ESRO8940), 19 April 1972.

A small working group with representatives from ESRO and CNES was set up to deal with this matter. They identified three possible levels of interaction by team members with industry: 1. specialised advice, for example, for the preparation of specifications or the analysis of industrial tenders; 2. 'follow-up' of work in industry, and 3. supervision of work in industry under the delegated authority of the project manager. These contacts had to respect two guidelines. Firstly, in line with the recommendations of the so-called *Cooper Report* to ESRO, interventions in industry had to be restricted to the system level; in an effort to give industry as much responsibility as possible, there was to be no "interference" at sub-system and component level. Secondly, it was laid down that contacts between industrial staff and team members could only take place with the agreement of the project group and that it was preferable if not essential to have a member of the project team present during such contacts. By these procedures ESRO aimed to submit CST staff to the same discipline as the ESTEC engineers, so as to avoid changes being made by the contractors which could affect the cost, quality or time scale of the subsystem. [846]

The functional division of labour between ESTEC and CST within the project was to respect the experience already acquired in each centre and to keep the interfaces between the different functional support units as 'clean' as possible. [847] Two ways of dividing up tasks had been agreed by March 1972, one in the ratio ESRO:CNES of 60:40, the other of 55:45. They were technically equivalent, but it was decided to adopt the former as this made the project more "visibly" an ESRO project and was "presentationally preferable". [848] Probably no one was deluded by these cosmetic manoeuvres; as we mentioned earlier, the French engineers had already developed key systems of the spacecraft to an advanced level, and it was widely accepted that they maintain control over them. Thus ESRO was to be responsible for power supplies, telecommunications, quality control, part of the ground segment, notably the hardware and some software aspects of the central control station and, of course, overall management. CST on the other hand maintained control over the main subsystem on which the whole Meteosat mission rested, viz. the radiometer instrument package (mechanical-optical system, IR and visible light detectors) along with its electronics for data storage, timing coding/decoding etc., which they had developed to an advanced stage with Matra. Its engineers were also responsible for the equally critical attitude control thrusters and the nutation damper, which oriented and stabilised the satellite in its orbit. CST also developed the technology for the acquisition and processing of the image signal, i.e. for the hardware and software necessary for the processing of raw-image data as well as storage and read-out (to tape transmitters) of processed image data. In short, the final division of labour in the Europeanised Meteosat preserved the French team in Toulouse intact, along with its in-house skills and knowledge of crucial subsystems of the space and ground segments. This would obviously give French engineers and industry an enormous advantage if or when a fully operational system of successive meteorological satellites giving continuous Earth coverage was put in place. [849]

The basing of the project in Toulouse and the allocation of critical subsystems to CST engineers were, in France's eyes, the *sine qua non* for the Europeanisation of the Meteosat project and they were prepared to back their demands with threats. At the Council meeting in December 1971, member states of ESRO, including France, declared their intention to participate in the so-called "first package

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846 This paragraph is based on the minutes of the meeting of the working group (Groupe de Travail de Management Technique 'Meteosat') held on 8 February 1972 (52018). For the recommendations of the Cooper report, see the remark by the Director of ESTEC made at the 7th meeting of the IAPC, ESRO/IAPC/MIN/7, 13 October 1971 (ESRO9334), at p.6.

847 E.g. in Macchia's memo to Hocker commenting on the paper to be prepared for the Programme Board meeting of 21 March 1972, 8 March 1972 (52019). See also ESRO/AF(72)20, 25 January 1972 (ESRO2319), point (m).

848 From minutes of the first meeting of the Meteorological Programme Board held on 21 March 1972, ESRO/PB-MET/MIN/1, 19 April 1972 (ESRO8940).

849 The division of labour is described in ESRO/C(71)63, 2 December 1971 (ESRO604), in the memo from Contzen to Hocker *Programme de satellite météorologique* - Groupe de négociations ESRO/CNES, 17 February 1972 (52019) and in the formal *Agreement with CNES*, ESRO/PB-MET(72)3, rev.3, 17 May 1972 (ESRO8957). For the importance of the various subsystems, see ESRO/IAPC/71133, 42 12 January 1971 (ESRO9370).

deal" which made provision for three applications satellites, including one for meteorology. The French delegation was heartened, it said, by the spirit of compromise which had reigned during the negotiations leading up to this deal –, of which its willingness to accept a structure for Meteosat which "differed very substantially from the one that France had originally put forward" was just one sign. That said, France was now "at the extreme limits" of the concessions that it was prepared to make and the attitude of its partners to its outstanding demands would be taken "as a critical test of the will of the Organisation to translate into practice the principles regarding co-ordination of European space programmes" which it had just enunciated. Put differently the success of the first package deal and indeed the survival of the joint European space effort as a whole was linked by France to having its bottom-line conditions for the Europeanisation of Meteosat respected. [850]

One last little anecdote is indicative of the tensions and ambiguities surrounding the process of Europeanisation. By May 1972 the Meteosat programme had been so completely transformed institutionally, if not technically, that some members of the Ad Hoc Group felt that it should lose all visible trace of its French origins. Even the Project Manager at the time, W. Nellessen began to be unsure about what he was actually manager of: was it Meteosat or GEMS (GEostationary Meteorological Satellite). A near-final version by Tessier of one of the annexes to the formal agreement between participating states hesitated between Metsat and Meteosat. [851] The French engineers at CNES were, needless to say, deeply offended – it seemed as though no efforts would be spared to marginalise and even to humiliate them –, and in the event the original name was kept.

7.4.2 The ground segment: interfacing with the users. The responsibilities of national meteorological services in data analysis and satellite operation

Until mid-1971 the ground segment had been of secondary interest in discussions among European meteorologists on their preferred satellite-based system. Their main concern was to define the most suitable spacecraft and its instrument package, bearing in mind the requirements of the FGGE in 1977/8. [852] This was partly a matter of scheduling: the decision on the appropriate space segment had to be taken by 1971/72 if the satellite was to be launched by 1976. The ground segment would not take as long to put in place and could be defined afterwards. It was also due to scientific uncertainty: the field of meteorological data analysis was evolving rapidly and would certainly make further strides once the first results were available from the new generation of US geostationary satellites. Finally it raised thorny questions about the division of labour, cost and responsibility between those responsible for the space segment and the users who would exploit the meteorological data. The situation in France was typical in this regard. Meteosat had been the baby of engineers at CNES, who found in it a viable and technologically challenging programme. The French meteorological service was barely involved in its planning and was indifferent, if not hostile, to a scheme which would ultimately require it to transform old work habits and to spend a lot of money.

The debates over management control ensuing from the French proposal to Europeanise Meteosat forced the European meteorologists to look closely at the organisation of the ground segment. Two additional factors oriented them in this direction. Firstly, there was a symbiotic link between the space and ground elements of Meteosat. Image processing, in particular, depended heavily on the specifications imposed on the satellite's attitude control and stability systems, the images themselves even being able to serve as a parameter for controlling the spacecraft in its orbit. [853] Secondly, it rapidly

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850 Annex III to the minutes of the 44th Council session, 20 December 1971, at which the deal was officially announced - it was brokered by Puppi - contains the French delegation's statements, ESRO/C/MIN/44, 6 January 1972 (ESRO42).

851 See memo Nellessen to Tessier, 15 May 1972, memo *An Estimation of the GEMS Post-Launch Running Costs* by Wassgren (ESOC), 21 June 1972 (52023) and early versions of Table 7-2 (below) in (52022).

852 This is the case, for example, in document ESRO/IAPC(71)12, 1 July 1971 (ESRO9349), in which the Ad Hoc Group formulated its priorities for the European meteorological programme - and speaks only of satellites.

853 See the minutes of the meeting of the working group on the technical management of Meteosat held on 8 February 1971(52018).

emerged that, contrary to the impression given by the French delegation in June, virtually no work had been done in France on the ground segment. What is more, according to Tessier, the director of the national meteorological service was not at all keen to have the central station on French soil as it would impose too heavy a load on his budget. [854] It will indeed be remembered that in their initial offer to Europeanise their satellite, the French delegation suggested that the ESRO Council could decide on the location of this station. The Ad Hoc Group, meeting in Paris in September 1971, thus decided to renew its efforts concerning the ground segment. It was proposed that a team of about six people (called the GFGMS group), including engineers from CNES and ESRO and two meteorologists nominated by the chairman, be set up to deal with the preliminary studies needed by industry, possibly liaising with NOAA. [855]

By November 1971 the meteorologists had revised their original statement of needs produced for the IAPC four months before by formally adding a ground segment to the European system. This system would "provide and operate the ground stations required to control the spacecraft, acquire its data and reduce them to meteorological parameters effectively in real time". It would contain a central station, as well as 'principal' stations equipped with antennas up to about 5 m in diameter and 'local' stations which would be as simple as possible. The central station was "taken to mean the complex of telemetry and command, pre-processing and processing centres". The principal stations were to be equipped to see all the image information relating to their own neighbourhood (2000 km x 2000 km), as well as images of the Earth's disc at intervals of not more than three hours. Local stations were to be able to see local images at least once every three hours. Costing these items, the secretariat budgeted for a central station and pre-processing centre equipped with a major computer, as well as for "development of prototype specifications for a principal station". The processing centre(s), the principal and the local stations, as well as data collection platforms would be financed outside the ESRO space programme, though further information was required from the meteorological authorities before a more definite division of labour could be provided. [856]

This division of financial responsibility between the pre-processing and processing of meteorological data was intended to involve the meteorologists directly in the funding and functioning of the ground segment. The Secretariat accepted that a major central computer was needed to transform raw data coming down from the satellite into information which could be analysed by the meteorologists. The processing of that data, they felt, should be under the control of the weathermen, however. The French members of the Ad Hoc Group (Bessemoulin and Morel) supported them. They were emphatic that meteorological data processing could be kept quite distinct from "the technical operations of satellite control, navigation and raw data calibration and gridding". The relationship between the functions could only be decided, they said, once one had a better idea of the requirements for the data processing system itself.

This attempt to give the meteorologists responsibility for a major component of the ground segment failed. The majority of the Ad Hoc Group and notably the British and German representatives of the 'Wetterdienst" (Stewart and Regula), preferred a centralised system combining all the functions in one coordinated unit. They accepted, however, that the telemetry and command functions might be executed up to a hundred kilometres away from the pre-pre-processing and processing functions so that the antenna would be free from interference. [857] As the UK delegate to the first meeting of the Programme Board put it, "complete real-time processing of meteorological data is a complex task

[854] See Tessier's memo *Refléxions preliminaires sur la proposition d'européanisation de Meteosat*, 13 September 1971(52014).

[855] The minutes of this sixth meeting are dated 5 October 1971 and are in file (52014).

[856] The meteorologist's addendum to their previous statement of needs (IAPC(71)12) was ESRO/IAPC(71)32, 8 November 1971 (ESRO9369). See also ESRO/IAPC(71)31, 7 December 1971 and a draft dated 29 October 1971(52014). The secretariat's costings are in ESRO/IAPC(71)34, 17 November 1971 (ESRO9371).

[857] See the Minutes of the *Seventh Meeting of the Space Meteorology Grou*p held in Brussels on 4-5 November 1971, dated 7 December 1971 (52016). The quotation is from Appendix 6, which the French insisted be added.

needing continuous use of a CDC 6600 computer and many staff," and was beyond the means of national stations. To "avoid having the satellite produce a large amount of data that could not be exploited by the national agencies for lack of sufficient computer capacity", he said, it was essential to foresee a properly equipped central station in the European programme. [858] In the face of this pressure, the French capitulated and the Ad Hoc Group decided unanimously in favour of "the lumping of the meteorological and space sections of the central station". This was located at ESOC in Darmstadt, while the DATTS function (see Table 7-2) was situated in Odenwald.[859]

Meteorologists could, however, still be involved in some basic tasks of the central system, even if the 'meteorological and space sections' were lumped together. A definition of their role required a detailed analysis of just what was involved in treating meteorological data with computers and breaking down the tasks in such a way that a meaningful line could be drawn between European and national activities. To sharpen their thinking on this, some members of the GFGMS subgroup spent a month in the USA visiting NOAA and having in-depth discussions with leading scientists at the Universities of Chicago and Wisconsin "to study fundamental methods involved in the extraction of meteorological data". Their deliberations were complemented by an additional working party chaired by Regula and composed of representatives of the national meteorological services. [860] The GFGMS working group's report was ready in March 1972. It identified the tasks required to "transform spacecraft data into useful meteorological information", bearing in mind the degree of interconnection between the "processing of attitude, orbital and meteorological data". [861] By May its findings had been fused with the conclusions of the Regula subgroup.

Table 7-2 shows the tasks accorded to the central ground facility as shown in the formal "Arrangement" binding together the participating states in the Meteosat programme, which was ready for signature in July 1972. [862] The Central Facility was "to perform the tasks which [were] too expensive and/or too involved to be performed several times in parallel." The locus of its interface with the national meteorological services was the MIEC (Meteorological Information Extraction Centre). The "general philosophy" here was that the MIEC was to perform data extraction only on a global scale and on a quantitative basis (i.e. data which could be used directly for numerical modelling). This data was to be "as independent as possible" of other meteorological data and was to deal with winds, sea surface temperatures, cloud coverage, cloud top heights and radiation balance. The MIEC was not to concern itself with qualitative applications (the issue of warnings, general surveys of the weather system) or with quantitative applications on less than global scale. [863] These would be considered the task of the national meteorological services who would use their own computers. On the last point the Directors of the national meteorological services insisted that "they would have sufficient computer capacity available to receive and make the best possible use of the meteorological data supplied by the satellite". [864]

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858 The minutes of the first meeting of the (Provisional) Programme Board, ESRO/PB-MET/MIN/1, held on 21 March 1972, are dated 19 April 1972 (ESRO8940).

859 From *Minutes of the 8th Meeting of the Space Meteorology Group* held on 9-10 February 1972, dated 7 March 1972 (52018). At this meeting Stewart gave the arguments he felt weighed in favour of centralisation; it would avoid wasting the spacecraft's disseminating capabilities, it would enhance the security and reliability of the system and it would economise on operational exploitation costs.

860 The terms of this subgroup are spelt out in an undated document in (52019).

861 The two quotations are from ESRO/PB-MET(72)2, 16 March 1972 (ESRO8956). The GFGMS report, *Study of Meteorological Data Processing Methods* is in (52021).

862 The Arrangement between ESRO and some of its member states "concerning the execution of a meteorological satellite programme" is ESRO/C/13 rev. 5, 13July 1972 (ESRO622).

863 From the Regula group's report on the ground segment ESRO/PB-MET(72)5, 29 May 1972 (ESRO8959) and Annex 1 to ESRO/PB-MET(72)7, 1 June 1972, European Contribution to Space Meteorology (ESRO8961).
See also Schneider's description at a meeting in Washington DC on 19-20 September 1972 (52025).

864 From the Statement by 'the Chairman of the Ad Hoc Group on Space Meteorology' to the second meeting of the (Provisional) Programme board. ESRO/PB/MET/MIN/2, Annex II, 21 June 1972 (ESRO8941)

Table 7-2. Tasks of the different ground facilities as agreed in the Arrangement between the participating states in the Meteosat programme, July 1972.

Term		Abbrev-iation	Main Functions
(1)	Ground Facility Meteosat	GFM	Combines (2) to (5)
(2)	Data Acquisition, Telecommand, Tracking Station	DATTS	Data Acquisition (Meteorological and Housekeeping Data) Telecommand , Tracking
(3)	Operations Control Centre	OCC	Control of Spacecraft and Operations
(4)	Data Referencing and Conditioning Centre	DRCC	Phase Adjustment of Radiometer Data, Gridding and Annotation. Orbit and Attitude Computations. Editing, Imagery: - Rectification - Projection Conversion - Information Transformation
(5)	Meteorological Information Extraction Centre	MIEC	Extraction of Meteorological Information - Sea Surface Temperatures - Wind Fields - Cloud Analysis (coverage and top height) - Radiation Balance - Editing - Handling of Data Collection Platforms (DCP) Data
(6)	Meteorological Terminal	MT	Equipment Required by the GFM to Provide the Interface with the Link with the Global Telecommunications System (GTS) of the World Weather Watch (WWW)
(7)	Meteorological Centre	MT	Meteorological Analysis by Users
(8)	Primary Data User's Station	PDUS	Reception and Display of Full Resolution Image Data (in digital form). Reception of APT Type Transmissions (in analogue form)
(9)	Secondary Data User's Station	SDUS	Reception and Display of APT Type Transmissions (in analogue form).
(10)	Data Collection Platform	DCP	*In situ* Collection of Meteorological and Related Data

The central processing facility was not simply meant to have a data-processing and distribution function; it was also to archive data and have a related research capability intended to improve the methods of extraction of data in the five identified areas. The centre was also to have a "flexible" policy whereby results obtained in universities and national services, once operational, could be fed back to the MIEC and integrated into its systems. In summary the ESRO ground segment was to provide national meteorological services with qualitative data comprising images in suitable formats transmitted to their PDUS and SDUS and quantitative data extracted from raw space data by the central facility on items such as wind fields, which would be disseminated through existing meteorological telecommunications networks. Who would pay for what? According to the final "Arrangement", ESRO would bear the entire cost of the ground facilities specified in Table 7-2 except for the software of the MIEC and all the modifications it might require and the links between the meteorological terminal and the national meteorological centres. This was taken by Schneider, the Ad Hoc Group Chairman, to mean that "the programme and operating costs of the MIEC will be met by the meteorological services themselves, as well as the cost of a small group of research workers whose major task will be to develop new methods of extraction". This cost, he went on to say, represented 4-5% of the budget of a meteorological service at that time.

Even this Arrangement was not to last too long however. One of the first things the meteorologists did after the Meteosat Arrangement was signed in July 1972 was to plan the software effort for the MIEC. This was one main point of entry into the system for users, the point at which they could impose their working requirements on it. The directors of the meteorological services divided the work that needed to be done into several phases; identification of products required, software definition, software specification and writing of computer programmes. The first two phases would require about four meteorologists who could work from their home bases, the last two would involve an increasing number of computer experts and would require a close interaction with ESOC. However, it quickly emerged that identifying the tasks was one thing, providing the legal and financial framework for carrying them out was another. Some meteorological services felt unable to finance the travel costs of their experts to the two or three working meetings needed during phases I and II. No one quite knew how to administer or to define the level of contributions to the common fund that was going to be needed to pay for the more costly phases III and IV. It also emerged that no figures were available at all on the cost of development of the MIEC software. [865]

The Programme Board discussed these matters with growing concern early in 1973. It decided that it was essential for ESRO to contribute to the development of the MIEC software too. One way was for the Organisation to sign individual contracts with national meteorological authorities in both participating and non-participating states, an arrangement which would extend the scope of the user community and enable the users to express their interest directly. The other was to revise the Annexes to the Arrangement signed only a few months before, with the associated risk that ESOC would have more room to impose its will on the users. The Programme Manager at the time, De Leo (he would be replaced by Dieter Lennertz very shortly) felt that this was essential anyway. The intimate links between software and hardware, he wrote, meant that the software definition had to be "controlled by the same organism responsible for the hardware" [866] Meeting on 29 March 1973, the Programme Board chose this path in the interests of cost and efficiency. An additional sum of 1.5 MAU was allocated to the Meteosat programme for the "new task of the preparation, development and pre-operational optimisation of the software" for the MIEC. [867]

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865 For reports on their preliminary meetings see ESOC memo Wassgren to Walker, 19 September 1972 (ESRO52025), minutes of the Dublin meeting of the Ad Hoc Group on 26-27 September 1972, ESRO/SMAHG/MIN11, 6 October 1972 (ESRO52025); minutes of the meeting held in Offenbach on 14 November 1972, document dated 23 November 1972 (ESRO52026), and letters from Regula to Tessier, 10 October 1972 and Schneider to Hocker, 4 December 1972 (ESRO52026).

866 Memo De Leo to Contzen, 15 November 1972 (ESRO52026)

867 See minutes of the meetings held on 16 February 1973 and 29 March 1973, ESRO/PB-MET/MIN/4, 13 March 1973 (ESRO8943), ESRO/PB-MET/MIN/5, 10 May 1973 (ESRO8944) and document ESRO/PB-MET(73)5, 15 February 1973 (ESRO8971).

The reluctance of the meteorologists to play a major role in the processing of data coming from Meteosat was symptomatic of the prudence with which the bulk of the weathermen approached the entire project. Initially they had led their colleagues to believe that they would assume full responsibility for the ground segment. In September 1971, the Italian delegate to the IAPC had suggested, for example, that "all ground equipment would be placed under the responsibility of the national meteorological services". The meteorologists retreated steadily from this position, however. 'All ground equipment' was first cut back to a share of the costs of the processing centre. In the minutes of the March 1972 meeting of the Ad Hoc Group we read that the meteorologists "agreed that the data acquisition and pre-processing centres should come under the ESRO budget and that the meteorological processing centre should be shared jointly between ESRO and the meteorological services". The British delegate to the next meeting of the group in May revised this further: now it was "agreed that the data acquisition and pre-processing centres should come under the ESRO budget, but that the exact interface between these and the meteorological centres needed to be discussed more fully [...]." [868] That proposal was transformed into a fixed commitment to pay for the MIEC software in the Meteosat "Agreement" signed in July 1972 – but then even that 'Agreement' was revised just nine months later to remove even this task from the shoulders, and the budgets, of the meteorological community. It was clear by 1973 that it was going to be a long uphill struggle to enrol the meteorological community fully into an operational meteorological satellite system.

7.5 The start of the programme

The "Arrangement Between Certain Member States of the European Space Research Organisation and the European Space Research Organisation Concerning the Execution of a Meteorological Satellite Programme," along with its Annexes describing the details of the Meteosat programme and its cost (an envelope of 115 MAU at mid-1971 prices for the period 1972-79) was approved by the ESRO Council at its 47th session on 12 July 1972. The resolution that formalised the decision noted that arrangements still had to be made to cover both the operation of the Central Facility and the operational phase of the programme and that "ESRO could be considered as one possibility" for the latter. [869] The Arrangement came into force before the foreseen deadline (30 September 1972) with two thirds of the contributions guaranteed. The eight participating states and their contributions were: the Federal Republic of Germany (25.66%), Belgium (4.06%), Denmark (2.41%), France (23.70%), Italy (15.07%), the United Kingdom (20.60%), Sweden (5.02%) and Switzerland (3.48%). [870]

In the first year or two after the Arrangement was signed, a number of technical and financial changes were made to the Meteosat programme and the appropriate institutional framework was put in place. We shall quickly summarise these elements before plunging into a discussion of the subsequent evolution of the programme.

7.5.1 The STAG

One of the first things the meteorologists did was to formalise their relationship as users by suggesting that a group of expert advisers be put in place, in addition to the Programme Board, to represent their interests and to monitor the Meteosat programme. It was felt that such a group was needed to keep an eye on the technical aspects of the programme, including data processing and to co-ordinate relations between the users in meteorological services as well as the scientific research community. This body, the STAG (Scientific and Technical Advisory Group) comprised up to two representatives from each

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868 For the first quotation, see Annex II to ESRO/IAPC/MIN/7, 13 October 1971 (ESRO9334). The minutes of the ninth (March) and tenth meetings of the Space Meteorology Group, dated 6 April 1972 and 25 May 1972, are to be found in (52019) and (52022), respectively.

869 ESRO/C/MIN/47, dated 26 July 1972; the resolution is ESRO/C/XLVII/Res. 1, 12 July 1972 (ESRO45).

870 The document is ESRO/C(72) 13, rev.5, 13 July 1972. During the next year a further 1.5 MAU was provided for preparing the MIEC software, this to be distributed as for the main programme.

of the participating states. [871] As an advisory body, their recommendations to the Programme Board did not tie the hands of the delegations. The STAG held its first meeting on 11 December 1972 and appointed Stewart (UK) its chairman, representing the meteorological services and Morel (F) its vice-chairman, representing university research - a combination specifically sought by the French. [872] The Ad Hoc Group on Space Meteorology dissolved itself at the same time and the directors of the national meteorological services decided that they should continue to meet formally in a regular manner, but outside the framework of ESRO.

The management of the interface at the working level between the meteorologist users and the ESRO Executive proved far more difficult to harmonise and was indeed the source of ongoing friction which was amplified by the difficulties with the ground system that we shall be describing shortly. The first salvos were fired at the second meeting of the STAG. The German delegation asked if the users might receive copies of the specifications sent out to the firms tendering for work. The secretariat refused, insisting that "the execution of the technical aspects and the control of the industrial consortia" were its responsibility. The French delegate to the STAG could not accept this. That policy may have been acceptable for scientific satellites, he said, but the Agency should recognise that applications opened "a new era", as the spacecraft also had to satisfy customers who had a right to know what they were getting and who wanted to acquire for themselves the requisite competencies in the new technologies. At the very least, the Executive should be prepared to make a presentation of the project to the users before the final designs were frozen so that they might propose changes.[873] A year later the French delegate went further, suggesting specifically that the Organisation's secretariat be obliged to report to both the STAG and the Programme Board "to present in details the substance of the specifications before putting out calls for tenders relating to major parts of the programme". He also wanted the internal assessments of the industrial proposals after the calls for tenders to be divulged to the two bodies. [874]

As far as policy as a whole was concerned, the French delegation gathered little support. At a meeting of the Programme Board in November 1973 the consensus was that it should not be standard practice to make a technical presentation of industrial proposals to the delegations. This was likely to undercut the authority of the Administrative and Finance Committee, the only body authorised to award major contracts and to encourage firms to lobby national delegations directly, to the detriment of the Organisation. [875] These formal arguments notwithstanding, there were ongoing tensions over specific cases in which the meteorologists felt that their views were being ignored. For example, in November 1973 the plans for the central building, in which they had requested an increase of office space, had been "completely changed" to the detriment of the meteorologists and there had been no discussion with the users concerning the tasks to be undertaken in important sections of the ground facility. [876] In February 1975 the German delegate to the STAG was "surprised" that the Group had not been asked to monitor work on the software specifications more closely, while the British delegate "deplored the fact that during the dialogue with industry the necessary adjustments had been made on the advice of the MIEC group" without consulting the STAG, which was accordingly unable to advise the Programme Board correctly. Two months later it was the turn of the French to "deplore the fact that the Secretariat's work schedule for the placing of the software contract for the Meteosat computer system did not make sufficient provision for the users to intervene". [877]

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871 The full terms of reference are in ESROIPB-METJIIIJRes. 11, 5 October 1972 (ESRO8942). They are a selective fusion of the views of the French delegation, ESRO/PB-MET(62)l1, 29 September 1972 (ESRO8965) and the meteorological directors, Annex 4 to ESRO/SMAHG/MIN11, 6 October 1972 (ESRO52025).

872 ESRO/STAG(72)4, 11 December 1972 (ESRO9042).

873 ESRO/STAG/MIN/2, meeting on 29 January 1973, document 19 March 1973 (ESRO9026).

874 ESRO/PB-MET/MIN/8, meeting on 6 February 1974, document 15 March 1974 (ESRO8947).

875 ESRO/PB-MET/MIN/7, 7 November 1973, document 20 December 1973 (ESRO8946)

876 ESROIPB-MET(73)19, 16 November 1973 (ESRO8984).

877 ESRO/STAG/MIN/12, meeting on 19 February 1975, document 8 April 1975 (ESRO9036); ESRO/PB-MET/MIN/14, meeting on 25 February 1975, document 18 April 1975 (ESRO8953).

ESRO/ESA staff, of course, made what efforts they judged reasonable to meet the users' objections while defending themselves stoutly, even if with growing frustration: typically Programme Manager Lennertz "again asked the Group not to interfere with the normal process of the [tender] procedure which was in strict conformity with the Organisation's rules; an intervention by the STAG in order to modify the specifications which it had previously approved could, in the extreme, invalidate the call for tenders causing it to be done afresh [...]". [878] It is not the task of the historian to adjudicate in this affair. What is important is that each party in this dispute was defending its own interests and felt that the other was behaving unreasonably and – and this is the most important point to retain here - that the feeling that they were being unjustifiably excluded led the meteorologists to become increasingly hostile towards ESA. That hostility was exacerbated by the difficulties with the ground facility which plagued Meteosat- 1 throughout its active life.

7.5.2 The third channel and the Lannion ground station

Two developments, both of them promoted by the French delegation, were adopted to improve the quality of the data from the Meteosat system. Firstly, an additional infrared channel conceived by P. Morel and corresponding to the water vapour absorption band, was added to the two channels originally foreseen on the radiometer.[879] Its main scientific functions were to give additional information on winds in the upper troposphere, particularly in the tropics, where coverage from existing observing systems was very inadequate. This would be done using newly available sensors to observe cloud movements and the configurations of cirrus, as well as to detect and locate jet streams and to measure temperature contrasts. Other information available from the channel – water vapour distribution, inference of vertical motion, cloud analysis and improvements in the determination of cloud-top temperature in the mid-troposphere – was of an experimental nature and would be of value for research.

The third channel lived rather precipitously for a few years. Feasibility studies of the device made in 1974 led to a cost increase of 100% over the original estimates and it became clear that the chances of having the package ready for the first Meteosat flight unit (Fl) were rather remote. Indeed, in November 1974 the secretariat reported that the way things stood the third channel could probably not be integrated into Fl without delaying its launch (scheduled for April 1977). The radiometer for Fl would thus be built with just two channels, as originally planned. The three-channel radiometer would be prepared for the spare flight unit F2. A final decision on which payload was to be integrated into the Fl satellite would be taken in mid-1976. This led the Belgian delegation to wonder whether it was worth proceeding with the channel at all if its chances of being used were remote, particularly when money was being cut from the science programme. The French delegation resisted this suggestion, as did the representatives of Britain and Germany. Their overriding argument was that the additional channel was a really novel development and one important way in which Meteosat differed from existing American satellites.[880]

The second modification requested by the French was to extend the geographical coverage of data available to Europe by including meteorological information from the American SMS satellite in the system. The two satellites had a common longitudinal frontier roughly over the middle of the Atlantic Ocean, the US satellite (to be situated at longitude 70-75° W) "seeing" the western part of the ocean, while Meteosat (at 0°) observed the eastern part (see Fig: 7-1). Data from the former thus

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878 ESRO/STAG/MIN/12, meeting on 19 February 1975, document 8 April 1975 (ESRO9036).

879 The proposal is ESRO/STAG(72)6, 28 December 1972 (ESRO9044) and the first debate is ESRO/STAG/MIN/3, meeting on 27 March 1973, document 15 June 1973 (ESRO9027), producing ESRO/STAG(73) 11, 30 April 1973 (ESRO9055) and ESROJPB-MET/MIN/6, meeting 72 on 7 June 1973, document 23 July 1973 (ESRO8945).

880 See ESROIPB-MET(74)24, 23 September 1974 (ESRO9008), ESRO/STAG/MIN/l0, 11 September 1974, document 6 December 1974 (ESRO9034), ESRO/PB-MET/MIN/1 3, 26 November 1974, document 24 January 1975 (ESRO8952), ESA/PB-MET/MIN/4, 29 January 1976, document 24 March 1976 (ESA3530). The cost increase for having a channel on each radiometer was about 370 kAU, ESA/STAG/MIN/3, 11 February 1976, document 7 April 1976 (ESA3692)

complemented that from Meteosat, providing advance information on depressions and frontal systems moving westwards, as well as assisting navigation over transatlantic air corridors from Europe. The French claimed, however, that the Meteosat central facility at Odenwald was too far west to receive signals from SMS. They thus suggested that their existing centre at Lannion, which was about 150 km from the extreme western point of the hexagon, be used instead to relay signals from SMS via Meteosat to European meteorologists at their Primary and Secondary Data User Stations (PDUS and SDUS). A technically well-qualified team with several years of experience of operational work had been built up at the base and France was prepared to invest FF 3.7 million to upgrade the station appropriately. A further FF 1 million would be required from ESRO

The proposal certainly had scientific and operational advantages. But more was at stake. The French presented their proposal at the meeting of the Programme Board held soon after the Council had agreed to situate the Meteosat central facility at ESOC/Odenwald. And even if the delegates from Britain and the UK had their doubts about the relevance of the French idea for the Meteosat programme as such, the French made it clear that they would reopen the debate on the site if their offer was refused for "reasons other than the position of the SMS satellite". With that the matter was closed in their favour. [881]

7.6 The ongoing technical problems with ground facility computer and software

The tender evaluation and the Secretariat's recommendation for the ground computer system were discussed at the AFC meeting in Copenhagen on 4-5 July 1974. The committee was faced with a dilemma: none of the European firms bidding for the contract could match the offers made by the American suppliers. The ESRO Secretariat thus proposed that the contract be awarded to the American company CDC whose offer was judged "the best received" [882]. Wishing to promote European technology in this sector, however, the AFC decided that the two companies concerned, ICL (UK) and CII (France), be given another chance. Study contracts of 20 kAU were awarded to each and they were invited to resubmit tenders in the light of revised mission requirements to be provided by the meteorologists. As for costs, the AFC also agreed to accept a European offer if it was not more than 10% more expensive than the CDC offer recommended by the Secretariat. [883]

In coming to this decision the AFC clearly had the long-term interests of the European computer industry in mind. As the French delegation to the Programme Board pointed out, a non-European solution should only be adopted if it was "absolutely necessary", since it would impossible to change back once Meteosat became operational as all the systems would have been developed. [884] The AFC had, however, also been advised by the STAG, which had met the week before to discuss the computer contract. Here, somewhat against their status as independent experts and going beyond their formal role which was limited to making technical judgements, the French and British meteorologists suggested that the European solutions could be saved. While not casting aspersions on the excellence of the work done by the Project Manager and the Tender Evaluation Board, the STAG did feel that the technical specifications in the tender documents sent out by ESRO "did not correspond exactly to the true needs of the meteorologists and that there might be some room for adjustment of the requirements to enable European proposals to meet them." The AFC's decision to reopen the tender procedure thus

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881 See ESRO/STAG(72)5, 12 January 1973 (ESRO9043); ESRO/PB-MET(73)14, rev. 1, 8 November 1973 (ESRO8979); ESRO/PB-MET/MIN/4, meeting on 16 February 1973, 13 March 1973 (ESRO8943); ESRO/PB-MET/MIN/6, 7 June 1973, document 23 July 1973 (ESRO8945); and ESRO/STAG(73)12 (ESRO9056).

882 See ESRO/AF(74)67.

883 ESRO/AF(74)l19, 23 September 1974 (ESRO2714).

884 In ESRO/PB-MET(74)19, 17 July 1974 (ESRO9003).

had at least the appearance of being based not only on political/industrial considerations, but also on technical arguments. [885]

Towards the end of July a small group of experts nominated by the STAG met at ESOC to revise the technical specifications of the ground facility. In the light of the difficulties the European computer firms were having, they concentrated their efforts on reducing the demands on the Central Processing Unit (CPU). In particular, they sought ways of reducing the total and/or peak load on the CPU imposed by each task, by changing the requirements in terms of geographical coverage, spatial frequency (grid size), extraction method, the frequency with which a product was generated, and the time of issue of the product. Their overall aim was to save CPU time by reducing the quantity of the data rather than the quality. Thus typically they recommended that measurement of cloud top height should be restricted to areas used by aircraft, that reference images for wind processing should be provided every second hour rather than every hour, and so on.

Changes of this kind had two immediate effects. Firstly, since less data was generated and less frequently there would be a loss of quality control of the meteorological products. Secondly, with the rescheduling of the use of CPU time there would be less spare capacity in off-peak periods, to the detriment of the outside research community for whom such slots had been specifically earmarked. [886] The Programme Board endorsed the report, though it was noted that the two original European proposals were still unacceptable notwithstanding the efforts to adapt the specifications to their capabilities. [887]

Table 7-3: Scores of the offers made by four firms for the ground computer system and the costs of the hire-purchase option (rent until 1 July 1977 and then buy). From ESRO/AF(74)l 19, Annex, Tables 3 and 6, 23 September 1974 (ESRO2714)

Proposal		Admin. Eval.	Technical Eval.	Weighted Score	Cost (MAU)
IBM		72.4	69.2	70.0	15.955
CDC	Option A	53.6	71.3	66.9	12.839
	Option B	53.6	65.3	62.4	10.897
ICL		52.8	64.5	61.6	14.416
CII	Option A	58.4	54.9	55.8	14.390
	Option B	58.4	52.4	53.9	13.194

Table 7-3 summarises the scores achieved for the resubmitted tenders after assessment by the Tender Evaluation Board. Marks were given along three axes: administrative - which covered features like organisation and management, planning and time schedule, costing and contract conditions - technical and a weighted overall score. Leaving aside the question of cost, IBM came in first, CDC came next, its option A, which involved using two of its Cyber 175 mainframes outscoring its option B which used the less powerful Cyber 174. Of the two European firms, ICL was distinctly superior offering to use two P4 computers from its "New Range", though its weighted score was slightly below the lowest US score. The French consortium CII performed very poorly by comparison. Its option A used the WIS 80 mainframe with Siemens 330 minicomputers; Option B had the less powerful CII Mitra 15 replace the Siemens.

Technical considerations had of course to be combined with those of cost. The immediate purchase of any system was excluded for budgetary reasons. Rental, which the Secretariat favoured because of the flexibility it allowed in terms of future system development, was rejected outright by the

885 For the debate in the STAG see ESRO/STAG/MIN/9, meeting 26 June 1974, document 2 July 1974 (ESRO9033) and ESRO/PB-MET(74)17, 11 July 1974 (ESRO9001).

886 See ESRO/PB-MET(74)20, 29 July 1974 (ESRO9004) for the full report by the STAG expert group.

887 See ESRO/PB-MET/MIN/11, meeting on 31 July 1994, document 12 September 1974 (ESRO8950).

meteorologists. They insisted that all capital expenditures were to be borne on the Meteosat programme budget, the national services only being prepared to contribute "relatively moderate running costs". [888] This left the hire-purchase option (see Table 7-3, last column). Bearing all considerations in mind, the Secretariat again recommended to the AFC that CDC Option B be chosen for the ground facility. If the AFC insisted on a European solution, the only viable option would be ICL. The Secretariat emphasised, though, that there were doubts about the credibility of its delivery schedule, since it had suggested an entirely new and radically different machine to its usual product line. What is more the cost of the British machine was considerably over the 'CDC+10%' criterion laid down by the AFC and its payment profile, which showed a sharp peak early on, was inconsistent with ESRO's planned annual budgetary provisions. If the AFC wanted to recommend ICL despite the superiority of the CDC, the British firm would have to give satisfaction on these points. [889]

The AFC duly met on 3 October 1974 – and opted for the European solution. The contract for the computer for the Meteosat ground facility would be awarded to ICL on condition that it satisfied the three conditions specified by the Secretariat. While these were being negotiated, the AFC said, parallel discussions should be started with CII to see if it could not improve its proposals. If after five weeks ICL had not satisfied the Secretariat, the choice would automatically fall on CII subject to the latter having presented a satisfactory offer. If after this time lapse neither European firm could provide the necessary technical guarantees, the contract would be awarded to CDC. As for the 'CDC+10%' cost guideline, the AFC was prepared to waive this if the British and French firms made offers which were acceptable on other grounds. After further cliff-hanging negotiations, the contract was finally awarded to ICL.[890]

The decision to adopt a European solution for the Meteosat ground computer and to award the contract to ICL for a P4 "New Range" system was a controversial one. Of course, as the French delegate to the Programme Board put it, "in the present economic situation in Europe the industrial preference clause was of the greatest importance and it was highly desirable not to create a precedent that ran counter to it". [891] On The other hand, as he also remarked (in an attempt to defend CII), since the P4 embodied a radically new concept and was still under development, the Organisation was running a considerable risk in choosing the British firm. Indeed these sombre warnings, biased as they may have been by the disappointment felt by the rejection of the French consortium, proved to be only too true. For the difficulties surrounding the commissioning of the ICL machine were immense and the Executive was forced on more than one occasion to consider taking drastic measures to have a ground system available at launch. Indeed that the risks incumbent on choosing the ICL computer did not have disastrous effects on the programme was only because there were repeated slippages in the launch date due to a rescheduling of the FGGE window (advanced to the end of 1978) and then to delays at Cape Kennedy. These delays gave the ICL engineers more time to get their system up and running than would otherwise have been the case.

The difficulties that ICL was having with its new system emerged clearly in 1976 and after a number of high level meetings between the supplier and the client a new delivery schedule was drawn up. It shifted the expected delivery date for the complete system forward by twelve months to 31 July 1977. The single most important reason for the delay was the technical problems the firm was having with the operating system software of the new series (now numbered 2980) and with the adaptation to ESA requirements of the complete network. To resolve the problems ICL undertook to strengthen its teams working on the system and to place a senior engineer in overall charge of the development activities. The Executive, for its part, insisted that ICL must provide a certain number of facilities for the Agency by the key date of 15 November 1976. Failing that, it suggested that ESA might have to consider replacing the ICL central processor by another. Indeed the Executive was so sceptical about the British

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888 For this see ESRO/STAG/MIN/9, meeting 26 June 1974, document 2 July 1974 (ESRO9033) and ESRO/PB-MET(74)17, 11 February 1974 81(ESRO9001).

889 From ESRO/AF(74)1 19, 23 September 1974 (ESRO2714).

890 See ESRO/AF(74)1 19, Add.2, 29 October 1974 (ESRO2714).

891 ESRO/PB-MET/MIN/12, meeting 2 October 1974, document 13 November 1974 (ESRO8951).

firm meeting even the revised schedule that steps had already been taken in October 1976 to explore the possibility of a changeover, with IBM, CDC and CII-Honeywell Bull. [892]

The delays in the delivery of the operating system software had effects downstream on the application software needed for the extraction of meteorological products. A new schedule for the latter was worked out which phased its introduction with the state of readiness of the central system. Four levels were identified. The first allowed for the basic operation and control of the spacecraft, but provided no products for the users. Level II was essentially experimental, its goal being to provide users with significant sets of data in order to enable everybody to start working. To this end it made provision for image processing and wind extraction, though with limitations on quality and quantity, as well as for archiving of nearly all data. The meteorologists hoped that these two functions would be available at launch. Levels III and IV were to be implemented within six months after launch. The former corresponded to the gradual introduction of full-scale processing, while Level IV was the fully operational state. [893]

On the milestone date of 15 November 1976 the situation was not encouraging. ICL was not able to demonstrate successfully all the facilities foreseen for that key day. The magnetic tape handling using standard Fortran was the most serious problem. In addition, the operating system software was too large, leaving insufficient CPU capacity for the other functions. However, the threat to replace the ICL 2980 with another mainframe proved difficult to implement. Three offers had been received (from CDC, Honeywell Bull and IBM), but all were deemed unacceptable mainly because of late delivery of the integrated system. This meant that it was necessary to continue with ICL despite its limitations. At the same time the Executive decided to take certain precautions: to see whether it was possible to transfer the load on the ICL 2980 temporarily to other centres in Europe, toask IBM to quote for a link between IBM equipment and the existing peripheral computers, to monitor ICL even more closely etc. In any event it was now clear that it would only be possible to attain Level II performance at the nominal launch date (31 August 1977) if ICL managed to improve the performance and stability of the operating system. If another solution had to be adopted, it was unlikely that even this minimum performance criterion would be satisfied on time. [894]

The STAG was asked whether it would be prepared to consider delaying the launch date by three months to ease the pressure and to increase the Executive's margin for manoeuvre with both ICL and other suppliers; it refused. However both the Group and the Programme Board were frustrated and angry with ICL and were strongly tempted to replace the British computer with an IBM. The German representative to the STAG, Professor Bolle, claimed that ICL's method of programming was four or five years behind that of the Telefunken Ti 440 used at his institute. What is more, he deplored the fact that the research activities originally planned and in which institutes in the Federal Republic were particularly interested, were being submerged by problems with the data-processing system. After an anguished debate, the Programme Board, meeting in April, decided to accept the Executive's claim that "it had no grounds whatever to fear that ICL would be unable to fulfil its commitments" and to maintain the choice of the firm despite their misgivings. [895]

The Executive had undoubtedly stuck its neck out in choosing to maintain the ICL option. One mishap however worked to their advantage. In July 1977 it was announced that the launch of ESA's telecommunications satellite OTS had to be postponed for technical reasons. In the light of the new launch schedule proposed by NASA the ESA DG and the Council decided that, for financial reasons, the foreseen Meteosat launch slot should be accorded to OTS. This meant shifting the launch date of

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892 ESA/PB-MET(76) 13, 15 October 1976 (ESA3571).

893 See ESA/STAG/MIN/5, Annex 2, meeting on 15-16 September 1976, document 15 October 1976 (ESA3694), ESA/PB-MET(76)14, 18 October 1976 (ESA3572).

894 ESA/PB-MET(76)22, 6 December 1976 (ESA3580).

895 ESA/STAG/MIN/7, meeting on 1012/77, document 7 March 1977 (ESA3696) and ESA/PB-MET/MIN/9, meeting on 1414/77, document 9 May 1977 (ESA3535). For a list of research institutes see ESA/PB-MET(79)WP/3, 9 May 1977 (ESA3657). See also Annex to letter Luksch to Regula, 30 January 1979 (ESA4647).

the meteorological satellite back by about two months. These weeks of grace were invaluable to Meteosat. A programme review held on 12 and 13 September confirmed that at least the minimum requirements would be fulfilled by the data processing system by the time of the rescheduled launch in mid-November. [896]

We shall not trace in detail the evolution of the ground facility in the post-launch period. Suffice it to say that, in September 1978, ten months after launch, the situation was precarious.[897] Despite the Executive's reassurances, the chairman of the Ad Hoc Group set up to monitor the operational phase, the French meteorologist Pastre, "was far more pessimistic than [...] the Executive, firstly because, although the satellite had been operating for a year, no mission was functioning nominally and, secondly, because the problems connected with the setting-up of the system were coming to light from day-to-day [...]". It seemed, Pastre concluded, "that it would be very difficult to achieve the expected results". Even if a lot of data were being disseminated, it was disseminated irregularly. As for the extraction of meteorological parameters, the winds product was satisfactory and though software existed for the remainder of the parameters, it was "not much in line with reality". As for archiving, an aspect of the mission which was particularly important for the research community, the situation, said Pastre "gave cause for concern".

A year later the situation had improved, but was still far from perfect. [898] Reporting to the STAG in September 1979 Pastre remarked that a number of the Meteosat system missions "had reached a quasi-operational stage", namely the image-taking mission and the dissemination mission. The production of wind vectors was also classed as "operational". The other MIEC products were not, but could be said to be "well under way". [899] They were behind schedule due to calibration problems, lack of staff and the priority given to winds. All the same, cloud top heights were expected by mid-November, sea-surface temperature and water vapour measurements a month later. Radiation balance was far from ready. As for archiving, the Pastre group felt that "the situation was bad" and that "the chances for improvement were slim". In the event, two months later one of Meteosat's onboard electronics systems failed, drastically reducing the satellite's capabilities.

The difficulties with the ground system caused immense damage to the relationships between ESOC and the meteorological community. The former, as one would expect, tried to put the best possible interpretation on the difficulties all were having with the ground system, systematically resorting to the central computer as the root cause of the problem. The users were most unhappy with the quality and regularity of the products disseminated. They also felt that the Agency was not consulting with them enough, was not taking their priorities into account, and was providing specious explanations for the problems they were encountering. Indeed the relationship between the two parties in this period deteriorated so drastically that it would take three or four years of hard work for ESA to regain the confidence of the meteorologists. This is an issue we shall come back to again in part II of this chapter.

7.7 The launch of Meteosat

Every launch is a nail-biting affair and none more so than that of Meteosat. The launch campaign started in the second half of September with the shipment to the United States of the F1 flight model. On 13 September the delayed OTS launch took place using a Delta 3914 rocket – which exploded, dropping the European telecommunications satellite into the ocean. The investigation revealed that the problem that had led to the explosion of the 3914 would not affect the 2914 which was to be used for

896 ESA/PB-MET/MIN/10 Annex II, September 1977 (ESA3526).

897 For this paragraph see ESA/STAG/MIN/13, meeting 27 September 1978, document 25 October 1978 (ESA3702).

898 For this paragraph see ESA/STAG/MIN/16, meeting 12 September 1979, document 23 October 1979 (ESA3705).

899 See e.g. *Meteosat Operations Report*, 1 January - 30 June 1979 (ESA4754) for a detailed description of the products available at this time.

the meteorological satellite. All the same, Meteosat's launch date was postponed by 12 days as a result. Other minor problems caused additional delays, but countdown finally got under way on 20 November. Then, quite unexpectedly, just two hours before scheduled lift-off NASA cancelled the launch. Stray radio signals had been picked up in the Cape Kennedy area which were identical to those used to destroy NASA rockets in flight. The US Agency refused to launch until the source of the signals had been identified. Furious, Ernst Trendelenburg, ESA's Director of Scientific and Meteorological Programmes, made an inflammatory statement in which he suggested that NASA was exaggerating the risk. The press had a field day, with speculation running wild: did the signal come from a Soviet spy ship disguised as a trawler which was in the area just when a military Polaris rocket was launched? Was NASA being overcautious because it did not dare have another failure, particularly since the Air Force was lobbying to take over the space programme? Was it a ploy intended to sabotage the European programme and so to ensure that the WMO would choose an American satellite to replace a Soviet meteorological satellite intended for the world system? [900]

Two days later – after Trendelenburg and the visiting ministers had already left – the source of the signal had been detected. It seemed that the Redstone tracking ship off the coast of Florida had inadvertently sent out launcher destruct signals. NASA was not prepared to accept the explanation, however, without verbal confirmation from the test engineer concerned and he had left for a vacation in Texas in his caravan! Lennertz writes: sitting at Mission Control Centre on 22 November "about two hours prior to the planned lift-off (our last chance!) I received a phone call on my 'hot-line' from the NASA representative saying "[...] with military help (helicopters?) we found the guy, he confirmed the dummy test, I lift my launch objection, go ahead and good luck!". When I informed the launch team via our intercom system nobody could suppress his tears of joy and of relief – after two aborted launch attempts and two sleepless nights!"[901]

Meteosat was launched without mishap on 23 November at 01:35 GMT. It separated from the launcher about 25 minutes later and reached its nominal position at 0° in geostationary orbit on 7 December 1977. The first images from the satellite in the three spectral bands, visible, infrared and water vapour absorption, were received on the 9, 10 and 11 December 1994.[902] Degradation of its IR signals soon thereafter was traced to ice contamination of the radiometer optics and was quickly rectified. [903] A far more serious degradation occurred two years after launch, however. On 24 November 1979 an Undervoltage Protection Unit on-board the satellite switched off some of its loads and all efforts by ESA to bring the satellite back into fully operational mode failed.[904] Meteosat remained in orbit for several more years, but only its Data Collection Platform mission continued to function correctly.

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900 See, for example, *Le Figaro*, 23 November 1977.

901 D. Lennertz, private communication with L. Sebesta. See also *ESA Bulletin* No. 11, December 1977, pp.59-61.

902 ESA/PB-METIMIN/11, Annex II, 16 January 1978 (ESA3537) and

903 ESA/STAG(78)2, 7 April 1978 (ESA3737) and ESA/PB-MET(78)9, 10 May 1978 (ESA3601).

904 ESA/PB-MET(79)26, Add. 1, 7 December 1979 (ESA3636).

B: The Transition to an Operational System

7.8 The first debates: ESRO/ESA Will operate the system for three years

The moment when a satellite system changes from being pre-operational to operational is debatable. Different interest groups will define it according to their particular needs. In Meteosat's case the international meteorological community wanted to interpret the concept of pre-operational as widely as possible so as to leave the handover to them of managerial and financial responsibility to the last possible moment. In October 1971 one of the working groups set up by the Ad Hoc Group on Space Meteorology (chaired by the British meteorologist Stewart) suggested that the definition of pre-operational should in fact cover the first four to five years of the satellite programme. For meteorologists, he said, a system could only be regarded as operational when "perfect continuity" of data provision was ensured. This involved integrating the European satellite into the global system, making sure that the individual elements interacted properly and making provision for replacing a spacecraft as soon as it failed (e.g. by having one spare geostationary satellite in orbit at any one time and moving it to the required parking orbit when one of the four others broke down). For Stewart's group a satellite could be regularly providing data of value to meteorologists for forecasting purposes and scientific modelling, yet pre-operational in that "continuity of observations in the world system [was] not guaranteed". [905]

The question of who should operate Meteosat preoccupied the Programme Board from the time it first met in March 1972. As the ESRO Secretariat pointed out, the then near-final text of the Meteosat "Arrangement", in line with original French planning, made provision for the production of two flight units of the satellite and a set of spare units, but for just one launch. No second launch had been budgeted for, even in the event that the first one failed. Nor had the stage at which the satellite would be handed over to the users been defined. In addition, there was the question of a follow-on programme and the putting in place of a fully operational meteorological satellite system.[906]

Taking the bull by the horns, in June 1972 the German delegation tried to insert two clauses into the draft Arrangement to deal with some of these ambiguities. Firstly it suggested that the document make specific provision for launching a second satellite "if that proves necessary after the launch of the first one". Secondly, it wanted a clause added stating that the programme would include provision for "operating the ground segment from six months after the successful launch of the satellite [the time estimated for 'running in' the first unit] until the end of the programme". Germany realised that these issues were controversial. It coupled the clauses with the provision that if an agreement could not be reached on these provisions by the end of the Project Definition Phase, any participant would have the right to withdraw from the programme.[907] Taking its argument further, Germany, with the UK's

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905 ESROIIAPC7I(31), 7 December 1975 (ESRO9368). There is a draft in (52014).

906 The minutes of this meeting are document ESRO/PB-METIMIN/l, 21 March 1972, file (ESRO8940), 19 April 1972.

907 See ESRO/PB-MET(72)4, rev. 2 add. 2, 6 June 1972, Article 7, (ESRO8958).

support, said that for practical reasons it would favour ESRO taking responsibility for the operation of the first satellite. [908]

Germany's initiative was inspired by the conviction that it was simply unrealistic to expect the meteorological services to operate the first Meteosat. Rather then, accept forthwith the burden, all the time insisting that the meteorologists put the machinery in place to take over as soon as they could. After all, the meteorologists were aware of the problem. Reporting to the Programme Board in June 1972, the chairman of the ESRO Ad Hoc Group on Space Meteorology, Schneider, who was also the Director of the Swiss national meteorological service remarked that "it appears that the cost of launching a really operational satellite would have to be borne entirely by the meteorological services themselves and represents a considerable sum, the exact amount of which is difficult to estimate". Suggesting that it might amount to about 10% of the budget of national meteorological services from 1978-79 onwards, he asked that every effort be made to draw the attention of the ministries concerned to the need for this impending commitment.[909]

The German suggestion received a mixed welcome. No one wanted to tinker with the Arrangement at this stage: it was opened for signature just a few weeks later on 12 July 1972. But the source of the problem lay elsewhere: it was financial/institutional. The money for meteorological services came mostly from the Ministries of Transport. The money for space activities came from entirely different government departments: ministries involved in science and technology programmes in the various participating states. As these also happened to be the ministries represented in the ESRO/ESA committee structure, they naturally resented seeing their funds used to finance an operational activity for another government department, and that at the expense of the research and development budget. In the event, the matter was left to rest. The Council, voting the Arrangement on 12 July 1972, inserted a clause in the preamble to its resolution which stated that "adequate arrangements still have to be made to cover both the operation of the Central Facility and the operational phases of the programme".[910]

No major shift occurred in the positions just described over the next eighteen months. The ESRO Secretariat prepared a number of documents showing the managerial, legal and financial implications of its taking responsibility for the operation of the first satellite. In the light of the meteorologists' vacillations this solution, it was stressed, would guarantee Europe's participation in the GARP by ensuring continuity in the management and control of Meteosat and would also be cost-effective. It was understood that this was only a short-term solution driven by pragmatic concerns. The question of who would operate Meteosat was a political one, as the French stressed. The long-term aim of the programme was that "the users themselves should acquire the ability to design and manage future systems without further recourse to technological research funds".[911]

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908 See ESRO/PB-METIMIN/3, 5 October 1972, document dated 20 November 1972 (ESRO8942). From ESRO/PB-METIMINI3, q.v. This move was, predictably, welcomed by the meteorologists, though the French delegation was unhappy with the idea, arguing that this was a matter for the Council and not the Programme Board to decide. This was not simply a stalling move; it was also part and parcel of French attempts at this time to clarify the relationships between the Boards and the Council to be defined in the ESA Convention then being discussed.

909 See Schneider's statement to the second meeting of the (provisional) Programme Board, Annex II to ESRO/PB/MET/MIN/2, the meeting held on 21 June 1972, document (ESRO8941), 15 June 1972 and the Summary Report on the Informal Conference of Directors of European Meteorological Services, held on 27 April 1972 in (52023)

910 See ESRO/PB-MET/MIN/2, 15 June 1972, document dated 21 June 1972 (ESRO8941) and ESRO/PB-MET/MIN/3, 5 October 1972, document dated 20 November 1972 (ESRO8942). The Council resolution is ESRO/C/XLVII/Res. 1, 12 July 1972 (ESRO45).

911 The quotation is from the 8th meeting of the Programme Board, ESROJPB-MET/MIN/8, held on 6 February 1974, document dated 15 March 1974 (ESRO8947). See also ESRO/PB-MET(73)17, 2 November 1973 (ESRO8982) and ESRO/PB-MET(74)13, 20 June 1974 (ESRO8997) for various reports on this debate.

The French wanted the meteorologists to create immediately an entirely new structure with its own legal personality, budget and staff, and having responsibility for the operation of Meteosat. But as the Secretariat pointed out, for all its attraction, "one immediately thinks of all the difficulties inherent in creating an international legal instrument requiring ratification for the establishment of a new legal personality under international law." Better to proceed piecemeal, either by revising the existing Arrangement without changing the ceiling (as had been done when the costs of developing the software for the MIEC had been added in March 1973), or by adopting a protocol to the Arrangement which allowed for calling up additional funds. [912] With the figure of 17 MAU in the air for the operation of Meteosat up to the end of its useful life (as compared to just 1.5 MAU for the software), the Programme Board retained the latter solution.

The first draft of a Protocol to cover the management and control of a "pre-operational" meteorological satellite was laid before the Programme Board in October 1974, which raised only minor objections. When the Board next met in November, the entire atmosphere had changed. The text was violently opposed. The Italian delegation, reversing its previous position, "deplored the fact that under the Protocol the use of the system beyond the first six months of operation would become an ESRO programme, as the Organisation would thus be given tasks its structure was not designed for. The Delegation's view was that the users of the system should be prepared to take responsibility for it".[913] These sentiments were echoed by the French delegation, though the British and German delegations felt less strongly about the issue. In the event the Secretariat, which was somewhat taken aback by the sudden change of tack, was asked to draft a new document. The Board also passed a resolution inviting the delegations to put pressure on their governments to bring the users of the system together for the purpose of managing an operational satellite. [914]

The Programme Board turned to the Council for its view on the principle of ESRO/ESA taking responsibility for operational systems. The Council, at its meeting in March 1975 expressed itself in favour, though it was stressed that this was a specific case, justified, for example,. by the fact that it was unreasonable to expect the national meteorological services to have organised themselves into an operating agency by 1977. [915] With the objection against the principle lifted, by the end of 1975 a Protocol acceptable to all had been hammered out. [916] It reflected the determination of the participating states to reduce their commitments to the operational satellite to a minimum and to put as much pressure as possible on the meteorological agencies to take over responsibility for the system. On France's insistence and to send a clear message to the meteorologists, who were stalling on the management question, the Preamble specifically identified "the aim to entrust the management of an operational meteorological system composed of a space segment and an associated ground segment to

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912 See ESRO/PB-MET(74)l 3, 20 June 1974 for this paragraph. A third legal alternative was to have the Organisation conclude bilateral contracts for operating Meteosat with individual national meteorological authorities or to sign a single management contract with one body nominated by those authorities to act on its behalf.

913 At the 12th meeting of the Board the Italian delegation said that "it was in favour of the Organisation being responsible for operations beyond the first six months of the satellite's life", ESRO/PB-MET/MIN/12, meeting held on 2 October 1974, document dated 13 November 1974.

914 ESRO/PB-MET/MIN/13, meeting held on 26 November 1974, document dated 24 January 1975 (ESRO8952). The draft protocol is ESRO/PB-MET(74)21, rev. 1, 12 January 1974 (ESRO9005).

915 ESRO/C/MIN/73, 14 March 1975, document dated 27 March1975 (ESRO7O). In 1977 the Council meeting at Ministerial level officially expressed its desire "to take a positive attitude in relation to the management of operational systems" and undertook to "encourage the potential users of operational space systems to take over the management of these systems and to organise their exploitation" in those cases where organised users did not yet exist; see ESA/C-M(February 77) Res. 3, 15 February 1977.

916 The various versions of the Protocol are document ESRO/PB-MET(74)21, with its revisions the first of which is dated 12 November 1974 (ESRO9005). The final version is ESRO/PB-MET(74)21, rev. 8, 23 December 1975, or ESA/C(75)62 rev. 1, 23 December 1975.

a body representing European meteorological authorities".[917] The period during which the satellite would be under ESA's control was limited to three years in orbit (some delegations preferred two), including six months for checking-out the satellite after launch. [918] This corresponded to "the satellite design goal of 50% survival probability without degradation of any mission".[919] To avoid any misunderstandings the tasks to be undertaken by the Agency were described in great detail in the first Annex to the Protocol, while the cost envelope, which was kept as low as possible, was cut from an originally suggested 17 MAU at mid-1974 prices to 14.15 MAU at mid-1975 prices. [920]

Finally, in response to the great difficulties faced by some of the user ministries in finding the sums called for by the Protocol, extremely lax conditions were laid down for terminating the agreement or even for withdrawing from it completely. The Protocol could be terminated before the expiry of the three-year post-launch period by a double two-thirds majority of the Programme Board (some would have preferred unanimity) once "the management of Meteosat ha[d] been entrusted to a body representing European meteorological authorities" – or even if this step had not been taken. [921] Even more destabilising were the withdrawal conditions. The Protocol was to be open for signature from 1 January 1976 to 30 September 1976. Any government was free to withdraw by informing the Agency before the end of that year of its intention to do so and by giving written notice of the same by 31 March 1977. If one government announced its intention to withdraw, all others were free to follow suit. Formally then, Meteosat risked being put in orbit without any guarantee that the means could be found to use it.

Despite all these precautions, it proved extremely difficult for some of the participating states to find the resources needed to finance the operational programme. The deadline for the opening period was first extended from 30 September 1976 to 28 February and then to 30 April 1977. Three days before the second deadline had expired, only Belgium, Germany, Switzerland and the UK had signed the Protocol. France and Denmark came in two days later, so that the Protocol entered into force on 29 April 1977, though without the signatures of Italy and Sweden.[922] The former signed shortly thereafter, but Sweden was still unsure of its position. Arguing that the operational system was of little interest to it as the country was on the limits of Meteosat's direct vision (although of course the Scandinavians also could use the data on surrounding countries provided by the satellite), it first suggested that it might ask for a reduction in its percentage contribution (foreseen to be 5.02%) and then it refused to sign the Protocol altogether.[923]

Sweden's defection brought to a head another issue that had been simmering under the surface even before the Protocol was opened for signature, i.e. the scale of contributions. The Protocol, basing itself on the original Arrangement, simply took over the scale of contributions from the original document, based on GNP figures for 1967 to 1969. At the third meeting of Programme Board in November 1975, the UK, supported by Italy and Sweden, opposed this. It was argued that the operational phase covered by the Protocol was a new programme since it directly involved the users and that the old scale of

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[917] The directors of the national meteorological services meeting in January 1975 suggested that "in the longer term it was not perhaps necessary to set up a European body representing the meteorological authorities, since the management of the operational Meteosat system was to be integrated into the framework of the global observation system and, in liaison with the WMO, be studied in the light of the results of the FGGE", ESRO/PB-MET(75)4, 18 February 1975 (ESRO9017). For France's position see ESA/PB-MET/MIN/l, 17 June 1975, document dated 21 July 1975 (ESA3527).

[918] See ESA/PB-MET(75)5, 24 March 1975 (ESRO9018).

[919] ESA/PB-MET(74)21, rev.l, Annex A, 12 November 1974 (ESRO9005).

[920] For the details on the Annexes see ESA/STAG(75)3 , 22 August 1975 (ESA3711) and ESA/PB-MET(75)4 (ESA3555). The earlier cost estimate is proposed in ESRO/PB-MET(74)21, rev. 1.

[921] France's resistance to the unanimity condition is clear from her interventions in ESA/PB-MET/MINI1, 21 March 1972, document 19 April 1972 (ESRO8942).

[922] See ESA/C(77)34, 27 April 1977 and ESA/C(77)34, add. 1, 5 May 1977.

[923] ESA/PB-METJMIN/3, 12 November 1975, document dated 30 December 1975 (ESA3529); ESA/PB-MET/MIN/7, 7 December 1976, document dated 21 January 1977 (ESA3533); ESA/PB-MET(78)2, 1 February 1978 (ESA3594).

contributions was obsolete. The Swiss delegation, for its part, baulked at this suggestion, since it had just persuaded its authorities to sign the Protocol on the grounds that the operational phase was a logical extension of the development phase. With the Protocol due to be opened for signature in six weeks' time, no one wanted an additional delay now. The Board thus accepted to keep the original scale 'for the time being' and to reconsider the matter later. [924] Sweden's refusal to sign provided the opportunity to reconsider the affair since some steps had to be taken to make good the shortfall. The time had now come, the British said, to update the scale using current GNP figures and taking only seven instead of the original eight participants. This reduced the UK's percentage contribution by about 3% and Italy's by a little over 4%. Everyone else's share of the costs went up, Germany's by over 7%. [925]

Two factors worked against the changes proposed by the British. Firstly, to change the scales now would upset the industrial return figures. Secondly, as the Executive pointed out, technically no participating state should pay more than 25% of the total cost of a programme in which costs were divided on a GNP basis. [926] With Germany contributing almost 33% under the changed British scheme (and even a little over 25% in the original division of financing which included Sweden), it was obviously not in the UK's financial interest to press this point too hard at this stage. This did not settle the issue, however. Indeed the scale of contributions was to resurface as a bone of contention a few years later when a further extension to the Meteosat Arrangement was sought. That story is one to which we shall return later.

7.9 The second launch

The Arrangement for launching Meteosat was anomalous, if not incoherent in that, even if it allowed for the production of two flight units and a set of spares, it did not formally provide for the launch of a second satellite. While the rectification of this omission might appear, at first sight, to be a mere formality, it inevitably became tangled up with another question: Who would pay for the second flight unit and for its operation? The problem faced by the Programme Board was that the decision had to be taken well before Fl was launched, in order to maintain industrial commitments and book launch windows while, at the same time, the meteorological services were far from willing or able to take financial or institutional responsibility for an operational system. The Programme Board thus feared that it would be pressured by technical deadlines to agree to launch F2 only to find itself having to find even more money to operate it, and that from a science and technology budget. The meteorological services, for their part, would only rejoice at this saving to them – and the pressure on them to take over would be further reduced.

The question of flying F2 first became an important issue when the STAG was made aware of slippages in the planned dates of the GARP. Reporting on a WMO meeting in mid-May 1974, the French delegate (Prof. Morel) said that, to satisfy the proposed launch dates of the American Tiros-N system, the general campaign would now take place between January 1978 and the end of 1979, with two periods of peak observation in November-December 1978 and in May-June 1979. This slippage from 1977 to 1978/9 would enable Meteosat, scheduled for launch in late 1976 to be 'run-in' properly. But it also meant that the satellite would need to function satisfactorily in orbit for about three years – and its overall reliability in orbit was estimated to decrease exponentially from about 75% to 40% in this time frame. It was therefore necessary to make provision for more hydrazine on F1 and to consider following it up with F2, not simply as a hedge against launch failure, but also as a protection

[924] ESA/PB-MET/MIN/3, 12 November 1975, document dated 30 December 1975 (ESA3529).
[925] The UK delegate's position is spelt out in ESA/PB-MET(78)2, 1 February 1978 (ESA3594).
[926] ESA/PR-MET/MIN/1 1, 12 December 1977, document dated 16 January 1978 (ESA3537) and ESA/PB-MET(78)8, 21 April 1978 (ESA3600).

against in-orbit failure. Only by doing so could Europe play its proper role in the GARP which was, after all, the main objective of the Meteosat programme. [927]

Of course, if there was a chance that F2 would be launched, it was only to be expected that the users would begin to think of how to improve its performance on the basis of the experience gained with F1. The STAG discussed this matter in depth at its meeting in May 1975. A range of improvements within the basic satellite concept were suggested, but bearing in mind the need to launch the satellite by the end of 1978 and to limit expenditure, only a few were retained: improvements to the temperature control and ground calibration of the radiometer, to the power supply system and to the UHF antenna. [928] These initiatives were coupled with a strong recommendation from the STAG to the effect that if the Programme Board did not make provision to launch F2 (costing about 12.5 MAU) there was a risk that "none of the investments made in the spacecraft or in the ground installation would produce benefits to technology or to meteorology. Ten years of planning and five years of intense technical effort would be wasted. Even if the failure was not its fault, a question mark would be placed against Europe's ability and determination to carry space projects through to a successful conclusion". [929]

The Programme Board accepted these arguments insofar as the use of F2 as a replacement for Fl was concerned. It was clear that some steps had to be taken to insure against loss on launch and that for that reason alone F2 should be made flight ready. The launch costs, the Secretariat assured the Board, could come from the 20% contingency in the budget (classically the Arrangement made automatic provision for this level of cost overrun). But, as the German delegate put it, the problem was not there. It only arose if F1 was launched successfully and performed as planned. In that event the money for F2 would have to be found by the meteorological services. As if to stress the point, the Board refused to accept even the limited number of changes to the satellite proposed by the STAG. Putting each improvement to the vote at its meeting in June 1976, it only adopted the modification to the temperature control of the detector and to the power supply. [930]

Over the next few months the pressure mounted on the Programme Board to launch F2 come what may. The offensive came from the Executive and from a Space Meteorology Working Group set up at the request of the Council and under the chairmanship of J. Mason, Director General of the British Meteorological Service (who was soon succeeded by R. Mittner, head of the French meteorological service). Meeting on 29 September 1976, the SMWG asked the ESA Director General to "address a strong request to the Programme Board" at its meeting in October to place an order for a launcher within the next few months. [931] NASA's launch windows were becoming crowded and the US Agency would now only order launch vehicles for which there existed firmly committed customers, so a definite decision had to be taken quickly. [932] More to the point, the Group felt that this launcher should not only be available as a backup if the launch of F1 failed. It "was unanimous in the view that it would be very wasteful having built F2 and procured a rocket, not to launch it". It therefore wanted ESA to prepare a document "setting out clearly the advantages of launching F2 *given that F1 is successful* [...]" (our italics), it being understood that this would be a new programme lying outside the scope of the existing Arrangement and Protocol.

But the SMWG did not stop at that. It also strongly endorsed a new suggestion by the ESA Executive that the qualification model built for Meteosat (prototype P2), refurbished at little extra cost, could be

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927 See ESRO/STAG/MIN/8, meeting held on 22 May 1974, document dated 26 June 1974 (ESRO9032). The reliability estimates are in ESRO/PB-MET(74)25, 3 September 1975 (ESRO9009). Later studies increased the 40% to 50% after three years, as we saw earlier.

928 See ESRO/STAG/MIN/14, 27-28 May 1975, document dated 19 August 1975 (ESRO9038), ESRO/PB-MET(75)3, 26 August 1975 (ESRO3554) and ESA/PB-MET(76)8, 24 May 1976 (ESRO3567).

929 ESRO/PB-MET(76)5, 16 January 1976 (ESRO3564) [ESRO/STAG(75)8, 17 December 1975]

930 ESA/PB-MET/MIN/4, 29 January 1976, document dated 24 March 1976 (ESA3530), ESA/PB-MET/MIN/5, 22 June 1976, document dated 30 July 1976 (ESA3531).

931 All the quotations in this paragraph are from the notes on this meeting, document ESA/SMWG(76)8 (ESRO4668).

932 ESA/PB-MET(76)15, 15 October 1976 (ESA3573).

launched as an Ariane passenger experiment, to fill "any gap that might develop between Fl/F2 and a fully operational F3 sequence onwards". This too, the SMWG said, would be a new programme. A week later the Council accepted that the L03 launch of Ariane, scheduled for May 1980, could be used in this way. The launch would have the Indian Telecommunications Satellite Apple as its central passenger and one or other Meteosat was one of several options for the principal passenger and indeed the one favoured by the Executive. [933] The Programme Board was given two months to exercise this option.

The Programme Board, confronted now with the demand to launch not just one or two, but three meteorological satellites, did what it could to resist this onslaught. At its meetings in October and December it authorised the DG to open negotiations immediately with NASA for a back-up launcher to cover the eventuality that F1 was destroyed on launch or failed within six months of being in orbit. Europe's participation in the GARP was thus protected. The Board also agreed that this launcher could be used for flying F2 if F1 worked satisfactorily – but in that case a new agreement would have to be drawn up by the States that wanted to participate in the launch. They would have to reimburse the funds already paid in advance to NASA by the Meteosat programme and would also have to bear the cost of launching the second flight unit. If they could not agree to do this, the option would be sold.

As for the Ariane option, the Board took a slightly more flexible line in order to ensure that it could book its place on L03. This launch could be treated as an "extension" of the Meteosat programme. The Board however was not willing at this stage to discuss the "new financial and administrative arrangements" that that extension would involve. Nor did it want to commit itself now to the model to be used: if Fl was a success, F2 would be the Ariane passenger, otherwise it would be P2. [934]

The Council, however, needed better guarantees than that. Meeting on 16 February 1977 it accepted to fly F2 on L03 – but gave the Board until midnight on 12 March to take a "decision concerning the financing". Failing that the slot would go to Symphonie.

The Programme Board capitulated at its meeting on 11 March 1977. To avoid losing the Ariane flight opportunity, it voted a number of amendments to the Meteosat Protocol allowing for the launching of F2 on L03 and accepting to pay for it from its budget. The Board's agreement was hedged around with a number of tight qualifications. Firstly, as Belgium insisted, this agreement was restricted to the use of F2 on Ariane and the 5.6 MAU estimated for the launch costs would have to come out of the 20% contingency margin. No extra money would be found for it. It was "in that event and only in that event, [that] the persons responsible, as regards technology, had the means and the will to finance the launch whereas the meteorological services did not have them". But what if F1 failed and F2 had to be used as a back-up with a Thor-Delta launcher? Could P2 fly on Ariane L03? No, said the French delegation, the agreement to use Ariane would become null and void in its eyes. "If an accident occurred with the first launch, thereby causing the whole programme to be called into question", the delegate said, "France must be freed from this undertaking" to fly a meteorological satellite on Ariane. In addition it was understood by all that the Board was only committing itself to launching F2, not to operating it. That would be the task of the meteorologists. [935]

With this decision, the Board's determination not to go down the road of operation was further undermined. They had now not only made provision for a backup launch from NASA in the event that the launch of Fl failed, they had also agreed to launch F2, using Ariane if necessary. They had been trapped from the start by an Arrangement that was illogical in that it only explicitly provided for the

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933 The Executive's proposal is ESA/STAG(76)12, 1 September 1976 (ESA3727) and the Council's recommendation is described in ESA/PB-MET(76)24, 30 November 1976 (ESA3582). See also ESA/C(76)114.

934 For this paragraph and the one before see ESA/PB-MET/VI/Res. 1, of 27 October 1976 (ESA3532) and ESA/PB-MET/VII/Res. of 7 December 1976, (ESA3533). See also ESA/PB-MET(76)21, 27 October 1976, (ESA3579) for the French view on a second launch.

935 For the debate see ESA/PB-MET/MIN/8, meeting held on 11 March 1977, document dated 29 March 1977 (ESA3534) and for the Amendments to the Arrangement see ESA/PB-MET(77)2, rev. 1.

launch of one satellite although two were built. Since that satellite was part of an international programme of considerable scientific interest, in which Europe wanted to show that she was a good partner, it was obviously necessary to make provision for a second launcher. So far so good. But then there was also great interest to be had in using Europe's own new launcher at discounted prices to orbit a flight model which had already been built. The problem was that the Ariane launch was only scheduled for May 1980. What if the meteorologists were still not organised by then? Who would pay for operating the second satellite? The Board could have said no to the Ariane offer, as they obviously risked stretching their commitment to a Meteosat system for yet another three years after the launch of the first satellite, scheduled for Autumn 1977. If they said yes, it was because of intense pressure from the Executive and the STAG, because they had paid for the satellite anyway, because they feared losing the Ariane slot to someone else and because they were sensitive to the argument that continuity in the programme was essential.

The determination of both the ESA Executive and the STAG to persist in the face of the Programme Board's resistance to any extension of the programme deserves further analysis. It reflects two different definitions of the problem of Meteosat operations, definitions which were inherent in the institutional logic of the actors concerned. The Programme Board's main preoccupation was to ensure that Meteosat and Europe fulfilled their obligations to the GARP. Funds had been put aside in the national ministries of science and technology for that purpose and for no other. If the system was to be used in the medium to long term as the basis of an operational European meteorological service, the funds had to come from another government department. The interface between these objectives was, of course, slippery and some overlap between missions was inevitable. But the Programme Board was determined not to let the meteorological services piggyback for too long on the original programme. If they wanted an operational system, they had to be prepared to set up the structure that it required and to find the money to pay for it. The Board feared that the more concessions it made to a possible follow-on programme, the less inclined the meteorological ministries would be to confront the issue, to decide what they wanted and to take the steps needed to get it.

The Executive, supported by the STAG, saw matters differently. What they feared above all was a break in the continuity of the Meteosat programme. Such a break would necessarily entail a dispersal of the teams at ESOC and elsewhere, teams which were developing the knowhow needed to manipulate and interpret meteorological data and to put it in a form useful for scientific model-building and everyday weather forecasting. They were aware of the reluctance of the meteorological services to take charge of the system, but they were convinced that once it was providing data, once "users bec[a]me accustomed to the various products coming from Meteosat, they [would] desire that these useful tools continue unabated". [936] It was also likely that other countries would come on board. Spain was interested, the African countries, who were particularly well covered by Meteosat, were very keen to use its data, and there was talk that a Saudi Arabian prince was seeking to associate his country with a prestigious international meteorological project and so on. [937] In short the Executive was convinced that once the feasibility and the attractions of an operational meteorological system had been demonstrated to the users, once they saw cloud images on their terminals, their doubts and hesitations would be swept away and they would become enthusiastic supporters of the system. Unfortunately for the administrators, results were only expected in 1978 and to ensure continuity a number of commitments had to be entered into well beforehand – precisely those commitments to which the Programme Board was hostile.

7.10 Extending the Protocol to cover the exploitation of F2

With Meteosat safely launched on 23 November 1977 and with a malfunction in its radiometer corrected from the ground in January 1978, the Executive thought it as well to capitalise on the recent

[936] ESA/STAG/76(12), 1 September 1976 (ESRO3727), ESA/SMWG(76)8, notes on a meeting held on 29 September 1976 (ESA4668).

[937] See memo from Tessier to the ESA DG concerning discussions at the WMO, 29 November 1977 (ESA5532).

successes and to push ahead immediately with securing funding for the exploitation of F2, due to begin at the end of 1980. Despite the negative attitude of the Programme Board, they hoped that it would be not too difficult to extend the operational phase foreseen in the Protocol for 30 more months to cover the orbital lifetime of F2. Of course they realised that this version would have to be more explicit about the interim role of the Agency pending the transfer of operational responsibility to an appropriate user Organisation. Apart from ensuring that the document was clear on this point, they saw no reason for "any delay in decisions being taken on the extension of the Protocol concerning the exploitation of Meteosat". [938] They were to be rudely surprised.

Indeed the debate on the extension of the Protocol to cover F2's operation was even more ferocious than that on the operation of F1 – if that were possible. The French again took the lead in sending every possible signal to the national meteorological authorities that they expected them to take over responsibility for the satellite system. [939] Britain and Italy again took the lead in objecting to the scale of contributions. Many delegations were furious to find that the Executive's proposed costs for the second operational phase were higher than they were for the first by about 25%. As a British administrator put it, "I should have thought that the experience gained during the first phase would have enabled some streamlining to take place which would allow a reduction in costs". [940] The Executive thus found itself unexpectedly assailed from many sides and it proved so difficult to find a compromise that at one stage in 1980 it looked as though F2 might be launched without the funds being available to operate it.

To analyse this process, in what follows we shall not again give a blow-by-blow account of the debates, which extended over more than two years, since some of the main issues have already been explored. We shall rather concentrate on the new element – the cost factor. Added to this and for variety, we shall describe the exchanges at one of the Programme Board meetings in some detail (the 21st, held in May 1980), so as to give the reader an idea of the intensity of the feelings aroused by the debate over the costs of operating F2.

Early in 1979 the cost to completion of the exploitation phase of Fl was estimated by the ESA Secretariat to be 20.77 MAU at mid-1978 price levels and 1979 conversion rates. [941] The Executive suggested that the cost of operating F2 for the same length of time (30 months) would be 26.27 MAU in the same monetary terms, i.e. 5.5 MAU higher. About 60% of this cost increase was attributed to "a more equitable distribution of the charges to be borne by the users of the Darmstadt Control Centre and the Odenwald Station". What had happened was this. The Council had insisted that from 1976 the user programmes should bear the entire costs of the ground facilities that they used. This was mostly waived in the case of the operation of F1 but, said the Executive, was to be applied to F2. This meant, for example, that since Meteosat would use four out of five of Odenwald's telecommunication links to and from space, the "Protocol will be charged 80% of the cost of the Odenwald station". What is more, since all such links originated in the Control Centre, the operational programme would have to be charged for four of Darmstadt's available channels. [942]

The Programme Board was incensed. Challenged to make savings, the Executive managed to reduce the envelope to 23.52 MAU by October 1979. Some steps had to be taken anyway to cover a shortfall in the cost-to-completion of F1 operations due to Sweden's non-participation and it carried some of these measures over to the new programme (reduction in on-site maintenance and in staff, selling computer time to other ESA users, etc.). [943] The Programme Board was still not satisfied however.

938 ESA/PB-MET(78)5, 12 May 1978 (ESA3597); ESA/PB-MET/MIN/13, 19 May 1978, document dated 3 July 1978 (ESA3539).
939 For their first salvo see ESA/PB-MET/MIN/14, meeting held on 28 September 1978, document dated 27 November 1978 (ESA3540).
940 Letter J.C. Hawkes to W. Luksch, 10 April 1979 (ESA5533).
941 ESA/PB-MET(78)17, 5 February 1979 and *Exp1anatory Note* on the budget structure, 15 January 1979 (ESA5533).
942 See ESA/PB-MET(78)18, rev. 1, add. 1, 7 May 1979.
943 ESA/PB-MET(79)20, 18 September 1979.

Taking an entirely new approach, it asked the STAG to establish "which tasks related to the exploitation of Meteosat should be performed by the Agency and which could possibly be executed elsewhere, in order to reduce the cost of the central facilities". The idea was obviously to transfer some of the data management functions now performed in-house over to the national meteorological stations.

The STAG took on the burden reluctantly. It identified some services which could possibly be done elsewhere – data collection system support, extraction of cloud wind vectors, perhaps extraction of cloud top height and radiation balance – but insisted that even these were best left at ESOC. What is more, the Group demanded that these activities should not be suppressed until the Board was sure that someone else could undertake them. As to alternative locations, the STAG stalled, arguing that they did not "consider it within their present terms of reference to explore where, by whom and at what cost these services could be provided".[944]

The French Delegation was very positive about this development. It followed up the STAG report with its own suggestions for cost savings, both by streamlining in-house practice (archiving procedures, image rectification procedures) and by transferring tasks to the meteorological services (extraction of meteorological parameters from the basic data, direct collection of data by SDUs). Citing an Executive suggestion that the costs of exploitation of F2 could be down to 6 MAU annually by 1987, the French argued that this latter figure should be the maximum annual expenditure for F2 exploitation from 1980 onwards. The French concluded by saying that they would only consider signing the Protocol if it included a detailed timetable making provision for the progressive implementation of the measures that it demanded during the period covered by the agreement.[945]

Undaunted the Executive laid its draft Protocol before the Board's 21st meeting in May 1980. It made no changes to the tasks to be undertaken by the Agency in the exploitation of F2, put no time limit (and so proposed no financial envelope) for the duration of the programme and at fixed annual expenditure at 10.5 MAU at mid-1979 prices and 1980 conversion rates. [946] We shall follow the debate on this proposal rather more closely than usual, so as to give the reader a feel for the atmosphere then prevailing at the Programme Board meeting.[947]

The first major issue discussed at the meeting was the scale of contributions. A majority of delegations were content to maintain the scale used in original Arrangement and in the first Protocol, increased *pro-rata* by the amount of the Swedish shortfall. However, at the meeting Denmark announced that she was not likely to participate in this next phase of the programme to cover F2 operations. This created considerable disarray. Contributions at the upper limits that some countries could accept (because figures had already been accepted by their authorities) left a funding shortfall of about 7% – and France said it was opposed to accepting any budget that was not 100% financed.

The Executive's proposal to have an open-ended fixed annual envelope rather than a global envelope for a programme of a certain duration also caused difficulty. Their argument for doing this was that it gave added flexibility to the arrangement, enabling the delegations to terminate the Protocol at any time and hand over the Meteosat activities to an operational Organisation. It was also obviously intended to avoid having to go through bruising debates each time a new satellite was launched and pending the putting in place of a suitable user Organisation. The idea was abolished under pressure from Germany, France and Italy and it was agreed to revert to a three-year commitment to a global cost estimate.

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944 ESA/PB-MET(80)3, 22 January 1980 (ESA3642) is the STAG Chairman's report.

945 The French statement to the Board meeting on 8 February 1980 is ESA/PB-MET/MIN/20, Annex II, dated 27 March 1980 (ESA3546). The Executive's long-range estimates of expenditure are in ESA/PB-MET(80)14, 28 April 1980 (ESA3653).

946 The Executive's draft is ESA/PB-MET(80)WP/5, 5 May 1980 (ESA3689).

947 See ESA/PB-MET/MIN/21, meeting held on 7 May 1980, document dated 6 June 1980 (ESA3547)

France also obviously objected to the 10.5 MAU annual budget and wanted to know why the possible cuts recommended by the STAG had not been considered. The Executive defended its proposal by pointing out that the majority of the member states – Germany in particular – did not favour such reductions. France remained unflinching. Hoping to strike a compromise, the STAG chairman said that he would be willing to speak to the Directors of the meteorological services at a meeting to be held the next day to see again what possible reductions could be made. The German delegation, which had made it clear that it would only accept an extension of the Protocol if the tasks assigned to ESOC were left unchanged, opposed this idea; the British and Italian delegations supported him. To break the deadlock and to move on to other matters, the STAG chairman was authorised to try anyway to find a compromise in discussion with his colleagues.

Emerging from this meeting in May 1980, the Executive was desperate and through the chairman of the Programme Board, addressed "to the ESA Council a strong appeal to the Member States' sense of solidarity so that the second Meteosat exploitation phase can be decided [...]."[948] But the delegations were not going to rush things now. The launch of F2 on Ariane L03, foreseen for May, had been delayed due to the failure of L02 and the protocol for the exploitation of F1 'only' expired six months later, on 23 November. So the cost-cutting exercise on the products available from ESOC was repeated by the Executive and was once again reluctantly accepted by the STAG, which yet again insisted that if implemented these measures "would inevitably lead to a reduction in the availability, quality and reliability of the services provided".[949] On 24 October 1980, the Programme Board finally adopted a text making provision for the exploitation of F2.

The Protocol made provision for the exploitation of the Meteosat for a further three years. The financial envelope was 24 MAU at mid-1979 prices and 1980 conversion rates. The scale of contributions saw a sharp drop in the UK's contribution compared to the scale in the original arrangement. However it only covered a little over 90% of expenditure. 9.58% was to be found from as yet uncommitted "Other Participants". As for the products, all the services were left intact after all, though, said the Executive, quantity had been preserved at the cost of quality. [950] The protocol came into force provisionally on 18 December 1980, subject only to the completion of internal formalities in the participating states. On 19 June 1981 Ariane L03 successfully placed the Indian satellite Apple and Meteosat flight model F2 into orbit.

It is once again incumbent on us to explore the roots of the French delegation's determination to cut costs in the second exploitation phase, to try to understand the motives for its tenacity. The underlying concern informing its position had not changed of course: it had never wanted the Board to take on this burden anyway and it was as determined as ever to get the national meteorological services to take over legal and financial responsibility for the Meteosat system. At the same time, things were moving on this front. In October 1978 the meteorologists began to study seriously the structure of their own operating Organisation, Eumetsat (see below). Even though final agreement could not be reached at an intergovernmental meeting held in January 1981, real progress was being made at that level. Patience was needed. But if most participating states in the Meteosat programme were prepared to be tolerant, France was determined to maintain the pressure relentlessly. Her delegation, like its partners, did not doubt that the programme was in a state of 'transition'. But it wanted that transition to be gradual, not sudden; it wanted the meteorological services bit by bit to take over more of the technical work being done at ESOC and to generate their meteorological products in-house. [951] What it resented most was that this did not seem to be happening. Already in 1973 the Programme Board had amended the original Arrangement to include the development of MIEC software in ESRO's tasks – something

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948 For the situation as perceived by the Executive see ESA/PB-MET(80) 13, 30 April 1980. Its appeal is ESA/C(80)45, 14 May 1980. See also ESA/C(80)53, 16 June 1980 for the quote. The Protocol is ESA/PB-MET(80)13, rev. 3, 29 October 1980 (ESA3652) and ESA/PB-MET(81)7, 20 January 1981.

949 For the two reports see ESA/PB-MET(80)1 3, rev. 1, add. 1, 19 June 1980 and, for the STAG report, ESA/PB-MET(80)29, 4 September 1980.

950 See ESA/PB-MET/MIN/24, 24 November 1980.

951 For an interesting analysis of this dimension of the French attitude, see the internal memo signed A. Moritz [unclear], *Extension du Protocole Meteosat..*, dated 21 May 1979 (ESA4647).

originally intended for the meteorological services. Now, it seemed, those same services had simply come to take it for granted that the Agency would do the bulk of the production of meteorological data. Indeed the reluctance of the STAG to recommend any cuts at ESOC and its refusal to consider what tasks might be performed in-house at national institutes, despite the general disappointment with the quality of the ground facility, attest to the technical gulf that had opened up between the ESA establishment and the home institutes.

It was this gulf that France wanted to close. This is why it hounded the Executive and the STAG to find ways to redistribute the technical tasks being done at ESOC, to the national services. At the end of the day it failed in its objectives. Thirty months of debate and thousands of hours and pages later, it had been accepted to pay for the second exploitation phase. Its cost had been aligned with that of the first, the UK and Italy had finally had the scale of contributions adjusted, but the tasks undertaken at ESOC had been left untouched. Insistent French efforts had brought them little satisfaction. But then technical solutions to problems that are essentially political rarely do achieve the hoped-for results.

7.11 The first steps towards setting up an operational system: building coalitions, rebuilding trust in ESA

Beginning in the late 1970s the meteorologists seriously discussed the institutional framework best suited to paying for and managing an operational satellite system. Progress was, however, painfully slow. At the heart of the problem was not simply the cost of a technological system which would involve important investments in the space and the ground segments. This was also an entirely new technology whose technical potential was not evident and whose reliability was not guaranteed. What is more the United States "had agreed to accept responsibility for a major part of the global observation system and to guarantee open and cost-free access to the data [...]".[952] If Europe could get most of its satellite-generated meteorological data free of charge from the USA, it was going to be difficult to convince ministries unused to expenditure in this sector to set up an operating agency authorised to spend large amounts of money for an independent European system.

The first tentative discussions concerning an appropriate institutional arrangement were explored by the directors of the meteorological services meeting in December 1972.[953] Various possible frameworks suggested themselves, but it was obviously too early to pursue the issue in depth. Indeed it was not until 1977 that the question was again tackled seriously. Several factors converged to focus the meteorologists' minds on the issue. Firstly, during the gruelling debate on the terms of the Protocol to operate the first Meteosat, which finally came into force in April 1977, it had been made abundantly clear in the Programme Board that this was merely a transitional arrangement and that the meteorologists simply had to take the steps needed to set up their own body if they really wanted an operational system. Secondly, the ESA Council, meeting at ministerial level in February 1977, deemed it important "to adopt a positive attitude in relation to the management of operational systems". In particular, in those cases where organised users did not exist – as in meteorology at that time – it authorised ESA to furnish the users with "all the technical and institutional assistance they may request [...], including the making available of facilities" to help them take over the management and exploitation of an operational system. [954] Pushed by the space ministries, formally offered all the help they needed by ESA and with the next phase of an operational programme due to start in at most three years' time, the meteorologists seriously began to face up to their needs.

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[952] See the minutes of the first Intergovernmental Conference on an Operational Meteosat System, 28-29 January 1981, CONF/OP/MET/MIN/1, 18 February 1981 (ESA5447)

[953] The summary minutes of this meeting are in file ESRO52027.

[954] See the Resolution on the Agency and Operational Systems adopted by the Ministerial Council meeting on 15 February 1977, ESA/C-M(February 77), Res. 3.

The ESA Space Meteorology Working Group produced a first survey of the situation in September 1977. [955] What was needed, it argued, was a light and inexpensive structure, available by the end of 1980, which was open to non-member states of ESA and which would enable the meteorological community to enter into legal commitments. There was no ideal way to meet all these requirements simultaneously. One could either create a new legal entity under international law (or, less satisfactorily, under the national law of a particular State), or one could make use of an existing legal entity. The former idea was judged to be the solution which, in the long term, would ensure "maximum flexibility and efficiency". The Group rejected it on account of cost and of the time that it would take to negotiate and ratify the corresponding agreement. As for using an existing entity, four possibilities were indicated. The meteorologists could follow the example of the PTTs. These had chosen one of their number to act as the sole interlocutor with ESA in the transitional phase towards the setting up of an independent telecommunications satellite user agency called Eutelsat. The problem here was: Which national service would take on this responsibility? Alternatively, the users could link up with the European Centre for Medium Range Weather Forecasts in Bracknell (UK), though this seemed a dubious option given the very different mission of the Centre. Finally there were the World Meteorological Organization, which had been involved indirectly in the Meteosat programme from the start through the GARP and ESA itself, authorised by the Ministerial Council in February to be "at the service of the meteorological community" with regard to the latter's setting up of an operational system. Only the last two options, the WMO and ESA, were deemed worthy of further consideration by the Working Group.

7.11.1 The Initiatives taken within the WMO framework

For the next six months there were ongoing discussions between senior representatives of the WMO, ESA and the SMWG [956]. Two main items emerged from these exchanges.

Firstly, the WMO undertook to call a conference of plenipotentiaries who would be invited to set up an Executive Council to define the programme, policy and budget of a European operational system. It was understood that the space segment would be under ESA's control. The ground segment could be managed either by the WMO, by ESA or by one of the national meteorological services reporting to the WMO. The precise modalities would be defined in an Agreement that would need to be ratified by the participating governments. This Agreement would be drawn up beforehand by an Informal Planning Meeting which would prepare the decisions for the Intergovernmental Conference.

Secondly, the prospect of involving states not already party to the Meteosat agreements in these meetings was enthusiastically pursued. Countries in Africa and the Middle East were particularly relevant, for several reasons. Firstly, the meteorological services were "experiencing difficulties in receiving surface and upper air observation data originating from African regions", data which were essential, for example for assisting long-haul aircraft flying over the continent. [957] Secondly, by expanding the number of participating states one not only shared costs more widely – even if African countries themselves could not provide much money, regional and world development associations and banks could be expected to contribute. [958] One also added a new political dimension to the programme, giving it additional appeal as aiding 'third world' development. Finally, one strengthened the support of the WMO for the scheme and so could bring even more pressure to bear on national

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955 See ESA/SMWG(77)5, 7 September 1977 (ESA5532) and ESA/SMWG(78)3, 20 March 1978 (ESA4937).

956 The relevant documents are letter from Gibson (ESA DG) to Davies (WMO Secretary General), 20 October 1977 (ESA5532), memo Tessier to Gibson on discussions at the WMO, 29 November 1977 (ESA5532), letter Davies to Gibson, 1/12/77 (ESA4938), memo Schneider to Gibson and summary of decisions taken at ESA/WMO meeting on 16 March 1978, 23 January 1978 (ESA5532), memo Tessier and Barbance to DG on meeting at WMO on 20-21 February 1978, 27 February 1978 (ESA5532).

957 See ESA/SMWG(78)9, 5 April 1978 (ESA4667) and also the memo from Tessier to the ESA DG regarding discussions at the WMO and dated 29 November 1977 (ESA5532).

958 An official from the WMO thought that Algeria, Nigeria, Lybia and Saudi Arabia might all be willing to contribute financially - see memo Tessier and Barbance on the meeting held at the WHO on 20-21 February 1978, 27 February 1978 (ESA5532).

bureaucracies. As an international organisation whose membership extended far beyond that of the Meteosat programme, the WMO particularly welcomed the involvement of a wide spectrum of nations in the operational system, all the more so those from the more deprived regions of the globe.

This attempt to broaden the political constituency by enrolling African countries in the operational system was given added impetus by the prospects of using part of the payload of an Italian satellite for meteorological purposes. The Italian delegation proposed to ESA that an available flight platform of the national Sirio satellite (Sirio-2) be launched on Ariane in 1980 and be used to receive and distribute meteorological information collected by eight regional meteorological centres and by a number of simplified stations distributed over the African continent. This "meteorological data distribution mission" (MDD) would be carried out within the framework of the World Weather Watch of the WMO and would help improve meteorological communication in Africa. The MDD would be joined on the platform by the LASSO mission, devoted to the synchronisation of atomic clocks using lasers. The ESA Council accepted this programme, which was strongly supported by the WMO, in December 1978, approximately three-quarters of the funding being provided by Italy. [959]

The ESA Executive, for its part, also went out of its way to build interest in Meteosat's products in Africa. In collaboration with the WMO, the United Nations and other bodies, it demonstrated the potential of the system by setting up a portable station which received data from the satellite which was then passed on to local meteorological stations and discussed by a European expert. Presentations of this kind were made in Nairobi in February 1978 at a meeting of all African members of the WMO (about 40 governments were represented), between May and June 1978, when stations were taken to Cairo, Athens and Tunis, and between September and December 1978, when a second series of demonstrations was made in Upper Volta, the Ivory Coast, Ghana and Morocco. [960] Although the ESA Executive found it difficult to assess the impact, if any, of its efforts, the African states meeting in February 1978 in Nairobi did conclude that they would gain considerable benefits from a meteorological satellite system. They added that they would need to make costly investments in ground equipment to reap these benefits and so recommended that the "Meteosat programme becomes a fully operational system and be continued for at least a period of 10 years". [961] The WMO undertook to send this recommendation to the Agency, as well as to the states participating in the Meteosat programme.

By February 1978 officials from ESA and the WMO, encouraged by these signs of support, were hoping to move ahead quickly. The directors of the national meteorological services were scheduled to meet in Reykjavik a few months later in May. Here they were, "in principle", to agree on the most suitable structure to put in place for an operational programme. Soon thereafter, at a meeting of the WMO Executive Committee, the Secretariat, stressing the interest of African countries in an operational meteorological system, would suggest that an Informal Planning Meeting for an eventual conference of plenipotentiaries could be arranged for the end of October or November 1978. The conference itself, which would formally set up an operational meteorological programme, would be held in 1979. [962]

All of this proved to be hopelessly optimistic. Meeting in Iceland in June the meteorologists once again discussed the precise form which a Eumetsat – the term now comes into regular use – might take. But they were still unsure how to proceed. To clarify their thoughts they set up two working groups in October. One, chaired by R. Mittner, the DG of the French meteorological office, was to look into the most suitable legal structure for Eumetsat. The other, chaired by A. Piaget, from the

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959 For the Sirio-2 programme and cost see ESA/SIR(78)4, 23 November 1978 (ESA3758).

960 For a survey of these promotional activities see ESA/IRAG(80)37, 23 December 1980.

961 This recommendation is appended to a report by Tessier and Barbance to ESA DG on a meeting held at the WMO on 20-21 February 1978, 27 February 1978 (ESA5532).

962 Memo Tessier and Barbance to ESA DG.

Swiss Meteorological Institute, was a mixed ESA/Eumetsat group charged to look into the relationship between the two bodies so as to ensure the continuation of an operational programme. [963]

The reasons for this slippage are complex. Many members of the meteorological community were unhappy with the WMO structure, believing that it was too heavy and complex for their rather narrower objectives. Certainly the costs of working with it did not seem commensurate with the one significant benefit it brought: formal collaboration with the African states. The weight of the African card, it should be said, was also undermined somewhat by the opposition of the Bundespost to the Sirio-2 MDD mission, which it felt violated a number of existing telecommunication agreements. Then there were the tensions between the meteorologists and ESA.

In 1978 there was a serious deterioration in the relationships between ESA and the national meteorological services which, at least in the view of ESA DG Roy Gibson, possibly explained what he called the latter's "present malaise". At the root of the problem, and this point was also brought to the Executive's attention by the WMO, was the multiplication of contacts between different persons and different directorates in ESA with the user bodies. The ensuing lack of coherence was amplified by the tendency of some staff members to discuss possibilities with users before the Agency had defined its official policy and by the temptation, to quote Gibson again, to tell the meteorological services "how much inferior are the competence and efficacy of other Directorates". This impression of a house divided against itself and lacking a clear policy of its own was reinforced by ongoing dissatisfaction with the management of the central data processing facility at ESOC. In short, in summer 1978 the meteorological services, which had been relying heavily on ESA to help lay the foundations for the operational system, were so disillusioned with the Agency that there were "persistent rumours that the Directors of these services dream of nothing better than the day when they can dispense with our services".[964]

7.11.2 New initiatives from ESA

The decision taken by the meteorological services to set up the Piaget group provided the Agency with an opportunity to set matters right. A. Lebeau, the Director of Future Programmes and Planning and the Deputy DG, decided to take personal responsibility for the affair. Writing to the Swiss meteorologist early in January l979 he claimed that the recent steps taken by the directors of the meteorological services "were a turning point in the relationship" between the two bodies and that ESA would need to organise itself internally to deal with the new situation that had arisen. To this end Lebeau reported that he had dissolved the Space Meteorology Working Group, which no longer served a useful purpose. He also indicated that he wanted all earlier, unofficial documents dealing with ESA/meteorological services relations to be ignored forthwith. Instead, the Deputy DG promised to provide a set of papers for the first meeting of the Piaget group on 23 and 24 January 1979 which would take up the whole issue again from scratch and which the Executive would be prepared to defend before the ESA Council. Lebeau himself would head the ESA delegation to this first meeting.[965]

Two documents were prepared for the first meeting.[966] One defined a set of guidelines governing the relationship to be established between ESA and Eumetsat. The other provisionally codified these in

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[963] See the memo from Lebeau to Gibson dated 11 December 1978 (ESA5532).

[964] All of the quotations are from a memo from Gibson to D/PFP, i.e. to A. Lebeau, the Director for Future Programmes and Planning, dated 24 August 1978 (ESA4647). See also the memo from Tessier to the DG dated 29 November 1977 reporting the impressions which the WMO had of ESA (ESA5532) and a memo from Van Reeth to D/PFP dated 18 December 1978 concerning the *Organisation des services météorologiques*, also in file ESA5532.

[965] For this paragraph see the memos of Lebeau to the DG dated 11 December 1978 (ESA5532) and 4 January 1979 (ESA5533) and letters Lebeau to Piaget, 4 January 1979 (ESA5533) and 11 January 1979 (ESA4647).

[966] For the terms of these proposals see documents ESA/Eumetsat nos 1 and 2, dated 11 February 1979 and 23 January 1979 (ESA5533).

outline draft protocols. They were necessarily tentative: since the area of competence and the final structure of Eumetsat were not yet known and were not ESA's affair, Lebeau's group had to make a number of implicit assumptions which might later require revision.

ESA's proposal was structured around two main axes. Firstly, it foresaw a major operational role for ESA, with services provided which would be paid for by the 'client' Eumetsat. The document stressed that the boundary between what was to be done by ESA and what fell under the responsibility of the meteorological services had to be clearly defined by Eumetsat. It was assumed though that ESA provided the satellites as specified by Eumetsat, controlled them in orbit and handled some aspects of data acquisition and data pre-processing. Eumetsat would pay all ESA's internal and external costs in this regard on a no profit/no loss to the Agency basis, it being understood that the customer would have complete visibility over the expenditure. It was stressed that once the Council had approved the arrangements made, no ESA committee could 'interfere': "these activities [would] be carried out by the Executive on the basis of direct responsibility *vis-à-vis* Eumetsat".

The second main activity proposed by the Executive was one of research and development. Lebeau's team suggested that ESA might promote, and seek Council approval for, optional programmes, funded from the Agency's budget, which would seek to develop meteorological technologies. These programmes would be monitored by the Council and a Programme Board in the usual way, but would be aligned with the requirements specified by the user, from whom "prior approval" would be sought. In this way the Agency hoped "to enable European meteorology to be ready for the next stage in the evolution of space technology with the help of the development instrument" that was ESA.

These ideas were discussed at the first meeting of Piaget's group at the end of January. [967] While the customer-client dimension raised little difficulty, the R&D aspect caused the meteorologists great concern. They wanted these played down as much as possible: the operational programme and its costing should be based on a satellite that was identical to the current Meteosat series with only minor modifications. It was particularly desirable to improve the reliability and quality of the data disseminated in the infrared and water vapour channels and of the DCP data collection and transmission function. The ground segment was to remain the same as that of Meteosat at 'Level IV performance' (see part A of this chapter), although the possibility of funding a control centre without the MIEC should also be envisaged.[968]

After this flurry of activity nothing much happened for a year. There were two reasons for this. Firstly, there were ongoing disputes about the most appropriate legal structure for Eumetsat. The British submitted a draft convention to the Legal Working Group which did not bestow the organ with its own legal identity, thus respecting the UK's wish not to establish a new international Organisation. The French chairman of the Group, Mittner, refused this approach and in May asked CNES to draw up another draft convention, this time granting legal personality to Eumetsat.[969] Secondly, it took time to provide a realistic estimate of the cost of the programme. Throughout 1979 the Agency sought from industry (for the space segment) and from ESOC (for the ground segment) the data required to provide a considered figure for the cost-to-completion of the kind of programme the meteorologists were

[967] For reports on this meeting see Piaget's minutes sent to Tessier on 30 January 1979 and Tessier's own summary dated 2 February 1979 (ESA5533). A draft agreement between ESA and Eumetsat based on these discussions was produced within a month: it is dated 26 February 1979 (ESA5533)

[968] Costs were not apparently discussed in detail at this meeting. An internal document produced the week before and which assumed that the programme would comprise three identical satellites launched at three-yearly intervals from 1983 onwards came up with a ballpark figure of about 400 MAU in 1979 prices: see document dated 19 January 1979 (ESA5533).

[969] See memo Tessier dated 18 May 1979 on the debates inside the Legal Group (ESA5533). See also his memo of 11 July 1979 (ESA5533).

interested in. This document was ready at the end of January 1980 and was circulated by ESA DG Gibson to the heads of the meteorological services concerned.[970]

The cost estimates assumed that five satellites would be built, and launched by Ariane, to provide an operational service for ten years beginning in 1984. To ensure continuity in the system two would be in orbit at once, one operational the other on standby. All satellites were assumed to be identical to Meteosat F2 (i.e. no major R&D programme was provided for, as the meteorologists had requested). At the same time two modifications were proposed: the development of a new transponder to replace an obsolete model and the use of the S-band subsystem to replace the VHF telemetry, tracking and command subsystem. The ground segment was described in detail and a number of changes proposed, though always within the framework of the existing architecture. The overall cost of the system was estimated to be 343 MAU (mid-1979 prices and 1980 conversion rates). Provision was made for suppressing the fifth launch (-37 MAU), suppressing the MIEC component in the ground segment (-11 MAU) and adding a meteorological data distribution subsystem similar to that provided by Sirio-2 (+30 MAU).

As 1980 wore on, the ESA Executive became increasingly alarmed by the slow progress being made with the definition of the operational programme (as too did the Programme Board and France in particular, as we saw above). The final estimates by industry of the cost of the programme were due in by April; it soon emerged that they would not be ready until July. Concerned, in May 1980, the ESA DG suggested that the directors of the meteorological services meet anyway to discuss the timetable of the operational programme in the light of the long delivery times required for certain high reliability components and to define a period of validity for a fixed price industrial bid. No one liked the idea. Taking over the reins, the new ESA DG Erik Quistgaard tried again early in June to set up a meeting for the 23rd of that month. He insisted that he was not seeking "commitment" but only "reactions" to the various outstanding issues concerning the programme. This initiative bore no fruit either.[971] Where did the blockage lie?

Not, we should say at once, with the legal instrument. The majority of the Legal Group had come around to the French position and were willing to endow Eumetsat with its own legal personality (though there was talk of changing its name so as not to prejudice the possibility of non-European participation). The real difficulty concerned the technical content and so the cost of the programme. Here it was Germany (which expected to pay about 25% of the cost, equivalent to some DM 220 Million) that had dug in its heels. The Federal Republic wanted to see cost reductions in the original estimates, wanted to see participation extended and wanted Eumetsat set up before it would commit itself to the scheme. More specifically it wanted the number of satellites reduced to three, a reduction in the Meteosat missions (e.g. a suppression of the DCPs) and the transfer of certain meteorological missions, if possible, to other ESA programmes. As the Italians also remarked, the overall cost of the programme "was very high compared with the budgets of the meteorological services involved" and the meteorologists would have to try to find ways to reduce programme content so as to make savings. [972]

Concerned that so little progress was being made, the Programme Board asked the Agency to take the initiative and to arrange anyway for an inter-governmental conference on an operational meteorological system. Meeting on 26 June 1980, the ESA Council duly authorised the Agency to "offer its good offices for the organisation of an Inter-Governmental Conference". Its aim was to allow those who were interested at least "to confirm their willingness to establish an operational meteorological satellite system in Europe and to have preliminary discussions about the technical,

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970 See Preliminary estimate of the cost of an operational Meteosat programme, undated but about January 1980 and the memo Tessier to Louis, 7 November 1979 (ESA5533).

971 See letter Gibson to directors of meteorological services, 13 May 1980 and the reply from Mittner, 4 June 1980 and letter Quistgaard to directors, 10 June 1980 and reply Simmen, 12 June 1980 (ESA4877).

972 See memo Tessier to DPFP, 28 March 1980 (ESA5533). The Italian reaction is in letter Pirro to Gibson, 22 April 1980 (ESA5549)

financial and institutional parameters of such a system". The letter of invitation was sent by the ESA DG early in October to the Ministers of Foreign Affairs in all countries which might have an interest in such a system (in fact the 18 member states of the ECMWF plus Norway) on the understanding that it would be directed from there to the most suitable post-box.[973]

7.12 January 1981: The first Intergovernmental Conference on an operational system and the subsequent deadlock.

The conference duly took place at ESA Headquarters on 28 and 29 January 1981. [974] It was attended by representatives from all invited states bar two – Finland and Iceland. Four major points emerged during the proceedings.

Firstly, no one doubted the enormous benefits of a meteorological satellite system, not simply for weather forecasting, but also for agriculture and fisheries, nor did anyone doubt that it was immensely important for Europe to make its own contribution to the worldwide system.[975] As the Chairman (Sir J. Mason, DG of the UK Meteorological Office put it), "it was necessary to realise that whereas in previous years the United States had agreed to accept responsibility for a major part of the global observation system and to guarantee open and cost-free access to the data, it was by no means certain that this would continue to be their attitude if other partners did not agree to make a reasonable effort". China and India were about to embark on meteorological systems and Europe could not afford to be left out of the club.

Secondly, there was general agreement that the most suitable operational programme was one that made use of three standard satellites which were essentially copies of the classical Meteosat model, but which would have improved reliability, increased onboard consumables and so an increased service life (and slightly higher cost). This was 'Option 2' put forward by the Executive and estimated to cost 261 MAU for an exploitation duration of 8.5 years.[976] It was stressed again that no major technological innovations should be incorporated into the space segment. This was not simply to reduce costs. There was a general feeling that the Meteosat system was already very advanced, particularly the water vapour channel, and that the data provided by the satellite were ahead of the numerical models that were available for interpreting them. It was, said the Chairman, "the data acquisition aspect that caused the greatest concern" and where the most fundamental improvements had to be made. "Meteosat realistically matched the present state of the art", said the Italian delegate and it would only be worth designing a new generation of satellites when the physical models had been improved.

Thirdly, these positive attitudes notwithstanding, very few countries were in a position to commit resources to the programme at this stage, their decisions being dependent on a further study of the matter and, crucially, on the number of other participants sharing the costs. Of the existing participating states in the Meteosat programme, only France and Switzerland were able to make firm commitments. The French delegation affirmed that its government had agreed to take part in an

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[973] See ESA/IRAG(80)26, 6 October 1980. The member states of the ECMWF were Austria, Belgium, Denmark, F.R. Germany, Finland, France, Greece, Iceland, Ireland, Italy, The Netherlands, Portugal, Spain, Sweden, Switzerland, Turkey, UK and Yugoslavia. See also ESA/PB-MET(80)37, 2 October 1980 (ESA3674).

[974] All of the information that follows on this conference, is from the minutes and their annexes unless otherwise stated, document CON/OP/MET/MIN/l and Annexes I-V, 18 February 1981 (ESA5447).

[975] For the applications of meteorological data and for a cost-benefit analysis of such a programme see, respectively, CONF/OP.MET/4, 28 November 1980 and CONF/OP.MET/5, 20 November 1980 (ESA5450).

[976] The other alternatives were the so-called 'Baseline' option, the five-satellite scheme costing 334 MAU which had been circulated earlier, 'Option 1' and a minimalist scheme of three satellites identical to the existing Meteosat spacecraft costing 239 MAU and having an estimated lifetime of 6.5 years in orbit. The possibility of adding an MDD costing 2.5-3.5 MAU similar to that on Sirio-2 was retained. See CONF/OP.MET/6, 28 November 1980 (ESA5451).

operational satellite programme, which it would finance according to the GNP rule up to a maximum of 25%. The Swiss delegation said that, subject to approval from its authorities, it could pay up to about 2% of a joint programme. Of the states that were not currently participating in the programme, all expressed great interest, some expressed a strong desire to become partners, some made it clear that there was no way that they could share in the costs. The possibility of obtaining financial support from the African states was effectively ruled out. As the French delegate pointed out, recent World Bank figures indicated that the GNP of these states together only amounted to 10% of that of the countries represented at the conference. This led to the suggestion that the possibility of getting financial support from international development organisations like the African Development Bank and the World Bank should be explored.

Finally, the conference also considered at some length the best institutional arrangement for a future Eumetsat. It went along with the conclusions of the Mittner working group, which were laid before delegates, that "Eumetsat" should have a "light" structure but should be endowed with its own legal personality.[977] Where it differed was that it felt strongly that the organ should be "more or less incorporated in an existing body" and the ECMWF in particular. Mittner's group had ruled this out on the grounds that "the incorporation of these new responsibilities within the framework of an already existing Convention would, in fact, involve procedures identical to those for the establishment of a new body". Some delegates felt that, be that as it may, this alternative might be preferable to setting up another international organisation.

To conclude its proceedings, the conference passed a resolution the content of which was summed up thus in the subsequent press release by ESA: "It was agreed that a working group should be set up to prepare the system requirements and outline specifications and to recommend an appropriate institutional framework for the implementation of a Meteosat operational programme". The conference also agreed to reconvene with a view to calling a meeting at plenipotentiary level once the results of this working group, to be chaired by Mittner and to include representatives from all countries that might be able to participate in an operational meteorological satellite system, were available.[978]

The Intergovernmental Conference took place in January 1981 under inauspicious circumstances. As the Chairman remarked in the course of the meeting, "General support for Meteosat is universal, but we could not be at a worse time economically for launching a new project and this means that the case we make [to our governments] has to be all the more convincing". More specifically though, the roots of the difficulty lay in Germany and everyone knew that until Germany had resolved the differences of opinion between different departments in the state apparatus it was difficult to make meaningful progress. This does not mean though that a step forward had not been taken. On the contrary the delegates to the conference had accepted the principle that an institution should be set up to take responsibility for an operational meteorological system, had decided to reconvene when an appropriate programme and framework for that institution had won general assent and had agreed to call a conference of plenipotentiaries to ratify their conclusions. It was with these specific goals in mind that the working group set to work immediately. They were covering familiar terrain, to be sure, but at least now they were doing so in the definite hope of arriving at a speedy conclusion – Germany permitting. And there lay the rub. For what the members of the working group did not know as they walked away from the conference in January was that it would take two more years to find a structure and to define a programme that was acceptable to Bonn and her partners.

7.13 The activities of the MOP Working Group

The first meeting of the working group set up to define the operational programme (the so-called MOPWG) was held on 23 and 24 February 1981. It was chaired by the director of the French meteorological service, M. Mittner, and membership was open to all interested countries. In 1981, for

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977 Their report is CONF/OP.MET/7, 28 November 1980 (ESA5452).

978 The quotation is from the information sheet dated 30 January 1981 (ESA5549). The resolution is Annex V to CONF/OP. MET/MIN/1, 30 January 1981 (ESA5447).

example, those taking part in at least one or more meetings were not only from the remaining seven Meteosat participating states – B, CH, D, F, FRG, I, UK – but also from Greece, Iceland, The Netherlands, Portugal, Spain and Yugoslavia.[979] The MOPWG then was not an ESA body: indeed its credibility rested on its maintaining its autonomy *vis-à-vis* the Agency. ESA was to provide secretarial support, but otherwise to keep a low profile. Régis Tessier – a man who enjoyed both the esteem and the trust of the meteorologists – was the Agency's central point of contact with the MOPWG and the community and acted as the "Coordinator of the Meteosat Operational Programme".

The MOPWG set up two subgroups. One, chaired by the British meteorologist Ken Stewart (replaced later by his colleague John Morgan when Stewart retired), was to define the technical content of the programme. in consultation with Programme Manager Dieter Lennertz and a couple of other ESA staff. It rapidly converged on a system, improved *vis-à-vis* the pre-operational spacecraft in terms of satellite reliability and payload performance.[980]

The other MOPWG subgroup, the institutional subgroup chaired by M. Alt (France) had far more trouble in arriving at a consensus. Their task was to define the legal status and structure of Eumetsat and to define criteria for and to fix the scale of contributions to, the new body. In addition and granted the time that would elapse between the signature of the Eumetsat Convention and its ratification, the Alt group was called upon to propose interim arrangements that would enable the programme to be started as soon as possible after the conference of plenipotentiaries.[981]

The MOPWG was determined to move rapidly. It was sensitive to the pressure on meteorologists from the Programme Board to take responsibility for the operational system and it was concerned about the long lead times required for the manufacture of some key satellite components. Mittner planned to have four meetings of the MOPWG by June, to reconvene the Intergovernmental Conference by September, and to have the Convention creating Eumetsat signed by mid-October 1981.[982]

By June 1981 the MOPWG had prepared all the main legal documents it could and had identified the questions still unresolved pending German agreement, which was expected a few months later. The date of the Intergovernmental Conference was surely slipping, but it was still hoped to hold it before the year was out. Then on 3 September came the bombshell. A telex from Bonn informed Tessier that the German decision was postponed to "the beginning of 1982". [983] In an exchange of telephone calls and correspondence, it emerged that the main source of the blockage did not lie in the Federal Ministry of Transport (whose Minister, Volker Hauff, was a former Minister of Research and Technology). Everyone in the BMV was in favour of German participation. The problem lay in the Ministry of Finance, which was particularly concerned about the low level of industrial return foreseen in the operational programme: it was about 10% compared to a possible German contribution of as much as 25%. [984] Disappointed, the MOPWG decided to suspend its activities and to postpone the convening of the Intergovernmental Conference until the German situation had been resolved. [985]

This proved to be extremely time-consuming, primarily due to internal technical difficulties in the Federal Republic. The date on which a German decision was promised thus slipped steadily as 1982

979 The participating states and the dates are summarised in MOPWG 5(81)48 (ESA5498)

980 The terms of reference are Annex 2 to MOPWG 1(81)6, 413/81 (ESA553 1).

981 See MOPWG 1(81)6, 4 March 1981 and Annex 1, for the tasks and formal terms of reference of this subgroup.

982 The calendar is in MOPWGI(81)2, but see also the minutes of the first meeting MOPWG 1(81)6, 4 March 1981 (ESA5531). See also Tessier memo on the first meeting dated 26 February 1981 (ESA5556).

983 Telex Schultze to Tessier, 3 September 1981 (ESA5543).

984 See memo Tessier on MOPWG status, 21 September 1981 (ESA5557), memo Lennertz on the operational programme, 2 October 1981 (ESA4877) and letters Hauff to Quistgaard, 9 December 1981 (ESA5541) and reply (ESA5543).

985 For a summary of their activities and these conclusions see MOPWG 5(81)48, 16 November 1981 and rev. 1, 25 November 1981 (ESA5498). See also memo Tessier to the DG, 18 November 1981 (ESA5543).

wore on. Finally, the Federal government decided in favour of participation in the operational programme at a cabinet meeting on 14 July 1982. It was agreed that the full costs would be borne by the Ministry of Transport and that Germany's contribution to the programme had to be well below 25%. [986]

With the German position resolved at last, a new round of meetings of the MOPWG got under way. They were now chaired by Dr Mohr of the German weather services, Mittner having retired from his post in France at the end of 1981. Progress was rapid, despite the complexity of some outstanding issues and a successful Intergovernmental Conference was held on 21-23 March 1983. It was followed by a conference of plenipotentiaries held in Geneva on 23 May 1983 where the Eumetsat Convention was opened for signature and a number of other legal declarations were adopted.

In discussing these developments we have decided to divide the material by theme, retaining when necessary a chronological sequence within each topic treated. In this way we hope the reader will gain an idea of the complexity of the issues tackled by the MOPWG and its subgroups without becoming lost in the details of the microprocess of decision making. Before getting under way, however, a few words are in order on the reasons for the hold-up in Germany.

A full analysis of why the Federal Republic's representatives took so long to adopt the operational Meteosat programme is not possible without access to archives that will probably only be opened in a decade or two. Some plausible speculations, based on interviews, do however suggest themselves. Firstly, there was the classical problem that the government Ministry involved, the Ministry of Transport, had to introduce a new budget line into its activities, had to come around to the idea that space meteorology was one of its functions and one for which it had to bear the administrative and, above all, financial burden. A second reason was related to this. The national bureaucrats and administrators who would be involved in the operational system were not those who had watched over the earlier development of the system, nor were they attached to a ministry whose central mission was research and development. They thus brought with them an entirely different ethos and persuading them of the merits of the programme also required slowly building up an atmosphere of trust and mutual confidence with them. That took time and it tangibly retarded the rapid adoption of the operational programme. In short the operational programme called for a "cultural revolution" (Tessier) in the attitudes of the civil servants in the ministries responsible for it and they were only prepared to move ahead once they felt they knew what they were committing themselves to.[987]

7.13.1 The space segment: the satellite and its payload

The technical description of the system was quickly frozen. After all, this was not to be a development project and the aim was to identify those improvements to the performance of the existing Meteosats that experience had shown were desirable and which were not too costly. A first account of the operational system was provided in the draft Eumetsat Convention in June 1981. It was only changed slightly in some details as the start of the programme slipped and the industrial situation changed (e.g. some products used in Meteosat F1 and F2 were no longer available). [988]

The technical subgroup proposed to increase satellite lifetime both by increasing the on-board consumables (electric power and propellant) and by improving the reliability of the electronics associated with the radiometer and the telecommunications. As for the payload, an additional channel was added for the simultaneous transmission of the visual, infrared and water vapour signals. The

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986 See letter Rehm (for the Minister) to Quistgaard, 29 July 1982 (ESA5543) and the draft minutes of the ESA Management Board held on 27 July 1982 (ESA5542).

987 Private communications, Lennertz and Tessier.

988 For an early system description see MOPWG 1(81)4, 11 February 1981 (ESA5531), MOPWG 2(81)7, 13 July 1981 (ESA5539) and Annex I to the draft Eumetsat Convention, MOPWG 4(81)40, 23 June 1981. The following paragraph is based on these texts along with the summary report by the technical subgroup to the reconvened Intergovernmental Conference, CONF/OP.MET/10, 9 February 1983 (ESA5455) and memo from Laurentie to DIOPS (ESOC), dated 1 October 1982 (ESA5559).

signal-to-noise ratio of the water vapour channel was also improved. A more accurate calibration scheme, using on-board calibration implemented by temperature control of a black body, was suggested for both the infrared and water vapour channels. Finally, a frequency band of new high-power transponders was used for an MDD capability – provision would be made for an MDD capability similar to that used on Sirio-2 (which was destroyed on launch). As for ground-sector performance, this was to be at least as good as that of the pre-operational system, though provision was made for improving reliability and reducing operating costs.

Figure 7-5 indicates schematically the proposed differences between the pre-operational and operational meteorological spacecraft.

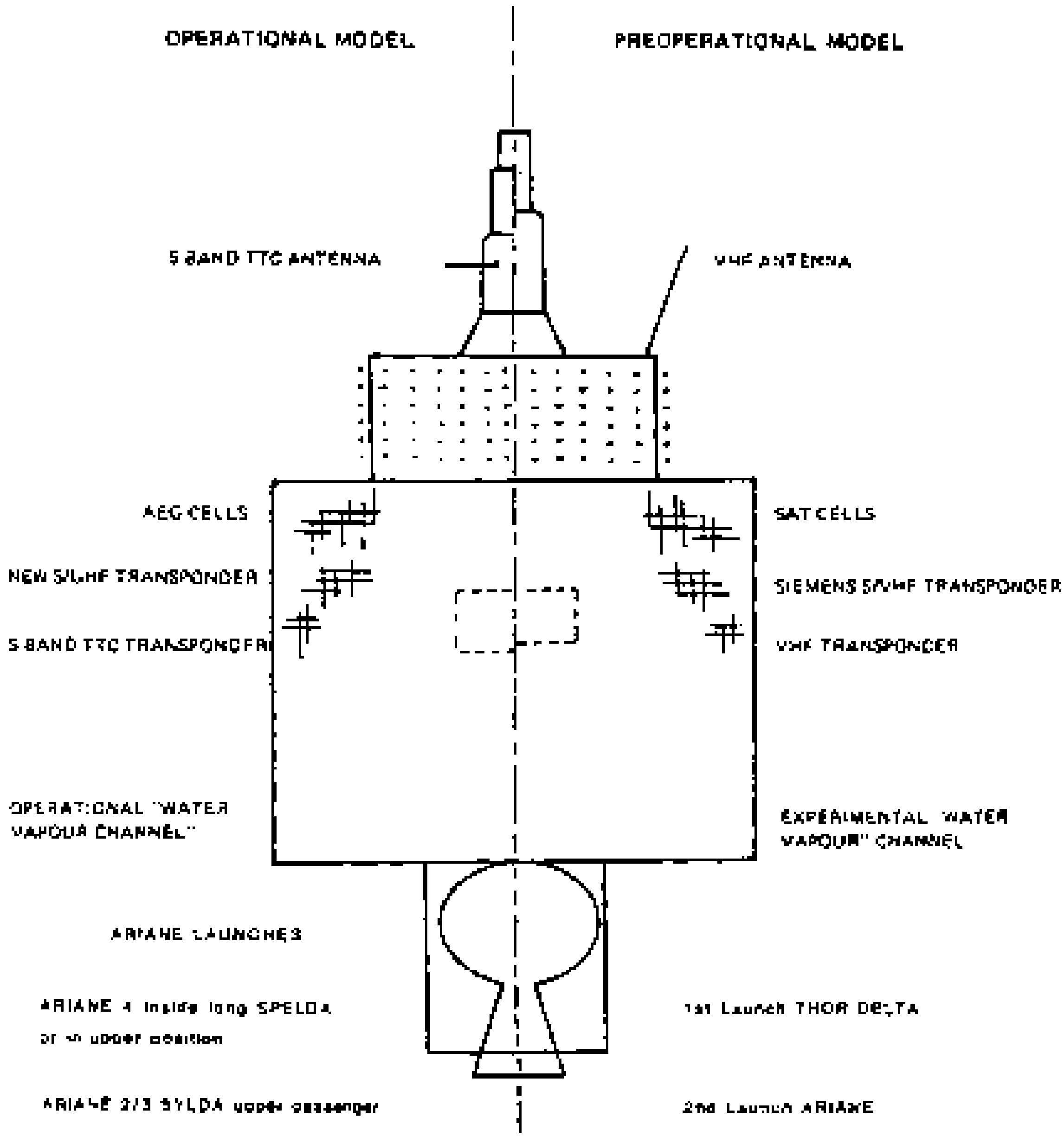

Figure 7-5: Schematic of the differences between the pre-operational and operational Meteosats showing the proposed changes and improvements, as presented by ESA to the Intergovernmental Conference in March 1983 (CONF/OP. MET/13).

7.13.2 The space segment: the launch schedule and the revival of P2

In a well designed operational system, each active satellite is complemented by one on stand-by in case of failure. With each satellite having a 50% probability of surviving for at least three years, a decade of 'guaranteed' operations requires building five satellites. This approach was too costly for the Intergovernmental Conference which, it will be remembered, wanted the number of satellites reduced to three (or perhaps four) and their lifetime extended. To cut costs it was also desirable that only one satellite integration team be used. Within these constraints the technical subgroup decided that a second satellite should be launched as soon as possible after the first, bearing in mind the workload of the team, while the third satellite could be integrated after the first two and launched when justified by the status of the programme and the availability of dual launch slots on Ariane. This approach provided for a high probability of an in-orbit spare for all except the first 18 months of the operational programme (i.e. the presumed time gap between the first and second launches). [989]

The launch schedule proposed in mid-1981 reflected this philosophy and the conviction that the Convention would be ratified before the year was out. It was proposed to build three satellites and a spare. MOl would be launched once it was ready, presumably in the second half of 1985. MO2 would follow 18 months later, in the first half of 1987. MO3 would be launched with a somewhat greater delay after MO2 (i.e. in the second half of 1989), though this date was flexible. The launches of MOl, MO2 and MO3 would be insured to cover the costs of launching the spare MO4 in case it should be needed. The overall scheme provided for an operational programme lasting 12.5 years from the end of 1981, or 8.5 years from the launch of MOl. By the end of this period (i.e. 1993/4) the time would be ripe for launching second-generation meteorological satellites using more advanced technologies.[990]

The slippage in the signature of the Convention caused by the situation in Germany forced a reconsideration of this launch schedule. By August 1982 it was clear that the operational programme could not be formally started before mid-1983, meaning that MOl would not be launch-ready until 1987. This not only raised serious questions about the desirable length of the programme: perhaps only two MOs should be developed and the transition then made to the second-generation of satellites?[991] It also meant that there was very likely to be an important break in service between the "pre-operational" and operational systems. After all Meteosat F2 had been launched in June 1981. With a nominal life of four years, this meant that there would be a gap in the operational system between 1985 and 1987. How was this gap to be bridged?

The most cost-effective way to provide for the possible interruption of service between Meteosat F2 and MO1 seemed to be to launch the second model of the Meteosat pre-operational series (labelled P2). P2 had been used as a qualification model for the Thor-Delta launch of F1 and then, after modification, for the Ariane launch of F2. It underwent both of these baseline tests without problems. Though it was unlikely that it would be as reliable as a new spacecraft a decade after manufacture, the ESA Meteorological Programme Office (MPO) in Toulouse suggested that it could be made flight ready with only minor refurbishment.[992]

The P2 "bridging" solution was discussed by the technical subgroup meeting on 9 September 1982 and favourably received. In mid-November the Ariane Programme Board agreed to launch P2 as a passenger on the first Ariane-4 test flight towards the end of 1985, at marginal cost.[993] The technical group proposed that this launch be followed by those of MO1 and MO2 at intervals of 18 months

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989 The launch philosophy is described in the summary report by the technical subgroup to the Intergovernmental Conference. CONF/OP.MET/l0, 9 February 1983 (ESA5455).

990 For this paragraph see Annex I to the draft Eumetsat Convention, MOPWG 4(81)40, 23 June 1981.

991 See letter Mason to Tessier, 15 March 1982 (ESA5541)

992 The idea of using P2 had been discussed by Stewart's subgroup early in 1981, but shelved at that time - see the early draft ot Annex I to the Eumetsat Convention dated 27 February 1981 and signed C. Pastre (ESA5538). The possibilities of its reuse are discussed in ESA/PB-MET(82)12, 24 March 1982 and ESA/PB-MET(83)1, 20 January 1983.

993 See memo Orye dated 13 December 1982 (ESA5550).

each, while MO3 could, if necessary be launched two years later (second half of 1990). The programme now comprised P2 plus three satellites and a fourth spare, it being understood that the launch of the old flight model should not under any circumstances delay the launch of MO1.

A schematic launch schedule which implicitly assumes that Meteosat P2 would be operated and which was prepared for the intergovernmental meeting, is shown in Figure 7-6.

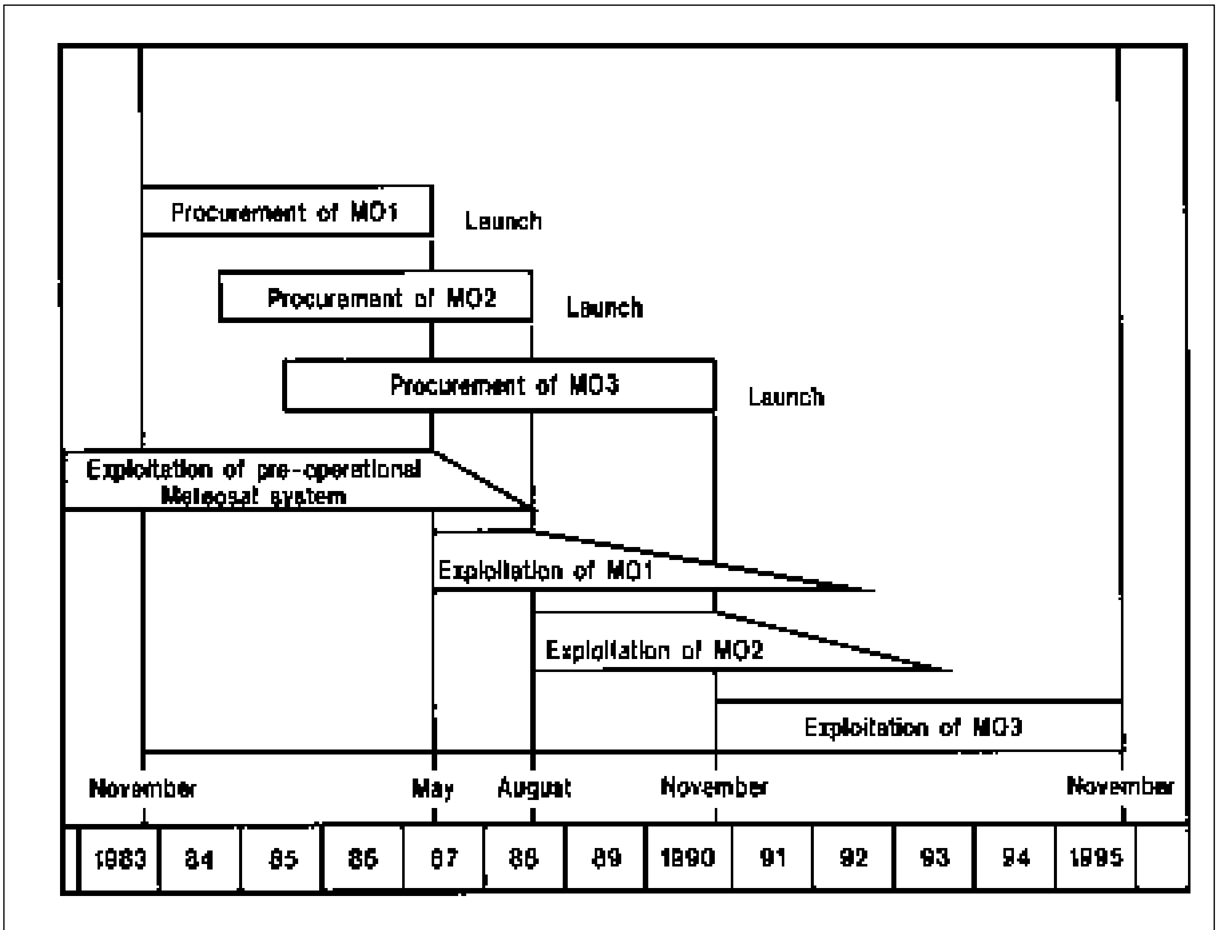

Figure 7-6: Information on the operational programme showing the desired launch schedule, presented in a folder prepared by ESA for the delegates to the March 1983 Intergovernmental Conference and entitled "A Way to Tomorrow's Weather: The Meteosat Operational Programme."

Who would pay for the additional satellite? The Programme Board had made it clear, we will remember, that it would not pay for this. Thus the subgroup decided to add the cost of refurbishing and launching P2 (estimated at 8.6 MAU, of which 2.0 MAU was for the launch) to the new operational programme. [994] The MOPWG also looked into the arrangements for operational expenditure. The protocol signed by PB-MET for managing Meteosat Fl and F2 was due to expire on 23 November 1983. The MOPWG subgroup thus suggested that the new programme should take over the cost not only of refurbishing, launching and operating P2, but also of operating these two earlier flight models from 24 November 1983 onwards. [995]

This elegant solution was short-lived. At a meeting between the German and French Ministers for Transport on 10 December 1982 the former stipulated that the satellite programme had to be restricted to three satellites, so that if P2 was used only two of the improved spacecraft could be launched (i.e. the other two units foreseen at the time would not be integrated except in case of failure). [996] This suggestion, if implemented, seriously threatened the operational reliability of the programme and so was to be avoided at all costs.

Faced with this threat, Tessier discussed an alternative solution with the German delegation: keep the operational programme with its three satellites and pay for flying P2 from the existing pre-operational programme, despite the earlier hostility of the Programme Board. This programme had cost to date 127.8 MAU in mid-1971 prices, i.e. 111.13% of its initial financial envelope. The 8.2 MAU for refurbishing and launching P2 could thus be taken from this budget within the 120% cost overrun limit. The German delegation let it be known that it found this alternative acceptable and that it would be prepared to maintain the new programme intact while paying for P2 from the old. Most delegations to the meeting of the MOPWG in mid-January 1983 were willing to go along with them. [997]

Of course the Programme Board for the pre-operational Meteosat had to accept this new burden. Meeting on 9 February 1983, it decided to delay its decision pending the results of the Intergovernmental Conference scheduled for the end of March. To conclude we need only remark that, in the light of the importance of P2 for guaranteeing continuity of operation and of the Intergovernmental Conference's decision to take over the operating costs of the pre-operational programme as from 24 November 1983, the Programme Board capitulated and subsequently agreed to bear the costs of refurbishing and launching P2. [998]

7.13.3 Ground segment management

Although it had always been understood that ESA would be the Agency responsible for setting up an operational system, in November 1982 it was still not evident that it should also be responsible for the exploitation of the in-orbit satellites. As the UK delegate to a meeting of the MOPWG then put it, even if it was agreed that the programme be carried out as an operational activity of the Agency, the Eumetsat Council had to be left the freedom "to determine the body to which it would entrust the

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994 The cost figures are in ESAJPB-MET(83)1, 20 January 1983. See also MOPWG 7(82)71, 19 October 1982 (ESA5514).

995 For the technical subgroup's deliberations, see the chairman's report its third meeting, MOPWG 6(82)56, 9 September 1982 (ESA5504), the MOP space segment description, MOPWG 6(82)57, 9 September 1982 (ESA5505), Revision 1 of Annex I to the ESA Convention, 9 September 1982 (ESA5534), Revision 2 of same, dated 20 September 1982 and attached to MOPWG 7(82)68 rev. I (ESA5511).

996 This is reported in MOPWG 8(83)82, 13 January 1983 (ESA5523). Tessier claimed afterwards that the German delegation had never supported the P2 + 3 MOPs solution.

997 Memo Tessier 20 December 1982 entitled Contenu du Programme Operationnel (ESA5550), memo Tessier Option P2 du Programme Operationnel, 13 January 1983 (ESA5550), the minutes of the 8th MOPWG held on 17-18 January 1983, MOPWG 8(83)84, 9 March 1983 (ESA5524) and ESA/PB-MET(83)1, 20 January 1983.

998 See the minutes of the 34th PB-MET meeting on 9 February 1983 and the resolution it adopted on 16 June 1983, ESA/PB-MET/XXXVIIRes. 1(Final). See also memo Tessier to Mallett, 7 March 1983, fax Mallett to all PB-MET delegates, 31 March 1983 and letter Lafferranderie to the German BMFT, 21 June 1983 (ESA5550).

ground segment operations which would, in fact, not begin until around 1987". [999] Behind this remark lay the meteorologists' dissatisfaction with ESOC's performance, which had surfaced on more than one occasion in the years before (see Part A of this chapter) and an ongoing suspicion that they were being overcharged for the services rendered by the establishment.

The suggestion that operational activities as such should be taken away from ESOC had surfaced very early on in the discussions with the meteorologists. Commenting on the debates at the second meeting of the MOPWG in March 1981, Tessier remarked that "a certain consensus" was developing among the community that "system exploitation" as opposed to development might not be attributed to ESA. [1000] This idea was given a further twist later that year when the Director General of Eurosat, P. Blassel, suggested that this semi-private company might take over the task of operating the Meteosat system. Indeed the Eurosat solution was one of the main preoccupations of the Executive during the long wait for the German green light.

Eurosat was a European grouping of banks and industries set up in 1972 to facilitate the transition of satellite systems from the development to the operational phase. In May 1976 and in anticipation of the Meteosat operational programme, the ESA Council passed a resolution that specifically identified Eurosat as the kind of organisation which might serve this purpose in consultation with the Agency. The resolution identified certain tasks that might be suitable in this regard: funding parts of the ground systems of ESA's experimental programmes which might subsequently be used operationally, prefinancing operational systems derived from ESA's experimental systems and making them available to users, etc. [1001] Thus authorised, ESA contracted out several parts of the Meteosat system to the company. Eurosat provided control teams to supervise in-orbit operation of Meteosat satellites at ESOC in Darmstadt and was responsible for the promotional activities of Meteosat products in Europe and Africa in 1978/9, etc. On the basis of this experience Blassel wrote to all the heads of the meteorological services in December 1981 offering Eurosat's help. Although the offer was vague it suggested that the firm, in consultation with ESA, might for example set up "an adequate legal entity" for managing the operational system, might make arrangements for pre-financing the operating costs of the system and could also explore with the services ways of raising revenue to cover part of these costs, e.g. by selling some meteorological products to "certain categories of end-users who are not linked to Meteorological Services".[1002]

These offers caused considerable consternation in some quarters in ESA, who felt that an activity with which they had had a long historical attachment was at risk of being wrenched from their hands.[1003] For one thing, the DG himself seemed seduced by the idea, initially at least. "In my opinion", he wrote when the issue first surfaced in spring 1981, "ESA should try to get away from operational systems, especially when we are talking about an operation time stretching from 7-10 years".[1004] Secondly, the meteorologists themselves became increasingly interested in the option. Eurosat explained its activities at a meeting of their directors in The Hague on 14 April 1982. Dr Lingelbach of the German Weather Service was subsequently reported to have found the presentation "impressive and the offer of prefinancing attractive" [1005] Finally, the idea of commercialising meteorological products previously

999 At the seventh meeting of the MOPWG on the 8-10 November 1982, MOPWG 7(82)76, 22 November 1982 (ESA5517).

1000 See his memos dated 31 March 1981 (ESA5556) and 7 April 1981 (ESA5555).

1001 ESA/C/VII/Res. 1, 11 May 1976.

1002 See letter Blassel to directors of meteorological services dated 23 December 1981, copied with letter Blassel to Tessier, 23 December 1981. See also letter Blassel to Quistgaard, 23 December 1981 and Kuegler to ESA Council Chairman Curien, 6 February 1981 (ESA5544). Some of these ideas were further elaborated in a private converstaion with Bourély in the ESA Legal Affairs department - see memo 10 December 1982 - and in a meeting at ESOC with Tessier and others on 29 March 1982, see memo dated 31 March 1982 (ESA5544).

1003 For extensive documentation on the internal debates see the material Tessier's file (ESA5544).

1004 Memo dated 22 April 1981 in (ESA4877).

1005 See Aide Memoire signed by Jensen (ESOC) and dated 23 April 1982 (ESA5551). See also document Eurosat, DG/PB/gdm/8826. Genève, 13 June 1982 (ESA5544).

provided free of charge was very much 'in the air' at the time. The Reagan administration in the USA was considering taking this path, consistent with its deregulation policies. Indeed in July 1981 Comsat President Dr Joseph V. Charyk told the US Congress that he wanted the firm to "take responsibility for developing, expanding and operating" on a commercial basis the Landsat Earth Resources and the NOAA/GOES meteorological satellite systems which Comsat would combine into a single programme. Indeed, opposition notwithstanding, in March 1983 it was reported that the US President had decided that "the satellites used by the weather bureau will be privately owned".[1006]

The Eurosat option effectively evaporated in July 1982; the Federal Government let it be known that it wanted Meteosat operations to be at an existing centre in Germany.[1007] The meteorologists, meeting shortly afterwards, formally decided not to make use of Eurosat as they were still not in a position to judge what advantages this might have.[1008] Anyway the firm was sold to Matra towards the end of 1982 making "its future intentions [...] unclear", to quote Tessier.[1009] With that Eurosat dropped out of the picture. It did not mean that the question of the ground segment was settled, however.

Firstly, there was the question of programme management. The meteorologists wanted "a strong and clean management scheme" with the responsibilities of the Programme Manager clearly defined and with the interface between him and the "customer" clearly identified. "Full visibility" over the running of the programme was also called for. The customer was not to be left passively on the sidelines, but was to receive regular status reports on the state of the programme and be able, through Eumetsat, to participate in "significant meetings at ESA or with the contractors".[1010]

To satisfy these requirements the ESA proposal in March 1983 gave overall control of the programme to a single person, the Programme Manager. He would be located at the Agency's headquarters and would be "the unique point of contact between the Agency and the Customer", centralising the information passing to and from the Agency and organising the monitoring of ESA activities by Eumetsat. Subordinate to him there would be one person responsible for the space segment and one for the ground segment. The space segment project manager and his team would be located at Toulouse would draw support from ESTEC. It would comprise no more than 13 persons up to the launch of the first MOP and this number would be reduced to 6 by the end of the programme. Exploitation would be handled by a ground segment project manager and his team. This team, numbering 21 persons for the duration of operations, would be located at ESOC.[1011] These changes meant, in fact, breaking up the experienced ESA-MPO team in Toulouse, which had successfully managed the Meteosat programme until then, and relocating some members elsewhere – with the result that Programme Manager Lennertz and some of his colleagues left ESA.

The second major issue concerning the ground segment operations was financial. The meteorologists looked very carefully at ESA's proposal for managing this segment, which originally "did not fully correspond to the stated requirements" in the overall system description "and a time-consuming critical examination (by the Technical Sub-Group) proved necessary"[1012] The meteorologists were also most

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1006 For information on the US situation see memo Mellors (ESA, Washington D.C.) to Tessier, 16 July 1981 (ESA5555), articles in *Aerospace Daily* (pp. 134-5) (for Comsat citations) and *Defense Daily* (p. 130) of 24 July 1981, memo Pryke (ESA Washington D.C.) to ESA, 19 November 1982 (ESA5543) and the International Herald Tribune of 9 March 1983 (ESA5543), from which the final quotation is taken.

1007 See the draft minutes of the ESA Management Board meeting on 27 July 1972 (ESA5542). See also the report on the Instutional sub-group meeting held on 14-15 December 1982, MOPWG 8(83)82, 13 January 1983 (ESA5523).

1008 See the minutes of the Alt subgroup held on 9-10 September 1982, MOPWG 6(82)58, 13 September 1982 (ESA5540).

1009 See memo Tessier to the ESA DG dated 27 October 1982 (ESA5555).

1010 This paragraph from letter Mohr to Quistgaard, 24 November 1983 (ESA5543). For the DG's reassurances on all issues but that of charges, see his letter to Mohr, 2 February 1983 (ESA5555)

1011 See the Technical and Financial Proposal of the European Space Agency, CONF/OP.MET/l 3, circulated by Quistgaard on 14 February 1983 (ESA5458) and the viewgraphs presumably presented to the conference (ESA5560).

1012 For the quotes see MOPWG 7(82)73

unhappy with the proposed charging policy for the use of ESOC facilities, being suspicious that they were being called upon to "subsidise the European space policy", as the chairman of the MOPWG Dr Mohr put it. [1013] In particular, they vigorously contested the share of the fixed support costs being proposed by ESA for managing the programme, arguing above all that since this was an operational programme based on a tried and tested system it would be far cheaper to run than a usual ESA programme, which was plagued by many more uncertainties. This issue touched a matter of principle about how ESA calculated charges to users and the Council was called upon to arbitrate. It reduced the Executive's proposed 41 MAU under this budget heading to 29 MAU to meet the meteorologists objections. [1014]

These exchanges with the meteorologists were, of course, the historical legacy of the tension that had surrounded the relationships between the partners for years. Striking the right balance of power between them had always been difficult, to the extent that, as we remember, the meteorologists at one stage seriously thought of dispensing with ESA's services entirely. The operational meteorological programme was not only built on the scientific and technical foundations of its predecessor. As Régis Tessier said in speaking of the meteorological community, "Due to their past experience with PB-MET they will insist on having a better control and monitoring of the programme from the administrative, financial and technical point of view, [and] will request that all charges and overheads charged to the programme be fully justified."[1015] The pre-operational programme had proved to be a multifaceted learning process for both ESA and its 'client'.

7.13.4 The cost of the operational system

While there may have been squabbles over some budget line items, like the customer's share of the fixed costs at ESOC, by and large there were no major disputes over the global cost of the operational system. Table 7-4 shows the evolution of the overall cost of the programme between the two Intergovernmental Conferences. The programme was scheduled to start in June 1983 and to last for 12.5 years. Here we shall simply make a few comments on these figures.[1016]

The first point to notice is the increase in the cost of the basic programme from 250 MAU to 350 MAU in two years. Half of this increase was due to inflation and the change in conversion rates. The other half comprised, firstly, the increase in satellite costs, which were anticipated since the earlier figures were based on an outdated (1980) offer from the COSMOS consortium. Secondly, there was a similar increase in the costs to be paid to ESTEC for the exploitation phase, just that item which, as we have seen, was so hotly contested by the meteorologists. Thirdly, launch insurance has also now been budgeted for. This was to cover the cost of insuring both MOl and MO2 for launch and for the first few weeks in orbit. The sum insured was sufficient to cover the main elements of integration and the launch of MO4.[1017] The aim here of course was to avoid a repetition of the situation that had arisen with the pre-operational programme, where no provision had been made for launching the spare spacecraft in the event of a threat to the continuity of operations.

Our table also shows that the delay in the start up of the programme cost the meteorologists dear. The (pre-operational) Programme Board had agreed with difficulty to absorb the operational costs of Meteosat F1 and F2 until 23 November 1983. They were also being asked to pay for the launch of P2,

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1013 Letter Mohr to Quistgaard, 24 January 1983 (ESA5543).

1014 For the material surrounding this issue see the reponse to the Mohr letter of 24 January 1983 by H. Frank, ESA Finance, 3 December 1983 (ESA5545) and the Executive's explanation to the Council of the consequences for the rest of the programme of conceding the meteorologists a reduction of 24.6 MAU, ESA/C(83)8, 14 February 1983 and Add. 1, 18 February 1983. The meteorologist's arguments are in Annex II to this document. The Council meeting on 23 February 1983 in fact adopted the compromise proposed by the Executive - a reduction of 12 MAU; see letter Quistgaard, CONF/OP.MET/13, add.1, 28 February 1983.

1015 Memo to the DG dated 14 January 1983 (ESA5555).

1016 The notes to the table give the sources used in what follows.

1017 From meeting of Technical Subgroup on 20 October 1982, MOPWG 7(82)73, 8 November 1982 (ESA5515).

scheduled for 1985. The cost of operating these satellites from 24 November onwards was estimated to be 30 MAU, a cost which the meteorologists necessarily had to bear for 'bridging' the two programmes until MOPl was launched, in principle in 1986/87.

Table 7-4: The evolution of the overall cost of the operational meteorological satellite system between the first and second Intergovernmental Conferences, January 1981 and March 1983.

Budget item	**January 1981 IGC, (1979/80)[1]**	**Updated, (1981/82)[2]**	**March 1983 IGC, (1982/83)[3]**
Satellite procurement	98	127	139
Launching activities	67	80	80
Ground segment investments	9	10	13
Exploitation phase	52	57	69
Programme management & support activities	25	31	33
Launch insurance			9
Reserve for contingencies			6
Sub-Total	**251**	**306**	**350**
Bridging activities			29
Sub-Total			**378**
Eumetsat secretariat			10
Eumetsat contingency margin			12
Total			**400**

Notes:

Since all figures are rounded, totals do not always agree exactly.

1. MAU at 1979 prices, 1980 conversion rates. These data are for the three improved satellites option proposed to the Intergovernmental Conference in January 1981, CONF/OP-MET/6, 28 November 1980 (ESA5451) and as broken down in letter Vandeput to Piaget, 10/5182 (ESA5559). The latter source has been used for the launching activities cost, i.e. launcher, launch operations and ground station costs during the LEOP (Launch and Early Orbit Phase) as it assumed double Ariane launches.
2. Previous column simply updated to MAU at 1981 prices, 1982 conversion rates. From letter Vandeput to Piaget.
3. MAU at 1982 prices, 1983 conversion rates. Data from the DG's offer to the Intergovernmental Conference in March 1983, CONF/OP-MET/l3, 14 February 1983 and, for the Eumetsat expenses, from the Eumetsat Convention, CONF/OP-MET/12, rev.3, Annex, 24 March 1983 (ESA5457).

Finally, 10 MAU was set aside for the Eumetsat secretariat and the same figure for 'contingency' expenditure by the new Organisation. The former was calculated on the assumption that there would be a two-year interim period before the secretariat was officially set up and that it would cost 1 MAU/year thereafter until the end of the programme. The latter reflected the wish of the participating states to allow Eumetsat to engage in activities not foreseen in the operational programme – a point we shall return to below.

7.13.5 The scale of contributions

The scale of contributions of the states participating in the operational programme continued to be an extraordinarily thorny matter. The classical approach was to base this on GNP or, alternatively, on net national product (NNP).[1018] However, the automatic application of such a formula was strongly resisted by many countries. Some of the smaller countries wanted to restrict their contribution to a fixed sum per annum for fear that their share of costs would otherwise be beyond their means. (They also wanted all voting majorities in the Convention decoupled from percentage contributions, i.e. they were against double two-thirds majorities, so as not to find their ability to influence the programme unduly reduced.[1019]) In addition several countries were concerned about their low level of industrial return. Since the foreseen operational satellites were essentially 'Chinese copies' of their predecessors, it was evident that the same industrial structure would be more or less retained: the consortium COSMOS with SNIAS (i.e. Aérospatiale) as prime contractor. This arrangement not only benefited France, but also made it very difficult for potential new arrivals (e.g. the Netherlands or Spain) to get much industrial work. These differences proved to be simply insoluble in 1981 and the Executive was invited to try to find a way to satisfy the different interests concerned.[1020]

With Germany's decision to take part and the decision making process restarted, the Executive formally presented a new concept which had solicited considerable interest when discussed with some of the participating states earlier in the year. They suggested breaking down the budget and applying different scales to different parts of it, depending on the interest that a particular state had in that activity.

Two types of scale were used, one *pro-rata* to industrial return, the other *pro-rata* to the NNP. The costs of satellite procurement, about 38% of the budget envelope, would be distributed *pro-rata* to industrial return. The costs of programme management, ground segment and system exploitation, satellite insurance and the technical contingency, another 38%, would be distributed *pro-rata* to the NNP of all the participating states (assumed to be 19) on the grounds that they would all benefit 'equally' from these activities. Finally, the costs of launcher activities, the remaining 25% of the budget, would be shared *pro-rata* to NNP for the eleven ESA Member States who had invested in the launcher programme.

A contribution scale based on this system, but using old NNP figures from 1976-1978 and preliminary estimates of programme costs and of industrial return, was provided by the Executive in August 1982. It is shown, along with the unweighted NNP calculations, in Table 7-5, which clearly shows the difference made by the weighted system. The percentage contribution for a country like France, which gained major industrial returns from the programme, increased by 9%, while some smaller countries, or those with little or no industrial involvement, saw their contributions fall sharply: those of Norway or of Portugal, for example, fell by almost two-thirds while that of the Netherlands fell by about a quarter.

However illuminating this exercise was, ver, it was quickly accepted by the institutional subgroup that there was no point in trying to fix a scale of contributions using a formula: France, for example, was obviously opposed to tying contributions to industrial return.[1021] That granted, the subgroups decided

[1018] GNP represents the value of all the goods produced and services rendered by the factors of production of a given country. It does not take account of capital depreciation; NNP does. A slightly modified version of NNP called NNP at factor cost was used to calculate scales in the ESA mandatory programme. See document *GNP, NNP and GDP scales of contribution*, MOPWG 5(81)47, 20 October 1981 (ESA5497).

[1019] Second meeting of the Group held on 26-27 March 1981, MOPWG 2(81)21, 15 April 1981 (ESA5530).

[1020] For these issues see minutes of fourth MOPWG, MOPWG 4(81)44, 2 July 1981 (ESA5528) and reports MOPWG 5(81)48, 16 November 1981 (ESA5498) and *Brief Status of...MOP Preparatory Activities and Plans*, undated but early January 1982 (ESA5542).

[1021] See MOPWG 6(82)58, 13 September 1982 (ESA5540) and Lafferranderie's report on the same meeting, the 6th of the subgroup (ESA5541). For France see MOPWG 7(82)68, rev. 1, 29 October 1982 (ESA5511).

Table 7-5: Scales of contributions proposed by the Executive based on NNP only and on a weighted system that took account of industrial return.

Country	**NNP[1]**	**With Ind. Return[2]**
Belgium	3.77	4.36
Denmark	2.11	1.76
France	17.98	27.28
Germany	23.73	23.06
Ireland	0.46	0.30
Italy	10.47	11.38
The Netherlands	5.04	3.67
Spain	6.33	4.51
Sweden	3.57	2.33
Switzerland	3.35	2.56
United Kingdom	11.56	14.37
Austria	2.05	0.78
Finland	1.39	0.53
Greece	1.30	0.49
Luxembourg	0.17	0.06
Norway	1.47	0.56
Portugal	0.80	0.30
Turkey	2.20	0.84
Yugoslavia	2.25	0.86

Notes:

1. Column 2 assumes a wide participation and calculates contributions on Net National Income at Factor Cost only. Calculated by the Executive in August 1982 using NNP data for 1976-1978 – see MOPWG 6(82)53, 18 August 1983 (ESA5501). An updated calculation based on NNP data for 1979-81 is in (ESA5537).
2. Column 3 is from the same source, but has weighed satellite procurement *pro-rata* to industrial return, launcher costs are shared between ESA member states according to NNP and the remaining services are shared by all participants *pro-rata* to NNP.

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hat this decision which, even if partly informed by the data just provided, was essentially political and was best left to the Intergovernmental Conference.

7.13.6 Institutional and legal instruments

The appropriate institutional framework for the future user's organisation, said the chairman of the MOPWG in his final report, "proved to be [the task] most difficult to carry out and the one that entailed the most work". [1022] There were, it will be remembered, three alternatives. Some delegations felt that Eumetsat should be an independent organisation having its own legal personality and with the

[1022] In his paper prepared for the Intergovernmental Conference, CONF/OP-METI9, 9 February 1983 (ESA5454).

authority to receive and disburse funds on behalf of its members. Its directing body would be a Council that would meet periodically. Its executive would comprise a permanent secretariat of about a dozen people who would support the Council and monitor the programme being carried out by the operating agency or agencies. Against that, there were delegations who were not at all keen to create new international organisations. They suggested that Eumetsat might be merged into an existing organisation, like the ECMWF. If this was not possible there was a third way. A new body could be set up, authorised to contract out the operational system to ESA, to the ECMWF, to Eurosat or whatever, but it was not to have legal personality. At the Intergovernmental Conference in January 1981 the Chairman summed up the debate on this issue in vague terms: "a consensus had been reached", said Sir John Mason, "for the establishment of a body that should be endowed with legal personality even though it might be more or less incorporated in an existing body".[1023]

Sir John's definition of the consensus informed the first deliberations of the new institutional subgroup. At the end of March its most favoured solution was the setting up an independent body with its own legal identity and permanent secretariat which relied upon services provided at cost by the ECMWF in Bracknell. [1024] The director of the Bracknell centre was not *a priori* against the idea and indicated that he could offer administrative and financial support to the tune of six to eight staff, though he had no office space to house the Eumetsat secretariat.[1025] A draft convention for a small international organisation with its own 'legal personality and a draft agreement between the participating states and the ECMWF were produced.

In June 1981, however, the German delegation insisted that it was against the creation of a new international organisation. The subgroup thus felt obliged to formalise the legal texts creating an independent body that did not have its own legal personality. ESA's legal services produced a 'Eumetsat Agreement' in terms of which the 'Contracting Parties' simply established a Council to administer their affairs. This Council mandated another organisation to carry out the operational programme on its behalf. A draft complementary 'Arrangement' spelling out the terms of the relationship between the Council and the mandated organisation (assumed to be ESA for illustrative purposes) was also produced.

None of these issues had been resolved when the government of the Federal Republic finally decided to contribute to a European meteorological programme in July 1982. What is more, in the interim another possibility had entered the picture: having recourse to Eurosat for operating parts of the system (see above). The deadlock was broken at the end of September. The German delegation to the MOPWG aligned itself with the majority and accepted that Eumetsat be constituted as a new international organisation with its own legal personality and authorised to entrust the operational system to another agency.[1026]

1023 From the report of the institutional subgroup to the previous conference, CONF/OP-MET/7, 28 November 1980 (ESA5452) and from the minutes of that meeting on 28-29 January 1981, CONF/OP/MET/MIN/I, 18 February 1981 (ESA5447). See also MOPWG 1(81)6, 4 March 1981 and its Annex 1 (ESA5531) and, for the secretariat, MOPWG 2(81)11, rev.1, 8 April 1981 (ESA5469).

1024 See Tessier's report on the second WG meeting, memo dated 31 March 1981 (ESA5556).

1025 ECMWF DG's offer is in MOPWG 2(81)12, 25 March 1981 (ESA5470). For the legal complications surrounding Eumetsat/ECMWF arrangements see the memo drafted by Stewart (apparently) and dated 15 May 1987 (ESA5536). See also the report by the Institutional Subgroup to the March 1983 Intergovernmental Conference, CONF/OP.MET/11, 10 February 1983 (ESA5456).

1026 For the FRG position memo Tessier on the meeting of the 6th MOPWG, 24 September 1982 (ESA5555). In fact the official decision took longer than expected: in January 1983 it was still not formally taken, though it was evident that this was now only a question of days - see minutes of the 8th MOPWG meeting held on 17-18 January 1983, document MOPWG 8(83)84, 17 February 1983 (ESA5524).

With this decision taken the working groups rapidly converged on a consensus regarding the institutional and legal modalities of the new organisation.[1027]

The first question resolved was that of the body to be mandated to operate the system. The Working Group could not see any particular advantage in having recourse to Eurosat. The use of the ECMWF also posed a number of practical problems. The Convention of the Centre would have to be interpreted rather broadly to permit it to carry out such tasks, its staff and premises would need to be expanded and since the two activities, those of the ECMWF and of Eumetsat, would be supported by different constellations of member states, they would have to be hermetically sealed from one another administratively and financially. The Working Group thus decided that Eumetsat should entrust the operational system to ESA.

Two other related procedural decisions were taken. The first concerned the arrangements for the interim period between the signature and the ratification of the Eumetsat Convention. If the system was to function from end 1986/early 1987, it was necessary to place industrial contracts and to reserve launch slots immediately. The solution adopted was to make the Meteosat Operational Programme an optional ESA programme scheduled to last about two years and anticipating as much as possible the definitive programme. This programme would be under the control of a Programme Board whose structure and functioning resembled as much as possible that of the Eumetsat Council which would eventually succeed it when the Eumetsat Convention came into force.

The second decision concerned the functions, organisation and cost of the Eumetsat secretariat. It was foreseen that this would ultimately comprise about ten people, including a satellite engineer and a space meteorologist, aided by two man-years of outside consultancy support. [1028] However, the full complement would only be needed once the organisation came into being. In the interim period ESA would ensure many of the secretarial functions on behalf of the new body. During this time all that was needed then was a shadow Eumetsat secretariat of two meteorologists and a financial expert who would monitor the programme during its initial phases when, in fact, many of the major technical and financial commitments were made. [1029] On 9 December 1982 the ESA Council accepted that the new Meteosat programme be carried out as an operational programme of the Agency and that in the interim period it be started as an ESA optional programme with its own Programme Board and small secretariat. Provision was made for non-member states of ESA to be members of this Board.[1030]

All of these institutional arrangements were embodied in the appropriate legal texts. It is not our intention to analyse these texts in detail; what we would like to do, though, is to indicate some of those aspects pertaining specifically to the interface between ESA and the meteorological community and its representative bodies.

1027 At the last minute, the Dutch delegation suggested that nothing change at all: that it was not really necessary to set up a new institution to organise the meteorologists and that one should consider continuing the operational programme using the existing arrangements inside ESA for the pre-operational programme. This option was not pursued – see the minutes of the meeting of the institutional subgroup on 9-10 September 1982, MOPWG 6(82)58, 13 September 1982 (ESA5540) and Lafferranderie's summary (ESA5541). The rapid development now may be gauged from the minutes of the successive meetings: 9-10 September 1982, MOPWG 6(82)58, 13 September 1982 (ESA5540), 20-21 September 1982, MOPWG 7(82)68, rev.1, 29 October 1982 (ESA5511), 20-22 October 1982, MOPWG 7(82)73 (ESA5515), 8-10 November 1982, MOPWG 7(82)76 (ESA5517)

1028 See MOPWG 7(82)70, October 1982 (ESA5513), the discussion at the MOPWG 7th meeting, MOPWG 7(82)76, 22 November 1982 (ESA5517) and CONF/OP-MET/16, 9 February 1983 (ESA5461).

1029 For the interim unit see MOPWG 8(82)77, 2 December 1982, 6 December 1982 (ESA5518) and MOPWG 8(83)82, 13 January 1983 (ESA5523).

1030 The resolution is ESA/C/LVI/Res. 2 (Final).

Firstly, there was the question of whether or not ESA should have a monopoly over the operational system. At the end of 1982 there was considerable reluctance to give the Agency such a role, particularly in the light of ongoing friction over the management and costs of the ground segment. The UK delegation to the MOPWG meeting in November was quite explicit about this: one should not take it for granted that "all the elements of the programme had to be considered as tasks definitely entrusted to the Agency" and the Eumetsat Council would need to be legally empowered to mandate another body to take over this part of the work, which would only begin in 1987 anyway. [1031] Nothing quite as explicit emerged in the final legal documents though some provision was made for Eumetsat to develop other meteorological observation systems which made use of space techniques, e.g. a network of drifting buoys or a constant-altitude balloon system, in which tracking and data collection would be performed by satellite. [1032]

The powers of the Programme Board/Eumetsat Council and its interface with ESA also deserve some comment. On the one hand the Board exercised considerable autonomy *vis-à-vis* ESA. For example, it was authorised to approve the award of major industrial contracts, taking the place of the Industrial Policy Committee in this regard. At the same time the Board and its secretariat were given the opportunity to shape ESA activities which directly affected the users. The secretariat, for example, was to be kept "fully and promptly informed of the progress of the work" entrusted to ESA and could "take part in meetings that [were] important for the execution of the programme". The Board, for its part, was to give advice "on the Agency's research and development work in the field of meteorological satellites". [1033]

Of course, with the passage of time some of these provisions, which obviously reflected the perception of the ESA/Eumetsat relationship in 1983, needed looking at again. The provisions for the start of new programmes was a crucial case in point. The requirement in the Convention that new programmes needed unanimity, as well as the lack of a generally applicable algorithm for calculating scales of contributions were later to be regretted (Eumetsat reverted to GNP for all programmes after the MOP). The precise roles of the two bodies in the development of new technologies also required clearer definition. The conclusion finally agreed was that Eumetsat would define its technical requirements in consultation with ESA and that ESA would be given first refusal to develop a prototype satellite meeting these requirements. Eumetsat would seek alternative means of achieving its objectives only if the two organisations failed to reach a mutually satisfactory agreement. [1034]

7.14 The second Intergovernmental Conference, the plenipotentiary conference and the birth of Eumetsat

The Intergovernmental Conference was reconvened by its Chairman, Sir John Mason, on 2l to 23 March. The overall tone of the opening statements by the delegations was extremely positive and led those present to hope that the conference of plenipotentiaries to sign the Eumetsat Convention could be held two to three months hence. Only three issues related to the draft Eumetsat Convention proved controversial.

1031 See the UK intervention at the MOPWG meeting on 8-10 November 1982, MOPWG 7(82)76, 22 November 1972 (ESA5517). This freedom was quite explicit in the draft Eumetsat Agreement, i.e. the document assuming that it would not have legal personality – see Arts 5.2.a(iv) and 5.2.b(vii), MOPWG 4(81)34 rev.3, 13 September 1982.

1032 The meteorologist's new ideas were defined in the final report of the institutional subgroup, CONF/OP-MET/11, 10 February 1983 (ESA5456).

1033 The quotations are from the (draft) Implementing Rules, ESA/C(83)WP/3, rev.2, 8 March 1983, Art. 3.1 and Art. 4.2.

1034 From J. Morgan, "Eumetsat. the European Organisation for Meteorological Satellites", in the *Proceedings of the ESA/EUI International Colloquium, The Implementation of the ESA Convention. Lessons from the Past* (Dordrecht: Martinus Nijhoff, 1994).

The first concerned the seat and official languages of the new organisation. Germany, appealing to its significant contribution to the programme, offered to house Eumetsat in Darmstadt or Offenbach, while France indicated that its government would like to see the headquarters in Paris. The FRG delegation also wanted German to be one of the official languages, whereupon Italy said that if languages other than English and French were sanctioned, Italian would have to be included too. These manoeuvres are of course typical when a new European organisation is being set up. More interesting in this case is that the conference refused to allow them to block progress. It was decided that if France and Germany could not reach agreement the Eumetsat Convention would simply state that its headquarters would be on the ESA premises in Paris and that its final location would be a matter for the Eumetsat Council to decide. Conference also agreed that the usual two official languages would be used, but that the same Council would decide on the working languages when it first met.

The conference in March resolved two other difficult, interconnected issues: the scale of contributions and the percentages required for the start up of the programme and the ratification of the Convention. These issues had in fact threatened to jeopardise the calling of the meeting. A count made of contributions in November 1982 reached only 77% of firm commitments – and conference Chairman Mason felt that there was no point in reconvening unless the pledged contributions amounted to 85%. [1035] Two items of good news followed. Meeting together on 10 December in Paris the German and French Ministers of Transport agreed to propose to their respective governments an increase of 1.5% in their contributions potentially bringing both up to 22% and the total to just over the 80% threshold. Then in mid-January Spain let it be known that she would contribute with 4.5%: the 85% total required by Sir John was within reach.[1036]

Matters did not quite turn out that way at the Intergovernmental Conference in March, however. A first 'tour de table' brought forth total commitments amounting to about 82% of the costs of the programme, the major contributors being France (22%) and Germany (19%, though she "did not rule out the possibility that fresh efforts might shortly enable [the delegation] to raise the figure to 21%"). In the light of this situation, two delegations, those from Italy and the Netherlands, promptly reduced their previous offers (by 1.4% and 0.45%, respectively), on the grounds that the costs-to-completion of the operational programme were far from covered. The scale of contributions then agreed (see column 4, Table 7-6) barely crossed the 80% threshold and left 19.72% to be found.

The shortfall in contributions immediately triggered a debate about the provisions that should apply for the start of the programme and the ratification of the Convention. The Executive pleaded that both be possible with 80% of the contributions guaranteed: other Agency programmes had begun with shortfalls, the commitments were the minima for some countries and it was most likely that others would join over the passage of time. It would be fatal to stop the programme start-up by setting unrealistic thresholds. Not all delegations agreed and various figures ranging from thresholds of 80% to 90% were bandied about. In the event the conference agreed that the programme could get under way with 80% of the contributions guaranteed but that 85% of the contributions would have to be assured for the Eumetsat Convention to enter into force. [1037]

[1035] See letter Mason to Lingelbach, 22 November 1982 (ESA5543).

[1036] See the report by the chairman of the institutional subgroup, MOPWG 8(83)82, 13 January 1983 (ESA5523) and handwritten memo by Tessier, 17 January 1983, 18h30 (ESA5557). Also Spanish intervention at the 8th meeting of the MOPWG held on 17-18 January 1983, MOPWG 8(83)84, 17 February 1983 (ESA5524).

[1037] For the debate see items 5 and 6 in the conference minutes, CONF/OP-MET/MIN/2, meeting held on 21-24 March 1983, document dated 8 April 1983 (ESA5446).The Convention as adopted is CONF/OP-MET/12, rev.3, 24 March 1983 and its corr. 1, 19 April 1983 (ESA5457), while the terms for the start up are in the Interim Arrangements, covered by draft declaration CONF/OP-MET/14, Annex II, rev. 1, 24 March 1983, attached to ESA/C(83)46, 24 March 1983. A summary of the proceedings is in ESA/PB-MET(83)8, 12 April 1983.

Table 7-6:. Various scales of contributions proposed or adopted at successive phases of the operational programme.

Country	**NNP[1]**	**With Industrial Return[2]**	**IGC March 1983[3]**	**Prep^{y} Conf. May 1983[4]**	**Eumetsat August 1986[5]**
Belgium	3.77	4.36	4.00	4.00	4.40
Denmark	2.11	1.76			0.58
France	17.98	27.28	22.00	22.00	25.60
Germany	23.73	23.06	19.00	21.00	26.39
Ireland	0.46	0.30			0.11
Italy	10.47	11.38	10.00	11.00	12.00
The Netherlands	5.04	3.67	2.55	3.00	3.00
Spain	6.33	4.51	4.50	4.50	5.24
Sweden	3.57	2.33	0.93	0.93	0.93
Switzerland	3.35	2.56	2.60	2.60	3.03
United Kingdom	11.56	14.37	14.40	14.40	16.76
Austria	2.05	0.78			
Finland	1.39	0.53			0.35
Greece	1.30	0.49			0.30
Luxembourg	0.17	0.06			
Norway	1.47	0.56		0.50	0.50
Portugal	0.80	0.30	0.30	0.30	0.30
Turkey	2.20	0.84		0.80	0.50
Yugoslavia	2.25	0.86			
Total	**100**	**100**	**80.28**	**85.03**	**99.99**

Notes:

1. Column 2 assumes a wide participation and calculates contributions on Net National Income at Factor Cost only. Calculated by the Executive in August 1982 using NNP data for 1976-1978 (see MOPWG 6(82)53,
18 August 1983 (ESA5501)). An updated calculation based on NNP data for 1979-81 is in (ESA5537).
2. Column 3 is from the same source but has weighted satellite procurement *pro-rata* to industrial return, launcher costs are shared between ESA Member States according to NNP and the remaining services are shared by all participants *pro-rata* to NNP.
3. Column 4 gives the firm contributions promised at the Intergovernmental Conference in March 1983, totalling 80.28% (from CONF/OP-MET/12, rev. 3, 24 March 1983 (ESA5457)).
4. Column 5 gives the contributions agreed at the conference of plenipotentiaries on 24 May 1983, totalling 85.03%, memo Lafferranderie, 26 May 1983 (ESA5546).
5. Column 6 gives the revised scale adopted by the Eumetsat Council meeting in August 1986. The scale was to apply from 1987 (from Eumetsat Annual Report, 1986/7, p.45).

The conference of plenipotentiaries for the signature of the Eumetsat Convention was held in Geneva on 24 May 1983 [1038] It was attended by representatives from 16 European countries (see Table 7-4: Austria, Luxembourg and Yugoslavia were not represented). Twelve of them announced that they would contribute to the programme at the levels shown in the second last column of Table 7-6. Germany had increased its contribution by 2%, bringing it closer to France's. The Dutch and the Italians had also decided to make a greater effort and two new countries (Norway and Turkey) had decided to participate. Finland and Ireland and also Denmark and Greece, had indicated their intention to participate. [1039] With just over 85% of the contributions guaranteed, work could start on the operational meteorological satellite programme with the knowledge that the creation of Eumetsat now only waited on parliamentary ratification.

Improved industrial returns undoubtedly affected the German and Dutch decisions to increase their share of the costs of the programme. Certainly most of the firms involved had been used for the pre-operational satellites and were responsible for the same tasks. The ESA Executive had made some significant changes, however. In Germany, ERNO had replaced an American supplier for the thrusters, AEG had been chosen for the solar generator and ATN (previously Siemens) would build the new transponder. In the Netherlands, Fokker had replaced Matra for manufacturing the radiometer structure. The new distribution of tasks is shown in Figure 7-7.[1040]

A brief word by way of conclusion. The Eumetsat Convention finally entered into force on 19 June 1986, five years to the day after the launch of Meteosat F2 and no less than 17 years after the Directors of the meteorological services had formed their first 'Ad-hoc Group on Space Meteorology'. At this time the cost-to-completion of the programme was still only 86% covered. The problem was resolved a few months later at the second meeting of the Eumetsat Council in August 1986. The member states agreed to increase their contributions to make good the deficit, with the results shown in the last column of Table 7-6. [1041] Significant increases in contribution were registered for Germany (+4.39%), which had won the battle to have the Eumetsat headquarters in Darmstadt, for France (+3.6%), which had a major industrial interest and a satellite team kept intact and gaining experience in Toulouse and for Britain (+2.36%), which had one of its meteorologists, John Morgan, appointed the first Director of Eumetsat.

7.15 Closing remark: Why the sudden acceleration?

The rapid evolution of events between September 1982 and March 1983 and the success of both the reconvened Intergovernmental Conference and the Conference of Plenipotentiaries give us pause for thought. The shift from a pre-operational to an operational system and the corresponding shift in responsibility from research and development agencies and budgets to the meteorologists and their ministries, ground to a total halt at the end of 1981 after over a decade of debate and five years of intense deliberations. 18 months later Eumetsat was born. Why this change of pace, why this acceleration in the decision making process?

Germany's decision to participate, which was both financially and politically important, was obviously one key factor. There were also pressing technical arguments. It was important to have the plenipotentiary Conference before the end of June 1983, for example. The Ariane launcher cost was governed by a convention between ESA and Arianespace which was due to expire at the end of that month. Arianespace let it be known that it would launch the three operational satellites at a preferential

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1038 See the draft minutes by Lafferranderie, 4 October 1983 (ESA5546) and his memo 26 May 1983 (ESA5546).The (draft) Final Act of the Conference of Plenipotentiaries is CONF/OP-MET/15, rev. 1, 24 March 1983 (ESA5460).

1039 See memo Lafferranderie, 26 May 1983 (ESA5546).

1040 From ESA/PB-OM(83)3, 7/6183 (ESA5463). A new British firm IGC also entered the scheme as co-contractor for a new task, central parts procurement. CASA (Spain) was another new arrival, having been awarded the apogee booster motor adaptor after industrial competition.

1041 This material is from the Eumetsat Annual Report for 1986/87, pp.14, 45.

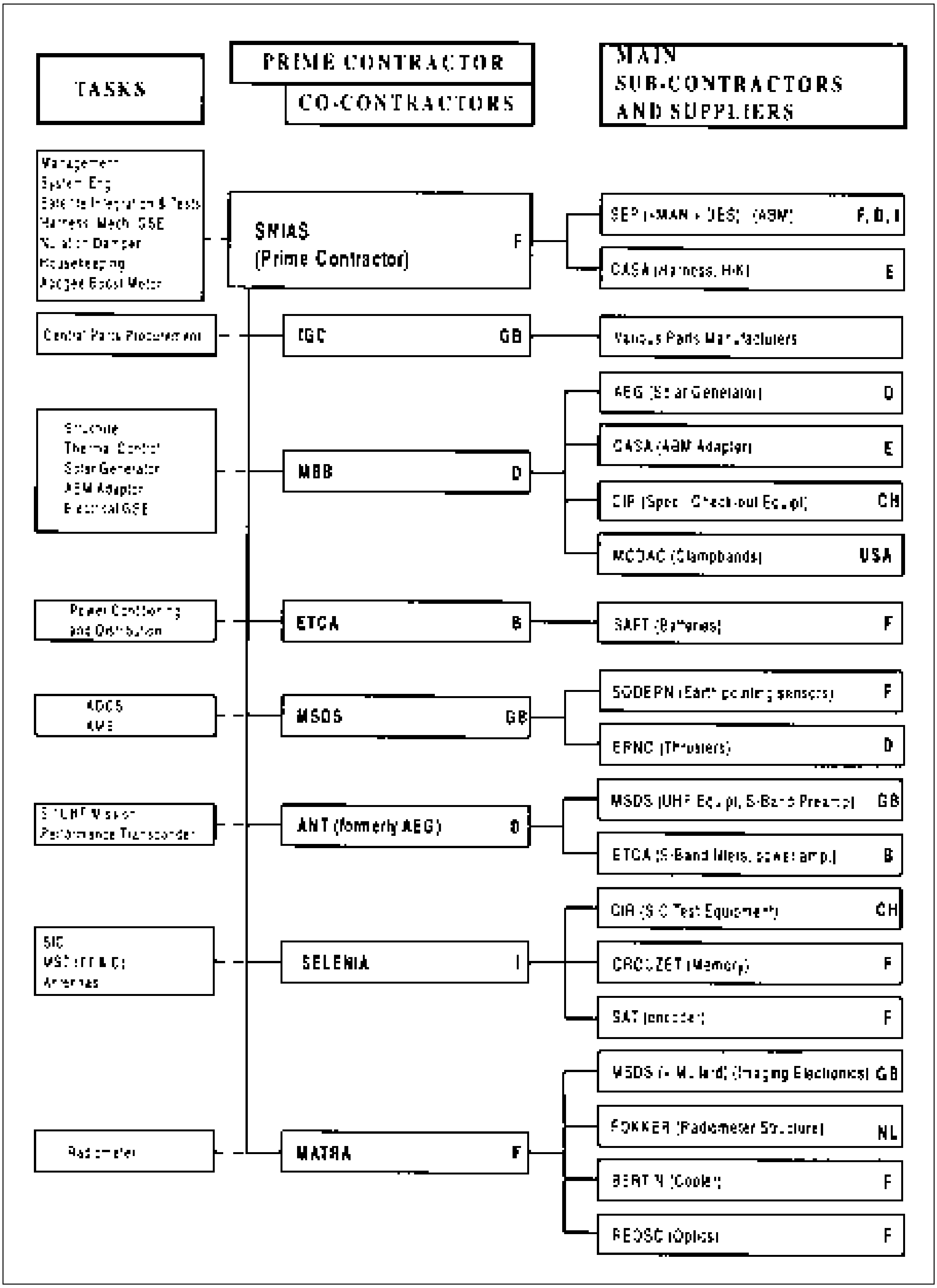

Figure 7-7: The industrial set up of the consortium, prime contractor Aérospatiale, proposed for building the operational satellites and their payloads in June 1983 (ESA/PB-OM(83)3, Annex II, 7 June 1983, ESA(5483)).

fixed price based on that convention if the launch contract was signed before 1 July 1983; after that date normal market prices would apply. There was also a need to avoid a gap in operations when the current protocol expired on 23 November 1983, which meant making firm commitments to staff and to computer suppliers by the end of May. These arguments apart, there are others of a more general character which must not be forgotten. [1042]

Firstly, there is no doubt that in the early 1980s meteorological satellites 'came of age' as a technology. Meteorological services, initially sceptical about making the major investments required in both the space and ground segments, were now convinced of the value of space-based data, seeing them as "one of the fundamental components of their observation system". [1043] Ironically, the partial failure in orbit of Meteosat-1 might have helped this process along. As Eumetsat Director John Morgan put it recently, "At the time it seemed as if this gap in services might arouse some doubts as to the reliability and risks of the technology, but in fact it seemed to help persuade the meteorological services that a fully operational service was needed, with full in-orbit redundancy".[1044] Be that as it may, there was nothing like a successful demonstration of the product. The Finnish delegation to the Intergovernmental Conference in March explicitly tied his country's decision to participate in the programme to the demonstration organised three months before in Helsinki, with the active participation of the Finnish Meteorological Institute. This showed convincingly, he said, "the usefulness of Meteosat data for our purposes".[1045]

But it was not only weathermen 'on the ground' who now wanted satellite data; it was also scientific researchers. Indeed the final version of the Eumetsat Convention explicitly made reference in its preamble, to the value of "space technologies applicable to *meteorological research* and weather forecasting" (our emphasis). This research dimension was evident from the active and growing interest of scientific users in the products of Meteosat. ESA organised a number of meetings of this constituency not only to extend the base of support for the programme in the participating states, but also to improve the products and to adapt them better to scientific users' needs. The first of such meetings was held in Darmstadt in June 1979 and attracted 48 scientists from eleven countries, 21 from Germany. The second was held in London in March 1980 and attracted 77 scientists from nine countries, including again 21 from Germany and 38 from the UK. This strong scientific interest in satellite data for medium-to-long-range forecasting was expressed institutionally at a European level in the ECMWF. And it was surely one important consideration persuading the German cabinet to participate in the operational programme. In his opening statement to the Intergovernmental Conference the German delegate immediately "stressed the progress achieved in exploitation of [Meteosat's] data *for research work purposes* and for applications with very diverse objectives" (our emphasis). [1046]

Developments in the USA also surely accelerated the European process. Of particular importance was the Reagan administration's interest in commercialising the products of meteorological satellites (a clear sign of the coming of age of the technology). Indeed, as we saw above, in March 1983 it was announced that the President had decided that deregulation should extend to this sphere. The move away from what Sir John Mason called "the sacred principle of the free exchange of data and

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1042 See the memo *Reasonsfor keeping to the June deadline*, CONF/OP-MET/INF.2, rev. 1, 22 March 1983 (ESA5547) and the letter from C.A. Daoud (Arianespace) to W. Thoma (ESA), 26 October 1982 (ESA5566).

1043 According to the French delegate to the March conference, CONF/OP-METIMIN/2, 814/83 (ESA5446).

1044 J. Morgan, "Eumetsat. the European Organisation for Meteorological Satellites", in the *Proceedings of the ESA/EUI International Colloquium, The Implementation of the ESA Convention. Lessons from the Past* (Dordrecht: Martinus Nijhoff, 1994), p.168.

1045 On the Finnish demonstration see the memo from R. Wolf (ESOC) to the Meteosat Promotion Group, 14 December 1982 (ESA5543). The quotation is from the minutes, CONF/OP-MET/MIN/2, 8 April 1983 (ESA5446).

1046 For the scientific users meetings see the reports ESA/PB-MET(79)21, 3 September 1979 (ESA3631) and ESA/PB-MET(80)17, 22 April 1980 (ESA3656). The German delegation' statement is in CONF/OP-MET/MIN/2, 8 April 1983 (ESA5446).

products" caused great concern in Europe. At the same time the threat that one might have to buy data also gave an enormous boost to the European operational programme. If the US government was to reduce its share in the global meteorological system, leaving the scope of weather coverage provided by the USA to be determined by market forces, it was clearly preferable to spend money on a European system than to buy American. By developing such a system one might not only put a brake on this process before it took root. One could also strengthen one's bargaining position *vis-à-vis* the USA by showing unambiguously that "Europe intends to take part in the global observing system and to provide meteorological data from satellites to the African and Middle East countries", so capturing markets and winning political influence. [1047]

Another factor to consider is the enormous effort made to promote the operational system by the ESA executive and by Tessier and Lafferranderie in particular. As Tessier put it in a memo to his DG Quistgaard in March 1983, "It must be remembered that two years ago the meteorologists were opposed to the execution of the Meteosat Operational Programme by ESA. Due to the permanent effort and professionalism of some ESA staff members", his memo went on, "the meteorologists have reconsidered their position and the Agency is regaining their confidence" [1048] In fact, as we pointed out above, as early as 1978 DG Gibson was concerned by the deterioration of the relationships between the two communities, the meteorological services seeming to want to dispense with the Agency's services as soon as possible. Things were improved but still delicate by the end of 1980. The Mittner subgroup reporting to the first Intergovernmental Conference with one eye on the running of the ground segment, remarked that 'it might be preferable not to ask the Agency to execute all the tasks that the programme would comprise, since some of them might be carried out at less cost by other bodies, certain of them perhaps-by the Meteorological Services themselves". [1049] By March 1983 trust had been rebuilt by the Executive's willingness to listen to the meteorologists' point of view and to devise a charging and management system for the ground-segment which recognised that their concerns were justifiable and had to be seriously taken into account. Previously ESA seemed to be rather arrogantly indifferent to the requests of the user community. Now, through the enormous efforts and hard work of Tessier and Lafferranderie, it was seen as treating the users as a 'customer' whose wishes had to be respected and who had to be helped in every possible way to bring their system to fruition.

Finally, to understand the rapid agreement reached between September 1982 and March 1983 we must not overlook the political dimension. It was not simply that Germany decided to participate, so guaranteeing, along with France, about 50% of the programme costs. It was also a question of consultation and discussion at the highest levels of power: the meeting between the two Ministers of Transport in Paris in December 1982 is symptomatic of this. In other words the accelerated progress made at the end of 1982 was not simply linked to German willingness to participate, it was not simply a question of money, of pooling resources in a European collaborative effort. The programme in the two countries became identified with Franco-German political collaboration in the European theatre, an element of the foreign policies of both. The launch of the Meteosat Operational Programme and the creation of Eumetsat, when they finally took place, confirm what former French Research Minister Hubert Curien once said: that you can get nothing done in Europe unless France and Germany agree.

1047 Sir John's comment was made, significantly, in his opening address to the March 1983 Intergovernmental Conference, see CONF/OP-MET/MIN/2, 8 April 1983 (ESA5446). See also the memo *Reasons for keeping to the June deadline*, CONF/OP-MET/INF.2, rev. 1, 22 March 1983 (ESA5547).

1048 See memo Tessier to Quistgaard, 10 March 1983 (ESA5555).

1049 Mittner subgroup report to January 1981 conference, CONF/OP-MET/7, 28 November 1980 (ESA5452).

Chapter 8:
The Aeronautical Satellite System: an Example of International Bargaining

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8.1 The meaning

The evolution of navigation systems, be they for boats, submarines, or aeroplanes, has been a fundamental component of the increasing accuracy of their missions. The importance of accuracy within a transportation service has changed remarkably, depending on the historical period and the actual use of the vehicle: the increase in accuracy for boats in the 16th century meant a dramatic decrease of wreckage due to poor navigation, the increase in accuracy for bombers during World War II meant better targeting, i.e. more buildings and people could be destroyed with the same number of bombs. Safety on the one hand, and performance on the other, have seemed to be the core values pursued through accuracy. The increase in performance according to these parameters has been classically considered of vital importance within the military realm; recent studies, however, have shown how the progress towards accuracy even in this realm is not linear and cannot be explained by this main "rational" concern, but rather by a series of vested political, social and economic interests which are sometimes contradictory.[1050]

This is all the more true for the civil realm, where the benefits of increased accuracy in terms of safety and performance have to be balanced not only against the vested interests of different groups, but also against a series of risks, such as the forecasting of future traffic and of costs (increasing fuel prices, inflation) whose definition can vary with time and with the political stand of the one who makes the forecast. Unlike the military realm, where the cost-effectiveness judgements are frequently dismissed on the basis of a superior strategic interest, the civilian realm attaches great importance to judgements of this kind.

During the 1970s, the evolution of the air navigation system seemed to share the global trend of every information technology: a trend towards centralisation, towards a sort of Orwellian "Big Brother" surveying and controlling human beings.[1051] In the case of aircraft, this change corresponded to a progressive shift of power from the pilot, who had for centuries been enabled by the classic navigation systems to determine the position of his transport means himself, to the controller. From the mid-thirties onwards, air-traffic control (ATC) systems determined the position of all users through central surveillance stations,[1052,] thereby dispossessing the pilots of what they felt as a well-rooted, old privilege. The road to accuracy also corresponded to the increased complexity of avionics and ground terminals. Since the advent of the first radio navigation system, each time the system was improved a new "black box" was added in the aeroplane cockpit and a new terrestrial infrastructure set up.

Yet, the efficiency of these terrestrial systems was still very low for intercontinental flights (it was obviously difficult to set up ground facilities in oceans) and very costly (as a ratio between the cost of the aircraft and the cost of its avionics) for general aviation. By the 1960s, ground-based radars could not operate beyond a zone of about 300 nautical miles radius. Thus, they could not be used for ATC over oceanic areas: this meant that, for the purpose of collision avoidance, the crew of an aircraft

1050 For this, see Donald MacKenzie, *Inventing accuracy: a historical sociology of nuclear missile guidance* (Cambridge: MIT Press) 1990.

1051 Nathan Goldaman, *Space Policy* (Ames: Iowa State University Press) 1992, pp. 155-156

1052 "There are two modes of surveillance: dependent surveillance which relies on the aircraft's position *measured on board* and transmitted to the ground; independent surveillance which relies on the aircraft's position *measured from the ground* (e.g. by means of a radar, or any satellite system)". Definition given by R. Collette to L. Sebesta, letter 3 July 1995.

flying over the North Atlantic Ocean, for example, had to rely entirely on its navigation instruments to determine the aircraft's position and was requested to transmit periodically the estimated position data to the control centre. For this purpose, a very limited number of HF voice channels was available and these began to be saturated by the end of the decade or to suffer from performance degradation due to propagation phenomena.[1053]

Soon after Early Bird introduced commercial telecommunication services across the Atlantic Ocean by satellite (1965), discussions began on whether satellites could have a significant part to play in the future development of civil aviation – providing a more accurate means of communication and ATC – or whether, conversely, the growth of civil aviation would provide a stimulus for the technological development of yet another kind of commercial satellite.

The rapid increase in aircraft traffic over the oceans forecast for the 1970s (a projected 10% per year)[1054], the expected introduction of larger and faster civilian aircraft for overseas flights (the Concorde, the Boeing 747 and the Supersonic Transport Aircraft, SST) and the anticipated growing scarcity and unsuitability of existing high-frequency radio communications channels, all highlighted the potential of satellites in this field for both communications and air traffic control (position fixing purposes or automatic reporting of aircraft position) in order to expedite and maintain a safe and orderly flow of air traffic and to optimise flight schedules.[1055]

Voice and data communications, surveillance functions in ground-air-ground networks using radio transmission including relay via an active Earth satellite, navigation by computation of a position fix utilising equipment self-contained within the vehicle (based upon the time of arrival of signals from two or more satellites whose ephemerides were known), and search and rescue duties were among the most important activities foreseen.

Aeronautical services, as well as other specialised services such as maritime services, were not specifically included among those to be provided by Intelsat, the global commercial communications satellite system which had ruled the provision and management of public telecommunications via satellite since the interim agreement of 1964. Radio navigation or flight control were thus universally considered as outside Intelsat's competence – and would continue to be so, against American wishes,

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1053 Historical Archives of the European University Institute, Florence (HAEUI), ESRO/ST/341, ESRO Scientific and Technical Committee, Applications Satellites Traffic Control Systems, 2 February 1970.

1054 The first official estimates were prepared by 1970 by FAA. "FAA Operational Requirements 1970-80 for Aeronautical Satellite Services via Satellites", 17 November 1970, cited in HAEUI folder 50771 "The National Program on Satellite Telecommunications for International Civil Aviation Operations", 19 March 1971, attached to letter Nilson to Hammarström,2 April 1971.

1055 Safety regulations in the late 1960s were such that aircraft flying at the same altitude had to be separated by 120 nautical miles laterally and 20 minutes of flight time longitudinally. Without a satellite system, it was considered feasible to reduce these figures to 90 or even 60 nautical miles and 10 minutes respectively. By using a satellite system. it was expected to provide ATC centres with sufficiently accurate aircraft position data for the values to be further reduced to 30 nautical miles and 5 minutes, ESRO General Report, 1970, p.14.

even after the coming into force, in February 1973, of the new permanent agreement of August 197l.[1056] Article XIV(e) of this new text would just mandate members establishing separate systems for "specialised telecommunications services [...], domestic or international" to "furnish all relevant information to the Assembly of Parties, through the Board of Governors". The Assembly, taking into account the advice of the Board, would make recommendations similar to those for the setting up of separate domestic services - whereas the Board would express "in the form of a recommendation, its findings regarding the technical compatibility of such facilities and their operation with the use of the radio frequency spectrum and orbital space by the existing or planned Intelsat space segment" (Art. XIV(c)). The focus put (i) on the advisory capacities (as opposed to the executive capacities) of the Board and (ii) on technical coordination alone, rather than on technical coordination and the economic harmfulness of the systems, as was the case for telecommunication satellites) greatly simplified decisions, diminished the probability of arbitrary decisions and liberalised the setting up of such services.[1057]

Theoretically, air navigation systems offered a splendid opportunity for Europeans for starting at much the same time as the US and working cooperatively for the North Atlantic traffic where the essential European need lay (more than 50% of aircraft flying over the Atlantic were operated by European airlines). The Europeans could, for the first time, participate in a new type of application satellite programme from its inception. The aim would be to participate in the development and use of the system. An early involvement would give Europe the possibility to acquire a satellite technology which would enable it to compete in the field of applications satellites for communication, broadcasting and navigation. This would imply having a say from the opening stages in the definition of the basic parameters and management rules of the new system, which had a good chance of becoming commercially viable and rewarding, provided that it was universally adopted by civilian airlines.

As we shall see in detail later, there were two motives of a different nature behind European willingness to get involved in these kinds of applications satellites. On the one hand, from an industrial point of view, the area seemed to open new economic and technological opportunities; an early entrance into the field would give European industry a competitive position with regard to the future market, as a supplier of hardware for the space, air and ground segments. On the other hand, politically speaking, the setting up of such a system could be a lever in the Intelsat negotiations due to start in 1969. This would contribute to the credibility of Europe as a potential partner (in case of a cooperative venture) or competitor (in case of a unilateral action), and thus help to foster its requests to moderate the American monopolistic situation in the area of telecommunication satellites.[1058]

1056 Steven Levy, "Intelsat: Technology, politics and the transformation of a regime", *International Organization.* vol 29. n. 2. Summer 1975, pp 673-674. More precisely, during the negotiations of the permanent agreement, the American delegation proposed a very broad definition of public telecommunication including "all telecommunication services, fixed or mobile, which can be provided by satellite, to meet the communication needs of the general public or any segment thereof..." cited in *ibid.,* p.674. This definition was endorsed in paragraph k of art. 1, but was complemented by two important specifications: one that excluded from the definition "those mobile services of a type not provided under the Interim Agreement and the Special Agreement" [which did not include maritime or aeronautics services], the other which made reference to "specialised telecommunication services" over which Intelsat action would be drastically restricted – these services including radio navigation services, broadcasting satellite services for reception by the general public, space research services, meteorological services, and Earth resources services.

1057 Marcellus S. Snow, *The International Telecommunications Satellite Organisation (Intelsat),* (Baden-Baden: Nomos Verlagsgesellschaft) 1987, pp.84-87.

1058 HAEUI, folder 51220, DG/529041B/hw, Minute (no author), 12 September 1968.

8.2 The actors

The problems of an aeronautical satellite programme potentially interested many separate sets of actors: users, producers and managers of the future system. They were:

- airlines flying international oceanic routes;
- the International Civil Aviation Organisation (ICAO), whose aim was to promote safety of flight in international air navigation and whose approval was needed for any operational activation of the new communication services required for air traffic control;
- aviation administrations responsible for air traffic control services (air traffic control services were, in some countries, responsible exclusively for operational procedures, in others also for matters falling within the long-term policies);
- Comsat, the semi-private American corporation that managed Intelsat [1059];
- national agencies responsible for R and D in application satellites technology;
- private firms working in the field.

A seventh, institutionally less visible, but nevertheless important, actor in the field was the category of pilots and air traffic controllers who were supposed to be the material beneficiaries of the projected system.

Each set of actors perceived the problem taking into consideration their primary goals, which differed substantially, as we shall soon see, and their specific roles.[1060] Economic impacts on prices of the service represented, for example, one important consideration of civilian companies when evaluating future adoption of satellite communications. Even if excluded from the financing of the experimental pre-operational satellite, it was obviously the airlines that would have to finalise, through fees, the major part of the equipment in an operational system and they would have to provide the avionics on board their aircraft. The advisability of making the necessary capital investment was influenced by both the reliability and marginal cost-benefit of the system. This last element, on the other hand, was inevitably linked to the traffic volume and the evolution of costs and international prices, and was bound to change following their changing estimates.

Other actors were more interested in safety requirements, industrial, security considerations, or the pride of "special" elite professions (the pilots and the controllers). A special mention should be given to political considerations, which implied issues of an internal nature – the power struggle between NASA, the Department of Transport / Federal Aviation Administration (DOT/FAA), the Office of Telecommunication Policy (OTP) and, behind the scenes, the Department of Defense (DoD), for the development and management of the American part of the system - and of more international flavour – US-European relationships in the highly critical period of the 1970s (the cooperative project outlived Nixon's, Ford's and Carter's presidencies and was only definitely abandoned during Reagan's administration).

1059 For Intelsat provisions, see chapter 10.

1060 For the fundamental impact of users requirements over the definition of big technology projects in space application satellites (remote sensing and meteorology) see Pamela Mack, *Viewing the Earth: the Social Construction of the Landsat Satellite System* (Cambridge: MIT Press) 1990 and Pamela Mack, *Making big technologies serve the user: US remote sensing programs*, in John Krige (ed.), *Choosing big technologies* (Chur: Harwood Academic Publishers) 1993, pp.95-107.

As far as US industry was concerned, although it was thought that a large potential market (estimated at about $1 billion in a decade) could develop for mobile users of (aeronautical and maritime) satellite communication, the expected initial growth rate of such a market was slow. A political impetus was needed in order to impress on the civilian airlines the need and opportunity to use satellites for aeronautical communications.[1061] The private sector was willing to exploit a new potential market, but it asked, and received, help from the state (it could benefit from the R and D funds put aside by NASA for Application Technology Satellites) and from the regulating international aeronautical organisations in order to impose this revolutionary shift on the potential users.

In 1966 the airlines and the Federal Aviation Administration[1062] began satellite communications experiments at VHF (Very High Frequencies) with NASA Application Technology Satellites (ATS) 1 and 3.[1063] Satellite-compatible avionics were developed in parallel. In view of the probable future congestion of VHF bands, thoughts were given, especially at European urging, to the study of an L-band (low frequencies) system to solve communication and surveillance requirements in the latter half of the 1970s.[1064]

At the same time, the International Civil Aviation Organisation (ICAO) began discussing technical specifications and international understanding on operating procedures within the new system from 1968 onwards.[1065] As we have already seen, ICAO, whose membership in the mid-1960s included 120 contracting states (each one being represented in the Assembly), was responsible for adopting telecommunication standards for international civil aviation to assure safe and efficient operation. The development and approval within the ICAO of any standard, procedure and practice (SARPs) – with which participating states were requested to comply to the maximum extent possible – was a delicate procedure, based on technical as well as political considerations. It required approval by the majority of the contracting states and by two-thirds of the 27 members of the Council, the governing body of the organisation.[1066] The approval of ICAO would thus be necessary for the adoption by international airlines of any operational air traffic control system by satellites.

In March 1968, the ASTRA (Application of Space Techniques Relating to Aviation) panel was established within the Air Navigation Commission (ANC) of the ICAO. Among its terms of reference

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1061 Nixon Project, Washington, WHCF, Subject Files, UT1, box 14, Memorandum Walsh to Kissinger on Aerosat, National Security Council Action 35902, 20 December 1971.

1062 Created by the Federal Aviation Act of 1958, the FAA was given sole responsibility for controlling both civil and military air traffic in the National Airspace System – certain airspace being reserved, though, for military use only.

1063 The overall objective of the Application Technology Satellite (ATS) programme was to investigate and flight-test technological developments for a number of satellite applications. They were used for developing and stockpiling technologies to be used by Intelsat and by various military systems. Funds for the first five ATS missions were released in 1964 and ATS 1 was launched in 1966. By 1973, all funding for the continuation of the programme beyond the original five missions – of which the last one ATS 5, launched in August 1969, partially failed – was cancelled by the Congress; ATS 6, the last ATS satellite, was launched in May 1974 and it was used, among other missions, to improve the communications links during the Apollo-Soyuz Test Project in July 1975; see Linda Neuman Ezell, *NASA Historical Data Book, vol. III, Programs and Projects 1969-1978* (Washington DC: NASA), 1988, pp. 325-329; Burton Edelson, *The Experimental Years*, in Joel Alper and Joseph Pelton (eds.), *The Intelsat Global Satellite System* (New York; The American Institute of Aeronautics and Astronautics) 1984, pp 51-52.

1064 George Low Papers, Rensselaer Polytechnic Institute, Folsom Library, box 19, folder 2, Letter George Low, NASA Acting Administrator to James Begg, Under Secretary of Transportation, 6 November 1970.

1065 The 1968 General Assembly resolved "that ICAO be responsible for stating the position of international civil aviation on all related outer space matters, and for stating international civil aviation's particular requirements in respect of applications of space technology". Quoted in HAEUI, folder 50242, attachment to draft letter from the Chairman of the ESRO Council to the European Ministers responsible for Aeronautical Activities, 22 February 1971.

1066 Nixon Project WHCF. Subject Files. UTI, box 14. *Summary of International Aviation and Foreign Policy Issues in the Aeronautical Satellite Program*, by the Department of State.

was the study of those applications of space techniques that offered improvements in the safety, regularity and efficiency of international air operations. Members of the ASTRA panel were experts from Australia, Canada, France, the Federal Republic of Germany, Japan, the UK, the USA, the International Air Transportation Association (IATA), the International Telecommunications Union and the World Meteorological Organisation.[1067]

Discussions among members revealed deep divisions on the parameters of the new system, first of all on the issue of radio frequencies to be used (the US position in favour of VHF being supported by IATA, but strongly opposed by the other members). The establishment of a unified programme along with an informal constituency around a single parameter would have avoided these polarisations and, thus, the risk of ICAO being blocked over the issue of standardisation.

In July 1968 the European Space Conference asked ELDO and ESRO to gather information on satellite navigational systems.[1068] This interest was confirmed by the decisions taken by the European Space Conference in Bad Godesberg (November 1968) whereby the activities of ESRO were extended beyond the traditional scientific field to applications.[1069] A much debated question in times of deep financial and organisational crisis, this new trend was confined, for the moment, to preliminary studies in communications, meteorological, aeronautical and Earth observation satellites.[1070] The studies on the Air Traffic Control (ATC) Satellite should cover technical, operational and economical aspects of the system, to be partly performed by industry.

ESRO studies were facilitated by the fact that France – the Centre National d'Etudes Spatiales (CNES) and the Secretariat Général de 1'Aviation Civile (SGAC) – and the UK – the Department of Trade and Industry and the Royal Aircraft Establishment – made available the results of their previous studies in the aeronautical field. In particular, CNES and SGAC provided information on a complete feasibility study know as "Dioscures" – a project for an air-traffic control system through the use of balloons covering the North Atlantic Ocean. For these experiments, up to three aircraft flew over the Bay of Biscay, communicating at various elevation angles and sea states via balloon-borne transponders with an experimental ground station installed at the CNES balloon base at Aire-sur-Adour. The efforts of CNES and SGAC represented by far the largest in Europe directed towards the definition of the requirements for an Air Traffic Control Satellite System over the Atlantic Ocean and towards the exploration of the most up-to-date techniques.

Economic and operational studies were also provided, as already hinted, by the UK.[1071] From the beginning, the British resisted the perspective of a European project based on the French system, on

1067 HAEUI, folder 50242, Attachment to Draft letter from the Chairman of the ESRO Council to the European Ministers responsible for Aeronautical Activities, 22 February 1971. IATA is an international association of civilian airline companies for setting up fares and service standards.

1068 HAEUI, CSE/CS(68)PV/4, 4 July 1968.

1069 John Krige and Arturo Russo, *Europe in Space, 1960-1973* (ESA Publications Division), 1994, pp.55-65.

1070 Any decision on the Eurovision Eurafrica satellite, at the core of the commercial satellite programme, was postponed for the moment; see *ibid.,* and A. Russo, *The early development of the Telecommunications Satellite Programme in ESRO (1965-1971),* ESA Report HSR-9 (Noordwijk ESA) 1993, pp. 48-50.

1071 HAEUI, folder 8695. ESRO/PB-AERO(72)4, 12 October 1972. Experimental Programme. Costing Study of Satellite Navigation System, minutes of meeting No. 1 held in Paris on 13 August 1968, Manuali (CNES), Collette (ESTEC), Ortner (HQ), Trollope (HQ). Project Dioscures, whose first technical report was dated the beginning of 1967, proposed a system for determining the position of the vehicle by measurement of distance from two geostationary satellites using transmission in the L-band: the method was also proposed by the American RCA and GE, but the French were trying to introduce sophisticated aircraft antenna to reduce the satellite size and mass within the limits of the ELDO launcher capabilities; HAEUI, folder 51220, Aide-memoire concerning the Feasibility study of an Air-traffic-control-satellite system, ATCS/PB146, no author, 10 June 1969; HAEUI, folder 50242, Letter Aubinière (Director General CNES) to Bondi (Director General ESRO), 9 March 1970.

the grounds of its insufficient cost efficiency.[1072] Eurocontrol, on the other hand, stated that the ATC system would be economically justifiable by the SST only.[1073]

An Air Traffic Control "ad hoc" group of member states' aeronautical experts was set up on 29 May 1969 by ESRO (chairman John J. Robinson) with the purpose of developing users requirements, gathering extensive information on all systems proposed (there existed more than one method to determine the position of a vehicle), assessing their relative merits and shortcomings, preparing system costs and cost/benefit analysis, proceeding further towards the development of satellite parameters and, more generally, harmonising European views in anticipation of the ICAO ASTRA meetings.[1074] In the first and following meetings, the group laid great stress on the importance and urgency of studying a traffic control system using geostationary satellites, able to perform its duties by the end of the 1970s.[1075]

Besides the "ad hoc" group, two parties were working on the ESRO side of the aeronautical satellite project:

- the Directorate of Programmes and Planning (DPP) (more precisely, the Space Application Division of the DPP), headed by Jean-Albert Dinkespiler, whose tasks were: (i) to function as a filter between the Ad Hoc Group and the various ESRO bodies (STC, AFC, Council); (ii) to assure the agreements of the establishments and services potentially involved or affected by the decisions taken and (iii) to coordinate contacts between ESRO and NASA.

- ESTEC (and, within ESTEC, the Satellite and Sounding Rockets Department) which was responsible for conducting intramurally or extramurally the studies necessary for arriving at final system specifications, meeting the mission requirements as defined by the Ad Hoc Group and the DPP. ESTEC was deemed to make the largest use of experience and expertise existing within its departments and ATF specialised divisions. In order to implement projects resulting from Council decisions, ESTEC was authorised to have direct contacts with national outside parties involved – CNES, SGAC or NASA.[1076]

8.3 The first ESRO-NASA contacts, 1969-1970

Soon after the creation of the "ad hoc" group, Hermann Bondi, ESRO's Director General, approached Thomas Paine, the new NASA Administrator, in order to coordinate efforts. The first ESRO-NASA exploratory discussions were held in NASA's headquarters in June 1969, under the newly elected Nixon administration.[1077] Their aim was to "discuss the possibility and the way of performing common NASA/ESRO studies for a NASA/ESRO Air Traffic Control Satellite System (NETCOS)".[1078] This and further meetings were mainly devoted to technical discussions in order to compare ESRO and NASA mission specifications and to arrive at a common set. By the end of July 1969, approval was given to a

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1072 HAEUI, folder 51220, Letter Dinkespiler to Ortner, 19 September 1968.

1073 HAEUI. folder 50242, Draft status report on European operations and economic studies in the field of Air Traffic Control by means of satellites (ATCS), by Lennertz, Directorate Programmes and Planning, Annex V,16 July 1969.

1074 Minutes of the first meeting of the ATC "ad hoc" group (29 May at ESRO); HAEUI, folder 51220, J.A. Dinkespiler, Director Programmes and Planning was in charge of organising this group; HAEUI, folder 50242, Draft status report on European operations and economic studies in the field of Air Traffic Control by means of Satellites (ATCS), by Lennertz, Directorate Programmes and Planning, Annex V, 16 July 1969

1075 *ESRO General Report,. 1969.* p.128.

1076 HAEUI, folder 50242, The Air Traffic Control Satellite Project, Note concerning the distribution of responsibilities and co-operation between services involved, 20 March 1970.

1077 HAEUI, folder 50242, Letter Bondi to Paine, 30 June 1969; *ibid.,* Letter Paine to Bondi, 18 July 1969.

1078 On the American side, Barnes, Coerr, Ehrlich, Marsten and Morris; European representatives were Dinkespiler, Lennertz, Mayer and Vandenkerckhove; HAEUI, folder 51220 ESRO, Internal Minutes of the 1st NASA/ESRO meeting on ATC, 26 and 27 June 1969.

first draft of a NASA/ESRO mission specification (later to be frequently revised) for an experimental, pre-operational air traffic control satellite system, to determine operational system requirements in the areas of technology and services and to determine the extent to which such technology could actually be used in controlling aircraft.

The main tasks of the system were:

- to monitor flight progress and separation between aircraft via satellite independent radio-determination techniques: the satellite radio-determination system should provide the Air Traffic Control centres with independent position determinations of sufficient accuracy and fix rate to permit the separation between aircraft to be reduced;

- to allow for communication – voice, digital data exchange and telegraph telecommunications – between aircraft and ground station(s) (at least one on each side of the Atlantic) and between Air Traffic Control centres.[1079]

The extension of these functions to ship traffic was deemed desirable but premature. Parameters for ground stations, aircraft avionics and radio frequencies (for both satellite/aircraft/satellite and ground/satellite/ground links) were specified.

Technical characteristics such as transmission bands, the number of channels available, reliability and lifetime of the satellites, coverage, and distribution of channels in that coverage, channel quality requirements, surveillance accuracy, the number of satellites and rockets to be used were still, and would remain for a long time, uncertain. For these reasons, cost estimates for the experimental pre-operational satellite were tentative and reached an overall expense of $120 million for both NASA and ESRO contributions - including the development of a 250 kg spacecraft, four flight units and three Delta launchers, ground facilities and aircraft equipment plus internal costs.

A revised version of common mission specifications was presented for comment to the ICAO in October 1969 and February 1970. The panel recognised that the project would be "an important contribution to joint international research and development' and agreed to recommend to the Air Navigation Commission (ANC) "that states directly concerned with this programme accept and act on any ICAO requirements and keep ICAO fully informed of all developments".[1080]

By December 1969 the first working session including ESRO, NASA, the FAA and European ATC experts (Eurocontrol, UK Board of Trade, SGAC) was organised in Paris, the common leadership being provided by A. Jones (NASA, Goddard Space Flight Center, earlier director of the Syncom project) and D. Lennertz (ESRO, Manager Air Traffic Control Mission).[1081]

Throughout 1969 and 1970, at NASA's insistence, ESRO/NASA discussions were kept exploratory and informal; neither management responsibilities nor industrial arrangements for the development of a common satellite were ever discussed. Moreover, NASA did not seem to have any combined official position with FAA, responsible since 1958 for controlling both civil and military air traffic in the

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1079 HAEUI, folder 50242. First Draft of a common NASA/ESRO Mission Specification for a NASA/ESRO Traffic Control Satellite (NETCOS) System, 25 July 1969. Earth terminals, communications and air traffic control (ATC) centres were all generally defined as ground stations.

1080 Cited in *ESRO/ELDO Bulletin* No. 9, April 1970, p.18.

1081 Information about this meeting is given in HAEUI folder 50782, minutes of the 4th NASA/ESRO review and coordination meeting on NETCOS, 10-12 December 1969.

National Airspace System.[1082] Its difficulties were increased by the fact that the new Nixon Administration, which entered office in January 1969, seemed willing to take a strong position on the question of communication by satellite – and, actually, a proposal to establish a special office attached directly to the White House was presented by Nixon to Congress in February 1970.

All the same, the ELDO General Report of 1969 noted with satisfaction "an encouraging similarity of views on various essential technical aspects".[1083] By 1970, Europeans felt entitled to believe that there was a broad understanding "that the formula to be drawn up should not follow that of previous cooperative programmes but should rather permit closer involvement of both sides of the Atlantic in all respects: in particular in the management of the programme, the design, development and manufacture of the hardware, and the development and use of the software.[1084] This formula fitted with the invitation that Thomas Paine had extended in October 1969 to Europeans to participate in the American post-Apollo programme and helped to create a rather rosy picture of the prospects of collaboration in space with the US in future. In the document that had been presented to Europeans on that occasion, the US declared themselves "ready to provide launch services and share technology wherever possible" and to "make arrangements to involve foreign experts in the detailed definition of future United States space programs and in conceptual design studies required to achieve them".[1085]

The European position on financing, management and contracts was clarified to American partners by J.A. Dinkespiler in a letter sent to A. Frutkin, NASA's Assistant Administrator for International Affairs, in April 1970. A NASA/ESRO Integrated Project Team responsible for the execution of the programme was foreseen. External contracts were to be placed for the development, manufacture and test of space, air and ground segments; the distribution of work between the USA and Europe was to be done in terms of percentage of contributions, which were to be equally shared between the USA and Europe (with no transfer of funds across the Atlantic foreseen). The creation of consortia including European-US firms was deemed necessary: two consortia should be selected under tender action, to develop competitively the Project Definition Phase, at the end of which one consortium would be selected for the subsequent development phase.[1086] The principle of availability and exchange of results obtained during the execution of the project – a principle which would be soon accepted in Intelsat – was also asserted.[1087]

By March 1970 the possibility of using ATC satellites over the Atlantic beyond 1975 was positively considered by ESRO. An Experimental Programme was immediately started in view of the aircraft/balloon [1088] tests to be carried out in September of the same year. Participation of the UK, the USA (NASA) and Germany (observers only) was obtained as well as coordination with the French programme of tests. Air traffic safety and savings on operational costs for airline companies, resulting from the reduction of aircraft separation distances (lateral, longitudinal and vertical), were two of the main merits of the project.[1089]

1082 HAEUI. folder 51220, Vandenkerckhove report on discussions with NASA (Paris, 1-2 December 1969). attached to DPP/AS/MAR/12 403, 23 December 1969. See also HAEUI, folder 50771, Report on attendance at 6th NASA/ESRO Review and Coordination Meeting on Aeronautical Satellites, NASA, 15-16 June 1970. and Associated Discussions, ESTEC.

1083 *ESRO General Report 1969,* p.128.

1084 HAEUI folder 51220, Air and Maritime Traffic Control Satellite System.

1085 See Lorenza Sebesta, "The Politics of Technological Co-operation in Space: US-European Negotiations on the post-Apollo Programme", *History and Technology,* 1994, vol. 11. p.325.

1086 HAEUI. folder 50242, Letter Dinkespiler to Frutkin, 1 April 1970.

1087 *Ibid,* Letter Bondi to Frutkin, 20 May 1970.

1088 Transponders carried by balloons were used as simulations of aeronautical satellites with the purpose of measuring multipath effects in the L-band, comparing various modulation techniques for voice data and ranging signals and testing the performance of high gain aircraft antennas.

1089 HAEUI, folder 50242, ESRO, 8779/PB/LV 16 March 1970, Considerations concerning the preparation of the Air Traffic Control Satellite Project.

After consultation with British, French and German air traffic control agencies, Bondi informed Frutkin about European willingness to proceed with an L-band system, instead of the hybrid VHF/L-band system the US were proposing.[1090] The third ASTRA panel of ICAO meeting in February and March 1970 also stated its preference for the UHF frequency band for the system.[1091]

In July 1970, the ESRO Council accepted in principle the guidelines for cooperation between NASA and ESRO concerning the execution of an experimental and pre-operational aeronautical satellite system over the North Atlantic.[1092] Thereafter, the Ministerial Meeting of the ESC formally decided "to embark upon a programme of applications satellites" and in particular "to execute an aeronautical satellite programme and to make an immediate start on the project definition in co-operation with NASA". The Conference also decided to make available to ESRO for the rest of 1970 and for 1971 $5.8 million for this purpose. This decision was taken in the context that the estimated share of the cost to Europe of a North-Atlantic pre-operational system would be of the order of $60 million (i.e. half of a $120 million system). Informal presentations of the programme to European civilian airlines were made in August in Washington by the FAA/NASA and in Paris by ESRO. The beginning of discussions on an ESRO-NASA Memorandum of Understanding was scheduled for September 1970 and specifications, work statements and supporting working papers jointly prepared by ESRO and NASA.[1093]

The placing of the contracts for these studies, however, was delayed pending the American Government decision on the preferred frequency band and on the assignment of management responsibility within the USA.[1094]

While awaiting the partner's decision, on 22 December 1970, ESRO approved a $5 million budget allocation for Phase-B studies of the technical parameters and design of an air traffic control satellite system for the North Atlantic.

8.4 The first official American position on satellite telecommunication for international civil aviation operations, January 1971

On 7 January 1971 the reasons for NASA's cautious attitude towards Europe became clear. In a much publicised "Statement of Government Policy on Satellite Telecommunications for International Civil Aviation Operations", the Office of Telecommunication Policy (OTP) – a creation of the newly elected Nixon Administration to keep under control both NASA's policies and private firms' behaviour (especially on export licences) on telecommunication policy - defined US policy *vis-à-vis* satellite

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1090 HAEUI, folder 50771, Letter Bondi to Frutkin, 14 May 1970.

1091 HAEUI, folder 50242, Report of studies carried out in the field of aeronautical satellite systems during the period January to June 1970 (ESRO).

1092 Pre-operational differed from experimental systems in that they would perform operational as well as technical evaluations. While such systems might often be designed as potential operational systems, they might also provide only some of the functions that would be required ultimately in an operational system. This definition is taken from the "Statement of Government Policy on Satellite Telecommunications for International Civil Aviation Operations", 7 January 1971. *cit*

1093 For the July ESC Ministerial Meeting see *ESRO/ELDO Bulletin* No. 11, September 1970, pp. 8-24; also HAEUI, folder 50242, letter Depasse to Frutkin, 3 August 1970.

1094 *ESRO/ELDO Bulletin* No. 13, April 1971; *ESRO News,* p.22.

communications for overseas civilian aeronautical operations. This policy was to provide the framework for the development of aeronautical satellite programmes during the 1970s.[1095]

OTP was directed from September 1970 by Clay T. Whitehead, a young and resolute system analyst coming from the Rand Corporation. The office was directly attached to that of the US President. Among its main objectives, the directive was to "assure that program institutional arrangements" be "responsive to the requirements of users, compatible with the evolving National Aviation System, and consistent with the foreign policy objectives and commitments of the United States".

Because of the involvement of the international community, the State Department was to be responsible, on behalf of the Department of Transportation/Federal Aviation Administration (DOT/FAA) (which had the statutory responsibility for air traffic control), for seeking "international *utilisation* of the pre-operational system and should initiate cooperative activity with other nations to establish an operational system in the Atlantic and Pacific ocean areas by l980".[1096] The statement advocated that "unambiguous leadership" for the programme be vested in the DOT/FAA. It would be given the "responsibility for defining requirements, program budgeting, and management of pre-operational and operational systems activity" for the Pacific by 1973 and by 1975 for the Atlantic.[1097] DoT should also explore along with "appropriate government agencies" the possibility of performing both aviation and maritime services from a single system.

The FAA should "contract for services on a lease basis in contrast to government procurement and ownership of systems". NASA was left to "conduct independent research and development on technologies which have broad application and, under the management and budget of the Department of Transportation, to provide other technical support unique to transportation applications".[1098]

As far as technical parameters were concerned, in line with repeated European suggestions, the hypothesis of a hybrid satellite was abandoned and the UHF frequency band near 1600 MHz scheduled for both operational and pre-operational satellite air traffic control and communication.

Before publication, when the document had been circulated at the level of a draft within the responsible agencies, NASA had strongly reacted to both the prospect of such a restricted role for itself and to the limited internationalisation of the programme. From this point of view, it had been pointed out that "US policy should recognise the desires of the Europeans to participate in the *development as well as the utilisation* [emphasis added] of the pre-operational system in the Atlantic and the desirability to the USA, from cost-sharing and other standpoints, of having them do so". Therefore, NASA expected to continue, in concert with DoT and the Department of State, to work

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1095 The policy was established "with participation by interested agencies in the Executive Branch". George F. Mansur, Deputy Director, OTP, chaired the study group and coordinated the OTP policy formulation. WHCF, Subject Files, UT1, box 14, Executive Office of the President, Press Release, Nixon Administration announces policy on aeronautical satellite communications, 7 January 1971. This statement was supplemented by another one issued on 19 March 1971, "The National Program on Satellite Telecommunications for International Civil Aviation Operations", (HAEUI, folder 50771, attached to letter Nilson to Hammarström, 2 April 1971) which followed the same lines.

1096 Emphasis added by the author. Pre-operational were those "aeronautical systems with emphasis on performing operational as well as technical evaluations. For the purpose of their evaluation they would need to operate in parallel with conventional communication and/or radio-determination systems serving Air Traffic Control. It is understood that carriage of the airborne elements of such systems would be on a voluntary basis. It is also understood that while such systems might be designed as potential operational systems, they might also provide only some of the functions that would be required ultimately in an operational system". Nixon Project, WHCF, subject files, UT1 box 14, Executive Office of the President. Office of Telecommunications Policy, Statement of Government Policy on Satellite Telecommunications for International Civil Aviation Operations, 7 January 1971.

1097 *Ibid.*

1098 Nixon Project, WHCF, subject files, UT1 box 14, Executive Office of the President, Office of Telecommunications Policy, Statement of Government Policy on Satellite Telecommunications for International Civil Aviation Operations, 7 January 1971.

cooperatively with ESRO in further studies of the system to meet the requirements stated by the DOT-NASA memorandum and agreed by Europeans.

As far as NASA's role was concerned, the National Aeronautics and Space Act of 1958 had advocated for NASA the responsibility to develop advanced research for prospective applications, i.e. *experimental* satellites. As had happened with meteorological satellites (where NASA was collaborating with the Department of Commerce), NASA considered that its budgetary and management responsibilities should extend in aeronautical satellites to the pre-operational systems, in case the experimental satellites were successful.[1099] In this case "NASA should be responsible for the actual development, working against requirements specified by the responsible operating agency, at the appropriate time, for use in pre-operational or operational systems". In the case of the US-ESRO satellite, NASA considered that DOT/FAA should be the lead agency, specifying the requirements to be met and managing pre-operational and operational activities.[1100]

Some features of the OTP policy statement seemed to go against the preliminary guidelines reached between ESRO and NASA – mainly the international utilisation of the system, versus its joint development and utilisation,[1101] and the contract on lease basis versus the government procurement and ownership of systems. Moreover, the legitimacy of NASA as credible negotiator on the US side was heavily damaged by the decision to entrust the whole responsibility for the satellite, in both the pre-operational and operational phase, to the FAA/DOT.[1102]

It is important to remember that OTP's inflexible attitude towards co-operation on Aerosat fitted into its extremely negative attitude towards US-European co-operation in space in general. In February 1971, one month after the release of the OTP policy statement, Whitehead heavily criticised the contents of US-European negotiations on the post-Apollo programme, whose sole effects would be, in his opinion, to give away US space launchers, space operations and related know-how at too low a price.[1103]

8.5 'There is room for mild optimism, but we have a lot of hard work ahead of us':[1104] towards the first ESRO – FAA Memorandum of Understanding, June-December 1971

ESRO quickly reacted to the OTP announcement of January with an ESRO Council decision of 23 February 1971 to start three research contracts, each amounting to $600,000, with three European industrial consortia (MESH/AEG, COSMOS and STAR) for the predevelopment of the payload and other critical subsystems, to be launched in 1974-75 by an American Delta or by a Europa II rocket. These studies were started on 1 April 1971 and terminated in January 1973 when additional funds of

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1099 For interagency disagreements between NASA, the Weather Bureau and the Department of Defense on weather satellites see Pamela Mack, *Making big technologies serve the user: US remote sensing programs,* in John Krige (ed.), *Choosing big technologies* (Chur: Harwood Academic Publishers) 1993, pp. 96-99.

1100 Low Papers, box 19, Letter Low to Whitehead, 31 December 1970.

1101 In "The National Program on Satellite Telecommunications for International Civil Aviation Operations" statement, the American position towards international participation had been somehow bettered. Along with the new formulation "DOT/FAA, in coordination with the Department of State, should seek co-operation with other interested governments as appropriate in planning and implementing the National Programme", see HAEUI, folder 50771, OTP, "The National Program on Satellite Telecommunications for International Civil Aviation Operations", 19 March 1971; attached to Letter Nilson to Hammarström, 2 April 1971.

1102 HAEUI, folder 50242, Draft letter from the Chairman of the ESRO Council to the European Ministers responsible for Aeronautical Activities, 22 February 1971.

1103 L. Sebesta, *art. cit.,* pp. 329-330.

1104 The expression was used by Roy Gibson in his report on the Washington meeting, HAEUI, folder 50933,. Memorandum Gibson to Hammarström, 21 June 1971.

$ 300,000 each were given for the continuation of the predevelopment effort on payload elements.[1105] The specification and work statement took into account the result of the ICAO ASTRA panel meetings and were prepared by ESRO under guidance from the Ad Hoc Group.[1106]

Soon after, G. Puppi, Chairman of ESRO Council, addressed a letter to all delegations proposing the creation of a European delegation (later to be called the European Ministerial Group for Aeronautical Satellites, which had its first meeting on 30 April 1971, headed by J.J. Robinson and, later, by the Spanish Minister for Air, Salvador Diaz-Benjumea) to explore the possibilities of further co-operation with the USA in the light of these new developments.[1107]

Facing the prospect of the development of a rival system to a wholly US project – which could result in a potentially dangerous adversary within ICAO – the Office of Management and Budget (OMB) instructed DoT on 11 June 1971 to "fully explore the possibilities of making this [the aeronautical satellite programme] an international project" in order to further international co-operation in line with the President's overall objectives, to share the costs of the programme and to ensure necessary approval by the ICAO. Ten of the twenty-seven members of the ICAO Council could veto standards – and both the Europeans and Canada had actually implied that they would veto a US-only system.[1108]

A first exploratory informal meeting took place between the US (the Federal Aviation Administration and NASA) ESRO (the European Ministerial Group for Aeronautical Satellites, set up in March), Australia, Canada, Japan and the Philippines on 15-17 June 1971 in Washington. Europeans and Americans decided to stop their unilateral studies. The Europeans made it unequivocally clear that they would not accept a pre-operational programme in which they would merely be subscribers to services provided by a system unilaterally established by the US. The Europeans also made clear that financial support for a cooperative programme was available and if such a programme were not attainable, they would proceed on their own.[1109]

Notwithstanding the US delegation's initial hesitation on the cooperative formula for fear of consequent delays, the principle of a unified, joint programme for pre-operational aeronautical satellites was considered desirable: this was an impressive departure from the OTP's public declaration. Yet, problematic areas, which would be permanent weak points throughout the negotiations, clearly emerged under the more optimistic generalisations. These were questions related to the cost-sharing, the leasing versus pre-funded programme, the procurement procedures, the system management and launch priorities.[1110] A joint International Collaboration ad-hoc Group (ICAHG or ASIC) (with four Americans, four Europeans, a Canadian, an Australian, a Japanese and a Filipino representative) was formed in order to consider the whole range of technical and administrative problems associated with the programme.

Its proposals for the creation of a unified aeronautical satellite system, to be called from now on Aerosat, were discussed at a second meeting, held in Madrid from 3 to 5 August, under the chairmanship of the Salvador Diaz-Benjumea. "For the first time", commented the scientific expert of

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[1105] ESRO/PB-AERO(73)34, Annex I,Activities financed through the 1973 Aerosat Budget, 14 November 1973.

[1106] HAEUI, folder 50242, ESRO/CERS Communiqué: System Definition and Design Studies Aeronautical Satellite Programme, 21 April 1971.

[1107] HAEUI, folder 50933, First Report of the European Ministerial Group for Aeronautical Satellites to Minister Lefèvre, ESC, 17 June 1971.

[1108] NSC action 35902; Nixon Project, WHCF, Subject Files, UT1 box 14, Memorandum from John Walsh to General Haig on About-face on Aerosat, 21 October 1971.

[1109] Nixon Project WHCF, Subject Files, UT1, box 14, Summary of international aviation and foreign policy issues in the aeronautical satellite program, no date, no author (but, probably, by the Department of State).

[1110] HAEUI folder 50933,First Report of the European Ministerial Group for Aeronautical Satellites to Minister Lefèvre, Chairman, European Space Conference, 17 June 1971.

Le Monde, "co-operation with the United States in the field of application satellites seems to be getting under way under conditions of equality".[1111]

According to the European report of the meeting, "The Aeronautical Satellite Meeting concluded that to bridge the gap in time and knowledge between the current experimental efforts and an operational satellite capability anticipated around 1980, a pre-operational aeronautical satellite system for the Atlantic and Pacific Oceans be jointly developed, funded, managed, implemented and evaluated by Europe (participating ESRO Member States and other European states associated with ESRO), the US (FAA) and other interested states, based on the principle of equal sharing of responsibilities, expenses and effort between the major parties (US/Europe) in which other states can participate, and based on a system specification to be jointly prepared". A distinction was made between the integrated programme, to cover the space segment, satellite development, the manufacturing of the spacecraft flight units, the launches, the satellite control facilities, the programme management, and the coordinated programme, which should cover ground stations and developments of avionics.[1112]

The signature of a Memorandum of Understanding to formalise the agreement along these lines was envisaged for October, as was the creation of an Aerosat Council for managing the project, to be composed of an equal number of European and American representatives. In the meantime, the ICAHG would try to prepare a request for proposals (RFP), intended to generate proposals for design, manufacture and launch of not less than four geostationary satellites to provide pre-operational aeronautical services. This programme was to be funded by the states concerned in accordance with their respective national policies.[1113]

After a further meeting in Washington (19-20 August),[1114] the FAA reached an agreement on a joint project with ESRO (representing ten European nations), Australia, Canada and Japan in London in November.[1115] Four launches would take place between 1974 and 1980, after which the operational system would be gradually set in motion. The agreement was limited to a pre-operational system for test and evaluation purposes, with the operational follow-on system to be negotiated in the future.

The essential features of the MOU were:

- provision for joint US-European procurement of four identical stationary satellites, two over the Atlantic and two over the Pacific, to be placed in orbit by 1977 at a cost ranging between $125 million and $142 million (integrated programme);

- provision for separate but coordinated procurement of ground stations and pre-production aircraft avionics (coordinated programme)

- provision for use without charge of satellite capability by the major partners and the other nations wishing to join in the coordinated aeronautics experimentation (thus, the FAA was renouncing the leasing concept for the pre-operational phase of Aerosat). The US appeared to provide by far the most relevant users and were expected to use about two-thirds of the system capability without user charges;

- Europeans were ready to assume half the full programme cost – half the launch cost, half the administrative cost of the management facility and the necessary US procurement to fulfil contractual obligations allocated to European subcontractors by an anticipated American prime contractor. The Americans agreed on a kind of *juste retour* principle whereby Europe would

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[1111] Dominique Verguèse. "Les Etats Unis et l'Europe étudient la création d'un nouveau système de communication par satellite", *Le Monde,* 9 September 1971.
[1112] HAEUI, folder 9356, Report of the "Aeronautical Satellite (Aerosat) Meeting", Madrid, 3-4 August 1971.
[1113] HAEUI, folder 50933, ESRO/CERS Communiqué, 6 August 1971.
[1114] All ESRO members except Denmark participated.
[1115] HAEUI, folder 7706, ESRO AF(71)75, rev. 3, London, 22 November 1971.

obtain half of the industrial contracts. While the choice of the prime contractor should be made according to an international bid (best price, best time and best cost) the prime contractor should have European partners carrying out the work;

- provisions for joint and equal management requiring unanimous US-European agreement through an Aerosat Council on which the US and the Europeans, as a group, would each have one vote. This would be equivalent to a veto by either party;

- provisions for joint and equal ownership of the satellites. Because of the pre-operational character of the programme, ownership of the follow-on operational system, whose use would become mandatory after approval by ICAO, was to be the subject of future negotiations. Australia, Canada and, most probably Japan, would participate on a non-partnership, advisory basis, each contributing $4 million and engaging in the testing and evaluation effort, but on a non-production basis.

- The MOU furthermore established that the FAA and ESRO should "ensure by means of their contract with the Aerosat contractor that they [were] able to obtain a full disclosure of all technical information and inventions generated by work performed on their behalf and that they [obtained] from the Aerosat contractor the right, without additional payment to him, to disclose and use, and authorise others, under the jurisdiction of the Member States of ESRO participating in the Joint Aerosat programme, of the United States, of the Commonwealth of Australia, of Canada and of Japan, to disclose and use, within the same jurisdiction, such technical information and inventions including any new embodiment so generated of a previously existing invention incorporated in such information" (art. 11, point 1). This article was similar in spirit and wording to the one introduced in the permanent Intelsat agreement signed in August 1971, by which Europeans had obtained a much more liberal access to technology developed within Intelsat than previously anticipated in the Interim agreement.[1116]

The MOU was to terminate on or before 1 January 1980.

[1116] The text of the agreement, opened for signature in August 1971 and entered into force in February 1973 (done and entered into force at the same dates) is in *Space Law and Related Documents. International Space* Law *Documents. US Space Law Documents,* 101st Congress, 2nd Session, June 1990, pp. 211-318. Under article 17, Intelsat would have "the right without payment to have disclosed to it all inventions and technical information generated by work performed by it or on its behalf" (point I) and "the right to disclose and have disclosed to Signatories and others within the jurisdiction of any Party and to use and authorise and have authorised Signatories and such others to use such inventions and technical information; (a). without payment, in connection with the Intelsat space segment and any Earth station operating in conjunction therewith, and (b). for any other purpose, on fair and reasonable terms and conditions to be settled between Signatories or others within the jurisdiction of any Party and the owner or originator of such invention and technical information or any duly authorised entity or person having property interested therein". Point D of article 17 further specified that Intelsat should ensure for itself the right, on fair and reasonable terms and conditions, to disclose and have disclosed to Signatories and others within the jurisdiction of any Party, and to use and authorise and have authorised Signatories and such others to use, inventions and technical information directly utilised in the execution of work performed on its behalf but not included in paragraph B, to the extent that the person who had performed the work was entitled to grant such aid and to the extent that such disclosure and use was necessary for the effective exercise of the rights obtained pursuant to paragraph B. A similar provision was contained in point 4 of article 11 of the Aerosat MOU.

8.6 "About-face on Aerosat':[1117] the deadlock on the ESRO-FAA Memorandum of Understanding

Despite positive consideration by the ASTRA panel of the NASA/ESRO programme, critical remarks about Aerosat were aired in 1971 by one of the major airline companies, TWA, by the organisation set up by commercial airlines to provide joint point-to-point communications for all owners in the HF band (not entitled at the time to provide satellite communication services), ARINC, and by IATA, on grounds of 'conservative' concerns. This behaviour was not unexpected, in view of the reluctance usually shown by organisations to adopt any new project implying long term investments and deep organisational change that could be to the detriment of their current position. The airlines resented having substantially been excluded from negotiations on requirements and parameters; their criticisms also concerned costs implied in the future operational project (future increase in user charges) and its reliability (fear of possible UHF problems, for example).[1118]

To these diffuse criticisms by future potential users, OTP added three strong objections to the text of the Memorandum – in this respect it is very interesting to note that George Mansur, a close collaborator of Whitehead in OTP, was Director of ARINC.[1119] Peter Flanigan, Special Assistant to the President, was soon informed by Whitehead about these objections, which touched upon the ownership of the system, the production sharing versus competitive bid and the opportunities for use by maritime and other interested partners.[1120]

1. Ownership. Traditionally, commercial communications were provided by government-owned postal, telephone and telegraph (PTT) administrations in Europe, while a semi-private corporation, Comsat, was entrusted to do the same for communications by satellites in the USA. Comsat's almost monopolistic situation within Intelsat had been resented by Europeans since 1964 and this resentment was aired during the negotiations of the permanent agreement, begun in 1969. In Aerosat, Europeans had decided to struggle for an international "version" of their state-owned systems. Therefore, the MOU established that the FAA and ESRO would become "co-owners of the satellites" (art. 7, point 4) and stated that ESRO and the FAA should "equally share the responsibilities, expenses and efforts on the Integrated Program" (art. 1, point 1)[1121]. By contrast, the policy issued by OTP in January stated that the Government should "utilise commercial telecommunications facilities and services to the maximum extent feasible in both pre-operational and operational systems". Though the expression "to the maximum extent feasible" seemed to leave a door open for some flexibility, OTP later clarified its wish to define the expression restrictively. Alexis Johnson, Under Secretary of State and State representative for US-European space cooperative affairs, was told in August 1971 that "ownership of the system [was] to be in the private sector with the FAA service requirements provided through lease arrangements"[1122].

1117 This expression is used under the heading "subject" by John Walsh, member of the National Security Council, in a memorandum addressed to General Haig on 21 October 1971; Nixon Project, WHSF (Special Files), Staff Member and Office Files, Flanigan, box 9.

1118 HAEUI, folder 50933, Telegram from Israel to Vielliers, 22 October 1971; *ibid.,* Discussion paper by Israel (David Israel was Director, Office of Systems Engineering Management of the FAA) for the FAA/ATA/ARINC meeting, 1 November 1971.

1119 Information provided to L. Sebesta by R.C. Collette, letter 3 July 1995.

1120 Nixon Project, WHCF, subject files, UT1, box 14. Letter Clay Whitehead to Alexis Johnson, Under Secretary for political affairs, 12 August 1971; *ibid..* Memorandum for Mr. Flanigan, Attachment A, 14 February 1972.

1121 The Joint Aeronautical Satellite Programme (referred to as the Joint Aerosat Programme) consisted of an integrated programme and a coordinated programme: this last one dealt with ground facilities (communications centres and Earth terminals) and aircraft avionics (development installation, testing and pre-operational evaluation of the necessary aircraft avionics).

1122 Nixon Project, WHCF, subject files, UTl, box 14, Letter Clay Whitehead to Alexis Johnson, Under Secretary for Political Affairs, 12 August 1971.

2. Production sharing versus competitive bid. In general terms, cost/efficiency considerations pushed for the choice of the most qualified among the bidders, while political concerns on the necessity to catch up technologically went in the opposite direction, suggesting some sort of affirmative action to support weaker firms. It was the same question that had divided European space organisations and had been solved in ESRO through the *juste retour* formula, by which the percentage of European contracts had to be linked to the contribution of the country involved [1123].

OTP's directive did not deal directly with this topic. However, the omission, against NASA's suggestion, of any reference to the share of development and management clearly indicated OTP's reluctance to co-handle these phases of the project. This reluctance was repeatedly clarified to FAA officials by George Mansur in summer 1971: the principle of competitive bidding had to be considered "implicit" in the OTP directive. Performance requirements, in contrast to equipment specifications, had to be the guidelines for any cooperative venture. In order to reinforce his statement, Mansur made reference to a "clear precedent not to enter into arrangements with any nations whereby predetermined 'production sharing' by formula [was] a criterion for co-operation". American policy within NATO and Intelsat were the "clear precedent" he was referring to[1124].

References to both NATO and Intelsat were somewhat dubious. NATO's application of international bids for armaments had been discussed within the US administration since the beginning of the 1950s, when the creation of an integrated defence production and procurement system was discussed. The criterion did not come to have universal support either among European allies or within the US administration. Favoured by the Department of Defence – especially concerned to keep international orders for its own military-industrial complex – it had been opposed by the Department of State and the European Co-operation Administration (ECA), willing to use arms production for political purposes. The latter two understood quite well that the structural and historical advantage of the US military sector would inevitably mean assigning all the contracts to US firms. Therefore, European states would be pushed, in their opinion, to give public subventions to military industries, keeping prices artificially low in order to compete in the international bids. In any case, the integrated system of procurement had failed by the end of the 1950s and NATO integrated production was limited to some aeronautical projects[1125].

Reference to Intelsat as an example of international bidding was rather ironical. One of the big controversial issues within Intelsat, as regulated by the Interim Agreement (still in force until the ratification of the permanent one), had been Comsat's willingness to give priority to in-house R and D over international contracts in order to give primary consideration to the corporation's need to increase its managerial competence and to discharge its task with the maximum possible efficiency. It was only under pressure from the other members that the percentage of contract expenditures had been progressively increased from 13% in 1968 to 50% by the end of the consortium's life, in l972[1126]. Reference to the procurement practice of "open international invitations to tender", with some

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1123 John Krige and Arturo Russo, *Europe in Space, 1960-1973* (Noordwijk, ESA Publications Division), 1994, pp. 121-122.

1124 Memorandum for the file, on Aerosat, Results of meetings of 15.16 and 17 June 1971, George Mansur, 21 June 1971, *ibid.*.

1125 Till Geiger and Lorenza Sebesta, "National Defence Policies and the Failure of Military Integration in NATO. American Military Assistance and Western European Rearmament, 1949-1954", in F. H. Heller and J. R. Gillingham (eds.), The United States and the Integration of Europe, Legacies of the Post-War Era (New York: St Martin's Press) 1996, 253 - 279. See also Ine Megens. American aid to NATO allies in the 1950s. The Dutch Case. PhD Thesis. Groningen. 1994, pp. 183-189.

1126 Steven Levy, "Intelsat: Technology, politics and the transformation of a regime". *cit.*, pp. 661-664. The text of the Agreements establishing interim arrangements for a global commercial communications satellite system is in *Department of State Press Release* No. 364, 28 July 1964, reproduced in House of Representatives, *Hearings before a Subcommittee of the Committee on Government Ooperations,* 88th Congress, Second Session (Washington DC: US General Publishing Office) 1964, pp. 775-786.

limitations provided in the article, was added to the Intelsat permanent agreement (art. 16) originally against Comsat's will[1127].

The FAA-ESRO MOU, on the contrary, "in view of the special nature of this partnership and to encourage the broadest future participation and competition on the industrial side" agreed that "the objectives of keeping costs to a minimum and entrusting the work to a competent industrial contractor [should] be accomplished with *fair and reasonable distribution of work* among member states of ESRO participating in the Joint Aerosat programme and the United States" (art. 7, point 3)[1128].

3. Multiple (or general) user system. Guidelines provided by the OTP in January favoured the creation of a "single system" to support both maritime and aviation services "in order to assure economic benefits". This directive, though, left the Department of Transport the freedom to "work with appropriate Government agencies to explore the feasibility and desirability of such an approach". The ESRO-FAA memorandum, on the contrary, envisioned a pre-operational aeronautical satellite and did not make reference to the potential users of the system other than aeronautical companies.

On the basis of these three main objections, Whitehead and Mansur tried from August 1971 onwards to stop negotiations in order to obtain "an in-depth policy review prior to formalisation of a joint program"[1129]. Their reservations, Mansur stated, were shared by the industry and by the civilian airlines [1130].

John Shaffer, Administrator FAA, did not deflect from his decision to pursue discussions with the Europeans, though admitting that proposed arrangements should be "subject to further review within the US government". On the contrary, he showed resentment for OTP's comments, which he qualified as "unfortunate" and which "could undermine our important relationships and dealings with the world's civilian aviation community. We certainly appreciated", continued Shaffer, "your point that this pre-operational Aerosat program has implications well beyond FAA's unique aeronautical interests; however, it is also important to note that FAA interests, responsibilities, and commitments to international civil aviation go well beyond and are much deeper than the telecommunication aspects of the Aerosat program. This duality must be recognised by both parties" [1131].

By the time the FAA began seeking budgetary approval, serious problems were raised by other high-level officials, such as Peter Flanigan, Special Assistant to the President, very close to Whitehead, and Donald Rice, from the Office of Management and Budget (OMB). OMB's policy was part of a broader trend of the late 60s against the start of any public-funded space application programme if not supported by a strong financial partnership of potential users[1132]. All this had to be framed in a period of retrenchmen of space expenses after the attainment of the lunar goal and in the context of serious internal and international economic crises.

In this specific case, criticisms stemmed from two main observations: (i) "US industry should be allowed to exploit its good competitive position in an unrestrained way"; (ii) "a joint program would transfer to Europe technology which was expensively developed with US investment". Still, John Walsh, an authoritative member of the highly influential National Security Council, treated the first observation as a (highly disputable) "philosophical" stand, considered the technology transfer "more imagined than real", and favoured an open-minded approach to the problem. "Our already fumbling

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1127 The provision of the interim agreement (contained in point c of art. 10 of the Special Agreement) attached to the Agreement establishing interim arrangements for a global commercial communications satellite system, done in July 1964.

1128 Possible participation by the industry of Australia, Canada and Japan was not excluded.

1129 Nixon Project WHCF, Subject files, UT1, box 14, Letter Whitehead to John Shaffer, Administrator, Federal Aviation Administration, 17 September 1971.

1130 *Ibid.,* Letter Mansur to Shaffer, 24 September 1971.

1131 *Ibid.,* Letter Shaffer to Mansur, 29 September 1971.

1132 Homer Newell, *Beyond the Atmosphere, Early Years of Space Science* (Washington DC: NASA History Series) 1980, pp. 374-375.

post-Apollo co-operation effort", he stated, "might be further crippled by our withdrawal from Aerosat". "We are too far down the road", he added, "to back out with any semblance of grace at this time".

Henry Kissinger, the National Security Advisor to the President, was called upon to settle the dispute: Walsh prepared for his signature a Memorandum favouring the ratification[1133]. State Department support for the ESRO-FAA memorandum was stated in two subsequent documents: a memorandum by Philip Trezise, Assistant Secretary for Economic Affairs, sent to Rice (OMB) on 20 October 1971, and a higher level document sent from Under Secretary Johnson to Kissinger on 1 November[1134]. The latter summed up the standard opinions in favour of co-operation:

- the unfavourable impact that a withdrawal could have "not only in future co-operation in post-Apollo and other space-related activities, but on overall US-European relations";
- a clear diminution of American influence in ICAO and, in case the US decided to go it alone over the Pacific, a possible decision by the Europeans to proceed unilaterally over the Atlantic. In this last case the Europeans had the power to make their own systems specifications as operational standard by ICAO over any competing US proposals – and the US had given (limited) assurances on their willingness to launch European satellites;
- a favourable balance of payments effect.

As for the technology transfer, Johnson thought that "given the state of the art in Europe, the benefits of a joint program (could) be obtained without the loss of United States technological advantage". Moreover the MOU included provisions ensuring the application of the standard technological export controls through the Munitions Control regulations.[1135]

These two documents reached Kissinger, as well as a supplementary piece of information on the industry position on the subject. Apparently, this paper had been prepared to offset claims by the OTP that US industry was totally opposed to the ESRO-FAA memorandum. Satellite manufacturers General Electric, TRW, RCA, Philco-Ford and Hughes during their conversations with representatives of the Department of State and DOT/FAA favoured, it was stated, such an agreement[1136]. Moreover, with the exception of Hughes, they did not favour any "lease" arrangement.

On 17 November, Johnson was reached by a telegram, then passed to the White House, from the US Embassy in London, which stressed in strong terms European, and especially British, concerns about a possible delay in the signature of the Memorandum. "The British", it was said, "feel Aerosat is a single element of space program for which (airline attitudes not withstanding) there is definite and early need". The hypothesis of a reconsideration of the US position was seen by the British as "pretty disastrous" (inverted commas used in the text to report UK position). In addition, the British

1133 Nixon Project WHSF (Special Files), Staff Member and Office Files,. Flanigan, box 9, Memorandum Welsh to General Haig, 21 October 1971, "About-face on Aerosat", National Security Council urgent action.

1134 Nixon Project WHSF (Special Files) Staff Members and Office Files, Flanigan, box 9, Letter Philip Trezise to Donald Rice, 20 October 1971; *ibid.,* Memorandum Alexis Johnson to Henry Kissinger on DOT/FAA Pre-operational Aeronautical Satellite Program, 1 November 1971.

1135 Nixon Project WHSF (Special Files) Staff Members and Office Files, Flanigan, box 9, Memorandum Alexis Johnson to Henry Kissinger on DOT/FAA Pre-operational Aeronautical Satellite Program, 1 November 1971.

1136 In passing this document to Kissinger, Walsh commented on the industry's support, "I believe that a more apt description is that 'they can live with' an international program"; Nixon Project, WHSF (Special files), Staff Members and Office Files, Flanigan, box 9,. Memorandum John Walsh to Kissinger on Aerosat National Security Council information 34695.

government was counting on Aerosat "to help its 'European problem' by which it meant the overcoming of "the ambiguous British position caused by limited UK enthusiasm for European launcher development and other parts of the European space programme". It was hoped that the memorandum could be signed before ESRO's decisive Council meeting in December 1971 in order to help foster Europe's difficult redirection of work towards application satellites.[1137]

The memorandum, the draft of which had been prepared by Walsh, was duly signed by Kissinger on 22 November 1971, showing Kissinger's support for the State Department views: "I share your concern", stated Kissinger, "that withdrawing from negotiations at this stage would unfavourably impact overall US-European relations".[1138]

Soon after, the ESRO Council approved the so-called "first package deal", whereby nine Member States (Belgium, France, the Federal Republic of Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom) agreed to take forward the line of action approved at Bad Godesberg three years earlier. Three new satellite programmes were approved. The Aeronautical Satellite Programme, with a forecast cost of 100 MAU, was one of them – the other two being a yet undecided meteorological satellite programme (for a total of 115 MAU) and an equally yet undecided communications satellite programme (100 MAU being committed for its experimental phase)[1139].

An Arrangement between the nine Member States and ESRO concerning the execution of an Aeronautical Satellite Programme entered into force on 20 December 1971. Under this Arrangement, the participants decided to undertake, in co-operation with states that were not members of ESRO (the USA, Australia, Canada and Japan), a programme aiming at the design, development, launching and exploitation of a pre-operational air traffic control system up to a ceiling of 100 MAU plus a 20% overrun (a clause which would subsequently be applied to all ESA optional programmes) calculated on the cost of the Space Segment Capability[1140]. The envelope was to cover the organisation's share of the integrated programme, the part of the programme that provided for the placing of the satellites in orbit as well as their operation throughout the 7-year period envisaged for the duration of the programme. The coordinated programme, covering the setting up of aircraft avionics and ground terminals, was not included in the provisions of this memorandum.[1141]

Between 22 November 1971 and 9 February 1972, Kissinger reversed his position. His memorandum written on the latter date opposed the FAA-ESRO MOU on the basis of a review of domestic, Congressional and international considerations not further specified. OTP was directed to provide an updated statement of policy and to undertake responsibility for the substantive portion of the reopened negotiations[1142]. By March 1972, the American government let the Europeans know that the MOU that had been negotiated *ad referendum* was unacceptable: the FAA would not be able to sign the draft agreement prepared in 1971.

This decision has to be understood in the framework of a more restrained attitude towards co-operation with Europe in space which developed in the US from the end of 1970 onwards. As a matter

1137 Nixon Project, WHSF. Staff Members and Office Files, Flanigan. box 9, Telegram from US Embassy London to Secretary of State, 17 November 1971.

1138 "and have consequently so informed Mr. Flanigan" the memorandum ended. The text without signature is attached to Nixon Project, WHSF (Special Files), Staff Members and Office Files, Flanigan, box 9, Memo Walsh to Kissinger on Aerosat. 15 November 1971; the signed copy of Memorandum Kissinger to Johnson, 22 November 1971, is in Nixon Project WHCF, Subject Files. [EX], OS,. box 1.

1139 J. Krige and A. Russo, *op. cit*., pp. 105-107. Spain did not participate in the communications satellite programme.

1140 HAEUI, ESRO/AF(71)81. rev. 3. On 12 April 1973 the ESRO Council decided not to modify such an agreement, though proposing minor amendments to its annexes; HAEUI, folder 8682, ESRO/PB-AERO/MIN/13 February 1974, 11th Meeting (21 January 1974).

1141 HAEUI, folder 8772. ESRO/PB-AERO(75)8, The Aerosat Project, 6 May 1975.

1142 Nixon Project WHCF, Subject File, UT1 box 14, Memorandum Kissinger to the Secretary of State and the Secretary of Transportation, 9 February 1972.

of fact, international negotiations on the post-Apollo programme, which had been going on between the US and Europeans since the end of 1969, also experienced a final reduction of scope during the same months: in June 1972 the Europeans were informed that co-operation on the Space Transportation System (STS) had to be focussed on Spacelab, one of the three elements originally open for foreign participation, the other two being the Shuttle and the Tug.[1143]

Some of the reasons presumably conducive to the hardening of the American position in this context can also help us in explaining the outcome of the Aerosat negotiations. A special reference must be made, first of all, to NASA's decreasing willingness to collaborate with Europeans on the generous, yet indefinite, terms set out by Paine, after his departure from the Agency, in September 1970.

American interest was later weakened by the tormented decision taken at the ESRO Council of July 1971 to complement the Bad Godesberg resolution on launchers (i.e. that European launchers would be used provided they did not cost more than 125% of the equivalent US ones) with the provision that the US should formally agree in principle to provide launchers for all application satellites referred to in the resolution, for both their experimental and operational phases.[1144]

The signature of the Intelsat agreement in August 1971 further curtailed US interest in European co-operation and the effectiveness of the pro-European constituency at the Department of State. In addition, as has been already noted, there was a parallel increasing preoccupation shown by the officials of the new Administration about technological transfer or, as it was generally referred to, about the "give out” of American technology at cheap prices to allies in both military and civilian realms. This preoccupation, initially shared by a restricted number of high level officials inf Nixon's entourage (Flanigan and Whitehead first of all), led to a thorough scrutiny of the problem by the National Security Council, which ended in 1972 with the adoption of a still classified national policy on the matter. Last but not least, one should remember that the reduction in scope of US-European co-operation occurred during the final stages of the preparation of the US-USSR Summit of Moscow (May 1972), one of the outcomes of which was the decision to announce the bilateral cooperative space mission Apollo-Soyuz, on which official negotiations had begun in October 1970.[1145]

There is no doubt that within the context of American foreign policy of that period, US-USSR détente (of which Apollo-Soyuz was an important element) had a clear priority over preserving ties with the old European allies. A brief sketch of the US-European relationship within the context of American policy during the climax year 1971 will serve to better clarify this point.

Two events symbolise the drama in the country: the first was the start of the publication, in June 1971, by *The New York Times* of the Pentagon Papers, which heavily criticised the government's handling of the whole Vietnam war, and, through it, the whole question of the USA's "mission" in the world; the second was the top-secret meeting called by Nixon in summer 1971 to discuss the disastrous balance-of-payments deficit (accompanied by a severe reduction of gold reserves and the first US trade deficit since 1894) and to try to solve it. Neither representatives of the Department of State nor Kissinger himself were present at the meeting. The President relied, instead, on Treasury Secretary John Connally, who urged Nixon to put an end to the Bretton Woods system by refusing to sell foreign central banks any more gold and to stop defending the dollar's value at the Bretton Woods fixed exchange rates (thereby enabling the USA to continue running their deficit). In a blunt and somewhat coarse compact version of his philosophy, Connolly explained that “all foreigners are out to screw us, and it's our job to screw them first".[1146] When Nixon announced his New Economic Policy (NEP) on 15 August 1971, he warned against international money speculators who had been waging a war on the American dollar. Among the most popular decisions besides the floating of the dollar, there was

1143 L. Sebesta, *United States-European space co-operation in the post-Apollo programme,* ESA Report HSR-15 (ESA) 1995, pp. 32-35.

1144 J. Krige and A. Russo, *op. cit.,* p.108.

1145 For all these aspects, see L. Sebesta, "The Politics of Technological Co-operation in Space: US-European Negotiations on the post-Apollo programme", cit., pp. 334-336.

1146 Seymour Hersh, *The Price of Power,* (New York: Summit Books) 1983, p.462.

the 10% tax on the value of all imports. What was generally perceived, among the same members of the Administration, as a general crusade against the other industrial democracies led to a war of nerves between the USA and a combative, and enlarged, European Economic Community – a treaty of accession was to be signed by the UK, Ireland, Denmark and Norway in January 1972.[1147]

Within this context, it was all too obvious that the Atlanticist constituency in the Department of State felt isolated and deprived of any real chance of advancing the European cause. It is a well-known fact that economic crises feed isolationism; problems with internal social cohesion and national identity are not a favourable background for extensive cooperative efforts.

Nothing was heard about the alternative American position during 1972. In the meantime the 7th Air Navigation Conference of ICAO, meeting in April 1972, encouraged the states and international organisations "to carry out an international programme to provide a satellite system for experimentation and system evaluation"; "to develop in a timely manner specifications of airborne equipment to operate in such system"; "to make available to ICAO the plans, specification and program of the system"; "to ensure adequate liaison with ICAO on questions of mutual interest relating to the evaluation and development program".[1148]

On 31 October 1972, at the first meeting of the AERO Programme Board – established through the December 1971 Arrangement between ESRO Member States and ESRO – a new group of experts charged with negotiating with the FAA – composed of Robinson (UK), Villiers (France), Eckhardt (Federal Republic of Germany) and Stadermann (Netherlands) – was created. Though willing to reopen negotiations with the US, the Europeans were firm in reaffirming the necessity to secure a clause explicitly providing for work in industry to be shared on a fifty-fifty basis between Europe and the USA. Moreover, the Board considered that, until an international solution had been firmly secured, steps should be taken to safeguard a wholly European solution.[1149]

In order to move forward their decision, ESRO members enquired in October about the availability of US launchers for an aeronautical satellite to be launched over the Atlantic Ocean in early 1977, followed by a second satellite over the same ocean about one year later. Prices, time periods between order and launch dates, cost and payments schedules of Delta 2914, Atlas Agena and Atlas Centaur rockets were requested by the Europeans and provided by the Americans.[1150]

On the other hand, the Europeans accepted the American wish to separate the handling of the avionics and ground terminal system, i.e. the use of the system (coordinated programme), from the development and ownership of the purely space capability (the space segment programme), to be negotiated directly with a commercial entity. To this end, at the beginning of November 1972, ESRO issued a press release in which it declared that “In pursuance of its intention to execute an aeronautical satellite (Aerosat) programme, ESRO now plans on the one hand to select a suitably qualified American industrial partner to co-finance the development of the space segment, and on the other to

1147 Frank Costigliola, *France and the United States. The Cold Alliance Since World War II (*New York: Twayne Publishers) 1992, pp. 167-172. On this point see also Pierre Melandri, *Une incertaine alliance. Les Etats-Unis et 1'Europe, 1973-1983* (Paris: Publications de la Sorbonne) 1988, pp. 45-77; and the insightful account written by the then American Ambassador to the European Community, Robert Schätzel, *The Unhinged Alliance. America and the European Community,* (New York: Harper) 1975, pp. 42-53.

1148 Cited in HAEUI, folder 8698, ESRO/PB-AERO(72)l, 13 October 1972. HAEUI, folder 8692. see also *ibid.,* letter Hocker (ESRO Director General) to Fletcher 3 October 1972, Annex I ESRO/PB-AERO(72)7.

1149 HAEUI, folder 8671, ESRO/PB-AERO/MIN/l, ESRO Aeronautical Satellite Programme Board. First meeting (31 October 1972), 21 November 1972.

1150 Approximate costs for a Delta launch were $10 million, rising to $15 million for an Atlas Agena and $19 million for an Atlas Centaur; HAEUI, letter Frutkin to Hocker, Annex I to ESRO/PB-AERO(72)7, 25 October 1972.

enter into an agreement with the US and other interested aeronautical authorities covering utilisation of the proposed system".[1151]

By February 1973, Comsat, Fairchild Industries, ITT World Communications Inc., RCA Global Communications and Western Union International Inc. had informed ESRO of their interest in collaborating on the Aerosat programme. Negotiations towards contractual arrangements were to be initiated in April 1973 with Comsat and RCA in parallel, whose proposals had been deemed equally excellent.[1152]

8.7 A fresh start

Comsat had been the first American commercial corporation to contact European authorities. In March 1972, McConnell, chairman of Comsat's board of directors, and Charyk offered to A. Hocker (Director General of ESRO) possible arrangements for the establishment of a joint ESRO-Comsat aeronautical satellite. In September, Comsat wrote to the OTP in order to know if its intervention would be acceptable to the US government. Under the agreement envisaged by Comsat and reported to OTP, there would be joint ESRO-Comsat management, and contracts would be awarded in response to bids offering the best combination of quality, price and the most favourable delivery time. The communication capacity of the satellites would be allocated to the partners in proportion to their investment in the joint programme. Comsat was prepared to commit up to 50% of the programme; it would offer to lease channels to the FAA from its share of this capacity.[1153]

In a quite anodyne response, Whitehead clarified that an arrangement between ESRO and Comsat ("or any qualified US company") would be “not inconsistent with national policy”. In a following explanatory note, OTP stressed that such a programme should be pre-operational in nature and "without prejudice to any future operational system". The leasing of circuits provided by such a system, however, would be dependent on its meeting US Government requirements and on the availability of funds through Congressional appropriations.[1154]

In order to answer Comsat’s requests and to respond to European enquiries on the modifications requested in the rejected Memorandum of Understanding, an agreement was reached in October 1972 between the Department of State, the Department of Transportation and the OTP on a new position on Aerosat. This ended the stalemate lasting from the previous February. The US Government was to negotiate the definition of the experiment (e.g. the type and quality of signals to be used) with ESRO, but was to leave it up to an American company (Comsat or otherwise) to work out arrangements with ESRO for the provision of communications channels for experiments and eventually, if supported by Congressional appropriations, lease them from Comsat. ESRO was informed that, from now on, it should negotiate with a private US company an arrangement "to provide aeronautical satellite

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1151 ESRO, *General Report 1972,* pp. 122-123.

1152 ESRO/PB-AERO(72)10, 27 November 1972. Annex. Selection of a US partner for the Aerosat space segment. Report of the first phase, HAEUI, folder 8701, "Identification of Interested US Companies". HAEUI, folder 8716, ESRO/PB-AERO(73)15, 11 April 1973, Selection of a US Company for partnership with ESRO in the Aerosat Space Segment Programme, HAEUI, folder 8749, ESRO/PB-AERO(74)17 (2 August 1974), Annex, Choice of the US Co-owner.

1153 Nixon Project, WHCF, Subject Files, UTl box 14, Joseph Charyk, President Comsat to Clay Whitehead, 22 September 1972.

1154 HAEUI, folder 8697, ESRO/PB-AERO(72)2, 13 October 1972, Comsat Interest in Aerosat Programme, plus Annex I, Letter plus attachments addressed to Dr. Hocker from Dr. Charyk (Comsat). 18 September 1972: *ibid.;* Note handed over to the Director General of ESRO by Bromley Smith, US Office of Telecommunication Policy on 16 October 1972, Annex I to ESRO/PB-AERO(72)6.

communication services necessary to carry out a joint governmental oceanic air traffic control experimental program".[1155]

The year 1973 and the early part of 1974 were devoted to working out a new co-operation formula within this framework on the development and production of the payloads and on the availability of American launchers. Furthermore, some intra-European questions affecting the project needed clarification:

- the negative attitude expressed by the British National Air Traffic Services towards some basic features of the programme in April 1973[1156];
- the financing of the coordinated programme (avionics and ground stations);
- the amendment of the ESRO-ESRO Member States arrangement of 1971;
- the development of alternative all-European options – by exploiting capacities within already-existing programmes such as the OTS platform (Aerosat and OTS had several technical elements in common) or Marots.[1157]

Meanwhile, ESRO endeavoured to keep and develop the capacity of European industry regarding both system design and technology. Emphasis on the wish "that advanced technology be used, for the sake of promoting space techniques" was expressed by all delegations, especially the German and the French, during the debates in the AERO Programme Board.[1158] To this end some expenditure, though limited, was committed: 10.96 MAU at mid-1974 price levels up to 31 December 1974. Other specific interests, such as the British one to have the ground station on its soil as a prerequisite for its participation in the programme, were also discussed.[1159]

The main problem, as singled out in a memorandum by the French delegation, seemed to be that "Those responsible for space activities (might) rightly fear making heavy capital investments in a space applications system for the benefit of users whom they cannot clearly identify and who have not yet secured the means of carrying out a coherent specific action; they may also fear that this still-unclarified situation may continue in the future, particularly at the time when responsibility for taking decisions will rest mainly with civil aviation".[1160]

In August 1974, a new agreement was signed. The main differences between it and the previous FAA/ESRO draft were the following:

- The scope of the programme was reduced, providing experiments over the Atlantic region only. However, subsequent extension to the Pacific was not excluded. As a consequence, Australia and Japan were no longer parties in the programme, which involved only two satellites to be placed in orbit.
- While the European contribution would take the form of pre-financing of the system, the American contribution would consist of the leasing of circuits by the FAA from a private

1155 Nixon Project WHCF, Subject files. UTl box 14, Memorandum Whitehead to Kissinger and Flanigan. 2 October 1972.

1156 Reference to this letter is in HAEUI, folder 8717, Letter of the Director General of the organisation to the Minister for Aerospace and Shipping of the United Kingdom dated 13 April 1973, attached to ESRO/PB-AERO(73)16, 16 April 1973.

1157 HAEUI, ESRO/PB -AERO(73)25, Study of alternative European solutions for an Aerosat programme. 19 July 1973.

1158 See for example, HAEUI, folder 8673, ESRO/PB-AERO/MIN/3, 27 March 1973.

1159 *Ibid.*

1160 HAEUI, folder 8745, ESRO/PB-AERO(74)13, Memorandum from the French Delegation, 29 May 1974.

company.[1161] Therefore, the responsibility for the production and implementation of the space segment on the American side was entrusted to a private firm selected by ESRO and approved by the American Administration. By September 1974 Comsat was selected for this role. The principle of "diversification of procedure" was thus admitted: whereas ownership and pre-funding was adopted by ESRO and Canada, the US government opted for leasing the services from a private company, Comsat, which was to become owner of the space segment, for the USA. Thus Canada and Europe being owners of 6% and 47%, respectively, of this part of the system, would not have to pay leasing charges while the FAA, not being owner of the system, would have to reimburse (in the form of leasing charges) 47% of the capital advanced by Comsat.

- Following American pressure, an additional experimental VHF capability was introduced, hence introducing the obligation to use a more powerful launcher – a Thor-Delta 3914 instead of a 2914.[1162]

The joint programme would not include responsibility for the establishment of communications ground facilities and the development, installation and evaluation of aircraft avionics. Each .signatory would retain a fair degree of independence in respect of the implementation of its own part of this so-called coordinated programme. As would emerge from later discussion, a major problem for Europe in this respect was that while an efficient R and D organisation existed, there was no organisation of users for the operational phase of the programme.

At the request of the American authorities, the MOU contained a financial provision whereby the carrying out of the whole programme was subject to the express condition of the funds being available.

The programme was intended to be executed in fulfilment of recommendation 2/6 of the 7th Air Navigation Conference of the ICAO, which encouraged the states and international organisations "to carry out an international programme to provide a satellite system for experimentation and system evaluation"; to develop in a timely manner specifications of airborne equipment to operate in such a system"; “to make available to ICAO the plans, specification and programme of the system”; "to ensure adequate liaison with ICAO on questions of mutual interest relating to the evaluation and development program".[1163] The cost of the space segment programme was to be shared following a 47% (Europe) / 47% (USA) / 6% (Canada) scheme; procurement should be based on competitive tendering but, as in the case of the first memorandum, the percentage of industrial work was to reflect the proportion of each party’s contribution.

In September of the same year, by 7 votes to 1 (United Kingdom) and with one abstention (of the Federal Republic of Germany), the Aerosat Programme Board selected Comsat General as the American partner for the Aerosat programme. British and German reservations stemmed primarily from their desire not to help reinforce Comsat's monopoly in commercial satellite management. While Comsat was a managerial company with no industrial capacity, the UK stressed the strictly industrial character of RCA, which it preferred, "the attractiveness of its offer and the improvements that it had very recently suggested making as regards the geographical distribution of the work".[1164]

On 3 and 4 December 1974 the Aerosat Council, the governing body of the programme, met for the first time in Washington; the Council members represented the three principal parties in the

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1161 HAEUI, ESRO/PB-AERO/MIN/3. 27 March 1973.

1162 HAEUI, folder 8772. ESRO/PB-AERO(75)8, The Aerosat Project, 6 May 1975.

1163 Cited in HAEUI folder 8692, ESRO/PB-AERO(72)l, 13 October 1972.

1164 HAEUI, folder 8687, ESRO/PB-AERO/MIN/17, Draft Minutes 17th Meeting, 4-5 September 1974.

programme, the USA, Europe and Canada. The main concern at its first meeting was the adoption of a schedule for the requests for proposals (RFP), which was eventually issued in early 1976.[1165]

Following the signature of the MOU, the implementation of the "Joint Aerosat Evaluation Programme" started, on the space side, with preparations for procurement of the space segment and, on the aviation side, with the development of an overall system concept and evaluation programme and with the definition of the appropriate airborne and ground elements.[1166]

8.8 The FAA opts out

By 1975 the work of the Aerosat Council was in chaos. At its fourth meeting (London, 24-25 September 1975), the US Delegation advised the body of the FAA's financial problems with respect to the Programme . The reason was the escalation of the estimated Programme costs, which appeared to have become twice the estimates prepared in 1974 and discussed with the Congress ($ 67.5 million for the space segment, $ 104 million in total). After having discussed with Comsat General the terms of the lease contract, the FAA had apparently discovered that the lease scheme implied much higher costs than forecast. The severe impact of inflation played a great role in all this.[1167] "The credibility of the FAA as a partner" was put in doubt by a non-biased actor such as the Federal Republic of Germany: "The German delegation", as was stated on the Aerosat Programme Board extraordinary meeting of 3 October 1975 called after the American announcement, "wondered how it was possible that FAA had discovered that it did not have enough money. It wondered whether internal pressures within the United States were not responsible, and whether there was any point in Europe pursuing its interest in the Programme ".[1168]

In the meantime, a new situation was developing in civil aviation, as a reflection of the economic crises of the international system in the late 1960s. The abandonment of fixed exchange rates and inflationary policies, nascent protectionism, and, last but not least, the sudden and dramatic increase in oil prices in 1973-74, slowed economic performances and created very uncertain long-term perspectives for the development of air traffic. The cost of fuel, representing 25% of direct operational expenses in the early 1970s, increased by 50% in the early 1980s.[1169] In addition, the introduction of a wide-bodied jet at the end of the decade (the Boeing 747), coupled with the abandonment of the American project for a supersonic civilian aircraft, the SST, in Spring 1971, on grounds of cost and environmental concerns, and the postponement and reduction in the number of Concordes – both projects were conceived to be strong users of the system – all heavily undermined Aerosat[1170]. The successful introduction of inertial platforms and navigation system (INS), on the other hand, improved navigation accuracy and further weakened the position of Aerosat's sponsors.[1171]

1165 A contractor was selected at the time, General Electric (associated with a large number of European, Canadian and US subcontractors), and a contract signed early in 1977, when the work was stopped by lack of funds from the FAA, HAEUI, Assessment of Past Events, Draft 2 JLM (no author). 12 September 1977.

1166 HAEUI, Aerosat Development, attached to letter Geigner to Gibson, 17 April 1978.

1167 HAEUI, folder 3481, Statement by the US delegation, Annex ESA/PB-AERO(75)4, Aeronautical Satellite Programme Board, Fourth Meeting of the Aerosat Council, 2 October 1975

1168 HAEUI, folder 3465, ESA/PB-AERO/MIN/3, 15 October 1975, Aeronautical Satellite Programme Board, Extraordinary Meeting (3 October 1975).

1169 ESA papers microfiches, ESA/PB-AERO(82)2, Perspectives de l'utilisation des satellites dans l'aviation civile, 14 April 1982.

1170 For the cancellation of the SST project, see D. Dickson *The New Politics of Science* (Chicago and London: University of Chicago Press) 1988 (1st Edn 1984), pp. 224-225.

1171 These reflections were made in the French document "Aeronautical Satellites - Luxury Gadget Space Technology 'Consumer' or System of the Future?", presented at the ESRO AERO Programme Board, during the meeting of 29 May 1973, HAEUI folder 8723. The French preference was for the third answer. The document was later reprinted by G. Villiers, under the title "Aeronautical satellites: luxury gadgets or system of the future?", in *Revue Française de Navigation* n. 84, 1973.

In the wake of the Arab-Israeli war of October 1973, air traffic estimates made during the second half of the 1960s appeared much too optimistic. ICAO's North Atlantic System Planning Group estimated in 1974 that traffic over the North Atlantic would be 10% less in 1974 than in 1973 and would probably not regain the level of 1973 before 1978. Civilian airlines, along with IATA estimates, were expecting to enter a period of deficits and increasing costs for users. In these conditions, it was not at all sure that one could continue to count "even on luke-warm support from the airlines" and the civilian aviation authorities.

In fact, there was reason to think that the number of HF frequencies, use of which had been improved through technical improvements, would be sufficient until the early 1980s and that only towards the mid-1990s would the available frequencies cease to be adequate to meet requirements. Almost all previous cost-benefit analyses seemed challenged by these new developments.[1172]

At the Aerosat Council meeting of January 1976, the US delegation announced that it had solved its financial problems by adopting a modified approach to the financing of the programme. In particular:

- Launches would be excluded from the lease services. The American Government would furnish the two TD-3914 launches as part of its participation in the Aerosat Programme , and Comsat would be credited with an amount equivalent to NASA's reimbursable charges for these launches (this meant that the FAA would pay for both launchers at government prices, but the other parties would reimburse their share at commercial prices and the payment of their contributions would be made directly to Comsat General);[1173]

- The FAA would commence payment to Comsat General on the lease two years in advance of the original schedule, thereby reducing the total payments to Comsat.

These actions would result in a substantial reduction in Comsat General's direct investment and an earlier payback of their investments.[1174]

After less than a year, however, the FAA informed its European partners of yet another anticipated slippage. The news was transmitted informally at the beginning of September 1976, while the new American position was officially announced during the 6th Aerosat Council of 3-4 November 1976. The FAA's problem arose from a conflict between the Aerosat Programme 's provisions for long-term expenditures and American rules for authorising the commitment of Government funds when a product like Aerosat involved expenditure beyond the annual budget approval. Legal action would be necessary to obtain a waiver of the US Anti-Deficiency Act and it would take longer than originally planned.[1175] By the summer of 1977, the US further clarified their position; it was "virtually certain" that the FAA would not be able to proceed with the Aerosat Programme as planned in the 1974 MOU, due to unavailability of funds. In the eyes of the appropriations committees of the House and the Senate, Aerosat should be deleted, except for funds to conduct a feasibility study programme. The reasons cited were the increasing costs and a much more modest rate of growth in the North Atlantic traffic than previously expected. The US delegation at the Aerosat Council then proposed a

1172 This opinion was voiced by the UK delegation at the ESRO AERO Programme Board, ESRO/PB-AERO/MIN/18, 13 November 1974, folder 8688. In December 1975 the French delegation to the Aeronautical Satellite Programme Board provided the committee with an "Economic study on aeronautical satellites" which, notwithstanding major uncertainties as to many future developments, was substantially optimistic on the utility of satellite communications and its cost effectiveness from the 1980s onwards.

1173 HAEUI, folder 3505, ESA/PB-AERO(77) l, 5 April 1977.

1174 HAEUI, AC MIN 76-1, 21 January 1976, Annex IV, Agenda item 3.1. Statement of the US Delegation.

1175 HAEUI, AC MIN 76-3, Draft minutes of the 6th meeting, 3-4 November 1976, plus Annexes.

reconstruction of the Programme "having fuller support of both the provider and the user communities".[1176]

The unequivocal nature of the FAA's financial difficulties was confirmed during the 8th Meeting of the Aerosat Council in September 1977. The European delegation took note of this statement "more in sorrow than in anger".[1177] It was as if the exhausted European players felt relieved of the heavy burden of keeping alive a patient which had been moribund for too long. Yet it would take them another five years, until 1982, to dismantle the rather complex organisation which had been set up around Aerosat.

8.9 What next?

At the end of 1977 the ICAO Council disbanded the ASTRA Panel.[1178] The European Conference of Directors of Air Navigation, in analysing Aerosat history, noted that "the civil aviation community at large had never yet been sufficiently confident of the need and the cost-effectiveness of aeronautical satellite services. Only when the aeronautical administration and the air operators were convinced on this score", they continued, "would a way ahead have any chance of success".[1179] In the meantime, European studies began exploring the possibility of associating maritime and aeronautical services by sharing spare capacity within Marots satellites or of re-utilising existing satellite platform designs such as that of OTS.[1180]

In order to better understand the American position, it is worth mentioning that in June of the same year the first test satellite of the Navstar Global Positioning System (more commonly known as GPS) had been launched. Navstar was a military navigation satellite system for ground, air and sea mobiles. It was scheduled to become available to civilian users in the future, though in its lower accuracy version. Still, the Department of Defense (DoD) worried that higher accuracy signals "could be used for the targeting of foreign weapons like the Scud" or "for Third World or terrorist cruise missiles".[1181] It would take advantage of the FAA's contemplated computer modernisation programme in both the airborne part of the Programme and the Earth control centres. Implementation was forecast by the mid-1980s, while full operational capability would be achieved by mid-1995 (as indeed happened).

The military need for communication, navigation, identification systems of high reliability and invulnerability against intentional jamming, was obviously higher than that of the civilian field. It became even higher after the electoral victory of Reagan (November 1980) and the launching of the so called *Strategic Defense Initiative* (SDI).

DoD was, and continues to be, GPS's unique manager and the costs of the system were, and are, charged to US taxpayers via the military budget, although the system could be commercially exploited. This was,. first of all, a much easier way to fund, develop, build and manage a highly

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1176 HAEUI, AC WP 77-12 14 July 1977, Status of US Aerosat Programme; AC WP 77-14, 2 August 1977, US Position Paper, attached to AC MIN 77-1 draft.

1177 HAEUI, folder 3511, ESA/PB-AERO(77)7, Future of the Aerosat Programme, point 1: Report on the 8th Meeting of the Aerosat Council, 7 October 1977.

1178 HAEUI, Aerosat Council. 10th Meeting, May 1979, agenda item 4.1. External activities of interest to the Council, 15 March 1979.

1179 HAEUI, folder 3513, ESA/PB-AERO(77)9. Annex II. European Civil Aviation Secretariat, 2 December 1977.

1180 HAEUI, folder 3507, ESA/PB-AERO(77)3, Progress report on internal studies, 12 July 1977.

1181 Dwayne Day, "Transformation of National Security Space Programs in the Post-Cold War Era", paper presented at the 45th Congress of the International Astronautical Federation, 9-14 October, 1994, Jerusalem, Israel, p.12 and pp. 11-12 for general information on NAVSTAR. See also Glen A. Gilbert (President General Gilbert and Associates Inc.) *Fourth Generation ATC. An Integrated System Concept for the 1990s into the 21st Century,* presented to J. Lynn Helms (FAA Administrator), December 1981. For DoD interest in "selling" GPS to civilian authorities, see ESA Office, Washington DC, folder 137, Aerosat Aerosat Council, Notes on Preparatory Meeting of the Committee, 22 March 1972.

complex technological system than that of the anticipated US-European framework. The double function of the satellite (civilian and military) definitely put a stop to what had been increasingly perceived as a "nuisance", not an opportunity, by the American administration.

The decision of the US government not to provide its share of the cost, and the opposition of the airlines to the execution of the Programme , forced a reassessment of the Programme in order to determine whether or not satellite techniques had an application to civil aviation. In order to facilitate it, the following Aerosat Council meeting decided to involve in study programmes both the provider and the user communities. A Committee was then established (June 1978) – called the Committee to Review the Application of Satellite and other Techniques to Civil Aviation, abbreviated to ARC – in order to re-evaluate the requirement for an aeronautical satellite programme, to reach an international consensus on its future role, the related time scale and associated costs, and to develop a milestone chart for the critical elements of such a programme.[1182] The work performed by the ARC was continued, under the aegis of ICAO, by a special committee named Future Air Navigation Systems (FANS). The committee established recommendations and plans for a future Communications, Navigation and Surveillance/Air Traffic Management (CNS/ATM) system that were finally approved by ICAO in 1991.[1183]

Under the chairmanship of R.E. Cox of the British Civil Aviation Authority, the Committee had by May 1979 prepared a series of recommendations for a study programme dealing with the methodology, the subjects and areas for study and the tasks to be performed.[1184] By the end of 1981 it produced a three-volume study, the bulk of which (vol. III) was an FAA sponsored study called OASIS – an acronym for "Oceanic (and selected non-oceanic) Area Systems Improvements Study" – an assessment of the manner in which the volume and pattern of air traffic would change in the years until 2005 and an analysis of the contemporary navigation techniques. Among the most important declarations was the one according to which "Aerosat had foundered primarily because it could not be shown to be cost-effective".[1185]

As we hope to have shown, this is a rather simplistic way to dismiss a highly controversial story, with many different kinds of actors and their relative aims; a story which took place in a context of increasingly difficult US-European political and economic relations.

8.10 Epilogue

Technology and users' requirements constitute the basic formal parameters that actors must take into consideration when discussing cooperative projects involving commercial satellites.

On the one hand, technology sets the limits of the potential actions to be performed by a device; on the other hand, users' requirements – both technical and financial – contribute to defining its scope. In the case of Aerosat, the presentation of the project to ASTRA was originally considered a sufficient guarantee, in view of the fact that US/European negotiations had agreed on having a pre-operational satellite which was to be funded with public funds. No solution was found for a whole series of problems linked to the operational phase of the project. Decisions on it were postponed and negotiations were subsequently strictly limited to the pre-operational phase.

1182 HAEUI, no folder number, Aerosat Council,. Minutes of the 9th meeting, 18-19 January 1978; HAEUI, Aerosat Development, attached to letter Geigner to Gibson, 17 April 1978.

1183 Information provided to L. Sebesta by R.C. Collette, letter 3 July 1995.

1184 Recommendations for a study programme, prepared by the Committee to Review the Application of Satellite and other Techniques to Civil Aviation (March 1979), in HAEUI, Aerosat Council, 10th meeting, May 1979.

1185 HAEUI, ESA dep., microfiches, ESA/PB-AERO(81)4, Final Report of the Aerosat Council's Review Committee (ARC), 26 November 1981.

As the Aerosat case clearly shows, there is always room for negotiation on technical specifications – negotiations are time-consuming, but compromises can be elaborated. By comparison, in the case of projects that represent a breakthrough in technology, it is more difficult to attract the interest of users who tend to be conservative in guaranteeing for themselves the position already acquired in the management of the old system and the exploitation of technology already developed. Cost/effectiveness concerns also play an important role; this is all the more true, if, as in the case of Aerosat, it is not clear at which point the introduction of a new technique could have repercussions on tariffs for the service produced (this being especially true in a period of inflation and other uncertainties in operating costs due to uncertain factors such as oil prices).

Further difficulties emerge from the prospective competition between national firms that will be involved in the development and construction phase of the project. Whereas the pre-determined "production sharing" formula can defuse competition, it conflicts with cost/efficiency considerations and with the interests of those firms that would be best qualified for winning international bids.

This set of interrelated problems greatly increases the *structural* difficulties of cooperative ventures, those stemming from the fragmented character of such decision-making structures as the American one, and requires a strong political intervention to induce the various national actors to agree or to accept responsibility for their future hostility. National political leaders will accept to lose the support of some of their internal sponsors (such as, for example, industrialists) only if they perceive that they will get strong rewards from the cooperative endeavour they are promoting, or that their position will be remunerated by the international community in other related fields.[1186]

American political leaders lacked this perception: confronted with a determined internal opposition, they could not locate any strong reward in the prospective agreement. This negative perception was reinforced by a difficult phase in US-European relationships during the first half of the 1970s and, after 1977, by the setting up of the military-sponsored GPS. The US went their own way and Europeans were later 'co-opted' into their system.

This choice is worth some second thought. Leadership is obviously more efficient and economically rewarding for those who exercise it, and implies few risks of losing internal consensus in the short term. It requires, however, a politically hegemonic position and a technically dominant posture. Monopolies have to be enforced with overwhelming power politics and they always risk provoking the birth of at least one competitor in the international arena, when political as well as technical goals are at stake. The danger of antagonising potential allies is high in times of precarious political relations, prospective transformation within the international system or qualitative changes in technology, especially if the allies are important users. Co-operation through consensual modes is more time-consuming and needs higher diplomatic negotiating skills but, in the long term, the maintenance of a genuine cooperative regime seems more convenient than pure competition, even for the leading actor.

The later sharp contrast between the USA and the Europeans on the building up of an autonomous European multi-user satellite system with civilian and military functions of data relay, navigation, communications and Earth observation for both logistic military requirements and environmental monitoring, clearly shows the risks connected with the first course of action, i.e., agreements whose terms have been imposed through leadership instead of consensual modes.[1187]

1186 On the theoretical aspects of this argument, see Robert Putnam, "Diplomacy and domestic policy: the logic of two-level games", *International Organization,* Summer 1988, pp. 427-460.

1187 Assembly of Western European Union Colloquium, "Towards a European Space Observation System". 24-25 March 1995, San Agustin, Gran Canaria - downloaded from <www.weu.int>.

Chapter 9: The Decision Taken in the Early 1970s to Develop an Expendable European Heavy Satellite Launcher[1188]

J. Krige

Some years ago, and within the framework of this project, the then-PDG of Arianespace, Charles Bigot, enthused about the achievements of his company.[1189] The firm's share of the commercial market, originally estimated at 30-40%, had climbed to 65%. Sales abounded: 118 orders for the rocket had been placed since 1981, more than half of them outside Europe, and all major American private operators were clients, including the major international satellite operator Intelsat. Regularity drove reliability. First launched successfully on Christmas eve 1979, the European-built launcher had outperformed all its competitors in terms of getting hardware into orbit, which not only pleased customers, but which also meant that "space insurers had only been able to live and to survive for the previous six years thanks to Ariane": their net receipts from the rocket amounted to about $800 million. European industry, "to its great surprise", had also benefited to the tune of about FF 5 billion per year, without ongoing government subsidies. In short, Ariane was an outstanding technical and commercial success, the jewel in the crown of the collaborative European space effort. But a success, as the PDG indicated, which had not only been hard-won, but which had never been imagined by those who embarked on the project in the early 1970s. Ironically enough, Bigot himself was one of the many sceptics. Invited to take charge of the project in 1972, he refused "faute d'y croire suffisamment" [not believing in it enough] as he himself put it.

The name Ariane itself embodies this fragility. The circumstances surrounding its choice have been described on several occasions.[1190] Technically conceived by engineers in the French space agency CNES, its earliest versions were unromantically labelled LIIIS, a three stage launcher intended as a replacement or "substitute" for ELDO's Europa IIIB rocket. This would obviously not do from a

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1188 This text by John Krige is based on the extensive collection of documents deposited by ESA in the Historical Archives of the European Community, European University Institute, Florence, Italy. Of particular importance were the collections of papers dealings with the meetings of the ESRO, ELDO and ESA Councils, with those of the European Space Conference, and with those of the Ariane Programme Board. This source is open until 1983 and files from it are cited thus: ESAxxx. When no such indication is given it is simply because the ESA intermediate archives at ESA Headquarters in Paris were used.
A survey of the early history of the European space programme is to be found in J. Krige and A. Russo, *Europe in Space, 1960-1973* (ESA SP-1172, 1994). The early history of Ariane, as seen by its participants, is available in E. Chadeau (ed), *L'Ambition Technologique: Naissance d'Ariane* (Paris: Editions Rive Droite, 1995). This also has a valuable collection of French and American documents from the early 1970s. Some additional information is found in C. Carlier and M. Gilli, *Les trente premières années du CNES* (Paris: La Documentation française-CNES, 1994). The role of the US in facilitating the Ariane decision is described in chapter 10, this volume. See also L. Sebesta, "The Politics of Technological Cooperation in Space: US-European Negotiations on the Post-Apollo Programme", *History and Technology* Vol. 11(3), 317-41 (1994). An important collection of US documents is to be found in J.M. Logsdon (ed) *Exploring the Unknown. Selected Documents in the History of the US Civil Space Program. Vol. II. External Relationships* (Washington D.C.: NASA History Office, 1996).

1189 C. Bigot, "Commercialisation des Lanceurs", in *The Implementation of the ESA Convention: Lessons from the Past. Proceedings of the ESA/EUI International Colloquium, Florence, 25 and 26 October 1993* (Dordrecht: Martinus Nijhoff Publishers, 1994), pp. 141-56. For additional reflections on the reasons for the success of Arianespace see J. Krige and L. Guzzetti, *History of European Scientific and Technological Collaboration* (Brussels: EEC, European Science and Technology Forum, 1997), chapter 8.

1190 See notably Lebeau (pp. 90-1), Bignier (pp. 106-7) and Charbonnel (p. 109), in Chadeau (footnote 1188), Bignier, p. 160 in Carlier and Gilli (footnote 1188) and P. Creola, "Ariane - Les chemins de l'autonomie", in *L'Europe spatiale a vingt ans, 1964 -1984* (ESA SP-1060, 1984), 31-36. A copy of the page handed around by Lebeau is presented in this text.

political or public relations point of view. But it was difficult to find an acceptable alternative. At a meeting of the ESRO Council held in Brussels on 1 August 1973 one of the French delegates passed around a blank page asking those present for suggestions. Ariane was not among the two dozen names put forward, but Vega, a star of first magnitude in the constellation Lyra received three votes. This was briefly used in September 1973, though not without some misgivings.[1191] A Swiss delegate teasingly suggested that it was indicative of French imperialism; it was similar to Marianne, the name given to the French Republic as symbolised by the bust of a woman with red headdress, and adopted at the time of the Revolution. The Germans humorously drew attention to a different affinity with "l'esprit français". In Hamburg slang, to visit Ariane meant to make love between five and seven in the afternoon, i.e. after work and before returning home. In the event the French Minister for Industrial and Scientific Development, Jean Charbonnel, had the last word. He refused Vega when he learnt that it was the name of a Belgian beer, choosing instead to have recourse to Greek mythology – a source also calculated to appeal to President Pompidou. Ariane, said Charbonnel later, was adopted because of its analogy to Ariane's (Ariadne's in English) thread, and symbolised the difficult passage of a project which managed, all the same, to emerge from a labyrinth of setbacks.[1192]

The aim of this study is precisely to recapture the complexity of that labyrinth, to bracket for a moment the eventual success of the rocket and to reconstruct the tortuous process that led to its development and commercialisation. The doubts that surrounded Ariane at its inception were not essentially technical; technological solutions that were already relatively well-understood in Europe were deliberately adopted to improve reliability and to reduce costs. If governments hesitated, it was because they were not sure that Europe had the managerial experience to build a successful launcher, because they doubted that it could compete economically with NASA's Shuttle, and because they were not convinced that a sufficiently large market existed for it. Ariane was a French-inspired and French-led project. The decision to embark on it was informed above all by political, industrial and institutional considerations in that country, considerations that were contested by some of her European partners, and indeed within the French state apparatus itself, but considerations which eventually had sufficiently powerful allies for them to carry the day. It is this complex of motives, and the way in which they were transformed into, and embodied, in the Ariane Programme that will first be studied in this chapter. To understand them properly we must begin by surveying the political and economic climate in which the project was launched and situate it in the context of the major problems then being confronted in the European launcher programme being undertaken by ELDO.

9.1 The political and economic context

The early 1970s were a period of political and economic change in Western Europe and the United States of great complexity, and we can do little more than give a few pertinent elements here. Two pillars of the post-war political reconstruction of Europe, Konrad Adenauer and Charles de Gaulle had left the scene. In Germany Willy Brandt who had been elected Chancellor in October 1969, saw his position confirmed by the victory of the Social Democrat – Free Democrat coalition three years later. More than two decades of Christian Democratic rule were over, while Brandt's 'Ostpolitik' profoundly reconfigured East-West relations at one of its nodal points. In France the new Gaullist President Georges Pompidou, whose Prime Minister Jacques Chaban-Delmas had promised "a new society", felt obliged to replace the same in July 1972 by Pierre Messmer, "a genuine Gaullist, coherent and cold", following the exposure of Chaban-Delmas's efforts to evade taxes. Pompidou, himself now "un homme malade et irritable", died on 2 April 1974 and was shortly succeeded by Giscard d'Estaing. In Britain the Conservative Heath government, elected in June 1970, spent four tumultuous years coping with rising inflation and with bitter social and political divisions, above all with the Trade Unions and the miners, but also over the entry of the country into the European Common Market, eventually formalised, along with that of Denmark and Ireland, on 1 January 1973.

1191 At the first meeting of the L III S Launcher Interim Programme Board held on the 13 September 1973, document ESRO/IB-LIIIS/MIN/1, 11 February 1973 (ESRO 3358).

1192 The name was officially adopted by the ESRO Administrative and Finance Committee meeting on 27 and 28 September 1973, ESRO/AF/MIN/93, 19 October 1973 (ESRO 1133).

All countries were dominated by concerns over monetary policy pursuant on Nixon's decision in August 1971 to suspend the convertibility of the dollar into gold. The successive devaluations of the dollar, first in December 1971 and then by 10% in February 1973, created monetary turmoil. Currencies "floated" and exchange rates fluctuated wildly. In an attempt to stabilise the system, leading western European governments established in April 1972 a monetary "snake" intended to limit the changes in the values of their currencies *vis-à-vis* the dollar to a band of 2.25%. Sterling was part of the system for no more than a month, the lire for less than a year. Helmut Schmidt re-evaluated the Deutschmark twice in three months, by 3% in March 1973 and by a further 5.5% in June. Then came the oil crisis. The brief but historic Yom Kippur war which broke out on the 6 October 1973 accelerated the steps already being taken by the oil producing countries in the Middle East to take control of the volume and cost of crude on the market. By the end of the year the OPEC had announced that the six major producers in the Persian gulf would be doubling the price of crude: the era of "cheap energy" was over, and no one could guess what its impact would be on the world economy.

The early 1970s were also years of changing fortunes in the United States. Before being shamed out of office by the Watergate scandal, which broke in spring 1973, President Nixon had brought the war in Vietnam to an end, had made an historic visit to China and had developed a new rapprochement with the Soviet Union. The latter led, *inter alia*, to the signature of the SALT I agreements on strategic arms limitations between the two superpowers in May 1972, and to the simultaneous adoption of measures for peaceful cooperation in outer space, whose centrepiece was the Apollo-Soyuz capsule link-up. Indeed in the space field this was, at least briefly, a period marked by a new interest in the US for international collaboration in general. Europe was invited to play a part in NASA's so-called post-Apollo Programme. This was a major initiative which included in its earlier versions the construction of a space station serviced by a manned Space Shuttle. The Shuttle was heralded as a revolutionary space transport system which would render expendable launchers redundant.[1193] As such it did not simply demand a potential reorientation in Europe's space priorities; the post-Apollo Programme also, and deliberately so, placed a huge question mark over the continued technological interest and commercial viability of a European conventional launcher into which so much effort and money had already been put.

9.2 The failure of Europa II

It was against this uncertain and ambiguous background that ELDO's Europa II rocket exploded soon after launch on 5 November 1971, catalysing a fundamental reassessment of the entire space effort.[1194] Europa II was based on the original Europa I rocket: i.e. it used Britain's Blue Streak as first stage, France's Coralie as second stage, and Germany's Astris as third stage.[1195] However, Europa I could only put heavy payloads into low orbits, and had been upgraded in 1966 by the addition of inertial guidance and, on French insistence, by the inclusion of the so-called PAS, or Perigee-Apogee System. This ingenious system provided the launcher with a geostationary capability by adding a “fourth” stage (in this case the solid-fuelled third stage of the French rocket Diamant B was used). This stage transferred a satellite from a low-Earth parking orbit up to the geostationary orbit, where an integrated apogee motor pushed the spacecraft (weighing up to 170 kg in this case) into a circular path around the globe. Europa II was specifically designed to launch the Franco-German telecommunications satellite, Symphonie, a challenge all that more important since there were real fears in Europe at the time that

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1193 This programme has been described in detail in Sebesta (fn 1188).

1194 The demise of ELDO is discussed in chapter 1, this volume.

1195 For the history of ELDO see Krige and Russo (footnote 1188), chapters 3 and 6. See also M. de Maria and
J. Krige, "Early European Attempts in Launcher Technology: Original Sins in ELDO's Sad Parable", in J. Krige (ed) *Choosing Big Technologies* (Chur: Harwood, 1993), 109-37. For the Australian role in the programme see P. Morton, *Fire Across the Desert. Woomera and the Anglo-Australian Joint Project, 1946 - 1980* (Australian Department of Defence, 1989), chapter 23.

the US would not be willing to launch commercially competitive applications satellites.[1196] Hopes thus ran high when, before a crowd of VIPs and journalists, Europa II lifted off its pad after a trouble-free countdown, the first launch of the rocket from the new CNES base at Kourou in French Guiana. The trajectory appeared normal for about 130 seconds. Cheers turned to gasps as the rocket then gradually inclined downwards and towards the right; it was the first time there had ever been any trouble with Blue Streak. In fact signals from the inertial guidance system had failed, so that the launcher progressively deviated from its nominal trajectory. The ensuing stresses on the structure caused the first stage to break loose from the second at 150 seconds. The first stage then collided with the second and exploded, damaging the second stage which then exploded in its turn. After three minutes all was over.

Deep gloom pervaded ELDO.[1197] A commission of enquiry was immediately set up under the chairmanship of General Robert Aubinière. Its report, tabled in May 1972, was a searing indictment not simply of the entire structure of ELDO, but also of the professionalism and commitment to the Programme inside some sectors of European industry.[1198] The British computer used for the inertial guidance system was a prototype originally developed by Marconi for the Jaguar fighter aircraft, but subsequently modified to meet the required performance standards of that project. The model provided for ELDO had never been used operationally in any other project, and "considering the inadequate standard of manufacturing, inspection and acceptance" of the device it could "not be considered flightworthy". Integrated into the third, German-built stage of the rocket, it had failed because of electrical interference of a few volts on a 3m-long high impedance line between the computer and its power supply. Here the Aubinière report was scathing about the quality of work in the German firms involved, MBB, ERNO and ASAT, the last being responsible for integration. "There has not been any satisfactory integration of the wiring between the upper section manufactured by MBB and the lower section manufactured by ERNO. It obeys none of the elementary rules concerning separation of high and low level signals, separation of signals and electrical power supply screening, Earthing, bonding, etc."[1199] The fourth stage, built in France, was not spared either, though here the deficiencies were qualified as "minor".[1200]

The main problem was not however the "poor organisation and lack of sense of responsibility" of some firms. It lay in the overall management structure of the project itself. In particular, "resorting to national agencies for placing contracts led to the [ELDO] Secretariat's technical authority being effaced in cases where these agencies were powerful, or to constant confusion about the respective responsibilities of the Secretariat and the agency in cases where they were not".[1201] ELDO's technical staff were remote from the actual design and development work, and even when they tried to intervene, they sometimes "had great difficulty in obtaining access to firms and received no answers to technical questions they put".[1202] Problems deriving from the emasculated powers of the Secretariat and its technical staff were amplified by its poor internal organisation and by pressures exerted on ELDO by its Member States, who tended to put political considerations ahead of technical problems and cost-effective solutions.

These difficulties notwithstanding, Aubinière was convinced that Europa II was a viable rocket. The changes that had to be made were evident. ELDO, of which he had been appointed Secretary General

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1196 At the end of 1968 the directors of the Symphonie project had asked NASA if the US would be willing to launch their satellite; the answer was yes, "if we could arrive at a mutual understanding of the experimental character of the project", meaning satellites "used exclusively for experimental and demonstration purposes, not for the transmission of regular commercial or governmental traffic or broadcasts", quoted in Krige and Russo, p. 82.

1197 See the minutes of the 53rd session of the ELDO Council held two weeks later, ELDO/C(71)PV/6, 6 January 1972 (ELDO 1494).

1198 The *Report of the Project Review Commission* is document ELDO/C(72)18, 19 May 1972 (ELDO 1565).

1199 *Ibid,* p.20

1200 *Ibid,* p.23

1201 *Ibid,* p. 1

1202 *Ibid,* p. 14

in January 1972, had to "assume responsibility for the integration of the vehicle as a whole", reinforcing its "technical and administrative competence to take the place of the national authorities". To this end a Europa II project team had to be created, "highly centralised and comprising, under the authority of a single project manager, the engineers working on the execution of the project". This team would be supported by a specialised theoretical studies office dealing with such issues as trajectories, structural calculations, etc. Other supporting teams would deal with launch plans and launch operations. Formal procedures would be put in place inside ELDO to maintain control over industry and to assure quality. MBB and ERNO would have to be prepared to give priority to work on the third stage, and the ASAT team would have to be strengthened and remotivated so as to ensure higher technical standards and reliability in the final product.[1203] Time, money and an additional qualification launch would be needed to put these measures in place. However, the Aubinière Commission was convinced that with an additional 21 to 26 MAU the first operational launch of a Europa II rocket could be scheduled two years later, for the first half of 1974, and that the vehicle would "achieve a normal probability of correct functioning to match that of comparable space projects".[1204]

Even if Aubinière's committee of enquiry concluded that Europa II was a viable launcher, it also highlighted grave problems in European industry and in European management practices. It was clear, in fact it had been clear for several years, that the ELDO Secretariat lacked the means and the authority to monitor the fabrication and integration of the rocket. No one reading the report was surprised to learn this. What was difficult to swallow was the lack of motivation, the degree of incompetence, and the absence of adequate project management inside industry itself. It was hard to imagine that in a venture of this complexity it was necessary for the Commission to stress that "with regard to the upper part of the 3rd stage [...] the practices of attaching several wires to the same contact and crimping thin wires into contacts designed for thicker ones should cease". Or that, for the fourth stage, "the wiring should be entirely revised", and that e.g. "cable forms should be rigidly fixed to avoid any movement resulting in abrasion by sharp edges of the structure".[1205] Confidence in famous German firms dropped to a low ebb, a shock which undoubtedly shaped the subsequent decisions taken in the Federal Republic about where its priorities in the space programme lay, in particular its insistence on the need to strengthen European project management skills in large complex systems.

But it was not only Germany that was embarrassed; French industry and the national space agency CNES were also under the spotlight. After all, the fourth stage of Europa II was identical to the third stage of France's Diamant B, built by Sud-Aviation under the control of CNES, and yet even here elementary mistakes were made. Indeed the reputation of the French space agency as an able project manager suffered a serious blow when on 5 December 1971, just one month after the Europa II explosion, a Diamant B rocket launched from Kourou also exploded 20 seconds after ignition of its second stage motor. This was particularly significant because of the new role recently accorded to CNES in terms of launcher development. The Diamant A Programme, started in 1962, was under the joint responsibility of CNES and the military Direction technique des Engins of the DMA (Délégation Ministérielle pour l'Armement). This arrangement was changed in 1967 when the French minister responsible for space matters agreed to the development of Diamant B, at the same time giving CNES sole responsibility for civilian national and international launchers. The first launch of the rocket in March 1970 was a near-total success, the next two were trouble free, and now the fourth was a failure due to a rupture in its second stage motor (as was the fifth and last in May 1973, though here the rocket worked but the fairings failed to open).[1206] These setbacks showed that a centralised management system as such was no guarantee of success, so weakening the impact of the solutions proposed by

1203 *Ibid,* pp. 1-2, 32-35.
1204 *Ibid,* p. 5.
1205 *Ibid,* p. 46, 47
1206 See Carlier and Gilli (footnote 1188), pp. 20, 149-152.

Aubinière for ELDO. They also "undoubtedly provided ammunition for those who wondered whether CNES had the capacity to manage successfully a heavy launcher programme like Ariane".[1207]

9.3 Europa IIIB and the Shuttle 'sortie module'

The Causse Report discussed by the European Space Conference in 1968 identified as a prime goal for Europe the ability to place a two-ton satellite for direct TV broadcasting into geostationary orbit by the late 1970s. Europa II did not have this capability, and hence the Report suggested that ELDO proceed in two additional steps, via Europa III (Blue Streak plus a cryogenic stage to put 500 kg in geostationary orbit) to Europa IV. The refusal of the British to remain involved in launcher development, and to commit themselves to producing Blue Streak after 1980, forced the member states of ELDO to reconsider this scheme, however. In April 1969 the Council instructed the Secretariat to undertake detailed studies on what was now called the Europa IIIB rocket without the British first stage. $ 35 million were set aside for a preparatory phase whose results were reported to Council in April 1972.[1208]

Europa IIIB was a two-stage rocket, which in conjunction with the apogee motor built into the payload, was able to put a 750 kg communications satellite in geostationary orbit. The first stage used "a classical technology and a generation of motors thoroughly known and fully developed in Europe". In fact it was derived from Diamant and Coralie, was 3.8 m in diameter, was powered by four Viking turbo- pump motors of Franco-German origin, and was fuelled by 150 tons of nitrogen peroxide and UDMH (unsymmetric dimethylhydrazine), whence its label L150. The second stage, which required a major technical effort, used cryogenic techniques, and was described by the project team as an "essential step forward" intended to give European launcher technology "an opportunity to level up with that of other 'space nations'". It had the same diameter as the first stage (3.8 m), and was powered a single high pressure engine still to be developed. Figure 9-1 is a diagram of the rocket presented by the Europa III team inside ELDO in April 1972.[1209]

Two features of this proposal immediately excited the interest of the ELDO Council: the management scheme proposed and the cost. The management scheme called for the phased concentration of industrial tasks into the hands of a prime contractor, always under the direct control of the ELDO Secretariat, which would "take full responsibility, both technically and financially, for the achievement of Programme objectives". In Phase I there would be six contractors: a main contractor responsible for overall integration, separate contractors for the integration and structure and the propulsion of both the first and second stages, and another contractor for the construction of the site and the provision of range services. In Phase II, the number of contractors would be reduced to four by having just one contractor responsible for both aspects of each stage of the rocket. In Phase III, the production phase, all activities would come under the control of the main contractor, which would now become the prime contractor.[1210] Nobody liked this idea: the management structure seemed over complex, three phases seemed too many; and it was not clear how geographical returns were to be respected.[1211] To meet these objections, the Secretariat called together the five main firms involved (one in each of the participating states) who decided to set up a working group under the chairmanship of Mr Ludwig Bolköw. Its aim would be to put in place a new consortium (called Eurolauncher) to build Europa III,

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1207 This is Causse's judgement, in Chadeau (footnote 1188), p. 18.

1208 *Status of the Europa III Project,* CSE/CM(May 72)WP/5, 19 May 1972 (ESC 108). Britain did not contribute to the costs of this project.

1209 For this paragraph and the diagram see *Europa III Final Report Preparatory Phase Executive Summary* ELDO/C(72)13, 5 April 1972 (ELDO 1560). See also Causse in Chadeau (footnote 1188), pp. 27, 32.

1210 See *Europa III Final Report*, pp. 12, 17. The quotation is at p.17. See also *Status of the Europa III Project,* CSE/CM(MAY 72)WP/5, 19 May 1972 (ESC 108).

1211 See 56th session of the ELDO Council on 14 April 1972, ELDO/C(72)PV/2, 21 June 1972 (ELDO1544).

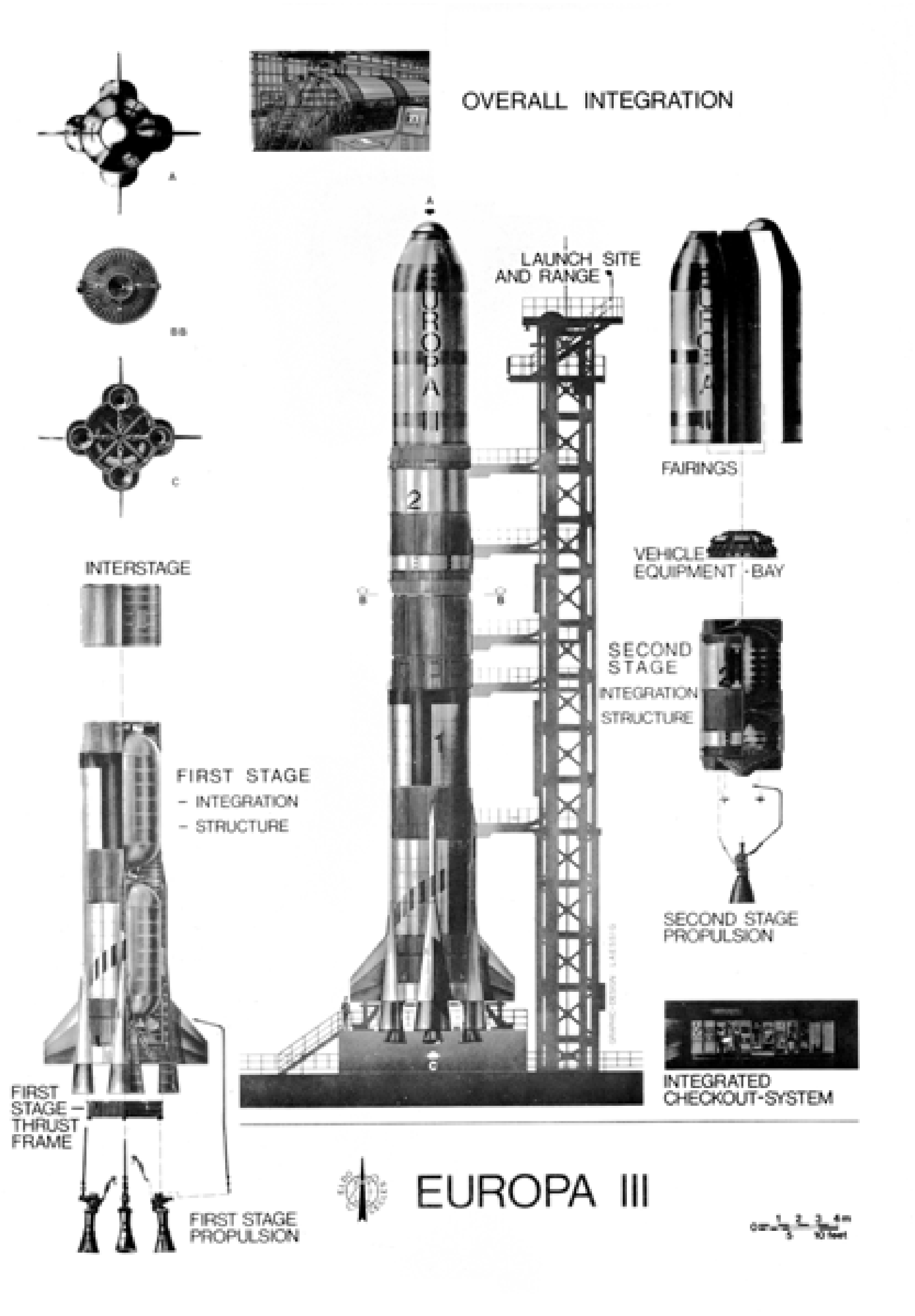

Figure 9-1: Europa III

and to promote it actively as an economic and efficient management system for the production of the rocket.[1212]

As for the development cost of Europa IIIB, this was estimated at 470 MAU plus a 20% contingency, which took the total to 565 MAU (or FF Delta38 million) at spring 1971 prices and exchange rates. The German delegation found this far too expensive, and demanded that a number of alternative configurations without a cryogenic upper stage be studied. All of these so-called low-cost solutions came out more expensive than Europa IIIB, however. In addition, they posed problems of geographical return and, since Germany suggested making using of solid fuelled boosters developed in the French Military Programme, raised issues of technology transfer, access by foreigners to French industry, and so on.[1213] Defeated, in June the ELDO Council decided to abandon the idea, and to pass the whole question of Europa III on to a Ministerial meeting then being planned.[1214]

Ministers met informally on 19 May 1972 to plan this gathering.[1215] It quickly emerged that a meeting in July, as originally envisaged, would be much too early. The nature of Europe's participation in the post-Apollo Programme was uppermost in their minds. On 5 January 1972, Nixon had approved the space Shuttle Programme. Around that decision, between December 1971 and February 1972 the Programme had undergone major changes. The space station concept had been radically altered and its development put back to after that of the Shuttle. The design of the latter had also undergone major changes, resulting in only parts of it being really reusable, and the scope for European participation being reduced from 12 elements to five. If in 1971 NASA had strongly encouraged the Europeans to be involved in the space tug – intended to carry a payload from the Shuttle up to geostationary orbit – now they were beginning to suggest that they might like to participate in the development of the sortie module, a Shuttle-borne, shirt-sleeve environment laboratory for scientific research. To clarify matters the Ministers agreed that a high-level European delegation should visit NASA in June. There, to their amazement, the tug was withdrawn, the number of Shuttle elements was reduced to four, all of relatively minor technological interest to Europe, and "the talks on European participation which (was) still desired – were suddenly focussed on the sortie module alone". Work on the tug was stopped, Shuttle technology studies were wound down and ESRO immediately intensified its work on a European sortie module concept in consultation with NASA. Final selection was scheduled for October 1972, whereupon the scheme would be presented to Ministers, who would have to decide if they wanted to embark on it.[1216]

In summer 1972, then, European space Ministers had a number of major decisions before them. Should they place their faith in General Aubinière and give him the resources and the management powers he wanted to bring the Europa II Programme to conclusion, so ensuring their 'freedom' to launch an operational version of Symphonie? Should they embark on the development of a new launcher despite their misgivings about the cost, the management structure and, indeed, the competence of some of the main firms involved? Should they finance a sortie module to be built in collaboration with NASA, even though the US authorities, with the Shuttle accepted by the President, seemed more than ever to be imposing solutions rather than discussing alternatives with their 'partners'? It was against this background that high-level discussions got under way in France about the possibilities of building yet another kind of launcher to replace the Europa series – but this time the attention was focussed, in the first instance, on a national launcher.

1212 See the Secretariat's *Rapport sur l'organisation industrielle pour le programme Europa III,* ELDO/C(72)29, 10 July 1972 (ELDO 1575).

1213 *Low Cost Launchers. Conclusions of the Europa III* Ad Hoc Group, ELDO/C(72)14 Add, 30 May 1972 (ELDO1561). For the French position see the Annex to ELDO/C(72)19, 29 May 1972 (ELDO 1566).

1214 See minutes of the 57th ELDO Council, 8 June 1972, ELDO/C(72)PV/3, 16 June 1972 (ESC 1545).

1215 The minutes of this *Informal Ministerial Meeting - 19th May 1972* are in (ESC 1473).

1216 The quotations are from the *Report by the Secretary General of the European Space Conference on the Status of European Space Programmes,* CSE/CM(October 72)WP1, 12 October 1972 (ESC 116).

9.4 Summer 1972. The Franco-German split on launcher policy and the emergence of LIIIS

A striking feature of the debates inside the ELDO Council in the first half of 1972 was the growing disillusionment of Germany with the idea of building a European launcher. These hesitations were all that more evident when contrasted with her earlier enthusiasm for such a project. Germany had strongly supported France in the Europa I/II Programmes and, like France, had contributed to the Preparatory phase of Europa III proportionally to its GNP. At the end of 1970, Leussink, the Minister responsible for space matters at the time, had even been prepared to "go it alone" with Belgium and France on a trilateral basis to build the rocket which, he and his counterparts said at the time, should not be sacrificed to participation in the post-Apollo Programme. Now Germany was changing its priorities, and the divergences between its position and that of France were becoming more evident by the day.

The French were not altogether surprised. Already in June 1971 an internal note in the Quai d'Orsay on Franco-German cooperation remarked that the two countries had very different space policies, particularly regarding Europa III.[1217] "For the Germans", it said, "the prime objective was the development of an industrial capability in their industry which was adequate to maintain them in the first league, and which would later enable them to collaborate meaningfully in American ventures (Intelsat, post-Apollo)".[1218] Indeed it was noteworthy that in the recently terminated negotiations to revise the Intelsat agreements, Germany had adopted a "prudent" line, and had not supported France in its efforts "to restrain a little more the domination of the system by the United States". France, for her part, was of course also interested in space technologies. However, her "major preoccupation was to ensure her autonomy in the area of telecommunications satellites, with a view to using these for radiodiffusion and direct television. [....] The availability of launchers", the text went on, "(either built by ourselves or purchased without any political or commercial conditions) is essential if one attaches a political interest to space activities and requires that Europe retain her freedom of expression in this sector". Fifteen months later, the gap between these two very different perceptions of space had grown to a gulf. Bonn, an internal French note suggested, had lost confidence in German firms after the Europa II failure and was convinced that the management skills required for a large project could best be obtained through post-Apollo collaboration. Internal dynamics might also have played a role: the new Social Democratic minister responsible for space, Von Dohnanyi, had blamed the weakness of the earlier Programmes on his Christian Democratic rivals and now had to do something spectacularly different to justify his accusations.[1219]

Whatever Von Dohnanyi's party political motivations may have been, he was reported in August 1972 as having three specific arguments for refusing to continue with the development of a European launcher: that the USA was always likely to supply Europe with a launcher, even if it could not give cast-iron guarantees in advance (and even if they did refuse once or twice, it would not really matter); that the market for such a launcher was too small to justify its development; and that anyway Europa III was of very little technological interest. The German Minister was reportedly so convinced by these arguments that he had only been stopped from informing some of his partners of his intention to withdraw from the entire Europa Programme by a veto in a meeting of the Ministerial Council by

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1217 See the *Note* dated 11 June 1971 which is reproduced in Chadeau (footnote 1188), pp. 383-6.

1218 Intelsat (the International Telecommunications Satellite Consortium) was set up following a conference in Washington in 1964. The interim agreements then established between the 80 member countries were replaced by definitive ones in 1971 after two years of negotiations. The main aim of Intelsat was the worldwide provision, on a commercial basis and without discrimination, of space segment facilities needed to meet the requirements of public telecommunications services for high-quality, high-reliability international telecommunications. A private American company, Comsat, represented the US in Intelsat, and also managed the Intelsat system under the interim agreements and during the transitional phase of the definitive agreements.

1219 CNES memorandum *Programme de Substitution et Cooperation Europeenne*, 15 September 1972, reproduced in Chadeau (footnote 1188), pp. 359-63.

Foreign Affairs Minister Scheel. Scheel insisted that such a move would place him in an extremely delicate political position.[1220]

Faced with the explosion of Europa II and the growing disenchantment of Germany with the European launcher Programme, the French government asked CNES and its traditional partner, the DMA's Direction Technique des Engins (the DTEn) which was, of course, attached to the Ministry of Defence) to study a new national launcher to replace Europa III. In the view of CNES President, Jean-François Denisse, such a launcher was needed not only to bypass possible US opposition to civilian telecommunications satellites but also to launch, without impediment, military telecom and reconnaissance satellites when the time came. A team was set up in February 1972, and within a month it had come up with a definition of new three-stage launcher called LIIIS whose configuration was defined in close collaboration with the DTEn and with three major French firms with considerable experience in the sector, Aérospatiale, SEP (Société européenne de propulsion) and Air Liquide. The launcher was presented for the first time to the Minister responsible for industrial and scientific development, François-Xavier Ortoli, in June 1972.[1221] Although we do not have detailed documentation concerning this period, the arguments for, and configuration of the French launcher as they appeared in September 1972 have been published. Let us look closely at this CNES paper entitled "Programme National de Lanceur de Satellites de Classe Identique à EUROPA IIIB".[1222]

The CNES proposal began by stressing the important developments foreseen in application satellites at the national, European and international levels – expert studies in Britain, Germany and France all agreed that in the decade of the 1980s the global market would amount to 20 to 24 satellites in the 400 - 500 kg class and 22 to 28 in the 700 - 800 kg class. To capture a significant portion of this market it was essential that LIIIS be able to place 700 - 800 kg into orbit with great reliability.[1223] It was also important that it be available by 1980 when the Shuttle was due to become operational. The European market on its own did not amount to more than about four satellites annually. The commercial viability of the rocket required, therefore, that it be operational at the same time so as to establish itself on the international market. This of course also meant that the unit cost of the rocket had to be competitive with that of equivalent American launchers, i.e. $16 million for the Atlas-Centaur and $12 million for a Shuttle mission (this being the figure being proposed by NASA at the time).

The best way to cut costs, reduce technical risks, and meet the tight deadline, the CNES paper suggested, was to make optimum use of technologies and know-how already acquired in French industry in the national and the European Programmes. "The experience gained on the Diamant and military launchers had to impregnate this Programme [...]", key 'components' which posed no basic problems, like the Viking motor and the low-pressure cryogenic motor HM6, had to be used, proven techniques for building structures using alloys specially developed in France had to be mobilised.

Starting from these principles, the report proposed that the first stage of Europa IIIB simply be recycled as the first stage of the national launcher LIIIS (labelled L150 with reference to the 150 tons of ergols needed; subsequently this was reduced to 140 tons, but the number was kept). To this would be added a cryogenic stage. Its diameter would be limited to 2 metres so as to be able to use existing equipment and testing facilities at Air Liquide, and it would be powered by the HM6 motor, whose development was already well advanced. Carrying six tons of ergols, its label was H6. An

[1220] See the translation of an article in *Die Welt* of 22 August 1972 made by the French Ambassador in Bonn, and a report from the French Scientific Councillor in Bonn to the Quai d'Orsay dated 30 June 1972, both in Chadeau (footnote 1188), pp. 399-402, and 387-88. The same source (pp. 352-4) describes NASA preparations for a visit from Von Dohnanyi in September 1972.

[1221] See Carlier and Gilli (footnote 1188), pp. 38-9, 157. They give no sources. Also Chadeau (footnote 1188), pp. 263-4.

[1222] The document is reproduced in part in Chadeau (footnote 1188), pp. 364-7

[1223] There is some ambiguity here. The official document gives these specifications. R. Orye remarks that, more precisely, LIIIS was to place (approx?) 1500 kg into geostationary transfer orbit, whereupon the apogee motor of the satellite would put 700-800 kg into geostationary orbit.

intermediary second stage was also needed, however, if the rocket was to put 700 - 800 kg in geostationary orbit. None of France's existing civilian or military rockets were suitable, either because they lacked the power or because they were geometrically incompatible with the other two stages. The report "refused to accept the high risk and the high investment needed for a large cryogenic stage". It therefore proposed basing the second stage on the first, using the same materials and a single Viking motor. The label of this stage was L30. The overall configuration of the launcher LIIIS proposed was thus L150 - L30 - H6. Figure 9-2 is a sketch of this rocket taken from another French document produced at about this time. It shows the upper stage of 2 m diameter surrounded by a detachable fairing of 2.8 m diameter and so aligned with the second stage.[1224]

What of the cost? Since the launcher was being built free from the constraints imposed by international collaboration, one could use simpler, less risky, and so cheaper technological solutions. The CNES report estimated that the development of LIIIS on a national basis would cost FF 1700 million 'hors taxes' in 1971 prices, plus a 10% contingency. A later figure increased this to FF 1824 million in 1973 prices, plus a contingency of 20%. These were far less than the estimated cost of Europa IIIB (over FF 3000 million as we saw), though somewhat more than France's contribution to ELDO. As for the unit cost of the launcher, opinions inside industry differed somewhat, though it seemed as though it would be around FF 50 million or some $10 million, including launch operations, and so competitive with the prevailing estimates of the cost of a Shuttle launch. A later figure gave FF 61 million in 1972 prices, to be compared with FF 89 million for an American Atlas-Centaur rocket of comparable performance.[1225]

The conservative technical and institutional considerations adopted for the launcher LIIIS, the determination to reduce risks by exploiting existing capabilities and to build the launcher nationally, were inspired by financial and political realism. But they were also strongly influenced by the conviction that the Shuttle, as NASA claimed at the time, would revolutionise space transport by dramatically reducing the cost per launch. These claims were taken seriously in Europe in the early 1970s, and weighed heavily on the minds of those who had to decide whether or not to proceed with an autonomous launch capability. Of course some people in Europe doubted the NASA figures, but they had no means of the challenging them at the time. In fact they were arrived at by NASA engineers in collaboration with a consulting firm on the assumption that NASA would become the primary launch provider for Europe and for the US civilian and military programmes in the 1980s, and that the Shuttle would make 500 flights over twelve years. It was this frequency of use that led to the price estimate of $10 million per launch. In fact in 1992 the cost per flight quoted by NASA was ten times higher in real terms ($107 million in 1971 dollars) and the Shuttle had never been launched more than nine times in any year.[1226] No one could know that when the decision on LIIIS was taken. As one of the senior advisors to President Pompidou on the launcher question was to put it later, for some people it looked as though we were imposing on our strained economy "an objective which ran the danger of looking ridiculous after a few years: we were building a conventionally powered DC6 just as the Americans were bringing a Boeing 747 into service".[1227] Put differently, in France the decision whether to proceed or not with such a launcher was essentially a political one, whose dynamics we will now describe a little more closely.

1224 From *Description d'un Lanceur Lourd Realisable dans le Cadre du Programme Complet de l'Europe*, undated, attached to letter Charbonnel to Lefèvre, 15 December 1972 (ESC 1457)

1225 The later figures are in the *Description d'un Lanceur Lourd...* just cited.

1226 H. E. McCurdy, "The Costing Models of the Early 1970s and the Launching of the Space Shuttle Program", in Chadeau (footnote 1188), pp. 205-224.

1227 See the remarks by B. Esambert in Chadeau (footnote 1188), pp. 95-98.

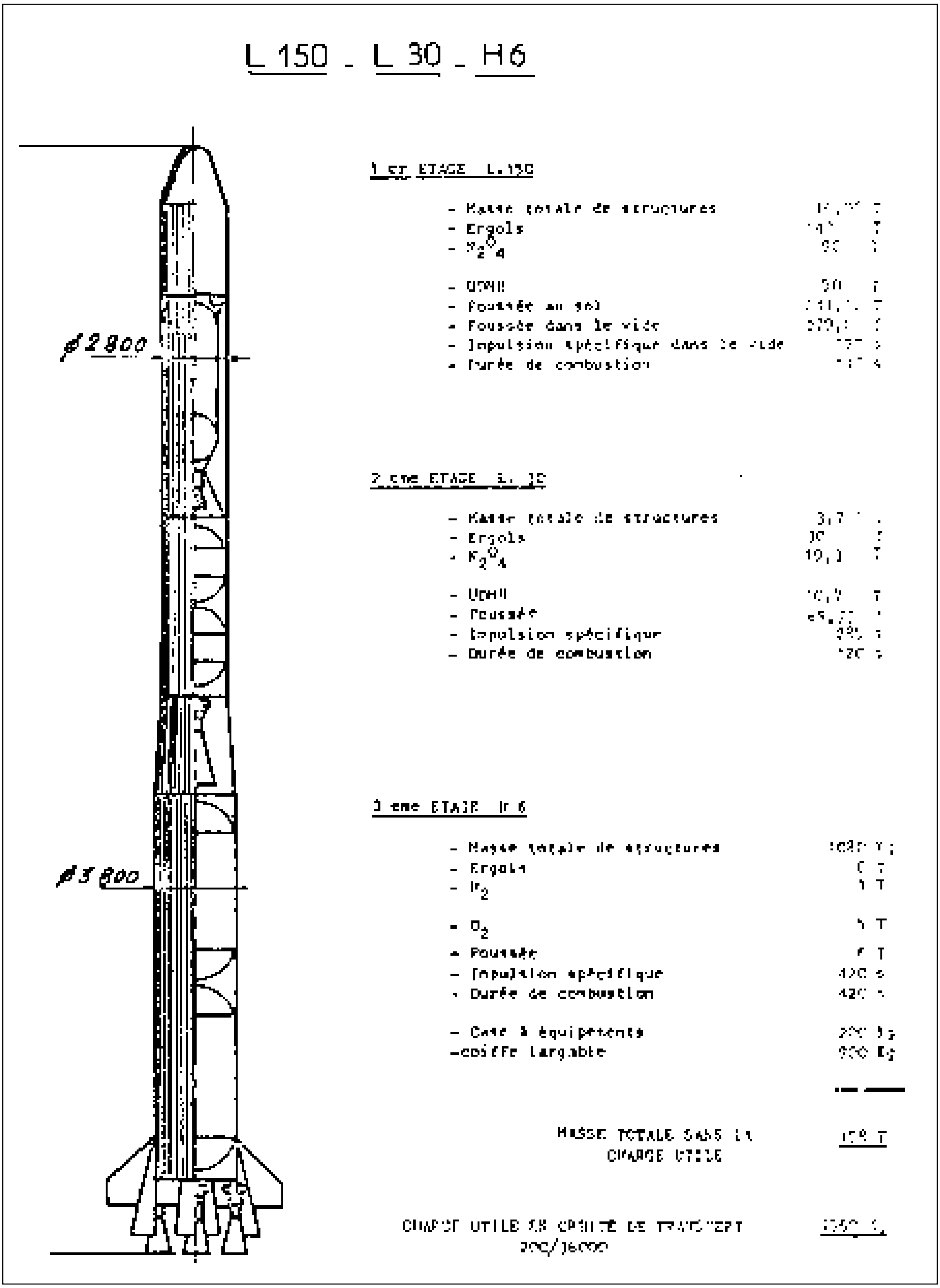

Figure 9-2: LIIIS Configuration

9.5 The French decision to develop a new heavy launcher

While it is difficult to trace the debate in France at the end of 1972 with any precision – our documents are too sparse and uneven in quality and reliability – we can give the broad lines of argument inside parts of the state system. Every department concerned seems to have been divided over how best to proceed, and it took the determination and conviction of a few very senior decision makers, and a deal with Germany, to embark on a heavy launcher programme.

The most important and recurrent theme inside the government was, as we have already mentioned, a deep-seated conviction that the US would try to dominate the commercial space market, and a determination to retain France's, and Europe's freedom of action in this sector. As French Minister Ortoli put it to his German counterpart Leussink in 1971, "Our objective in this domain is very straightforward: to ensure that Europe has access to the market by breaking an American monopoly and American domination. Indeed American policy in this domain is absolutely clear: it aims, on the contrary, to establish and to perpetuate its domination so as to give the United States an instrument of influence and of political action on the rest of the world at the same time as American industry benefits from a quasi-monopoly or, at least, a dominant position concerning all commercially viable applications in a field that is of the utmost importance for technological development."[1228] Within this general framework of mistrust (or political realism), the position adopted by the United States over the launch of the telecommunications satellite Symphonie provided corroborating evidence that they were determined to maintain their dominant position.[1229] In September 1972 NASA confirmed its earlier line, viz. that "If Symphonie is guaranteed by its developers, France and Germany, to be purely experimental, they will have no problem in getting a US reimbursable launch. To the extent that they wish to retain an option for eventual commercial use, a launching would have to be subject to the US version of the Intelsat clearance requirements". The 'US version' of those requirements, renegotiated the year before, was that if anyone wanted to launch a regional, commercial communication satellite system, as did Europe, "the US in effect will launch anything it supports <u>or</u> anything that two-thirds of the Intelsat membership will support".[1230] This position was judged by some Europeans to be particularly menacing. Matters were not helped by Nixon's official endorsement of this position on 9 October 1972, all the more so since the President now extended the offer made to Europeans two years earlier to all other countries. Clearly Europe could not expect any special treatment from the US, notwithstanding her involvement in the post-Apollo Programme: as the Chairman of the European Space Conference put it a month later, America will cooperate "on condition that launching our satellites is considered when the time comes, compatible with interests the American Government feels it ought to protect".[1231] This was brought home when the French and German negotiators (M. Bignier and H. Strub) went to Washington early in 1973 to discuss the terms for launching Symphonie with an American Thor-Delta rocket. They were stunned by American inflexibility; in the margin of the document laying down the US conditions the German representative scribbled the words "Es ist schwer!" (That's tough!).[1232]

Of course one might argue that the Europeans, and the French in particular, were asking the impossible of NASA in demanding that the US make a commitment to launch Symphonie irrespective of the political or commercial consequences for them. Indeed, as we have seen Von Dohnanyi thought that all of this was a storm in a teacup, and that the Americans could be relied on to meet European

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1228 See the summary minutes of the meeting between Ortoli, Leussink and Lefèvre on 1 June 1971, in Chadeau (footnote 1188), pp. 403-8.

1229 This is discussed at length in Sebesta's HSR Report cited in footnote 1188, and shall only be touched on here.

1230 Quotations from the NASA briefing prior to Von Dohnanyi's visit to Washington, 12 September 1972, quoted in Chadeau (footnote 1188), p. 352.

1231 Lefèvre to the Ministerial meeting on 8 November 1972, CSE/CM(Nov. 72) Add.1, 11 December 1972 (ESC 120). The text of Nixon's announcement is reproduced in the Annex to Sebesta, HSR-18 (footnote 1188).

1232 Quoted in A. Lebeau,"La naissance d'Ariane", in Chadeau (footnote 1188), pp. 75 -91, at p. 85.

requirements most of the time. Undoubtedly, each party interpreted US intentions in the way that suited it. By demanding cast-iron guarantees, and not getting them, the French had the perfect, self-fulfilling argument for justifying European launcher autonomy. By insisting that his Gallic partners were exaggerating the problem, the German Minister could justify, in turn, his lack of enthusiasm for the Europa Programme. At the same time, it must be said that the general position of NASA and the US hardly inspired confidence in Europe. Be it Symphonie, or Aerosat (the aeronautical satellite then being discussed),[1233] or post-Apollo, the US always seemed to be calling the shots. It was not simply that changes were made. What was irksome was the way in which it was done, e.g. in post-Apollo, "the Europeans being constantly informed [...] but without, it is true, being consulted about them".[1234] This determination by the US to maintain leadership and control in its space ventures with Europe – which reflected the prevailing balance of technological, industrial and financial power between them – gave the impression that they could never be relied on to strike an equitable deal with their partners. In this sense the definition of the LIIIS Programme as indispensable to European autonomy by some people in France owes much to the "maladroit intransigence" of the US, "based undoubtedly on the idea that Europe was not going to be able to carry out a successful launcher programme anyway".[1235]

That said, one must not overestimate the importance of this argument. It might have been crucial inside the space lobby, but it carried less weight without. The defence establishment is a case in point. Opinions here were divided over the military interest of space in the short term, and no General was easily going to give his support to a project which he thought might only be of value in 15 years time. But the Defence Minister himself, Michel Debré, was convinced in 1972 that a French space presence was imperative, and that if civilian launchers were not available France should develop military ones. As he put it later in his memoirs, he was always willing to fund an entirely national launcher from the defence budget so as to stop, as he put it, "the United States and Russia today, China and Japan tomorrow, from going freely into space and conquering the planets".[1236] Debré, it should be said, was a convinced Gaullist. The new Minister Roger Galley, who succeeded him in April 1973, did not think that the possible long-term military use of space could justify his department contributing to the costs of LIIIS.

Another related, if unusual argument for the project merits inclusion for the sake of completeness. As described by André Lebeau, who was intimately associated with the policy process in France in the early years, this was the idea that LIIIS could serve a dissuasive function.[1237] This concept, borrowed from the military field, was of course intrinsic to the thinking of those who had built France's independent nuclear force de dissuasion. It was only meaningful in such a context, depending on the production of missiles with nuclear-tipped warheads in sufficient numbers to constitute a threat to the enemy. It was a meaningless in a civilian field where production was to be predominantly market-driven. Its resonance with classical Gaullist preoccupations was, however, apparently strong enough for it to continue to weigh in the minds of some policy makers until the final decision was taken, whereupon it was consigned to oblivion. So much for the proponents of LIIIS. What of the opponents? The scientific community was unenthusiastic fearing, as usual, that the launcher programme would swallow all the available funds for space. But the most redoubtable opposition naturally came from the Finance Ministry. The LIIIS project was opposed by the Minister of Finance (Giscard d'Estaing) the very first time it was discussed in a restricted inter-ministerial meeting in June 1972. His opposition was further fuelled by the so-called Cannac report submitted in spring 1973. This commission was set

[1233] For details see chapter 8, this volume.

[1234] See *Main phases in the discussions between Europe and the United States on participation in the post-Apollo programme,* CSE/CM(May 72)WP/3, 19 May 1972 (CSE 106). These issues are discussed and analysed in depth by Sebesta in two papers (footnote 1188). See also Krige and Russo (footnote 1188), chapter 7.

[1235] The quote is from Lebeau in his contribution to Chadeau (footnote 1188), at p. 85. See also chapter 9, this volume.

[1236] The position of the defence establishment, and of Debré, is spelt out by various eyewitnesses in Chadeau (footnote 1188), pp. 103-5. Debré's successor in 1973, Galley seems to have been less enthusiastic. For the quotation see M. Debré *Gouverner. Memoires* (Paris: Albin Michel, 1988), Vol. III, p. 159.

[1237] Lebeau in Chadeau (footnote 1188), p. 89.

up at the request of Prime Minister Messmer to look into the distribution of the State's R and D effort across four strategic sectors: the nuclear, space, aeronautics, informatics. It concluded that LIIIS was not an economic priority, and that it was only defensible if there was a general increase in funding for research and development in the framework of the VIth national plan.[1238] The Treasury's opposition had one crucial consequence: it scuttled once and for all any idea that France could go it alone and build an all-national civilian launcher. Indeed the Ministry of Finance and the Budget Office only accepted to support the LIIIS project on condition that at least 35% of the financing came from France's European partners. The figure was not chosen arbitrarily; CNES estimated that, respecting industrial returns among the partners in the Europa III Programme, it could muster contributions amounting to about 30%.[1239] It was clear that if Treasury opposition was to be lifted the other government departments involved, along with CNES and the French space industry were going to have to make an all-out effort to cajole their compatriots in European countries, and above all in Germany, into a heavy launcher project.

9.6 The Ministerial conferences in December 1972 and July 1973

The debates over the future lines of European space policy in the latter half of 1972 were overshadowed by the impending Ministerial meeting whose date slipped progressively, but which was finally fixed for 20 December. It was becoming increasingly clear that procrastination was no longer possible. Nixon's endorsement of the Shuttle in January, and the identification in June of the sortie module as the only potentially interesting element for Europe in the post-Apollo Programme, imposed a deadline which, if missed, would imply that the opportunity of working with the United States would be lost. In August the US informed the Europeans that NASA required a commitment in principle by the end of the year, following which the formal agreements would be prepared for adoption no later than 15 August 1973. This commitment would be coupled with the funding of a definition phase, and if the cost figures arrived at "unacceptably exceed the financial ceiling agreed by the ESC Ministerial Conference, the Europeans would be allowed to withdraw from their commitment".[1240]

To prepare the ground for their decisions, the Ministers met informally on 8 November 1972. Several points emerged clearly at this meeting.[1241] Firstly, there was very little support for continuing with Europa III. It seemed, to quote the Belgian Minister Lefèvre, "too powerful for the initial missions envisaged and too advanced for operational phases of the 1980's whose requirements are moreover not at the moment sufficiently defined". It was also very expensive – costing at least $9.5 billion, said Von Dohnanyi, it "would require funds which are not available in the present budgets of the European partner states". Indeed for him France's determination to develop an independent European launcher made no technical, industrial or commercial sense; and was driven essentially by a wish for *grandeur,* by considerations of "prestige". Italy concurred. For her Minister a decision in favour of Europa III would "penalise decisively other activities", and was not needed politically since Italy was "highly confident on the future positive evolution of the political relationship between Europe and the US". The French naturally disagreed, but did hint that a new proposal was in the air, a proposal involving "other methods of management than those used so far and, therefore, other technical solutions to achieve the same objective".

The second point stressed at the meeting was that Germany was determined to participate in the sortie laboratory, and that she wanted a decision quickly: Europe would miss the "post-Apollo bus" if a decision to fund the project had not been taken by 15 August 1973. Italy was fully behind Germany, insisting that definition phase studies should be authorised immediately. France of course was not

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1238 See Carlier and Gilli (footnote 1188), pp. 39-40 and Esambert's contribution to Chadeau (footnote 1188) at p. 96.

1239 See Lebeau in Chadeau (footnote 1188), p. 87.

1240 *Report by the Secretary General of the European Space Conference on the Status of European Space Programmes*, CSE/CM(Dec. 72)5, rev. 1, 12 October 1972 (ESC 127).

1241 All the quotations in the next three paragraphs are from the minutes of this meeting, document CSE/CM(Nov.72),4, 17 November 1972 (ESC 120).

convinced. While recognising that there was some interest in the "manned flight" aspects of the module, Charbonnel insisted that "none of the economic needs of the next decade would be met by the development in Europe of the sortie lab, which can in no case be considered a substitute for the launcher programme".

Finally, these position statements notwithstanding, the chief protagonists also sent signals to each other that they were willing to compromise. Lefèvre had set the tone in his opening remarks by stressing the need to pool resources if Europe was to was to be able compete technologically with the great powers, and adding that a "community [was] only viable [...] if the very idea of all-round concessions to the opinions and aspirations of others [was] accepted from the outset". Charbonnel, who spoke after him, made the first move. France, he said, was "not at all closed to the idea of cooperating with the United States" and could envisage participating in a European sortie lab Programme "within the limit of our financial means, if, beforehand, all the measures have been taken to satisfy Europe's requirements, particularly with regard to launchers". Von Dohnanyi, who spoke next, rose to the challenge. "Our cabinet took a decision in October", he said, "which links participation in post-Apollo to continued funding for Europa III, an open question which [...] we wish to discuss further". Charbonnel made a definitive move to open LIIIS to European participation a month later. Discussions since the November meeting had led him to conclude, he wrote, that it would be impossible to continue with the Europa III Programme. In its place he would propose to the European Space Conference "the common development of a heavy launcher for which France would agree to be the prime contractor and provide the major part of the finance". Her partners would have to contribute "at least 40%" of the cost and agree that it would have "a suitable priority of use in Europe compared with means of launching developed outside Europe". In return his government "could envisage in parallel a limited participation in the post-Apollo Programme".[1242]

The French Minister developed these arguments at the Ministerial meeting on 20 December.[1243] He explained that France was "proposing to its partners to shoulder the major part of the funding and to bear the development risks of a launcher with a capability equivalent to EUROPA III, 750 kg in geostationary orbit, for an overall cost of 550 million units of account of which France would like 40% to be provided by its partners".[1244] The development plan and detailed characteristics of the launcher would be available by April. France wanted CNES to take executive responsibility for the project. It would entrust the work to a prime contractor, which would be a French firm or French-headed consortium. The prime contractor would be left to choose the foreign industrial partners who would participate in the venture, bearing in mind cost, timescale and the quality of their work. Participating states would be represented on a "steering committee", which would monitor the execution of the programme and collect the partner's financial contributions. The French proposal was received with sufficient interest for Lefèvre to remark that "signs of a certain breaking of the deadlock have begun to appear".[1245] Indeed at the end of the meeting the Ministers from France, Germany and Britain (whose position we will discuss in a moment) drafted a resolution in which, *inter alia*, they agreed in principle to carry out the sortie lab project and the French launcher within a common European framework. They also agreed to drop Europa III forthwith.[1246]

1242 Letter Charbonnel to Lefèvre, 15 December 1972, CSE/CM(Dec. 72)7, 19 December 1972 (ESC 129). The French original is in file (ESC 1457).

1243 The minutes of this meeting are document CSE/CM(Dec. 72)PV/1 for the morning session (ESC 121) and PV/2 for the afternoon session (ESC 122). Charbonnel's statement opened the afternoon session.

1244 Both these figures were of course overestimates. As we know from above the cost of 550 MAU was close to that of Europa III, and far greater than CNES's estimates for LIIIS, and the Finance Ministry in France had set a 35% limit on participation by other states.

1245 From Annex I to the minutes of the morning session.

1246 The resolution terminates the minutes of the afternoon session and was also released as SE/CM(Dec.72)8, 20 December 1972 (ESC 130).

The Ministerial decisions were duly implemented by the ELDO Council meeting the next day: Europa III was formally abandoned as from 31 December 1972, and its staff officially fired as from 1 February 1973. What is more, the future of Europa II was also put into question by the Council, even though it had not actually been discussed the day before. Germany did not want to fund the existing Programme for more than a month and Belgium was bickering about its rate of contribution.[1247] France struggled on valiantly with patchwork arrangements to save Europa II for Symphonie, but finally yielded to the inevitable. At the ELDO Council meeting on 27 April 1973, the two major contributors agreed that the Europa II Programme should be stopped immediately, even as the F12 launch vehicle was on its way to Guiana.[1248] The next six months saw detailed negotiations between the interested states on the management structure, financial contributions, geographical returns and legal texts surrounding the LIIIS and Spacelab projects in a context of great international financial insecurity.[1249] The draft arrangement for executing the LIIIS Programme foresaw expenditure of FF 2472 million (445 MAU) in 1 January 1973 prices, with a 20% contingency margin included. The draft agreement for the execution of Spacelab, as the sortie module was now called, was opened for signature from 1 March to 10 August 1973. The financial envelope for this Programme was set at 308 MAU in mid-1973 prices. As we mentioned earlier, participating states were still free to withdraw from this Programme before 10 August, however, if further studies indicated that these estimates would be significantly exceeded.[1250] ESRO DG Hocker reassured Ministers in July that these figures could indeed be kept to despite recent "rather severe changes in the Shuttle specifications".[1251] When Ministers met on 12 July to take stock of where they stood, the situation was far from promising.[1252] France and Germany had settled the terms of their financial participation in each other's pet projects: Paris would contribute 10% to Spacelab, while Bonn offered DM 320 million spread over eight years (about 18.5%) for LIIIS. No other major contributions were forthcoming, however. Britain was not interested in the launcher and the Italian delegate was not yet able to commit his new government, though he stressed that they would give "top priority" to Spacelab. Contributions from the remaining countries whose delegates were in a position to engage themselves (Belgium, Denmark, Spain and Switzerland) amounted to a little over 7%. The total participation of France's European partners, in other words, was only about 25% and so well below the threshold of 35% set by the Treasury. In fact Charbonnel's official position was that France could only afford 60% of the total cost. To avoid having to accept defeat, the Chairman of the Ministerial Space Conference, Charles Hanin, suggested that the meeting adjourn until the end of the month, imploring delegations which were still undecided to clarify their positions in the interim.

Hanin spent the next two weeks jetting between European capitals. His efforts bore little fruit, however. The only important new development was that Britain agreed to contribute £4 million to LIIIS, equivalent to 9.8%. This was conditional on France being willing to contribute to a British project called Marots, a maritime satellite which her Minister Michael Heseltine now introduced as part of the overall package. (The British position will be discussed in detail in section 9.7).

1247 See minutes of the 61st ELDO Council session, 21 December 1972, document ELDO/C(72)PV/7, 13 February 1973 (ELDO 1549).

1248 The minutes are ELDO/C(73)PV/3, 22 June 1973 (ELDO 1600).

1249 For an account of the inteministerial discussions between France and Germany see P. Louët, "Les aspects diplomatiques de la naissance d'Ariane, 1970-1973", in Chadeau (footnote 1188), pp. 117-129, at pp. 127-8.

1250 For these data see *Report on the Implementation of the Decisions of the Ministerial Conference of 20th December 1972,* CSE/CS(73)WP/4, 27 June 1973 (ESC 738).

1251 See his contribution in Annex 5 to the Minutes of the meeting on 12 July, CSE/CM(July 73)PV/1, 24 July 1973 (ESC 132). How wrong he was! See *Proceedings of the Workshop on the History of Spacelab, ESTEC, Noordwijk, 22-23 April 1997*, Report ESA SP-419.

1252 The minutes of the meeting on 12 July 1973 are document CSE/CM(July 73)PV/1, 24 July 1973 (ESC 132).

The Ministers reconvened on 31 July 1973.[1253] The Spacelab deadline was just two weeks away. Crisis was in the air. The core of the problem was Italy. Her level of commitment (an Italian contribution of as much as 20% to Spacelab was being spoken of) had major repercussions on how her partners distributed their available resources between the three projects. The Italian Ambassador was the first to speak – only to regret that he was still not in a position to commit his government which was "currently having to contend with extremely serious financial and monetary difficulties". In the hope of breaking the ensuing deadlock, the Italian Ambassador telephoned Rome. But no, the Italian position would indeed only be known by mid-September.

It was now or never. Hanin suspended the meeting and consulted in private with each of the participants. His aim was to bypass the public horse-trading between them and to get each delegation to admit in private the maximum figure which it was able to contribute. Speaking years afterwards of the experience, the Belgian Minister for Scientific Policy and Planning described the process in these terms:

> *"I had the impression that I had taken part in an extraordinary game of poker in which each player hoped that the other would make the move that he himself did not dare make. I was also struck by the interdependence of the three projects: the success of one depended on that of the others, each country refusing to take part in the other's projects if theirs was not accepted. The third strong feeling that I had was that at certain moments it is imperative that decisions be taken at any price, failing which they will never be taken at all.".*[1254]

Charbonnel now formally agreed to raise France's share to 62.5%. Ehmke raised Germany's contribution to a little over 20%, a gesture facilitated by the re-evaluation of the Deutschmark the month before. Belgium increased its contribution from 4% to 5%. And the Netherlands Minister, going against the agreed policy of his government, decided to contribute to the tune of 1%. Britain (steady at 19.25 MAU or 9.8%), Denmark (steady at 0.5%), Spain (steady at 2.00%) and Switzerland (up from 9.14% to 9.15%) confirmed their participation. That still left a shortfall of 6% on the LIIIS Programme. Exhausted by an all-night session of bargaining and "Seized suddenly by a strange sense of optimism, we decided that the countries which had not yet made up their minds would cover the shortfall" (Hanin writes).[1255] The agreement with the unusual budget line "Italy and others: 6%" for LIIIS (and 29.10% for Spacelab) was signed at 5 o'clock in the morning of 1 August 1973.

A strategy of this kind had the great advantage of both setting targets for participation and of pressuring the undecided governments to meet them. Indeed the Ministers who put their names to the LIIIS agreement in July were staking their political credibility on the percentages they had accepted for their countries. In the months ahead these figures were revised in the light of political contingency and an estimate of industrial returns. By December, when the formal "Arrangement" for undertaking what was now called the "Ariane Launcher Programme" came into force, the percentage contributions to be used in calculating voting weights were the following:[1256]

1253 The minutes of the second session are CSE/CM (July 73)PV/2, document dated 27 August 1973 (ESC 133).

1254 C. Hanin, in Chadeau (footnote 1188), p. 136.

1255 Hanin in Chadeau (footnote 1188), p. 136.

1256 From ESRO/IB-LIIIS(73)2, rev.2 , 3 December 1973 (ESRO 3372).

Table 9-1: Percentage Contributions to the Ariane Programme in September 1973

Participating State	Percentage
Germany	20.12[1]
Belgium	5.00
Denmark	0.50
Spain	2.00
France	62.50
Italy	9.74[2]
Netherlands	2.00
Sweden	9.10
Switzerland	9.20
(United Kingdom	2.47[3])
Other Countries	9.37

Notes[1257]

1. Germany agreed to contribute a fixed sum of DM 40 million each year for eight years, beginning in January 1974, revisable once, in January 1978, in the light of the price variation rate relevant to Germany for the years 1974-77 inclusive.
2. Italy agreed to contribute a fixed amount of LIt 5000 million over seven years. Half of this would be paid in equal amounts in January 1975, 1976, and 1977. The remaining half, as revised in the light of price levels on the 1 January 1978, would be distributed equally between the four years 1978 to 1989.
3. Equivalent to 19.25 MAU. As we point out below, the UK was not formally speaking a Participating State in the Ariane Programme, and its contribution appeared as 'other income'.

To conclude this section, let us stress again that the Participating States had very different motives for agreeing to build together a European launcher. For France it was a continuation of Gaullist aspirations, a symbol of mistrust for the United States, a means to ensure that Europe could launch telecommunication (and later military) satellites whenever she chose. If she collaborated with other countries it was because the Treasury demanded it, and because the Quai d'Orsay welcomed it as coherent with France playing a leading role in the post-war reconstruction of a scientifically and technologically united Europe. For Germany, matters were different. While considerations of industrial policy reinforced the arguments from Foreign Affairs, participation was also part of the deal: we contribute to LIIIS if you contribute to Spacelab. Britain's preoccupations were similarly pragmatic, though now tinged with a willingness to play her role as a 'new' European. She wanted French participation in Marots and she realised that the only way to get it was through paying towards the launcher, which would also satisfy pressure from British industry to be involved in a major European high-tech project.

For the smaller countries, and particularly those which were not members of the Common Market (like Switzerland and Sweden) the interest in the rocket was essentially to ensure that their firms got technically interesting contracts for part of the system; political considerations were very much in the background. Just how far in the background can be gauged when one remembers that these countries stayed out of ELDO partly because, at the time, rocketry had unavoidable military connotations which, they feared, would impugn their neutrality. If they reassessed their position it was because the thaw in East-West relations in the early 1970s was combined with a changing picture of space. When ELDO was launched in the early 1960s space had been seen as unavoidably linked to defence; now it was perceived as a domain for essentially commercial rather than military rivalry. Moreover, launchers had become space transportation systems embodying industrial know-how and skills valuable on the world market, rather than being weapons of destruction.

1257 See ESRO/C(73)41, Annex I, rev. 4, 24 September 1973 (ESRO 724).

In sum, when the agreement to embark on LIIIS/Vega/Ariane was signed, France alone – or, at least, a handful of senior officials, some CNES engineers and some sectors of industry in France – were convinced, or had convinced themselves, that the rocket was an indispensable asset to the European technological arsenal. And the scepticism which some of her partners felt about the merits and viability of the project persisted well beyond its gestation and birth, including in its mother country.

9.7 The British position

Britain's position demands separate treatment not only because it was indicative of her wish to play a more active role in Europe, a wish twice thwarted by de Gaulle in the 1960s, but also because France and the other partners agreed to her having an unusual position inside the LIIIS project. More specifically, the United Kingdom was not a signatory to the Ariane agreement along with the other Participating States. Rather she signed a separate bilateral agreement with France specifying the terms of her collaboration in the Programme.

Although Britain was a founder member of ELDO – indeed, through Blue Streak, the driving force behind its establishment – her enthusiasm for it gradually waned as costs rose, the rocket stages being built by her partners failed, and the government changed. From the mid-1960s onwards she began to disentangle herself from the Europa II Programme; she refused to contribute anything at all to Europa III. Then, finally, in September 1972, she declared that she would be leaving ELDO altogether as from 1 January 1973. France was particularly infuriated, insisting that it was legally impossible and politically deplorable that the UK should choose just this moment to withdraw, so striking yet another blow at the launcher Programme and at a coherent European space policy.[1258]

It was at about this time that Heseltine came forward with a new idea which he presented to his fellow Ministers at the informal meeting on 8 November 1972.[1259] "We are spending enough money to achieve results", said the British Minister, "but we are not spending it in the way it ought to be spent". To overcome this problem he suggested "that we establish in Europe one single space Agency to which we would transfer ELDO and ESRO and to which we would phase at an agreed rate the national commitments and programmes of the various European countries". This European space agency would have a number of specialised programmes to which potential participants would be free to contribute on an "à la carte" basis according to their interests. No one would be obliged to contribute to any programme, and their level of contribution would not be tied to their GNP, "which has always been the stumbling block up to now".

Heseltine's idea has been described as a shrewd political move: fusing the two existing organisations was "an elegant way not to withdraw from ELDO while not participating in the construction of launchers [...]".[1260] More fundamentally though it was an attempt to invert the logic of space spending. Thus far the national space budget had been driven by the programmes, notably at the European level. The engagements entered there imposed a level of expenditure fixed by political and industrial concerns, and with contributions based on Gross National Product. The British Minister wanted to regain control by having national authorities <u>first</u> decide how much they wanted to spend on space in the light of their overall R and D budgets, and <u>then</u> choosing what programmes to join and at what financial level. By phasing, in addition, national programmes into the European programme on this

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1258 For the evolution of the British position see Krige and Russo (footnote 1188), especially chapters 3 and 6. The implications of her formal denunciation of the ELDO Convention are to be found in document ELDO/C(72)9, 17 October 1972 (ELDO 1584). France's reply is ELDO/C(72)43, 27 October 1972 (ELDO 1588). For the exchanges with France see the ELDO Council minutes of the meetings on 27 October 1972, ELDO/C(72)PV/5, 27 November 1972 (ELDO 1547), and on the 22 November 1972, ELDO/C(72)PV/6, 11 January 1973 (ELDO 1548).

1259 See his statement reproduced at Annex II to the minutes, document CSE/CM(Nov. 72)4 , 17 November 1972 (ESC 120).

1260 The words are those of Maurice Lévy, one of the senior French officials who met Heseltine off his private plane when the British Minister came to describe his idea to Charbonnel; see Chadeau (footnote 1188), p. 101-2.

basis one had the most cost-efficient way of making use of available resources. His concerns were thus primarily financial, and inspired by the determination to reinforce the authority of national space authorities and, by extension, to recapture some of the national sovereignty sacrificed in the collaborative process.[1261]

In itself the idea that there should be a single space agency in Europe with optional programmes to which states contribute on an "à la carte" basis was not new; it had been suggested on many occasions over the previous five years. If it had not yet taken root it was because it struck a blow at the heart of the prevailing conception of the collaborative process. That process involved what Belgian Minister Théo Lefèvre described as a genuinely common "European" programme, without which each country would "appraise its participation in a given project by the sole yardstick of its national interest", at the expense of making "all-round concessions to the opinions and aspirations of others".[1262] It was becoming evident though that this conception of collaboration was now too restrictive. If the joint effort was not to break up altogether one would simply have to accept that the partners involved had not just different, but actually conflicting interests, and would have to find a way to accommodate them. This was case over launchers, where Britain's policies "appeared to conflict [...] and still do conflict" with those of France. But rather than stop those countries that wanted to do so from going ahead and building a rocket, Heseltine sought "a framework within which we can reconcile our differences or live together even though we have different views on what the policies we put forward are".[1263]

Survival demanded pragmatism. The British proposal (strongly supported by Belgium) to form a single agency out of ELDO and ESRO was accepted in principle by the Ministers meeting in December 1972. Implementing his policies at once, Heseltine went on to propose that various satellite programmes should be rationalised. In particular he felt that it was necessary to eliminate one of two maritime navigation satellites then under consideration: either GTS, a British national satellite originally intended for telecommunications but subsequently reoriented to maritime navigation, or Marots, which had similar objectives but which had been studied by ESRO.[1264] GTS was mainly an experimental, technological development satellite of the OTS class. Marots was a pre-operational satellite (i.e. it could be the first of a system intended to perform reliably with tested technologies), and to choose it was also to make a choice for long-term European space policy. In December Heseltine's preference was to Europeanise GTS. Six months later the UK government had decided instead to finance a major part of Marots, and to use this as a bargaining chip in dealing with France and Germany over Britain's contributions to their projects.

When the Ministers first met on 12 July Heseltine stated that he was still not interested in participating in LIIIS, but would contribute to Spacelab if there were sufficient European support for Marots. By the time that he and his counterparts reconvened on 31 July, the British Minister had changed his views. To facilitate agreement, he said, he was now prepared to associate himself with LIIIS as well, both contributions being conditional, of course, on Germany and France participating in Britain's pet project. As we saw above, at the end of the day Heseltine had agreed to put 9.8% into LIIIS, even

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1261 See also Heseltine's contribution to the Symposium organised jointly by ESA and the Science Museum, London, in November 1998. ESA SP-436.

1262 See his statement reproduced at Annex 1 to the minutes, document CSE/CM(Nov. 72)4, 17 November 1972 (ESC 120).

1263 See his contribution to the Ministerial meeting held on 20 December 1972, CSE/CM(Dec. 72)PV/2, 10 January 1973 (ESC 122).

1264 See *Report on the Implementation of the Decisions of the Ministerial Conference of 20th December 1972*, CSE/CS(73)WP/4, 27 June 1973, and the UK Amendment, add. 1, 28 June 1973 (ESC 738).

though the UK had "categorically declined to participate" just a couple of months before.[1265] In return France agreed to put 15% into Marots (which was far cheaper of course: about 60 MAU).[1266]

If Heseltine had changed his mind, it was because those responsible for LIIIS at CNES had agreed to attribute the development and supply of its inertial guidance system to British firms. The terms of this special arrangement, which tied the UK's contribution to a specific, technically crucial part of the Ariane system were defined in an independent bilateral agreement between Britain and France which was signed on 13 December 1973.[1267]

In terms of this agreement the UK government accepted to contribute up to 19.25 MAU in 1 January 1973 prices to the LIIIS project, of which 9.375 MAU was for the basic expenditure and the balance, one-sixth of the total, was available to cover technical contingencies. In return CNES undertook to let a contract to Marconi Space and Defence Systems Ltd, for all major studies, including the overall design, of the guidance system. From this would emerge the specifications of the two items of hardware constituting the system, the computer and its interface unit, and the inertial platform with its associated electronics (both including power conditioning equipment).[1268] This was a good deal for the UK. Institutionally, Britain's interests would still be protected by her delegates' participation in the Programme Board set up to the monitor the Ariane project, their votes weighted proportionately to their financial contribution, just like everyone else. Industrially, Britain had all the advantages ensuing from developing a highly-sophisticated piece of rocket technology, without its government taking any of the risks, or assuming any of the constraints, ensuing on participation in an expensive collaborative venture whose success was far from guaranteed. Politically, the bilateral arrangement was a major concession, and one not appreciated by France's partners in the Programme. Granted these privileges France had to make a gesture to soothe the ruffled feathers of her partners: she offered to have the contracts allocated to UK firms added to those allocated to French firms when calculating French "fair returns".[1269] In his desperate, last-minute efforts to build percentages and to satisfy his Treasury, Charbonnel had had little choice but to accept Heseltine's demands – so penalising slightly French industry and sinking once and for all Lefèvre's dream of maintaining a "genuinely 'European' space programme". The new Europe of the Nine would surely be different to the old Europe of the Six.

9.8 The arrangements for the execution of the launcher programme

The negotiations just described went along with a definition of the modalities of the LIIIS Programme. ESRO was to be the institutional umbrella for the Programme pending the coming into being of ESA. Its Council adopted an "Arrangement" with the participating states on 21 September 1973 (which

1265 See remark by the French delegation at meeting of the Committee of Alternates of the European Space Conference on 22 May 1973, document CSE/CS(73)PV/2, 29 May 1973 (ESC 674). The UK was still showing a preference for GTS at this meeting.

1266 See the minutes of the two sessions of the meeting, CSE/CM(July 73)PV/1, dated 24 July 1973 (ESC 132), and PV/2, dated 27 August 1973 (ESC 133). At this meeting Britain agreed to contribute 6.3% to Spacelab while Germany offered 20% to Marots, which the UK was funding to the tune of 56%.

1267 The document is ESRO/PB-ARIANE(73)4, rev.2, 12 February 1974 (ESRO 3374). What follows is based essentially on this text.

1268 It was agreed that this hardware would be open to competitive bidding to firms in all the participating states, not just in the UK. However, if at least one of these items were not awarded to British industry her basic contribution to the programme would be reduced from 9.375 MAU to 7.375 MAU. UK firms would also be allowed to bid on equal terms with the participating states for other parts of the rocket – gyroscope units, autopilot units, the pressurisation system of the second stage, and portions of the propellant system of the third stage. In this regard the agreement guaranteed British firms contracts for "some or all of these items" as well if the value of the contracts awarded on the inertial guidance system did not amount to at least 80% of 9.375 MAU (or of 7.375 MAU if no contract was awarded to UK industry for the hardware of the guidance system).

1269 See meeting of the Interim Programme Board on 8 November 1973, ESRO/IB-LIIIS/MIN/3, 28 November 1973 (ESRO 3360).

entered into force with the French signature of the text on 28 December that year). At its next meeting, on 6 December, it adopted an "Agreement" with CNES.[1270]

It is not our intention to discuss these documents in detail here. Instead we shall focus on the main areas of contention in them. These were three: financing and industrial return, management and control, and the move from the development and qualification of the launcher to its production. All of these were hotly debated between France and her partners in the project, the French being forced to assume ever-greater risks in return for which they demanded a large measure of control over development.[1271] Before embarking on a discussion of these items though, let us quickly remind the reader of the nature of the launcher eventually adopted.

9.8.1 Ariane's architecture, cost and development plan

The proposed European launcher was refined by the engineers at CNES in consultation with their colleagues in ELDO and in industry throughout 1973.[1272] The architecture finally adopted for the rocket is shown in Figure 9-3 [1273]; it differed somewhat from the earlier version of the national launcher shown in Figure 9-2. Ariane was designed to place payloads of 1500 kg into transfer orbit, so enabling the injection of satellites of some 750 kg into geostationary orbit. It was about 47 metres high and weighed 202 metric tons at lift-off. Its first stage was kept as identical as possible to that of Europa III B, except for a slight shortening of the cylindrical part of the tanks and a reduction of the weight of the propellants from 150 to 140 tons. The mixture of N_2O_4 and UDMH (unsymmetric dimethyl-hydrazine) was pressurised by hot gases drawn from the four Viking-2 engines which powered L140. The second stage, L33, had a diameter of 2.6 metres, carried 33 tons of the same propellants pressurised by helium, and was equipped with a single Viking-4 engine derived from the Viking-2. Stage three, H8, also had a diameter of 2.6 metres, and carried 8 tons of liquid hydrogen and liquid oxygen under pressure. The earlier idea of surrounding it with a jettisonable outside fairing was dropped, and the now-familiar bulbous fairing was adopted. This allowed for a payload of effective diameter 3 metres and height 4 metres.

The estimated cost of development of the rocket was lower than that of Europa III B, but more than that of the purely national launcher proposed in Figure 9-2. The basic figure agreed on was FF 2,060 million (or about 370.9 MAU) in 1 January 1973 prices. Since Member States were not allowed to withdraw from the Programme as long as its cost remained within 120% of this figure, this amounted to a commitment to spend 2472 MAU on developing the launcher. The launcher's production cost was estimated to be FF 51 million, to which had to be added 12 million for the cost of transport to Guiana, of propellants and of the launch team, plus a variable sum to cover expenses at the Kourou base. These figures assumed that there would be two launches per year and a reasonable grouping of orders. The global market for the 1980s was thought to be of the order 35 to 50 geostationary satellites in the 400 to 700 - 800 kg range.

1270 The *Arrangement Between Certain European Governments and the European Space Research Organisation Concerning the Execution of the [L III S] Launcher Programme* as adopted by the Council on 21 September is document ESRO/C(73)41, Annex I, rev.4, 24 September 1973 (ESRO 724). The name Ariane was fixed a week later by the Administrative and Finance Committee. The text was signed by the French government on 28 December 1973, and came into force on that date – see ESRO/PB-ARIANE(74)4, Annex (ESRO 3381). The *Agreement Between the European Space Research Organisation and the Centre National d'Etudes Spatiales (FRANCE) Concerning the Execution of the Ariane Launcher Programme* as approved by the ESRO Council meeting on 6 December 1973 is ESRO/C(73)41, Annex II, rev.3, 17 December 1973 (ESRO 724).

1271 See in particular the two informal meetings of the representatives of the participant states held on the 27 June 1973 and 3 July 1973, file (ESRO 6793), where the draft legal texts were discussed in depth.

1272 Unless otherwise stated the description that follows is based on Annex A to the *Arrangement* just cited.

1273 From *Ariane Launcher. Brief Description,* document DPP/LIIIS/56/AB/LU, 11 March 1975 (ESRO 6069).

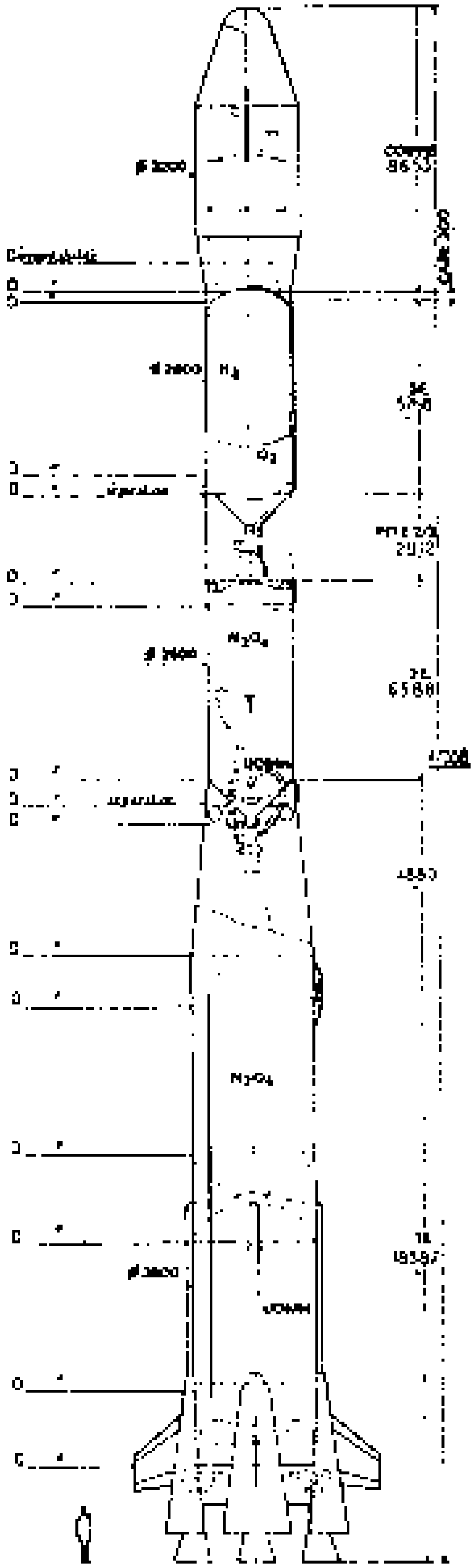

Figure 9-3: Ariane

The development plan, which covered seven years, was unusual in that the individual stages of the rocket were not tested separately. CNES's original idea was to test the upper stages apart from L140 in two separate firings so as to be sure that the novel and difficult cryogenic stage functioned properly. This was to be followed by two test launches of the complete vehicle. This plan was strongly criticised by an ELDO technical group. It entailed having the two upper stages ready by 1978 which, the group felt, was overly optimistic, technically risky and additionally expensive. It was suggested instead that the *complete* three-stage vehicle be launched in four test firings beginning late in 1979.[1274] CNES DG Bignier did not agree. The proposal to test the complete rocket was contrary to CNES's traditional policy of having "partial and progressive launches up to the final success" and "the risk", as Bignier put it, "was enormous".[1275] Notwithstanding his concern, it was decided to have two development firings and two qualification firings of the complete launcher without, as we said, testing individual stages separately.

9.8.2 Financing and industrial return

The overall financial commitment to the Ariane Programme comprised three items in addition to the 'direct expenditure' of 370.9 MAU for the development of the rocket as such. Firstly, 2.5 MAU were set aside for ESRO's and later ESA's internal expenditure. Secondly, and more controversially, a further 7 MAU were made available as a contribution to the cost of maintaining the launch complex at Kourou until the Ariane Programme got under way. Roughly half of this sum was to cover the maintenance of equipment transferred from the Europa III Programme. The balance was for maintenance of new installations for the project.[1276] Finally, there was a 20% contingency on the direct expenditure, amounting to 74.2 MAU. This gave a firm financial envelope for the execution of the Programme of 454.6 MAU (about FF 2525 million) in 1 January 1973 prices.

A key consideration determining participation in the Ariane project was CNES's engagement to ensure an 80% industrial return on work of "definite technological interest" to firms in the participating states. But 80% of what sum? Here Germany and Italy were emphatic: they wanted an 80% return on the *total* contribution that they were prepared to make including, notably, the 20% technical contingency. France, for its part, said that this was impossible, and that it could only ensure 80% returns on the direct expenditure involved in the rocket's development. In particular it was impossible to maintain the same guarantee for the geographical distribution of work in the expenditure of the 20% contingency, which would depend very much on the specific needs of the Programme.[1277] The final text involved the following compromise. All participating states would be guaranteed an 80% return in work of definite technological interest on their contribution to direct expenditure, i.e. on the basic development cost of the rocket. If this target could not be reached for one or more participants, their contributions would be reduced proportionally before the end of the development phase. If this left a shortfall in funding the French Government undertook to make up the difference. As for the distribution of work in the 20% contingency margin, it was agreed that CNES would do its best to "avoid any distortion in the fair return of the Participants [...]", without specifically committing itself to maintain the 80% level.[1278]

This was not the only situation in which the France agreed to extend its financial guarantees for the project. It was also prepared to bear full responsibility for cost overruns in excess of the 20% contingency margin. The limit to which it was prepared to go fluctuated, however, in the course of the

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1274 See *Comments by ELDO...* just cited.

1275 M. Bignier, "Les choix industriels et le rôle des entreprises", in Chadeau (footnote 1188), pp. 155-9, at pp. 155, 156.

1276 For the difficulty France had in getting some of her partners to agree to this sum, see the debate at the informal meetings on 7 June 1973 and 3 July 1973 (ESRO 6793), and the meeting of the Committee of Alternates on 25 July 1973, CSE/CS(73)PV/6, 30 July 1973 (ESC 678). The costs of Kourou remained a thorn in the side of the project throughout the 1970s - see section 9.9.2.

1277 See the exchanges at the meetings of the Programme Board on the 13/9 and the 19 September 1973, ESRO/IB-LIIIS/MIN/1, 11 October 1973 (ESRO 3358), and ESRO/IB-LIIIS/MIN/2, 24 October 1973 (ESRO 3359).

1278 See Article X of the *Arrangement*, ESRO/C(73)41, rev. 4, 24 September 1973 (ESRO 724).

negotiations depending on the other financial concessions its partners demanded of it. In the early versions of the draft "Arrangement" France was prepared to go as far guaranteeing further cost increases of 30% due to technical contingencies during the development phase of the Programme, i.e. it was prepared to see costs rise to 150% of the initial financial estimate. Its only condition was that no partner had the right to withdraw from the project until that limit had been reached. The assurances that it was forced to give regarding industrial returns, and its undertaking to reimburse its partners if the 80% target was not reached on the basic expenditures of the development phase, went along with a cut in this figure, however. In the final agreement France took sole responsibility for additional expenditures above the 20% contingency up to 135% of the initial development cost. If cost overruns went beyond the additional 15% that Paris was prepared to pay, the partners would discuss among themselves how best to proceed.[1279]

France's willingness to assume alone an additional cost overrun was partly a response to the anxieties being expressed in French industry about their ability to develop LIIIS under the conditions negotiated by their government. Their concern was expressed in May 1973 by both Pierre Usunier, Director of the Ballistics Systems and Space Division at Aérospatiale, and Pierre Soufflet, PDG of the Société européenne de propulsion, SEP. Usunier felt that there was no way in which his company, given its resources, could assume the role of industrial architect for the project as CNES had asked, or could meet an operational deadline for the rocket of 1980. Soufflet was emphatic that "for each development phase and for each of the propulsion units, the development plans that were presented to us seemed to be too tight, the number of test firings too few, and the level of redundancy in the installations too low." To build the rocket successfully it was essential, he went on, either to increase the basic cost envelope while retaining the 20% contingency margin, or to increase the contingency.[1280] Unable to alter the global budget of the project at this late stage, the French government was forced to extend the contingency margin to 135% at its own expense.

9.8.3 Management and control

The underlying principle shaping the industrial execution of the Ariane Programme was a simple one and was commensurate with the financial guarantees that France was prepared to give. As expressed by a French delegate to a meeting of the Committee of Alternates in May 1973, "France accepted the technical risks of the Programme and hence must have control over the technical management". This would be in the hands of the French space agency CNES.[1281] Once accepted – and no partner seriously challenged this position – this meant that external control over the Programme was reduced to keeping a watchful eye over what CNES was doing, all the while hoping that an awareness of the enormous investment that the French government was making would bring out the best in CNES's engineers and managers and in the main French industrial contractors.

The legal texts formalising the relationships between ESRO and CNES confirmed the dominant role played by the latter. The costs of the CNES project team and technical and administrative support staff, numbering approximately 100 people, were to be borne by the French government. This team, whose Head would also be appointed by CNES, would be entirely responsible for the technical and financial management of the Programme. In particular, it would "define and implement the organisation of industry" in line with the industrial return conditions, it would select the industrial

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[1279] For the changes in the French offer see successive versions of the *Arrangement*, e.g. Art. VII.2(a) in ESRO/C(73)41, Annex I, 8 June 1973 (ESRO 724), and Art. VII.2(b) in ESRO/C(73)41, rev. 4, 24 September 1973 (ESRO 724). See also the meeting of the Committee of Alternates on 20 September 1973, minutes CSE/CS(73)PV/7, 3 October 1973 (ESC 679), and Resolution, CSE/CS(73)42, 21 September 1973 (ESC 724).

[1280] See letter Usunier to the Délégation Ministérielle de l'Armement, 9 May 1973, and letter Soufflet to the CNES Director General, 15 May 1973, both in Chadeau (footnote 1188), pp. 437 and 441 respectively.

[1281] Maurice Lévy at the meeting on 22 May 1973, CSE/CS(73)PV/2, 29 May 1973 (ESC 674).

contractors, and it would place contracts with firms in accordance with the regulations in force at CNES.[1282]

On ESRO's side the main concern was to ensure that there would be "visibility" in respect of the management and execution of the project.[1283] The French delegation requested, and the participants accepted, that the Organisation assign no more than 10 people to this task. Having a greater number, said France, "would inevitably lead to non-observance of the spirit of the arrangement and to dual management of the execution of the Programme at ESRO and at CNES [...]", with unfortunate consequences.[1284] Thus in the formal "Agreement" with CNES, it was accepted that ESRO's staff would not "interfere with the CNES project team's own responsibilities". Non-interference meant that the ESRO team could attend some meetings as observers, e.g. internal meetings held by CNES and progress meetings between CNES and industry, and that they had the right to state their views there. They were not, however, allowed to be present when CNES personnel negotiated contracts with firms, and could only visit contracting and subcontracting firms if CNES agreed to it, and organised the meetings for them. The contract once passed, ESRO staff could "express their views" on the outcome, and the Programme Board could hear appeals from participant states who objected to the choice of a contractor by CNES.[1285] But by and large, in the management scheme adopted, neither ESRO's Executive nor its Programme Board had any meaningful control over CNES's dealings with industry. Indeed the only major external constraint on its action was the fundamental obligation to meet the 80% return coefficient on technologically interesting contracts.

Figure 9-4 is a schematic of the industrial organisation finally put in place early in 1975, showing the dominant position of CNES and the four French prime contractors, SNIAS (Aérospatiale), SEP, l'Air Liquide and Matra.[1286] The scale and complexity of the system were such that they obviously made it impossible for ESRO to "control the execution of the project" closely with its maximum of 10 staff members. Indeed granted the policy of non-interference in the dealings of CNES with industry, ESRO's role was mostly one of a financial and administrative nature: ensuring that CNES respected the terms of the various legal arrangements, notably the principle of fair return, informing the Programme Board of the advancement of the Programme, calling up contributions, making funds available to the French space agency, and so on. Its only really technical task was to define the specifications for the launcher/payload interface and to "establish potential coordination with effective users". In particular, it had no technical responsibility regarding the successful completion of the project. As Article X of the ESRO/CNES "Agreement" made clear, "CNES shall arrange for the acceptance of the elements of the launcher [...]" and "shall inform the Organisation of the dates of acceptance so that it may arrange to be represented".[1287] Indeed, as the Director General said, the LIIIS project was "distinctly different" from the others undertaken by the ESRO "whose basic feature [was] that they [were] integrated in the mechanism of the Organisation, which [was] responsible for their execution on behalf of the participating states". But then, as he stressed, the LIIIS management scheme reflected the level of the risk assumed by France in the project.[1288]

1282 See the *Agreement* between ESRO and CNES, Art. II, Art. VII, ESRO/C(73)41, Annex II, rev.3, 17 December 1973 (ESRO 724).

1283 See *Comments by the Director General* on the L.III.S project, ESRO/C(73)35, add. 1, 1 June 1973 (ESRO 718).

1284 See the *Note on the organisation of the L.III.S project* by the French delegation, CSE/CS(73)WP/2, and rev. 1, 22/5 and 23 May 1973 (ESC 736).

1285 See the ESRO/CNES *Agreement*, Art. V, ESRO/C(73)41, Annex II, rev. 3, 17 December 1973 (ESRO 724), and for the Programme Board the *Arrangement,* Art. IV.3(c), ESRO/C(73)41, Annex I, rev. 4, 24 September 1973 (ESRO 724).

1286 From the *Ariane Project,* ESA/AR(75)4, August 1975 (ESA 5084).

1287 See the ESRO/CNES *Agreement*, Art. X, ESRO/C(73)41, Annex II, rev. 3, 17 December 1973 (ESRO 724). For some concerns about these arrangements see the debate in the ESRO Council meeting on 1 June 1973, ESRO/C/MIN/57, 20 June 1973 (ESRO 55).

1288 See his *Comments* on the L.III.S project, ESRO/C(73)35, add. 1, 1 June 1973 (ESRO 718).

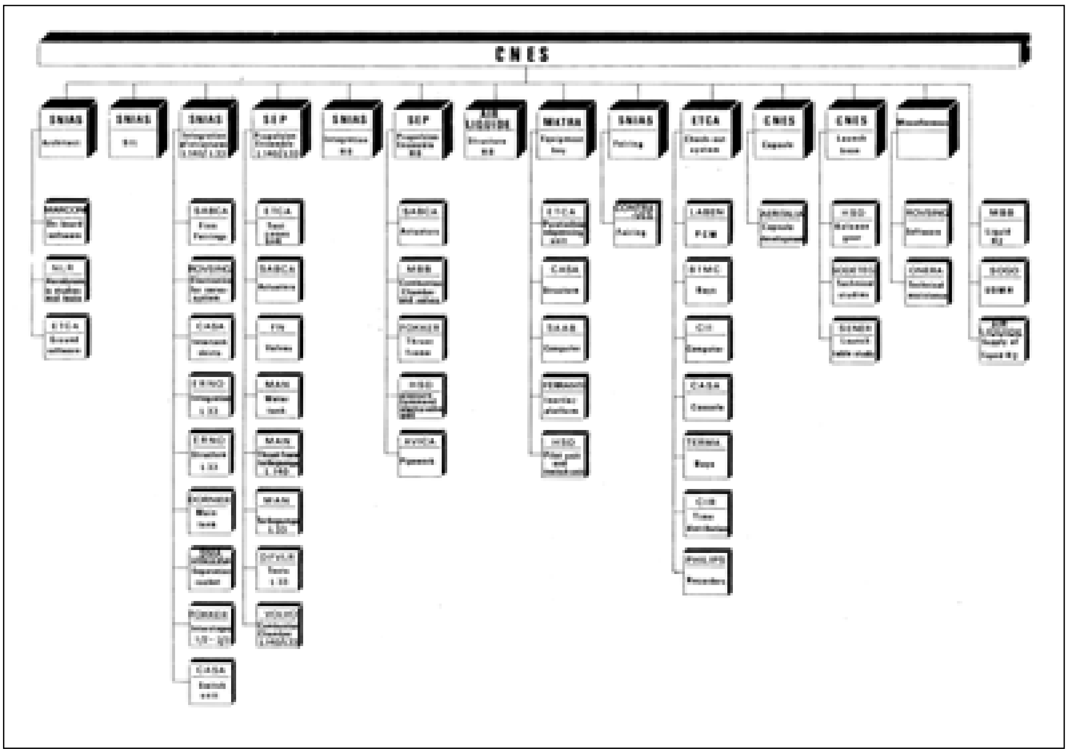

Figure 9-4: Simplified Industrial Organisation Chart

One last comment. While CNES was always presented inside ESRO/ESA as the agency responsible for the overall management of the launcher project, matters were actually a little more complicated than that. In fact CNES, while necessarily assuming overall responsibility for a civilian launcher project, also worked closely with the Ministry of Defence (Délégation Ministérielle pour l'Armement – DMA) in areas where it could benefit from its experience and some of its facilities. This collaboration was an automatic consequence of the regrouping of the French military and civilian rocket industries undertaken by the government at the end of the 1960s. If we mention it here it is only to highlight that, once the political arrangements had been agreed on in July 1973 the government emphasised how precious this collaboration was in its eyes. Writing to Charbonnel in August 1973, Prime Minister Messmer remarked that he could not:

> *"hide from you my worries about the management of the project. The precedent of there being inadequate control over certain aeronautical programmes, the unconfirmed but persistent rumours that the costs of LIIIS will be revised upwards by at least 20%, and CNES's recent failures [the second consecutive failure of Diamant B had occurred in May] lead me to believe that this body does not have the resources to carry a programme of this size through to a successful conclusion".*[1289]

Close collaboration with the DMA was thus imperative. CNES of course bitterly resented this criticism, and was quick to point out the bad track record of those responsible for the force de dissuasion.[1290] Be that as it may, it is worth emphasising again how heavily the failed firings of

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1289 See letter Pierre Messmer to the Minister of Industrial and Scientific Development (Charbonnel), 20 August 1973, reproduced in Chadeau (footnote 1188), pp. 442-3.

1290 See (draft) letter from Charbonnel to CNES President, 24 August 1973, *Note sur le role possible de la D.M.A. dans la conduite du programme L III S*, 18 September 1973, memo from Bignier entitled *Note à : Monsieur Mollaret*, 26 September 1973, and memo from Ministre des Armées (Galley) to his Prime Minister, 29 October 1973, reproduced in that order by Chadeau (footnote 1188), pp. 444-54.

Europa II and Diamant weighed on the Ariane Programme when it was undertaken, and how uncertain many were that Europe alone had the ability to bring a large technical project to fruition.

9.8.4 The production phase

The debates over the commitment which France's partners were willing to make not just to *develop*, but also to *produce*, Ariane were yet another index of the fears just mentioned. France was naturally not satisfied to make undertakings totalling at least 9.75 billion 1973 French Francs just to develop a rocket which was not used. By contrast, Germany in particular was not yet able to commit itself to the move to production. Her delegates were not convinced that the rocket could ever be commercially viable and felt that the estimates of the potential market for an expendable European launcher which we gave earlier (Section 9.8.1) were too optimistic.

The earliest versions of the LIIIS "Arrangement" implicitly engaged the partners to produce the launcher. Its very first Article committed the signatories to "undertake a programme having as its objective the development, including qualification, *with a view to a subsequent production phase* [our italics] of a satellite launcher called LIIIS. [...]." The decision to proceed to the production phase, which would be needed roughly two-and-a-half years before the end of the development phase, would be taken by the Programme Board once it judged that development "had made sufficient progress". This decision would be by simple majority vote of the participants representing also 50% of the contributions to the Programme.[1291]

These conditions were contested by Germany, who insisted that the vote to engage in production should be unanimous in the Programme Board (so enabling any one participant to veto it, of course).[1292] This was too restrictive for France, and a revised version of the "Arrangement", circulated a month later, clearly differentiated between the development and production phases of the Programme, and required that the decision to adopt the latter be taken in the Programme Board by a double two-thirds majority.[1293] To satisfy objections it was stipulated, however, that once the decision of principle had been taken, the formal protocol setting out the content of the production phase, its financial arrangements and the work distribution would have to be adopted unanimously.[1294]

But even this did not do. No sooner was the package deal agreed in July 1973 than Germany asked that the production phase "should be clearly excluded from the Arrangement".[1295] Thus Article I of the final version of the text spoke simply of the partners committing themselves to undertake "the first phase of a programme having as its objective the development, including qualification, of a satellite launcher [...]." The second phase of the Programme, production, was referred to, but it was said that it "would be decided upon at a later date." How that decision was to be taken was left open; the Programme Board would "establish the elements" needed for this purpose, and the participants interested in embarking on the second phase would conclude a new Arrangement between themselves when the time came. To protect the production phase from the risks ensuing on a state withdrawing after having been integrated into the project for seven years, the participants accepted "to keep in being, during the production phase, the industrial facilities set up during the development phase", and to do "nothing to hamper the use of these facilities" even if they were not party to the new Arrangement.

Member States' prudence over engaging themselves to use Ariane was also reflected in the concurrent negotiations over the ESA Convention. As we described in Chapter 1, France's attempts to have formal guarantees to use Ariane built into the text were thwarted. Instead Article VII simply engaged the signatories to use a European launcher if this did not present an "unreasonable disadvantage" *vis-à-vis* available alternatives. Also if Germany, France's erstwhile partner in promoting a European

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1291 See Articles I, II.4, IV.5 and V.I of ESRO/C(73)41, Annex I, 8 June 1973 (ESRO 724).
1292 See minutes of the informal meeting of participants held on 3 July 1973 (ESRO 6793).
1293 That is, two-thirds of the participants representing also two-thirds of the contributions.
1294 See Articles III.1, V.9.1 and V.9.2 of CSE/CS(73)27, rev. 1, Annex, 9 July 1973 (ESC 709).
1295 ESRO/IB-LIIIS/MIN/1, 11 October 1973 (ESRO 3358).

launcher, now backed away from inflexible commitments it was also because at this time she was just getting started on the major Spacelab joint venture with NASA, and she did not want to do anything to offend the American authorities, notably by showing too much enthusiasm for Ariane. We may judge just how prudent Germany was being in this regard from another little change she demanded in the LIIIS Arrangement. The first versions had, in their Preamble, a clause to the effect that the governments concerned were embarking on the launcher Programme bearing in mind "Europe's interest in having available an *independent capability* for the launching of application satellites [...]" (our italics). The German delegate had this stripped of its political connotations. "To avoid any ambiguity", he said, "it should be specified that the competitive capability referred to [...] was of a commercial nature".[1296] The final version of the same clause was adapted accordingly. It read that the project was being undertaken bearing in mind "Europe's interest in having available at the beginning of the 1980s an *economically competitive capability of its own* for placing satellites, particularly application satellites, in orbit" (our italics).[1297]

9.9 1974/75. Early snags

It is only to be expected that a Programme as costly and complex as Ariane would run into some snags. In the concluding section of this first part of our analysis we shall quickly deal with two of the most important, one on each side of the Atlantic.

9.9.1 In Paris

On the 2 April 1974 Georges Pompidou died. In the ensuing Presidential elections Valéry Giscard d'Estaing was elected his successor, taking up office in mid-May that year. This had immediate repercussions for the project. For not only did it signify the end of over 15 years of Gaullism in the Elysée, Giscard d'Estaing had also been Finance Minister under Pompidou and it was precisely from the Treasury, it will be remembered, that the strongest opposition had come in 1972 to the development of a European launcher. Indeed, according to Maurice Lévy, President of CNES at the time, the new French President "believed that the investment in Ariane was informed solely by the wish for national independence. He reasoned", Lévy went on, "that it would be more economic for Europe to buy launchers and telecommunication satellites from the United States".[1298]

Such convictions could not but send shock waves through the project. They were not long in coming. Soon after assuming office the new French Governmentdecided to reconsider its expenditure on research and to restrict the commitment of government funds pending finalisation of the French budget for 1975. CNES was accordingly instructed to defer the signature of contracts then under negotiation. This affected the Ariane Programme directly. Contracts with the 'Level 1' firms Aérospatiale, SEP, Air Liquide, Matra and ETCA were due to be signed on 31 July 1974. On 29 July CNES Director General Michel Bignier informed them that notification of the development contracts would be postponed to the end of September. This deadline was subsequently extended to 15 October.[1299]

On 16 October 1974 Giscard d'Estaing duly announced France's "decision to maintain and confirm France's participation in European programmes", including Ariane and application satellites.[1300] This decision was coupled with a number of "relevant conclusions". Firstly, that Ariane would be always be used for European missions unless technical reasons dictated otherwise (i.e. the cost of the launch compared to the Shuttle would generally not be considered) and would "handle all the geostationary missions envisaged by the Organisation [...]". Secondly, that the member states of ESRO/ESA would

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1296 See its remark at the meeting of the ESRO Council on 21 September 1973, ESRO/C/MIN/60, 3 October 1973 (ESRO 58).

1297 The earlier clause is in ESRO/C(73)41, Annex I, 8 June 1973, the later in ESRO/C(73)41, Annex I, rev. 4, 24 September 1973 (ESRO 724).

1298 M. Lévy, "Quelques souvenirs de la période 1970 - 1975", in *L'Europe spatiale a vingt ans. 1964, 1984. Témoignages de quelques pionniers* (ESA SP-1060, 1984), pp. 82-7, at p. 87.

1299 See ESRO/PB-ARIANE(74)30, 29 August 1974, and add. 1 (ESRO 3404).

1300 ESRO/PB-ARIANE(74)43, Annex (ESRO 3416) gives the news.

"resolutely steer European space cooperation towards jointly developed applications, with the latter being exploited by organisations grouping users" which would have to be "closely associated with the design and experimentation of the equipment in question". Both of these steps, the French explained, were intended to favour "Europe's independence in the field of space applications development – an independence based on having a launcher available [...]". To show that it meant business, the new government decided to suspend forthwith negotiations with the US to set up a launch site for American Thor-Delta (TD) or Atlas rockets at Kourou.[1301] "There was a conflict between the TD launcher market and the potential Ariane market", said the French Council delegate, and granted their huge investments in the latter the national authorities did not now want to encourage a development that might benefit their competitor, even if it was to the advantage of the launch site in Guiana. At the same time – and here was the third "relevant conclusion" – France insisted that the harmonisation of national and European programmes foreseen for ESA meant that its partners in the Agency assume collective "responsibility for certain national space investments that are of common benefit", notably, "the Kourou facilities, certain test facilities at Toulouse and the satellite tracking network".[1302] This new position forced some last-minute changes in the draft ESA Convention and triggered a rather tense debate over the funding of the launch base in French Guiana, which we described in Chapter 1.

9.9.2 In Washington

Granted the military and commercial aspects of rocketry, and the threat to the Shuttle Program, it was more or less inevitable that European requests to the US for hardware or assistance for the Ariane Programme would run foul of restrictions on the transfer of technology. A number of such cases arose in 1974/5.

The Ariane Programme required for its successful development 2000 tons of the rocket fuel UDMH (unsymmetric dimethylhydrazine) over five years. Europe was not in position to manufacture this itself. Thus in costing the Launcher Programme, provision was made to buy 1000 tons from the Food Machinery Company (FMC) in Baltimore, Maryland, which had supplied the fuel for the Europa Programme. The balance was to be manufactured by a new European installation capable of producing 200 to 300 tons a year.

In December 1973 CNES and ESRO were informed that the Baltimore firm had been instructed temporarily to halt production since the process had been found to have carcinogenic effects on the workforce. New norms of environmental health were being drawn up, and once they were defined the company would decide whether or not to restart its activities respecting the new constraints or to close down.[1303]

By February 1974 it looked very much as if the European Programme could not expect to have its UDMH needs met by the US. On being informed of the new environmental regulations, the FMC insisted that it had no choice but to close its doors. The US Air Force protested immediately, asking the company to seek a waiver for one final production run. This would apparently be possible if all the "labour force wore something akin to space suits", which would not involve new capital investments but which would sharply increase operating costs, and so the final cost of the product.[1304] ESRO asked NASA to ensure that its requirements were covered by this last run. However, since the argument for keeping the plant running was the protection of national security, and the supply problem affected the

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1301 For details see ESRO/C(74)63, 22 October 1974 (ESRO 823).

1302 All the quotations are from the minutes of the ESRO Council meeting on 30 October 1974, and the appended statement by the French delegation, ESRO/C/MIN/69, 8 November 1974 (ESRO 67). The new French position forced some changes in the ESA Convention which had already been accepted by all negotiators, so irritating immensely her partners and further delaying the establishment of ESA.

1303 Letter Bignier to ESRO DG, 6 December 1973, memo Collette to Kaltenecker, 7 December 1973, and letter Hocker to Frutkin, 12 December 1973, all in (ESRO 6418).

1304 Telex Mellors, ESRO Washington Office, to Dinkespiler and Orye, 5 February 1974 (ESRO 6418).

entire US Titan and Delta rocket launches, it seemed that "no guarantee could be expected on the provision of UDMH in general or for the Ariane Programme in particular".[1305]

Faced with this risk, CNES decided to approach the Soviet Union for UDMH. The agency was counting on its government taking advantage of the "special relationship existing between France and the USSR" to act as an intermediary between the Soviet authorities and ESRO. At the same time it decided to reduce its pressure on NASA to supply the Europeans with UDMH.[1306] By May 1974 CNES had been assured by the President of the USSR Academy of Sciences that the full requirements of the launcher development programme could be met, and had obtained an agreement in principle for the delivery of 1000 tons that year.[1307] Negotiations with the US for a further 200 tons for 1974 were still under way, but no firm answer had been given. In July the Programme Board agreed in principle that the Secretariat go ahead with the purchase of 1000 tons of Soviet UDMH at 20.25 FF/ kg, and of 200 tons of American UDMH at the new price of 30 FF/ kg.[1308]

It seems that American reluctance to provide the Europeans with UDMH was directly inspired by the production problems being faced by the Food Machinery Company, and that the State Department would have granted an export license for the fuel if they had been sure to have more than enough to meet national needs. In two other cases, however, lack of US cooperation was directly attributable to a refusal to transfer technology and know-how across the Atlantic. The US authorities refused to allow the Swiss firm Contraves to obtain a licence from McDonnell Douglas, the prime contractor for the Delta rocket, to manufacture the fairing separation system.[1309] Similarly, a consultancy contract between Aérospatiale and Martin Marietta, a major contractor on the Atlas, Centaur and Titan rockets, was refused by the US authorities in July 1974.[1310] Despite their "sympathy for Martin Marietta, and a tendency to wish to encourage their efforts to get into the European space market", Aérospatiale's requests for assistance in quality control and configuration management were deemed to be particularly "sensitive". They violated the US's policy to "discourage the transfer of technology and know-how related to the production of space hardware and launch services".[1311]

The difference between the treatment of the requests to FMC for rocket fuel and to Martin Marietta for management assistance is interesting for the light it throws on the nuances of American policy on technology transfer. The basic American position drew a clear distinction between the "sale of space hardware and services", which it encouraged since it had direct commercial benefits for the US, and the "transfer of technology and know-how related to the production of such hardware and services", which was discouraged because it would enable its competitors to build up an in-house capability. This principle applied even in the collaborative Spacelab Programme, where the general policy was that "Whenever possible and reasonable to do so, US assistance in the form of hardware and/or related information will be encouraged over technical assistance [...]", meaning "technology, design

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1305 Telex Mellors, ESRO Washington Office, to Orye, 12 February 1974 (ESRO 6418) and statement by Orye to the Programme Board, ESRO/PB-ARIANE/MIN/6, 12 June 1974 (ESRO 3363).

1306 Memo Collette, *UDMH pour Ariane,* 22 April 1974 (ESRO 6418), from which the quote is taken, ESRO/PB-ARIANE(74)13, Annex (ESRO 3389).

1307 ESRO/PB-ARIANE/MIN/7, 27 June 1974 (ESRO 3364).

1308 ESRO/PB-ARIANE(74)24, 21 June 1974 (ESRO 3398), and ESRO/PB-ARIANE/MIN/8, 1 August 1974 (ESRO 3365).

1309 ESRO/PB-ARIANE(75)2, 24 April 1975. See also P. Creola, "Ariane – les chemins de l'autonomie", in *L'Europe spatiale a vingt ans. 1964, 1984. Témoignages de quelques pionniers* (ESA SP-1060, 1984), pp. 31 - 36, at p.33.

1310 An extract from the contract dated 12 October 1973 is appended to a letter from Bignier to Frutkin, 11 October 1973, itself attached in copy to letter Bignier to Hocker, 31 October 1973 (ESRO 6418).

1311 The first two remarks are from a memo by Gibson, *Discussions US State Department - 11 March, 1974, ARIANE,* 13 March 1974 (ESRO 6418); the final citation is from ESRO/PB-ARIANE(74)26, 9 July 1974 (ESRO 3400).

production drawings, specifications or 'know-how'".[1312] The different approaches taken by the US authorities regarding the supply of rocket fuel and of management support to the Ariane Programme indicate that the same guidelines were in force here. The consequences for Europe were potentially damaging. For whereas the UDMH could be obtained from a rival source, the experience of McDonnell Douglas was precious. Preliminary contacts with Aérospatiale had led the American experts to conclude, wrote Gibson, that there was a "good deal being proposed in the Programme which repeats mistakes made as long as twelve years ago in the United States and that to this extent alone a consultancy would be advantageous".[1313]

All guidelines are of course open to negotiation. But obviously the US authorities were going to be less flexible in the case of Ariane than of Spacelab.[1314] It was not a collaborative programme, it threatened to break their monopoly in the Western Alliance on advanced launcher/missile technology, and what is more it was deliberately intended, at least by France, to ensure European autonomy in space. The effects of that autonomy were already manifest. The State Department, Gibson reported, was "specifically disturbed" by the news that France intended to sell the licence of the Viking engine to India for use with her own future launcher, and was also considering allowing Japan to manufacture the cryogenic stage of Ariane under licence.[1315] The latter was particularly irksome to the US authorities as they had already refused Tokyo's request for know-how on cryogenic technology. That said, here, as usual, opinions were divided in the state apparatus. Certainly the State Department claimed that its policy was now "one of neutrality", even if at one stage they had been asked to "act against the programme". The "gut reaction" of NASA Administrator James Fletcher, on the other hand, was one of hostility to Ariane (he never believed it could succeed), though his "latent opposition" was tempered by his recognition that it was part of a deal which included Germany taking responsibility for Spacelab in the post-Apollo framework. Then of course there were the "extremists" who even wanted to prevent the flow of advice "that could prevent Europe from repeating some of the mistakes the USA has made".[1316] Was it they who had ultimately managed to impose their views and who had put a stop to the consultancy contract foreseen between Aérospatiale and Martin Marietta?

1312 For these qoutations on US policy see the *Note by the Secretariat concerning the US policy with regard to transfer of technology* prepared for the Council, 24 September 1974 and the *Spacelab Programme Directive No. 1,* prepared by US Spacelab Program Director Douglas Lord, dated 16 October 1974, both in (ESRO 6418).

1313 See Gibson's *Note for the Record*, 18 February 1974 (ESRO 6418).

1314 The immensely valuable help given by American consultants to the Spacelab emerged clearly from the *Proceedings of the Workshop on the History of Spacelab, ESTEC, Noordwijk, The Netherlands, 22-23 April 1997* (ESA Report SP-411) organised within the framework of this project.

1315 For Gibson, see his *Discussions US State Department - 11 March, 1974, ARIANE,* 13 March 1974 (ESRO 6418). For a summary of France's dealings with India and Japan, see ESRO/PB-ARIANE(74)27, Annex I, Appendix 1, Appendix 2, 5 July 1974 (ESRO 3401).

1316 See the memo by Gibson just cited and also his note on *Discussions with Dr. David Elliot, US National Security Council,* 13 March 1974 (ESRO 6418).

Chapter 10: The Availability of American Launchers and Europe's Decision "To Go It Alone"

L. Sebesta

It has been widely recognised by scholars that America's strict policy on the availability of launchers for European telecommunication satellites influenced Europe's decision "to go it alone" in the field of expendable launchers.[1317] This decision was officially endorsed by Europe in July 1973 and led to the construction of Ariane which nowadays, after more than two decades of technical reliability and good management, has secured for itself a major portion of the world's commercial launches.

The reasons for the American position on launcher technology and facilities and how they evolved in time are still unclear: from the first restrictive directive, the National Security Action Memorandum (NSAM 338) on "Policy concerning US assistance in the development of foreign communications satellite capabilities" of September 1965, to the more flexible and uncertain position conceived in the second part of the decade, until the final return to the more restrictive formula of 1971 - 1972, publicly announced by President Nixon in October 1972.

This scenario was shaped by many different factors:

- the growing concern about the "technological gap" between Europe and the USA;
- the technological breakthroughs in the field of telecommunications satellites and launchers, their organisational consequences and the commercial concerns behind these developments;
- the increasing importance of ballistic missiles as a central feature of Atlantic Alliance military strategy and American policy of non-proliferation in nuclear warheads and delivery vehicles;
- a thorough European reassessment of space policy;
- a worsening of US-European relationships in concert with the international economic crises at the beginning of the 1970s.

This chapter analyses the tremendous changes that took place at these five levels and discusses how NASA tried to cope with them.

[1317] "(…) the fact that there was resistance in providing that assistance reinforced the position of those in Europe (particularly in France) who were arguing for developing an independent European space capability"; J. Logsdon, "International involvement in the US space station programme", *Space Policy*, February 1985, p.18. "The effect of this policy on Europe" writes Peter Creola, referring to President Nixon's policy statement on the availability of American launchers dated 9 October 1972, "was decisive". P. Creola, "European-US space cooperation at the crossroads", *Space Policy*, May 1990, p.99. "In a sense, it is fair to conclude that Ariane owes the USA a debt of gratitude"; A. Russo, "Launching Europe into space: the origin of the Ariane rocket" *Paper prepared for the International Astronautical Federation Annual Meeting, 1995*. This point of view was expressed in a much more vigorous way by André Lebeau, "Il ne semble pas exagéré de dire que si les Etats-Unis avaient vendu sans conditions particulières les deux lancements de Symphonie, la décision d'engager le programme Ariane n'aurait jamais pu être obtenue. Une intransigeance maladroite, fondée sans doute sur l'idée que l'Europe serait de toutes façons incapable de ressusciter son programme de lanceurs, vint à point pour fournir un appui décisif aux promoteurs de LIIIS"; A. Lebeau, *La naissance d'Ariane*,
E. Chadeau (ed.), *L'ambition technologique: naissance d'Ariane* (Paris: Editions Rive Droite) 1995, p.85.

10.1 The "technological gap"

The growing interest in technology as a key to economic growth emerged as common knowledge in the late 1950s and early 1960s on both sides of the Atlantic Ocean. As tariff barriers between the USA and Europe started to be lowered under the action of the Kennedy Round negotiators, non-tariff factors began to be perceived as prominent among those leading not only to economic growth but to successful international competition.

In Europe, this body of knowledge was mainly channelled into and institutionalised by the Organization for Economic Cooperation and Development (OECD).[1318] Its main assumption was that the expansion of labour force and capital, and their relative prices, do not alone explain some historical patterns of economic growth. A "residual factor" is needed to account for a significant percentage. This residual factor came to be identified progressively as knowledge, science and technology.

As pointed out by a then well-known study, sponsored by the OECD and published in 1965, the bulk of the world's financial and human resources in the field of research and technology was controlled by the USA and the Soviet Union.[1319] In particular, a "technology gap" divided the USA from its western allies. The higher US percentage of R & D devoted by the state (mostly by its military branches) to the "technology intensive" sectors, seemed not only to have a direct influence on US economic growth, but also to result in the better positioning of US firms in the international marketplace (with the exception of chemicals, which is resistant to any generalisation) and in the growing American investments in Western Europe since the end of the 1950s.

Europeans faced a dilemma. By allowing American investment in their countries, they were consigning their industry, or at least the technological sectors of it, to a subsidiary role. This would be reflected in resulting technological dependence, uncertainty over the availability of supplies and, finally, danger of losing their national freedom of decision-making in industrial policy. On the other hand, if Europeans refused to let American capital enter and adopted restrictive measures, they risked ending up as double losers, denying themselves the capital funds they needed to create employment, as well as the manufactured products.[1320]

A drive towards high-technology space applications was seen as a possible tactic to solve the technology gap; other pivotal sectors were considered to be electronics, computers and atomic energy.[1321]

Some American intellectuals shared the belief that technology represented a new revolution in modern industrial societies. "Power" wrote Galbraith in his notorious *The New Industrial State* "has, in fact, passed to what anyone in search of novelty might be justified in calling a new factor of production. This is the association of men of diverse technological knowledge, experience or other talent which modern industrial technology and planning require (. . .). It is on the effectiveness of this organisation, as most business doctrine now implicitly agrees, that the success of the modern business enterprise now depends".[1322]

European interpretations of the origins of the technological gap, however, were seldom accepted by American officials. Among them, there was a widespread inclination to underplay the role of the

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[1318] J-J.Salomon, *Science et Politique* (Paris: Seuil) 1970, pp. 51-54.

[1319] C. Freeman and A. Young, *The Research and Development Effort. Western Europe, North America and the Soviet Union. An Experimental International Comparison of Research Expenditures and Manpower in 1962* (Paris: OECD) 1965, p. 70

[1320] A. Grosser, *The Western Alliance. European-American Relations since 1945* (London: Macmillan) 1980 (ed. orig. in French, 1978), pp. 217-131.

[1321] J-J. Servan-Schreiber, *Le défi américain* (Paris: Denoel) 1967, pp. 119-125; see also National Archives Washington (NAW), RG 359, Letter David Beckler, Assistant to the Director, to Philip Hemily, Science Adviser, US Mission to the OECD, 3 June 1966.

[1322] J.K. Galbraith, *The New Industrial State* (Boston: Houghton Mifflin) 1967, pp. 58-59.

government-supported expenses for R & D military purposes which had a primary, even if indirect, impact, according to the European interpretation, in having created the technology gap.[1323]

American experts tended to emphasise instead the importance of the structural advantage of US firms (markets, labour, credit policy) and of the managerial qualities of American businessmen. The focus of the analysis was "the sociology of European industry which has not yet awakened to the managerial revolution that has been going on in the USA – treating the entire sequence of events from research to marketing as a system which can be optimised for purposes achieving maximum returns on investment in a competitive situation".[1324]

Yet, the USA recognised that the technology gap should be treated as "a problem with serious political overtones", as Secretary of State Dean Rusk reminded the NASA Administrator James Webb in August 1966, because is was perceived as such by the Europeans.[1325]

The origin of America's new trend in space cooperation *vis-à-vis* Europe has much to do with the willingness to reduce the political impact of the technological gap and, in the long term, its economic effects. The prospect of a continuation of such a marked difference was economically disturbing for both partners. As had happened in the period of the "dollar gap" of the 1940s, it was soon realised, even if seldom explicitly stated, that it was in America's interest to have a wealthy Europe as a viable partner, in order to increase the prospects for national economic growth.

Helping the Europeans to fill the gap in the space sector did not appear so much an act of generosity, as of far-sightedness; in the long run it appeared to be a necessity for expanding American growth, as pointed out by the State Department in 1966. "The first step" it was stated in an internal statement on political objectives for expanding cooperation in space "is to recognise that more than one kind of gap is being generated by our space effort". (…) "First, and more obvious, is the increasing gap in technology". "Second, and as yet not fully appreciated, there is a gap in awareness and understanding [of the] new opportunities and responsibilities [which are] evolving in the space age". Yet the reactions of countries that could not grasp the meaning of these changes would be very important "if the international adjustment to these changes is to be responsive to our own interests".[1326]

If the United States wanted to extend the markets for the emerging space applications field, first of all telecommunications, they needed partners ready to grasp the importance of the new challenges coming from space developments, they needed wealthy users and buyers around the world.

This far-sighted political vision held by the Department of State, however, would come under heavy attack in the late 1960s, when more and more American economic sectors began to face European competition.

1323 Within the extensive literature on the technology gap, see the insightful H.R. Nau, "A Political Interpretation of the Technological Gap Dispute", *Orbis*, vol XV, Summer 1971, n.2, pp. 507-527. Following his interpretation, "(…) what Americans regarded as simple technical adjustments involving the improvement of Europe's management and market capabilities, Europeans sensed as profound political issues going to the heart of the European unification process and the transformation of post-war Atlantic relationships", *ibidem*, p. 521.

1324 NAW, RG 359, box 574, Letter David Beckler, Assistant to the Director, to Philip Hemily, Science Adviser, US Mission to the OECD, 3 June 1966.

1325 NASA Historical Office, RG 255, 70-A-3458, box 7, Letter Rusk to Webb, 29 August 1966. On the need to reduce the political impact of the technology gap, see also NASA Historical Office, RG 255, 69-A-5089, box 5, Interim Report of the Work of the Space Council's ad hoc Committee on Expanded International Cooperation, enclosure 1, Statement concerning political objectives for expanded cooperation in space activities, presented for the Chairman at the working group meeting on October 20, 1966.

1326 NASA Historical Office, RG 255, 69-A-5089, box 5, Statement concerning political objectives for expanded cooperation in space activities, by the State Department, presented at the Working Group meeting on 20 October 1966.

European fears related to the technology gap, as we have seen, concentrated on some sectors which were intimately related to the space field, such as electronics, satellite communications, computers and aircraft.[1327] Space being "a classic example of a high technology sector"[1328], it seemed to offer a good opportunity to solve what was perceived by some as a relevant problem both in European economic growth and in US-European relationships.

Let us analyse some of its features:

- space has R & D intensive requirements for propulsion, guidance, satellites, ground based communications networks, manned and unmanned exploration; this implies high research and development costs compared with labour costs;
- it has substantial entry barriers, especially in the case of launchers, involving high initial fixed costs, the testing of prototypes and the associated infrastructures;
- it has long learning curves, estimated as at least one decade for launchers, so that the first entrants can keep a major advantage compared with latecomers;
- it is characterised by high technological and market uncertainties, coupled with rapid obsolescence;
- emphasis is placed on non-price technical competition, based more on reliability and quality control than on plain cost/effectiveness calculations.

Generally speaking, therefore, space is a sector in which it is very difficult to make calculations on the economic returns; it does not offer rapid pay-offs and it needs large markets in order to repay the high investments involved.

For all of these reasons, governments interested in the development of the space sector, played a central role in its management, at least in the beginning. They not only supported space research, but also functioned as major clients of the space industry, mainly through the military system. Consequently, through procurement, investments and public policies (regulations, incentives, fiscal policies), the state was able to influence the development and direction of technical progress. Governments, most of the time through their specialised agencies such as PTTs, were key actors in providing the expansion of markets for new applications related to space, such as telecommunications satellites.

All those planning and production techniques which had been developed during the war, in such institutions as the *MIT Radiation Laboratory,* had been adopted by the laboratories and firms working for NASA within the Apollo project, the new Mecca for systems engineering. Space became the privileged field for experimenting with the adaptation of these techniques to a civilian context.[1329]

1327 NAW, RG 359, Letter, David Beckler, Assistant to the Director, to Philip Hemily, Science Adviser, US Mission to the OECD, 3 June 1966.

1328 K. Hartley, *Aerospace: the Political Economy of an Industry*, in H.W. de Jong (ed.), *The Structure of European Industry* (Dordrecht/Boston/London: Kluwer Academic Publishers) 1988 (II revised edition), p. 340; see also K. Hayward, *International Collaboration in Civil Aerospace* (London: Frances Pinter) 1986, pp.4-5 and J. Müller, *European Collaboration in Advanced Technology* (Amsterdam: Elsevier) 1990, pp. 8-11.

1329 For the origins of the term *systems engineering*, see S. Schweber, *Theoretical Physics and the Restructuring of the Physical Sciences: 1925-1975*, in G. Gemelli (ed.), *Big Culture. Intellectual Cooperation in Large-Scale Cultural and Technical Systems. An Historical Approach* (Bologna: Clueb) 1994, pp. 143-144. For the adaptation of the *systems engineering* approach to the post-Apollo programme, see J. Logsdon, *The Decision to Go to the Moon: Project Apollo and the National Interest* (Cambridge: the MIT Press) 1970.

Space science, along with some other disciplines such as meteorology, oceanography and civilian nuclear research, had a well-established record of internationalism. It could count on an existing solid tradition of international coordination and personal links between scientists. Bilateral agreements had been established between Western European countries and the USA in this field since the foundation of NASA and they had been working very well.

In the space sector, the technology gap and the need to catch up with the USA thus served two political purposes: a) to convince Europeans to turn from science to technologically relevant and commercially viable endeavours and to participate in significant technologically advanced projects, such as Concorde, Airbus and telecommunications satellites and, finally, commercial launchers; b) to induce the Americans to choose high-technology areas, among others space, as the right place in which to allay European apprehensions.

This was not only publicly suggested by authors such as French journalist Jacques Servan-Schreiber – his book *Le défi américain* became a best seller in the USA when translated into English[1330] – it was also endorsed by European space organisations.[1331]

10.2 Intelsat and NSAM 338

The International Telecommunication Satellite Organization (which came to be known as Intelsat in 1965) was set up in August 1964 as a single commercial global satellite system regulating voice, telegraphy and high speed data, facsimile and television services.[1332] Intelsat's first successful operational communication satellite in geostationary orbit was Early Bird, which confirmed in 1965 the promising commercial potential of satellites in this area.

Under the provisional agreements, the American Communications Satellite Corporation (Comsat), a semi-private joint-stock company with the participation of American industry, was the executive body of Intelsat and, as manager, proposed and implemented projects. Investment shares (quotas) within Intelsat were determined by projections of long-distance traffic likely to be carried by satellite and Comsat received an initial 61% against 30% for European countries. Because the voting system was based on investment shares, Comsat established a *de facto* veto power, which it maintained notwithstanding the subsequent decrease of its quota, as new countries joined the venture.[1333] The privileged role of Comsat in Intelsat "assured efficiency and speed" in setting up a global satellite telecommunication system and its resources "proved critical to attracting interest on the part of developing countries in joining the enterprise"[1334]; yet it also helped to foster US hegemony in the field, rooted in an almost total monopoly of the industrial sector. In fact, the early entrance on to the market

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1330 J.-J. Servan-Schreiber, *Le défi américain*, cit., pp. 119-125.

1331 As an example of such a policy, see the following excerpt from an economic study by CETS (1967) which opposed any procurement from outside as far as satellite systems were concerned: "(...)expenditure by Europe in other countries on space tends to increase the 'technology gap'". Production at home, on the contrary, creates "(...) a host of indirect benefits otherwise known as 'spin-off' or 'fall-out', in the form of capabilities transferred into other areas of technology". These benefits are felt in all industries "in the form of new materials, design principles, processes and techniques as well as specialised equipment and machinery"; CETS: SCL/TPS/217E, *Economic Potential for Europe of Application Satellite*, 30 May 1967, cit. in J. Müller, "Historical background and start of the Telecom Programme", *Space Communications*, 8 (1991), p. 111.

1332 The text of the Agreements establishing interim arrangements for a global commercial communications satellite system is in *Department of State*, press release no. 364, July 28, 1964, reproduced in House of Representatives, *Hearings before a Subcommittee of the Committee on Government operations*, 88th Congress, Second Session (Washington DC: US GPO) 1964, pp. 775-786.

1333 R. Colino, *The Intelsat System: An Overview*, in J. Alper and J. Pelton (eds), *The Intelsat Global Satellite System* (New York: The American Institute of Aeronautics and Astronautics) 1984, p. 62. See also M. Snow, *The International Telecommunications Satellite Organization (Intelsat)*, (Baden-Baden: Nomos Verlagsgesellschaft) 1987, pp. 43-48.

1334 R. Colino, *art. cit.*, p. 62.

of American firms such as RCA, ATT and Hughes, and for some of them, the priviledged relationship, either with the military or with NASA, granted them the possibility to compare favourably in the system of international competitive bidding, whereby work was assigned to various Intelsat members.[1335] One of the main controversial issues within Intelsat had been Comsat's willingness to give priority to in-house R and D over international contracts, in order to give primary consideration to the corporation's need to increase its managerial competence and to discharge its task with the maximum possible efficiency. It was only under pressure from the other members, that the percentage of contract expenditures had progressively risen from 13% in 1968 to 50% by 1972. By that time, however, with 52% US capital invested, Intelsat spent 92% of its money in the American market, as pointed out by former Director General of ESRO Hermann Bondi in his Goddard Dinner address of 1971 and confirmed by later studies.[1336]

These institutional features, framed in the context of rising recriminations against the "technology gap", led to European accusations of America's desire to dominate the field.

The White House realised the degree of European dissatisfaction with the virtual US monopoly in the commercial satellites field and the danger that, through direct assistance from US firms, foreign satellite communications activity "could tend to proliferate development of competitive systems", thereby violating the spirit of Intelsat.[1337]

After lengthy negotiations with State, Defense, Commerce, NASA, and J.D. O' Connell, a draft was produced in August and approved by the President of the USA as National Security Action Memorandum (NSAM 338), "Policy concerning US assistance in the development of foreign communications satellite capabilities", in September 1965.[1338]

Its aim was "to guide government agencies in the dissemination of satellite technology and in the provision of assistance which is consistent with the overall policies". Three principles of special interest were then defined within these policies:

> *"The United States should refrain (emphasis in the original) from providing direct assistance to other countries which would significantly promote, stimulate or encourage proliferation of communications satellite systems".*

> *"The United States should not (emphasis in the original) consider requests for launch services or other assistance in the development of communications satellites for commercial purposes except for use in connection with the single global system established under the 1964 Agreements".*

The USA were ready, on the other hand, to provide satellite services to allies for their "vital security needs" – as would be done in some years through Skynet with the UK in order to assure her military

1335 D.J. Whalen, Billion Dollar Technology: *A Short Historical Overview of the Origins of Communications Satellite Technology, 1945-1965*, in A. Butrica (ed.), *Beyond the Ionosphere* (Washington D.C.: NASA) 1997, pp. 95-136.

1336 S. Levy, "Intelsat: Technology, politics and the transformation of a regime", *International Organization*, vol. 29, n.2, Summer 1975, pp. 661-664; NASA History Office, RG 255, 74-734, box 15, Address by Professor H. Bondi on International Cooperation in Space, 18 March 1971. On this point, see also M.E.Kinsley, *Outer Space and Inner Sanctums: Government, Business, and Satellite Communication* (New York: John Wiley and Sons) 1976.

1337 L.B. Johnson Library (LBJ), Austin, WHCF (Confidential Files) box 96, Letter J.D. O'Connell to Jack Valenti, Special Assistant to the President, 7 May 1965.

1338 NASA History Office, RG 255, 69-A-5089, box 5, , 25 August 1965, with cover note by J.D. O'Connell, 17 September 1965 approved as NSAM 338 on 13 September 1965, (also in LBJ, WHCF (confidential files), TR 105, box 96); see also National Security Archives, Washington DC, Policy concerning US assistance in the development of foreign communications satellite capabilities, with cover letter by McGeorge Bundy, 15 September 1965.

communication links with Australia and the Far East.[1339] All transactions involving technological assistance on satellites or launcher technology "should be conditioned upon express (written) assurances" by the foreign nation(s) that the technology and assistance obtained would be used only within the framework of Intelsat and arrangements to which the USA was participant and should not be transmitted to third countries without US authorisation.

This was indeed a very tight political directive which did not leave much room for flexibility in future international negotiations.

10.3 Military concerns: nuclear sharing problems in NATO and US-USSR non-proliferation policy

Reliance on nuclear weapons had been used since the signature of the Atlantic Alliance in 1949 to avert any serious friction over the two main objectives of the alliance: social stability and military security. Even after the loss of America's nuclear monopoly at the end of the same year, problems related to burden-sharing were postponed by accentuating the deterrent power of the American nuclear arsenal (as opposed to its value as a battlefield weapon.[1340])

However, it generated a fundamental concern among Europeans. What did military cooperation mean if it was the US which would take the ultimate political decision on the use of nuclear arms, even when these were to be used to defend their allies' territories, with the prospect of huge loss of human life?

This concern was reinforced by the launch of the Soviet Sputnik in October 1957: the fact that American territory would be from now on open to Soviet aggression through the use of intercontinental ballistic missiles (ICBM) weakened the deterrent value of the American nuclear arsenal. Would the USA be willing to risk an attack over their own territory for the sake of Europe? Massive retaliation, which had been adopted as the NATO strategy just a few months before the launch of Sputnik, and which called for an indiscriminate use of nuclear arms against any kind of enemy attack (be it nuclear or conventional), in order to reinforce the deterrent value of such weapons, already seemed to have been overtaken by events [1341].

Sputnik made obvious a process which had been going on for some years in the secrecy of defence research and development organisations, in both the United States and the Soviet Union: the shift of attention from the quality and quantity of nuclear weapons to the delivery systems. For people around the world, Sputnik epitomised the dual nature of launchers: the same vehicle that had put a scientific satellite in orbit could become, with some technical modifications and if associated with nuclear warheads, the focus of a new and revolutionary weapon system. For governments, military launchers became the new power symbol of the 1960s.

1339 A bilateral US-UK agreement along these lines was signed in 1967, whereby the UK would build an all-British satellite for military communications with Australia and the Far East within the framework of a collaborative Skynet military space communications system; J. Krige and A. Russo, *Europe in space, 1960-1973* (ESA: Noordwijk) 1994, p.62.

1340 T.H. Etzold, *The End of the Beginning. NATO's Adoption of Nuclear Strategy*, in O. Riste (ed.), *Western Security: The Formative Years* (New York: Columbia University Press) 1985, p. 291.

1341 NATO, *Texts of Final Communiqués 1949-1974* (Brussels: NATO Information Service, no date), 2-3 May 1957, p. 105.

The USA were caught in an inescapable dilemma: antagonising their allies on the topic of nuclear sharing was dangerous, because it opened the way to the development of independent nuclear forces, but to deprive the military and the President of the United States as Supreme chief of the Armed Forces of the right to have the last say on the use of nuclear weapons seemed to be strategically counter-productive and constitutionally illegitimate. Nor was it acceptable to promote the proliferation of nuclear armament (nuclear warheads and delivery systems) beyond the existing nuclear club.

In response to French "formal requests to the US for an IRBM [intermediate range ballistic missile] programme", the National Security Council approved two weeks after Sputnik a document which directed the Administration "to discourage production of nuclear weapons by a fourth country" and to "persuade France not to undertake independent production of such weapons".[1342]

Within the context of the so called flexible response, announced to NATO partners in May 1962, the shift toward a more cautious and measured use of nuclear weapons was accompanied by the stress on the need to centralise both planning and the use of the nuclear arsenal.[1343]

This strategy, quite clearly, could have backfired if independent nuclear forces came into existence. That is why, when publicly presenting it in June 1962, Secretary of Defense McNamara stressed how and why "In short, then, limited nuclear capabilities, operated independently, are dangerous, expensive, prone to obsolescence, and lacking in credibility as a deterrent".[1344]

1342 NSC 5721/1, US Policy on France, 19 October 1957, in FRUS, 1955-57, vol. XXVII, *Western Europe and Canada* (Washington DC: GPO) 1992, p. 109 and p. 192. For the US-French rift on nuclear issues, see McG. Bundy, *Danger and Survival. Choices about the bomb in the first fifty years* (New York: Random House) 1988, pp. 472-487; more generally, see P.Winand, *Eisenhower, Kennedy and the United States of Europe* (Basingstoke: Macmillan) 1993.

1343 In particular, nuclear weapons had to be targeted against military forces and logistic installations of the enemy, thereby leaving margin for political bargaining before an all-out counter-city attack.

1344 Here is the whole preceding paragraph: "In particular, relatively weak national nuclear forces with enemy cities as their targets are not likely to be sufficient to perform even the function of deterrence. If they are small, and perhaps vulnerable on the ground or in the air, or inaccurate, a major antagonist can take a variety of measures to counter them. Indeed, if a major antagonist came to believe there was a substantial likelihood of its being used independently, this force would be inviting a pre-emptive first strike against it. In the event of war, the use of such a force against the cities of a major nuclear power would be tantamount to suicide, whereas its employment against significant military targets would have a negligible affect on the outcome of the conflict. Meanwhile the creation of a single additional national nuclear force encourages the proliferation of nuclear power with all of its attendant dangers". Address by McNamara at the University of Michigan, 16 June 1962, *Department of State Bulletin*, 9 July 1962, pp. 67-68.

Though the name of de Gaulle was not there, nobody could doubt that the *force de frappe* and its strategy *tout azimut* was the subject of McNamara's considerations. Studies on the delivery vehicles and nuclear warheads had been accelerated by de Gaulle after he came back to power in June 1958. By 1961, the French Minister of Defence Pierre Messmer had decided to adopt solid propelled intermediate range ballistic missiles as part of the French *force de frappe*; the first French atomic bomb (tested in 1960) was a further proof of this determination.[1345]

At the same time, American efforts to devise a hybrid formula which could appease European requests for nuclear technology, US constitutional rules and Atlantic partnership – the MultiLateral Force (MLF) – was confronted with a slow albeit inexorable failure between 1962 and 1965.[1346]

When the USA announced in December 1962 their willingness to offer assistance (Polaris missiles) only to forces that were integrated under an American commander, France accused them of hegemonic attitudes. "In politics as in strategy" de Gaulle said in a much publicised discourse in January 1963 "it is as in economics, monopoly quite naturally appears to him who holds it as the best possible system".[1347]

By the mid 1960s, nuclear issues were at the core of the NATO difficulties that Americans and Europeans were trying to cope with in different ways. France's unwillingness to comply with the Atlantic strategy and its stated wish to build up its own nuclear arsenal were much resented by the US. They were interpreted as a sign of refusal of American nuclear and economic patronage over Europe.

As a matter of fact, de Gaulle's attacks against the dollar gold standard launched in February 1965 (by which France decided to present its dollars for conversion into gold) were coupled, one year later, with the withdrawal from NATO and, in 1967, with the first French nuclear ballistic missile tests.

1345 For the *force de frappe* and the organisational changes it implied see R. Rhenter, *Implications de la politique de défense dans les domaines de l'industrie aeronautique et de l'éspace,* in Institut Charles de Gaulle, *de Gaulle en son siècle*, tome IV, *La sécurité et l'indépendance de la France* (Paris: La Documentation Française-Plon) 1992, pp. 160-163. For an updated review of French nuclear policy, M.Vaisse (ed.), *La France et l'atome* (Bruxelles: Bruylant) 1994. Not surprisingly, a French mission headed by General Lavaud in March 1962, looking, *inter alia*, for enriched uranium, ended up with disappointing results. See *J.F. Kennedy Library, Boston, box 71, Memorandum of Conversation with general Lavaud, Mr. Nitze, General Wehle, Mr. Kuss, Colonel Cocke and Lt-Colonel Hoffman,* 13 March 1962, *cit.* in Frank Costigliola, *Kennedy, De Gaulle et le défi de la consultation entre alliés*, in Institut Charles de Gaulle, *de Gaulle en son siècle, tome IV, La sécurité et l'indépendance de la France* (Paris: La Documentation Française-Plon) 1992, p. 260. On the Lavaud mission see also P.Winand, *op. cit.*, pp. 231-232.

1346 In the best accredited version - among the many that were formulated between 1962 and 1965 - the Multilateral Force (MLF) was intended to be a coordinated multi-national deterrent nuclear force based on a fleet of submarines carrying Polaris missiles. Crews of a minimum of three nationalities would we hosted by the ships; decision-making would be shared, but not the ultimate responsibility for the use of the warheads, which would remain in US hands. See G. Ball, *The discipline of power* (Boston-Toronto: Little, Brown and Company) 1968, especially the chapter on "The Unfinished Business of Nuclear Management".

1347 "Excerpts from remarks by de Gaulle", news conference, 14 January 1963, *New York Times*, 15 January 1963, p.2. See also McGeorge Bundy, op. cit., pp. 492-492.

US policy had maybe retarded French achievements, but not altered de Gaulle's antagonistic attitudes and his willingness to build France's own *force de frappe*. On the contrary, US antagonism was welcomed by the French as a way to legitimise their independent political course.[1348]

The significance of French behaviour acquired a much more disturbing twist in the context of the new global non-proliferation policy inaugurated by the USA during the 1960s.

After the Cuban missile crisis of October 1962, the USSR and the USA were encouraged to ease the international tension that had reached its climax during that long week. Many factors pushed them to do so, among which were: increasing difficulties in controlling the technological diffusion of nuclear arms; consciousness of the potential destabilising effects of proliferation; preoccupations with the rising costs of nuclear technology; and fear of weakening their hegemony in the reciprocal spheres of influence due to nuclear proliferation among allies (this was not valid for the USSR).

The two superpowers agreed on and formalised common codes of conduct in different realms related to the nuclear field. The creation of regimes was considered less costly, less dangerous and no less productive (in terms of keeping the balance of power) than competition. Within this context, both powers agreed to limit the test and production of nuclear devices, in order to prevent their proliferation. The Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and Under Water (better known as the Test-Ban Treaty) and the hot-line agreements were signed in 1963, while the Non-Proliferation Treaty (NPT) was endorsed in 1968, after protracted negotiations.

These international developments were paralleled, internally, by the adoption of a National Security Action Memorandum on the limitation of proliferation of strategic delivery technology (NSAM 294). The ban on technology that might make a "significant" contribution to strategic delivery purposes included nuclear devices (bombs) and means of transportation (launchers).[1349] The enforcement of this policy, which left much room for discretion, of which the word "significant" was a clear demonstration, was entrusted to the Munitions Control of the State Department, which was the classic responsible authority for the control of technological information to be sold abroad, in connection with the Defense Department and the other agencies concerned.

In this context, France's autonomous course was interpreted not only as a refusal of the American patronage over Europe, but, more dangerously, as an attempt to disrupt the whole architecture of American non-proliferation policy.[1350]

10.4 The changing policy of Europe in space

As we have seen in Volume I, after Sputnik, and in parallel with the process that led, in 1958, to the creation of NASA, European scientists began to solicit the setting up of a collaborative organisation in the space field. The European Space Research Organisation (ESRO) Convention was eventually signed in 1962 (and entered into force two years later). ESRO was born out of many interests: a willingness to conduct scientifically ambitious experiments that national resources would not have

1348 For French withdrawal from NATO and the US position, see Draft aide memoire, no author, 26 April 1966, LBJ Library, NSAM, box 8. This was but the most resounding act of an articulated strategy of differentiation and independence from the major ally, see P. Milza and S. Bernstein, *Histoire du XXe siecle. 1945-1973, le monde entre guerre et paix*, tome 2 (Paris: Hatier, 1993), pp. 241-242. For de Gaulle's position *vis-à-vis* the US in the technological context, see W. McDougall, "Space-age Europe: Gaullism, Euro-Gaullism and the American Dilemma", *Technology and Culture*, n. 2, April 1985, pp. 181-183.

1349 Good indirect information on the content of the directive is to be found in LBJ, James Webb, box 2, Letter Webb (Administrator NASA) to McNamara (Secretary of Defense), 28 April 1966.

1350 Cit. in F.Costigliola, *France and the US: the Cold Alliance since World War II* (New York: Twayne's International History Series) 1992, p. 134.

permitted; a longing to benefit from the wave of *Europeanism* that followed the signature of the Treaties of Rome, and the desire on the part of some scientists to become independent of national military authorities. The relevance of space technology for future economic development was disputable at the time, notwithstanding the initial propaganda of some aerospace firms, which would be later organised through Eurospace; moreover, the direction of national industrial policies was perceived as a strictly governmental prerogative. Science, thus, had been prioritised as the undisputed focus of European cooperation and references to technological and industrial concerns were glossed over in the text of the agreement.[1351]

In parallel with these contacts, political negotiations began in 1960 aimed at building a European satellite launcher; these led to the signature, in the same year, of the European Launcher Development Organisation (ELDO) Convention, ratified in 1964. ELDO was born out of British willingness to Europeanise and convert to civilian use a military missile already in the development phase, the Blue Streak. The question of the missions of this launcher had always been in the background of an organisation which had been concentrated, first of all, on acquiring (or maintaining in the case of the UK) a technical expertise in a high technology area at a bearable price.

In 1963, Europeans decided to gather in a common ministerial conference with both foreign ministry officials and representatives of telecommunication administrations, CETS (the French initials for European Telecommunications Satellite Committee), to try to increase their bargaining power in Intelsat negotiations. The setting-up of this loose institutional framework was not sufficient, however, to reinforce their weak position *vis-à-vis* Comsat, the private American corporation promoted and supported by US government. European interest in the space field in general and in commercial satellites in particular was still lukewarm.

The total space budget of Europe in the mid 1960s was but a fraction of the amount of money devoted by the USA to the field.[1352] Though France had become the "third" in space at the beginning of 1965, with the successful launch of Diamant, the first satellite launcher built in Europe, it should be recognised that Diamant had a limited payload capacity.[1353] A total domination in the field of operational satellites (telecommunication, television, meteorology, navigation) was forecast for the 1970s, when US governmental credits would come to fruition.

The need for a shift in emphasis from scientific to technological-commercial endeavours was by no means straightforward: ESRO was a promising scientific enterprise, with limited costs, which could rely on the support of the US, which had so long provided launchers for national or European scientific satellites, free or at low cost.

Why should European countries abandon this track in order to get on a more costly, not clearly profitable adventure and what would be the privileged field of operation in application satellites?

In the field of launchers, Europa I, the first European civilian launcher envisaged by ELDO, was not suited to launch application satellites into geostationary orbit. With the setting up of Intelsat and the American successes in communication satellites, the question arose whether the European launcher should be built as first conceived, i.e. with upper stages of only medium performance, and considered as an essential industrial and managerial apprenticeship for a future more powerful launcher; whether

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1351 J. Krige and A. Russo, *Europe in space, 1960-1973*, ESA SP-1172, 1994.

1352 J. Müller, *European Collaboration in Advanced Technology*, *cit.* pp. 379 - 381

1353 LBJ Library, MS Files, 1963-69, box 37, CIA Special Report. *The race for third place in space*, 23 July 1965.

it should be abandoned for a model with higher performance; or whether it was worthwhile at all for Europe to have an autonomous launching capacity.[1354]

The British Labour government (1964-1970) was the most sceptical among Europeans; as early as 1966, the UK made it clear that, as far as launchers were concerned, it favoured reliance on the US. Europa I was predicted by the British to be "obsolescent and uncompetitive in cost and performance with launchers produced by the US" by the end of the decade.[1355]

This nearly brought about a disruption of ELDO in 1966 (and again in 1968) and was the basis of endless quarrels up to the 1970s. British Minister of Technology, Anthony Wedgwood-Benn, was "very much alarmed at the thought that because a thing is European, and because a thing is international, this somehow excuses us from applying economic criteria".[1356]

The UK was eventually persuaded to stay in ELDO and a first upgrading of the European launcher was accepted by ELDO in July 1966; this was ELDO-PAS, later renamed Europa II, which would add a perigee-apogee motor system – a solid-propellant unit developed within the Diamant Programme would be used as a perigee motor – that would make it possible to put a satellite of 170 kg (compared to the 140 kg of a Thor-Delta) into geosynchronous orbit.[1357]

In parallel, with active support from the French delegation, it was decided to move ELDO's site for operational launchings from Woomera (Australia) to the equatorial site of Kourou in French Guiana, where CNES was constructing a base for the French national programme.[1358] However, no firm decision could be taken on the opportunity to build a European telecommunication satellite providing public telecommunication services and television distribution until December 1971: industrial problems, conservatism on the part of users (who actually did not commit themselves in 1971 to using the envisaged system, but just agreed to be involved in the design), and a lack of clarity over the international legal framework for the operations (Intelsat provisions were renegotiated from 1969 to 1971) and uncertainty about the availability of launchers contributed to making this prospect gloomy[1359].

On the other hand, some Europeans were aware of the fact that the rules in Intelsat were only legal translations of the existing balance of power (investments, technical capabilities, national policies) within the area of satellites and, consequently, thought that in order to get to the renegotiation with a

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1354 For an insightful (positive) view on ELDO launcher development, see NASA History Office RG 255, 69-A-5089, box 7, A.V. Cleaver, "The Future of ELDO - an Industrial Point of View", paper presented at the 6th European Symposium on Space Technology, Brighton, 23 May 1966. Cleaver, then the chief engineer and manager, Rocket department, Rolls-Royce Limited, had been involved in the building of the Blue Streak since its original military version.

1355 Cit. in J. Krige, A. Russo, *op. cit.*, pp. 74-75.

1356 HAEUI, CSE/CM (November 68), cited in J. Krige, "Britain and European Space Policy in the 1960s and early 1970s", in *Science and Technology Policy*, vol. 5, n.2, 1992, p.15. European cost estimations at that time made clear that ELDO launchers were expected to be twice as expensive as their American counterparts; CSE/CM (November 1968)15, Add. l, Cost Estimates of the experimental satellite CETS-C, 11 December 1968, cit. in Muller, *art.cit.*, p.115.

1357 J.-P. Causse, *Les lanceurs européens avant Ariane*, in E. Chadeau (ed.), *op. cit.*, p.24.

1358 J. Krige and A. Russo, *op. cit.*, pp 74-76

1359 See Volume I, chapter 10.

good bargaining position, they should build up credible industrial and technical competence and political presence in the field.[1360] This was one of the elements behind the Franco-German Programme for Symphonie, which led to the fusion of the two national experimental telecommunication satellites (Saros 2 and Olympia) into a single spacecraft, whose launch was originally forecast for 1970.[1361] Symphonie, in the minds of its founding fathers, would put German and French industries in a favoured position if and when Europe could get around to building a common satellite, would constitute an asset during the Intelsat renegotiations to be held in 1969, would be a technological novelty and would test, as it did, American willingness to launch European commercial satellites.[1362]

More generally, an ESC (European Spoace Conference) *ad hoc* group on programmes pointed out in 1967 that the choice of whether or not to build a heavy launcher should be made "bearing in mind the need for Europe to retain its political, technological and cultural autonomy, not on the basis of purely economical considerations."[1363] A more comprehensive Advisory Committee report written in the same year, the Causse Report, stated that "(...) Europe should attempt to achieve independent capabilities of its own in such areas as application and scientific satellites, placing it in a position to share the early benefits of space exploration, to eventually become a desirable, respected and essential partner of other space powers, in order to share the full benefits of space flight activities in the decades ahead". Developing a broad space capability was both a prerequisite to any "fair partnership" in the design, production and management of space devices with the USA, and a backbone of European political, economic and cultural autonomy *vis-à-vis* the Americans. The capacity to broadcast radio and television programmes to different areas was considered too important to be left to the major space powers, which would be in a position to exercise monopolistic control over launching services. An even more powerful launcher was therefore envisaged as a primary long-term objective for Europe.[1364]

1360 "Particularly in the early post war years" writes Ruggie ", but well into the 1950s and even 1960s, American technological hegemony defined an order of relations within which others had to find their place. The United States was the major stimulus in launching international programs, and its technological superiority set the agenda and defined the parameters of debate more often than not". J. G. Ruggie, "International responses to technology: Concepts and trends", *International Organization*, vol. 29, n.2, Summer 1975, p. 566.

1361 The aim of the project was publicly announced by the German Federal Minister of Research Stoltenberg and by French Scientific Research Minister Maurice Schuman in April 1967; soon after the agreement was signed. Archives Nationales, Paris, Fontainbleau, côte 81/244, article 188, liasse 517, Communiqué de presse, Symphonie, 28 April 1967; *ibidem*, côte 82/254, article 25, liasse 80, Confidential note on the revision of French space policy on European launchers, no date (post 1966), no author (CNES or Minister of Foreign Affairs).

1362 NAW, RG 359, box 658 Memorandum N.G.Golovin (OST) to Hornig on trip to Europe, meeting with Bignier, 25 October 1967. Also in a draft of the 1966 Presidential annual report on activities and accomplishments under the Comsat act of 1966, LBJ Library, WHCF (CF), TR 105, box 96, Memorandum White House to the President, 8 February 1967.

1363 HAEUI, CSE/CM (July 67)6, 30 June 1967, Report by the chairman of the ad hoc Working Group on programs (30 May 1967), Bignier Report.

1364 HAEUI, CSE/CCP(67)5, December 1967, Report of the Advisory Committee on Programs, Causse Report.

10.5 Setting the rationale for an increased US-European cooperation

The upgrading of American cooperation in space was part of a major effort to capitalise on American space expenditures which reached their historical peak in the mid 1960s. In 1965, talking with NASA Administrator James Webb, President Johnson expressed the view that US space "should have more visibility abroad and should yield more return to our foreign policy objectives".[1365]

The following years were spent in achieving this aim. The mainstream road was publicising of the Apollo Programme, whose rationale had its roots in the cold war US-USSR confrontational climate. As a secondary path, but not less relevant in the long term, discussions began on the opportunity to upgrade space cooperation with the Europeans.

The increasing interest "in the use of space cooperation as a means toward achieving political objectives abroad" put NASA in a very delicate situation. Namely, the danger was that "cooperative projects to this end may not always reinforce NASA's programmatic needs. In such instances it should be up to the State Department and the White House to justify the projects, since NASA cannot itself justify a relaxation of its posture and programmatic needs".[1366]

US-European cooperation in space had been developed since the late 1950s on the "conservative" lines set up by Arnold Frutkin, the Director of NASA international affairs since September 1959: the US had been offering space for European, mainly scientific, experiments on board their satellites, or launching services for European scientific payloads. Common enterprises should be "purely scientific" and reciprocal responsibilities clearly set out, on a project-by-project basis, with no financial exchange. This cooperation was considered by the partners involved to be highly beneficial and the occasions for animosity were few.[1367] Why should this fruitful kind of cooperation be abandoned?

In order to get out of this impasse the Administration chose a two-pronged approach. At the end of 1965, NASA proposed that European partners collaborate on an ambitious scientific experiment, which stood within the limits of the political directives set up by NSAM and represented an upgrading of the existing cooperative rationale; soon after, a global reappraisal on US-European space cooperation was activated at high political level in order to make a qualitative jump in this field.

As far as the first tactic is concerned, in 1965 Webb offered Europeans the opportunity to cooperate on an ambitious scientific project, the Advanced Cooperation Project (ACP). The aim of the offer was to give the Europeans the opportunity to take responsibility for the developments of a technologically advanced spacecraft, a solar or Jupiter probe. The USA would provide the launch, the tracking and the

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1365 NASA History Office, RG 255, 70-A-2573, box 17, Memorandum Webb to William Moyers, Special Assistant to the President, 17 September 1965.

1366 NASA History Office, RG 255, 69-A-5089, box 5, Meeting of the Working Group on Expanded International Cooperation in Space Activities, Summary Notes, 22 September 1966.

1367 A. Frutkin, *International cooperation in space* (Englewood Cliffs: Prentice-Hall) 1965; H. Newell, *Beyond the Atmosphere. The Early Years of Space Science* (Washington: NASA) 1980; J.Logsdon, "US-European Cooperation in Space Science: A 25-Year Perspective", *Science*, 6 January 1984, vol. 223, p.12; H. Massey and M.O. Robins, *History of British Space Policy* (Cambridge: Cambridge University Press) 1986; see Volume I, chapter 12.

collection of data, granting the delivery of appropriate export clearances for technology licenses eventually required from European to American firms.[1368]

However, as explained by a French official to the American Ambassador in France, Charles Bohlen, it appeared as no more than "a bone to nibble on", in the sense that it would play at best a minor role in coming European decisions on boosters and application satellites.[1369] Ironically, as pointed out by some European critics, ACP tended to be perceived not as a help to foster space development, but as a way to "divert" Europe "from the essential economic benefits to be derived from space through the exploration of communications satellites".[1370] The ACP proposal met with varied reactions in the European scientific community; but by the Summer 1966, ESRO had officially declined it.

In line with the Presidential wish to make political use of space cooperation, ACP was eventually transformed into a bilateral FRG-USA venture, Helios.[1371] In the context of waning French support for NATO, and repeated German requests to liberalise the restrictive allied policy on nuclear weapons, the American proposal was a goodwill diplomatic move to support the technological development of the country. In this broader context, it was "politically important to cooperate as closely as possible with Germany". Secretary of State Dean Rusk explicitly stated to James Webb how "it would be particularly helpful if the President and Chancellor Erhard could announce significant and tangible progress in joint cooperation programs between our countries during the Chancellor's visit next month". "While we would not wish to minimise the importance of advanced multilateral space projects with Europe" he added later on "we do wish to increase the vigor and scope of space cooperation with Germany", a country whose role had become pivotal "to strengthen and revitalise NATO", especially after France's withdrawal from it.[1372] Germany was "the most faithful ally" of the USA in Europe[1373], interested in acquiring, through space products, that broad range of technologies it had been forbidden to get hold of through military production, since the end of the war.

American interest was reciprocated by the Federal Republic of Germany. Since the beginning of the 1960s, occupation costs and support costs paid by the FRG since the end of WWII for American forces stationed in their country were substituted by offset agreements whereby the German government would purchase military goods and services in an amount which would offset the local costs of American troops. Confronting the economic recession of the mid-1960s, the German long-term goal was to substitute at least part of the expenses in military items it had to purchase in the US by procurement of high-tech equipment and licences, in order to establish a tradition of technical cooperation and a re-establishment of German national technical capabilities. The State Department, apparently, reluctantly accepted the German proposal, provided that expenditure on technology

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1368 In the view of Newell, responsible for space science programmes in NASA, the construction of such a spacecraft would advance the technology frontier in many fields: sources of energy, special materials for construction, electronics, structures, power sources and their use in difficult conditions, propulsion, environmental control, guidance, measurement techniques and instrumentation, automation and computers. Last but not least it would require new and better management techniques and the use of operations analysis. Newell Papers, Suitland, box 58, folder 411, ESRO meeting with NASA Delegation, Summary of discussions (drafted by ESRO), 22 February 1966. At the same time, Webb had personal discussions with the German Minister of Science Stoltenberg and the principal British science advisor, Sir Solly Zuckerman, to support ACP; NASA History Office, RG 255, 69-A-5089, box 8, Frutkin Memorandum to Webb, 26 May 1966.

1369 NASA History Office, RG 255, 69-A-5089, box 5, Telegram from Bohlen to Department of State, 8 March 1966.

1370 Report for the Assembly of the Western European Union, by Hans Joachim von Merkatz, member of the FRG Bundestag, acting in his capacity as a member of the Assembly. The Western European Union was a consultative forum composed of Britain and the six EEC members, cited in "Europe accuses US on space plans", *The New York Times*, 9 June 1966.

1371 NASA History Office, RG 255, 70-A-3458, box 7, Letter Hocker to Webb, 3 August 1966.

1372 NASA History Office, RG 255, 70-A-3458, box 7, folder 1, Letter Dean Rusk to James Web, 29 August 1966; see also NAW, RG 359, box 755, Memorandum Daniel Margolis to Hornig, 13 December 1968.

1373 *Cit.* in F.Costigliola, *France and the US: the Cold Alliance since the World War II*, *cit.* p. 148.

represented only a small percentage of the whole military procurement under discussion.[1374] Moreover, on the verge of the economic recession of the mid-1960s, Ludwig Erhard was in need of external political legitimisation in order to plan for the future reversal of German policy *vis-à-vis* Eastern Europe - a policy that would be pursued with success by his successor. Kiesinger. In the meantime, space cooperation was given a high level political imprinting with the decision, in March 1966, to establish a special *ad hoc* committee of the National Aeronautics and Space Council (NASC), under the chairmanship of Deputy Under Secretary of State Alexis Johnson, to advise the President on this topic.[1375]

The uncertain evolution of European space policy represented a challenge for the Committee. The collapse of ELDO was feared because it seemed to open up the prospect of national developments of civilian and military launchers. From the point of view of US non-proliferation policy, ELDO was viewed with favour because "In such a framework rocket programs tend to be more open, serve peaceful uses and are subject to international control and absorb manpower and financial resources that might otherwise be diverted to purely national programs. National rocket programs tend to concentrate on militarily significant solid or storable fuelled systems, are less open, and less responsive to international controls. Any break up of ELDO might lead to strengthening national programs tending in the latter direction."[1376] Both the Committee and Frutkin thought that "The breakdown of ELDO would only stimulate undesirable booster development on a national basis elsewhere".[1377]

In parallel, the chairman of the group, Vice President Humphrey, and the Secretary of Defense McNamara shared the view that any increased emphasis on the peaceful uses of space technology would go hand in hand with a reduction in independent European military applications programmes. The aim of US policy, according to McNamara, should be that "of stimulating foreign involvement in space technology as a means of diverting energies from the development of nuclear systems.[1378]

In the case of France, it seemed likely that encouragement to proceed with upper stage hydrogen-oxygen (cryogenic) systems "might divert money and people from a nuclear delivery programme rather than contribute to that which is already under way using quite different technology."[1379]

1374 NAW, RG 359, box 755, Memorandum Daniel Margolis to Hornig, 13 December 1968.
See H. Zimmerman, '*...they got to put something in the family pot': The Burden-Sharing Problem in German-American Relations, 1960-1967*, *mimeo*, European University Institute, Florence, 1995.

1375 NASC was created in 1958 to advise the President on all aspect of space policy; it rarely performed this function during the 1960s.

1376 NASA History Office, RG 255, 69-A-5089, box 5, Committee on Expanded International Cooperation in Space Activities, "Cooperation involving launchers and launching technology", meeting n.1, 17 May 1966.

1377 *Ibidem* and RG 255, 69-A-5089, box 7 Memorandum Frutkin to Webb, Visit of Sir Solly Zuckerman, 5 May 1966.

1378 NAW, RG 359, box 566, Memorandum by the Vice President (Humphrey) to Donald Hornig, 6 April 1966; LBJ Library, James Webb, box 2, Letter Webb to McNamara, 28 April 1966.

1379 LBJ Library, James Webb, box 2, Letter Webb to Robert McNamara (Secretary of Defense), 28 April 1966.

As we have seen, the French *force de frappe* had been based from the beginning, on a solid fuelled propulsion system; so information on cryogenic propulsion was thought to be of no use for military purposes.[1380]

If ELDO's disruption was perceived as a potential danger from the perspective of US non-proliferation policy, the convergence of ESRO, ELDO and CETS was seen as a negative development from the point of view of commercial competition – because it could prelude the creation of a competitive global space power.

As expressed by Frutkin in May 1966, "The greatest danger now is that the crises in space affairs in Europe will lead to a total redirection of European space effort in competition with the United States. If ELDO, ESRO and CETS (...)were to become aligned (as is now being proposed) for the central purpose of establishing a communications satellite capability, this would become seriously disruptive of Intelsat. It seems very important" Frutkin continued "in view of this possibility and in view of the difficult 1969 Intelsat renegotiation that everything be done to give the Europeans as little cause for concern as necessary regarding US motivation. Certainly, no *dog-in-the-manger* attitude ought to be continued".[1381]

This was echoed by NASA administrator Webb's opinion, that "neither communication spacecraft development [the obvious reference was Symphonie], ELDO launch vehicle launch development, nor the Guiana range can any longer be delayed by US export restrictions. By the completion of the range in 1969-70, the European nations could, if they wish, be in a position to place in synchronous orbit an operable *comsat* spacecraft".[1382]

If it was impossible to stop foreigners from building up their regional systems, it would still be fruitful to keep them strictly integrated, and controlled, through Intelsat.[1383]

Charles Bohlen, the highly esteemed American Ambassador in Paris, was convinced that, owing to new developments in European space policy, the government would "have more to gain in the role of helpful partner *vis-à-vis* France and Europe than as a stern competitor".[1384]

10.6 Liberalising American policy *vis-à-vis* launchers technology and services

American policy was caught on the horns of a dilemma. The US were "*virtually at the limits of proposals for cooperation which [could] be made with any hope of success* (emphasis in the text), unless the US were to relax restrictions in the two areas of prime interest, vehicle technology and

[1380] M. Debré, *Gouverner. Mémoires, 1958-1962* (Paris: Albin Michel) 1988, p.375. See also J. Chevallier and P. Usunier, 'La mise en oeuvre scientifique et technique", Actes du colloque *de Gaulle et la dissuasion nucléaire (1958-1969)*, Salines Royales d'Arc-et-Senans, septembre 1984, p.12. It is important to remember that studies on cryogenic propulsion had been developed under the control and with the financial support of the Armed Forces. At that very moment, 1966, the French military were showing a strong willingness to stop their investment in such propellants, for which they could not see any short-term application. As a matter of fact, financing from the military began to decline and the firms involved in such production, mainly SEPR, lived under a "programme de survie" from 1966 to 1968, maintained thanks to the personal influence of Prime Minister Pompidou. Intervention by Pierre Sufflet, Directeur des Engins du Ministère des Armées, in E. Chadeau (ed.),*op. cit.*, pp. 173-174.

[1381] NASA History Office, RG 255, 69-A-5089, box 8, Memorandum Frutkin to Webb, 11 May 1966.

[1382] NASA History Office, RG 255, 70-A-3458, box 7, Letter Webb to James O'Connell, Special Assistant to the President for Telecommunications, 3 October 1966.

[1383] NASA History Office, RG 255, 69-A-5089, box 5, Summary Minutes of Working Group of International Cooperation Subcommittee of the NAEC, 19 May 1966.

[1384] NASA History Office, RG 255, 69-A-5089, box 5, Airgram Bohlen, American Embassy Paris, to Department of State, 23 November 1966.

experimentation with *comsats*".[1385] These were the areas regulated by NSAM 294 and NSAM 338, which began to be perceived by the NASA Administrator as "political irritants to European countries". Such an "obstructionism on the part of the US" was, without any doubt, "exacerbating existing political strains" already at work, especially on the US-French side.[1386] A revision of NSAM 338 could constitute a major improvement in US-European strained relationships in general, could improve the USA's negotiating position in future Intelsat discussions, due to open in 1969, and could have the added advantage of discouraging Europeans from adopting their new, costly, and potentially competitive independent action.[1387]

The underlying idea was to liberalise American national policy on launching communication satellites which had been set in NSAM 338 in very strict terms, leaving it to the new Intelsat rules and bodies to pursue the development of competitive international telecommunication satellites through a web of legal rules.[1388] This idea was embodied in a first Presidential directive endorsed in July 1966 under the name of NSAM 354, "US cooperation with the European Launcher Organisation (ELDO)".[1389] The document called for a positive support for ELDO and assistance to be given subject to the compliance of members to some preliminary conditions. Launcher vehicles, components and technology sold by the US should not be used:

1 for improving communication satellite capability other than a) to permit participation in the US National Defense Communication Satellite System; b) in accordance with the Intelsat agreements regulating (civilian) telecommunication satellite policy;

2 for improving nuclear missile delivery capabilities;

3 for transmittal to third countries.[1390]

In August of the same year, Europeans were offered American support in the development of a European launch vehicle capability through ELDO. In accordance with the dictates of NSAM 354, the US offered:

1385 NASA History Office, RG 255, 69-A-5089, box 5, International Projects in Prospect, sent by NASA to the Department of State on 19 May 1966, enclosed to the Agenda for the Second Meeting of the Working Group to be held on 9 June 1966, 3 June 1966.

1386 NASA History Office, RG 255, 70-A-3458, box 7, Letter Webb to O' Connell, Special Assistant to the President for Telecommunications, 3 October 1966.

1387 NASA History Office, RG 255, 70-A-3458, box 7, Memorandum on Communications satellite technology, no author, no date, received by NASA; *ibidem*, 69-A-5089, Memorandum Frutkin to Shapley, 16 June 1966.

1388 NASA History Office, RG 255, 69-A-5089, box 5, Summary Minutes of Working Group of International Cooperation Subcommittee of the NASC, 19 May 1966.

1389 NASA History Office, RG 255, 70-A-3458, box 7, f.1, Memorandum Frutkin to Webb on Space Council, Task group on assistance to ELDO, Supplementary notes on possible US assistance to ELDO, 14 June 1966; ibidem, 69-A-5089, box 5, Third Meeting of the Working Group (to be held on 7 July 1966), 29 June 1966; ibidem, Fourth Meeting of the Working Group (to be held on 9 August 1966), 4 August 1966.

1390 NASA History Office, RG 255, 70-A-3458, box 7, Memorandum Frutkin to Webb, Space Council Task Group on assistance to ELDO, 16 June 1966; NAW, RG 273, NSAM 354, US Cooperation with the European Launcher Development Organisation (ELDO), 29 July, 1966.

1. to permit the procurement of flight hardware in the US, including such items as a miniature integrating gyro (MIG) strapped-down "guidance" (auto-pilot) package used on the Scout vehicles.

2. to assist in the long-range development of follow-up ELDO projects using high-energy cryogenic upper stages (e.g. ELDO B) through a) technical information and contacts; b) making ELDO personnel aware of the major problems linked to systems design, integration and programme management of a high-energy upper stage such as Centaur; c) joint use of a high-energy upper stage developed in Europe.

3. to supplement ELDO launch capabilities either by the sale of configuration of Scout, Thor, Atlas vehicles (already approved in 1961), or by the sale of launch services for scientific and applications satellite projects.[1391]

Formal discussions began in September 1966 and were focussed, at ELDO's request, on general aspects of management techniques (in establishing adequate task definitions, in proceeding to contractor selection, in handling technical contracts) and on certain specific technical problems relating to injection into geostationary orbit by means of a perigee-apogee propulsive stage, this last information being intimately related to the development of the European ELDO-PAS Programme, directed towards the injection into orbit of a geostationary test satellite early in 1970.[1392]

The first visit by an ELDO team to NASA HQ and the Goddard Space Flight Center took place in May 1967 and various technical problems related to ELDO-PAS were discussed.[1393] The visit was described by the leading European delegate, Colonel Mellors as "a great success" in terms of both the "really useful information" given to the visitors and "the willingness with which it was imparted".[1394] On the other hand, ELDO's requests for technical advice on high-energy upper-stage studies were evaded, in "soft terms". By the beginning of 1968 "it was generally resolved that cooperative development of high-energy upper stages with ELDO should not be pursued".[1395]

1391 lnformation taken from HAEUI, Annex to ELDO/CM(July 68)WP/2, Possibilities and Problems of future US-European cooperation in the space field, Remarks by Trevanion H.E. Nesbitt, Deputy Director, Office of Space and Environmental Science Affairs, Department of State, at the Meeting of EUROSPACE, Munich, Germany, 21 June 1968. Atlas, already phased out as a US military vehicle, had a minimum of security difficulties (it used an old system of radio guidance, for example) and compared favourably against Blue Streak as a potential first stage for the European launcher; NASA History Office, RG 255, 70-A-3458, box 7, f.1, Memorandum Frutkin to Webb on Space Council, Task group on assistance to ELDO, Supplementary notes on possible US assistance to ELDO, 14 June 1966.

1392 NASA History Office, RG 255, 69-A-5089, box 7, Interim Response by ELDO to US Offer of Technical Assistance, by Clotaire Wood, NASA European Representative, 5 December 1966; ibidem, 70-A-3485, box 8, Letter W.H. Stephens, Secretariat ELDO, to C.Wood, NASA Representative, US Embassy, 23 January 1967.

1393 ELDO team was composed by W.J. Mellors, Asst. technical director PAS Project (ELDO), T.W. Wood, Head PAS Vehicle Section (ELDO), J.C.Poggi, Chief Engineer PAS Project (SEREB) and Lauroua, Head PAS Vehicle Coordinated Department (SEREB): NASA History Office, RG 255, 70-A-3485, box 8, Memorandum for the Record, ELDO, by Richard Barnes, 10 February 1967; *ibidem*, Letter Stephens to Frutkin, with Annex on Questions on Injection of Spin Stabilised Satellites into Geostationary Orbits, 24 March 1967; *ibidem*, Letter Mellors to Gilbert Ousley, Technology Directorate, Goddard Space Flight Center, 22 May 1967.

1394 *Ibidem*.

1395 NASA History Office, RG 255, 72-A-3153, box 6, ELDO-NASA relations, 1967, major events, attached to memorandum Lloyd Jones to Morris, 7 March 1968.

The original idea of helping ELDO and civilian launcher technology as a way of diverting funds away from military development faded away in the face of French progress in the development of strategic missile capabilities – which experienced a decisive breakthrough in 1967 – and of rising US commercial interest in satellites.

In July 1967, the revision of NSAM 338, recommended by the Special Assistant to the President for Telecommunications and Director of Telecommunications Management, Jim O'Connell, received Presidential endorsement.[1396] Substantial differences from the old document were not easily detected. However, the change in perspective was evident from the start.

Whereas the original text opened by declaring that "it is the policy of the United States to support development of a single global commercial communication satellite system to provide common carrier and public service communications", the opening policy declaration of the revised version read:

> *"The United States is committed to the encouragement of international cooperation in the exploration and use of outer space".*

The "policy" section of the text was preceded by a new introductory paragraph on the "purpose" of the document, which would be "to provide policy guidance for various elements of the United States Government in dealing with requests from foreign nations or foreign business entities for the transfer of or other assistance in the field of space technology applicable to communication satellite systems".

Rules for the transfer of technology were slightly liberalised in the sense that, for the comprehensive formulation contained in the old text a more flexible expression was substituted: "(...) within the limits fixed by national security considerations and other pertinent regulations, the United States may decline to make available space technology to other nations when a) such technology is critical to the development of a communication satellite capability and b) it has been determined that this technology will be used in a manner inconsistent with the concept of and commitments to the continuing development of a single global commercial communications satellite system as embodied in the 1964 agreement".

The restraints on the transfer of technology, however, were extensive: they dealt with every aspect of technology "critical to the development of a communications satellite capability in terms of time, quality, or costs: complete satellites or launch vehicles or components thereof; detailed engineering drawings pertaining to complete satellites or launch vehicles or components thereof; production techniques and equipment, and manufacturing or fabrication processes pertaining to complete satellites or launch vehicles or components thereof; launch services."[1397]

The main new assumption of the document was the inevitability of the development of new regional communication systems. "There is no reason" suggested E.C. Welsh of the National Aeronautics and Space Council "to pretend that such regional systems will not develop, so why not make the most of it to encourage them to become associated with the international system. If we do not, I would expect that the international system will be the one which breaks up and fails".[1398] If it was impossible to stop foreigners building up their regional systems, it would still be fruitful to keep them strictly integrated,

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[1396] National Security Archives, Washington DC, NSAM 338 revised, Policy concerning US assistance in the development of foreign communications satellite capabilities, 12 July 1967.

[1397] Foreign use of the national defence communication satellite system continued to be contemplated along the lines of the old text. As we have already seen, a bilateral US/UK agreement along these lines was signed in 1967, whereby the UK would build an all-British satellite for military communications with Australia and the Far East within the framework of a collaborative Skynet military space communications system; see J. Krige, A. Russo, *op. cit.*, p.62.

[1398] NASA History Office, RG 255, 69-A-5089, box 5, Memorandum for the File, by S.C. Welsh on *Questions regarding Communications Satellite Policy*, 25 November 1966.

and controlled, through Intelsat.[1399] More specifically, as stated in a NASA paper on foreign dissemination of technology, "The health of Intelsat is assured in part by the feeling of the major Intelsat partners that they are indeed partners and not puppets in an organisation dominated by the US. An important factor in the 1964 agreement is the provision of a method by which advanced members of Intelsat can secure the communications satellite technology enabling them to compete with the US for Intelsat contracts. Should too stringent imposition of US export controls lead these nations to the conclusion that the US did not intend to allow them to compete, their reaction might well be to work together toward a competing system or to jointly defeat the forthcoming 1969 negotiations for a more permanent global system".[1400]

American willingness to liberalise their policy with regard to European telecommunication satellites was put to the test in 1968, when the directors of the Franco-German Programme for the construction of an experimental telecommunication satellite, Symphonie, asked NASA if they could provide launch vehicles and service for two Symphonie satellites they were developing. After consulting with the Department of State, NASA replied in October 1968 "that we (NASA) would launch the two Symphonie satellites on a reimbursable basis if we could arrive at a mutual understanding of the experimental character of the project". Frutkin remembers having stressed the necessity for Europe to guarantee that Symphonie would never be used against Intelsat.[1401] In view of the ambiguous wording of the revised NSAM 338, Frutkin's cautious attitude was well understandable in its effort to respect the spirit of the directive.

This reply was interpreted, however, by Symphonie directors as an American refusal to launch European telecommunication satellites, should they proceed from the experimental phase to the operational one.[1402]

On the other hand, NASA understood the necessity to prevent any antagonism which would lead the Europeans to build up an autonomous commercial satellite system. As expressed by Thomas Paine, European willingness to build its own launcher was due to the fear that the US could block any expansion of future European telecommunication satellites by simply not providing the launching facilities.[1403] If Europe could abandon its "trouble-plagued and obsolescent vehicle program", Paine suggested to the newly elected President Nixon in the Summer of 1969, and reorient itself toward the purchasing of US launchings, "European funds would be freed for more constructive cooperative

1399 NASA History Office, RG 255, 69-A-5089, box 5, Summary Minutes of Working Group of International Cooperation Subcommittee of the NASC, 19 May 1966.

1400 NASA History Office, RG 255, 69-A-5089, box 5, NASA memorandum on "Control of Foreign Dissemination of Technology", 25 April 1966. Article X of the Special Agreement annexed to the Agreement Establishing the Interim Agreement provided for free access to all inventions, technical data and information arising from work performed for Intelsat; these should be used only within the Intelsat system for design, development, manufacture or use of equipment. See S. Levy, "Intelsat: Technology, politics and the transformation of a regime", *cit.*, pp. 655-680.

1401 The citation comes from a retrospective summary of US policy on launcher availability included in a letter sent from Paine to Senator Clinton Anderson; T. Paine Papers, Library of Congress, Manuscript Division (LCMD), Washington, box 26, Paine to Clinton Anderson, September 9, 1970. For Frutkin's testimony, see Interview with J. Logsdon and L. Sebesta, Washington DC, 8 November 1993. The existence of this letter, which was not found in NASA archives, is confirmed by a letter from Maurice Lévy (Scientific counsellor in French Embassy in Washington from 1968 to 1970) to Michel Bignier (Director International Affairs of CNES), dated 13 November 1968 -"As far as Symphonie is concerned, Frutkin gave me a copy of the letter sent to General Aubinière and Mayer (the two responsible for Symphonie). We spoke about what could happen next. Frutkin thinks that there won't be problem for national satellites, but regional operation systems should be a concern for Intelsat. It means that Intelsat should take a position on these systems". Archives Nationales, Paris, Fontainbleau, côte 77/606, art 19, Letter Lévy to Bignier, 13 November 1968. Maurice Lévy confirmed orally these circumstances; Interview with L. Sebesta, Paris, 8 December 1994.

1402 Interview L. Sebesta with Robert Aubinière, 12 December 1991, Paris.

1403 HAEUI, CSE/HF(69)32, Report on the Secretary General's activities resulting from instructions given to him by Senior Officials on 28/29 July 1969, 10 September 1969.

purposes", which would turn out to be the post-Apollo Programme and the new reusable Space Transportation System (the Shuttle).[1404]

10.7 The Post-Apollo programme and the permanent Intelsat agreements

Nixon became President in January 1969. Intelsat renegotiations opened in the Spring of that year: in July Apollo 11 placed the first men on the moon. In October of the same year, NASA's new administrator, Thomas Paine, offered Europeans the possibility to participate in the development and use of an ambitious space transportation and exploration system, the post-Apollo Programme, whose main technical features (later revised) were a space station module, a reusable transportation system, a *Tug* (to transfer payload from the shuttle orbit into geosynchronous orbit) and a nuclear propulsion stage (NERVA) to be used for interplanetary travel to Mars.

During post-Apollo negotiations, European willingness to participate in the new space venture and the question of US launcher availability would be linked until September 1971.

As explained by the European negotiators at the first US-European meeting to discuss Paine's offer, held in September 1970 "Owing to its limited means, Europe would be unable to finance at one and the same time the development of launchers for these programmes [defined early on as being essential European programmes, particularly in application satellites] and a significant participation in post-Apollo Programme developments". That is why European cooperation in any such programme had to be supplemented with American willingness to supply launchers "on a commercial basis and without political conditions". "(...) *on the assumption of substantial European participation in the post-Apollo Programme*" [emphasis in the original], the Americans replied, they were prepared to provide Europe, on a reimbursable basis and before the commissioning of the new Space Transportation System, "with launch services for any peaceful purpose consistent with existing international agreements".[1405]

As for the meaning of "substantial", it was made clear that the Europeans would be required to contribute to at least 10% of the overall development costs of the Space Transportation System. These costs were forecast as being $10.000 million over ten years; for Europe, this would mean $1 billion spread over the same period. Broadly speaking, Lefèvre said, this would correspond to the effort Europe was supposed to make in order to continue the development of the European launcher (some disagreement seemed to exist on this point, because in Ortoli's view, the cost of European participation in the Post-Apollo Programme would be twice that of the development of the European launcher).[1406]

At the request of the European representatives, the American delegates specified that "any peaceful purpose" would "include commercial purposes which could, as such, compete with American interests" ("This possibility was made quite clear by the European delegation before the Americans stated their position").[1407]

Post-Apollo negotiations, as already hinted, took place in parallel with the negotiations on Intelsat (1969-1971), in which the Europeans were striving to obtain a more equitable partnership within the system. Europeans did indeed obtain some good results in the bargaining process.[1408]

Among the issues under discussion was the possibility to set up regional satellites outside the Intelsat jurisdiction. Whereas the US initially argued against this right, the final draft (opened for signature in

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1404 LCMD, Thomas Paine Papers, box 23, Letter Paine to the President, August 22, 1969.

1405 HAEUI, CSE/CS (70) 23, Statement by Mr. van Eesbeek relating to the Washington Talks (16-17 September 1970) between the ESC delegation and ESC authorities, 8 October 1970.

1406 HAEUI, CSE/CM (November 70) PV/1, 4 November 1970, Annex 1, Declaration by Theodore Lefèvre.

1407 HAEUI, CEE/CE (70) 23, Statement by Mr. van Eesbeek relating to the Washington Talks, *cit.*

1408 S. Levy, "Intelsat: Technology, politics and the transformation of a regime", *International Organization*, *cit.* pp. 655-680. See also Volume I, chapter 13.

May 1971) opened the way for the establishment of separate space segment facilities to meet international public telecommunications services requirements of the various members. In every case, members should ensure technical compatibility with the Intelsat space segment and avoid significant economic harm to the global system. However, Intelsat was not permitted, as originally requested by the US, to enforce sanctions against violators, nor were its recommendations considered binding. This was all the more relevant because, in the new text, Comsat, the American signatory, was deprived of the veto power it had according to the Interim agreement.[1409]

However, these American concessions were balanced by a shift in the interpretation of the voting system formula contained in the same article. In order to reach an agreement on the proposed draft, the wording of article XIV was originally formulated in ambiguous terms – art. XIV, par. d. "(...) the Assembly of Parties, taking into account the advice of the Board of Governors, shall express, in the form of recommendations, its findings regarding the considerations set out in this paragraph (...)". Because of this, Europeans asked for a specification of the majority needed to have an international satellite approved – a prerequisite for it to be launched by the US.

In a letter sent by Johnson to Lefèvre on 2 October 1970, the US appeared prepared to launch a European satellite "in those cases where no negative finding is made by the appropriate Intelsat organ, regardless of the position taken by the US in the vote".[1410] – this somewhat baroque definition was understood to mean that a two thirds vote against the proposed satellite would be required to defeat it: if, on the contrary, less than two thirds of the 77 Intelsat members were opposed, the US would be prepared to launch it. Europe would need only just over one third of the votes to achieve Intelsat permission to launch its satellite.

As a matter of fact, on February l971 Johnson's offer was substantially limited. Instead of requiring a two-thirds vote of the assembly to defeat an eventual proposed regional satellite, a two-thirds affirmative vote was requested to support the feasibility for such a proposal.[1411] According to Low, Acting Administrator of NASA after the departure of Paine in September 1970, this reversal, if not accompanied by a specific advanced commitment by the US to support in Intelsat the principal regional European communication satellite proposal, would "effectively kill the chances for post-Apollo participation by Europe".[1412]

This change of position was linked to pressures exerted by Comsat and American aerospace companies, which had received the bulk of Intelsat contracts.[1413] Generally speaking, the origin of this change cannot be understood except in the context of the settlement of the new Office of Telecommunication Policy (OTP) in September 1970. OTP had been directed since its inception by Clay T. Whitehead, a young and resolute system analyst coming from MIT, and directly attached to the President of the US.[1414] Its aim was to define American policy *vis-à-vis* satellite communications for overseas civilian operations, focussing on the support of national aerospace companies, against what were perceived as attempts by NASA and the State Department to endanger the US monopoly in telecommunication satellites on the basis of uncertain political returns.

1409 *Ibidem*, pp. 670-671.

1410 HAEUI, CEE/Comité ad hoc (71)9, 22 April 1971, Letter from Johnson to Lefèvre, October 2, 1970, p.5.

1411 HAEUI, CSE/Comité ad hoc (71)10, Letter Johnson to Lefèvre, 5 February 1971. For Comsat's pressures; NASA History Office, RG 255, 74-734, box 17, 1971, Memorandum to the file (telecon. between Dr. Low and Under Secretary Alexis Johnson), 13 January 1971; *ibidem,* 74-734, box 14, Memorandum to the file (Lefèvre meeting preparation - Johnson/Charyk discussions), Frutkin, 25 January 1971.

1412 NASA History Office, RG 255, 74-734, box 17, 1971, Memorandum to the file (telecon. between Dr. Low and Under Secretary Alexis Johnson), 13 January 1971.

1413 RG 255, 74-734, box 14, Memorandum to the file by Frutkin on Lefèvre meeting preparation, Johnson-Charyk discussions, 25 January 1971. The authors are indebted to Andrew Butrica for providing this reference; see also M. Freudenheim, "Satellite splits US, Europeans", *San Francisco Sunday Examiner and Chronicle*, March 7, 1971, *cit.* in B. Valentine, "Europe and the post-Apollo experience", *Research Policy*, 1, 1971/72, p.117.

1414 M. Kinsley, *Outer Space and Inner Sanctums* (New York: Wiley and Sons) 1976, pp. 211-212.

On January 7, 1971 in a much publicised "Statement of Government Policy on Satellite Telecommunications for International Civil Aviation Operations", OTP called for an "international utilisation" (as opposed to international development and utilisation as had been proposed by NASA) of a pre-operational system for international civil aviation operations.[1415] The suggestion was made with reference to a specialised aeronautical communication satellite, Aerosat, but its rationale, it seemed, was valid for any commercial satellite.

On February 1971, one month after the release of OTP policy statement, Whitehead also heavily criticised the contents of US-European negotiations on the post-Apollo Programme, whose sole effects would be, in his opinion, to give away "space launchers, space operations and related know how at 10 cents on the dollar" (a reference to the American proposal that Europe share 10% of the development costs).[1416] It has to be stressed, however, that Whitehead was himself sceptical about the acceptability of the new American position on launchers, which he labelled as a "blatant US veto"; he suggested selling launch vehicles to the Europeans to launch from their own soil for whatever peaceful purpose they desire. But this proposition "would be unacceptable to Comsat and Senator Pastore", the influential leader of its political lobby in the Congress.[1417]

Europeans reacted strongly to the new restrictive American interpretation that, according to Lefèvre, was "confirmed neither by the joint preparatory work nor by the wording used in the text" (of Intelsat) and asked for further specification of the US position on the lines anticipated by Low.[1418]

It was not until September 1971, after the opening for signature of the new Intelsat Treaty, that Lefèvre received the clarifications he had been asking for since March.[1419]

First of all, the availability of American launchers would not be "conditioned on European participation in post-Apollo Programme". As for the conditions upon which the US would offer its launching services for satellites intended to provide international public telecommunication services, including European regional satellites, the US stuck to their "restrictive" interpretation of Article XIV (whereby the governing body would have to make "a favourable recommendation") – the proponents of a regional satellite would then bear the burden of persuading two-thirds of the Assembly that the proposal would not cause significant economic harm and be technically compatible with Intelsat. Moreover, the Intelsat recommendation seemed to be considered binding by the US, contrary to the general interpretation of the article.[1420]

As far as the acceptability of a European space segment for international public telecommunication services separated from those of Intelsat was concerned, the preliminary and provisional system outlined by the Director general of ESRO (H. Bondi) at the European Conference in Venice in

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1415 The policy was established "with participation by interested agencies in the Executive Branch" George F. Mansur, Deputy Director, OTP, chaired the study group and coordinated the OTP policy formulation. R. Nixon Project, NAW, WHCF, Subject Files, UTl, box 14, *Executive Office of the President, Press Release*, Nixon Administration announces policy on aeronautical satellite communications, January 7, 1971. This statement was supplemented by another one issued on 19 March 1971 "The National Program on Satellite Telecommunications for International Civil Aviation Operations" (attached to letter Nilson to Hammarström, 2 April 1971, HAEUI, folder 50771) which followed the same lines.

1416 Nixon Project, WHCF, Subject Files, box 2, Memorandum Whitehead to Flanigan, 6 February 1971.

1417 Fletcher Papers, University of Utah, Memorandum Low to Administrator, on Kissinger Meeting, 12 August 1971, held at the Institute of Space Policy, George Washington University, Washington DC.

1418 HAEUI, CEE/Comité ad hoc (71)12, Letter Lefèvre to Johnson, 3 March 1971.

1419 On this and other aspects related to the American decision-making process during the negotiations, see L. Sebesta, "The politics of technological cooperation in space: US-European negotiations on the post-Apollo programme", *History and Technology,* 1994, vol. 11, pp. 317-341.

1420 The text of the agreement, with annexes, done at Washington, August 20, 1971, entered into force February 12, 1973 and operating agreement, with annex (done and entered into force at the same dates) is in *Space Law and Related Documents. International Space Law Documents. US Space Law Documents*, 101st Congress, 2nd Session, S. Print 101-98, June 1990, pp. 211-318.

September 1970 [1421] was analysed by representatives of FCC, OTP and the State Department Bureau of Economic Affairs. The above-mentioned system "would appear to cause measurable, but not significant, economic harm to Intelsat". Thus, if this specific proposal were submitted for US consideration, they would support it in Intelsat. If voice and data were to be provided to both CEPT countries and North Africa, Lebanon and Israel, though, significant economic harm to Intelsat was forecast and the system would have been "clearly unacceptable" to the US.[1422]

Johnson's September letter was discussed by the representatives of the Committee of Alternates of the ESC; the new decoupling of launcher availability from the post-Apollo Programme was warmly received. Europeans should now provide the US with additional information.[1423]

On 20 December 1971, ESRO Council adopted a resolution on the restructuring of the organisation (the so called "first package deal"), which called, *inter alia*, for:

a) the US/European Joint Aeronautical Satellite Programme, Aerosat (even though the work on the Aerosat payload pre-development had started in European industry, the failure of the US to approve the Memorandum of Understanding concerning the Aerosat Programme had delayed the start of full-scale development of the spacecraft);

b) the Meteorological Satellite Programme;

c) the Communication Satellite Programme extended to the European Broadcasting Area as defined by the ITU.[1424]

The ESRO resolution also contained a statement on the policy to be followed by Europe concerning launch services. The resolution reaffirmed that European launchers would be given priority, on condition that their cost did not exceed 125% of relevant non-European ones. Should, however, such American launchers be denied, the price would be based on the cost of production, or even supplemented by the cost of specific development, if required.

In consideration of all that, Lefèvre requested from Johnson a further, clearer, statement on the availability of American launchers for the adopted European telecommunication satellite system.[1425] In particular, an account of the operational system, mission, geographical coverage, frequency bands and technical configuration of the European telecommunication satellite system was transmitted and

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[1421] This was foreseen to provide voice, data and television services (i.e. public telecommunications) within the CEPT countries and television-only to other countries of the European Broadcasting Area as defined by ITU - this extended from Iceland to the North African coast, and from Portugal to Lebanon and Israel.

[1422] HAEUI, CEE/Comité ad hoc (71)18, 8 November 1971, Annex I, text of the letter from Under-Secretary of State Johnson to Minister Lefèvre, dated 1st September 1971. The letter, which America requested to be confidential, was passed to the Belgian press (Le Soir, September 30, 1971) and then given widespread publicity. See also NASA History Office, RG 255, 74-734, box 16, Department of State Telegram, on European participation in the post-Apollo programme, Visit of Minister Lefèvre, 24 February 1971; *ibidem*, 74-734, box 16, Second Discussion with Representatives of the European Space Conference concerning European Participation in the post-Apollo programme, no author, 8 February 1971.

[1423] HAEUI, CSE/CS(71)PV/27th October 1971, Minutes of the Joint Meeting of the Committee of Alternates and the ad hoc Committee of Officials, 22 September 1971.

[1424] HAEUI, CSE/CM (Dec. 72)5, Report by the Secretary General of the European Space Conference on the Status of European Space Programmes, 7 December 1972. See also Volume I, chapter 9.

[1425] HAEUI, CEE/CE (72)1, 4 January 1972, Annex, Letter Lefèvre to Johnson, 23 December 1971. The whole exchange of correspondence between Lefèvre and Johnson until this date is in CSE/Comité ad hoc (71) 22, 22 December 1971. On the European Communication Satellites Programme, see Volume I, chapter 9.

Johnson was requested to state, on the basis of this document, "whether, considering the concept of the system as now decided in its final form", he could confirm that his government would be willing to support the project when it would be officially submitted to Intelsat by the participating countries, as specified in his letter of September 1971. In his reply (June 1972), Johnson made reference to three difficulties related to the proposed European Communication Satellites Programme: the economic impact (in terms of higher charges to users) and the technical incompatibility (the orbital position of the satellite should be moved by 10 degrees eastwards to avoid coverage of the US East Coast) and, most important of all, the definition of the European region.

Johnson clarified once and for all that the US would not support the Programme within Intelsat if an expanded coverage with respect to the European geographical area was expected. Actually Europeans, in tune with the ITU definition, gave to the "European Broadcasting Area" a much larger scope than the purely geographical one. It was bounded "on the West by the Western boundary of Region 1, on the East by the meridian 40° East of Greenwich and on the South by the parallel 30° North [thus, including the ex-French colonies in North Africa], so as to include the western part of the USSR and the territories bordering the Mediterranean, with the exception of the parts of Arabia and Saudi Arabia included in this sector. In addition, Iraq (was) included in the European Broadcasting Area".[1426]

On October 1972 Nixon officialised the American position on the availability of launchers in the following terms:

> *"United States launch assistance will be available to interested countries and international organisations for those satellite projects which are for peaceful purposes and are consistent with obligations under relevant international agreements and arrangements".*

With respect to satellites providing international public telecommunications services:

1 *"The US will provide appropriate launch assistance for those satellite systems on which Intelsat makes a favourable recommendation in accordance with article XIV of its definitive arrangements.*

2 *If launch assistance is requested in the absence of a favourable recommendation by Intelsat, the United States will provide launch assistance for those systems which the United States had supported within Intelsat so long as the country or international entity requesting the assistance considers in good faith that it has met its relative obligations under Article XIV of the definitive arrangement.*

3 *In those cases where requests for launch assistance are maintained in the absence of a favourable Intelsat recommendation and the United States had not supported the proposed system, the United States will reach a decision on such a request after taking into account the degree to which the proposed system would be modified in the light of the factors which were the basis for the lack of support within Intelsat".*[1427]

[1426] ITU definition is cited in HAEUI, ESRO/PB-TEL(72)5, Availability of launchers for the European Communication Satellites Programme, 22 September 1972.

[1427] United States policy governing the provision of launch assistance", October 9, 1972 (Washington: Office of the White House Press Secretary).

This declaration gave rise to dissimilar interpretations in Europe and in the US. Europeans saw it as sanctioning the *de facto* binding character of any Intelsat recommendation.[1428]

After the failure of the launch of Europa II in November 1971 and its abandonment in April 1973 (according to the contract with ELDO of 1970 Europa II was to have launched Symphonie) the directors of Symphonie decided to explore the possibility of having the two satellites launched by Soviet or American launchers. INTERCOSMOS did not object to the launch, but stated that it would be technically feasible only in 1976 (too late for the Europeans). On the other hand, the US were able to promise a first launch by 1975 through a Thor-Delta 2914. After protracted negotiations, whose exact content remains an object of dispute, an agreement was reached in June 1974. It confirmed the experimental character of Symphonie, but it also included the possibility to transform it into an operational one. In this last case "(...) the Government of the Federal Republic of Germany and the Government of the French Republic (...) confirm their intention of fulfilling the obligation contained in the Intelsat Agreement, especially its article XIV, and of accepting the recommendations of Intelsat insofar as they apply to the Symphonie programme.(...) understand that, in the absence of favourable recommendations from Intelsat, the assurances given by the President of the United States in his statement of October 9, 1972, shall, with appropriate modifications, apply to the decision to use this means of communication for international public telecommunication services".[1429]

According to French sources, the agreement was unwillingly accepted by the Symphonie Directors.[1430] As in the case of the Nixon declaration, to which the agreement referred, French officials perceived the text of this agreement as a *de facto* American veto on a future operational use of Symphonie. An interpretation which was not acknowledged by American officials.

Between Fletcher's letter and the decision of the Directors of Symphonie, the Ministerial meeting of the European Space Conference adopted the so-called "second package deal", approving three main Programmes: Ariane was one of them.[1431]

10.8 Conclusions

Between 1965 and 1973, NASA had to conform to ambiguous political directives going in the direction of liberalising launching services and international technology flow and opposite pressures from the rising American telecommunication community. NASA's task was to mould these opposed influences into a coherent policy *vis-à-vis* specific requests advanced by the Europeans on the availability of American launchers for telecommunication satellites.

An originally extremely restrictive national policy on commercial satellites, aimed to establish and guarantee for the future an American hegemony in the field, and on the availability of launchers was gradually liberalised in 1966-67.

1428 For the European view, see, among others, P. Creola, "European-US space cooperation at the crossroads", *Space Policy*, May 1990, p.99.

1429 Launching of French-German Symphonie Communications Satellites, Agreement effected by exchange of notes, signed in Washington June 21 and 24, 1974, entered in force June 24, 1974, in *United States Treaties and Other International Agreements,* vol. 25, Part 3, 1974 (Washington DC: US Government Printing Office) 1975. We are indebted to Richard Barnes for reminding us of the publication of this exchange of notes by the US Government in their TIAS series.

1430 Archives Nationales, Paris, Fontainbleau, côte 81/244 art. 188, liasse 517, Note pour le Conseil d'Administration du CNES par le Secrétaire executif français de Symphonie, Situation des possibilités de lancement du satellite Symphonie, 17 septembre 1973; *ibidem,* CNES, Secrétariat executif Symphonie, Rapport de présentation, 25 Octobre. 1973; *ibidem*, art. 187, liasse 515, DGRST, Note sur le programme Symphonie, 18 juin 1974. The two Symphonie satellites were placed in orbit on December 1974 and August 1975, C. Carlier, M. Gilli, *Les trente premieres années du CNES. L'Agence française de l'espace, 1962-1992* (Paris: La Documentation française) 1994, pp. 227-230.

1431 J. Krige, A. Russo, *op. cit.*, pp. 11-112.

Technological sharing in the field was seen as:

1 a possible way (for the Department of State) to defuse European criticism of the so-called technology gap;

2 a convenient diversion of funds from military rockets to civilian launchers in order to pursue a global policy of non-proliferation – this idea, originally supported by the Secretary of Defense and by NASA, was abandoned as soon as it was clear that France had acquired an autonomous military launching capability.

Furthermore, NASA considered the liberalisation of US launcher availability to be very important as a means of preventing Europe from 'going it alone' in this field and, eventually, setting up an independent satellite system outside Intelsat.

However, the change of administration, the increased economic relevance of telecommunication by satellite and the rising concerns about technological sharing, coupled with the signature of the definite Intelsat agreement, shifted the balance towards the anti-European constituency within the American administration. Some features of the new Intelsat agreement were especially disturbing for many: the limitation of Comsat quotas to less than 40%, the possibility to set up regional systems and the non-binding nature of Intelsat recommendations on compatibility.

The well-rooted industrially-supported inclination to maintain a monopoly in the field of commercial satellites (guaranteeing the monopoly of launcher technology seemed to be one of the more effective ways to do that, at least in the short term) was reinforced by the creation in September 1970 of the new Office of Telecommunication Policy and its policy of support to the national aerospace sector.

In response to repeated European requests concerning the availability of launchers for future European regional telecommunication satellite systems, the ambiguous wording of the Intelsat agreement was progressively clarified in terms unfavourable to the Europeans. A substantially restrictive interpretation of article XIV of the treaty was expressed, due primarily to Comsat pressures. The enlarged European notion of "regional" was not accepted and the binding character of Intelsat judgement practically imposed by stating the necessity for European telecommunication satellites to be accepted by Intelsat in order to be launched by the US.

With the agreement on the new Intelsat text and the Presidential endorsement in January 1972 of the Shuttle Programme, US interest in European support for the post-Apollo Programme and in Intelsat waned and, therefore, positions in support of an extension of US-European cooperation further weakened.

On the other hand, the Shuttle seemed to guarantee, in the long run, an extraordinary qualitative jump in launching systems and their cost/effectiveness; the new space transportation system would make any European expendable launcher "obsolescent". Thus, indirectly, the Presidential decision reduced US interest in preventing Europeans from 'going it alone' as it reduced, in parallel, US interest in the post-Apollo Programme which, by June 1972, was reduced to Spacelab.

Equally important, there seemed to occur a real shift in US policy *vis-à-vis* Europe: whereas the Kennedy and Johnson administrations had tried to appease Europeans, looking for their political support in the US-USSR confrontation, Nixon's priority shifted towards setting up détente with the USSR (and disentangling the US from Vietnam). A major economic crisis – a disastrous balance-of-payments deficit (accompanied by a severe reduction of gold reserves and the first US trade deficit since 1894) was registered in the Summer of 1971. The decision to stop selling gold to foreign banks in exchange for dollars and to refrain from defending the dollar's fixed gold exchange rates (the Bretton Woods system), plus the 10% tax imposed on the value of all imports, were troubling economic and political signals to European allies. As is frequently the case, economic crises fed isolationism, especially against a combative European Economic Community, due to be enlarged by the ratification of the access of the UK, Denmark and Ireland in January 1973. The EEC was coming to be seen as a strong competitor for foreign markets and its industries were beginning to erode the privileged position American firms had gained since the war.[1432]

Not surprisingly, efforts to liberalise American policy on technological sharing and the availability of launchers came full circle. They failed in front of prevailing internal economic interests, the changing priorities in US foreign policy and developments in Europe, in both military and space fields.

On the European side, the unwillingness of the US Administration to give the Europeans an unconditional assurance of future availability of launchers for operational telecommunication satellites was only one of the factors that led to the European decision to endorse the French-sponsored project to build the LIIIS launcher.

This decision has to be mainly analysed within the context of a strained US-French relationship (a legacy of de Gaulle - Johnson conflicts which would endure well into the 1970s) and a very confused situation in the European space field.

Institutional uncertainty on the future of European space organisation was acute from 1966 to 1971. Financial commitments were weak compared to those in the US, industrial experience in satellite technology was limited and international legislation was not yet defined. The attitudes of the users (CEPT and EBU) were conservative due to the uncertain commercial returns and costs of the new system and the anticipated technical and reliability problems.[1433]

It was not until December 1971 that the ESRO Council endorsed the start of a Telecommunication Programme consisting of a first phase (for the development and launching of an experimental satellite, OTS) and a further operational phase.[1434]

Furthermore, not all the Europeans objected to the arrangement of a qualified availability proposed by the US. The UK always criticised the autonomous solution and preferred the less expensive reliance on US satellites and launchers; Italy did not seem to be interested in projects, such as the new European launcher, that would not guarantee an appropriate industrial return to its industry; the Federal Republic of Germany, after the failure of the Europa II launch in November 1971 and after the definition of the post-Apollo Project in June 1972, was eager to assume the greatest financial burden and the prime contractorship for Spacelab while withdrawing its original support for an independent European launcher. France and Belgium were the only countries that never wavered from their support to the idea.

Even within France, however, not everybody was in favour of the autonomous launcher. The important thing is that those who did support it (first of all Pompidou who replaced de Gaulle in 1969) created a strong constituency and, during this process, (also) made good use of American policy on launchers to improve their position. Of equal importance is the fact that the technicians who first conceived LIIIS did not look for a technological breakthrough (politically and economically difficult to support under the historical circumstances), but for a technically easy and reliable object, based partly on the knowledge that France had acquired during the development of Diamant, partly on the experience acquired during the preparation for the Europa III Programme and partly on national

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1432 Costigliola, *op. cit.*, pp. 167-172. See also P. Melandri, *Une incertaine alliance. Les Etats-Unis et l'Europe, 1973-1983*, (Paris: Publications de la Sorbonne) 1988, pp. 45-77 and the insightful account written by the American Ambassador to the European Community, Robert Schaetzel, *The Unhinged Alliance. America and the European Community* (New York: Harper) 1975, pp. 42-53. For the rising competition from foreign industries, see S. Krasner, "US commercial and monetary policy: unravelling the paradox of external strength and internal weakness", *International Organization*, Fall 1977, n.4, pp. 635-671.

1433 J. Müller, "Historical background and start of the TELECOM Programme", *Space Communications*, 8(1991) pp. 105-140.

1434 See Volume II, chapter 10.

research performed in France and in the Federal Republic of Germany on cryogenic propulsion.[1435] Because, as part of the deal, France guaranteed to cover the cost overrun, the technological "austerity" was a prerequisite to minimise the financial risks for France. To build a launcher on a national basis, however, would not be financially possible or strategically convenient. Europeanisation was a necessity because the financial burden needed to be shared and future users secured.[1436]

In the end, all the reluctant European partners were eventually induced to participate in the second package deal. Europe's decision to build LIIIS (later renamed Ariane) had many roots and motives, among which was the US unwillingness to guarantee availability of launchers for operational commercial satellites, but it was by no means assured till the very end: the hectic horse-trading that took place in July 1973 testifies to the difficulty of such a process until the very last moment and magnifies the central role of international bargaining in it. In this context, if West Germany and the UK had not had their pet projects (Spacelab for Germany and Marots for Great Britain) to protect and for which to get support from the others, Ariane would probably have had a more traumatic birth, if it had been born at all.

[1435] See the illuminating contribution of A. Lebeau, "La naissance d'Ariane" in E. Chadeau (ed.) *op. cit.*, pp. 75-91 and the ensuing debate among eyewitnesses of the time, pp. 95-108.

[1436] Archives Nationales, Paris, côte 81/401, art. 70, liasse 179, CNES, Rapport group sectorial 6, Programmes d'études et développement des lanceurs, 30 juin 1970.

Chapter 11:
The Move from Ariane Development to Production and the Establishment of Arianespace

J. Krige

11.1 Introduction

As we stressed in Chapter 9, the decision to develop a European heavy launcher was an essentially political one. More precisely the issue of whether or not Europe should develop an expendable launcher was defined by some people in France as the issue of whether Europe wanted to depend on the United States for launch services. The ambiguities over the request to launch Symphonie were fundamental in this respect. One could speculate indefinitely over whether the American authorities might not have been willing to shift their position if the Europeans had taken a stronger line. One might be inclined to agree with the position of Germany at the time, particularly knowing the hopes that NASA pinned on having the Shuttle fly about 50 missions a year: that the US would never systematically refuse to orbit European payloads. But this is not the point. The negotiations over Symphonie played into the hands of, and were made use of by, those in France who were suspicious of US intentions and imbued with the determination to maintain French autonomy.

Maintaining French autonomy also meant maintaining the in-house ability at CNES and in industry to build launchers. This was why the French were so emphatic that the project should essentially be under CNES' control. Governments knew that once teams of project engineers and managers dispersed it was extremely difficult to reconstitute them. The engineers would not only have been reallocated to other tasks. They would be out of touch with the then-current state of the art of rocket technology. It is in this sense that the political decision to build Ariane was also an industrial policy decision.

That granted, once the development of the launcher got into its stride, and seemed to be advancing smoothly, the entire framework in which it was perceived changed. In the early 1970s the commitment to Ariane was overwhelmingly determined by political concerns. In the mid-1970s commercial concerns also started to shape the Programme. The question of whether to proceed or not was no longer primarily the question of whether one could trust the Americans; after all Europe now had its own launcher. It was rather the question of whether one could compete with the USA in the 'open' market. As Arnold Frutkin, responsible for international affairs in NASA said to André Lebeau in the early 1970s: "Maybe you will be able to build a technically successful launcher, but what you do not know how to do is to commercialise it, and it's there that we are waiting for you".[1437]

Legally speaking the Ariane “Arrangement” provided that the development and qualification of the launcher would be followed by a second phase in which it would be produced and marketed. It will be remembered that, faced with the German Delegation’s reluctance to commit itself to such a phase, the texts adopted simply stipulated that the Programme Board would need to define the terms under which this phase would be embarked on. No participant in the development phase was obliged to remain in the Programme. Assuming that Ariane would be qualified by 1981, and that it took three years to manufacture a launcher, it followed that the commitment of the participants to the production phase would be needed by mid-1978 if there was to be smooth transition in industry between the initial and the follow-on activities. At the end of 1975 the ESA Executive thus took the first steps towards setting up the legal, financial and institutional aspects required to ensure this changeover.[1438] By mid-1976 it had prepared a number of basic documents defining various dimensions of the production phase: the role of the Agency in it, and the division of responsibility between CNES and ESA, the industrial

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[1437] As cited by A. Lebeau in J. Krige and L. Guzzetti, *History of European Scientific and Technological Cooperation* (Brussels: EEC, 1997), p. 291.

[1438] The first plans are in ESA/C(75)58, 18 November 1975 (= ESA/PB-ARIANE(75)11).

organisation, an estimate of the potential market for the launcher, as well as cost figures for launches and a sales policy. For the next 18 months these documents provided the background to the debates in the Programme Board and the Council on the modalities of the production phase.[1439]

11.2 The promotion series

When the Executive first presented its suggestions for the "production" phase it proposed to relabel it an operational phase. The reasoning was simple: the launcher was formally to be regarded as qualified after its first four flights, and so had moved from the phase of development to that of use. This terminology was immediately contested by some members of the Programme Board in September 1976, however. Fearing that the market for Ariane would be small, and that it would still have to be funded by national ministries responsible for space affairs rather than by user-clients, they insisted that one allow for a transition period between development and operation.[1440]

It was the German Delegate who objected most strongly to speaking of an operational phase. He insisted that it would be unwise to assume that Ariane would be qualified, and so "operational" after the first four flights. If it were, it would be up to "the users only to finance the production phase" – and that, said the German delegate, was "a hypothesis of dubious realism". This was because his authorities feared that the Executive's 'mission models' which tried to estimate the demand for Ariane were far too optimistic.

The mission models proposed by the Executive distinguished between low, medium and high use for four categories of satellite: scientific, meteorological, Earth-observation and telecommunications.[1441] The low estimate included only missions "with a fairly reasonable probability" of being realised between 1981 and 1990. The high estimate included all possible candidates for an Ariane launch in this time window. The medium estimate removed some of these as being unlikely candidates for the European rocket, and smeared out the time taken for others. The Executive concluded that over the ten year period in question there would be a need for at least 24 (low) and as many as 46 (high estimate) launches. For 1981 to 1983, for which its data were more reliable, it felt that "ESA missions or derived missions alone should call for at least two launches a year, as from 1981". And since an optimal launch rate, given industry's capacity, was four launches per year, this meant that only two more non-ESA missions were needed. This seemed "equally feasible", though the Executive was quick to point out that of the possibility of fulfilling these targets depended on ESA's willingness to use Ariane itself as much as possible, and on its pricing policy for third-party launchings. These figures were contested by the German delegate. We should not allow ourselves to be "deluded by baseless optimism" about the future market for the launcher, he said. Instead "it would be vastly preferable to undertake a 'demonstration' programme, whose aim would be to demonstrate fully the launcher's quality and reliability". By thus prolonging the development phase with a demonstration phase of four 'production models' one could "consolidate technical confidence" in Ariane and convince more clients to use it.

This suggestion created considerable agitation in the Executive and among some delegations. The Director General feared that any delay in the move from development to full operation might be interpreted by potential customers as "a sign of Europe's lack of confidence in its own products". Echoing these sentiments, the French representative remarked that, if one wanted to produce a competitive launcher, it seemed "paradoxical to introduce a new demonstration phase into the programme, which would immediately cause future customers to doubt the quality of the product developed".

1439 The documents are ESA/C(76)R/12, 2 July 1976, ESA/C(76)R/12, add. 1, 16 September 1976.

1440 For the following paragraphs, unless otherwise stated, see ESA/PB-ARIANE/MIN/6, 24 September 1976, document dated 5 November 1976.

1441 See ESA/C(76)R/12, 2 July 1976, paragraph 7, and ESA/C(76)R/12, add. 1, 16 September 1976, paragraph 3, from which the quotations are taken.

Notwithstanding the hesitation, by the time the Council met in October 1976 there was general agreement on the principle, but still some doubts about the nomenclature.[1442] The French delegation could agree with its German counterparts that there were advantages in having an "intermediate phase which would serve as a running-in period for the organisation and management of the operations". What it and the Swiss delegation wanted to avoid at all cost, however, was any hint that development was not completed after four launchings (as specified in the original Arrangement) or that ESA lacked confidence in the technical capacity of Ariane. The compromise terminology ultimately adopted a few months later was the "promotion series".

The promotion series covered a period which, as the French delegation put it, was "neither wholly commercial nor [...] wholly one of research and development". It comprised the production of six launchers and the related launch services, a batch of six being needed to ensure a reasonable production run. It meant that Ariane could benefit from the financial and political support of the national space ministries for another two years, so hopefully enhancing its competitiveness on the world market. The series would be used to increase cost-effectiveness "by ruggedised construction, simplification of fabrication methods, and rationalisation of management and launch operations".[1443] But its overriding objective was to demonstrate the Agency's confidence in the performance and reliability of Ariane.[1444]

Of course the best way for ESA to show that it had confidence in the European launcher was to use it for its own Programmes. If it did not, it could hardly expect others to take the risk.[1445] As the French delegate put it to the Programme Board in December 1976, "the mere definition of a mission model was not enough; the existence of a clearly-specified user programme was a prerequisite to production". Four out of six of those launches, he added, should be ESA missions.[1446] However, as much as they might have liked to guarantee their market, the States participating in the Programme Board were not formally empowered to impose the launcher on any programme, be it funded by ESA or by a third-party. Users would have to be persuaded to buy Ariane, and that required an important change in approach. Before studying that change, however, let us quickly explain the efforts made to define the management structure.

11.3 The management scheme

ESA's original idea was that it, and it alone, would have overall responsibility for the procurement of Ariane launchers once the rocket was qualified. The aim, of course, was to overturn the earlier scheme whereby CNES had had effective control over development. This organisational structure had been more or less imposed on the Ariane project by France on the grounds that if it assumed the technical and financial risks of the Programme it had to be responsible for the technical management and oversee the work in industry. Her partners, and the Agency, had had little choice but to accede; now, the Executive thought, the moment had come to re-establish the equilibrium, to give the Ariane Programme a fully European dimension, and to restore to the Agency the responsibility that had earlier been denied it. CNES, and the French government, were not exactly enamoured of this idea, as one might well imagine, and it took two years to find a 'solution'.

1442 See the minutes of the Council meeting on 7-8 October 1976, ESA/C/MIN/10, 22 October 1976.

1443 See ESA/PB-ARIANE(76)WP/1, 16 November 1976 and ESA/PB-ARIANE(76)26, 8 December 1976. For the French delegation's comment see ESA/PB-ARIANE/MIN/9, meeting on 13 December 1976, document dated 24 January 1976.

1444 Report by Chairman of the Ariane Programme Board, ESA/C(76)133, 16 December 1976 (ESA 248).

1445 "Orders for launches from third-party users will only be 'captured' once the Agency has decided to use Ariane for its own missions" – *Production phase of the Ariane programme*, ESA/C-M(77)13, rev.1, 1 January 1977 (ESA 4518).

1446 See minutes of the 9th meeting on 13 December 1976, ESA/PB-ARIANE/MIN/9, 24 January 1977, and report by the chairman, ESA/C(76)133, 16 December 1976 (ESA 248).

Early in 1976 the ESA Director-General set up an internal working group headed by R. Orye to deal with this issue. Orye had played a major role in launchers in ELDO, and when that organisation had been wound up he had been transferred to ESRO/ESA to take responsibility for launchers inside the Agency. His group's mandate was to define a management structure for the production phase acceptable both to the Agency and to CNES. Two possibilities were envisioned. Firstly, that ESA had sole responsibility for the Programme. Secondly, that ESA and CNES had joint responsibility for the Programme.[1447]

Orye visited the US in March 1976 to see how NASA did it. It had always been assumed that ESA, like NASA, would be responsible for liaising with the launcher's users, acquiring clients, defining the interfaces between the satellites and the rocket, and taking care of the launch. But NASA's experience suggested that this was not enough: the body responsible for client relationships should also be the one responsible for launcher production. Industry could not play the latter role, since the launchers had to be ordered in batches to ensure production runs, and industry would not take such a risk on its own. What is more, government facilities and equipment were used, and States were necessarily involved because there were international legal obligations to be respected (like the 1967 Treaty on the Use of Outer Space). It was also sensible to combine responsibility for production with responsibility for use inside one single agency. By doing so one could smooth out production schedules by mutual adjustment with customer needs. One could also manage efficiently the configuration of the satellite in the launcher by overseeing the contract between the launcher industry and the client. Finally, for reasons of safety and insurance, it was "impossible" to decouple production from launch operation. In short, NASA's practices suggested that ESA should act as the "sole procurement Agency for operational launchers".[1448]

The American way of doing things was not the only, or even the most important argument for giving ESA a dominant role in the operational phase, however. The Executive stressed that in the European context neither industry, nor a national space agency like CNES, should assume responsibility for the Programme. Ariane was a European launcher financed by the participating States under the umbrella of ESA. ESA was therefore the only possible organ through which they could meaningfully exercise the control over the Programme which was theirs by right. It was imperative therefore that "the new Arrangement must not adopt the solution agreed on for the development phase of Ariane but, on the contrary, must make the operational phase of Ariane an activity of the Agency itself [...]".[1449]

On 1 April 1976 the Directors General of ESA and of CNES, Roy Gibson and Michel Bignier, had a first exchange of views on how to manage the Ariane Production Programme. CNES obviously preferred some scheme whereby the two agencies took joint responsibility for the Programme.[1450] This was immediately refused by Orye's internal working group. In addition to the political and legal arguments just mentioned, Orye also insisted that any such arrangement would require the establishment of a third, independent, higher-level decision making body to settle disputes between the two lead agencies. The clumsiness of such a scheme was apparent, he said, from the Aerosat Programme, then limping towards its final demise.[1451]

The working group emphasised again, then, that there should be "one centre of responsibility and of command" for the operational phase of Ariane, and that that centre should be ESA. Starting from this premise, and taking it for granted that CNES would have a significant but no longer dominant role in the Programme, a number of hybrid management schemes were suggested in mid-April 1976. Firstly,

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1447 See the report ESA/AR(76)02, CNES/DLA/AD/359, 14 May 1976 (ESA 4749).

1448 Memo by Orye, *US launcher production, contact with NASA,* 26 March 1976 (ESA 4917).

1449 See memo *Phase Opérationnelle Ariane; Rôle de l'Agence. Rapport Préliminaire du Groupe de travail interne,* 31 March 1976 (ESA 4820).

1450 Internal memo from Orye to the DG, *Phase opérationelle Ariane,* 15 April 1976 (ESA 4916).

1451 The programme has been described in chapter 8, this volume.

a linear scheme in which CNES's role was reduced to supplying functional support as and when needed to a programme totally under ESA's control. Secondly, a 'line and staff' system, in which there would be a division of tasks between ESA and CNES, with the European agency again assuming responsibility for, and control over, the whole. Finally, one could envisage a 'Meteosat' type arrangement, in which CNES personnel would be integrated into ESA teams, with the French agency providing additional functional support when needed from its Launcher Division.[1452] Whatever alternative was chosen, the ESA negotiators said, it must respect the principle that "The Director General could only delegate tasks, including those which were even only partially under his authority, to those over whom he had hierarchical authority within the Agency or, possibly, outside its walls, failing which the very fact that the Programme concerned is an Agency programme will be jeopardised".[1453]

By May a joint ESA/CNES working group (co-chaired by R. Orye for ESA and Y. Sillard for CNES) had begun to narrow down the options which might ultimately be acceptable to both agencies.[1454] Two schemes were rejected outright by one party or the other. Firstly, no one wanted an arrangement whereby the two bodies were co-responsible, on an equal footing, for the production programme. Secondly, the 'Meteosat' model, integrating ESA and CNES personnel under the authority of the European agency was refused by CNES on three grounds: that the launcher team responsible for the overlap between development and production should remain unchanged, failing which one ran serious technical and financial risks; that the technical and commercial success of the Programme would be enhanced by keeping the same project team intact as it had acquired "considerable technical and moral authority" over industry; and that if the CNES team were integrated into an ESA structure one would effectively abolish launcher activity inside the French space agency altogether. The ESA negotiators found none of these arguments convincing, of course, but realised that any acceptable scheme would have to leave CNES a large degree of control over the launcher. Two potentially workable schemes were presented to the Council in July 1976.[1455]

Both of these schemes respected the division of labour and of power in the original Arrangement. Both assumed that two quite distinct teams would be set up, with clearly defined and separate responsibilities. There would be an ESA team "responsible for commercial promotion of the launcher, relations with customers and potential users [...]" (our italics). And there would be a CNES team "responsible for the technical and financial management of industrial contracts [for producing launchers] and for launches" (our italics). These two teams together would form a Joint Programme Directorate. Hierarchical authority over these teams was allocated to the ESA Director General. However, in one case (we shall call it Scheme 1 – see Figure 11-1) both the head of the ESA group and the head of the CNES group were under his direct authority.[1456] In the other (Scheme 2, Figure 11-2) only the ESA team reported directly to him. The CNES team reported to the CNES Director General who was mandated by the ESA DG to manage the industrial contracts for production in accordance with the administrative rules of the French space agency. In the case of conflict, the two DGs would consult together, the ESA Director General having the right to decide the issue, and the CNES DG being able to contest his decision before the Ariane Programme Board.

How was one to choose between these two Schemes? The working group (following, it seems, the argument of CNES DG Bignier), suggested that it would depend on the level of financial involvement of the States participating in the Programme. Scheme 1 would probably be adopted if contributions

1452 For the Meteosat management scheme see chapter 7 this volume.

1453 From the *Document de travail n^{o} 2* of the internal working group, dated 14 April 1976 (ESA 4916). See also their first working paper, dated 12 April 1976 in the same file.

1454 *Rapport du Groupe de Travail sur l'Organisation ASE/CNES pour la Production d'Ariane*, 14 May 1976, ESA/AR(76)02, CNES/DLA/AD/359 (ESA 4749).

1455 ESA/C(76)R/12, 2 July 1976. All quotations in the following paragraph are from this document.

1456 During the overlap phase the head of the CNES group would still be answerable to the CNES DG with regard to development activities, *op. cit.* p. 15.

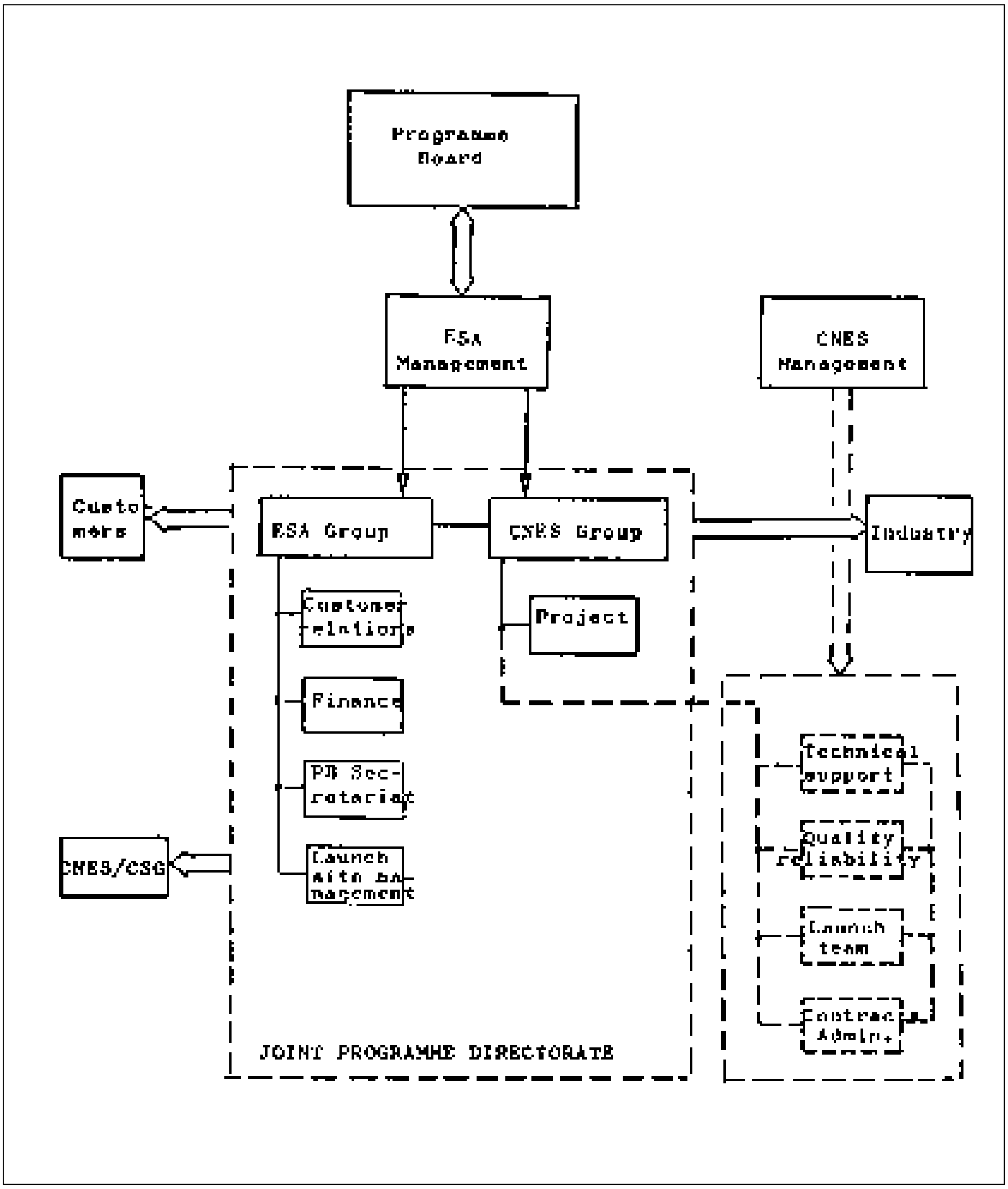

Figure 11-1: Scheme 1 - Joint Programme Directorate Under the Authority of the DG

were roughly proportional to GNP. Scheme 2 was the more likely one if France made a major contribution, as she had for the development phase.[1457]

At the beginning of July 1976 there were major changes at the level of senior management in CNES. President Maurice Lévy was replaced by Hubert Curien. Director-General Michel Bignier was replaced by Yves Sillard, and Frédéric d'Allest became responsible for launchers. This provided the ESA Director General with an opportunity to restate his position. Writing to CNES on 29 July Gibson suggested that one should decouple the management scheme from the question of financial contributions. The choice ultimately made, he went on to say, should respect three criteria: that CNES have a special place in any scheme, granted the particular and unique competence which it had in

[1457] See ESA/C(76)R/12, 2 July 1976, p. 17 as well as minutes of the 9th ESA Council meeting on 28-29 July 1976, ESA/C/MIN/9, 6 August 1976.

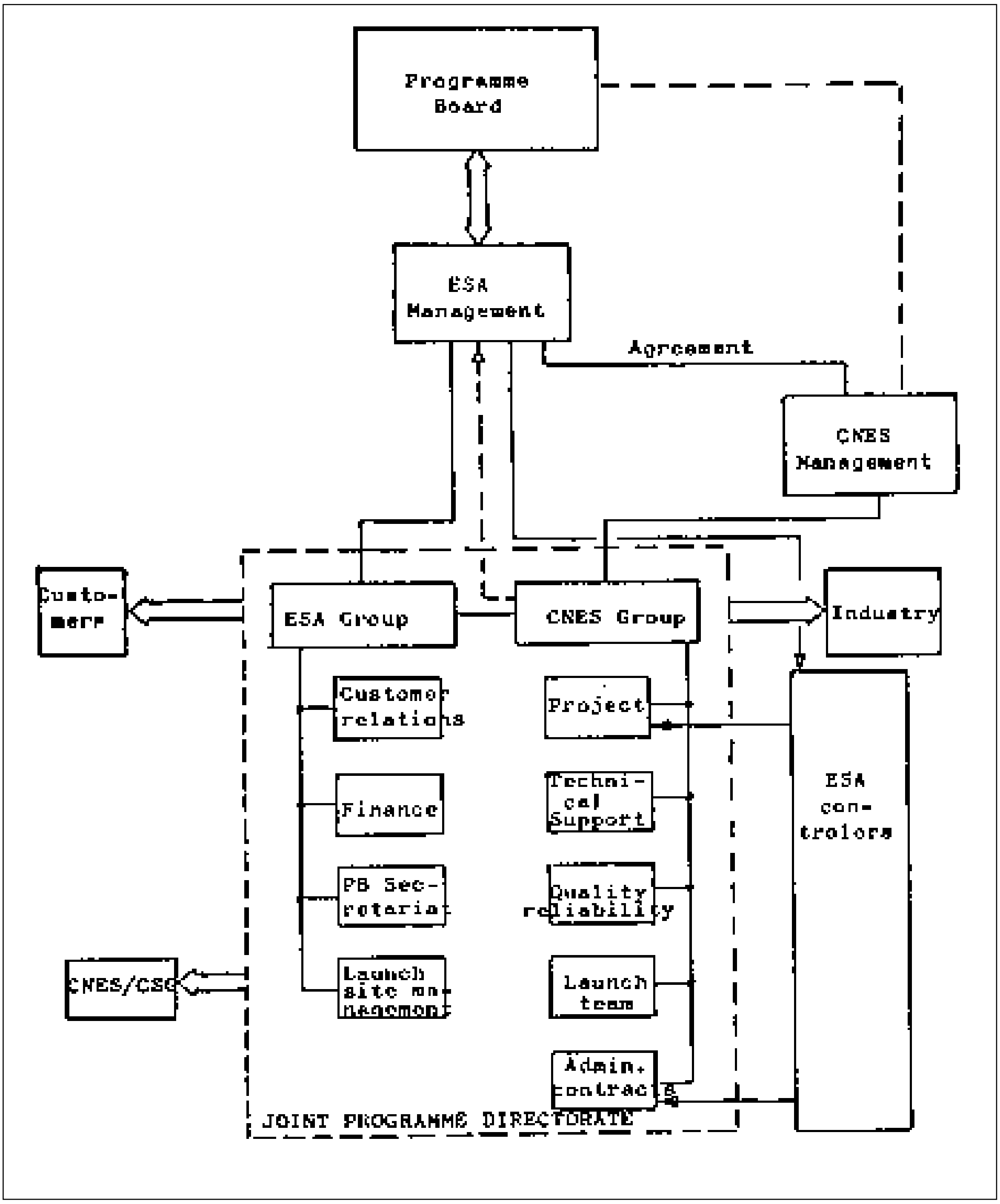

Figure 11-2: Scheme 2 - ESA Mandate to CNES and Joint Programme Directorate

Europe; that the relationship between CNES and ESA be based on genuine partnership and, finally; that the scheme adopted do nothing to undermine the efficiency of relationships with industry and clients.[1458]

The two teams, that from CNES now headed by d'Allest, met again immediately after the August break. The deadlock was total. CNES refused the arrangement whereby its launcher team reported directly to the ESA DG (even if in earlier negotiations under Sillard's leadership it had been more

[1458] Letter Gibson to the CNES President, 29 July 1976 (ESA 4916).

flexible on this point). Their negotiators simply rehearsed the arguments that they had previously used against the far more drastic (from their point of view) 'Meteosat' solution, i.e. that the scheme risked confusing lines of command *vis-à-vis* industry, that it did not properly respect the role of CNES's launcher division in the Programme, and that they wanted to tamper as little as possible with the existing structure during the production phase. ESA, for its part, was not prepared to accept an arrangement whereby the CNES team reported directly to its Director General (Scheme 2) on the grounds that it did not allow for the best possible integration of the production phase in the Agency's Programme. Scheme 1 did just this. It also avoided the risks of conflict inherent in the double hierarchy on which Scheme 2 was based. Since each Scheme was anchored in quite different contract systems – one deploying ESA's contracts procedures, the other deploying CNES's – the working group concluded that no middle ground was possible between the two variants, and there was no point in their continuing their deliberations. The matter was passed on to the Ariane Programme Board for discussion.[1459]

The issue was debated at length by the Programme Board meeting on 17 January 1977. The strongest argument in favour of Scheme 2 was that the firms involved in production would virtually have a "*de facto* monopoly" and "in the almost total absence of competition, it was hard to see how a modified team, answerable to two masters, could negotiate the most favourable industrial contracts possible and ensure the project's economic success". The major objection to Scheme 2 was that it left the way open for the CNES Director General to receive instructions from his national authorities which might conflict with those of the Programme Board – as had happened in 1974 when CNES was instructed by the new French government not to proceed with placing contracts for the development of Ariane. Germany, along with France, Sweden and the Netherlands, favoured this scheme, subject to there being assurances that the French national authorities did not again bypass ESA's decision-making structures. The delegates from Belgium, Italy, Spain and Switzerland, on the other hand, favoured Scheme 1, on the grounds that it located authority for the project clearly with ESA.[1460]

Towards the end of 1977 the ESA Council adopted what one might call a 'European' solution. The Agency would assume overall management for the manufacture of the launchers and for launch activities for the first slice of the production phase. It would also be responsible for relationships with users. However, ESA delegated to CNES the project management of launcher manufacture and launch operations up to and including physical separation of the payload. CNES would choose the industrial contractors bearing in mind the geographical distribution of work, and would now follow ESA's contractual procedures. Crucially, both teams, that from ESA and that from CNES were "jointly answerable to the Director General of ESA for the execution of their tasks". In the event of a conflict the team leaders could refer the matter to their respective DGs, who would consult together. ESA's Director General had the final say. The DG of CNES only had the right to appeal or, in fact to "report" to the Programme Board if the ESA DG agreed that he do so.[1461]

A year later the entire management scheme was changed again, essentially reverting back to the structure used for the development phase. Power shifted markedly back to CNES, though there were more constraints imposed on the French space agency than before. All of the arrangements just described in the first half of the previous paragraph remained intact, i.e. ESA would assume overall management of the manufacture of the launchers, delegating project management to CNES, which would apply ESA's contractual procedures. However, the idea of having a Joint Programme Directorate was abandoned. The ESA and CNES teams were each to be responsible to their own DG's after all, merely agreeing to hold "regular consultations" with each other. In the event of a conflict, the DG's of CNES and ESA would consult together. In a concession to the 'European' character of the

1459 *Conclusions de la réunion du groupe de travail ASE/CNES...du 2 septembre 1976*, 3 September 1976 (ESA 4916). See also ESA/PB-ARIANE(77)14, 5 January 1977.

1460 The minutes are ESA/PB-ARIANE/MIN/10, 22 February 1977. ESA/C(77)2, 21 January 1977 (ESA 250) reports on the deliberations of the Programme Board.

1461 From ESA/PB-ARIANE (78)31, rev. 3, 5 March 1978 and ESA/PB-ARIANE(77)14, rev. 3, Annex III, 22 November 1977. All quotations are from the latter document. For a draft project see letter Sillard to Gibson, 21 September 1977 (ESA 4820).

Programme it was accepted though that if they could not agree the ESA Director-General would decide the issue. Access to industry was once again controlled by CNES, just as in the development phase. ESA representatives could attend, as observers, the meetings organised by CNES with firms, notably progress meetings, and internal CNES meetings. They could also visit firms on their own account, but only "subject to informing CNES in advance", the visits themselves being "organised by the CNES project team". When all was said and done, then, very little changed in the day-to-day management of the first phase of the Ariane Production Programme, except perhaps that CNES had to apply ESA's contractual procedures.[1462]

11.4 Pricing policy: The producers hesitate to take the plunge

The definition of a charging policy for Ariane clients required that one bear in mind the price of equivalent American launchers. But what did an American launch cost for a client? This was difficult to fix for a number of reasons.

Firstly, as long as it had a monopoly, NASA never made fixed-price proposals for launchers. Its sales contracts stipulated that the buyer would pay the cost booked for the launch by the NASA accountants, with the possibility that the last billing could take place as much as three years after the launch. In practice this made it impossible to know what a launch cost until long after it was over. The initial price of COS-B, for example, launched by NASA in August 1975, had been $9.4 million. By December 1976 additional bills for $3.2 million (i.e. a 34% increase) had been paid by ESA, and the final price was still not known. Similarly, by December 1976 the cost of Meteosat, scheduled for launch the following summer, had already increased by over 40% from $ 10.6 million to $15.1 million.[1463]

To this fluid situation regarding expendable launchers were added the uncertainties over the cost of a Shuttle flight once the Space Transportation System was operational. Here NASA had let it be known that the selling price would be revisable in the light of the evolution of economic conditions. There would be a 'promotional' period of three years, after which prices would be set so as to recover the bulk of the expenditure over a twelve-year period. Faced with these uncertainties the ESA Executive suggested that NASA's prices for the Delta 3914 for payloads up to 450 kg would be about $18.5 million per launch. That for the Atlas/Centaur would be about $30 million for 900 kg payloads (both figures in current prices and to within 5 or 10%). It was almost impossible to make comparable estimates for the Shuttle, so the Executive remained faithful to the earliest known figures: about $10 million for 450 kg payloads, and about $20 million for 900 kg payloads.[1464]

The ESA Executive built up the price of producing the first six Ariane launchers for the promotional series as shown in Table 11-1. The global sum involved was just under 250 MAU, of which France was prepared to pay about 33 MAU from funds outside the ESA budget. The direct costs of manufacturing the six launchers amounted to 130 MAU. The Executive decided to set costs using a mission model which assumed that four of the first six launchers were bought by ESA and two by third parties, and which aimed to cover this sum. They suggested to the Council meeting at Ministerial level in February 1977 that the cost of an Ariane launch for ESA and ESA Member State missions be set at 24.5 MAU (about $25 million).[1465] This was around 125% of the assumed cost of the Delta 3914

1462 See draft proposal by Gibson to Sillard, 20 September 1978 (ESA4916) and the *Agreement between the Agency and CNES concerning the arrangements for the provision of Ariane launchers and launches,* ESA/PB-ARIANE(78)31, rev.3, 5 March 1979.

1463 This was apparently in response to a demand from the US Congress that NASA apply a true-price policy for launchers sold to foreign customers.

1464 This paragraph is based on ESA/PB-ARIANE(77)WP/1, 9 March 1977 (ESA 3451). For the cost increases imposed on ESRO/ESA satellites see Annexe II of the ESA/CNES report just cited and the Annex to ESA/PB-ARIANE(77)18, 5 April 1977.

1465 This was comprised of two elements: the direct costs of manufacture in industry (21.63 MAU) assuming two launches per year, plus the recurrent costs per launch (initially estimated at 2.65 MAU each, but later increased to 5 MAU – see Table 11-1).

Table 11-1. Itemised cost of the promotional series of six Arianes to be launched between 1981 and 1983[1466]

Item	Cost (MAU)
Start up costs, 1978-80*	3.5
ESA and CNES management costs, 1978-83	5 plus
CNES management costs borne by France outside ESA budget	9.70
Direct fabrication of 6 launchers	130
Recurring cost of launch operations	29
Cost of production & launch to be borne by ESA	**167**
In addition provision had to be made for:	
CSG expenditure	70.4
of which	
2/3 to be borne by ESA	47
1/3 to be borne by France outside ESA budget	23.4

Notes:

* To provide the facilities users needed at Kourou to check-out satellites once they arrived in French Guiana, and a sum to finance the development of the so-called SYLDA, or double-launch system enabling two satellites to be put in orbit with one rocket.

or the Shuttle for heavy payloads. For third-party clients the Executive proposed that the Agency charge 16.5 MAU, the same price as a Delta 3914 launch, and roughly the marginal cost of building an Ariane launcher (i.e. the basic infrastructure cost in industry required to keep the production line in being).[1467] Total income would thus be 4 x 24.5 = 98 MAU from ESA missions and 33 MAU from third parties, making 131 MAU. The shortfall of about 84 MAU was to be found by the participating States (see Table 11-1).

The promotion phase naturally had to be 'pre-financed' if it was going to get under way at all. The Executive proposed the following arrangements. ESA's share of the costs of start-up and management from 1978 to 1983 (see Table 11-1) would be borne *pro-rata* to the GNP of the participating States. The cost of the manufacture proper, by contrast, would be borne by the participating States *pro-rata* to their industrial return. As for the costs of financing CSG over and above the share assumed by France, the Executive proposed that they be regarded as a communal European asset, that they be charged to the General Budget and that all the Member States of the Agency contribute to them in proportion to their GNP.[1468]

1466 The table is from ESA/PB-ARIANE(77)18, add.1, 12 July 1977 (ESA 3295). This is the final version of the document as prepared after the Programme Board meeting in June. For, not very different, earlier versions see ESA/PB-ARIANE(77)18, 5 April 1977 (ESA 3295), and document ESA/PB-ARIANE(77)WP/1, 9 March 1977 (ESA 3451), which is a slightly modified version of ESA/C-M(77)13, rev. 1, 1 February 1977 (ESA 4518) and very close to the ESA/CNES report ESA/AR(77)02, CNES/DLA/DA/420, 7 March 1977 (ESA 4750). See also ESA/C(77)10, 21 January 1977 (ESA 258).

1467 Annex I in ESA/C-M(77)13, rev. 1, 1 January 1977 (ESA 4518).

1468 For this paragraph see ESA/C-M(77)13, rev. 1, and its Annex II, 1 February 1977 (ESA 4518).

The Executive hoped that the Ministers, meeting in February 1977, would pass a detailed resolution ratifying these proposals. They were to be disappointed – hardly surprising given the complexity and variety of the issues involved and the total lack of agreement inside the Programme Board as to how to solve them.[1469] The Ministers declared that they were not yet ready to take any firm positions on the production Programme, and invited the Council meeting at delegate level to take a final decision on the promotion series by June 1977.[1470]

It rapidly emerged that this would simply not be possible; the number of unresolved and interconnected issues involved was simply too great. As the Belgian Chairman of the Programme Board, J. Van Eesbeek, pointed out in May, the issues still to be settled included "sale price, production costs proper, start-up costs, time-schedule and duration of financial commitments, management costs, guarantees, and margin for technical contingencies" – to which the French delegation promptly added "the method of calculating industrial return, and the financial procedure (choice of exchange rates, possibly fixed ones)". The Board thus decided that it would be essential to circulate a questionnaire in which the participating States were asked to state their positions on these issues.[1471] In parallel, Van Eesbeek and ESA DG Gibson held meetings with national delegations to the Council. The results of these various initiatives were discussed at the 13th meeting of the Ariane Programme Board on 13 June 1977 where a consensus on at least some major points was reached.[1472]

Most delegations felt that the costs of the promotion phase should lump together the costs of the production and launch of Ariane (167 MAU), and derive the cost price per launcher from that figure. This gave a cost of 28 MAU for an Ariane launcher and launch, which was also roughly the price of the Atlas/Centaur rocket. This figure provided the reference point for the cost of launchers and launches to ESA and its Member States (see Table 11-2). It was realised that prices for third parties would have to be lower, and the Board agreed that their selling price should be decided on a case-by-case basis by the Council in the light of market conditions. In any event it was not to be below the marginal cost of production. At this meeting the participating States agreed to pre-finance the promotional series, and to bear the shortfall between manufacturing costs and sales proportionally to their industrial returns on fabrication.[1473]

Table 11-2. Ariane pricing scheme proposed by the Programme Board in summer 1977.

ESA or ESA Member State missions with Atlas/Centaur class payloads	28.5 MAU
ESA or ESA Member State missions with single, Delta-class payloads	22.5 MAU
ESA or ESA Member State missions with double, Delta-class payloads	14.5 MAU each
Payloads for third parties	case-by-case

1469 The difficulties were already apparent in the two preceding meetings of the Programme Board on 13 December 1976 and 17 January 1977, ESA/PB-ARIANE/MIN/9, 24 January 1977 and ESA/PB-ARIANE/MIN/10, 22 February 1977.

1470 ESA/C-M (February 1977) Dec. 2, 15 February 1977 (ESA 4523).

1471 See minutes of the meeting on 9 May, ESA/PB-ARIANE/MIN/12, 1 June 1977 for the quotations.

1472 Van Eesbeek's report after meeting with national delegations along with Gibson is ESA/C(77)42, 24 May 1977 (ESA 287). The questionnaire and the replies to it are documents ESA/PB-ARIANE(77)WP/2, 3 June 1977, and ESA/PB-ARIANE(77)WP/3, 21 June 1977. The summary of the results of this exercise and the debates in the Board at its 13th meeting are in van Eesbeek's report to Council, ESA/C(77)57, 28 June 1977. For a summary of some conclusions see ESA/PB-ARIANE(77)18, add. 1, 12 July 1977 (ESA 3295).

1473 Report by the chairman after the the 13th meeting of the Board, ESA/C(77)57, 28 June 1977 (ESA 301).

The subsequent discussion of these proposed prices in the Programme Board and the Council during the remainder of 1977 became bogged down in arguments of Byzantine complexity. The intentions of the delegates were laudable: they did not want to impose *a priori* a rigid price structure on the promotional series which would make it unattractive to 'clients'. At the same time to formalise flexibility turned out to be a nightmare. Take the question of aligning the prices of ESA Member State missions with those of ESA missions. This became particularly pertinent when in September 1977 the French government agreed to develop a national Earth observation satellite called SPOT which they were willing to launch with Ariane. Now the Programme Board realised that some flexibility would be needed in setting prices for ESA Member States, if only because those with little interest in the Ariane Programme might be tempted to purchase a cheaper American option. At the same time the delegates were unwilling to 'subsidise' a satellite like SPOT. It was thus suggested that, for Member State missions, the Programme Board could lay down a lower price than that of an ESA mission if it wanted. But it was proposed that this price would have to be accepted by a two-thirds majority, perhaps even a double two-thirds majority of the Board. And if it involved the participating States in additional expenditure that expenditure would have to be agreed to unanimously by them.[1474]

A similar question of price alignment arose over scientific and application satellites. This issue emerged somewhat out of the blue at a meeting of a Working Party set up in September to try to resolve the outstanding issues regarding the promotional series. There the British delegation suggested that no ESA scientific satellite should be charged more than 125% of the price of an equivalent American launcher, the famous Bad Godesberg formula of 1968.[1475] This was really only a matter of principle since, as the Programme Board pointed out, the only scientific satellite foreseen for the promotional series was Exosat, and special arrangements were being made for that. The British persisted, however, and in December the Council unanimously adopted a resolution to the effect that for the ESA Science Programme the price of an Ariane launch to be charged to "the Scientific Programme budget as presently defined shall not be more than 25% above that of the cheapest suitable and available non-ESA launch [...]".[1476]

While the Council meeting in December adopted a number of general principles it should be stressed that it did not adopt any texts defining the voting majorities required to settle the final prices of launchers, nor those specifying the procedures to adopt for making up shortfalls. Indeed, notwithstanding a number of declarations of principle, the Council did not actually authorise the start of the promotion series. This was because, even as the Programme Board and its Working Party were grappling with the legal niceties of the matter, some delegations, notably that of Germany, were beginning to rethink the whole concept of the promotion series. In a nutshell their new idea was that, instead of seeing the first batch of post-qualification launchers as needing to be funded by the Ariane Programme, it would be preferable to treat them from the start as launchers to be funded by the satellite programmes which bought them. Thus, rather than committing oneself to a promotional activity and adopting pricing policies and voting procedures intended to seduce clients, Germany (and the Netherlands) now refused to embark on a manufacturing phase *until the clients had been acquired* and the prices agreed with them.[1477]

Before we embark on this next phase of our analysis, and in the interest of bringing home the complexity of the issue, we want to describe two other debates that preoccupied the Board and the Council during the last six months of 1977. The first concerned the perverse effects which the use of Ariane could have on the industrial return which a Member State, specifically France, derived from

1474 For the evolution of this issue see ESA/PB-ARIANE(77)WP/5, 19 October 1977, (ESA 3455), and ESA/PB-ARIANE(77)14, rev.4 (undated). The issue is discussed at ESA/PB-ARIANE/MIN/15, held on 7 November 1977 (document dated 8 December 1977).

1475 ESA/PB-ARIANE(77)41, 7 December 1977, the report on the Working Party's deliberations. See also the UK's intervention at the Council on 21-22 November 1977.

1476 The resolutions on Exosat and on the 125% rule are ESA/C/XXII/Res. 7, 13 December 1977, and ESA/C/XXII/Res. 10, both attached to ESA/SPC(77)38, 15 December 1977 (ESA 2408).

1477 For the German and Netherlands' statements see ESA/PB-ARIANE/MIN/16, meeting on 9 December 1977, document dated 28 December 1977.

the space segment of an ESA programme.[1478] Before Europe had Ariane, all launch costs for ESA satellites were incurred in the USA, i.e. outside the Member States. They were thus not included in the calculation of industrial returns on the satellite programme in question. If however the industrial return associated with the manufacture of the launcher was now to be included in the calculation of returns on the satellite programme France, in particular, would find its industrial returns on the manufacture of the satellite heavily reduced. The argument may be illustrated as follows. Assume that there were 120 MAU of "noble" contracts in a particular satellite, and an additional 20 MAU's worth of work of technological interest in Ariane. Assume that France contributed 20% to the programme, and sought a return coefficient of unity on it, i.e. sought to get contracts worth 20% of 140 MAU = 28 MAU on the programme as a whole. However if it got a return coefficient of unity on the manufacture of the launcher, to which it contributed about 70%, it would already be awarded 14 MAU of *noble* contracts for just that part of the programme. That left France to get only a further 14 MAU's worth of *noble* contracts on the satellite. In other words, just because Europe now used Ariane, and France paid the bulk of the cost for it, its return from a satellite programme worth 120 MAU would be reduced to 14 MAU, and its return coefficient *on that part of the programme* would be 0.6.[1479] With its share in the space segment thus diminished, France might be particularly hostile to the mandatory Science Programme, where contributions were proportional to GNP. It would also be inclined to reduce sharply its contributions to optional programmes where its rate of participation would normally be assessed in the light of the return coefficients it could expect.

To get around this problem the Executive proposed that weighting factors be applied to the industrial returns emanating from participation in the manufacture of Ariane. Opinions were divided over just what that weighting factor should be, however.[1480] The final agreement reached was that the industrial return on the satellite should be calculated independently of the return on the launcher (or, as the legal text put it, “in the calculation of industrial return on the Agency’s programmes, the industrial return on the promotion series shall not be taken into account and its value shall be entered into the accounts separately”).[1481]

Financing the Kourou base proved to be a far more contentious issue. France, it will be remembered, was prepared to pay one-third of the ~70 MAU required for this from non-ESA funds; the remaining two-thirds were to be found by the Member States including France (see Table 11-1). And while no one objected to the principle there were ongoing negotiations on the level of contributions. France felt that, as a matter of principle, States should contribute proportionally to their GNP. Only Belgium agreed. Some countries, like Germany and Switzerland, wanted to make a fixed contribution. Others, like Denmark, Sweden, Italy, the Netherlands and the UK, wanted to pay according to their industrial return. Others again, like Spain, preferred a mixed GNP – industrial return formula.[1482] A deal was struck at the Council meeting in December. As we have just said there it was resolved that "in the calculation on the Agency's programmes, the industrial return on the promotion series shall not be taken into account [...]".[1483] With this concession made in its favour France now dropped its demand

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1478 ESA/PB-ARIANE(77)15, 19 April 1977.

1479 This argument is not presented as such by the Executive. We have inferred it from a study of Tables 3 and 4 of ESA/PB-ARIANE(77)15, 19 April 1977.

1480 The Executive's initial idea was that this factor should lie between 0.25 and 0.5. Debating the issue in June 1977 five delegations, including of course France, were happy to have launch expenditure completely neutralised (i.e. a weighting factor of zero) in calculating industrial returns on Agency programme's using Ariane. Others countries were less generous (Sweden favoured a factor 0.25, Italy 0.5) or undecided (Denmark and Spain) - see ESA/PB-ARIANE/MIN/13, meeting of 13 June 1977, document of 7 July 1977 (ESA 3216), then ESA/PB-ARIANE/MIN/16, the meeting held on 9 December 1977, document dated 28 December 1977, and the report on this meeting, ESA/C(77)125, 12 December 1977 (ESA 367).

1481 ESA/C/XXII/Res. 11, Article V, attached to ESA/PB-ARIANE(77)44, 28 December 1977.

1482 See notably ESA/PB-ARIANE/MIN/16, the meeting held on 9 December 1977, document dated 28 December 1977, and the report on this meeting, ESA/C(77)125, 12 December 1977 (ESA 367). See also ESA/PB-ARIANE(77)18, add. 2, rev. 1, 22 December 1977.

1483 ESA/C/XXII/Res. 11, Article V, attached to ESA/PB-ARIANE(77)44, 28 December 1977.

that the costs of the CSG to be borne by ESA had to be shared solely on the basis of GNP. However, the issue remained so difficult to resolve that the Council decided to postpone again the vote on the financing of the launch base.[1484]

11.5 Pricing policy: Shifting the burden of production to the users

As we mentioned earlier, even while the States participating in the Ariane Programme were trying to define a pricing policy and woo clients, an entirely different way of thinking about the move from development to production began to be put in place. It amounted to turning on its head the approach initially taken. In the promotional series the participating States were being asked to pre-finance the manufacture of six launchers. The Ariane Programme Board laid down guidelines for the price and it was up to the Executive to find clients. Once the launchers had been sold the initial investment would be recovered, at least in part, from the client. This had the enormous disadvantage that the participating States were committing themselves to produce six launchers without any firm guarantee that they would be sold. The kind of difficulties we have just described are indicative of the unpleasant consequences that this had: what should ideally have been a predominantly commercial matter became highly politicised, creating tensions and resentment inside the European space community, which could only harm it. Hence the new idea: let us embark on the production programme only with the clients already assured, tailoring supply to demand. Put differently, let us look the production programme 'from the point of view of the user' – and have the client, rather than the 'producers' finance the manufacture and the launch of *its own* Ariane. The only additional money that the Ariane Programme Board had to find would thus be the difference between real cost and the price to the user, and that for a market guaranteed in advance.

It was the German delegation, and indirectly that from The Netherlands, which first floated this new approach at the end of 1977. At the meeting of the Programme Board on 9 December 1977 the German delegation announced that its government had not yet decided on its participation in the Ariane Production Programme, but that they were "scrutinising the possibility of participation within the framework of the user programmes we are supporting". The Netherlands delegate independently and indirectly also supported a different approach to the production question. He stated that the work that his country received from the Ariane Programme "was not of high technological interest" and that its ongoing involvement was motivated by the country's "interest in European co-operation". That granted, the Dutch felt that they could only join in the promotional phase if "a firm destination for the each of the six launchers" was known. "It could not take the risk", the delegate said, "of a considerable increase in the deficit which would occur if some of the launchers remained unsold".[1485]

By spring 1978, Gibson, in consultation with the German and French Delegations, had put flesh on this idea.[1486] In March he proposed to the Ariane Programme Board that five (not six, as originally foreseen) launchers be produced. Four of these were now pre-assigned to clients: ESA programmes Exosat, ECS-1 and Marots-B and the French SPOT satellite for Earth observation. The fifth would be a back-up launcher to be accorded to one of the four programmes if needed. If not, it would be sold to another user.

The suggested prices of the launchers were those agreed by the Council a few months before: 24.44 MAU for ECS and Marots, 30.95 MAU for SPOT and the specially agreed price of 22.37 MAU for Exosat. These launch prices, plus a 10% contingency margin, would be paid by the user programmes in the same way as were the satellites in question, i.e. *pro-rata* to the scale of contributions by the States participating in such programmes. This meant of course that France would bear the full cost of SPOT. The estimated actual cost price of a launch was now 35.873 MAU, this

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1484 The minutes are ESA/C/MIN/22, document dated 4 January 1978.

1485 ESA/PB-ARIANE/MIN/16, meeting on 9 December 1977, document dated 28 December 1977.

1486 The first version of Gibson's proposal is ESA/C(78)24, 22 March 1978.

being the (slightly increased) cost of manufacture of each of the five launchers (rather than the previous six) plus a 10% contingency margin.[1487]

How would the shortfall, which fell in the range of 23 MAU to 32 MAU, be covered? Gibson suggested that the difference could also be called up under the relevant user programme, and reimbursed to it by States participating in the Ariane Production Programme proportional to their industrial return in fabrication.

How would the back-up launcher be paid for? Here the DG proposed that the cost of its manufacture be divided equally between the four user programmes. This financial burden, he said, could be shared within each according to the rates of participation in that programme. If it was used for one of them that client would reimburse the others. If it was sold to another user, all would be reimbursed accordingly.

This scheme was discussed in the Ariane Programme Board in March and at Council twice in April 1978.[1488] There was general agreement with the change of approach, with the increase in the cost price per launcher, and with the funding mechanisms for the three ESA programme satellites. Sharp differences of opinion arose, however, over how to fund the shortfall for the SPOT satellite, and how to pre-finance the back-up launcher. Germany simply refused to pay anything for the former: "Germany was not obliged to contribute to the funding of a launcher for a programme that was not an Agency one, and the Member State concerned must bear all the relevant costs", said her delegate. (At the same time Germany was quite willing to subsidise the difference between the actual cost and the price of 18 MAU offered to launch an Intelsat satellite – "the case of a customer that was a non-Member State or an outside body must be dealt with apart", said the German delegate). To get around this difficulty it was agreed that the price of all Atlas/Centaur class satellites, including SPOT, which had been set by the Council in December at 30.95 MAU, now be increased to 32.612 MAU plus a 10% contingency margin (= 35.873 MAU). This amounted to saying that France would pay in full the actual cost of production of the launcher for its SPOT satellite.

Prefinancing the back-up launcher proved even more contentious. As the UK pointed out, if it was to pre-finance one quarter of the costs of the supplementary launcher proportionally to its contribution to the Marots Programme, it would pay 70% of that quarter (in fact about 5.7 MAU). Other delegations sympathised. After discussing several approaches a majority of the delegates seemed to be prepared to pay for the cost of the back-up launcher proportional to their industrial return in the promotion series. But it was again Germany and The Netherlands, now backed by Spain, that opposed this approach. If one was looking at the manufacture of launchers from a client's point of view, they said, coherence demanded that the client pre-finance a back-up launcher only if it was to be used for a programme in which he was involved. This meant that they were only prepared to finance the 'three-quarters' of the launcher that was destined for the ESA programmes. The one-quarter destined for SPOT, they said, would have to be paid for fully by France – a position which the French delegation saw as "totally unjustified".

At its meeting early in April the Council was not quite able to resolve this problem. Pragmatic considerations showed a way out of the deadlock, however. As the French delegation to the meeting pointed out, since the launch of SPOT would probably not take place until the end of 1983 anyway, whereas the ESA missions were all scheduled for 1981, it was most unlikely that the reserve launcher would be used for her national project. France therefore proposed that the prefinancing of the back-up launcher be charged entirely to the three ESA programmes *pro-rata* to industrial return. This proposal was ratified by the Council meeting at the end of April 1978. There, in a long and complex resolution,

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[1487] A further 11.73 MAU was needed for Exosat's fourth stage.

[1488] The minutes of the Programme Board held on 22 March are ESA/PB-ARIANE/MIN/17, document dated 7 April 1978. The proceedings are summarised in the chairman's report to Council, ESA/C(78)32, 4 April 1978 (ESA 403). Gibson's revised proposal prepared for the Council in the light of the Board's debates is ESA/C(78)24, rev. 1, 3 April 1978. The Council meetings on 6-7 April 1978 and 25-26 April 1978 are ESA/C/MIN/23(II), 20 April 1978 and ESA/C/MIN/24, 18 May 1978.

it was agreed that the Member States manufacturing the five launchers would assume the cost of the back-up launcher, up to a maximum of 35.873 MAU, in proportion to their industrial return on the manufacture of the five launchers. The same principles would apply to funding the shortfall between the agreed prices of the three ESA launchers and the manufacturing cost of those launchers, again up to a maximum of 35.873 MAU per launch.[1489]

A third controversial issue surfaced at this meeting at the end of April: the question of whether one should make provision for building more than the five launchers now foreseen.[1490] The draft resolution prepared for the Council had a clause stipulating that if users requested additional launchers to be supplied before the end of 1983, these would be included in the promotional series on terms to be agreed by the Member States. Several delegations, however, could not accept this idea. After all, they argued, the guiding principle now was that a commitment would only be made to build launchers for which there were guaranteed clients. If there was to be a clause suggesting that the production of additional launchers could be undertaken, both Italy and Germany were emphatic that a unanimous decision would be required for it. Frustrated, the Director General and the Council Chairman (W. Finke, from Germany), supported by the Swiss delegate, implored their colleagues not to discredit their own efforts in the eyes of outside users. It was "vital for the participants in the Programme", said the latter, "to demonstrate *vis-à-vis* their future customers their will to promote the European launcher". In the event the Council made only a lukewarm gesture in this direction. It did not exclude, in Article XIII of its Resolution, the possibility of building additional launchers before the end of 1983 "on terms agreed by Member States". However, it also stipulated that in adopting this clause no participant was now committing itself financially to such a step.

Even then the struggle to get the manufacture of five additional launchers under way was not yet over. The main Council resolution had two annexes attached to it, one dealing with the technical conditions of the Production Programme, including the scheduled launch dates, the other dealing with the payment schedules.[1491] The delay occurred because the ESA Boards dealing with Exosat and with ECS and Marots were being asked to commit themselves three years in advance to a launch window three months wide (e.g. second quarter of 1981), and had to accept that if this was changed the culpable user programme would pay "any unavoidable resulting increase in the cost of the launcher and the launching" (Art. IX(b)). Of course some delegates insisted that it was totally unrealistic to expect users to make such commitments so far in advance. The drawing up of the annual payment schedule necessary to pre-finance the programme required that they did so, however. After two more months of deliberations the entire resolution with its annexes committing the participants to fabricating five launchers to meet launch dates in 1981 (for the three ESA programmes) and for SPOT (in 1983) was finally adopted.[1492]

The long and tortuous path we have just described had a salutary effect on some of those involved in the Ariane Programme. It showed above all the extraordinary difficulty which governments, at the end of the 1970s, had in committing themselves to producing a European launcher. The political need had been satisfied. Financial concerns, and the fear that the Shuttle would capture much of Ariane's potential market, dominated the horizons of their thinking.

1489 ESA/C/XXIV/Res. 3 (final), Art. VI, 26 April 1978, attached to minutes of the meeting held on 25-26 April 1978, ESA/C/MIN/24, dated 18 May 1978. The draft version discussed at the meeting is attached to ESA/C(78)45, 19 April 1978 (ESA416).

1490 The minutes are ESA/C/MIN/24, dated 18 May 1978. The draft resolution was ESA/C(78)45, 19 April 1978. The final resolution adopted by the Council with the Article XIII cited later in this paragraph is attached to its minutes. It was circulated later as ESA/C(78)8, 3 May 1978.

1491 This document is the one just cited, i.e. ESA/C(78)8, 3 May 1978. For the debate on the Annexes see e.g. ESA/PB-ARIANE/MIN/18, meeting held on 18 May 1978, document dated 13 June 1978, and the next meeting on 14/6, ESA/PB-ARIANE/MIN/19, dated 7/78. The Programme Board chairman's report to Council after these two meetings is ESA/C(78)74, 20 June 1978 (ESA 442).

1492 The document is ESA/PB-ARIANE(78)21, 6 July 1978.

Their original plans for the promotional series had been shaped by the idea that one should produce a small batch of launchers consistent with industrial efficiency; the ESA Ariane team would go out and procure clients for them. The financial risks of this approach soon turned out to be too great, however. In the United States the huge military and civilian space sectors, and the domination by US industry of the world market for launcher, meant that firms could commit themselves to long production runs without hesitation and could benefit from economies of scale. In Europe the situation was quite different. The military sector was relatively small and anyway not accessible to Ariane, by virtue of ESA's commitment to engage in space activities for "peaceful purposes". What is more, the guaranteed market for Ariane was not only very small; some clients, even European clients, notably the scientists, were also very cautious. France apart, therefore, most governments were thus extremely loath to embark on an ambitious production programme without having any firm idea of what the future demand for the product would be.

To these general considerations must be added more specific features about the bureaucratic functioning of the space sector in Europe. It cannot be denied that there had been a seemingly unending round of negotiations over relatively small amounts of money, with countries defining the situation as they saw it in the narrowest terms of national interest. Decisions could be held up for months because of disputes over what scale of contributions to invoke, each delegate backing the system that was cheapest to him. All the same, much of this was little more than classical political bargaining. At the end of the day the deadline for a decision on the start of a production phase was respected. In 1975 the Executive, in consultation with industry of course, said that funds had to be committed by mid-1978 if production lines were to be kept running. And sure enough, by spring 1978 positions which had previously seemed impossible to delegates were now acceptable.

Behind these debates was an issue touching on the role of the Agency itself. This was that of the relationship between ESA as an organisation for funnelling government R & D funds into industry, and ESA as having a role in facilitating and promoting the use of 'its' products. We have already seen how the concept of the role which the Agency should play had weighed on the minds of the German delegates when the question of starting a production phase arose: they insisted that it be called a promotional phase and that its scope be carefully delimited. They did this specifically because they felt that it was not ESA's role to run 'operational' programmes. That concern in turn was not inspired by purely political or ideological considerations. It reflected the internal structure of the state apparatus, a structure in which funds intended for R and D were carefully distinguished institutionally from funds intended for operational activities. Different government departments with different budgets and missions were involved. The debate over the move to the production of Ariane resembles in this respect the debate over the start of an operational meteorological programme. It took five years for the meteorological services to embark on the latter, five years during which ESA's Meteosat Programme Board anguished over funding successive models of a satellite which, they insisted, should be paid for by the users and their associated government departments, not by R and D funds.[1493] This was essentially a matter of principle not of cash.

It is far too simple then to see what we have just described as reflecting 'bureaucratic inertia' or as 'the defence of narrow national interest'. Rather it was a consequence of the organisation of the modern state into distinct government departments each having different responsibilities and agendas, complicated by the fact that here some dozen governments were involved. Seen from that point of view one can say that the process worked relatively smoothly and quickly; driven as it was by the determination to find a compromise!

However, it was clear to all that for an activity that was so expensive, so important politically, ideologically and industrially for Europe, and which cut across so many different government departments, a totally different kind of structure was needed, a structure relatively free from the internal logic of the state apparatus. This where the story of Arianespace begins...

[1493] This is explored in detail in chapter 7 this volume.

Table 11-3. Evolution of weight of votes in Intelsat in the course of 1977[1494]

Member States	Before 1 March 1977	After 1 March 1977
United States	30.87%	24.51%
ESA Member States	28.66%	29.96%
Other European States	0.74%	1.00%

11.6 The establishment of Arianespace

11.6.1 The first initiatives and the setting up of a private European launcher company

In 1977 there were high hopes in the Agency that, with the US losing its dominant position in the Intelsat Board of Governors in March 1977 (See Table 11-3), Ariane would be chosen for one or moreof the Intelsat V satellites. Four of the series were scheduled to be launched between August 1979 and July 1980 using NASA's Atlas/Centaur. A fifth launcher was on standby and the sixth and seventh of the package were foreseen for summer 1982. NASA had already proposed, via Comsat, to launch these with the Shuttle. However, since the launch window corresponded with the availability of the Ariane promotion series, it was clear that for the first time a viable European alternative would be available.

On 3 February 1977 the Ariane Programme was presented to the Intelsat Board of Governors, who were favourably impressed. A feasibility study was carried out by Comsat in consultation with an ESA/CNES team. It was concluded that Ariane could launch units six and seven if its performance was increased from 1670 kg to 1710 kg in transfer orbit, which was easily done. As for cost, ESA DG Gibson had proposed a tentative price of $25 million, which seemed to be roughly what Intelsat would have paid for an Atlas/Centaur launch. Indeed the only question mark over the use of Ariane was its reliability. "However", Comsat reported, "ESA has emphasised the low risk of the proposed approach and has undertaken to guarantee that customers will have full program visibility."[1495]

In December 1978 it was announced that the Intelsat Board of Governors had decided to launch an Intelsat V satellite with Ariane. It had been sold at $21.35 million, this being the marginal cost of fabrication of the launcher plus launch costs, and was scheduled for launch in 1981. Intelsat's choice was thanks both to the hard promotional work done by the ESA Executive and to the efforts of the European Governors in the Board who had used their new voting weight to impose the European option.

It is hard to overestimate the boost this gave to the Ariane project. The signal had been given that Europe, notwithstanding the threat of the Shuttle, was now perceived as having a viable, alternative launch service which was going to be competitive on the international launcher market. Indeed early in 1979 it was becoming clear that the demand for Ariane in the period 1981-83 covered by the 'promotional' series was likely to outstrip the supply of five launchers finally agreed only six months before. A minimalist mission model called for four more launchers. A maximalist model foresaw the need for fabricating as many as seven additional launchers.[1496]

This issue was discussed at meetings of the Ariane Programme Board in March and April 1979.[1497] Two striking features emerged. First, that "a large majority of delegations had [...] insisted on the necessity of an early decision for the second series of Ariane launchers, the volume of which remains

1494 From ESA/C(77)R/2, 14 February 1977.

1495 For the above see ESA/C(77)R/2, 14 February 1977, ESA/PB-ARIANE(76)15, 1 July 1976 and ESA/C(76)62 and Annex, 24 June 1976, from which the final quotation is taken.

1496 ESA/PB-ARIANE(79)13, 5 March 1979 gives the mission models.

1497 The Executive's proposals prepared for these meetings are documents ESA/PB-ARIANE(79)13, 5 March 1979, ESA/PB-ARIANE(79)19, 10 April 1979. See also ESA/C(79)43, 28 March 1979 (ESA 568).

to be clarified", to quote the new Swiss Chairman of the Board, Peter Creola.[1498] Second, that France was not counted among that majority. The French delegation was all in favour of authorising the fabrication of the Intelsat V launcher as soon as possible, so increasing the number of launchers in the promotional series from five to six.[1499] But further than that it was not prepared to go. Why not?: "in view of the approaches made by its authorities to the other participants with a view to setting up a new structure for producing the launcher", said the French Delegate.[1500]

In fact in January 1979, the month after the Intelsat decision, CNES passed to the ESA DG a report entitled "Création d'une structure industrielle de production et de commercialisation des lancements par le lanceur Ariane".[1501] In February, and again in April, the DG passed on a number of comments to delegations about this proposal.[1502] On 23 May and on 15 June a working group comprising R. Orye and M. Bourély (the latter from ESA's legal affairs department) and a CNES team led by M. Lefèvre tried, in vain, to reach agreement on the modalities of this new structure. On 12 June a group of firms interested in producing Ariane signed a protocol at the air show in Le Bourget just outside Paris indicating that they intended to participate in this venture. And in a letter to the ESA DG dated 10 July 1979 the head of the French delegation to ESA, Hubert Curien, officially described the new industrial structure which his government had in mind for the production of Ariane launchers.[1503]

The French began by pointing out the "factual impossibility" of reaching agreement in the ESA framework on the production phase of Ariane. Manufacture had been restricted to a limited promotional series financed by way of satellite programmes. This approach ran counter to "sound industrial and commercial" practices. As an alternative Curien suggested that the Agency confide the manufacturing, marketing and launches of Ariane to a private company to be established under French law, and temporarily named Transpace. This engagement would be made for a renewable period of ten years, and would start with the production of the L11 launcher.

Transpace would comprise CNES and the firms which had taken part in the production phase of Ariane; indeed 32 of the 35 firms consulted, representing almost 93% of its capital had already joined it. The company would be characterised by "rapid decision-making processes, essential for a competitive market". Its partners would participate in the risks of operational production and would engage in financial and commercial operations (pre-financing, customer credit, marketing etc) which would be "flexible and efficient". It would not seek direct government subsidies, but function on the basis of sales to its customers. Transpace would do its best to respect the distribution of industrial work established during the development phase. It would also set up mechanisms to ensure that its clients respected ESA's commitments to the peaceful use of outer space. It would normally give priority to ESA and then to its Member States in the provision of launchers and launch slots. As for price, all sales to ESA and the participating States concluded prior to 1984, i.e. for all launches scheduled up to 1986, would be (roughly) at the prices already agreed by Council. These might be changed subsequently, but not exceeded. The price of Ariane to third parties (i.e. clients other than ESA or its Member States) would be entirely at the discretion of Transpace.

1498 From the 25th meeting on 8-9 March 1979, ESA/PB-ARIANE/MIN/25, 10 April 1979.

1499 The French proposal is ESA/PB-ARIANE(79)17, 8 March 1979. The Council authorised this step at its 30th meeting on 3-4 April, 1979, ESA/C/XXX/Res. 7.

1500 At the meeting of the Board on 23 April 1979, ESA/PB-ARIANE/MIN/26, 1 June 1979 at which France was alone in voting against the Executive's proposal to proceed immediately to the acquisition of further launchers (most delegations abstained). The Executive's report on the meeting is ESA/C(79)62, 30 April 1979 (ESA 587).

1501 The following information is derived from ESA/C(79)104, Annex, 16 July 1979 (ESA 623), and two internal memos from Bourély to Gibson, both headed *Transpace* and dated 22 June 1979 and 27 June 1979 (ESA 4917). See also the fax from the (HAEUI) ESA Washington Office dated 28 March 1979 with text "AR/40/RO/WW" (ESA 4916).

1502 His letter of 12 February 1979 is document ESA/PB-ARIANE(79)14, 2 March 1979.

1503 ESA/C(79)93, 10 July 1979 (ESA 616). The following three paragraphs are based entirely on this document and its Annexes.

For its sound functioning Transpace required certain commitments from the participating States in their turn. Firstly, it needed them to undertake to use the launcher for ESA and national programmes for which it was suited "with regard to quality and price". The participants were also invited to make available to the new company, free of charge, the facilities and equipment acquired within the framework of the Ariane development and promotional phases both by ESA and by national authorities, along with the intellectual property rights deriving from these earlier phases. Finally, the participants were asked to pay for the operating and maintenance costs of the Guiana Space Centre in Kourou. In return Transpace would pay a fee for the use of the CSG on the basis of a sliding scale which increased from 1% of the sale price of a launcher for the first 15 launches up to 6% of the price from the 31st launch onwards.

The French proposal was discussed extensively by ESA DG Gibson in consultation with the Member States representatives, and by the Council meeting in July, in September and in October 1979. The overall idea was well received; indeed when it first discussed the suggestion in July the Council quickly passed a resolution stating that Ariane "production should be entrusted to an industrial structure".[1504]

The first major concern was the scope of the involvement of Transpace in launch activities. As Gibson put it – and he was supported in this by the Belgian and Swiss delegations, for example – the idea of making industry responsible for the *manufacture* and the *marketing* of the launcher was "wholly laudable". But he had "serious doubts" about whether "virtually complete responsibility for *launching*" (our italics) should be given to an industrial firm. "Hitherto, and in every country in the world, launches have been carried out either by the government itself (USSR) or by a public entity (NASA, CNES or NASDA)", Gibson stressed, so that "political responsibility for the launch was accepted at government level". This was not only because governments were politically, legally and financially responsible for launches from their territories in terms of the Outer Space Treaty of 1967 and its instruments. It was also because they usually assumed the risks of damage to third parties associated with launches. In this regard Gibson noted that Transpace intended to take out civil liability insurance up to a maximum of FF 400 million, which was just about one-third of the insurance cover provided by NASA ($300 million).[1505]

A second major concern was the dominant role which French firms and institutions had in the company: almost 60% of the capital was French. This heavy French presence inevitably entailed the risk of a "break-up of the European solidarity" whereby France's partners might no longer feel themselves directly responsible for the production programme. As the Swiss delegation explained, the dominance of one Member State might mean that "in the long run, Ariane would lose its European character, an event that would be regrettable from a marketing aspect and at the same time have an adverse effect on Europe's space image". Gibson took the argument a step further. Referring indirectly to Germany, we assume, the DG remarked that the new scheme should not be such as to provide "an alibi to those ESA Member States who subscribed to the Ariane Arrangement more for reasons of political solidarity than real conviction in the European launcher". Whether one liked it or not, governmental support for Ariane was going to be needed for some years to come, and nothing should be done to alienate those who had contributed something like 300 MAU to the development of the rocket.

With French shareholders preponderant, there was also the risk that ESA and its Member States would lose control over decisions inside Transpace which affected them directly. For example ESA and its Member States would depend for the availability of launchers on decisions "in which the shareholders subject to the French Government's authority will be able to impose their viewpoints through CNES, a French public body, and certain firms subject to government control". Admittedly the French had

1504 ESA/C/XXXIII/Res. 3, 26 July 1979, taken at Council meeting of 25-26 July 1979.

1505 His reactions are in ESA/PB-ARIANE(79)14, 2 March 1979, and the view he put forward after extensive consultations with delegations is ESA/C(79)104, 16 July 1979 (ESA 623). The Swiss and Belgian delegations made their statements at the 33rd Council meeting on 25-6 July 1979, ESA/C/MIN/33, 20 September 1979.

proposed that ESA's DG be appointed to the post of "censor" on the Board of Directors of Transpace. But, Gibson insisted this did not give the Agency "power to intervene in the decisions taken by the President and Managing Director or the Board of Directors"; it could only exercise its monitoring role "retrospectively".[1506]

There were also fears about committing the valuable asset that was Ariane to a company whose financial future was far from certain. Gibson remarked that its very small capital (FF 150 million) and expected receipts from launches led one to wonder whether the firm would be able to achieve "financial equilibrium let alone profitability". And "if the Company failed in its sales policy", the Swiss delegate to the Council asked in July, "what solution would still be open to Member States to save the launcher, and what measures, in particular financial ones, would they have to take?" [1507]

There was widespread concern, then, that the extent of the autonomy Transpace was seeking from government control, in the interests of a flexible and aggressive marketing strategy, was simply incompatible with the backing it expected to get from the Member States and with the political and financial realities of its potential market. And while steady progress was made, by October 1979 three or four unresolved issues stood out concerning the relationship between ESA and Arianespace, as the firm came to be called at about this time. These were pricing policy, launching policy, including guarantees for launch slots and the mechanisms required to ensure that launchers were used for peaceful purposes, and the legal framework for the commercial production of the launcher. We shall treat them in reverse order.

When France made its proposal to establish Transpace it did not concern itself too much about the legal niceties of the firm's relationship with ESA. In particular it did not take it for granted that the link would be within the framework of the ESA Convention – which had not yet come into force because the French government had not yet ratified its May 1975 signature. France's partners, however, wanted their relationship with Arianespace formalised within that framework to ensure that the necessary legal instruments remained within the authority of the ESA Council, and did not have to be presented to national parliaments for ratification, which would slow down everything even more. That in turn meant that the French Government now had to ratify that Convention to give this new major programme the required legal solidity. A cat-and-mouse game started, in which the French Delegation, while stating its willingness to accede to its partners' request, made the invocation of their preferred legal framework conditional on their respecting a number of French demands.[1508]

If the Convention were used, there were two possible ways of formally ensuring that the production of Ariane was undertaken within its terms. It could either be carried out as an optional programme in terms of Article V.1(b), or as an operational activity in terms of Article V.2. The ESA DG and the Executive strongly favoured the former approach, if only because it bound the activity unambiguously into the framework of the Agency as a programme carried out by (some of) its Member States. Institutionally speaking this simplified issues like making the Agency's facilities and intellectual property rights available to the firm, granting it fiscal and customs exemptions, and assuming international liability for damage. In operational activities as defined by Article V(2) of the Convention, by contrast, ESA simply provided a service to an outside body, at the latter's expense, and on terms to be defined on a case-by-case basis.[1509]

As 1979 wore on, the French Delegation progressively refined the enabling legal texts to accommodate the remarks of its partners and the Executive. On 9 October it submitted to the Council a draft declaration by potential participating governments on the Ariane production phase. It was to be complemented by a convention to be drawn up subsequently between Arianespace and ESA along the lines of the declaration and "defining the detailed arrangements governing their co-operation". The

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1506 ESA/C(79)104, 16 July 1979.

1507 ESA/C(79)104, 16 July 1979 for Gibson's remark, Annex II to the minutes of the 33rd Council meeting for the Swiss delegation's comment (ESA/C/MIN/33, 20 September 1979).

1508 See for example ESA/C(79)104, add. 2, 3 September 1979 and ESA/C(79)127, 9 October 1979.

1509 See ESA/C(79)117, Annex I, 9 October 1979.

declaration was accompanied by a (draft) resolution in which the Council agreed to carry out "the operational activity associated with the Ariane launcher production phase, within the framework of Article V.2 of the ESA Convention [...]". The declaration was to be opened for signature three weeks later on 30 October, and would enter into force three months after that date.[1510]

The draft declaration was discussed by the Council on 23 October. It immediately ran into trouble: the Belgian, Dutch, Spanish and Swiss delegations, for example, all wanted the production effort to be undertaken as an optional programme. Now at the limit of its patience – "discussions had been going on for a year" and "a further meeting for discussion would probably be ineffective", it said – the French delegation announced that it would it would submit a revised text of the Declaration to the next Council meeting and that it would subscribe to it there and then.[1511]

France's threat was intended to focus the minds of her partners and their governments on the need to converge rapidly on an agreed legal framework for the functioning of Arianespace. And while some of them doubtless resented her strong-arm tactics, her cause was given an enormous boost on Christmas Eve, 1979. Just before 17.15 (GMT) on 24 December Ariane soared into the cloud-speckled sky above Kourou on its maiden flight, successfully placing its technological capsule into orbit 15 minutes later. Shortly thereafter the French Delegation submitted a revised Declaration, open for signature by interested Member States for three months from 14 January 1980. The Declaration was accompanied by a Resolution which was adopted by the Council at its meeting on 23 and 24 January. In this Resolution the Council accepted that Ariane launcher production be considered as an ESA operational activity in terms of Article V.2 of the ESA Convention. Council delegates also agreed to use Ariane for the Agency's programmes and accepted a price scheme. Finally they authorised the ESA DG to open negotiations with Arianespace on the terms of the Convention defining the relationships between the two bodies.[1512] Negotiations on the text of this Convention dragged on throughout 1980, the document being finally accepted by the Council in December of that year and signed on 15 May 1981.[1513] Just a few months before, on 30 October 1980, the French government also deposited its instrument of ratification of the ESA Convention, which finally came into force.

France's determination to carefully circumscribe ESA's involvement in Arianespace by making launcher production an operational activity, rather than an optional programme of the Agency, was reflected throughout the structure of the firm. Arianespace was set up officially on 16 March 1980. Its mission was to finance, produce, market *and launch* Ariane once the promotional series was over, contrary to what Gibson had suggested when the French proposal was first made. The concerns that the DG had expressed about the low level of civil liability insurance taken out by Arianespace were laid to rest by the French government, which assumed responsibility for the payment of any damages demanded by victims, Arianespace reimbursing the government up to a limit of FF 400 million.[1514] Gibson's hopes to limit French influence in the Board and to give ESA a direct role in company policy

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1510 ESA/C(79)127, 9 October 1979. The first quote is from Art. 3.6(a) of the Declaration, the second from Art.2 of the Resolution.

1511 ESA/C/MIN/36, meeting on 23 October 1979, document 19 November 1979. Swiss amendments circulated immediately are ESA/C(79)127, add. 2, 19 October 1979. The ESA DG also quickly circulated a note pointing to a number of legal ambiguities and lacunae in the French text - see ESA/C(79)153, 16 November 1979

1512 The *Declaration by Certain European Governments Relating to the Ariane Launcher Production Phase* is ESA/C(80)8,rev. 1, 11 January 1980. The Council minutes are ESA/C/MIN/39, 31 January 1980, and the Resolution passed there is ESA/C/XXXIX/Res. 8, 24 January 1980.

1513 The meetings of the working party chaired by van Reeth which discussed this Convention are ESA/C(80)WP/9, 20 August 1980 for the meeting of 23 July 1980 (ESA 4576), WP/14, 25 September 1980, for the meeting on 9 September 1980 (ESA 4581), WP/19, 21 October 1980 for the meeting on 29 September 1980 (ESA 4586), WP/23, 29 December 1980, for the meeting on 6-7 November 1980 (ESA 4588), WP/24, 22 December 1980, for the meeting on 11 December 1980 (ESA 4589). The agreed text of the *Convention Between the European Space Agency and Arianespace* is ESA/C(80)WP/8, rev. 4, 18 November 1980. The Council minutes are ESA/C/MIN/45, 27 January 1981 for the Council meeting on 15-16 December 1980.

1514 See Declaration, Arts. III.3.8 and IV.4.1, ESA/C(80)8, 11 January 1980 (ESA 691).

were also dashed. French firms (three representatives, one each from the prime contractors SNIAS, SEP and Matra) and CNES (four representatives) were in a majority on the twelve-member Board of Directors in 1982. The remaining five positions were occupied by representatives from participating European industries (ERNO, MBB, SABCA, Volvo and Contraves). ESA, for its part, only had one of six 'Censor' seats. This enabled its representative to participate in Board activities but without voting rights. Gibson and some Member States had insisted that Arianespace should be embedded firmly in an intergovernmental context. The French had always resisted this view, wanting the operational use of the launcher to be "implemented on a purely economic basis in an industrial context" in the open market.[1515] And it was that conception of the firm's role that had prevailed.

11.6.2 Launching policy

It would be wrong to think, on the basis of what we have just said, that Arianespace operated free of any constraints imposed by ESA and the Member States. Although they had virtually no control over company policy at Board level, they did insist on guarantees of services in certain areas, guarantees which respected their historical role in the birth of the launcher and the reasons for which European governments had agreed to co-finance its development in the first place. First and foremost, there was of course the area of industrial policy as expressed through respect for the principle of fair return. Two other key areas where mutual agreement was essential were launching policy and pricing policy.

Launching policy covered a number of different, if related, issues. Firstly, there was the question of the conditions under which one would launch satellites for third parties, conspicuously those with military objectives. The Preamble to the ESA Convention was unambiguous on this point: the organisation was dedicated to developing a European Space Programme "for exclusively peaceful purposes". And as difficult as this may have been for Arianespace, particularly when one remembers the huge market for American launchers provided by the US Department of Defense, there was no question of allowing the company freely to launch satellites for any client who would buy them, regardless of the military potential of the payload. More generally, however, different European governments had different and even competing foreign policy objectives in different parts of the world. They might well disagree on the advisability of the sale of even a civilian launch to a government because it conflicted with their broader strategic objectives in that area of the globe. A realistic policy for sales to third parties was needed, a policy which did not *a priori* put Arianespace at a serious disadvantage in the market, and which respected the different sensitivities of the participating States.[1516]

The following procedure was adopted for maintaining the "peaceful" character of Ariane sales to third parties (i.e. excluding ESA Member States and bodies under their jurisdiction).[1517] A special committee was set up by the States participating in the production process. Its task was to decide whether a projected launch would be carried out for peaceful purposes as defined in the Outer Space Treaty of 1967 and in the ESA Convention. If one-third of the members of this committee had doubts in this regard they could convene a meeting with their counterparts. The committee could prohibit the sale by a two-thirds majority representing also 15% of the contributions – an arrangement that enabled the smaller, neutral countries like Sweden and Switzerland to impose their will if they wished. This decision was binding on Arianespace, and the French government was to ensure that the firm refused the client.

1515 This paragraph is based on R. Deschamps, *Arianespace: A Private European Launch Service Experience,* paper AIAA-82-1803, AIAA/DGLR/AAS/BIS Space Systems Conference, October 18-20, 1982, Washington DC, from which the quotation is also taken. Deschamps was the General Secretary of the firm at the time.

1516 See the debate in ESA/C/MIN/34, meeting held on 10-11 September 1979, document dated 8 October 1979.

1517 See Arts I.1.2(a) and I.1.6(a) of the Declaration, ESA/C(80)8, 11 January 1980 (ESA 691), and Arts. 6.1, 6.2 and 6.3 of the ESA-Arianespace Convention, ESA/C(80)WP/8, rev.4, 18 November 1980 (ESA 4575).

A more flexible arrangement, originally suggested by the Swedish delegate, was adopted for those cases in which a government did not want, for its own reasons, to "associate itself" with a particular launch.[1518] In such cases it could simply withdraw from the particular sale in question, on the understanding that it would respect its commitments in terms of the other sales. At the same time it would normally continue to make its national industrial facilities available for producing the rocket, its political declarations notwithstanding. If it also wanted its industry to withdraw, it would have to "authorise and facilitate the transfer of the manufacture of the relevant supplies to the industries of the other participating States [...]". Under no circumstances could it stop other States who had no objection to the sale, and their industries, from building the launcher in question. By this device a government was able to respect its public political engagements all the while keeping its industrial activities intact behind the scenes if it wished to – which was more or less imperative, in fact – and without imposing its will on any of its partners.

The second important dimension of launching policy was the question of ensuring that the Agency's programmes and those of the participants in the production programme were given a "real" priority in the use of Ariane, all the while ensuring that these bodies would not exploit that priority "in a way that would be prejudicial to the interests of Arianespace".[1519] This need to give European government programmes priority was simply the counterpart to the French delegation's demand that the Agency agree to use Ariane in conformity with the provisions of Article VIII.1 of the ESA Convention (i.e. "if this does not present an unreasonable disadvantage compared with other launchers or space transport means available at the envisaged time in respect of cost, reliability and mission suitability").[1520] This request in a weakened form, we should add, was extended in the Declaration of January 1980 to cover the national programmes of the participants in the production programme (under the same conditions of availability).[1521] What is more the same Declaration required the participants also to "endeavour to support the use of the Ariane launcher" in international programmes in which they were involved.[1522] In short, Arianespace wanted to be sure that, like its American competitors, it could normally count on the governments which had financed its development to use it – in return for which it would guarantee them the launch slots they wanted.

Matters were not that simple, of course, and an enormous amount of time was spent and ink was spilt trying to define an acceptable policy for allocating launch slots and dealing with launch slippages and failures.[1523] The basic principles were laid down in the Declaration: that ESA programmes and the participating States would have priority over third-party customers for launch services and slots, and that in the event of a conflict of priority between the first two, ESA programmes would have priority.[1524] The Convention elaborated upon this in its Article 3, which was the longest in the text, running to more than a dozen clauses and subclauses and including an Annex ,which laid down guidelines for a standard clause to be inserted in all Arianespace contracts with third parties, explaining the obligations of the company to ESA and the participating States. It is impossible to

[1518] See ESA/C/MIN/36, meeting on 23 October 1979, document 19 November 1979, ESA/C(79)127, 9 October 1979 (ESA 644), Arts. I.1.6(b) and (c) of the Declaration, ESA/C(80)8, 11 January 1980 (ESA 691), and Arts. 6.4 and 6.5 of the ESA-Arianespace Convention, ESA/C(80)WP/8, rev.4, 18 November 1980 (ESA 4575).

[1519] As the Swiss delegation put it at the first meeting of the Convention working party on 23 July 1980, ESA/C(80)WP/9, 20 August 1980 (ESA 4576).

[1520] The demand is in ESA/C/XXXIX/Res. 8, Art. IV, adopted on 24 January 1980.

[1521] But not without difficulty. When the French first proposed this idea, the DG and several delegations insisted that Member States "could not formally commit themselves always to use Ariane for their national programmes" - ESA/C/MIN/34, meeting on 10-11 September 1979, document 8 October 1979. The Declaration reflected this by softening the wording. The participants "declared" that they would use Ariane for ESA's programmes, but merely "agree[d] to take the Ariane launcher into account" for their national programmes - see Art. 1.4(b) of ESA/C(80)8, rev.1, 11 January 1980.

[1522] See Art. 1.4(c) of the Declaration ESA/C(80)8, rev.1.

[1523] See the minutes of the working party on the Convention cited above, and e.g. ESA/C(80)WP/8, 10 July 1980, Art. 3 (ESA 4575), ESA/C(80)WP/11, 4 September 1980 (ESA 4578), and ESA/C(80)WP/15, 29 September 1980 (ESA 4582).

[1524] Art. III.3.6 of the Declaration.

summarise these arrangements in a few words, and tedious to repeat them literally. To illustrate, we note that Arianespace undertook to preserve the launch ranking of an ESA or participant state mission if their slot slipped due to a delay with the launcher. If there was a launch failure these two classes of client also had the right to the first slot, or failing this the second slot compatible with the availability of their backup payload. Finally, the company undertook to pay "special attention" to the constraints imposed by scientific missions, such as narrow launch windows imposed by their need to satisfy certain specific objectives, of which the rendezvous of Giotto with Halley's comet was a dramatic example.[1525]

11.6.3 Pricing policy

Table 11-4 lists the prices for launches to ESA and the participants in the Ariane Production Programme as proposed by the French delegation in summer 1979. They were not be changed throughout the subsequent debates and were confirmed in the Declaration opened in January 1980 and in the ESA-Arianespace Convention formalised a year later. This is not to say that pricing policy was unproblematic, though. Two aspects in particular were discussed: price discrimination between ESA and the participating States, on the one hand, and third parties on the other, and the implications of the differential between the launch price of single and double Delta class payloads.

Table 11-4. Arianespace prices for ESA and for national programmes of participants in the production phase, for contracts signed before 1 July 1983, in m. c. of 1 July 1978[1526]

Type of launch	MFF	MAU
Single launch using Ariane's full capacity	175	30.95
Single launch of Thor-Delta class satellite	150	26.53
Thor-Delta satellite as part of a dual launch	95	16.80

When the French delegation first set its Ariane prices for ESA and the participants, it fixed them at roughly 25% above the prices which they expected equivalent American launchers would cost. They also reserved the right to offer Ariane to third parties at any price which the company chose (meaning at considerably lower prices). They also proposed that this price scheme only remain in force for contracts signed before 1984. For the subsequent period the figures given in Table 11-4 would be maxima which would not be exceeded.

This pricing policy was immediately contested by the German and Swiss delegations who "considered it essential to fix a single launch price, applicable to the world market" and who stressed that several Member States "would find it extremely difficult to give an undertaking to use Ariane exclusively, irrespective of the prices charged for competing launchers". To achieve non-discriminatory prices the German delegation suggested that each participating state "should for a limited time support in an appropriate manner its industry participating in Ariane production". This "additional financial help" would ultimately enable the firm "to produce and market Ariane on its own responsibility".[1527]

Nobody liked the German idea very much, but anyway within a month the whole situation had evolved and the problem had resolved itself, as it were. The French Delegation recognised that its partners had difficulty undertaking a ten-year commitment to use Ariane at prices that might be higher than those on the world market. However, they went on, the situation on that market had recently undergone major changes. Early in 1979 the reference price for the Shuttle quoted by NASA for placing an Ariane-class payload in geostationary orbit had been FF 111 million. Several factors had seriously undermined US competitivity since, however. Firstly, the envisaged commissioning date of

[1525] See Art. 3 and Annex I of ESA/C(80)WP/8, rev.4, 18 November 1980. The example is from the Annex.
[1526] From Annex III to the ESA-Arianespace Convention, ESA/PB-ARIANE(80)35, rev.2, 18 November 1980.
[1527] See ESA/C/MIN/34, meeting on 10-11 September 1979, and its Annex II, document dated 8 October 1979.

the Shuttle had slipped steadily; the estimated time needed to refurbish the orbiter had increased from two weeks to five, and the number of operational flights planned for the first five years had been cut by one-third. Granted NASA's obligations to the US government, it was clear that the Shuttle's availability for commercial launches was seriously reduced. In addition, the Senate and the Comptroller General were insisting that NASA charged 'true prices' for the Shuttle, and if that was done the cost of a flight after an initial transitional period would rise by between 25% and 56% (to FF 175 million) for placing an Ariane-class payload into geostationary orbit.

Secondly, confronted with this situation, NASA has had to guarantee to users of the Shuttle that conventional launchers, namely the Thor-Delta and the Atlas Centaur, would be available for a further 18 months. The cost per launch of the latter, on the basis of NASA's offer for an Intelsat V launch, was likely to be $40 - 45 million, or about FF 180 million in 1978 prices and exchange rates. The cost of a Thor-Delta launch would be of the order of FF 102 million.

The changed situation in the US meant that the prices being suggested for Ariane were now comparable to those prevailing on the world market. To apply them, said the French delegation, would not require a major additional effort on the part of ESA or the participating States, as had originally been thought. What is more, given the upward trend of prices in the US, the French delegation suggested that there was no need to lay down now a price for the next phase of the Ariane Programme.[1528]

The Declaration adopted in January 1980 confirmed this approach. The prices given in Table 11-4 were adopted for ESA programmes and national programmes of participating States, it being understood that in both cases Ariane would be bought unless its use was "unreasonably disadvantageous" for the client. These were also the "recommended" prices for third parties, though the firm was free to deviate from them if it wished, the financial consequences being "borne by Arianespace alone". As for the next phase, for launches scheduled after 1 July 1986, a new set of prices would be adopted in the light of the international situation at the time, and it would be non-discriminatory, i.e. it would be applicable to *all* clients.[1529]

One striking feature of the data in Table 11-4 is the difference between the cost of launching a Thor-Delta class satellite,depending on whether it was flown alone or in a double launch. In the latter case it cost about the same as an equivalent launch with an American rocket (about FF 100 million). If launched alone by Ariane, on the other hand, its price increased by 50% to ESA and the participating States. This was a source of considerable difficulty in the ESA-Arianespace Convention negotiated in the course of 1980.

An early draft of this document declared that a client asking to fly a Thor-Delta class satellite would be charged FF 150 million "so long as a second passenger has not been identified", going on to say that the firm would "use its best endeavours to find a second passenger".[1530] Of course, since one could only be sure that there would be a second passenger *after* a launch – last-minute cancellations were always possible – it meant, said the Executive, that the first client would be invoiced for FF 150 million up to the launch, and the difference in price between a single and a dual launch would be reimbursed to it afterwards "if applicable".[1531] In other words ESA and the participating States might find themselves paying FF 150 million for a launch which would have cost FF 102 million if they had used the Thor-Delta.

1528 For the above paragraphs on the situation in the US as described by the French see ESA/C(79)127, 9 October 1979 and, above all, ESA/C(79)127, add.1, 9 October 1979 (ESA 644). ESA/C(79)117, 9 October 1979 (ESA 634), contains an alternative proposal by the ESA DG.

1529 The relevant articles are Arts 1.4 and 1.5. The prices are in Annex 1. The Declaration is ESA/C(80)8, 11 January 1980 (ESA 691).

1530 ESA/C(80)WP/8, 10 July 1980 (ESA 4575), Art. 5.1.

1531 In ESA/C(80)WP/11, par. 11.4 (ESA 4578). For the debate see, e.g. ESA/C(80)WP/23, 29 December 1980, the minutes of the meeting of the "participants and potential participants" Working Party on 6-7 November 1980 (ESA 4588).

Many delegations found this totally unacceptable. They were not prepared to pay more than 25% above the cost of an equivalent American launcher for their programmes, particularly the Science Programme. But if they would only know the price of a launch after it had taken place, as the Executive suggested, "it would be quite impossible to make any valid comparison with the cost of alternative launchers or any rational choice of which system to employ", as the UK delegate put it.[1532]

The solution adopted in the ESA-Arianespace Convention for Thor-Delta class satellites left the pricing system intact but gave the client more control over the cost of his launch. A customer booking a slot for his satellite would normally arrange a payments schedule for a single launch costing FF 150 million. Arianespace and the customer would seek to find a partner. If they managed to do so within 18 months of the scheduled launch, the payments schedule would become that of a dual launch (i.e. costing FF 95 million). If they could not, or if for anyr reason the second passenger dropped out, the first client had a number of options open to him:. he could defer his launch until a second passenger was found; he could agree to pay the full price of a single launch, or he could even cancel the launch, paying the penalties agreed to in the launch contract with Arianespace.[1533]

One last point before closing this section. The new pricing policy for Ariane, applicable to launches taking place between 31 December 1986 and 30 June 1989, was adopted by the ESA Council in February 1984.[1534] It applied, in fact, to all users. It was based on a sliding scale in which the price varied linearly with the mass of the satellite between FF 240.9 million (mid-1983 economic conditions, for 1140 kg into geostationary transfer orbit) and FF 443 million (for 2500 kg into GTO). The figures were calculated using a mission model estimate of six launches per year and were intended to provide for full-cost recovery to Arianespace. Confident of its future, Arianespace was now establishing its presence on the world market. Within a few months of this decision, however, that presence was being challenged from across the Atlantic by a petition which threatened to have dramatic implications not only for the company, but for all European high-technology firms.

11.7 The TCI Affair[1535]

11.7.1 The charge

On 23 May 1984 the ninth launch of Ariane went off without a hitch. L09 was the fourth straight success of the European launcher in less than a year. It was also the first time that Ariane had launched a non-governmental satellite and indeed the first time that it had been used by an American commercial satellite operator – it placed a Southern Pacific Communications *Spacenet* communications satellite in geostationary orbit. Arianespace no longer depended then on ESA and European governments for orders. It was also gaining a foothold in the highly competitive commercial market, as well as wooing US clients. In fact Arianespace's order book was looking very healthy. Fourteen more launches had been booked for 28 clients and the company had already captured about 30% of the world launcher market.[1536]

On 25 May 1984, two days after L09, a Maryland-based firm called Transpace Carriers Inc. (TCI) filed a petition against eleven European governments and their space-related agencies, in particular ESA (of which they were Member States) and the French space agency CNES. . It accused them of

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1532 In ESA/C(80)WP/16, 1 October 1983 (ESA 4583). See also ESA/C(80)WP/15, 29 September 1980 (ESA 4582).

1533 ESA/PB-ARIANE(80)35, rev.2, 18 November 1980, Art. 5.

1534 ESA/C/LII/Res. 5 (Final) adopted by the Council on 24 February 1984,and Annexed to ESA/C/MIN/62, 10 April 1984.

1535 The primary sources quoted in this section are from a collection of documents on the TCI affair held at ESA Headquarters, Paris. We would like to thank G. Lafferranderie, as well as L. Mounier and Miss N. Tinjod, for making them available to us. See also John Krige, "The Commercial Challenge to Arianespace: the TCI Affair", *Space Policy* 15 (1999).

1536 For a complete list of Ariane's first 60 flights see C. Carlier and M. Gilli, *Les trente premières années du CNES* (Paris: La documentation française, 1994), pp. 180-1.

aiding and abetting the European firm, to quote the *Washington Post,* in "illegally 'dumping' its rocket launch services on the US market".[1537]

TCI was the first private American launch service company. On 16 May, so just ten days before L09, the firm had reached an agreement with NASA on the terms of its acquisition of the Delta launcher vehicle programme. The Delta was the workhorse of the United States' stable of expendable launchers (ELVs), having successfully launched 164 satellites over 24 years. It (and the Atlas Centaur, manufactured by General Dynamics) were being commercialised in line with the US President Reagan's policies of deregulation. In 1982 and again in 1983 the President had strongly endorsed the commercial exploitation of space systems, and of expendable launchers in particular. In February 1984 the White House had released a stirring statement drawing attention to the many benefits that would flow from the "vital new industry" that would take shape "as private concerns [began] to supply and launch ELVs".[1538] As part of its strategy of breaking into the market, TCI, the first member of this 'vital new industry', accused Arianespace before the office of the US Trade Representative of "predatory pricing" and of "unfair practices [which] may result in a near foreign monopoly" of ELVs. TCI claimed that this could cost the US "many thousands of jobs" as well as its "substantial technological base" in space-oriented industries. It would also harm the US balance of payments and deprive the government of tax revenues.[1539]

TCI insisted that Arianespace was subsidised by European governments in several ways. Firstly, through a two-tiered pricing system whereby European customers were charged 25-33% more per launch than export clients. Then, by having access to launch and range facilities, as well as CNES administrative, management and technical personnel, at an unreasonably low cost. Finally, by subsidising mission insurance rates which would otherwise be passed on to the client. TCI asked the President of the United States to demand that these practices be suspended forthwith. Pending their elimination, the petition went on, TCI requested the President "to retaliate by prohibiting Arianespace SA from advertising and marketing its services in the United States and by imposing economic sanctions against the goods and services of the Member States of ESA".[1540]

This was not only a call for a trade war with Europe, however; domestic policy concerns were also very much at stake. Indeed TCI's initiative was also, and quite deliberately so, a political move intended to test the US Government's determination to deregulate space activities in a viable way. The Reagan Administration of course intended to preserve Government support for the Space Shuttle in parallel with its disengagement from the expendable launcher market. The golden future that the President announced for firms like TCI was thus intimately tied up with his pricing policy for the Shuttle. TCI denied this naturally. The firm insisted in its petition that it was not in competition with the Shuttle because the STS was designed and intended for a different market – US military payloads, Spacelab, microgravity experiments, and so on. But this was disingenuous. TCI's direct attack on the European launcher was also, indirectly, an attempt to embarrass its main, government supported competitor on the domestic American market, and to influence its pricing policies.

1537 The quotation is from the *Washington Post*, 27 May 1984.

1538 White House Press Release on Presidential Remarks at the Signing Ceremony for the Launch Vehicle Order, 24 February 1984.

1539 From the *Washington Post,* 27 May 1984 and the TCI press release dated 29 May 1984.

1540 *Petition seeking Presidential Action Under Section 301 of the Trade Act of 1974...by Transpace Carriers, Inc. against the Governments of Belgium, Denmark...and their Space-Related Instrumentalities*, and filed before the Office of the US Trade Representative, Chairwoman, Section 301 Committee, on 25 May 1984 by the Council for the Petitioner.

In 1984 NASA's price per Shuttle flight to foreign governments and mature commercial users was $38 million (1984 dollars).[1541] This was an average cost based on a mission model drawn up in 1977 which assumed that the Shuttle would make 572 flights over its first twelve years. It was intended to recover all operating and production costs, including orbiters and related equipment. It rapidly emerged, however, that the Shuttle, even though reusable, was "a highly complex and labor intensive system, was going to take longer to refurbish for reflight than previously expected and be much more expensive to operate". Thus when Phase II prices to be applied in fiscal years 1986-1988 were under consideration, all hope of recovering the losses incurred in Phase I was now abandoned. It was decided to invoice only "out-of-pocket expenses", so to recover only a part of the Shuttle's operating costs. A new price of $71 million per flight (1982 dollars) was established, based on a mission model of 311 flights.

In 1985, in the midst of the TCI affair, the debate on the pricing policy for Phase III (FY 1988-1991) was in full swing in the United States. Table 11-5 summarises the pricing options available as spelt out by the US Congress's Budget Office. The mission model of 24 flights per year assumed that NASA would provide between two and four flights for the foreign and commercial launch market (where TCI and General Dynamics were to operate). The cost that NASA was considering charging at this time, $87 million per flight, was based on the recovery of average operating costs only. It was obviously, to quote the Budget Office again, "substantially less than the price that would have been required to implement the original pricing policy of full-cost recovery". It would also, as the figure shows, kill the domestic ELV industry.

TCI boldly claimed in its petition that whereas Arianespace alleged that it required "subsidies" to compete with the Shuttle, it, the American operator, was "confident that it [could] compete successfully against the Shuttle, even though TCI's prices [were] above those charged by the Shuttle".[1542] However, as the proposed Shuttle Phase III prices became public, the vulnerability of the American private operators to the STS became blatantly apparent. Indeed even the figure of $87 million per flight suggested in March 1985 was felt by NASA to be too high. In a letter to President Reagan, dated 24 April 1985, NASA Administrator James Beggs suggested that the flight price to foreign and commercial users be reduced to $71.4 million. The Shuttle, he said, was a "national asset" and would "not be able to compete effectively with the European Ariane launch vehicle at a price of $87 million per flight".[1543] The President yielded, and set the base price of a Shuttle flight at $74 million (1982 dollars) as from 1 October 1988[1544] – even though Beggs admitted in his letter that "spokesmen for the US companies who are attempting to market commercial ELV's have testified to the Congress that Shuttle prices on the order of $120-150 Million per flight would be required in order for them to compete with the Shuttle".

US pricing policy on launchers in 1984/5 was thus torn between the fundamental contradiction of trying to protect the Shuttle from Ariane while encouraging private industry to develop a viable commercial ELV service in parallel. It was also motivated, according to Van Reeth, by the "popular but sincere belief among informed and interested persons in Washington [that] 'if a foreign entity gains a *high tech* contract, it is due to Government subsidies, if the US gains such a contract it is due to

1541 This paragraph relies heavily on *Pricing Options for the Space Shuttle,* Congress of the United States, Congressional Budget Office, March 1985. See also G. van Reeth, "Section 301 of the US Trade Law and its Application in the Case of the TCI Complaint Against the European Space Agency and its Member States", paper given at the ECSL Summer Course on Space Law and Policy, University of Aberdeen, 12-16 August 1995, by courtesy of the author; R. Williamson (Space Policy Institute, The George Washington University, Washington DC), "The US-Europe Technology Gap in Space Transportation: The View from the United States", (Draft) paper dated 13 March 1998, by courtesy of Lorenza Sebesta; B.A. Stone, "Understanding the Cost Bases of Space Shuttle Pricing Policies for Commercial and Foreign Customers", *J. of Parametrics,* Vol III, No. 1 (1984), 1-6.

1542 *Petition Seeking Presidential Action...*, pp. 20-1.

1543 Letter Beggs to Reagan, 24 April 1984.

1544 The price went along with the novel idea that Shuttle flights for foreign and commercial customers would be 'auctioned' with this starting price - see ESA/C(85)77, add. 1, 12 September 1985.

Table 11-5: Shuttle Pricing Policy

Price Per Flight in 1999 (millions of 1982 dollars)				
Pricing Policy	**Definition of Costs**	**With 24 Flights**	**With 28 Flights**	**Policy Implications**
Marginal Cost Prices				
Short-Run Marginal Cost	Variable operational costs.	42	42	Maximum use of shuttle. Likely end to domestic expendable launch vehicles (ELVs). Direct competition with Arianespace. If NASA's costs are underestimated, revenues will not cover cost. High flight rate encourages future expansion
Long-Run Marginal Cost	Variable operational costs, plus a capital charge for an orbiter dedicated to foreign and commercial flights	76	76	Shuttle should maintain current market share and generated net federal revenues. Domestic ELV firms have little change of success.
Full-Cost Prices				
Full Operational Cost	All operational costs. Approximation of proposed NASA policy for 1989 through 1991	84	98	Largely the same as for long-run marginal price.
Full Cost Less Development	All operational costs. Orbiters at replacement cost ($ 1.7 billion each), plus other investment but excluding research and development.	106	128	Shuttle will lose part of its market share unless Arianespace increases its price as well. Prospects for domestic ELVs improved but still uncertain. Less than full use of shuttle.
Full Cost	All operational costs, plus all investment valued at historic costs.	150	186	Shuttle losses all but specialised foreign and commercial payloads-flight rate will be below efficient level. Reduced net federal revenues. Domestic ELVs will do well, particularly if Arianespace increases price. Investors in new space processing may reduce planned spending. Little immediate need to expand shuttle system.

Source: Congressional Budget Office
Note: Estimates reflect base-case assumptions about interest rate and depreciation.
Alternative assumptions would generally result in higher costs for options with capital costs.
Operational costs based on estimates by NASA.

superior technology'".[1545] Hence one 'obvious' way out of the dilemma was to remove what the Congress called "government subsidies" from the European launcher, so enabling Shuttle prices to float upwards and creating a niche for the newly privatised US expendable launcher firms. As the Congressional report put it, "in addition to a higher Shuttle price, an aggressive trade policy that seeks to eliminate Arianespace subsidies might be a necessary precondition to investment in American ELVs".[1546] New private operators like TCI could hardly attack NASA directly. But if they could force Ariane prices upwards they could eliminate one key argument for low Shuttle prices, and so increase their chances of capturing a slice of the commercial satellite market

TCI's petition claiming that Arianespace was being unfairly subsidised was filed to the Office of the US Trade Representative under Section 301(a)(2)(B) of the Trade Act of 1974, as amended. This authorised the President "to respond to any act, policy or practice of a foreign country or instrumentality that [he deemed] unjustifiable, unreasonable or discriminatory and burdens or restricts United States commerce".[1547] In terms of the Section 301 procedures the Trade Representative had 45 days to decide whether or not such a claim merited further investigation (i.e. up to 9 July 1984 in this case). His decision was based on information and statements of position from all interested parties. If an investigation was initiated it would be in the hands of a dedicated Section 301 committee on which the departments (or 'agencies') of the US government specifically affected by this issue would be represented. The committee would be chaired by the Associate General Counsel of the Trade Representative's Office, Mrs Jeanne Archibald at the time. It had up to one year from the opening of the enquiry to hear evidence from all those concerned. During this period it was possible for the dispute to be settled 'informally' by consultation, conciliation, etc. If that did not happen then the USTR would pass on his recommendation to the President on the expiration of the year. The President had a further 21 days to decide "what action, if any, to take".

The TCI initiative caused grave anxiety in Arianespace and the ESA Member States. The French and German governments, in particular, saw in it a potential threat to European high technology in general "(today Ariane, tomorrow the Airbus, Esprit programmes, etc.)".[1548] What the ESA Executive and the Council particularly disliked was that they were being challenged by a strictly national procedure in which they were not directly represented, and in which they were being accused of unfair practices in a context in which there were as yet no internationally agreed standards of good conduct for commercial space transportation. What they sought then was to shift the whole context and terms of the conflict to political negotiations outside the terms of reference of Section 301. Here, in consultation with their American counterparts they wanted to lay down "conditions for healthy competition" between the two sides of the Atlantic. In their eyes the 301 investigation, as the French Ambassador to Washington put it, "could only complicate pointlessly a dialogue that it was in the interest of Europe and the United States to open in order to reach commercially reasonable solutions". ESA's ultimate hope was to arrive at a mutually satisfactory agreement on pricing policies by consultation, thereby terminating the domestic 301 investigation.[1549]

On 20 June 1984 ESA DG Erik Quistgaard submitted to Mrs Archibald a letter confirming his wish for intergovernmental consultations to be conducted in parallel with the Section 301 investigation. Quistgaard's letter was accompanied by a nine-page Aide-Mémoire which briefly tried to refute TCI's claims that Ariane benefited from discriminatory subsidies. It pointed out that even if European governments gave preference to their own launcher, that preference was not unconditional, as they frequently used American launch systems – unlike the situation in the USA where, thanks to the low Shuttle prices, "NASA enjoys a *de facto* monopoly in respect of Government satellites". The DG went on to point out that for the Phase II Ariane prices, relating to launches after 1 January 1987, the ESA Council had just adopted a resolution laying down a price list based on full recovery cost as a basis for

1545 Van Reeth, *op. cit.*
1546 *Pricing Options for the Space Shuttle,* Congress of the United States, Congressional Budget Office, March 1985, p. xv.
1547 ESA/C(84)R/14, 12 June 1984. See also van Reeth, *op. cit.*
1548 ESA/C(84)R/14, 12 June 1984.
1549 ESA/C(84)R/14, add. 2, 28 June 1984.

Ariane flights irrespective of the user (cf. above).[1550] It was the Shuttle that was the rival to TCI and to Ariane, insisted Quistgaard. The practices and policies followed by European governments were "in no way unreasonable", he added, and they did not affect the economic interests of the US nor prejudice TCI in any way.

European objections notwithstanding, on 9 July 1984 the US Trade Representative decided that an investigation of the TCI petition was indeed warranted. He recognised that governments of all countries had supported R&D costs for the development of launchers. But this was not at issue, he said. What was contentious was the other support which TCI claimed Arianespace had received, and which discriminated unfairly against its competitors in the terms of Section 301. Hinting that such support involved important government subsidies to the European company, he ended by saying that he was requesting "consultations with the European Space Agency to seek ways of making certain that competition in this sector will be equitable, and to bring greater transparency to the actions of governments *vis-à-vis* commercial space activities".[1551]

The US reply put ESA and its Member States in a somewhat ambiguous position. To collaborate would be enter a process in which Europe, but not the United States, would be called on to justify its launcher pricing policies. This was intolerable. However a refusal to collaborate would leave the USTR free to make a recommendation on the basis of an internal investigation alone, with potentially serious consequences. It seemed preferable then to make the most of the conciliatory suggestion that the US was indeed interested in consulting with ESA on how to improve competitivity and transparency of pricing policies in the launcher area. But not under any conditions. Writing to the US Ambassador in Paris in September the new ESA DG Reimar Lüst spelt out the Europeans' terms. Firstly, that the consultations in question be conducted at governmental level, and be independent of the Section 301 procedure. Secondly, that these consultations be not limited to discussing "the nature and extent of government assistance to Arianespace SA", as was happening with the 301 investigation. They would have to include an analysis of the pricing policies and practices adopted for *all* launchers, including the Delta and the Shuttle.[1552] Within a week the US had seemingly agreed. In the interests of "bringing greater transparency to the actions of governments" the reply promised full information, on a reciprocal basis, of government policies and practices, including financial assistance to "the operation of commercial satellite launching services".[1553]

11.7.2 The consultations

Four meetings between European and American representatives were duly held in November and December 1984, and in February and May 1985.[1554] The European team was led by ESA's Director of Administration, George van Reeth. It included, from ESA, R. Orye, who was responsible for the Ariane Programme, ESA's Legal Advisor, G. Lafferranderie and L. Mounier from the Agency's legal affairs service. CNES was represented by its DG and Deputy DG (F. D'Allest and J-M. Luton). The European delegation was completed by representatives from the three governments which had been actively involved in diplomatic initiatives ever since the TCI affair emerged, France, Germany (including C. Patermann from the BMFT) and Switzerland (represented by P. Creola). The US team was headed by the Chairwoman of the Section 301 enquiry, Mrs Jeanne Archibald, and included representatives from the Departments of Transport, of Commerce, of Agriculture, as well as the State

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1550 The Resolution is ESA/C/LXII/Res. 5 (Final), adopted on 24 February 1984, attached to ESA/C/MIN/62, minutes of the meeting on 23-4 February 1984, document dated 10 April 1984.

1551 ESA/C(84)R/14, add. 3. The quotations are from the "Talking Points" submitted by the US Embassy in Paris and attached to the document.

1552 ESA/C(84)R/17, 31 July 1984, ESA/C(84)R/19, 6 August 1984, and ESA/C(84)R/21, 19 September 1984.

1553 ESA/C(84)R/21, add. 1, 8 October 1984.

1554 For the delegations see *Summary of Conclusions of Third Consultative Meeting...* ESA/DOC N° 18, 26 February 1985. For reports on the the first meetings see, in addition to this document, ESA/C(85)R/1, 16 January 1985, and ESA/C(85)R/1, add. 1, 27 February 1985. The fourth meeting is described in ESA/C(85)R/20, 4 June 1985.

Department, the CIA and NASA. These meetings, to quote van Reeth, "were conducted in a fair and even pleasant atmosphere, mainly due to the cohesive attitude of the European delegation [...] and also to the fair and professional attitude of the Chairwoman of the US Delegation [...]".[1555] For all that the Europeans were frustrated on several counts.

Firstly, over the scope of the consultations. From the start there were doubts about what the US meant by limiting the discussions to *commercial* satellite launching services. In order to get the process under way, the Europeans assumed that the consultations encompassed *all* launching services, including the Shuttle. The US delegation, on the other hand, initially insisted that the Shuttle had been built for government requirements and was only "incidentally" involved on the commercial market. They also refused to give any information on the terms for the commercialisation of ELVs. ESA's delegation was thus confronted with "a deliberate attitude of eluding questions" and a "total absence of actual figures or examples".[1556] The situation improved at the fourth and final meeting when the American delegation was "forthcoming" about the estimated amount of aid the US government would offer to a firm like TCI. However they still systematically refused to answer any questions touching, even indirectly the, future, Phase III Shuttle pricing policy.

The second irritating feature for the Europeans was the repeated statements in the US press pre-empting the outcome of the 301 investigation and leaking the contents of the consultations. This occurred notwithstanding the undertaking by both sides to respect confidentiality. NASA Administrator Beggs' behaviour was particularly infuriating. A copy of the *Space Commerce Bulletin* in November 1984 reported Beggs as writing to Reagan that "Ariane prices are subsidised by the European Governments". In February 1985 the same source reported Beggs as saying that the ESA delegation had refused to discuss Ariane pricing policy in detail, and of turning the consultations into an occasion for getting Shuttle cost data. "If we're stupid enough to give it to them", Beggs went on, "which apparently some folks around here think we ought to do, then they will have competitive information on the cheap. All it costs is the price of a ticket over here".[1557] These statements and leaks intended for domestic consumption made the European delegation extremely wary of passing on information which might be used, they knew not how, to influence the outcome of the Section 301 investigation.

Finally, the Europeans were also struck by the lack of coherence in the American delegation to the consultations, especially when compared to their own internal organisation. The report on the second meeting held in December 1984 spoke of the "discomposure of the US Delegation, which was more hesitant in its statements and less precise in its questions, and reflected the divergences and indecision observed in Washington on the commercialisation of space activities".[1558] The full impact of this dissension was evident from a leak, this one reassuring for the Europeans, which occurred in June, just before the Section 301 committee was to make its recommendation. The *Space Commerce Bulletin* carried a headline reading "Arianespace isn't heavily subsidised". The item went on to claim that a document then circulating in Washington pointed out that the European firm was "recovering full costs and turning profit". The paper was written anonymously, but the *SCB* surmised that "it was authored by one or more NASA officials as 'dissent' or 'alternative' to similar classified reports prepared by Office of Management & Budget [...]".[1559]

This difference between the two sides, and indeed the different ways in which they dealt with questions and related to their local political milieux, was indicative of the very different perceptions

[1555] See G. Van Reeth, *Section 301...*, *op. cit.*

[1556] For the questions and an idea of the answers of both sides see *Questions and Supporting Documentation* requested by the ESA delegation to the consultations, ESA/DOC N° 12, undated, and *Responses of the European Delegation to the Questions Submitted on 26 November 1984 by the US Government,* ESA/DOC N° 14, undated, but around December 1984. The quotation is from ESA/C(85)R/1, add.1, 27 February 1985. See also ESA/C/(85)R/1, 16 January 1985.

[1557] ESA/C(85)R/1, 16 January 1985, and ESA/C(85)R/1, add. 1, 27 February 1985.

[1558] ESA/C(85)R/1, 16 January 1985.

[1559] Attached to ESA/C(85)R/20, 4 June 1985.

which the two delegations had of the purposes of the consultations. For the Europeans these were formal, confidential intergovernmental discussions whose long-term aim was to define together pricing policies for space transport systems which would leave room for all on the market. The discussions were outside and above the domestic political process. On the US side, by contrast, matters were blurred by the very fact that the leader of the American delegation was also the Chairwoman of the Section 301 committee that was investigating the TCI charge. Thus for them the 'consultations' were primarily a 'fact-finding' mission. They were both a procedure enabling the US to get inside information on European pricing policies, and a means whereby Europeans could have an impact on the deliberations of the committee. Hence the resentment by the Europeans at the lack of reciprocity on the part of the US when it came to sharing data. At the same time if there was an increased openness on the part of the latter by June it was surely because, now realising the weakness of their case, they began to warm to the idea of defining together with the Europeans the ground rules of a pricing policy which could ensure "equitable" competition in the provision of launch services.

11.7.3 The outcome

On the evening of 9 July 1985 Mrs Archibald's Section 301 Committee, which had investigated the TCI charges against Arianespace, submitted its recommendations to the White House. The next day the ESA Member States submitted an Aide-Mémoire to Washington accompanied by a *Statement of Facts, Views and Conclusions* in which they sought to rebut those charges.[1560] A week later, on 17 July 1985, Reagan took his decision.

We do not want to repeat here all the arguments advanced by the Europeans in reply to the TCI petition. In essence they insisted that European practices were those commonly undertaken by governments and their agencies in the provision of launch services, and that they certainly did far less to distort the market than the equivalent practices in the US, notably regarding the Shuttle. To give the flavour of the counterattack, we shall just summarise two of these arguments: that against the charge that Arianespace engaged in two-tier pricing, and that against the claim that it arranged advantageous and discriminatory loans for customers, helped by the presence of French nationalised banks on its Board of Directors.

The European statement began by differentiating between the two phases of Ariane's pricing policy (cf. section 11.7). The first, we will remember, defined in January 1980, applied to contracts concluded prior to 1 July 1983. The second, adopted in February 1984, was applicable to contracts for launches between 31 December 1986 and 30 June 1989. In the first period, the Europeans argued, the price "was intended to assume at least full-cost recovery on ESA and Member State launches [...] in order reasonably to allow Arianespace to have a chance to enter the market in competition with the Shuttle, which was subsidised to the extent of many hundreds of millions of dollars". These prices were also the recommended prices for commercial and foreign customers, "it being understood that any deviation from the price [was] borne <u>solely</u> by Arianespace at its own financial risk". The second pricing policy assumed that the company had now successfully entered the market, and so set prices at, but not above, full-cost recovery point. These prices were now the recommended prices for *all* customers, and again Arianespace was free to deviate from them if it took the consequences itself. Based on these policies Arianespace "did not make profits during its first three years of operations due to the necessity to adapt its price to the Shuttle's artificially low prices". The firm did, however, manage to break even in 1984. But that was not because it was "subsidised". One key factor aiding profitability was the sharp variation in the exchange rate between the French Franc and the dollar, which went from about \$1 = FF 5.60 in 1981 to \$1 = FF 9.60 at the end of 1984. Since Ariane's prices were in French Francs the company could offer very competitive prices on the US market without losing money.[1561]

1560 *Statements of Facts, Views and Conclusions Made by the Governments Members of the European Space Agency at the Conclusion of Consulations Held with the US Government on Commercialisation of Space Launch Activities,* 10 July 1985.

1561 *Statement of Facts...,* p. 10, and accompanying aide-mémoire of 12 July 1985, p. 3.

As for preferential financing, the Europeans first stressed that there was no way in which ESA, granted its missions and its objectives, could finance any of Arianespace's customers. They did accept, however, that some customers benefited from export credits from national lending institutions. But not only were the financing conditions fully consistent with OECD arrangements and terms. They were also less favourable than the credits granted by Eximbank to NASA's foreign customers. For example, Eximbank had offered to finance 85% of the cost of a $155 million Shuttle flight for Mexico. The French finance house Coface was only prepared to offer credit on a launcher proportionally to the value of French produced components in the product, i.e. about two-thirds in the case of Ariane. What is more, Eximbank credits were not just higher in percentage terms, they also covered larger sums, were available for launch insurance (which Coface's were not) and were of a longer duration than the French equivalent.[1562]

In the conclusion to their paper the European governments insisted that, even if the charges brought against them were true, which they could not be, legally speaking, their practices and policies "would pale by comparison – both qualitatively and quantitatively – with the US practices and policies" with respect to Shuttle pricing and assistance to US private expendable launcher companies. The existing Shuttle pricing policy for foreign and commercial users, they said, did not cover amortisation of the orbiter vehicle production costs, nor the cost of spares, and did not compensate for overly optimistic launch rates and operating cost projections. The resulting subsidies to this class of customer, they estimated, was about $200 million per year of Shuttle operations, roughly the price of four to five Ariane launchers and launches in 1984. Granted these practices, it was "difficult for the US Government then to criticise, as an unreasonable burden on US commerce, the alleged practices and policies attributed to ESA and the Member States [...]".[1563]

The Presidential decision taken on 17 July, in line with the recommendations of the Archibald Committee, rejected the TCI petition. "Many of the factual allegations were not supported by evidence on the record", Reagan stated. "While other allegations were substantiated", he went on, "the practices were not sufficiently different from US practice in this field to be considered unreasonable under Section 301". As a result, the President said, "I have determined that these conditions do not require affirmative US action at this time".[1564] With that the TCI affair was closed.

As we pointed out earlier, from the start of the TCI affair the Europeans had insisted that they were more than willing to open consultations with their US partners on how best to establish the conditions for "healthy competition" in the launcher field. What they meant of course was that they wanted to try to find a way, in consultation with the US, of reducing what they saw as discriminatory practices in favour of the Shuttle. The final aide-mémoire of 12 July was unambiguous on this point. The member governments of ESA, it stated, were not going to allow a viable private launch industry in Europe "to be stifled as a result of unfair economic practices of the US Government in pricing and marketing its Shuttle launch services to commercial and foreign satellite operators".[1565]

Reagan's announcement a week later took up this theme. It may be in the mutual interest of the ESA members States and the US government, Reagan suggested, "to engage in international discussions aimed at establishing appropriate guidelines for the commercial launch industry". He was not of course doing this just to please the Europeans. As the President made clear, it was necessary to establish such guidelines "because of my decision to commercialise expendable launch services in the United States [...]" and the need to lay down a new Shuttle pricing policy commensurate with that objective.[1566] Thus were launched a new round of US/European consultations aimed at defining together what came to be called the "Rules of the Road" specifying permissible levels of government

[1562] *ibid.*, p. 16.

[1563] *Ibid.*, p. 30 and the accompanying aide-mémoire, p. 11.

[1564] The text is attached to ESA/C(85)77. See also US *Federal Register,* Volume 50, No. 140, July 22, 1985, Presidential Documents, pp. 29631-3.

[1565] Aide-mémoire of 12 July 1985 accompanying *Statement of Facts,...*. of 10 July 1985.

[1566] US *Federal Register, op. cit.*

support to the commercial launch service industry. It was one of the most important spin-offs of the Transpace affair.[1567]

[1567] ESA's first set of proposals for such guidelines are attached as Annex IV, dated 9 May 1985, to the *Statement of Facts,....* of 10 July 1985. For a summary of the ESA/USA consultations in the two years after the TCI affair see ESA/C(87)R/14, 1 June 1987. For an overview see G. van Reeth, "Levelling the Playing Field: A European Perspective, 2nd Kraft A. Ehricke Memorial Lecture on Commercial Launch Services", *43rd Congress of the International Astronautical Federation,* August 28-September 5, 1992, Washington DC, Paper IAA-92-0141.

Chapter 12:
Extending the Family. The Upgrading of Ariane-1 and the Decision to Develop Ariane-5

J. Krige

12.1 Ariane Follow-on Development

12.1.1 The Preparatory Phase

At the end of 1978 the Executive circulated a major discussion paper proposing that the Agency embark on an Ariane 'Follow-on Development Programme'.[1568] The basic aim of this programme was to increase the performance of the European launcher, then rated at 1700 kg into geostationary transfer orbit (GTO), by developing two new variants of the basic model. The first, Ariane-2, would be able to put 1950 kg in transfer orbit, while Ariane-3 was designed to place 2300 kg in the GTO. Two main considerations drove this initiative.

First was the evolution of the launcher market and the imminent competition from the Shuttle. The upgrading of Ariane was essential, the Executive said, if the initial objective of the programme – the maintenance of a competitive, autonomous European launcher capability in the area of applications – was to be respected. A study of the applications programmes envisaged by ESA and its Member States indicated that there was a demand for two types of satellites, those in the ECS/Marecs class, which required one ton in geostationary transfer orbit, and those of the Meteosat class, calling for 0.7 tons in GTO. The new performance levels were calculated to enable launches of two satellites of these classes using the Ariane dual launch system SYLDA (Système de Lancement Double Ariane), so substantially reducing the cost per kilogram in orbit. They were also essential if Ariane was to be able to compete with the Shuttle for third party clients. NASA was developing two motors to inject satellites from a Shuttle in low Earth orbit into the geostationary transfer orbit. These "brought into being" two new classes of satellite, known respectively as SSUS-D and SSUS-A, Spinning Solid Upper Stage for Delta (D) or Atlas (A) class satellites. "The proposed increase of the Ariane performance makes it capable of executing either single or dual launches of such satellites", said the Executive, "a factor that is vital for competitivity and for promoting sales to third countries".

The second consideration driving the Executive to propose a Follow-on Development Programme was the need to keep active the teams and facilities engaged in the development of Ariane. In mid-1978 the expenditure on development, which had climbed steadily for almost five years, reached a peak and began to fall off sharply. The industrial manpower employed on development and manufacture began to drop off in parallel. Experienced teams risked being dissolved and engineers risked being left idle, particularly those at SEP's Vernon establishment, where 90% of the activity was devoted to Ariane. Test facilities in Germany and France would no longer be required for development or manufacture and would cease to be used. The Follow-on Development Programme was also intended to mobilise this human and industrial capital from 1979 onwards in a new project upgrading Ariane's performance.

After evaluating various possible ways of improving the launcher's capability the ESA and CNES teams proposed three major technical modifications to the existing launcher: an increase in the chamber pressure of the Viking engines, an increase from 8 to 10 tons of the amount of propellant in the third stage, and the addition of solid propellant boosters. These technical modifications led to the definition of two new launchers, Ariane-2 (1950 kg in GTO) and Ariane-3 (2300 kg in GTO).

1568 These documents are *Ariane Follow-on Development Programme*, ESA/EXEC(78)2, November 1978 (ESA 4476) and the summary prepared for Council, ESA/C(78)136, 20 November 1978 (ESA 499).

In Ariane-2 the thrust level of the Viking 5 engine in the first stage and of the Viking 4 engine in the second would be increased by raising the combustion pressure by 4 bars above that in Ariane 1 (54 bars). The capacity of the cryogenic third stage would be increased by 2 tons, by lengthening the cylindrical portions of the liquid oxygen and liquid hydrogen tanks by 1250 mm. The structure would need to be reinforced to absorb the increased stress, on the ground and in flight, of the now heavier stage, and the thrust of the HM7 engine would be increased by raising the combustion pressure from 30 to 35 bars. It was also decided to lengthen the fairing by 500 mm, increasing its volume and adapting it to the use of the SYLDA system.

Ariane-3 differed from Ariane-2 by the addition of two solid boosters of about 1 metre diameter and 6 metres long, each carrying a mass of propellant of approximately 7 tons. Preliminary studies were also under way on a variant which had four boosters instead of just two. Figure 12-1 shows schematically the three versions of the launcher.[1569]

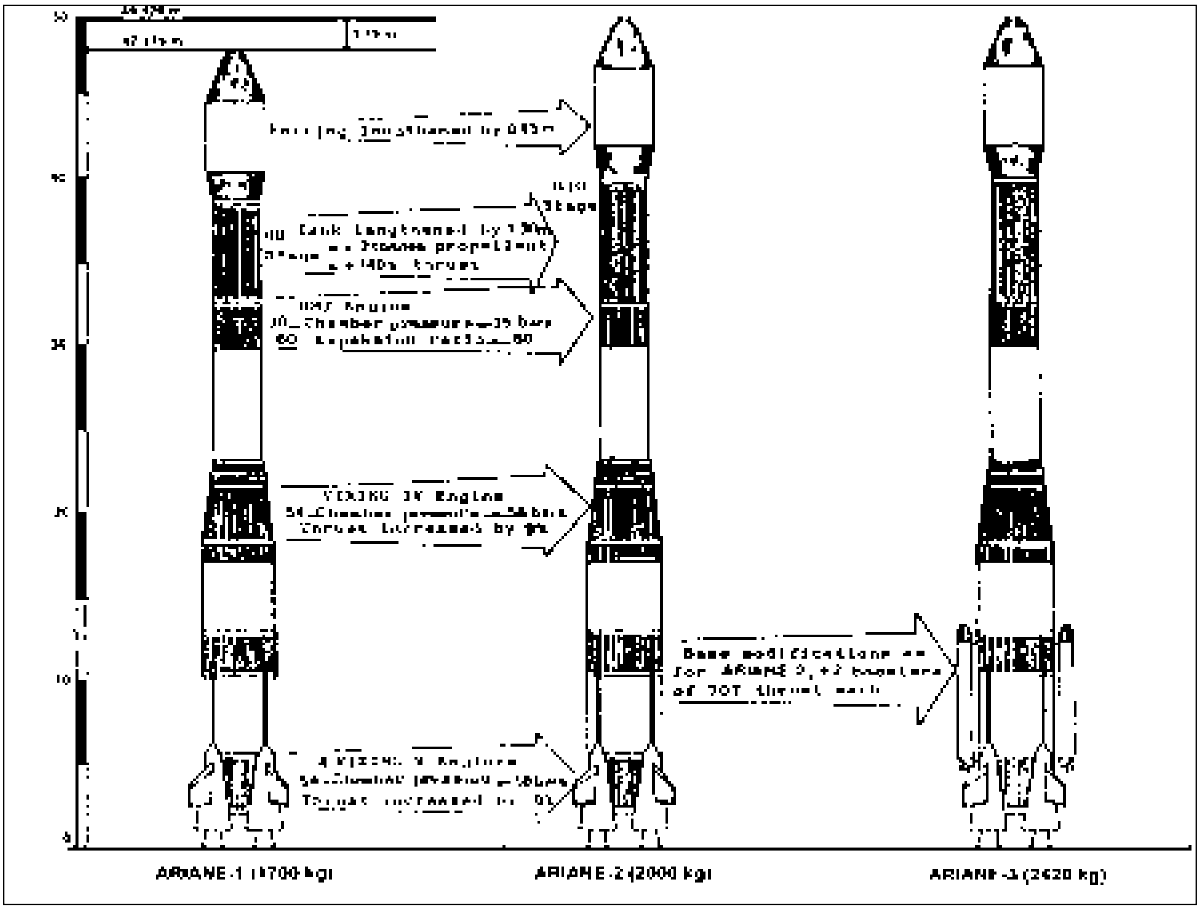

Figure 12- 1. Early versions of Ariane-2 and 3 showing their relationship to Ariane-1 (Source: ESA/C(80)3, 21 January 1980).

The estimated cost of the Follow-on Development Programme was 60.4 MAU in mid-1978 economic conditions, or about 10% of the cost of the initial development programme. It was decided not to make test flights of Ariane-2 and 3. Instead ground tests would be made to qualify the elements which had undergone major modifications and the new elements like the boosters. To reduce launcher costs further the programme also provided for the demonstration of the feasibility of recovering the first stage two or three times and then, depending on the results of this demonstration, for the development and qualification of the facilities required for recovery. As for scheduling, the ESA and CNES teams

[1569] It is from ESA/C(80)3, 21 January 1980.

estimated that if work began in mid-1979 Ariane-2 could be available in March 1982, and Ariane-3 in March 1983.

On the industrial side, there was little room for change in the existing distribution of work, as the follow-on programme mostly entailed modifications to existing systems. Booster development was the only major new item, and it was agreed by the Participating States at the outset that the work for it would be done in Italy. Preliminary estimates of manufacturing costs indicated that they would be only a few per cent higher than the cost of fabricating the basic Ariane launcher.

The Executive's proposal was examined by the Council meeting on 12 and 13 December 1978. It was considered in conjunction with a proposal for the follow-on development of Europe's other major infrastructure programme, Spacelab. Regarding both projects the German delegation stressed that it was too early to take a definite decision. It was, the delegation insisted, basically in favour of upgrading the European launcher. However, just as it felt that initial experience on the utilisation of Spacelab should be gained before embarking on a follow-on programme, so it felt that the successful completion of the flight testing programme of Ariane was essential before embarking on a new phase.[1570] This position was reiterated when the Programme Board met in February 1979. The German delegation, along with some other delegations, approved the proposal to raise the performance of Ariane to 2300 kg in GTO, but felt that it was "premature to start the follow-on programme before possible users had been identified and the qualification flights had taken place". Notwithstanding the hesitations of Germany (and Spain, which was most unhappy about its industrial return in the Ariane Programme), the Executive was asked to prepare a detailed proposal on a "preparatory phase". This phase would involve those tasks associated with the eventual development of an upgraded launcher which necessarily had to be undertaken soon if continuity in development was to be assured.[1571]

In June 1979 the Council agreed to embark on a preparatory phase, to be carried out as optional programme in the framework of ESA and costing 3.6 MAU.[1572] Of this amount 1.6 MAU was for studies and tests related to the development of the boosters and to increasing the capacity of the third stage, while 2.0 MAU was for the acquisition of long-lead items associated therewith (e.g. solid propellant ingredients). What was still not settled was the scale of contributions. One option held that it should be according to the work allocated during just the preparatory phase (of which initial estimates had 69% for Italy, 16% for France and 12% for Germany). An alternative was to use a scale based on the envisaged distribution of work for the development of the Ariane-2 and 3 configurations. After protracted negotiations it was the latter scheme that was adopted. Only four states agreed to participate in the Programme, the others seeing no industrial benefit in it. The scale of contributions was settled at France 56%, Italy 28%, Germany 12% and Switzerland 1.2%.[1573]

12.1.2 The four slice solution

On Christmas Eve 1979 the first, and successful launch of Ariane took place. Its psychological impact was enormous. In the words of the resolution adopted by the Programme Board meeting soon thereafter, it was "a brilliant demonstration of [Europe's] industrial competence in carrying out a high-technology multinational programme", and gave "the assurance that, within a short time, Europe [would] have its own satellite launching capability".[1574] One of the main obstacles to the formal

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1570 From the minutes of the 28th Council meeting in December 1978, ESA/C/MIN/28, 26 January 1979, Annex IV, and add. 1, 19 February 1979.

1571 ESA/PB-ARIANE/MIN/24, 4 April 1979, meeting held on 6 and 7 February 1979. The idea of the preparatory phase is developed in ESA/PB-ARIANE(79)8, 24 January 1979.

1572 The minutes of the meeting held on the 26 and 29 June 1979 are ESA/C/MIN/32, 19 July 1979. The resolution is ESA/C/XXXII/Res. 9, 28 June 1979. The background papers by the Executive are ESA/PB-ARIANE(79)16, 28 February 1979 and ESA/C(79)35, 14 March 1979, and its add. 1 and add. 2 (ESA 560). See also ESA/PB-ARIANE/MIN/26, 1 June 1979, meeting held on 23 April 1979.

1573 See ESA/PB-ARIANE(79)30, 29 August 1979 and ESA/C(79)119, 4 October 1979 (ESA 636).

1574 ESA/PB-ARIANE/XXX/Res.1 taken at meeting on 29-30 January 1980, attached to ESA/PB-ARIANE/MIN/30, 13 February 1980.

commitment to a Follow-on Development Programme (FOD) was thus removed, and the Executive immediately presented its revised proposal to upgrade Ariane and to make it more competitive with American launchers. It turned out to be more difficult to win assent to that programme than hoped, not because of any intrinsic doubts about its value and necessity, but because of a number of technical and administrative problems that it posed to national state bureaucracies.

The main consideration impeding the rapid adoption of the Ariane FOD proposed by the Executive in January 1980 was the escalation in its proposed cost since the first estimates had been presented to governments. The initial cost of the FOD as presented in 1978 had been just over 60 MAU; the new figure was almost 139 MAU in mid-1979 conditions. The main cause of this increase was "a considerable under-estimation of industrial costs", e.g. for the modification and development of the fairings, though other items, like a downrange station in the Ivory Coast, had been added.[1575] No one objected in principle when the Programme Board first discussed this Programme, but the Swiss delegate "keenly regretted that the estimates relating to the Programme had been so profoundly modified less than a month after the Swiss authorities, on the basis of previous figures, had agreed to Switzerland's participation in the Programme". The German delegate raised another technical doubt: the cost increase might lead many national authorities to see the FOD as "a new development programme rather than an uprating programme". This would complicate considerably its passage through the bureaucracy.

Faced with these objections the Executive prepared a new proposal for the next meeting of the Board. Here it did two things: it reduced the overall financial envelope of the Programme, and cut the FOD into four slices, each one of them optional for those Member States who declared their interest in the Programme as a whole, itself optional. What is more the cost of the first slice was estimated to be just over 70 MAU at mid-1979 prices, i.e. eminently close to the figure first proposed in 1978 (adjusted for inflation).

How were costs reduced? In addition to making some technical changes to the launchers themselves, some items were totally removed from the Programme – for example, the downrange station in the Ivory Coast, and several contingency allowances (on the grounds that these would be automatically covered by the 20% rule anyway). The Executive also left undefined some items which had been previously budgeted for – the modifications to the fairing and the design and development of the recovery system for the first stage, for example – restricting these activities to the study phase.

Within this framework the Executive proposed that the FOD be fragmented as follows.

Slice 1, costing about 70 MAU, would cover the modifications to the launcher which were needed to bring its performance up to 2420 kg into GTO. Slice 2 would be dedicated to increasing the capacity of the fairing, and its full cost was left open, pending studies then under way, particularly regarding the option of increasing its diameter. The third slice would concern the possible recovery of the first stage. Here too only 1.3 MAU was earmarked for the demonstration of the feasibility of the scheme; the costs of design and development, originally estimated at about 15 MAU, were now left open, and dependent on the results of the feasibility study. Finally slice 4 (2 MAU) involved the study of a second launch site, which would allow for an increase in the launch rate above six per year and which would be needed if a further, bigger launcher (Ariane-4) were agreed on, as this would require a new servicing tower.[1576]

The new proposal was discussed by the Programme Board meeting on 20 and 21 March 1980.[1577] While there was general agreement with the idea of carving up the Follow-on Development Programme, there were concerns about setting a deadline for the start of Slice 2 which, the Executive said, should be agreed before June 1980. Several delegations also drew a sharp distinction between financing

1575 ESA/C(80)3, 11 January 1980, with cover note ESA/PB-ARIANE(80)5, 21 January 1980.
1576 ESA/C(80)3, rev.1, 7 March 1980, attached to ESA/PB-ARIANE(80)15 is the revised proposal describing the slices.
1577 EDSA/PB-ARIANE/MIN/31, document dated 6 May 1980.

improvements to the performance of the launcher (as in Slices 1 and 2), and financing measures which, they felt, simply increased cost-effectiveness (as in Slice 3). The latter, they suggested, should be the responsibility of Arianespace, recently established (see Chapter 11). But these were essentially technicalities. The Board was "anxious that every effort be made to enable a decision on the Programme to be taken as soon as possible", and asked the Council to authorise the start of the FOD subject to the potential participants formally declaring their interest in it, and adopting the appropriate institutional measures for its implementation.[1578] These arrangements were subsequently discussed at an *ad hoc* meeting of delegates on 7 May, from which a draft declaration emerged.[1579] Notwithstanding the failed launch of L02 on 23 May (the rocket was destroyed about 105 seconds after lift-off),[1580] this proposal won general approval in the Council on 26 June, subject only to the deletion of a clause which engaged the participants to take a decision on Slice 2 of the Programme in July 1980.[1581] The Member States were not to be deterred by one setback, no matter how distressing, and a week later Germany, Belgium, Spain, France, Italy and Switzerland had subscribed to the declaration.

The declaration committed the participating states to embark on the first slice of the FOD at a cost of 70.12 MAU at mid-1979 price levels. It left participants free to participate in any slice that they wished (Switzerland, hosting the firm manufacturing the fairings, would make a major contribution to Slice 2, for example, while Denmark would only participate in Slice 4). It authorised ESA to draw up an agreement with CNES for the implementation of the work "on conditions similar to those of the preparatory phase of the Follow-on Development Programme". It also allowed for the preparation of a convention with Arianespace intended to ensure that the firm "incorporates the improvements resulting from the present Programme in the industrial manufacturing process of the Ariane launcher". A provisional scale of contributions was defined for nine participating states, in which France paid about 60% of the costs, and Germany and Italy about 18% each, the final distribution to be settled by October 1980 on the basis of the contracts awarded to industry.[1582]

With Slice 1 agreed, the Executive quickly prepared a more detailed definition of the other three slices of the FOD.[1583] Slice 2 now had two components. Firstly, it was proposed simply to modify the fairing of Ariane to enable it accommodate two satellites of the STS/SSUS D class using the Sylda. Secondly, it was suggested that a large diameter fairing also be developed for use with both Ariane-3 and ultimately Ariane-4 (see section 3.1.3). The external diameter of this fairing would be increased to 4 metres, its length would be compatible with a single launch on Ariane-3 or a dual launch on Ariane-4, and the complete payload would be integrated under the fairing in the payload building before being mounted on the launcher. The SYLDA structure as such would be abolished, and the upper satellite would simply be supported by the lower part of the fairing. The total cost of this Programme was 11.4 MAU, the bulk of it for the large diameter fairing. In September 1980 the Programme Board agreed on the desirability of embarking on the first component of this slice of the Programme, in which Switzerland emerged as the only participating state.[1584]

As regards Slice 3, in its August 1980 proposal the Executive simply called for a commitment to study the feasibility of recovering the first stage and boosters of the launcher, to be parachuted back into the

1578 Report of the Chairman of the Board to the Council, ESA/C(80)26, 24 March 1980 (ESA 707).

1579 ESA/AR-FOD/MIN/1, 12 June 1980 (ESA 4656).

1580 ESA/PB-ARIANE(80)21, 26 June 1980 gives the launch sequence, while the report of the ESA/CNES review group is attached to ESA/PB-ARIANE(80)40, 15 October 1980.

1581 ESA/C/MIN/42, 26 August 1980.

1582 An early proposal for the institutional framework is ESA/C(80)14, rev.1, 7 March 1980 (ESA 697). The near final Declaration is ESA/PB-ARIANE(80)12, rev.3, 9 May 1980 while the final version is ESA/C/XLII/Dec.1(Final). The final text of the associated Implementing Rules is ESA/PB-ARIANE(80)28, rev.3, 21 May 1981. The delay in settling them was caused by doubts about how to define a launcher as qualified if there were no test flights - see ESA/PB-ARIANE(81)4, 13 January 1981. The near final version of the Agreement with CNES for the FOD is ESA/PB-ARIANE(82)17, rev.3, 4 February 1983.

1583 ESA/PB-ARIANE(80)37, 26 August 1980.

1584 ESA/PB-ARIANE(80)37, rev.1, 24 September 1980.

sea, and to assessing the economic interest of the operation (which could amount to as much as 2 MAU per flight). The cost of this first phase was estimated to be just over 2 MAU; if successful it was thought that development might require a further 7.2 MAU at mid-1979 prices. In October, France, Germany and the Netherlands agreed to undertake this first phase of this Programme. The UK was included via a bilateral arrangement between London and Paris.[1585]

It proved difficult to implement the feasibility study. The failure of the fifth launch of Ariane on 10 September 1982, due to problems with its third stage, made everyone nervous.[1586] Plans to test the recovery system on the first flight of V6 were abandoned in the interests of excluding all possible perturbing factors. This delayed the Programme considerably, as the performance margins on the last three launches of the promotion series and the first four Ariane-3 launches were insufficient.[1587] Costs escalated while Arianespace became increasingly unwilling to tamper with a successful product. In April 1984, while confirming his interest in the recovery project, the company's Director General Charles Bigot laid down extremely tight terms under which he was prepared to use any Slice 3 hardware operationally. All necessary qualification and validation tasks had to be carried out, clients had to have no doubt that the refurbished launcher was as reliable as the existing one, and the economic value of the scheme had to be demonstrated "without reservation".[1588] In the event by March 1985 the feasibility study for Slice 3 had reached the 120% limit of expenditure, and the development phase was still not decided.[1589]

In fact it was never undertaken. The recovery system was tested on 2 July 1985 on launch V14 which was used to send the Giotto scientific satellite to explore Halley's comet. It ended in failure, due to a malfunction in the parachute system. Granted the time required to qualify an improved system it was decided to abandon the idea of launcher recovery, not simply for Ariane-2/3 but also for Ariane-4, on the grounds that it was not economically attractive enough.[1590]

Finally we come to Slice 4. By October 1980, when the Programme Board discussed financing the development of a second launch site, the context in which the decision had to be taken was changing rapidly. In particular the ESA DG was involved in negotiations to launch an Intelsat VI satellite whose RFQ (Request for Quotation) was due to be issued in March 1981. Intelsat was willing to make its satellite compatible with both Ariane and the Shuttle, but only on condition that the new, more powerful Ariane-4 system had been fully approved, since Ariane-3 could not lift the foreseen 3500 - 4000 kg satellite. This in turn meant that the Europeans would have to commit themselves to providing a second launch complex labelled ELA 2 (Ensemble de Lancement Ariane) at Kourou.[1591] Faced with this new situation the Executive provided strong arguments for embarking on the construction of ELA 2 whether or not the contract with Intelsat was signed. They stressed the possible disruption to launch schedules if an accident at lift-off damaged the launch pad. They noted that NASA, which had two sites for each of its Delta and Atlas rockets, was pointing to the lack of launch guarantees by its European competitor, occasioned by the fact that it had only one launch site. A single launch site also restricted the rescheduling of launches entailed by changes in satellite development timetables, while two launch sites also enabled one to increase the launch rate. ESA and CNES engineers also pointed out that a new launch site would be needed anyway for Ariane-4, if only because the existing towers were too small.[1592] At the meeting of the Programme Board on 17 October

1585 ESA/PB-ARIANE(80)44, 29 October 1980 has the Declaration as an attachment.
1586 For a first report see ESA/PB-ARIANE(82)35, 20 September 1982.
1587 ESA/PB-ARIANE(84)24, rev.1, 3 September 1984.
1588 Letter Bigot to ESA DG, 24 April 1984, ESA/PB-ARIANE(84)24, rev.1, Annex, 3 September 1984.
1589 ESA/PB-ARIANE(85)16, 25 March 1985.
1590 ESA/PB-ARIANE(85)53, 21 November 1985.
1591 For the Intelsat negotiations see the DG's internal memo of 7 November 1980, *Ariane-4; Required Actions* in (ESA4801).
1592 ESA/PB-ARIANE(80)39 and later ESA/PB-ARIANE(81)10, 15 January 1981.

1980 Germany, Belgium and France agreed to put up 90% of the costs required to define the requirements for this second launch site (amounting to 2 MAU).[1593]

Slice 4 was never extended beyond that phase. Instead, in the light of the Intelsat negotiations, at the end of April 1981 a number of Member States undertook to fund a number of interim measures costing 7 MAU "to ensure that the infrastructure work in Guiana relating to the second Ariane launch site can start" so that ELA 2 could be operational at the end of 1984.[1594] In July 1981 the development of the second launch facility was definitively transformed into an optional programme in its own right at a cost of some 100 MAU. It comprised two main zones, one for launcher preparation and one for the launch itself, connected by railway lines. Its aim was to provide redundancy for the existing launch site, to increase operational flexibility and competitiveness by reducing the interval between launches to a minimum and by optimising operational costs, and to develop a payload preparation zone in keeping with the operational objectives of the Ariane Programme. The Declaration was subscribed to by seven states, Germany, Belgium, Denmark, Spain, France, Italy and Switzerland. The UK again participated via a bilateral agreement with France.[1595]

The FOD made a major contribution to the technical and financial success of Ariane. The first flight of Ariane-3, V10, took place on 4 August 1984. The rocket placed an ECS2 and a Telecom 1A satellite in orbit. Ariane-2 and Ariane-3 made 16 more flights, only two of which were failures. The last in the series was an Ariane-3 rocket launched on 12 July 1989, which placed the Olympus satellite in orbit.

12.1.3 Ariane-4

Early in 1981 the ESA Executive prepared a paper for the Ariane Programme Board describing in broad outline the technical specifications and cost of the kind of European launcher that would be required from 1985 onwards, and giving an idea of how the design of Ariane-4 would differ from that of Ariane-2/3. [1596] The potential telecommunications market was uppermost in their minds. As we already mentioned, discussions between the ESA and Intelsat Executives a few months before indicated that the new Intelsat VI series of satellites would be designed to be compatible with both the Shuttle and a more powerful Ariane rocket – on condition that when the contracts for the spacecraft were awarded early in 1982 formal agreement to proceed with Ariane-4 had been achieved.[1597]

The definitive Programme Proposal was laid before the Programme Board in September 1981.[1598] It began by stressing the great strides already made in capturing a slice of the launcher market. It was safe to say that the European launcher would be used for some twenty launches of about thirty satellites between the end of 1981 and 1985. More importantly, all international calls for satellite tenders now required that the spacecraft be compatible with Ariane. In short, "Ariane [had] become a reality on the market for launch services, alongside the American Thor Delta and Atlas Centaur and the Shuttle". Indeed Ariane-3 could launch two satellites compatible with the most powerful Thor Delta (the 3920) with greater precision, in a less severe environment, providing a larger volume for the payload, and at a slightly lower cost (FF 105 million as against FF 110 million in 1978 prices). Both

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1593 For the decision to undertake the slice see ESA/PB-ARIANE(80)44, 29 October 1980. The level of guaranteed contributions required to start the study was revised down from 95% to 90% in ESA/PB-ARIANE(80)44, add.1, 9 December 1980.

1594 For a survey of the issue see ESA/C(81)30, 14 April 1981. See also the minutes of the special Programme Board meeting on 19 April 1981, ESA/PB-ARIANE/MIN/39, 30 April 198. The interim measures were adopted on 29 April 1981, ESA/C/XLVII/Res. 1 (Final), and the Declaration by the Participating States was circulated as ESA/C(81)43, Add. 1.

1595 The Declaration for the optional programme is ESA/PB-ARIANE/XLI, Dec (Final), rev. 4, drawn up on 9 July 1981, updated on 10 December 1981 and 17 March 1982. It was issued as ESA/C(81)55 rev. 2. The final scale of contributions is in ESA/C(83)19

1596 The document is ESA/PB-ARIANE(81)11, 13 January 1981.

1597 Memo R. Orye to Directors, 5 November 1980 (ESA 4801).

1598 It is document ESA/PB-ARIANE(81)47, rev. 1, 24 September 1981, discussed at the Board's meeting on 24-5 September 1981, ESA/PB-ARIANE/MIN/42, 22 October 1981.

Ariane-2 and 3 could launch heavier payloads than the Atlas Centaur under equivalent technical and financial conditions.

Ariane also had considerable technical advantages over the Shuttle. The mass at lift-off of the Shuttle was ten times greater than that of Ariane. However, the mass placed in low-Earth orbit was only six times greater, and that in geostationary transfer orbit only twice greater, than that possible with Ariane. This was because the entire Orbiter had to be placed in low orbit each time, and because of the need to fit a complex perigee system, weighing five times the mass of the satellite, for transfer purposes. Safety requirements imposed by the man-rating of the Shuttle meant that solid boosters needed to be used for these perigee motors, reducing the precision of the orbit achieved. The possibility of returning to Earth with the satellite in case of a launch abort also imposed severe requirements on the dimensions of the spacecraft since the stresses on its structure were located along different axes during ascent and re-entry. Table 12-1, drawn from an internal document of July 1980 summarises the technical differences between the two systems, as seen by Intelsat, and illustrates the distinct advantages of an expendable system of the Ariane-4 class over the re-usable Shuttle concept.[1599]

The perigee motors which NASA planned to fit to the Shuttle cargo bay for transfer purposes defined two classes of satellites: 'small', with transfer masses of 1300 to 1500 kg and mounted perpendicularly to the Shuttle cargo bay, and 'heavy'. The latter would be mounted longitudinally in the bay, and would typically be the of Intelsat VI type, i.e. mass 3500 to 4000 kg and diameter 3.6 metres.[1600] This version meant that if Ariane was to remain technically competitive with the Shuttle a more powerful version than Ariane-2/3 was essential. The latter was limited to 2400 kg and would not even be able to carry out dual launches of some satellites optimised for the Shuttle's cargo bay. Of course it was difficult to know if the European launcher could be price-competitive – in principle, Shuttle prices were currently lower but then they were constantly being revised upwards. On the other hand to stop now would systematically eliminate the European launcher from the world market.

The Executive suggested that the new rocket should be able to launch together a direct TV satellite of about 2300 kg and a telecommunications satellite of about 1200 - 1500 kg, or a satellite of the Intelsat VI class. Its payload capability had to be some 4300 kg and there had to be a substantial increase in the useful volume in the fairing to ensure that the launcher's performance was adapted to growth in the market over a decade. The resulting configuration proposed for Ariane-4 was intended to make the maximum possible use of the technologies already developed for Ariane-3 and to be flexible enough to be adapted to a range of different clients (see Figure 12-2).

The rocket consisted of a central body derived from Ariane-3, with three powered stages surmounted by an equipment bay. Flexibility was achieved by attaching one or two pairs of boosters to the first stage, and by having a set of fairings of different sizes and shapes. Basic propulsion was provided by

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1599 From *Launch systems for Intelsat VI*, BG/T-33-18E W July 1980, 23 July 1980, attached to memo R. Orye to Directors, 5 November 1980 (ESA 4801).

1600 The Intelsat paper of July 1980 just quoted considered three ways the transfer might be achieved. One involved using an Inertial Upper Stage which was completely integrated with the STS for both perigee and apogee injection, and which had been flight-qualified prior to its use on Intelsat VI. The main drawback here was one of cost. A second solution involved the NASA contractor developing a new stage for perigee injection (the so-called SSUS-X) by making maximum use of existing qualified hardware and previous STS integration experience. This approach minimised cost and risk. The contractor would, however, have to negotiate and administer a large subcontract, and the system would impose on the Intelsat spacecraft the constraints associated with a shared launch (see Table 12-1). The third alternative overcame this drawback, but involved actually integrating the perigee injection system into the Intelsat spacecraft. It had two notable disadvantages compared to the other two solutions. For one thing, Intelsat would be the programme manager for the development of the perigee stage, which could lead to interface disputes with NASA. For another, since this type of design tended to be STS-optimised it would need significant spacecraft modifications to make it compatible with Ariane

Table 12-1. Comparison of Ariane-4 and Shuttle as launch systems for the Intelsat VI series of spacecraft, as seen by Intelsat in July 1980.[1601]

Feature	Ariane-4 cargoes	STS cargoes
Size and mass of spacecraft	Size limited by fairings and mass by the transfer orbit payload capability	Both greater than Ariane-4. Since STS is limited to low orbits it needs an upper stage system for geosynchronous missions.
Dedicated and shared launches	Always dedicated launches for Intelsat VI type satellites	If launched on a shared basis into standard NASA launch window, constraints would be imposed on spacecraft thermal and power subsystem design and on that of attitude determination subsystem
Thermal provisions	No special provisions	Often require independent thermal conditioning systems and/or sunshields, or special spacecraft manoeuvres, when cargo doors are open
Command, control and monitor interfaces with the spacecraft/upper stage	Mostly throughputs, which would be terminated at lift-off	Safety conditions require significant redundancy for some circuits at launch and that these are exercised throughout the parking orbit and until payload is safely ejected from cargo bay
Spacecraft propulsion and pyrotechnic systems	As for Atlas/Centaur and are easily accommodated by the present reliable spacecraft designs	Drastically affected by safety requirements. For Intelsat V NASA classified as catastrophic to the Orbiter, the inadvertent operation of apogee motor firing, thruster firing, antenna deployment, solar array deployment and spacecraft separation. All had to be two-failure tolerant, both mechanical and electrical, with all inhibits being monitored
Cost (estimates in 1980 dollars)	$55m for a dedicated launch	$70M for a dedicated launch $43-49M for a shared launch

four Viking engines, as in Ariane-3, fed from two propellant tanks with a total capacity of 220 tons, compared to 140 tons for Ariane-3. Burn times were about 200 seconds (148 seconds for Ariane-3).[1602] The enlarged capacity was obtained by lengthening the tanks, so increasing the height of the first stage by over 6 metres, to approximately 27.9 metres. The second and third stages and the equipment bay were essentially identical to those of Ariane-3. The second stage (L33) was powered by a Viking engine fuelled by 33 - 34 tons of propellant, and it was topped by H10, a cryogenic stage burning 10.5 tons of LOX.

1601 From *Launch systems for Intelsat VI*, BG/T-33-18E W July 1980, 23 July 1980, attached to memo R. Orye to Directors, 5 November 1980 (ESA 4801).

1602 R. Orye suggests 210 secs, but the figure of 200 secs was given in the document.

boosters were the new element in the launcher, though they were based largely on existing technology. They were about 16 metres high and 2.3 metres in diameter, and their Viking 6 engines were fuelled by 37.5 tons of UDMH and N_2O_4.

The monocone fairings had a diameter of 4 metres (useful diameter 3.65 metres) and could be 9.6 or 11.8 metres high. The SPELDA adapter for dual launches was planned for use with a 4 metre diameter fairing having a height of 8.3 metres. SPELDA (= Structure Porteuse Externe de Lancement Double Ariane) had an external part which served as a boat-tail for the fairing, unlike SYLDA which was housed entirely inside the fairing.

As shown in Table 12-2, Ariane-4 could put between 2000 and 4300 kg into geostationary transfer orbit, a figure to be compared to the 2400/2460 kg of Ariane-3. Its development cost in mid-1981 prices was estimated by the Executive to be just over 225 MAU, of which 214 MAU were for industrial work. The balance was split more or less equally between the costs of managing the Programme in ESA and in CNES, and the cost of managing the facilities (~6 MAU).[1603]

[1603] For these cost figures see ESA/PB-ARIANE(81)47, rev. 1, add. 1, 26 November 1981.

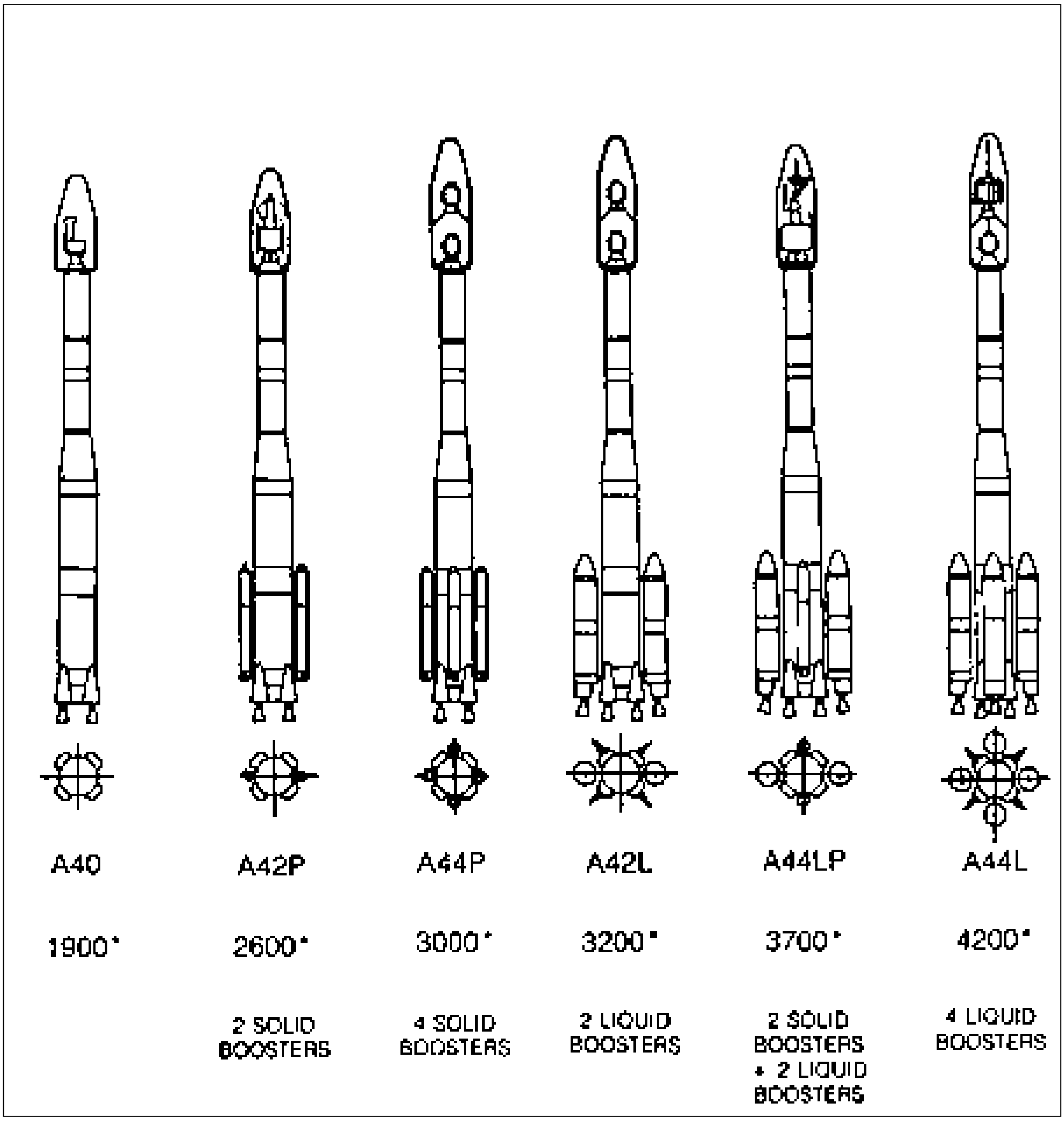

Figure 12-2. Configuration of the Ariane-4 launcher showing the bulbous fairings (Source: ESA/PB-ARIANE(81)47, rev. 1, 24 September 1981).

Table 12-2. Estimated mass in transfer orbit of spacecraft launched by Ariane-4 under various configurations with solid and liquid boosters.[1604]

Model	Solid	Liquid	Payload in orbit
Ariane-40	None	None	2000 kg
Ariane-42p	Two	None	2740 kg
Ariane-44p	Four	None	3180 kg
Ariane-42L	None	Two	3300 kg
Ariane-44Lp	Two	Two	3840 kg
Ariane-44L	None	Four	4300 kg

The Executive made an effort to estimate the competitivity of the new launcher with the Shuttle. This was difficult as the prices of the American system in 1986, when Ariane-4 was to become operational, were difficult to know. NASA had announced that they would rise by 56% after 1985, to $30 million (1975 dollars) but it was possible that this was an optimistic assessment. In any event the Executive showed that if NASA raised the Shuttle price by 80% instead of the 56% announced, and if Ariane launch prices were aligned on those of the Shuttle, then no matter what mission model was chosen Arianespace would break even or show a surplus if the rocket was sold at the estimated production cost of FF 290 million (1980 francs, $ 58 million). Under some mission model assumptions it was even possible for Arianespace to break even if the Shuttle price only increased by the announced 56%. The commercial viability of the rocket was then more or less assured.

It was important for ESA to make a commitment to develop Ariane-4 before the end of 1981 so as to have a rocket agreed when the choice was made for the Intelsat VI spacecraft. The bids had been submitted in July, the contractor was due to be selected in November/December 1981, and the contract placed in March 1982. The invitation to tender had insisted on the compatibility of all spacecraft with both the Shuttle and Ariane. The assurances given Intelsat until then had sufficed to ensure that the European rocket still had a fair chance. But this goodwill was not guaranteed to last, particularly if some low-price bids were made for spacecraft not compatible with Ariane-4. The Executive proposed that the development of Ariane-4 be treated as an optional ESA programme. Since for such programmes any Member State had the right to declare itself not interested within three months of the corresponding Council resolution being passed, the Executive suggested that the Council should formally commit itself by October, to develop Ariane-4.[1605] This deadline was duly respected. A resolution approving the execution of the development of Ariane-4, and inviting the interested Member States to adopt as soon as possible the relevant legal and financial provisions was adopted by the Council on 28 October 1981.[1606]

A lengthy discussion of the final shape of the Programme was held at the Ariane Programme Board meeting on 5-6 November, 1981.[1607] A number of changes were made to the launcher in the light of this debate.[1608]. At the insistence of the Italian delegation, the possibility of using more powerful solid-fuel boosters, in which Italian industry had made considerable investments, was included. The basic cost envelope of the rocket was reduced to 200 MAU, mostly at the expense of the industrial work. It was

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1604 From ESA/PB-ARIANE(81)47, rev. 1, 24 September 1981, p.14.

1605 We remind the reader that unless otherwise stated the material above is all from ESA/PB-ARIANE(81)47, rev. 1, 24 September 1981.

1606 A draft resolution is attached to ESA/C(81)73, 23 October 1981, while the final version is ESA/C/L/Res. 4 (Final), 30 October 1981, attached to ESA/C/MIN/50, the minutes of the meeting held on 27-8 October 1981, document dated 30 November 1981.

1607 The minutes are ESA/PB-ARIANE/MIN/43, document dated 22 December 1981.

1608 See (Draft) Declaration ESA/PB-ARIANE(81)49, rev. 1, 12 November 1981. Other legal texts defined in this period were the Implementing Rules defining the different responsibilities of the Programme Board, ESA and CNES, ESA/PB-ARIANE(81)55, rev. 4, 26 February 1982 (see also ESA/PB-ARIANE(81)57, 27 November 1981), and the Agreement between ESA and CNES, of which an early draft is ESA/PB-ARIANE(82)26, rev.2, 4 October 1982.

subsequently increased again to 207.16 MAU.[1609] The Declaration by the proposed participants was revised to express these changes, but it naturally took some time for it to wend its way through the various national bureaucracies of the participating states. To speed up its adoption, on 13 January 1982 the French delegation guaranteed the funding necessary to cover the 80% of the envelope required for the declaration to enter into force, so that work on the Programme could get under way immediately.[1610]

Table 12-3. Evolution of the scale of contributions with the changing circumstances surrounding the Ariane-4 development Programme.

Country	Initial scale of contributions % in Feb '82	Geographical Dist. of Work % in Feb '84	'Definitive scale' % in Feb '84	Revised scale % in Feb '85
Germany	20.79	19.5	20.79	18.19
Belgium	2.80	3.64	3.68	4.58
Denmark	0.15	1.47	0.18	0.18
Spain	2.50	2.16	1.70	2.00
France	52.90	56.22	56.22	56.99
Ireland	0.04	0.08	0.04	0.08
Italy	7.75	7.21	7.75	6.97
The Netherlands	2.00	1.25	1.40	1.10
United Kingdom	3.55	4.95	5.10	3.73
Sweden	1.39	1.39	1.46	1.21
Switzerland	1.60	1.68	1.68	1.75
Coverage	100%	100%	100%	96.68%

The scale of contributions evolved along with the distribution of work and underwent an important change when it was found that the cost-to-completion of the project would be substantially more than originally foreseen. An initial scale of contributions was proposed in December 1981, and slightly modified in February 1982 to accommodate the increase in the cost-to-completion from 200 MAU to 207 MAU and the distribution of work at the start of the Programme (Column 2, Table 12-3).[1611] As the project evolved, so too did the distribution of work, and two years later, in February 1984, a new and 'definitive' scale was drawn up to reflect the new situation (Columns 3 and 4, Table 12-3).[1612] This scale was soon changed again, however, for in June 1984 the delegations were informed that the project cost would exceed 120% of the financial envelope foreseen when the Programme was adopted. The Executive, in consultation with CNES, proposed that a new financial envelope be adopted which was 140% of the original cost-to-completion, or 376.2 MAU in mid-1983 prices. Meeting in February 1985 all of the participating states agreed to waive their right to withdraw from the Programme, a right which they were entitled to exercise since it had crossed the 120% cost increase threshold. They could only accept a compromise scale of contributions, however, which left a little over 3% of the budget uncovered (Column 5, Table 12-3).[1613]

Two main reasons were given for the cost overrun. Firstly there were unanticipated impacts from difficulties encountered with programmes under way (promotion, production and Ariane-3), amounting to 40 MAU in 1980 prices. Almost half of this was for qualification of the first stage of the

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1609 See ESA/PB-ARIANE/MIN/45, meeting held on 25-6 January, 1982, document dated 4 March 1982.

1610 ESA/PB-ARIANE(82)8, 18 January 1982.

1611 The initial scale as set forth in ESA/PB-ARIANE/XLIV/Dec. 1was amended at the meeting of the Programme Board on 25-6 January 1982, minutes ESA/PB-ARIANE/MIN/45, document dated 10 March 1982 and adjusted to fit the distribution of work – see ESA/PB-ARIANE(82)11, 10 February 1982.

1612 ESA/PB-ARIANE(84)2, 10 February 1984.

1613 ESA/PB-ARIANE(85)12, 1 March 1985, to which is attached the Resolution adopted by the Programme Board on 19 February 1985. The preparatory document is ESA/PB-ARIANE(84)42, add. 1, 22 January 1985.

rocket, originally planned as part of the Ariane-3 Programme. The second main reason for the cost overrun lay in technical problems specific to Ariane-4 (amounting to 35.5 MAU in 1980 prices) and which affected all components of the rocket.[1614] These technical changes, it should be said, were distinct from those innovations or additions made to the design of the rocket after the project was first adopted. To accommodate such changes the *Slice* system was implemented. Thus the initial Programme agreed on in 1981 and now costing 376 MAU was called Slice 1. Subsequent slices were for specific new components and the distribution of work and funding of them was used to redress imbalances in industrial returns on the overall Programme. Slice 2, for example, was for a carbon fibre skirt between stages 2 and 3, a light-weight technology which reduced the weight of the rocket by 53 kg and so improved performance. The financial envelope was estimated to be 3.354 MAU in 1983 prices, and although 91% of the work would be done in the Netherlands and the remainder in France, the Netherlands agreed to fund the entire slice.[1615] Slice 3 was for a gyrolaser inertial platform. Slice 4 funded the development and qualification of a payload adapter, and the supply of a dummy representative of a satellite. Slice 5 was a technological support programme for Ariane-3 and 4 and Slice 6 was for adapters between the launcher and the spacecraft.[1616]

Slice 5 deserves special mention. A product improvement programme for Ariane-3 and Ariane-4 was an integral part of the European Long-term Space Plan approved by Ministers in Rome in 1985. As the Executive put it to the Ariane Programme Board in April 1985, "Experience in the United States and Europe with aircraft, aero-engines and launchers has shown that a product improvement programme is essential if a complex technological system is to maintain its capabilities".[1617] Its aim was to gradually and continuously improve the reliability and safety of the launchers in service over a period of some ten years. It was broken down into two kinds of activity. Firstly, continuous activities, programmable in advance (like "checking changes in the characteristics of the launcher, by means of thorough analysis of data measured during flight" or "inspecting hardware after use where this can be wholly or partially recovered"). Secondly, one-off activities, programmable as the occasion arose (e.g. eliminating identified weaknesses in the launcher or introducing improvements stemming from the availability of new technologies). As the content of the programme would necessarily evolve, the Executive proposed that the annual level of expenditure be about 15 MAU, while the precise definition of the content and its approval by the Programme Board be on a three-yearly basis.

The first formal Declaration by the States participating in the Programme was drawn up on 27 February 1986.[1618] It made provision for 38.6 MAU of funding (in mid-1985 prices) to cover the first three years of the Programme (1986 to 1988). Towards the end of that period it was agreed to fund what was now called the ARTA (Ariane Research and Technology Accompaniment Programme) for another four years at a cost of 147 MAU in mid-1988 prices. Later another declaration was adopted making 248 MAU (mid-1987 prices) available to cover work over the decade from 1989 to 1999. This ongoing Improvement Programme, in the words of Raymond Orye, is "considered to be one of the key elements in the Ariane Operational Programme's success".[1619]

The close technological affinity between Ariane-4 and Ariane-3 necessarily entailed that the fortunes of the new member of the family were tied up with that of its predecessor. The failures of Flight 15 and then of Flight 18 of Ariane-3 in September 1985 and in May 1986, respectively, necessarily impacted on the development schedule of Ariane-4. Its first flight with two solid and two liquid boosters took place on 15 June 1988. A string of successes of the Ariane series over the next few months and the potential of the market led Arianespace to place an order for 50 more launchers on 15 February 1989. These incorporated important technical changes to the second and third stages

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1614 For details see ESA/PB-ARIANE(84)42, 26 November 198
1615 See ESA/PB-ARIANE(84)6, 2 February 1984.
1616 The declarations concerning these slices, including more detail on their technical content, are available in the collection of ESA Basic Texts.
1617 See ESA/PB-ARIANE(85)19, 3 April 1985, and ESA/PB-ARIANE(85)19, rev. 1, 28 August 1995
1618 These texts are in the collection of ESA Basic Texts, now available on CD-ROM.
1619 R. Orye, private communication with J. Krige.

which increased the useful payload by about 200 kg. The fiftieth flight of Ariane was the first of Ariane-4 equipped with a new, longer and more powerful third stage and it took place on 16 April 1992.[1620] The hundredth Ariane rocket in this series climbed into the sky above Kourou in September 1997.

12.2 Ariane-5

Towards the end of 1980 the ESA Executive began to encourage reflection on the programmes which would form the backbone of the Agency in the decade to come. The major programmes adopted in the first and second package deals, Ariane and Spacelab, had reached maturity, as had some of the application satellites. With this first phase of development over, the time had now come to look ahead. A ten-year plan was needed which recognised that Europe could not hope to be competitive with the superpowers in all space areas, and which (following preliminary consultations with delegations) would need to define a baseline programme costing some 450 MAU annually (1979 price level, 1980 conversion rates).[1621]

This was the first step towards the definition of the Long-Term Space Programme which we described in Chapter 2 of this volume. We shall simply concentrate here on those aspects of this Programme which had a direct bearing on the decision to embark on the development of Ariane-5 at the Ministerial Conference in Rome in 1985 and in The Hague in 1987.

In 1980/81 the policy to be adopted in the medium term was pretty clear. It required developing the Ariane family up to Ariane-4 and making the best use of Spacelab. However, at this early stage "the balance between the launcher and manned flight activities cannot be identified until we have seen, and analysed, the results of the early Ariane series and the early Spacelab flights". As for the long term, studies which were necessarily still of a rather general nature were under way on the mission objectives and timing of a launch vehicle beyond Ariane-4. The ultimate configuration of the so-called Future European Launcher (FEL) would depend on considerations which included manned vs. unmanned systems; expendable vs. full or partly recoverable launchers; and the political implications (total European independence vs. US/European cooperation).

One version of the launcher being studied by CNES, the so-called "Ariane-5" approach, foresaw something like 5 tons in transfer orbit, for a launcher that was partly recoverable and not man-rated. No commitment on the FEL was needed yet; that would only be necessary in mid-1984. However, a new large cryogenic engine, the HM60 (60 tons of thrust, later called Vulcain) was needed whatever vehicle route was taken. Since the development cycle for such an engine was long, the Executive recommended that work begin on it in mid-1982.[1622]

This stepwise approach was endorsed by Delegations. They felt that the delays in the Ariane and Shuttle Programmes "created an unfavourable climate for taking decisions".[1623] One could better proceed once the European launcher was qualified and the Shuttle was in routine operation. What was required for the moment was to get the data needed to enable a sound decision to be taken in 1984.[1624]

As the time to make the first important financial commitments approached, the Executive began to firm up its ideas. It submitted preparatory programme proposals to the 50th meeting of the Council in October 1981, and again to the 51st meeting in December 1981. Another slightly revised version was submitted to the Council in April 1982, was looked at by the Ariane and Spacelab Programme Boards

1620 The above information is from C. Carlier and M. Gilli, *Les trente premières années du CNES. L'Agence francaise de l'espace, 1962-1992* (Paris: La Documentation francaise, 1994), 174, 180-1.
1621 ESA/C(80)80, 5 November 1980; ESA/C(81)8, 24 January 1981.
1622 ESA/C(81)8, 24 January 1981, pp. 7,
1623 ESA/C(81)35, 3 April 1981.
1624 ESA/C(81)27, 3 April 1981.

in May and laid again before Council in June, where a resolution was adopted voting funds for a first round of preparatory studies.[1625]

"The problem associated with the definition of the next generation of European launchers", the Executive said, "is not only to define the launch capability, but mainly to know for which orbit it should be optimised". One had to try to forecast the orbit carrying the main space traffic in 1995, remembering of course that the Shuttle was optimised for low-Earth orbit (LEO). Bearing this in mind the content of the preparatory programme regarding launchers as specified for the Council and the Ariane Programme Board in May 1982 was "A definition of the possible design concepts for future European launchers aimed at lowering launch costs, mainly for putting satellites into geostationary orbit, and able to extend this reduction in cost to the low-orbit field, especially if the frequency of low-orbit missions were to increase significantly. This definition will identify the likely stages of development that could lead to designs for partially or wholly recoverable launchers".[1626]

The launcher was not the only element in the Long-term Preparatory Programme of course. The Executive in fact identified three core objectives: maintenance of Europe's competitive position in respect of geostationary-orbit launch systems, extending it to include LEO; developing an orbital infrastructure and a return capability; and continued cooperation with the US in the field of manned space systems. These last two were given added weight in the spring of 1982 following NASA's announcement that the permanent presence of a man in space should constitute the main objective of the US program after the Shuttle, and its determination to open manned space programmes to international participation.[1627] To prepare the ground for decisions in each of these areas the Executive sought authorisation to spend 12.1 MAU (1981 prices) to be spread between 1982 and 1985. Some 40% of this would be for launcher studies, about 35% for the orbital infrastructure theme, and about 25% for the theme of cooperation with the US.[1628]

An indication of the work to be undertaken in 1982 was provided. It included systems studies on reusable launchers, studies on large cryogenic engine designs for such a launcher, participation of European industry in US manned space station studies, etc. In view of the fundamental nature and variety of the subjects involved in the Programme the Executive suggested that all Member States participate in the Programme, even though it be optional, and that they contribute to it on a GNP basis.[1629] This request for funding, and the associated resolutions, were laid before the Council on several occasions over a period of six months. In the absence of a decision, and with time running short, the DG decided to start some of the most urgent studies, e.g. of a large cryogenic engine, being looked into by SEP for CNES, using funds from the General Budget.[1630]

On 22 June 1982 the Council unanimously adopted a resolution concerning a 'long-term preparatory programme' for space transportation systems. Its preamble noted that both the Ariane and Spacelab Programmes, and their FOD phases, would be completed towards the middle of the 1980s, and that it was essential to prepare the ground now for "subsequent decisions on an overall European space transportation capability". This study had to take account of work already done in ESA and in national programmes, as well as look into the place of Europe "in the programme of in-orbit structures currently being examined by NASA". To that end Council agreed that a preparatory programme for a long-term space transportation system be carried out as an optional ESA programme, it encouraged all Member States to participate in such a programme, and it invited the DG to find ways of making it mandatory eventually.[1631] On 8 April 1983 the first meeting of the associated Long-Term Space

1625 The relevant documents for these early discussions are ESA/C(81)58, 7 October 1981; ESA/C(81)84, 25 November 1981; ESA/C(82)47, 13 April 1982; ESA/C(82)58, 17 May 1982, ESA/C(82)67, 14 June 1982.
1626 ESA/C82)58, ESA/PB-ARIANE(82)23, 18 May 1982.
1627 The space station decision is analysed in this volume, chapter 15.
1628 ESA/C(81)84, 25 November 1984.
1629 ESA/C82)58, ESA/PB-ARIANE(82)23, 18 May 1982.
1630 ESA/C(82)47, 13 April 1982.
1631 ESA/C/LIV/Res. 1 (Final), 22 June 1982.

Transportation Systems Preparatory Programme Committee took place, with Mr Olivier (NL) in the Chair.[1632]

The main priority in 1983 was to settle the programme for the large cryogenic engine HM60; it would take about ten years to develop and so it was a time-critical element in the development of any future launcher. HM60 had in fact been under study since 1979 under national leadership and financing, mainly by France, Germany and Sweden. With an overall cost of about 700 MAU, and with transnational industrial allegiances already in place, CNES suggested to the Ariane Programme Board meeting in July and again in October 1983, that the development of the launcher should now be Europeanised. In particular CNES proposed that an interim phase lasting from 1 January 1984 to 31 December 1985 be financed collectively; it was estimated to cost some 177 MAU in 1983 prices (this was later revised down to 138 MAU). This was to be used for the detailed design and real scale technology developments of critical subsystems of the new launcher and for the design and construction of the required test facilities. This proposal was officially confirmed by the French delegation to the Council in a letter dated 3 November 1983.[1633]

In preparing its documents and presentation, the CNES worked closely with the ESA Executive, which endorsed the concept of HM60 and the wish to Europeanise it. Along with CNES it agreed that it would be advisable to embark on an *Interim Technology Phase,* intended to get a better understanding of "critical technologies" and to define and construct the necessary test facilities. At the same time the Executive affirmed that, "without invalidating the fact that the competence and expertise of CNES will be relied on to the largest extent possible, the Executive also wishes to be involved in all aspects of future launchers to a significantly larger extent than has been the case in respect of the Ariane 1 to Ariane-4 Programmes". It added that it wanted to "strengthen its ability to contribute to the definition of future launchers", increasing its manpower so as to "ensure efficient guidance for and monitoring of the study and development work in all its detailed aspects".[1634]

This proposal was quickly rejected by Frédéric d'Allest, the then Director General of CNES, from both the Programme and management points of view.[1635] Regarding the former, he interpreted the Executive's suggestion for an Interim Technology Phase as meaning a simple technology programme. This was unnecessary in d'Allest's view. After three years of work and 20 MAU of investment the industrial partners had made their main technical choices, verified their feasibility, and established the calendar and the cost estimates for the development of an engine which was compatible with all the then-envisaged configurations of the next generation of European launchers. As for the management scheme, d'Allest was emphatic that "the French government had authorised CNES to propose the Programme for Europeanisation under conditions identical to those for the Ariane-3 and 4 Programmes, both as regarding the terms for the execution and management of the Programme and the obligations which France was prepared to assume". There was no question for CNES then of a change in the management structure such as that called for by the Executive.

In replying to d'Allest the Executive stressed that in fact there was no major point of disagreement between it and CNES, with which there was "a high level of mutual understanding and agreement".[1636] In particular it was not suggesting that there be just "a simple technological programme" nor that

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1632 The minutes of the first meeting of the Programme Committee on 8 April are ESA/LTT-PC/MIN/1, document dated 29 April 1983. For the difficulties in getting the programme under way see ESA/LTT-PC(83)2, 17 March 1983.

1633 ESA/PB-ARIANE(83)35, 5 July 1983; ESA/PB-ARIANE/MIN/53, 16 September 1983; ESA/PB-ARIANE/MIN/54, 7 November 1983. See also ESA/C(83)100, 13 October 1983. The figure of 176.7 MAU was the first official figure proposed to the potential participants in ESA/PB-ARIANE(83)53, 14 November 1983.

1634 ESA/PB-ARIANE(83)42, 7 September 1983, ESA/LTT-PC(83)8, 7 September 1983.

1635 See letter from d'Allest under cover ESA/PB-ARIANE(83)42, add.1, 5 October 1983.

1636 See reply of the Executive to d'Allest' s letter, ESA/PB-ARIANE(83)42, add.2, 6 October 1983.

studies already carried out be repeated. On the other hand, and here was the rub, it was "understandable that the Executive considers that all participants should be associated in the process of selection of the technical parameters and solutions to be adopted".

The difficulties in settling the management structure of the HM60 Programme continued in the summer of 1984. The Executive's proposal to set up a Programme Team which would be actively engaged in the management of the project was rejected outright by the French. They received indirect support from Germany and Italy who also wanted to maintain control over their Columbus project, which they proposed for Europeanisation at this time, notwithstanding the Agency's in-house competence in its Spacelab area. A first meeting of potential participants was held on 15 June 1984, and was attended by representatives from Belgium, Denmark, France, Germany, Italy, Spain, Sweden and Switzerland. While still seeking to define a suitable management structure, they did propose an enabling resolution to the Council which was adopted at its meeting on 28 June.[1637] The text of the declaration binding together the participants was finally settled during a meeting of the Ariane Programme Board in Kourou on 22 October, and was opened for signature on 1 November 1984. It was adopted by the Board at its 60th meeting, leaving the Ministerial Council meeting in Rome on 30 and 31 January 1985 the task simply to "endorse the agreement to undertake the large cryogenic engine preparatory programme".[1638] The cost of the development programme was now set at 138.3 MAU. The participants and their contributions were Germany (22%), Belgium (5%), Spain (3%), France (53%), Italy (15%), Netherlands (1%), and Sweden (5%).[1639]

The agreed management structure effectively left control of the programme in the hands of CNES even though it accorded the Agency “overall responsibility for the preparatory programme”.[1640] CNES was responsible for the technical direction and financial management of the programme. It drew up the programme system specifications and the technical specifications. It determined and set up the industrial organisation and concluded the industrial contracts in line with ESA’s rules and regulations. The Agency’s role was essentially one of monitoring the correct execution of the tasks it confided to CNES: e.g. its representatives could participate in meetings between CNES and the firms but their role was restricted to stating their views “without interfering with the responsibilities delegated to CNES”. They did however have the right to vote in all programme reviews.

The differences between the Executive and CNES were inspired by a deeper concern. In fact what the Executive wanted to avoid above all was that "premature engine design freezes" did not foreclose the choice of the configuration of the launcher. In particular it felt that the option of choosing between an expendable and an at least partly reusable launcher should be left open for as long as possible. It explained its reasoning in a long paper circulated in March 1984.[1641]

The Executive identified three priority capabilities for the next generation of launchers. Firstly, payload accommodation with the Shuttle. It was stressed that if Europe was to compete for satellite clients with the United States its launcher had to offer at least a payload of 4.5m diameter and a mass capability of 30 tons for two satellites (or 15 tons for one) into geostationary orbit. Secondly, the Executive argued that associated mass capability into the LEO was also essential. “EVEN FOR GEO MISSIONS”, its paper claimed, “the Shuttle may restrict the launch market to LEO only”.[1642] This was because the current trend was for GEO missions to integrate perigee/apogee propulsion into the satellite, whereas before the perigee stage had been distinct. The third priority was improved reliability. The paper suggested that the new launcher should be reliable enough to carry manned

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1637 ESA/C(84)57, 21 June 1984; ESA/C(84)58, 18 June 1984; ESA/C/LXIV/Res. 3 (Final), 28 June 1984.

1638 ESA/PB-ARIANE/LX/Dec. 2 (Final), rev. 2, 22 October 1984; ESA/PB-ARIANE(85)6, 12 February 1985.

1639 ESA/PB-ARIANE(85)6, 12 February 1985.

1640 ESA/LEG/74, 25 September 1985.

1641 ESA/LTT-PC(84)3, 16 March 1984.

1642 ESA/LTT-PC(84)3, 16 March 1984, p. 2.

payloads into LEO and that launch costs should be sufficiently low to make industrial activities in space profitable. To satisfy both of these conditions the need for full or semi-reusability was desirable. Reusability and reliability were in fact coupled. For the only way to keep down launch costs with a stage which had a high level of inherent reliability, and so was extremely expensive to produce, was to reuse it. As the Executive put it, "Making a stage recoverable and reusable anyway implies a high reliability because its loss would be an unacceptable financial setback".[1643] Put differently, reusability was the way to resolve the otherwise contradictory demands of developing a rocket which was sufficiently reliable for manned payloads and yet not so expensive that it priced itself out of the market, notably for the industrial use of space.

As the upper stages needed to reach the geostationary orbit were always expendable, the question of reusability concerned only the first two stages required to reach the LEO. In fact the Executive felt that it was probably only interesting to reuse the first stage (its conclusions waiting on a study being undertaken by Aérospatiale). This was because if the second stage was reusable the first had to be larger and so heavier, with a corresponding loss in cost-effectiveness. A partly reusable launcher, recycling only the first stage, would probably only have to be used a couple of dozen times to achieve economies.

That said, a word of caution is necessary. The paper we have just summarised, "Results of the First Study Phase", and presented to the Long-Term Space Transportation Systems Preparatory Programme Committee in March 1984, was issued in the name of the Executive. Some of its basic arguments were apparently not generally shared. In particular, according to Orye writing in 1999, the insistence on the importance of the LEO, "has never been the Ariane's team's (CNES and ESA) position, and past events have proven that position". Orye also notes that the arguments for the industrial use of space which were advanced to defend the importance of this orbit were highly speculative.[1644]

The characteristics of the market imposed by the Shuttle were not the only concerns guiding the Executive's thinking. They obviously also had to make suggestions which were technically and industrially possible in Europe and which were compatible with schemes already under consideration in the Member States. This meant, above all, that they had to relate their proposals for future studies to the work being done in CNES on the Ariane-5 launcher.

CNES had looked into three possible configurations for Ariane-5, all of them assuming that the launcher would be expendable.[1645] The first, basic model (A5 reference) used a first stage derived from Ariane-4, and cryogenic (LO2/LH2) propulsion for the second stage. Most of the design work since 1983 for the HM60 cryogenic engine had been undertaken to satisfy the thrust of 80 tons in vacuum that this configuration called for. By the spring of 1984 CNES had decided to drop this version and to concentrate efforts on one or two others.

A5P (P for *poudre*) was one alternative. Here the first stage used large solid boosters of about 160 tons of propellant mass each. The second stage was cryogenic again, with a thrust of 100 tons in vacuum.

Finally there was A5C (for *cryo*) which used two cryogenic stages and essentially the same engine (only the nozzle differed). Comparative studies of A5P and A5C were under way in spring 1984, and one solution would be selected for a complete development programme and for proposal to Member States in time for a decision in 1985.

To combine CNES's advances with their own complementary ideas, the Executive proposed future studies should assume that the next generation of Europe's launchers would pass through two phases. There would first be an interim, expendable launcher, which would be upgraded later to a semi-

1643 ESA/LTT-PC(84)3, 16 March 1984, p. 4.
1644 R. Orye, private communication with J. Krige, 18 August 1999.
1645 ESA/LTT-PC(84)3, 16 March 1984, p. 7.

reusable launcher suitable for manned payloads. One of CNES's A5 models could be used for the interim phase, though if the Executive's plans were accepted this would mean that it would have to be compatible with semi-reusability. This more or less excluded A5P, since solid propulsion was best when expendable. A5C and A5 reference were possible candidates, and the Executive felt that, notwithstanding CNES's decision to abandon the latter alternative, it might be worth reconsidering it from the point of view of its potential for upgrading to reusable. It concluded that "the definition and costing of an interim expendable and the resulting semi-reusable cryogenic launcher family will be the main task to be carried out from October 1984 until the end of 1985".[1646]

This paper was discussed by the Long Term Programme Preparatory Committee at its meeting on 3-4 April 1984. The Executive's ideas for launchers, and indeed its proposals for the next slice of the study programme, were not well received by the delegates. Firstly, there were doubts expressed by the delegates from Denmark, Germany and Switzerland of the interest of the LEO. As the Swiss representative put it, "the concept of a launch into the LEO followed by placing in geostationary orbit, which was specific to the Shuttle, was not desirable". To them the Executive (Mr Pfeffer) replied that 15 tons in LEO was CNES's choice, and was linked to France's intention to launch a manned vehicle (i.e. Hermes) which it would later submit for Europeanisation. And anyway, the Executive continued, since optimisation of a three stage launcher for a high orbit involved second stage burn-out close to the LEO, the problem of the future launcher was effectively reduced to that of "a 2-stage launcher achieving LEO as economically as possible". The second objection raised was to the idea of reusability, and here the French delegation was firm: in its view "the future European launcher (after Ariane-4) would be expendable and (...) further studies by the Executive and industry on semi-reusable and interim expendable launchers are superfluous".[1647]

In July 1985 France announced that the Ariane-5P option with two solid boosters "would probably be adopted for the Ariane-5 launcher, and which would be presented in more detail in September". The Executive necessarily adjusted to the new situation. It continued to insist that the studies on Ariane-5 should not be restricted to one configuration only, as indeed many delegates agreed: Germany in particular wanted some lower cost alternatives explored. But it no longer made any explicit reference to re-usability.[1648]

Six months later Ministers meeting in Rome gave the green light to the Ariane-5 Programme based on CNES's proposals. The timing was fortuitous. As the French delegation noted, "I do not need to remind you that in 1984 Europe's Ariane put more commercial satellites into the right orbit than the United States (...)". And, he went on "You may remember how hesitant several of our predecessors round this table were, twelve years ago, with their doubts about Ariane's viability. Now we have proof," he added, "that Ariane is not in the least outdated since it was the outright winner last year". The new package deal under consideration that day, Minister Curien went on to stress, had to ensure that Europe had a coherent and independent space programme, and above all that the space station in which it was to collaborate with the US was really an international space station. This in turn meant that "Ariane-5 will have to be designed taking into account the fact that it will also be lifting a plane (i.e. Hermes) and the plane will have to be designed so that it can dock with the station".[1649] It was in this spirit that the Ministers, in a major resolution, 'welcomed' and 'endorsed' "the proposal to undertake, as an optional programme in the field of space transportation systems, the development of the Ariane-5 launcher, equipped with the large cryogenic engine HM-60 with a view to completing it by 1995 and at a cost currently estimated at 2600 MAU (...)".[1650]

[1646] The concluding paragraph of ESA/LTT-PC(84)3, 16 March 1984.
[1647] ESA/C(84)40, and Annexes , 25 April 1984. See also ESA/LTT-PC/MIN/3, meeting held on 3-4 April 1984, document dated 26 April 1984,
[1648] ESA/LTT-PC/MIN/5, meeting on 9 July 1984, document dated 3 August 1984. See also ESA/LTT-PC(84)6, rev. 2, 26 June 1964.
[1649] ESA/C-M(85)MIN/1, Rev. 1, Annex XIV, 25 September 1985.
[1650] ESA/C-M/LXVII/Res. 1 (Final), adopted on 31 January 1985, dated 4 February 1985.

Encouraged by the conclusions of the Rome Ministerial Meeting, on 10 April 1985 the acting DG of CNES, Jean Marie Luton, wrote to ESA's DG Reimar Lüst suggesting that the procedure for Europeanising the Ariane-5 Launcher Programme could be accelerated. He included a dossier summarising the conditions under which the development of this launcher could be undertaken as an optional ESA programme. To avoid any misunderstandings Luton added immediately that "the management arrangements for this programme would be identical to those applicable to the earlier Ariane Programmes, and CNES for its part undertakes to assume the same responsibilities as it currently has for the earlier Programmes". Optimally a preparatory programme would be started at the end of that year, and development programme proper could then get under way in the latter half of 1986.[1651]

CNES's Programme Proposal of April 1985[1652] began by stressing again that, while the current generation of Ariane launchers would be able to compete successfully on the world market up until the early-mid 1990s, they would gradually lose out after that. One of the main reasons for this was the restriction imposed by the maximum satellite diameter of 3.65 metres which could be accommodated by Ariane-4. Both the Shuttle, and an uprated version of Titan (Titan 34 D7) under development for the US Air Force, provided for diameters of 4.55m (the usable diameter of the Shuttle cargo bay). This would also determine the size of any elements of manned space stations or multi-mission platforms. Granted these US alternatives, and the pricing policy adopted by NASA for the Shuttle, any competitor would have to launch payloads of this size with the same degree of reliability and for a comparable cost/ kg in orbit. To accommodate this evolution Europe had to develop "an entirely new launch system".

The mission model for Ariane-5 from 1995 onwards distinguished between three kinds of orbits. Firstly, the low-Earth orbit. Activity here was likely to intensify with an increase in the Soviet presence, with the joint building by the US and Europe of a manned space station and automatic platforms, and with Europe setting up its own in-orbit infrastructure and the corresponding access and intervention systems. Then there was the geostationary orbit, where activity was likely to be roughly the same as in the late 1980s, with an average of 20 to 40 payloads launched worldwide. Ariane-5 could hope to get 30% of this market. Finally there was the sun-synchronous orbit, with 3 to 10 envisaged payloads, of which Ariane-5 could again hope for a third of the market share. Classifying payloads by mass, CNES estimated that Ariane-5 could count on 8 to 15 launches a year, 4 to 6 into geostationary orbit, 3 to 6 into low-Earth orbit, and 1 to 3 into sun-synchronous orbits.

The performance specifications for each of these orbits were as follows. Firstly, for satellites, stations or station modules in low-Earth orbits, Ariane-5 had to be able to place 15,000 kg into the reference orbit 400 km x 400 km/30°. For a launch from Kourou into a geostationary transfer orbit of the 200 km x 36000 km type, 5200 kg had to be guaranteed. The reference orbit for sun-synchronous missions was that of the French SPOT satellite, i.e. 800 km x 800 km/98.6°, for which the design performance was 10,000 kg (far more than SPOT, but suitable for multiple launches or for the launch of large observation stations or "automatic factories for the manufacture of materials"). Ariane-5 also had to be able to deal with manned missions of the Hermes spaceplane, which would be carried out in two types of orbit, low circular (300 to 500 km, 0 to 60° inclination), and sun-synchronous, 500 to 900 km, 90 to 100° inclination. In both cases the launcher would have to put the spaceplane in a transfer orbit, and depending on its mission (servicing an orbital station or a sun-synchronous platform) the available mass for launch to the transfer orbit varied from 16,700 kg to 13,100 kg. Finally, Ariane-5 was to be able to make dual launches and, exceptionally, triple launches. Provision was also required for the launch of subsidiary payloads at no, or at almost no cost (e.g. radio amateur satellites, small scientific satellites, etc).

1651 ESA/PB-ARIANE(85)21, Annex 1, 12 April 1985.

1652 It is included with the minutes of the Ariane Programme Board but it has no ESAor CNES document number.

The usable volume of the launcher was expressed in terms of a cylinder whose diameter was fixed at the 4.55 metres required for it to be compatible with that of the Shuttle's cargo bay. The height could be 2 x 4 metres for a dual satellite launch, and 9 metres for a station module. A triple launch was possible with 3 x 4 metres high usable volumes. Reliability of 0.98 was needed to make this parameter comparable to the US's man-rated system, and so guaranteeing similar insurance rates.[1653] Cost had to be 20% below that of Ariane-44L for 8 launches a year of 5,200 kg into the geostationary orbit. A specific cost less than or equal to 4$/ kg (at mid-1983 prices) into low Earth orbit was necessary to compete with the pricing policy for the Shuttle, and the final configuration had to be able to evolve without calling into question its overall configuration. This evolution was needed to reduce launch cost, to upgrade performance in a particular orbit, to increase volume (diameter and/or length) available for payloads, and to improve reliability.

The design suggested by CNES to achieve these objectives had two basic configurations (see Figure 12-3). Common to both was a lower composite, responsible for lift-off and the initial launch phase. It comprised two large solid propellant boosters (P170) each containing 170 tons of propellant and delivering a lift-off thrust of about 450T each. Each booster was over 25 metres long and had a diameter of about 3 metres. The boosters were strapped to the sides of main stage (H120) which was powered by the HM60 cryogenic engine and contained 120 tons of liquid hydrogen and oxygen. This stage, which was also about 25 metres long, had a diameter of 5.4 metres. It was ignited on the ground and burnt for about 500 seconds; the boosters functioned for about 120 seconds.

Two types of upper stage were envisaged. One, called L4, used storable propellants (MMH/N_2O_4) and was to be used for all low-orbit and sun-synchronous missions, or to place 5.2 tons in geostationary transfer orbit. The second type of upper stage (H10) was cryogenic and derived from the third stage of Ariane-3. It was used to achieve enhanced performance (8 tons) in geostationary missions. The upper composite also comprised a vehicle equipment bay housing most of the equipment of the electrical system, and an attitude control and roll system , as well as upper sections consisting of a nose fairing and structure supporting a payload for a single launch. To this could be added a bearing structure for dual or triple launches (the SPELTRA: Structure Porteuse Externe pour Lancement Triple Ariane).

All of these upper elements could be replaced, for manned missions, by the Hermes spaceplane mounted atop an adapter sitting on the H120 stage. It had its own electrical systems, including guidance, navigation and control, so that it could perform the vehicle equipment bay’s functions.

The preparation and launch of Ariane-5 required the construction of a new dedicated launch site, ELA-3. The launch preparation differed from its predecessors in that the mass of the P170 boosters (about 200 tons) was thought to rule out the possibility of loading them in Kourou; instead it was planned to ship their three segments separately from Europe in completed form. Subsequently it was decided to load the two large segments at the CSG. The H120, H10 and L4 stages and the other elements of the launcher, by contrast, would arrive complete in Kourou, where the entire launcher would be assembled as before.

[1653] A letter from C. Bigot, the DG of Arianespace to the ESA DG stressed this point: see ESA/PB-ARIANE(85)21, Annex 2, 12 April 1985. Bigot made the same point about insurance very forcefully in his presentation at the conference FI 1995

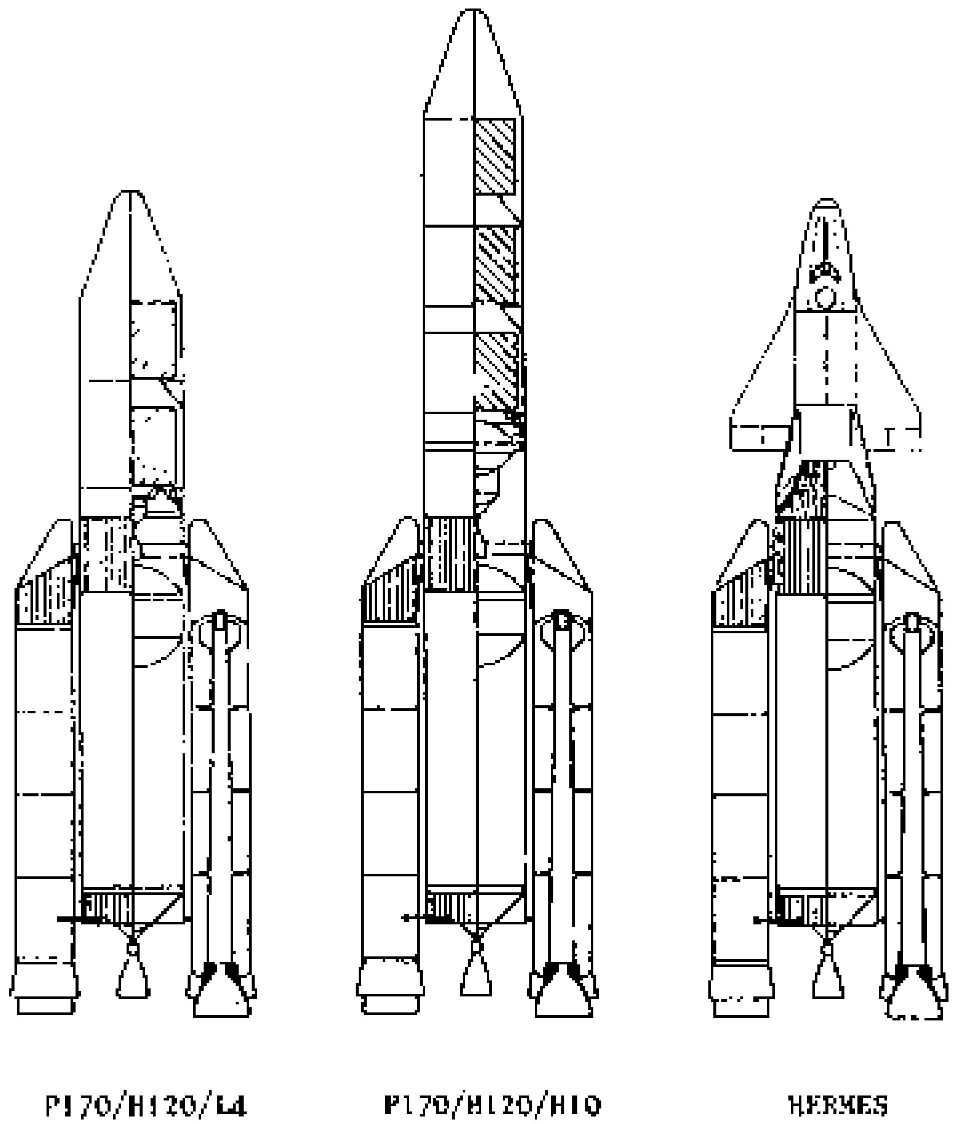

Figure 12-3. Configurations of the Ariane-5 launcher
(Source: CNES Programme Proposal, Ariane-5, April 1985).

Table 12-4: Estimated Ariane Cost to Completion in April 1985

System studies and tests	125 MAU
170 booster	355 MAU
H120 propulsion system	270 MAU
HM60 cryogenic engine (including test facilities)	738 MAU
Other elements of the lower composite	95 MAU
Upper composite	200 MAU
Ground facilities in Europe	80 MAU
CSG facilities	450 MAU
Flight tests	185 MAU
TOTAL	2498 MAU
Management costs for ESA/CNES, plus outside consultancies	102 MAU
GRAND TOTAL	**2600 MAU**

The estimated cost-to-completion of the Ariane-5 Programme as described in the April 1985 CNES proposal was the previously mentioned figure of 2600 MAU in mid-1983 prices, including Agency costs and mission costs. This figure included the development of the H60 engine; it was broken down as shown in Table 12-4.

Table 12-5: Anticipated geographical returns "over the entire Programme" as estimated by CNES in 1985, i.e. in view of work planned for the development of the HM60 engine and of the participation of all countries in the development of ground facilities in exact proportion to their participation in the development of the launcher itself.

Country	Minimum% return	Maximum% return
Germany	21	25
Belgium	4	6
Denmark	0.5	0.5
Spain	2	3
France	51	53
Ireland	0.2	0.2
Italy	10	15
Norway	1	2
The Netherlands	1	3
Sweden	3	5
Switzerland	1	2
United Kingdom	3	6
TOTAL	**97.7**	**120.7**

While the industrial structure would develop as the project evolved, and in the light of the contributions of the various partners, a number of firms had already been chosen for level-1 contractor tasks. These were Aérospatiale (Industrial architect), SEP-Bordeaux - BPD (solid propulsion), SEP-Vernon (H120 and H10 cryogenic propulsion), MBB (L4 storable-propellant propulsion), MATRA (vehicle equipment bay including attitude and roll system), and Air Liquide (cryogenic tanks).[1654] For the entire Programme, including the development of the H60 engine, and assuming the participation of all countries in the development of ground facilities at the same rate as their participation in the launcher itself, the geographical returns shown in Table 12-5 were expected.

1654 This distribution of work is that given in the CNES programme Proposal which states that these firms "had already been selected for the level-1 contractor tasks". R. Orye (private communication, 18 August 1999) says that the attitude and roll system was developed by ERNO and that the cryogenic tanks were a joint venture Cryospace aerospatiale/ Air Liquide.

Development was foreseen to pass through two phases. The first, lasting from January 1986 to March 1987, was estimated to cost 258.5 MAU at mid-1983 prices, of which about 190 MAU was for HM60. This figure included the 135.8 MAU already allocated to the cryogenic motor. In other words it was being suggested that the AR5 and HM60 Programmes be unified, and constitute in future a single Ariane-5 Programme.[1655] The ultimate objective was to have a launcher which would be operational no later than 1995 for commercial launches of automatic payloads, and able to carry out manned missions by 1997.

In June 1985 the ESA Council approved the execution of the preparatory programme within the framework of the Agency, the only doubts raised being the provisional estimates for industrial returns and the corresponding scale of contributions.[1656] The Member States participating in the programme finalised the corresponding declaration in November 1985 and subscribed to it in January 1986.[1657] This was followed by the formal decision to move ahead with development, at the Ministerial meeting in The Hague on 10 and 11 November 1987.[1658] Here Ministers approved "the execution within the Agency of the Ariane-5 launcher development Programme starting on 1 January 1988 (...)" at a cost of 3496 MAU in mid-1986 prices.[1659] If one added to this the cost of the preparatory Programme (616 MAU) the overall financial envelope of the Ariane-5 Programme thus came to 4114 MAU.[1660]

It is noteworthy that, notwithstanding the increase in cost, the Ministers committed their governments to embarking on the full development programme immediately. In fact Ariane-5 was the only one of the three major interconnected components of The Hague package deal which received this level of engagement. Even if Ministers agreed in principle to adopt the Columbus and Hermes Programmes, they were worried about the technical, financial and political dimensions of these projects, and would only commit themselves to a three-year Phase 1 "designed to reduce risks", after which a decision to proceed would be taken.[1661]

This confidence in Ariane, it should be said, was not shared by the British whose Minister, Kenneth Clarke, totally reversed the position of his predecessor Minister G. Pattie in Rome. The UK delegation in 1985 "enthusiastically" welcomed the Long Term Plan and Pattie made a point of saying that "Perhaps we have not said sufficiently clearly in the past how much we appreciate the lead given by France in the development of the independent Ariane launch capability."[1662] Clarke's attitude in 1987 was that the Long Term plan was far too expensive, that it did not engage the private sector enough, and that it was premature to engage in programmes like Columbus and Hermes while negotiations with the US over the use of the Space Station were still under way. Regarding Ariane-5 in particular, he was not satisfied that the demand would merit the investment, he suggested that if the market was going to be lucrative, the private sector should be prepared to contribute to the costs of development and he wondered whether or not the launcher's design was optimised for competitivity in the world market in the late 1990s. "Are we making the same mistake as the US in trying to achieve a manned vehicle and a competitive launcher in the one basic system", Clarke mused.[1663] The British Minister for

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1655 ESA/PB-ARIANE(85)21, 12 April 1985.

1656 ESA/C/MIN/70, meeting held on 11-2 June 1985, document dated 8 August 1985, and ESA/C/LXX/Res.1, Final, approved on 12 June 1985.

1657 ESA/C(85)127; ESA/PB-ARIANE(86)1, 15 January 1986; ESA/PB-ARIANE/LXVII/Dec. 2 (Final), Annex A.

1658 The minutes are ESA/C-M/MIN/80 (Final), document dated 13 December 1988.

1659 ESA/C-M/LXXX/Res. 1 (Final), 10 November 1987.

1660 From ESA/PB-ARIANE/LXXXV/Dec. 1 (Final) rev. 5, first drawn up on 4 December 1987. The preparatory programme benefitted from two extensions; see ESA/PB-ARIANE(87)30, 18 June 1987 which recapitualtes the work covered in extension 1 (covering the period 1/4 - 31 July 1987) and proposes that for extension 2 (from 1 August to 31 December 1987). The purpose of these extensions was simply to ensure continuity in the work on the launcher and its cryogenic engine until after the Ministerial Conference.

1661 This is descrbed in more detail in this volume, chapter 2.

1662 ESA/C-M(85)MIN/1, rev. 1, Annex IV.

1663 ESA/C-M/MIN/80 (Final), Annex IV, document dated 13 December 1988.

Trade and Industry was in a minority of one. His stance, apart from isolating his delegation and irritating his colleagues by its extreme character, raised enormous financial difficulties for his partners who had assumed that a contribution from London would be forthcoming when calculating their financial shares.

The increase in the cost of developing Ariane-5 was partly due the increase in the performance specifications of the launcher which caused some changes in its design.[1664] For example, the 1985 CNES proposal had guaranteed a mass in geostationary transfer orbit of 5200 kg; the launcher agreed on in December 1987 guaranteed a total mass of 6800 kg in GTO. If before, for low-Earth orbits, Ariane-5 had to be able to place 15,000 kg in a the reference orbit 400 km x 400 km/30°, now it was designed to place station modules or platforms with a guaranteed mass of 18000 kg in an orbit of 550 km x 550 km/28.5°. The final mass of Hermes was also increased to 21000 kg. To achieve these objectives the charge of the boosters was increased from 170 tons to 230 tons of solid propellant. The main stage powered by the HM60 Vulcain engine carried 155 tons of liquid hydrogen and oxygen, instead of the previous 120 tons, and its burn time was increased from about 500 to 615 seconds. The upper stage for automatic launches (L4) was augmented to become L5 (and much later, L7 then L9). Provision was now also made for three test flights, the last of which would be used for launching Hermes into circular low-Earth orbit. Table 12-6 gives the scale of contributions adopted at the start of the Programme.

Table 12-6: Percentage participation in the Ariane-5 development programme

Participant	Scale (%)
Austria	0.40
Germany	22.00
Belgium	6.00
Denmark	0.40
Spain	3.00
France	46.20
Ireland	0.20
Italy	15.00
Norway	0.60
Netherlands	2.10
Sweden	2.00
Switzerland	2.00
Not covered	0.10
TOTAL	**100.00**

This brings us to the end of our story of Ariane-5.[1665] Perhaps the most important thing to remember about this rocket is that its development was embarked on at the height of the technological assault by the Reagan administration on the Soviet Union, an assault in which space once again benefited from superpower rivalry and could summon up massive financial resources for major projects, not only in the USA but also, by ricochet, in Europe. In the decade since The Hague Ministerial Conference the entire global context has changed, both politically and economically. While the Shuttle is no longer a competitor to Ariane, and Arianespace has a major market share, Ariane-5 now has to confront competition from a increasing diversity of launch systems funded by hitherto unexpected governmental partners in a context of economic deregulation. It is impossible for the historian to write perceptively of events that have occurred so recently. Better then to stop our narrative here.

[1664] For this paragraph see Annex A to the *Declaration on the Ariane-5 Launcher Development Programme* drawn up on 4 December 1987 and updated on 12 June 1992, ESA/PB-ARIANE/LXXXV/Dec. 1 (Final), rev. 5.

[1665] The Epilogue to this volume takes up some of the elements of the subsequent tale.

Chapter 13: Spacelab in Context

L. Sebesta

A: The first phase, 1969-1973

13.1 Introduction

Spacelab basically consists of two types of payload carrier elements: a pressurised manned laboratory module and a series of external unpressurised instrument platforms or pallets, suitable for conducting research and application activities on Shuttle sortie missions lasting seven to thirty days. Modules and pallets are conceived to be flown separately or in various configurations, depending on mission requirements. Basic subsystem elements are accommodated in the forward end of the module (subsystem train) or, for pallet-only missions, in an *igloo*.[1666]

Spacelab has the flexibility to accommodate both multidisciplinary experiments and complementary items devoted to a single scientific or applications discipline. The Laboratory Module hosts experimental devices, data processing and electrical power equipment, an environmental control system and crew control stations. The staff of up to six scientists relies on the Shuttle Orbiter for living quarters, for communications and data transmissions and other related functions, but carries out its experimental activities in the Laboratory Module. Pallet experiment equipment can be remotely controlled from the Laboratory or, eventually, from the Orbiter.[1667] This system has some special features which cannot be offered by traditional scientific satellites, such as the immediate recovery of data and samples, the reuse of equipment and material, the adaptability of a single system to very diverse missions, the reduction of the time interval between proposing an idea for an experiment and obtaining the results, flexibility during the flight, since the experimenter can take decisions while the experiment is in progress, and the lower instrument reliability required, because of the presence of the experimenter.

That is why pallet and module configurations were welcomed by those scientists whose disciplines, such as material sciences (alloys, optical and electronic components, composites), Earth-survey (geophysics, ecology, meteorology), biology and medicine (including embryology, physiology, cellular biology, vaccine research), would benefit from its 'microgravity' environment and/or the possibility to host scientists for the performance of certain tasks.[1668] It has to be noted that these were disciplines which entered the "space dimension" for the first time and had not previously been represented in the classic scientific decision-making groups of ESRO and, later, ESA. Their legitimacy as "pure space sciences" was therefore not unchallenged among the traditional space science community who, in a context of "conservative" science budgets, perceived these disciplines as potential competitors for limited resources. They preferred to consider at least some of the research areas dealing with microgravity, those concerned with material sciences for example, as applied

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1666 For a technical description of the Spacelab as flown in its first mission, Spacelab-l (28 November-8 December 1983) see A. Thirkettle, F. Di Mauro and R. Stephens, "Spacelab - From Early Integration to First Flight: Part 1", *ESA Bulletin*, No. 38, May 1984, pp. 70-79 and A. Thirkettle, F. Di Mauro and R. Stephens, "Spacelab - From Early Integration to First Flight: Part 2", *ESA Bulletin*, No. 39, August 1984, pp. 70-84.

1667 HAEUI, ESRO/C(73)45, rev. 1, Memorandum of Understanding between the NASA and the European Space Research Organisation for a Cooperative Programme Concerning Development, Procurement and Use of a Space Laboratory in conjunction with the Space Shuttle System, 26 July 1973 (approved at the 59th Meeting of the Council on 1 August 1973), Preamble and Article II; reprinted in its entirety in Douglas Lord, *Spacelab. An International Success Story* (Washington: NASA) 1987.

1668 HAEUI, ESA, dep. 2, 52053, *ESRO News Release*, ESRO to undertake Sortie Lab project definition phase, Background Document, 10 November 1972.

sciences, bordering on technology. The senior staff of ESA's highest level scientific structures, such as Ernst Trendelenburg, Director of Scientific and Meteorological Programmes, not infrequently shared this point of view.

The elements which were considered as advantages by these new disciplines were not greeted with the same degree of interest by others which did not specifically need them, such as space physics, astronomy and astrophysics. Since the 1950s, these scientists had been tuning their instruments and research to the then-existing space vehicles (sounding rockets and satellites launched by small launchers); the adoption of Spacelab would mean a complete reorientation toward a new vehicle, yet undefined in terms of costs, time schedules and technical characteristics. Moreover, human presence would interfere with the precision of the scientific instruments; instead of perceiving it as an asset, it seemed therefore plausible to them to think about it as a dangerous and expensive nuisance. Pallet-only configurations were therefore originally conceived to accommodate the requirements of classical space scientists and reduce their objections to short-duration manned science flights, which did not fit with the requirements of their scientific culture, experience, and experiments.[1669]

The objective of the Spacelab programme, however, was not restricted to its final use. For European governments, engineers and industrialists, its biggest challenge was to be found more in the construction of the technological object *per se*, and in its integration with the major system, the Space Shuttle, than in the functions it could help to perform. First of all, Spacelab represented the first joint European effort in manned space exploration through a general support capability to be flown in low orbit for a potential multi-disciplinary user community (scientists and engineers without the need for full astronaut training). It was a far more expensive and complex enterprise than any previously associated with the building of European satellites. Secondly and not less relevant, Spacelab was conceived as a major US-European cooperative programme involving the development, procurement and use of the laboratory in conjunction with the Shuttle. Since 1970, there had been, on the European side, a conscious attempt to move from a project-oriented cooperation, limited to one specific project at a time, as had been the cooperative projects of the 1960s, to an activity-oriented cooperation whose aim was "to develop an expertise in a whole activity through a succession of initially undefined projects",[1670] the Spacelab programme was the embodiment of this new willingness. It is interesting to remark here that as early as 1976 the ESA Council, considering NASA's Space Station study programme and "noting the impact of, and relationship between" the Spacelab and the future Space Station, drew the attention of Member States to the importance of giving an early assessment of the opportunity to participate in the project.[1671]

Furthermore, the Federal Republic of Germany, as the main contractor and even, though in lesser degree, the other European participants, were eager to strengthen the industrial and technological links with the USA with regard to all aspects of such a new enterprise, which would extend from support capabilities for manned space exploration in low orbit to the Space Transportation System (STS) as a whole. After a decade of debates and recriminations on the "technological gap" between the USA and Europe, the time was ripe for Europe to be directly exposed, through a common enterprise, to an industrial *savoir faire*, which seemed to be embodied more in the organisation and management of complex programmes than in technical specifications.[1672]

Spacelab was in fact envisaged as "an integral part of the US programme in the post-Apollo period", and a major one, if we consider that in June 1972, when presenting the then current US mission model for the period 1973 through 1986, NASA expected an average of 25 missions per year (once the

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[1669] For a deeper reflection on this point see chapter 14, this volume. On the scientific aspects of Spacelab, see also D. Shapland and M. Rycroft, *Spacelab. Research in Earth Orbit* (Cambridge, Cambridge University Press) 1984.

[1670] HAEUI, ESRO/C/469, Director General's Policy Statement, 18 November 1970.

[1671] HAEUI, ESA/C/MIN/X, Res. 2, 8 October 1976.

[1672] cf. L. Sebesta, "A new political tool for the 1960s: the technological gap". Paper presented at the conference "Beyond the Cold War: the United States and the renewal of Europe", Florence/Bologna, 16-19 October 1994.

Shuttle was operational) and the same number of missions for DoD. Among NASA missions, approximately 8 per year would be sortie missions "in the fields of life science, space technology, and materials science, communication and navigation, Earth observation, astronomy, and space physics". It is interesting to remember that, since that time no more sortie missions were planned for the first three areas after 1985, when the Space Station was supposed to accommodate experiments in those areas.[1673]

Spacelab was constrained by the performance capabilities of the Orbiter and, more generally, by the Shuttle, in more than one respect. First of all, it was constrained by the technical features of the Shuttle, which influenced such relevant characteristics as the mass and electric power available for subsystems and instruments, the flight schedule, the duration of the mission and the presence of additional elements such as the instrument pointing system (IPS).[1674] Secondly, Spacelab needed the Shuttle to get to orbit, perform its duties and come back to Earth. It would be carried into orbit in the payload bay of the Shuttle Orbiter, and would remain attached to the Shuttle throughout the mission. During this time, the Orbiter would provide such important services as safety monitoring and control over payload elements. The crew members were supposed to work in the Spacelab, but, as already noted, sleep in the Shuttle Orbiter. Access to the module would be by means of a tunnel. At the end of each mission, the Orbiter would make a runway landing and the laboratory would be retrieved from the bay.

Cooperation with the USA was sanctioned by two diplomatic agreements signed in 1973. The obligations specified therein left to the European partner the whole financial and industrial responsibility of defining, designing, developing, qualifying and delivering to NASA one prototype Engineering Model (EM), one Flight Unit (FU), ground engineering support for the first two flights and spares/documentation. NASA was to support the European effort, provide general managerial and technical information, monitor ESRO's technical progress, specify interfaces, develop the tunnel, operate Spacelab within the Shuttle Programme and procure a second Spacelab if the first met its design and price requirements.[1675] The development of Spacelab as an ESRO special project was ruled by an Arrangement between certain ESRO Member States and ESRO. It was in the discharge of the complex duties linked to this process, in its coordination with the other major European project, Ariane, and in the implementation of the tasks and cooperation with the US, from the design to the day-to-day management of the production phase, that the newly born ESA tested-out its new institutional structures and managerial and industrial capacities as well as its political willingness to grow more influential in space affairs. As such, policy-making about Spacelab helps us to clarify not only the story of a remarkable European technological and scientific endeavour in the field of human space exploration, but some major features of the European space effort as it developed during the sweeping renovation of the 1970s.

At the same time, because of the necessity to solve the problem of interfaces between Spacelab and the Shuttle, because of the changes in the schedules and technical features of the Shuttle, because of

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1673 HAEUI, CSE/CS(72)15, Report of the ESA Delegation on discussions held with the US Delegation on European participation in the post-Apollo programme (14-16 June 1972), 22 June 1972. A more generous estimate, regarding the STS mission model for the period 1980-1990, seems to have been offered to the Europeans one year later. It forecast that about 40% of the Shuttle flights would be devoted to sortie missions. ESRO/C (73)49, 13 July 1973, Director General's recommendation on the Spacelab programme; see also "Europe and post-Apollo", no author, *ESRO/ELDO Bulletin*, No. 22, August 1973, p.13.

1674 A very accurate pointing device for experiments, to be flown on a stabilised platform, IPS was not mentioned in the legal instruments (MOU and IGA). However, as we shall see, it was eventually developed, under a separate contract, by Dornier as an integral part of the Spacelab programme. HAEUI, 4865, Internal communication: Reinhold to DG, 6 September 1976.

1675 A. Thirkettle, F. Di Mauro, R. Stephens, "Spacelab. From Early Integration to First Flight. Part 1", *ESA Bulletin*, May 1984, p.70. Parts 1 and 2 of this article deal with the engineering model and Spacelab-1 test programmes at ERNO and the ground processing at KSC between April 1978 and December 1985.

American leadership in managing complex technological programmes and because of the specific know-how of the consultants put to work with European firms, US-European cooperation on Spacelab was lengthy, complex and deep in character. NASA not only provided technical support and advice in management and programme control, it was also there to become familiar with Spacelab in view of its ultimate responsibility for its operation.[1676] Despite divergences and discussions during the negotiations of the agreements and their implementation, the Spacelab programme was generally perceived, by the actors involved and the public at large, as a conspicuously good example of international collaboration.

The aim of this paper is to reconstruct the phases of negotiation and signature of the legal instruments governing the cooperation, as well as the implementation of the agreement, in order to capture the decision-making strategies followed at the political and industrial levels. These strategies will be placed in the broader context of US-European relationships, European activities in space and the international economic setting.[1677]

13.2 Early European-US contacts

The evolution of the US-European negotiations on the post-Apollo programme from 1969 onwards has been discussed in Volume 1.[1678] The American programme changed over time and its originally very ambitious scope was reduced, due to a severe limitation of American funds. Finally, by January 1972, the US President approved NASA's Space Shuttle programme, the pillar of the new programme: the Space Station was delayed for an undetermined period, while the "Tug's" future was uncertain. Offers of collaboration to the Europeans were restricted as well: in June 1972, talks on European participation in the post-Apollo programme were focussed on *sortie modules*, one of their many names at the time, intended to help in performing space science, applications and technology activities.

In US eyes this choice reflected some of the traditional concerns of NASA in cooperation with foreign countries: the space laboratory had to be self-funded (by Europe), essentially separable from the Shuttle, and even though it was an integral part of the post-Apollo programme as a whole, it did not require the transfer of highly advanced technical information. The laboratory as conceived by NASA in mid-1972 could be built in Europe. The US felt confident that "the tasks entrusted to Europe (were) those for which European firms (had) a capability". This implied that US assistance would be "limited": "if found necessary and appropriate Europe would be allowed to buy existing American

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1676 For this last point, see Michel Bignier, "Spacelab Development", *ESA Bulletin*, No. 36, November 1983, p.9.

1677 A complete account of the European industrial effort, centred on the experience of ERNO, can be found in Klaus Berge, *Spacelab: Aufbruch in den achten Kontinent* (no place: no publisher) 1988 - Chapter 2 of the book, dealing with the period 1973/74, is written by Heinz Stöwer; for a complementary version, more focussed on the Italian participation, see Ernesto Vallerani, *Italy and Space. Habitat Modules* (Milano: McGraw-Hill Libri Italia srl) 1995, especially pp. 1-80. Douglas Lord's book cited in footnote. 1667 gives an account of the design and development phases as well as of the planning of Spacelab use, as seen from the American side.

1678 L. Sebesta, "United States-European space cooperation in the post-Apollo programme", ESA HSR-15, 1995; see also, by the same author, "The politics of technological cooperation in space: US-European negotiations on the post-Apollo programme", History and Technology, vol. XI, n.3, 1994, pp. 317-341.

equipment ('black boxes')"[1679] From the preliminary discussions held in June 1972, it emerged that no firm commitment as to the number of modules the US would eventually procure could be taken, nor was it clear what relationship would exist between the sortie module and the advanced experiment module which would be attached to the Space station after 1985; it would not imply the application of any special pricing policy for the use of the Space Transportation System (European users would be charged on the same basis as comparable non-US government domestic users) and it would not change the conditions of access by Europe to launching systems as settled in Alexis Johnson's letter to Lefèvre of September 1971.[1680] The motivations behind the American offer "were purely political and commercial or technical factors had practically no influence".[1681]

For Europe, the choice whether to accept the American invitation had a much broader significance. The Spacelab, as it would be called by Europeans from 1973, would inaugurate a new approach to the utilisation of space, whose underlying principle was to support life in space for a long duration. In the words of ESRO Director General, Alexander Hocker, Spacelab was "the indispensable element to transform the Shuttle into a first generation Space Station".[1682] This principle implied the need for the utmost reliability of the technology used and for a fail-safe philosophy for the essential subsystem functions. In the fulfilment of their task, the Europeans had to achieve a major goal, i.e., to build a low cost space research facility in terms of both development and operations, available to as wide a range of experimenters as possible, with some features which made it more attractive than automated systems, at least for some disciplines.

More precisely:

1 they had to meet a range of users' needs and therefore guarantee the versatility, i.e. they should offer various configurations of the laboratory;

2 they had to offer flexibility to the users, since the experimenters should be able to take decisions on the spot, while the experiment was in progress, and offer immediate recovery of data;

3 they had to limit the final costs and offer an affordable service to scientists by guaranteeing:
   - multiple re-uses of the same module and pallet;
   - the use of ground laboratory equipment on board (an objective only partially fulfilled) rather than Spacelab-specific instruments;
   - to keep to a minimum experiment and orbiter interface changes for the different configurations.[1683]

1679 HAEUI, CSE/CS(72)15, Report of the ESC Delegation on discussions held with the US delegation on European participation in the post-Apollo programme (14-16 June 1972), 22 June 1972. As already stated in informal discussions in April 1972, in the most "sensitive" cases of classified technology, if the basic technology could not be transferred, the US would undertake. if necessary, to sell the hardware itself; CSE/CS(72)13, Neuilly, 8 May 1972, Report by the Secretary General of the ESC on the informal discussions with American officials regarding participation in the post-Apollo programme. It may be of some interest to note that, revising the minutes of the June meeting (originally transcribed in Europe), Pollack objected to the wording of the mentioned sentence, suggesting a more equitable "(...)Europe would be assisted perhaps through the sale of existing American 'black boxes', or in other ways". HAEUI, CSE/CS(72) 15 add. 1, Letter from M. Pollack to the ESC Secretary General (30 June 1972), 3 July 1972

1680 When the post-Apollo programme was originally presented to the Europeans, it seemed that their participation would contribute to induce a liberalisation of US policy as far as the availability of launchers for telecommunications satellites was concerned. Johnson's letter of September 1971 clarified that the availability of US launchers for telecommunications satellites would not be conditioned on European participation in the post-Apollo programme, but would depend on a positive vote by a two-thirds majority of the Intelsat Assembly. For an analysis of this point, see chapter 10.

1681 HAEUI, CSE/CS(72)15, Report of the ESA Delegation on discussions held with the US Delegation on European participation in the post-Apollo programme (14-16 June 1972), 22 June 1972.

1682 ESRO/C (73)49, Director General's recommendation on the Spacelab programme, 13 July 1973.

1683 HAEUI, CSE/CS (72) WP/5 rev. 1, Report by the Secretary General of the ESC on the discussions between Europe and the United States on participation in the post-Apollo programme, September 1972.

At the same time, specifications were linked to Shuttle interfaces, timetables and needs. Decisions on feasibility should therefore entail trade-off studies between performance, cost and schedule. It was clear, moreover, that some technological areas would have to be advanced, if the programme was to be 100% European. In fact, a certain number of "off-the-shelf" items (available from stock or to be obtained from a running production line in the most extreme definition) would be available with little or no development in Europe. A few of them however, involved such long term and costly development and production in the USA that their development in Europe would represent a major undertaking, not commensurate with the Sortie Laboratory time scale and cost envelope.[1684] Europeans, who were participating in their first manned space programme, hoped to be able to draw some information from US sources on those areas such as:

- reliability and safety, crew protection and life-support systems characteristic of manned spacecraft, in which Europe had no experience at all;
- construction of large-diameter pressurised structures with a very low leakage rate;
- development of active thermal control, to keep the temperature inside the laboratory at a constant level;
- development of a complex data processing system in view of the large volume of information to be handled and of the necessary flexibility of use, because of the variety of experiments hosted and the diversity of missions;
- provision of electric power supply by means of systems (without solar panels) entirely new to Europe.[1685]

Vallerani reports in his book that "the greatest need was felt in certain aspects of programme control and the organisation of the various activities". The USA had the opportunity to develop such an expertise in both military programmes (the Polaris missiles for example) and civilian space-related undertakings, such as the Apollo programme.[1686]

European activities were at first directed:

- to set up industrial feasibility studies for concept definitions and to acquire the technical and managerial capabilities to build the laboratory;
- to devise a collaborative European-American institutional framework for its development and its integration with the Shuttle;
- to match the project to the ongoing European space programme.

After the decision to focus US-European collaboration on a Sortie Laboratory, a NASA technical team visited ESTEC in Noordwijk between 26 and 30 June 1972, at the invitation of the European Space Conference, to share information acquired through previous NASA studies. This would help ESA to assess what financial and technical resources would be required for Europe to develop the Sortie Laboratory. At the conclusion of the team visit, Jean Lagarde, ESTEC lead systems engineer (and formerly ESC Liaison Representative in Washington) prepared a summary report for ESRO. The

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1684 *Ibidem.*

1685 HAEUI, ESA, dep. 2, *ESRO News Release* (on the ESRO Council meeting of 9 November 1972), ESRO to undertake Sortie Lab definition phase, 10 November 1972.

1686 E. Vallerani, *op. cit.*, p.17. We will come back to this aspect when dealing with the industrial implementation of the programme.

financial estimate included in this report was $250 million (in 1972 dollars), which included development costs of a prototype and the delivery of the first flight model.[1687]

In the meantime, diplomatic contacts started in order to agree on common grounds for cooperation. On 17-18 August 1972, a meeting between the ESC Secretariat and NASA officials was held in NASA Headquarters, Washington DC. Discussions focussed on the form and content of possible agreements on the Sortie Laboratory (in the US version), Space Laboratory (in the European version) or SL (in a neutral one).[1688] It was agreed that the laboratory was an essential part of the US Space Transportation System and that, according to European requests, it would not be developed in parallel in the USA, should the Europeans take up the responsibility for its production. However, NASA was adamant in maintaining that the construction of the Spacelab would not guarantee any preferential treatment in the use of the Shuttle; countries participating in the development of the Sortie Laboratory would only enjoy a *priority* right to use it and would be entitled to appoint crew members for its flights.

NASA was to retain overall responsibility for the total programme and the last word in such vital areas as Shuttle/Sortie Laboratory interfaces, quality control and safety. In particular NASA would wish to be in a position to assess the efficiency of the management plan proposed by the European agency for the Spacelab and stressed the necessity for a "unitary management agency" on the European side. On the other hand, NASA offered arrangements to let the European agency participate in the Shuttle interface control activity, defining user requirements and in the regular review of the Shuttle programme. Moreover, a wide range of NASA assistance would be available free or at marginal cost, including provision of US designs and technology (except where specific considerations from the security and proprietary rights point of view prevented this), quality control, acceptance testing, cost control, audit and use of US facilities. The USA would favour a "government agreement", albeit very "slender". This kind of highly visible political agreement had been avoided by NASA since the inception of US-European cooperation and the (prudent) willingness to frame Spacelab in such a form was a proof of the high stakes involved.[1689]

In September 1972, the Department of State informed ESC of an amendment to the overall system planning: NASA would not need to embark on actual development work for the Sortie Laboratory, if left alone, before 15 August 1973 (it was considered that it would take the US one year less than Europe to build a space laboratory).[1690] It was proposed that European commitment in principle be made at the September Conference of 1972 and formal agreements concluded by end-October. This commitment would lead Europe to immediately start a thorough definition phase (full-scale project definition effort). Should the cost established by this study unacceptably exceed the financial ceiling agreed by the ESC Ministerial Conference, the Europeans would be allowed, through an escape clause, to withdraw from their commitment at any time before August 15 1973. This clause was later introduced into the ESRO-Member States agreement of February 1973.

1687 The team comprised nine people, led by Robert Lohman, director of Program Integration in the Sortie Lab Task Force. Dale Myers, NASA Associate Administrator for Manned Space Flight, joined the team for an executive session with Hammarström, ESTEC Director; HAEUI, CSE/CS(72)18, att. annex I, Report on the technical discussions between NASA and ESRO (26-29 June 1972), 4 July 1972; CSE/CSWP/5 rev. 1, Report by the Secretary General of the ESC on the discussions between Europe and the United States on participation in the post-Apollo programme, September 1972; see also D. Lord, *op. cit.*, p.18 and pp. 23-24.

1688 CSE/CS(72)25 and Annex I to VI, Report on discussions between ESC Secretariat and NASA officials in Washington on 17-18 August 1972 regarding the form and content of agreements necessary in the event of European participation in the post-Apollo programme, 28 August 1972. See this document for the following discussion. The US designation makes reference to the functions performed in relation to the Shuttle (sortie missions), while the European denomination captures the innovative gist of the space laboratory *per se*, as compared with the traditional laboratories at work on Earth.

1689 D. Lord, *op. cit.*, p.24.

1690 ESRO/C(72)48, Annex I, US Aide Memoire (21 August 1972), 13 September 1972.

This temporary accommodation was essential to leave the Europeans the time to introduce the programme in a broader package deal – which would be finally approved in July 1973. By the end of 1972, Europe decided to "freeze" the name of the laboratory. From now onwards it would be Spacelab; this decision was transmitted to the American partners during the meeting of the NASA/ESRO Sortie Laboratory Working Group on 12 January 1973.[1691]

13.3 Spacelab in the European context

The approval of a cooperative Spacelab programme was the last stage of long and complex negotiations on European participation in the American post-Apollo programme. Originally very ambitious, these negotiations had been progressively restricted in scope.[1692] The limitation of cooperation to Spacelab, and thus the limitations of the costs of cooperation,[1693] only partially solved the problems that Europe had to confront in the same period, since interest in Spacelab had to be balanced not only against its own costs, but in the context of a series of uncertainties relating to the European space programme as a whole.[1694]

Spacelab was but one of the three major concerns of the member states, the other two being:

- the future organisational nature of Europe in space, in the context of two concerns: from the tactical point of view, the disruptive power of the impending liquidation of ELDO had to be neutralised; from the strategic point of view, the new European concerns linked to the application capabilities of satellites (first of all in telecommunications) could not be coped with by an organisation set up for mainly scientific purposes, ESRO.

- the new configuration of a launcher capable of meeting all the new European needs in the field of application satellites,[1695]

The apparent irreconcilability of French and British positions over these points came to the forefront during the informal meeting of ESC Ministers and representatives of participating states (8 November 1972) called to organise the subsequent December CSE meeting.[1696]

Attention was focussed on a difficult dilemma; what should have been given priority, the institutional framework or the programme toward which this framework would orient its work? Charbonnel, the French representative, subordinated the solution of the European space institutional problems to the "definition of a programme worthy of Europe", i.e. a common programme of heavy launchers capable of orbiting the payloads which Europe would develop for its needs in the field of space applications

[1691] HAEUI, ESA, dep. 2, 52054, NASA/ESRO Sortie Lab Working Group, Minutes for the Meeting (12 January 1973), no author, no date; *Ibidem*, ESA, dep. 2, 5606, "Spacelab Guidelines and Constraints for Program Definition", by Douglas Lord and Jean-Pierre Causse, 23 March 1973. However, the first document on "Spacelab Guidelines and Constraints for Program Definition" (March 1973) mentioned the fact that Sortie Lab was still in use in the USA. However, Spacelab was always used, from there on, every time the programme was mentioned in coordinated documents.

[1692] See footnote 1677

[1693] The cost of Spacelab was then estimated at $ 200-250 million, against an estimated cost for (the abandoned) Tug of about $ 500 million. This difference has been considered in the literature as an important element in favouring the positive resolution of the launcher-versus-post-Apollo dilemma, since it freed relevant European financial contributions in favour of Ariane. See John Logsdon, "International involvement in the US space station program", in *Space Policy*, February 1985, p. 24.

[1694] CSE/CS(72)WP/5, rev. l, *cit.*

[1695] For a broader analysis of these aspects of the ESRO-ELDO crisis, see J. Krige, A. Russo, *Europe in Space, 1960-1972*, ESA SP-1172, September 1994.

[1696] CSE/CM(Nov. 72)4, Meeting of Ministers in Paris on 8th November 1972 under the Chairmanship of Theo Lefèvre, plus Annexes, 17 November 1972; see also J. Krige, A. Russo, *op. cit.*

(in the three main fields of telecommunications, air navigation control and meteorology) and which would even enable it to export commercially viable complete systems. Faced with the reluctance of certain states to join in the Europa III programme of ELDO, France was prepared to carry out, on a different technical and institutional basis, a programme meeting the same objective, i.e. LIIIS, the future Ariane.

Considering the organisational question as one which would have implied a great loss of time and energy, France was more prone to begin by solving the problem which, in its opinion, was most urgent for the future, the one of launchers. Why this choice?

- because dismissing the programme would be seen by public opinion in European countries as an unacceptable abdication of a political responsibility;

- because the funding needed to complete the programme was minimal compared with the sums Europe had so far invested. As recalled by Chairman Lefèvre during his opening remarks, this would have implied not only a loss of technology, but also a loss of markets;

- because the absence of a European launcher would deprive the Symphonie project of some of its meaning, the value of which as an example was paramount at a time when Europe was undertaking important application programmes.

On the other hand, taking into primary consideration the financial constraints under which the Conservatives (back in power since 1970) found themselves, the UK representative, Heseltine, subordinated any decision on the programme to the prior solution of the institutional framework. In view of what was thought to be poor cost-effectiveness, European performance in space during the previous decade (whose results "do not measure up to a financial commitment of this proportion"), the UK singled out the organisational problem and the duplication between national and European space programmes as the causes of this ("we are spending enough money to achieve results but we are not spending it in the way it ought to be spent").

Moreover, neither France nor the UK seemed enthusiastic about joining the US in the post-Apollo programme. France, noting that while the Spacelab "would enable Europe to take an interest for the first time in the problems of manned flight, … none of the economic needs of the next decade would be met by the development in Europe of a Sortie Laboratory, which can in no case be considered a substitute for a launchers programme", stated it was ready to participate to the programme only if all the measures were taken to satisfy Europe's requirements particularly with regard to launchers. The UK stated that, for the time being, the UK would not participate to the post-Apollo programme and thought it could change this position only if progress were made in the creation of a single European Agency.

Only Germany seemed to be ready to accept the US invitation. Despite this continuing divergence, some countries agreed, under certain conditions, to finance the Phase-B studies for the Sortie Laboratory (reduced to a single approach selected from the alternatives identified in the first phase, Phase-A). The Committee of Alternates gave its political blessing and invited the ESRO Council to comply. The ESRO Council accepted this request and authorised its Director General, Alexander Hocker, to take the necessary implementing steps.[1697]

Reports on the activities of ESRO and ELDO and on the post-Apollo programme were offered at the start of the ESC Ministerial conference of December 1972. Each of the three areas had its specific sets of unsolved problems. In spite of the dilatory position of the UK – whose delegates stressed how the "Government did not believe in the need for a European launcher programme" and how the arguments

[1697] CSE/CM(Dec.72)5, 7 December 1972.

in favour of the post-Apollo programme were not considered "overwhelming"- and some uncertainty on the Italian side – which subordinated participation in the launcher programme to fruitful cooperation in the post-Apollo programme and asked for the acceptance of the rule of *juste retour* for the common programmes – the resolution of the Ministerial Conference registered an important agreement on some points which had been objects of intense debate:

1 the setting up of a new organisation, ESA, if possible by January 1974, created from ELDO and ESRO

2 The Sortie Laboratory and the French launcher proposal (LIIIS) to be managed within a common European framework (Europa III being dropped)

3 there should be a rationalisation of the various satellite programmes, including GTS (the geostationary technology satellite programme had been initiated by the UK as a national project; originally intended for telecommunications purposes, it was subsequently reoriented to meet requirements for aiding maritime navigation and was later merged with Marots).[1698]

The first element of the far reaching decisions arrived at in the meeting was the decision to set up a new unique European Space Agency (ESA), whose programme would consist of a compulsory "basic" programme – science, general activities and facilities – with GNP related contributions and an "optional" programme -including Spacelab, launchers and applications satellites – in which the Member States were free to decide on their participation and financial contribution.[1699]

One element that greatly contributed to convince uncertain states to comply with the second decision was the suggestion put forward by France and Germany about the financing of the launching programme – a fixed amount for European countries other than France rather than a fixed percentage for every state. The other one was represented by the technical features of LIIIS, nearly as powerful as Europa III, but not requiring such a large and sophisticated cryogenic stage.[1700]

A compromise was being worked out between two projects which had seemed for a long time mutually exclusive, mainly for economic reasons: the European launcher and participation in the post-Apollo programme. The UK re-entered the game, introducing Marots into the bargain. This equilibrium was reached mainly thanks to an agreement between France and the FRG on a reciprocal participation in the launcher and Space Laboratory projects, where the two countries would respectively provide the majority of funds for the two projects. This compromise was eventually finalised in July 1973, after a series of sometimes harsh discussions and horse-trading among European partners.[1701] It was in the context of this rather perturbed diplomatic setting that European-US negotiations on the Spacelab agreements took place.

1698 CSE/CM(Dec.72)8, 20/I 2/1972; CSE/CM(Dec.72)PV/2, plus Annexes, 10 January 1973.

1699 See chapter 1.

1700 CSE/CM (Dec.72)PV/2, Minutes of the Afternoon Session of the ESC held in Brussels on 20 December 1972, Statement by Charbonnel, Ministre du Développement Industriel et Scientifique, France, 10 January 1973. The LIIIS rocket would be able of putting payloads of 1500 kg into transfer orbit, or of 750 kg into geostationary orbit with the aid of an apogee motor. The French government was willing to assume 60% of the expenses of the development phase (estimated at 550 MAU by Charbonnel) which was due to start on 1 January 1974 and to end with qualification of the launcher in 1980. LIIIS should be assured a suitable priority of use in Europe compared with means of launching developed outside Europe. The technical and financial management of the LIIIS would be entrusted to CNES; CNES would define the industrial arrangements and place contracts with industry on behalf of the programme participants; there would be a Programme Board to monitor the distribution of work among the various participants and act as the appeals body for a participant with respect to the choice of firms made by CNES.

1701 J. Krige, A. Russo, *op. cit.*, pp. 111-112.

13.4 The legal instruments

Albeit provisional in kind, the ESC December (1972) decision gave the green light to the opening of the last stage of US-European negotiations. At the end of the Brussels meeting, Minister Lefèvre wrote to Secretary of State William Rogers to inform him about the European decision and, with a resolution of January 1973, ESRO's Council authorised its Director General to negotiate with NASA and the participating countries the legal framework for the programme, pending the arrangements between ESRO and the Member States.[1702]

Meanwhile, Europe had to study how it might participate in the post-Apollo programme on the basis of the American offer. The Federal Republic of Germany proposed to undertake the development of Spacelab under Art. VIII of the ESRO convention, as a special project. An Arrangement between certain ESRO member states and ESRO was therefore drafted and approved by the ESRO Council in February 1973. Open for signature from 1 March to 23 September, it entered into force on 10 August l973.[1703]

It determined the objectives and the main elements of the programme, together with the conditions for its execution. It called for the creation of a Spacelab Programme Board (which had already been set up in an interim form) to be responsible for the programme and ensure its implementation, keeping the Director General informed and ensuring close links between ESRO and future users.

The fair return rule was applied, though in a generic form: the geographical distribution of contracts should "correspond to the percentage contribution of participants" (Art. 8). Although optional, all ESA Member States except Sweden eventually funded it (Belgium, Denmark, the Federal Republic of Germany, France, Italy, the Netherlands, Spain, Switzerland, the United Kingdom), plus Austria which voluntary associated itself to the programme at a later stage. The countries decided to establish a financial envelope of 308 MAU at mid- 1973 prices (1 MAU = approximately 1.2 US dollars) divided over Phase-B (the definition phase), the main design, development and construction contract, ESRO internal costs including overhead, and, finally, contingencies including space technology and modifications resulting from the Shuttle programme.[1704]

Germany was due to pay the largest share of the cost during Phase C/D (52.55%), the other main contributions coming from Italy (18.00%), France (10.00%) and the United Kingdom (6.30%).[1705] The percentages would be slightly revised in October.[1706] The arrangements provided for a review of the overall amount at the end of sub-Phase-A2 of the definition phase (end July 1973). If the financial hypothesis was not confirmed, but significantly exceeded, those participants who so wished could withdraw. At the same time, it was anticipated that members should bear up to 20% overruns on the estimated cost to completion (and the Programme Board should decide on the additional expenditure by a two-thirds majority); should this percentage be exceeded, everyone had the right to withdraw from the project (Art 6).

The early months of 1973 were devoted to the drawing up of the final text of the US/European diplomatic instruments, with meetings, drafts, phone calls and *aides memoire* going back and forth between the US and Europe. As a normal procedure, each European revision was submitted for approval to the Spacelab Interim Board, chaired by Massimo Trella, and then forwarded as an *aide memoire* to the US government via the German Chargé d'Affaires, on behalf of the European participating members.[1707] It had been agreed in June 1972 that two instruments would be worked out,

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[1702] HAEUI, ESRO/C/LIII/Res. 1 (Final), Resolution on the Spacelab programme, 18 January 1973.

[1703] See *Basic Texts of the European Space Agency*, Vol. II, Spacelab, Columbus 1988, note p. Al a/2.

[1704] "Europe and post-Apollo", no author, *ESRO/ELDO Bulletin,* No. 22, August 1973, p.12.

[1705] HAEUI, ESRO C(73)2 rev. 3, Arrangement between certain member states of the European Space Research Organisation and the European Space Research Organisation concerning the execution of the Spacelab programme, approved at the 54th meeting of the Council on 15 February 1973, Annex B.

[1706] HAEUI, ESRO IB-Spacelab(73) 26, 3 October 1973.

[1707] HAEUI, see the series of documents under ESA/IB-SL.

i.e. an executive agreement between agencies of both sides and a governmental agreement between the US government and the participating European governments to reinforce the political commitment of both parties.[1708]

The ESRO Director General, Hocker, skilfully handled the delicate balance between the need to respect the national sovereignty of the Member States and therefore leaving them the final say on each revision and the need to expedite the sometimes extended discussions. The State Department represented only one government; ESRO's Director General represented nine countries with their not always converging interests. Legally speaking, as we have seen, he was given special powers by the agreement between ESRO and Member States for the execution of the programme. Politically, however, national views needed to be respected, at least for some major decisions.

In a way, the need to confront their American partner with a single voice forced European members to smooth their differences and devise new mechanisms for harmonising their views, thereby leading to stronger bindings. On the other hand, it can be said that the attainment of a single European voice on such delicate topics as ownership, management and a follow-on development programme, was a good proof of the flexibility of Member States, especially those with a high financial stake in the project, of the diplomatic skills of policy-makers, liaison personnel and managers involved and, last but not least, of the shared willingness to find viable compromises in the light of a prominent political goal at the time, i.e. European integration. It has to be remembered that, after protracted negotiations, British membership of the European Community was formalised in January 1973, at the very moment at which ESRO was defining the text of the legal instruments for the Spacelab programme.[1709]

The legal framework for cooperation on Spacelab was set out in two documents:

- an intergovernmental agreement negotiated between certain ESRO Member States and the US Government, dealing with the political commitment of the member states with regard to carrying out the programme. It placed this endeavour in the general context of cooperation between the USA and Europe and in relation to the Space Shuttle system.[1710]
- a Memorandum of Understanding negotiated between ESRO and NASA to define the tasks and responsibilities of each organisation in carrying out this cooperative programme.[1711]

From 14 August to 24 September 1973, the Intergovernmental Agreement was opened for signature in Paris. It entered into force at different times, depending on the date of ratification. To implement this agreement, the NASA-ESRO Memorandum of Understanding, marking "the beginning of a new era",

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1708 HAEUI, CSE/CS(72)15, Report of the ESC Delegation on discussions held with the US Delegation on European participation in the post-Apollo programme (14-16 June 1972), 22 June 1972.

1709 Great Britain entered the European Community along with Ireland and Denmark.

1710 HAEUI, Agreement between the Government of the United States of America and certain Governments, Members of the European Space Research Organisation, for a Cooperative Programme Concerning Development, Procurement and Use of a Space Laboratory in Conjunction with the Space Shuttle System, ESRO/C(73)46, rev. 1, approved at the 10th Meeting of the Spacelab Programme Interim Board (SPIB) (31 July 1973), 26 July 1973.

1711 HAEUI, Memorandum of Understanding between NASA and the European Space Research Organisation for a Cooperative Programme Concerning Development, Procurement and Use of a Space Laboratory in conjunction with the Space Shuttle System, ESRO/C(73)45, rev. l, 26 July 1973-approved at the 59th Meeting of the Council (1 August 1973). It is to be stressed that articles of the MOU were in Roman numbers, while the inter-governmental agreement used Arabic numeration.

was signed.[1712] Some of the articles deserve special attention, not only for their objective importance in defining the rationale of the programme, but because they were much debated before being approved and would be the focus of future debates.

As already mentioned in the introduction, according to article I, ESRO would undertake to *design, develop, manufacture and deliver the first flight unit of Spacelab*, and other materials described in the Memorandum. Spacelab would be used as an element to be integrated with the Space Shuttle. ESRO would design, develop and manufacture such elements as ESRO and NASA might agree to be necessary for the programme in addition to those listed in the document (Art. V.1.c).[1713] Phasing, scheduling and working arrangements would be worked out jointly in the Joint Programme Plan (whose preliminary version had been produced in July 1973). The plan would be based on the results of the preliminary design studies in progress in Europe and in the USA, on the user requirements and on the final definition of the Shuttle (Art. IV). NASA would provide managerial consultation and technical interface information. It would monitor the implementation of ESRO activities, develop selected peripheral components and manage all operational activities after the delivery of the Spacelab (Art. V.2).

The first operational Shuttle flight was scheduled for late 1979, which meant that the Spacelab flight unit should be delivered to NASA at least one year before, to enable the Agency to integrate experiments into Spacelab and Spacelab into the Shuttle orbiter. European preoccupations during the opening stages of negotiations revolved around the concept of ownership: they hoped to be able to assure for themselves the development and *ownership* of the Spacelab, while they were ready to guarantee free and unrestricted use and control of the first Spacelab unit to their partners. It became rather clear, though, that NASA would never agree to this. Due to the integration of Spacelab into the Shuttle system, reference to European ownership of Spacelab, they stated, would be perceived in the USA as implying a shared ownership of the Space Transportation System as a whole. To overcome this difficulty, no mention of the question was made in the final text.[1714] In practical terms, this silence would not favour Europe: the US would make "unrestricted use of the first Spacelab unit free of costs" (Art. IX and Art. 7) and would have "full control of the first Spacelab unit", including the right to make any modification it desired (Art. XI and Art. 7), but Spacelab would remain the property of ESA after delivery and ESA would be liable "for damage occurring in connection with a Space Shuttle launch, flight or descent" during the first Spacelab unit mission (Art. 11), while sharing liability for subsequent missions.[1715]

As for the *scope* of Spacelab, it would "support a wide spectrum of missions for peaceful purposes" and "would accept readily the addition of special equipment for particular mission requirements" (Art. II). NASA had the overall responsibility for the total programme and the last say in such vital

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1712 This is a excerpt from the declaration signed during the ceremony of the American signature of the ESRO/NASA MOU, at Washington, on 24 September 1973; *cit*. in "Spacelab Memorandum of Understanding Signed in Washington", (no author) *ESRO/ELDO Bulletin*, n.23, November 1973, p.18 (pp. 18-19 for the whole article). The MOU had been approved at the 59th meeting of the ESRO Council on 1 August 1973 and signed on 14 August, thereby entering into force on that date; see *Basic Texts of the European Space Agency, cit*., note p. Al c/2.

1713 On the basis of this article, it was decided in March 1976 by the NASA/ESA Joint Spacelab Working Group that ESA would develop IPS; HAEUI, Communication interne, Reinhold to DG, 6 September 1976.

1714 HAEUI, ESA, dep. 2, 52055, *Communication interne on NASA/ESRO Spacelab Agreement,* Gibson to Kaltenecker, 29 January 1973; *Ibidem*, ESA, dep. 2, 52055, *Communication interne on Agency to Agency agreement, Spacelab*, from Gibson to Director General, 1 March 1973; HAEUI, ESA, dep. 2, 52049, European text (proposed), US text (revision), 25 April 1973; HAEUI, ESA, dep. 2, 52055, *Note pour le dossier, Propriété du premier Spacelab*, by Lafferranderie, 4 November 1974.

1715 HAEUI, ESA, dep. 2, 52055, *Note pour le dossier, Propriété du premier Spacelab*, by Lafferranderie, 4 November 1974; see also the retrospective comments in *ibidem*, ESA/IRAC (82)R/2, Annex III, *Report on possible extension and/or expansion of the cooperation established between Europe and the United States of America in the Spacelab Programme*, prepared by J. Arets, J.L. Collette, F. Emiliani, C. Reinhold, G. Seibert, June 1981.

areas as Shuttle/Spacelab interfaces, quality control and safety, "including the right to make final determination as to its use for peaceful purposes" (Art. 7 and Art. XI). However, "the experimental objectives of the first flight will be jointly planned on a cooperative basis" (Art. XI).

As far as the *commercial use* was concerned, the European request for the establishment of "mutually agreeable standards and conditions" was converted, in the final text, into the search for "the maximum practicable harmonisation of the respective policies" (Art. 7), whereby each country was free to adopt such standards and conditions as it deemed appropriate.[1716]. Construction of the Spacelab would not guarantee any preferential treatment in the *use of the Shuttle system, nor in the access for scientists to subsequent flights of Spacelab*. A European request for "a formal commitment to have unconditional access and use of the Shuttle at least when it is used for a European Space mission" was denied.[1717] Art. 7 thereby stated that the US would "make the Space Shuttle available for Spacelab missions (experiments and applications) of the European Partners and their nationals on either a cooperative or cost-reimbursable basis". Pricing policy was left undecided; actually, NASA was unable to anticipate, until 1977, what the Shuttle charging policy would be.

Although the first flight of the first Spacelab unit would be "jointly planned on a cooperative basis" (Art. XI) (which meant, in the language of the agreement, non-cost for Europe as far as the launching services were concerned), the definition of the nature of subsequent flights remained open to question. This elusive aspect of the agreements (and the fact that Shuttle pricing policy would be constantly revised upwards after 1977), though understandable on technical grounds, because the Shuttle development was still in its infancy at the time, would greatly weaken the consistency of the Spacelab project, preventing any long term cost-benefit analysis between European investments, flight costs, and flight objectives.[1718] Because the instrumentation originally foreseen for the inclusion in the First Spacelab Payload (FSLP) needed to be repeatedly taken into space in order to give significant results, the uncertainty about the Shuttle charging policy frustrated the possibility of rational planning of the scientific uses of Spacelab.[1719]

NASA's guarantee to European scientists was limited to providing access to Spacelab for experiments or applications proposed for reimbursable flights by Governments participating in the Spacelab programme, in preference to those of third countries. Selection on cooperative (i.e. non-cost) flights should follow normal NASA policy, with European proposals given preference over the proposals of third countries only if they were at least equal in merit to the third country's proposals (Art. XI). On the other hand, countries participating in the development of the Spacelab would be entitled *to appoint European crew members* for its flights – "It is contemplated that there will be a European member of the flight crew of the first Spacelab flight" (Art. XI).

The question of *commonality* between Spacelab and the Shuttle, one which would pose serious financial problems for Europe during the development phase, was repeatedly debated during the negotiations. It was difficult to establish, in theory, whether integration should follow the criteria to minimise development and operational costs of the Spacelab or whether reliability and Shuttle requirements should be prioritised. Whereas the USA was in favour of a provision which specified that an effort should be made "for Spacelab to optimise commonality with Shuttle components", faced with resolute European resistance, the compromise formula adopted made reference to the more balanced

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[1716] For the European view, HAEUI, ESA, dep. 2, 52055, Communication interne on Spacelab Agreements, from Gibson to Director General, 5 July 1973.

[1717] HAEUI, ESA, Dep. 2, 52050, Aide Memoire on Spacelab Government/Government Agreement, attached to Letter Gibson to Knörich, 1 June 1973.

[1718] For pricing policy, see Papers of James Fletcher, Manuscript Division, University of Utah, Marriot Library, Salt Lake City, box 43, Letter Gibson to Fletcher, STS Charging Policy, 12 July 1976; see also, *A Report to the Committee on Appropriations, US House of Representatives. on the Cost Comparisons and related issues of operating the Space Shuttle and various foreign and US expendable launch vehicles, by the Surveys and Investigations Staff*, April 1985.

[1719] See, for example, the case of LIDAR, cited in chapter 14.

need "to optimise commonality between Spacelab and Shuttle components" (Art. 11).[1720] Choices on modifications would actually be done, as we shall see, on an *ad hoc* basis.

NASA was resolute in refusing to give guarantees about the effects on Spacelab of design changes to the Shuttle. Although recognising "the desirability of avoiding changes resulting in a disproportionate impact on the Spacelab programme", the Agency reserved to itself "the right to require changes affecting the interfaces or operational interactions between the Shuttle and the Spacelab". In the case of changes - to the Shuttle affecting Spacelab "to the extent that changes affect the Shuttle and Spacelab programme, NASA and ESRO will bear the increases in the costs of their respective Shuttle and Spacelab development costs" (Art. IX). The formula endorsed was the one proposed by NASA since January.[1721] During the implementation of the agreement, the meaning of "disproportionate" would be subject to different interpretations

As for *technology*, while both partners believed that the Spacelab could be developed with existing European capabilities and resources, it was recognised that some commercial procurements of components and services from the US were likely (Art. 6).[1722] Data processing systems had been singled out, as we have seen, as one of the areas in which US help would be most needed. A contract ($12 million) for the software components of the data system was eventually placed by ESA with TRW.[1723] On the other hand, to the great disappointment of ESRO, the USA resolutely refused any access to technology not directly linked to the development of Spacelab.[1724] The major reason for European interest in the collaboration, as we have already noted, seemed to stem from hopes of gaining "programme management and systems engineering experience (...) rather than in specific technical know-how or direct commercial benefits".[1725]

NASA agreed to procure from ESRO "whatever *additional items* (Spacelab) of this type it may require for programmatic reasons, provided that they are available to the agreed specifications and schedules and at reasonable prices to be agreed"(Art. VIII). "NASA should give an initial procurement order *of at least one Spacelab at the latest two years before the delivery" of the first Spacelab unit*. (Art. VIII). On the other hand, the article introduced an element of ambiguity concerning the timing of future procurement orders, recognising, in the following paragraph, "the desirability of gaining operational experience with the first flight unit before ordering additional units" and the parallel (and contradictory) need to maintain continuing production capability. NASA's commitment to buy at least one Spacelab was a compromise between the European desire for a long-term commitment to procure Spacelab from Europe and the financial constraints and economic interests of the USA.[1726] As in the case of the formula "substantial duplication", the wording "at reasonable prices to be agreed" seems to have given rise to some problems because it was later difficult to find a cost basis for "reasonable

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1720 For the US-European debate, HAEUI, ESA, dep. 2, 52055, Communication interne on Spacelab Agreements, from Gibson to Director General, 5 July 1973.

1721 HAEUI, ESA, dep. 2, 52055, Communication interne on NASA/ESRO Spacelab Agreement, Gibson to Kaltenecker, 29 January 1973.

1722 CSE/CS(72)15, Report of the ESC Delegation on discussions held with the US delegation on European participation in the post-Apollo programme, 22 June 1972. As already stated in informal discussions in April 1972, in the most "sensitive" cases of classified technology, if the basic technology could not be transferred, the US would undertake, if necessary to sell the hardware itself; CSE/CS(72)13, Report by the Secretary General of the ESC on the informal discussions with American officials regarding participation in the post-Apollo programme, 8 May 1972.

1723 It was the only direct ESA contract to the US, the others being signed on an industry-to-industry basis; see interview M. Bignier, 6 December 1996, Paris.

1724 HAEUI, ESA, dep. 2, 52050, Aide Memoire on Spacelab Government/Government Agreement, 1 June 1973.

1725 D. Lord, *op.cit*., p.59; see also E. Vallerani, *op. cit*., p.17.

1726 For the European position, HAEUI, ESA, dep. 2, 52050, Aide Memoire on Spacelab Government/Government Agreement, attached to Letter Gibson to Knörich, 1 June 1973.

prices" proposed by European industry.[1727] Article VII specified that the financial commitments of ESRO and NASA to carry out the programme were subject to their respective funding procedures which meant, in the case of the US, the yearly approval of the Congress. NASA also agreed to refrain from "separate and *independent development* of any Spacelab substantially duplicating the design and capabilities of the first Spacelab unless ESRO fails to produce such Spacelab" (Art. VIII). This element was represented as a *sine qua non* condition by European negotiators since 1972. In view of the fact that the Marshall Space Center had accumulated extensive knowledge about Sortie Cans since the inception of the post-Apollo programme and was involved in concept analysis within Phase-B of the current programme, the relevance of the conciliatory US attitude cannot be underrated.[1728] The application of the clause, unfortunately, would be under dispute for many years and "the dividing lines between duplication, substantial duplication and substantial modification very difficult to draw".[1729]

It must be stressed that, whereas the USA considered Spacelab as a sort of revised and expanded Helios project - and originally made reference to the German-American agreement of 1969 on Helios as a possible base for the new one – Europeans argued that this agreement should represent the first phase of a long-term cooperation in space exploration by orbital systems. For this reason they insisted in having a provision introduced in Art. 1 of the IGA whereby the programme would provide "for consideration of the timely expansion and extension of this cooperation as their mutual interests warrant" (Art. 1). This was in line with the call made by the Director General since 1970, in favour of orienting cooperation towards an area of activities, rather than *ad hoc* projects. Probably, however, the US representatives took some time to understand the underlying importance of such a change in European attitude.[1730]

Finally, the expiration date was set at 1 January 1985 and, in any case, at least five years after the date of the first flight unit of the Spacelab (Art. 16). If no notice of termination were given prior to the expiration date, the agreement would be automatically extended for three years.

[1727] HAEUI, ESA/IRAC (82)R/2, Annex III, Report on possible extension and/or expansion of the cooperation established between Europe and the United States of America in the Spacelab Programme, prepared by J. Arets, J.L. Colette, F. Emiliani, C. Reinhold, G. Seibert, June 1981.

[1728] HAEUI, ESA, dep 2, 52054, Minutes of the NASA/ESRO Meeting on the Technical and Managerial Problems related to Phase-A of the Space Laboratory Programme, 22 November 1972. See also E. Vallerani, *op. cit*., p. 12.

[1729] HAEUI, ESA/IRAC (82)R/2, Annex III, Report on possible extension and/or expansion of the cooperation established between Europe and the United States of America in the Spacelab Programme, prepared by J .Arets, J.L. Collette, F. Emiliani, C. Reinhold, G. Seibert, June 1981.

[1730] Aide Memoire on Spacelab Government/Government Agreement, cited in footnote 1717.

B: The implementation of the programme, 1973-1983

13.5 Introduction

Agreements, like law in general, have meaning only in their implementation. Studying the implementation of a programme such as Spacelab is always a delicate task for the historian. Official documents tend to downplay divergences. With some exceptions, personal memories and published accounts emphasise good relationships rather than problems, especially when sponsored by one of the operating agencies. Last but not least, during cooperative ventures it is sometimes preferable to communicate dissent by voice, e.g. telephone calls, rather than by a written document. Written formalisation polarises positions and forces the partner "to retaliate" with an answer of the same formal quality. To force a showdown can be counter-productive if the negotiating partner is in a weak position relative to other political actors at home (for example NASA *vis-à-vis* the Congress!).

Gibson gives evidence of such a danger, reporting about one of his meetings with high level NASA officials, among whom its Administrator Robert Frosch, subsequent to a letter of strong protest on Spacelab programme implementation, sent by him to NASA in June 1978. "It quickly became apparent" reports Gibson in a note for the record "that their main concern was concentrated on the fact that I had written rather than telephoned. There were repeated references to the embarrassment of having such a letter on the record, the difficulty of even being able to reply in writing, and the fact that Congress may become aware of its existence". "My attitude" reports Gibson "was to say that the contents of the letter represented the minimum compatible with the complaints of Member States, and that these had reached the point where they could not be explained by telephone calls".[1731] We do not want to expand on this particular issue here: the example was just taken to show how much the use of phone calls, and private (not recorded) conversations, can influence the actual outcome of international negotiations and joint programmes, without leaving a tangible trace for the historian.

It is equally important to understand that the position taken by a given individual during the negotiating process has to be viewed in the context of the place occupied by that person in his own hierarchy. Frequently, officials in lower positions can be less flexible if they perceive that this can strengthen their position within their own organisation. Bignier reflected on this point after his first mission to the US as Spacelab Programme Director, stressing how staff at the lowest levels in the power hierarchies tended to be stiffer on certain points.[1732] Equally important, a hard initial position was not necessarily a negative sign: it could simply be used to gain space for flexibility during the negotiations, and to be able to appear generous towards the partner.[1733]

Another major problem arises from the use that is subsequently made by policy makers of old agreements to influence new agreements. What are, in retrospect, considered as weak points of the old agreement are emphasised in order to legitimise requests that are aimed at repairing what is presented as being a misapplication, or in more extreme terms, an abuse of the agreement by the partner. The Spacelab agreement was used during the Space Station negotiations to alert Europeans about *what not to do this time* and to clarify to the US partner what would not be acceptable. In this context, old negotiations acquire a very strong political significance, which can bias later judgements.

1731 HAEUI, ESA, dep 2, 5506, Note for the Record, Meeting with Dr. Frosch in Washington (14 July 1978), by R. Gibson, 17 July 1978.

1732 He was referring to the discussions on the integration programme to be executed at the NASA Marshall Space Flight Center.

1733 HAEUI, ESA, dep. 2, 5596, Compte rendu de la mission de D/SL, Washington du 21 au 23 mars 1977, by M. Bignier, 25 March 1977.

The historian is therefore required to draw a delicate balance between what is not said in official documents and (some) oral interviews and what is overstated in more "politicised" sources. It must be stressed that because one of our purposes, underlying even if seldom specified, is to overcome future problems through knowledge of past experience, it is precisely the experiences which caused most trouble that attract the attention of historians. Last but not least, the analysis of conflict situations during cooperative ventures (as is true of crises in international relations), helps to open up the black box of decision-making, revealing the interests at stake.

Implementation, especially in such long-term enterprises, has two facets. On the one hand we have the day-to-day work of the men striving to attain a goal, to coordinate their tasks, to solve technical and managerial problems, to respect schedules and financial estimates and to monitor the development programme. This is an activity partly recorded in committees such as the ESA/NASA Joint Spacelab Working Group (JSLWG) or the Spacelab Programme Board (PB-SL) reporting to the ESA Council, and in programme evaluations and reviews – but it mainly takes place in the firms involved and at ESTEC. On the other hand, the goal as finally attained is seldom identical to the one set out at the beginning. Financial pressures, political and technical constraints constantly force its redefinition. A continuous feedback process is required between the political and the technical echelons as well as frequent bargains at the higher political level, to define rules and clauses that have deliberately been left open during the drafting of the legal instruments. This is even more true in the cases, such as Spacelab, in which changes are frequent. They can be imposed by European necessities in terms of savings or users needs, or by outside decisions, such as the restriction of funds by the US Congress which imply changes in the Shuttle design, or by technical accidents which generate slips in its schedules.

The technical competence of one partner, Europe in this case, may be a prerequisite but is not a sufficient guarantee for the happy ending of the story. A successful cooperation requires political willingness, which depends on internal and international interests at stake and bargaining capacities, which increase with each partner's knowledge of the other. They imply a common recognition of national goals, good communication channels, flexibility and mutual trust. Cooperation is something that goes against the well-rooted concept of national sovereignty; its main difficulties lie precisely in the need to keep to it formally and yet, to circumvent it in practice. In the implementation of these tasks lies the core of a cooperative programme.

The prospect of a repetition of cooperation eases the whole process. During the Spacelab negotiations, as we have already seen, Europeans insisted on introducing into the text of the legal instruments a formula whereby the partners anticipated the extension of cooperation beyond Spacelab; policy-makers were probably (and quite rightly) expecting that the prospect of a long-term cooperation based on reciprocity would reduce the risk of arrangements which penalised one of the partners excessively. In the case of repetition and in the absence of a superior juridical authority, this approach is normally met with a tit-for-tat behaviour which leads to a fatal deterioration of cooperation. It is in nobody's interest, therefore, to disavow commitments.

As the industrial work proceeded on the Spacelab programme, arguments started between ESA and NASA "on the precise definitions of the commitments and responsibilities undertaken in the existing agreements". What had been considered a skilfully phrased diplomatic formula such as "reasonable prices", "disproportionate impact" or "substantial duplication" needed to be given a specific content, while the arguments that had been deliberately left unsaid, to avert conflict, especially with regard to the contents of the deliverable items and the post-delivery phase, came to the forefront as topics of dispute.[1734] If the actors are working on the base of a loose agreement, the more work progresses towards the attainment of the goal, the more it becomes necessary to resolve the ambiguities which originally made the agreement possible. Friction arises between partners and bargaining can be tough, especially if, as in the case of Spacelab, partners are confronted with rises in costs and changes in design over a very long time. It is, however, a basic premise that the knowledge of each other acquired during the first phases of the cooperation, and the increased mutual interest developed during the attainment of the final goal, should favour compromises on *ad hoc* points that would be difficult to handle at the outset of cooperation. As we shall see, this is what happened most frequently during the Spacelab experience. Whenever a cooperation is invested with strong political significance, the credibility of both partners is equally at stake and the risk of losing it is a great cement for the enterprise.

In order to facilitate bargaining and mutual agreement between the two agencies and to clarify any eventual misunderstandings, an Annual Review was foreseen in Article VI, to be conducted and discussed by the NASA Administrator and the ESA Director General. The first meeting between Hocker and Fletcher was held on 20 May 1974. These discussions actually played a very important role in resolving misunderstandings and interpreting those clauses which had been left vague in the agreements whenever it was deemed necessary to do so. This was done at the highest level in the agencies and in the quickest way, while reaffirming each time the political importance of the cooperation.[1735] Good communication between Europe and the US was further pursued through the setting up of a network of joint working groups and the diplomatic skills of the people in charge of the programme.

13.6 The early involvement of industry[1736]

By June 1974 ESRO had passed over four thousand industrial contracts worth about $900 million.[1737] The total cost of the Spacelab programme alone was originally expected to be $250 (or 308 MAU), but ended up much higher. The challenge for European industry was a major one.

While early American studies on modules such as RAMs (research and applications modules) were performed in close connection with studies on the original Space Station, later studies were more focussed on manned laboratories in the context of a broader modular space station, such as the sortie cans. They had to be hosted in the Shuttle cargo bay and devoted to short term missions.[1738] In 1970 the European Space Conference authorised the first studies related to the Space Transportation System.[1739] From June to November 1972, three European consortia, COSMOS, STAR and MESH, concentrated on a modular orbital system to be flown by the Shuttle. They named it Sortie Laboratory or Space Laboratory and proceeded to three preliminary definition Phase-A studies. The COSMOS team was led by MBB (Messerschmitt-Bölkow-Blohm), which had participated as contractor to the Convair studies on RAM, and included SNIAS (FR), MSDS (UK), Selenia (I), ETCA (B), CASA (Spain) and CIR (CH). The MESH team was lead by the ERNO division of the VFW-Fokker Corporation, which had also participated in Convair studies and included Battelle (CH), BTM (B), Aeritalia (I), HSD (UK), INTA (S), MATRA (FR) and Philips (NL). The STAR team was lead by the British

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1734 HAEUI, ESA/IRAC (82)R/2, Annex III, Report on possible extension and/or expansion of the cooperation established between Europe and the United States of America in the Spacelab Programme, prepared by
J. Arets, J.L. Collette, F. Emiliani, C. Reinhold, G. Seibert, June 1981.

1735 *Ibidem*.

1736 On this point, see the insightful accounts in K. Berge, *op. cit*., pp. 1 - 19.

1737 R. Gibson, "Space Development - Europe or how the octopus learned to dance" (Transcript of a speech made at the Financial Times World Aerospace Conference, San Francisco, 15 October 1974), *ESRO/ELDO Bulletin*, No. 26, December 1974, p. 9.

1738 D. Lord, *op. cit*., pp. 35-48.

1739 See L. Sebesta, ESA HSR-15, *cit.*, pp. 8-9; where reference in note is omitted, we refer to M. Bignier, "Spacelab Development", *ESA Bulletin*, No. 36, November 1983, pp. 6-11.

Aircraft Corporation (BAC) and included Dornier (FRG), Contraves (CH), Thomson-CSF (F), GSE-FIAR(I) and Montedel (I).[1740]

As the Phase-A studies were approaching their end, in November 1972, the Council of ESRO authorised the Director General to carry out the detailed definition (Phase-B) studies, to arrive at a firm costing on which states could make their final decision. Belgium, the Federal Republic of Germany, Italy and Spain indicated their intention to finance this work. Soon afterwards, at the Ministerial meeting of ESC on 20 December 1972, ESRO was entrusted with the task of implementing the programme. During the ESRO Council meeting of January 1973, the German delegation stated that "since each of the three European space consortia had a very flexible structure, changes could be made to adopt their composition to the requirements of the new programme". This was achieved during the following months.[1741]

By January 1973 it was decided by the Interim Spacelab Programme Board, chaired by Professor Massimo Trella, that the distribution of work for Phase-B was to be organised, to the maximum extent possible, so as to ensure return to those states which, by the following month, would engage themselves in these studies. A provision was added whereby states could withdraw during 1973 if the results of the Phase-B studies should indicate that the original financial estimate of 308 MAU would be significantly exceeded. This tactic persuaded states other than the four original ones to get involved in the project, leaving an escape clause for them to withdraw at a later time. Politically, it was much easier for a Minister to gain approval for the commitment of a limited amount of funds, especially if, as happened in the case of the UK, it could be made explicit that the government was free to withdraw after completion of Phase-B studies. Nine states engaged, at different times, in these studies. By the end of Phase-B, the original financial estimate was confirmed and the division of costs among states was clarified (ESC Council of July 1973). None of them, eventually, withdrew from the enterprise – and Austria later joined the team.

Because of the higher percentage of expenses borne by the Federal Republic of Germany, and the existence of the fair-return principle, the prime contract was to be awarded to a German prime contractor. This consideration, along with the special technical requirements of Spacelab (the consortia were created to build unmanned satellites such as ESRO I and ESRO II and were not suitable for performing all the tasks required for this new undertaking) as well as the magnitude of the contract that would enable the participation of more firms than those usually required for earlier ESRO contracts, forced a total redirection of the previous three-consortium scheme. In fact it seemed appropriate:

> *that Phase B2/3 contracts be awarded to ERNO and Messerschmitt-Bölkow-Blohm, the two firms that had led the MESH and COSMOS consortia respectively in the Phase-A studies, with the provision that these firms, in selecting their co-contractors and subcontractors, must give serious consideration to a complete restructuring of their groups, bearing in mind the points previously raised [technical requirements of firms and magnitude of the contract], and also taking into consideration the STAR consortium firms that had taken part in the earlier work, as well as the fact that geographical allocation of the work at subsystem level must bear a close resemblance to the percentage contributions of the participating States. In other words, the selection of ERNO and MBB as prime contractors did not necessarily imply the selection of the MESH and COSMOS consortia, but that there should be a re-grouping around the prime contractors of as many as possible of the qualified industrial firms in the participating countries.*[1742]

1740 ` E. Vallerani, *op. cit*., p.14; D. Lord, *op. cit*., pp. 48-52.

1741 HAEUI, ESRO/C/MIN/53 (18 January 1973), 29 January 1973.

1742 "Europe and post-Apollo", no author, *ESRO/ELDO Bulletin*, No.22, August 1973, p.10; on the influence of Spacelab on the dissolution of the three original consortia, see also: Interview G. Van Reeth, by J. Krige and L. Sebesta, San Vincente, Italy, 11 July 1996.

The three initial consortia were therefore reorganised into two by February 1973.

Early in 1974, the ESRO project team at ESTEC issued to industry a Request for Proposals (RFP) for the design and development contract (Phase-C/D) and, as a result of the subsequent evaluation, the Director General recommended to the Administration and Finance Committee the choice of the industrial consortium lead by VFW-Fokker/ERNO against its rival MBB. This was not an easy choice. Generally speaking, MBB, which had accumulated more experience in aerospace production in previous years, appeared to many the favourite to win. The Tender Evaluation Board, however, after setting up ten panels to carry out the detailed evaluation, considered both proposals technically and financially acceptable and felt unable to recommend a choice between the two in view of the closeness of the final markings (approximately 1% difference). In accordance with standard practice, the Board's report was submitted to the ESRO's Adjudication Committee, under the chairmanship of the Director General, and finally chose ERNO on the following grounds:

1 "superior technical concept;

2 higher state of technical preparedness and depth of design for immediate implementation of Phase-C/D;

3 greater suitability of concept to user's wishes;

4 particular strength of top management aspects;

5 shortcomings of the proposals more easily 'repairable' both because of their nature and because some would come to bear only later on in the project."[1743]

The trade-off between quality, price, geographical distribution and political concerns is something whose complexity our sources cannot help us to grasp. It is however interesting to locate the geopolitical realities that it reproduced.[1744] The North, where Bremen was located, was the place where the Social Democrat Premier Willy Brandt had built up his political career as the major of Berlin, before becoming Chancellor in 1969, at the head of a Social Democrat/Liberal coalition, succeeding the long-established Christian Democrat government.[1745] The South, and Munich, where MBB was located, had in contrast benefited from governmental policies and industrial orders in the past. In fact the development of a strong technological region in Bavaria had been always high on the agenda of the Christian Democrat Minister of Defence Franz Joseph Strauss.

Notwithstanding, "the choice" recalled Roy Gibson, Acting Director General of ESRO, in October 1974 "was made after extended discussions within the Secretariat, and without any political pressure (from Germany or elsewhere)". Quoting again Gibson, the trade-off complied with the following steps: "Inside the Secretariat we have for many years taken steps to isolate the technicians from the need in their evaluation to attempt to quantify the importance of geographical distribution. The Tender

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1743 "Spacelab" (no author), *ESRO/ELDO Bulletin,* No. 25, July 1974, p.22.

1744 Douglas Lord hints at the "political overtones" of the choice; D. Lord, *op. cit.*, p.73. Vallerani describes how "the ESRO TEB tried to work in isolation, ignoring political pressures and concentrating on the technical aspects"; E. Vallerani, *op. cit.*, p.26. For a general introduction (in English) to the development of space policy and industries in the Federal Republic of Germany, see Johannes Weyer, *European Star Wars; the emergence of space technology through the interaction of military and civilian interest-groups*, in Everett Mendelssohn, Merrit Roe Smith, Peter Weingart (eds), *Science, technology and the military* (Dordrecht: Kluwer Academic Publishers) 1988, pp. 243-288.

1745 It is interesting to note that at the national election (November 1972) which had taken place after the sweeping international economic crises of 1971, the CDU-CSU lost its majority in Parliament for the first time in its history (44.9% against 45.8% for the SPD). Willy Brandt was succeeded as Chancellor by Helmut Schmidt in May 1974.

Evaluation Board makes its recommendations in the light of quality, cost and availability. The Board also notes those offers which are technically unacceptable. A separate committee – often meeting at Director level – adds geographical distribution considerations where this is necessary (relatively rarely). The most important contracts (around 30 per year) go to a delegate body, the Administrative and Finance Committee. This committee has two or three times reversed the recommendation of the Secretariat but in no case was the Secretariat instructed to award a contract which it considered to be technically unacceptable".[1746]

The first Annual Review between ESRO Director General, Alexander Hocker and NASA Administrator, James Fletcher, took place some days after the Director General's recommendation in favour of VFW-Fokker/ERNO, and before proceeding to Phase-C/D. The discussion soon focussed on the failure of both contractors to satisfy the target payload masses for the various configurations of Spacelab, by significant amounts. Adjustments in design and goals, and a reduction in the mass growth margins, arrived at with American assistance, contributed to solving the problem. Mass reduction needs, on the other hand, forced a revision of the original design, inducing a higher level of sophistication than initially envisaged.[1747]

In June 1974 the European industrial team led by VFW-Fokker/ERNO was awarded the six-year, 180 MAU ($216 million) Spacelab design and development contract, whereby the programme entered the design and development phase. The contract specified the deadline for the first unit, fully qualified and ready for installation of experiments, as April 1979 – the first launch being expected for early 1980. Two engineering models (one for ESRO and one for NASA), three sets of ground support equipment and spares were included in the contract. Commitment for the Instrument Pointing System (IPS) was postponed because the design and cost details were considered inadequate for development commitment. After protracted discussions with the US side and as a result of a tender action in October 1975, the programme for the development of the IPS was initiated in December 1976 and a contract was awarded to Dornier in June 1977 for IPS Phase-C/D, for a total value of 19 MAU (at December 1976 price levels).[1748]

During the Summer, ESRO and industry representatives of the Spacelab team visited the USA to discuss design details, operations and interfaces. They were led by Heinz Stöwer, acting Programme Director for ESRO and Hans Hoffmann, ERNO Project Manager.[1749] Hoffmann, with the administrative help of Hans Kappler and Bernard Kosegarten, Commercial and Financial Directors, and the support of his deputy Klaus Berge and later, Ants Kutzer (previously Project Leader of the German satellites *Azur* and *Helios*), would guarantee the continuity of management within ERNO during the whole project.[1750] The first NASA/ESRO Joint Programme Plan was produced in September 1974 in conformity with Article IV of the MOU. In order to clarify the working arrangements between the two agencies, it also amplified the overall description of the programme and of the phasing and scheduling

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1746 R. Gibson, "Space Development - Europe or how the octopus learned to dance" (Transcript of a speech made at the Financial Times World Aerospace Conference, San Francisco, 15 October 1974), *ESRO/ELDO Bulletin*, No.26, December 1974, p.9 (pp. 8-11).

1747 Papers of James Fletcher, Manuscript Division, University of Utah Marriot Library, Salt Lake City, box 20, note Frutkin to Fletcher, 2 June 1974; E. Vallerani, *op. cit*., p.26.; D. Lord, *op. cit.*, pp. 74-75.

1748 HAEUI, ESA/PB-SL(77) 13, 8 September 1977, Status of the IPS Development; a summary of IPS contractual history can be found in HAEUI, 6124, ESA/IPC(81)72, 5 November 1981, Industrial Policy Committee proposal to place a rider. The funding constraints and technical problems linked to the software used to control the various operational steps of the IPS, as well as the need to redesign it in order to comply with the Shuttle-Orbiter-induced load requirements after 1980, caused extended redesign and difficulties throughout the programme. Despite these inconveniences, IPS was finally loaded on Spacelab-2 in July-August 1985. The full IPS story still remains to be told. For a preliminary assessment, see H. Heusmann and P. Wolf "The Spacelab Instrument Pointing System (IPS) and its First Flight", *ESA Bulletin*, No. 44, November 1985, pp. 75-79.

1749 D. Lord, *op. cit.*, pp. 86-87.

1750 For a complete scheme of the ERNO organisation, See K. Berge, *op. cit*., p.10. See also E. Vallerani, *op. cit.*, p.39.

mentioned in Articles II and III of the MOU.[1751] The production was divided into various sub-systems, many of which were manufactured by subcontractors. VFW-Fokker/ERNO was responsible for the development, integration and test of the total system and ten European co-contractors, supported by 36 subcontractors, collaborated. At the height of the development phase, about 2000 people were employed in European industry to perform tasks related to the programme.[1752]

One of the more complex and debated tasks was performed by the Command and Data Management sub system, which contained three computers, one to handle the subsystems, one for experimenters' needs and one as a backup. After some resistance from the USA, which intended to use IBM machines, it was handed over to Engins MATRA (France).[1753] Other important tasks were performed by the other nine co-contractors: Aeritalia (Italy) responsible for one whole subsystem, the module structure, and part of the environmental control device (i.e. the thermal control); Dornier Systems (Germany) which built the environmental control and life support system and, later the IPS; Hawker-Siddeley Dynamics, later part of the nationalised British Aerospace (UK), responsible for the pallet structure; AEG-Telefunken (Germany), which built the electrical power system; Bell Telephone Manufacturing (Belgium), INTA (Spain), Fokker (The Netherlands), SABCA (Belgium) and Kampsax (Denmark). Other European firms, as well as ERNO itself, were involved with the production of other subsystems, as subcontractors.[1754]

US firms were involved from the beginning in Spacelab. They worked either directly for ESA (as in the case of TRW for the software system) or, more frequently, through agreements with private industry. Eventually, the technology passed over to European partners was in the form of know-how, not of black boxes.[1755] McDonnell Douglas, one of the first American companies to be deeply involved in man-in-orbit activities, which had contributed to NASA-funded studies on sortie cans for the Marshall Space Flight Center (and which had lost the bid for the Shuttle), welcomed the approaches by ERNO and provided up to 35 consultants to the firm, 5 to Aeritalia and 2 to Fokker. As recalled by Vallerani, "it went so as far as to set up a European branch, with head offices in Bremen" to manage its consultancy contracts.[1756] At the same time, suffering from what was perceived as an undue loss of industrial procurement opportunities in a time of need, it critically scrutinised European firms in the opening stages of collaboration.[1757] Martin Marietta joined the MBB team. Consultants in general provided an important input during and after Phase-B studies and stayed on until the engineering model was delivered to NASA in 1980. The contribution of TRW consultants to ERNO, MATRA and BTM was important in easing problems related to payloads and avionics.[1758]

1751 NASA-ESRO Joint Programme Plan for Spacelab, by Douglas Lord, Director, Spacelab Program, NASA and Heinz Stöwer, Acting Head of Spacelab Programme, ESRO, 26 September 1974; reproduced in D. Lord, *op. cit.*, pp. 461-467.

1752 M. Bignier, "Spacelab Development", *cit.*, p.8.

1753 D. Lord, *op. cit.*, pp. 93-95. The then Programme Director Jean-Pierre Causse played an important role in ensuring that the computers and aluminium for the module were procured from European sources; Intervention K. Berge, Spacelab Workshop, Noordwijk, 22 April 1997.

1754 Switzerland and Austria were only represented by sub-contractors, with CIR and VMW respectively; see A. Thirkettle, F. Di Mauro, R. Stephens, *Art. cit* ,part 1, p.71; K. Berge, *op. cit.*, p. 11; D. Lord, *op. cit.*,p. 85 and pp. 175-205.

1755 Intervention K. Berge, Spacelab Workshop, Noordwijk, 22 April 1997.

1756 E. Vallerani, *op. cit.*, p.18.

1757 On this point, see the interventions of L. Tedeman and H.E.W. Hoffmann, Spacelab Workshop, Noordwijk, 22-23 April 1997.

1758 D. Lord, *op. cit.*, pp. 85-86; for schedule extension of TRW support personnel at ERNO due to the unavailability of experienced ERNO personnel, see HAEUI, ESA, dep. 2, 5580, Letter Pfeiffer, Project Manager, Spacelab, ESTEC, to Berge, ERNO, 6 February 1979. *Aviation Week and Space Technology* estimated in 1973 "that 20% of Spacelab's $300 million total cost (would) be spent in the US to buy technology, systems skills and hardware": "Space Technology. US to Extend Export Dominance", *Aviation Week and Space Technology,* May 28, 1973, pp. 222-229, p.222 for quotation. For a broader reference to the role of US consultants, see intervention of K. Berge, H. Hoffmann and R. Pfeiffer, Spacelab Workshop, Noordwijk, 22-23 April 1997.

13.7 General guidelines for payload selection and the institutional framework of the programme

The objectives of Spacelab, which had been defined in concise terms in the MOU as being "peaceful", were among the most relevant topics discussed during the first annual review of Spacelab programme (20 May 1974), where Fletcher and Hocker met to discuss its future development. In the guidelines set out by NASA for the discussion, the payload was said to be "open to science, applications, and technology experiments"; it should not, however, "carry experiments where the results will not be freely disseminated or where the main purpose [would be] for direct commercial exploitation". We already saw how the topic of commercialisation had given rise to debates during the negotiations, the Europeans being prone to establish common codes of conduct, the USA to "harmonise" the respective ones. The will to preserve their freedom in such a delicate domain probably prompted the USA to abandon the prospect of cooperation in commercial areas altogether. This limitation, which was not in the original text of the MOU, was a proof of the persisting difficulties in cooperating when financial returns were anticipated and, therefore, competition envisaged. The guidelines and procedures for selection of the first Spacelab payload, proposed by the NASA/ESRO JPG were approved. The principal objective of the first payload would be the verification of the main Spacelab design aspects and capabilities and the performance of a series of scientific experiments.[1759]

As far as the organisation is concerned, Spacelab development would be managed by Europeans, with the assistance of the USA. While France, in the Ariane programme, had made the assumption of the largest financial share conditional on the acceptance by the other partners of CNES management, the Spacelab programme, pending the establishment of ESA, was managed by ESRO and later ESA. This reality was reflected in the numbers of ESA personnel involved in the two projects: 120 for Spacelab and 25 for Ariane.[1760]

The Federal Republic of Germany, though being by far the most important contributor, was not entrusted with the predominant institutional role it claimed;[1761] as a matter of fact, after the nomination of Jean-Pierre Causse as first Programme Director in March 1973, the role of the Director of the programme was always entrusted to a French citizen, except for the period during which Heinz Stöwer was Acting Programme Director.

The programme was supervised by the *Spacelab Programme Board* (PB-SL), as indicated by Article 4 of the agreement between ESRO and its members in 1973 and by US/European agreements. The Board, composed of representatives of the participants, provided the Director General with all the necessary instructions regarding the interfaces of the programme with the Shuttle, and ensured links with the user community. After existing as an interim board (the Spacelab Interim Board), the PB-SL had its first meeting on 30 September 1975, under the chairmanship of the Italian aeronautical engineer Luigi Broglio.

Generally speaking, the structural changes introduced after the birth of ESA favoured increased independence of the Agency from its Member States. Three programme directorates were created – Communications Programmes, Science and Meteorological Programmes and Spacelab Programme. Whereas in ESRO the responsibility for implementation rested ultimately on the Council, the more focussed ESA Directorates, reporting directly to the Director General, permitted direct action and less dependence on national inclinations. This relative autonomy during the implementation, was further enhanced in the case of Spacelab by the existence of the ESRO Member States Agreement whereby members had delegated the Organisation the power to take practical steps for the implementation of the agreement.

1759 Papers of James Fletcher, Manuscript Division, University of Utah Marriot Library, Salt Lake City, box 20, Diary Note by Frutkin, First Spacelab Payload Selection: Guidelines, Procedures, Constraints and Timetable, l0 May 1974. For more details on this point, see chapter 14.

1760 Interview M. Bignier by L. Sebesta, 6 December 1996, Paris.

1761 Intervention J-P. Causse, Spacelab Workshop, Noordwijk, 22 April 1997.

The implementation of the programme was ascribed to two Heads of Programme, or *Spacelab Programme Directors*, since it had been established that there would not be joint management responsibility of the programme: one for ESRO (originally, Jean-Pierre Causse) and one for NASA (Douglas Lord). While Lord kept his post until 1980, to be replaced later by James Harrington, there were several replacements on the European side. Causse left his post in April 1974 to become Director of Research of the firm Saint-Gobain and after that Heinz Stöwer took up the delicate double post of Acting Programme Director and Project Manager. Stöwer left the first post in March 1975, when Bernard Deloffre (French chief executive of the Symphonie satellite programme and former Director of the Space Launch Centre of Kourou in Guiana) was nominated Programme Director. Deloffre left his post in June 1976 and, after an interim of four months covered by Gibson and Trella, Michel Bignier (ex Director General of CNES) took up his task in November.

Two *Project Managers* were responsible for day-to-day and more technical coordination. The ESRO Project Manager at ESTEC was Heinz Stöwer and the NASA Project Manager at the Marshall Space Flight Center was Thomas (Jack) Lee. Stöwer was substituted as Project Manager in March 1977 by Robert Pfeiffer (who had directed the Franco-German experimental telecommunication satellite Symphonie). Franco Emiliani, number two to both Stöwer and Pfeiffer, assured management continuity. In 1983, Pfeiffer was replaced by G. Altmann. Despite the split of management along geopolitical and industrial lines, cooperation was achieved through many consultative joint groups. At the end of November 1972 the *ESRO/NASA Joint Sortie Laboratory Working Group* jointly chaired by Johannes Ortner (ESRO Assistant Director for Space Missions) and Douglas Lord (Director of the NASA Sortie Laboratory Task Force) met in Washington. The same committee had been working to coordinate technical activities on orbital system studies for the two previous years. From now onwards it was to monitor the exchange of technical information, resolve interface questions between Spacelab and the Shuttle, to coordinate changes in requirements or contents and settle cost issues.[1762] By the third meeting Jean-Pierre Causse, named Head of the Spacelab Programme, replaced Johannes Ortner as ESRO committee chairman. The name of the group was changed into the *ESRO/NASA Joint Spacelab Working Group (JSLWG)* after the decision to use Spacelab as the official name of the project. Constraints originating from the Shuttle's technical and financial features were to be matched against users' requirements for Spacelab design and operations, which were solicited, from 1973 onwards, through the *Joint ESRO/NASA User Requirements Group (JURG).* This was initially co-chaired by Gerald Sharp (NASA) and Johannes Ortner (ESRO) and eventually revived in 1978 to report on users' requirements *vis-à-vis* improvements of Spacelab within the Follow-on Development Programme. Both co-chairmen of JURG were therefore full members of JSLWG.[1763]

One cannot fail to notice the importance of the procedure set up by the MOU whereby the two heads of ESRO (later ESA) and NASA would meet regularly to solve major problems arising in the implementation of the programme. These meetings were indeed extremely useful in showing to the public how Spacelab was identified by both NASA and ESA as being among their top political priorities, and in reinforcing the authority of the Director General *vis-à-vis* industry, when he had to force it towards some special requirements in terms of time or financial schedules. There was a remarkable stability in contacts between Gibson (Acting Director General of ESRO from July 1974 to April 1975 and thereafter Director General of ESA until May 1980, when he was replaced by Quistgaard) and Fletcher, NASA Administrator, who left the agency in May 1977 to be replaced by Frosch.[1764] Gibson himself was always in close and direct contact with the senior managers of Spacelab throughout the programme.

1762 Article VI of the Memorandum of Understanding; see also M. Bignier, 'Spacelab Development", *cit.*

1763 HAEUI, ESA, 4876, Inter-office Memorandum, Charter for JURG, by Bignier, 23 March 1978. Other joint working groups were created to manage specific aspects, such as the Spacelab Operations Working Group, the Software Coordination Group and the Avionics Ad Hoc Group; see D. Lord, *op. cit.*, p.100. Other groups discussed the scientific aspects of Spacelab, such as the NASA/ESRO Joint Planning Group co-chaired by Gerald Sharp (NASA) and Jacques Collet (ESRO). For more details, see chapter 14.

1764 Robert Frosch would be eventually replaced, in June 1981, by James Beggs.

On the industrial side, a structure was soon created to coordinate the work of the co-contractors, to increase the effectiveness of leadership to be played by ERNO, to solve interface problems and to transmit, without excessive loss of time and energy, changes in design and in time schedules. This was the *Board of Directors of the Spacelab Consortium*, which met every three months. Sessions were held, at different locations, to increase everybody's sense of participating in a "common mission".[1765] Bignier used the Board to be kept informed of progress in industrial work in a delicate period of the programme, participating in the last part of these meetings. This gave the firms a sense of being in touch with the latest political development of the programme, enabling the Director, at the same time, to be in close touch with the problems on the production side in order, if necessary, to solve them quickly and informally.[1766] Finally, mention should be made of ESA's representative in Washington, Wilfred Mellors, and NASA's representative in Paris, P. Murphy (initially); they were the channels that filtered political information pertaining to the country where they were based, giving the officials back at home an invaluable framework for decisions and behaviour at high-level diplomatic meetings. This complex institutional framework was put on the credit side of the programme by both US and European observers.[1767]

13.8 The management: early challenges and creative solutions

The implementation of the programme can be considered as a story whose main scenes took place in a somewhat isolated context, mainly in ESA/ESTEC (where the overall project direction, control and coordination with NASA was performed) and in ERNO and its co and sub-contractors firms. Yet, the development of this story was linked to the external environment in a layered way: the outer of these was the economic system of the 1970s, which deeply influenced the financial aspects of the project: at an intermediate level there was the Shuttle system, in which Spacelab was deeply embedded and on which it was totally dependent: finally, there were all the questions related to the implementation of the programme, the main actors here being on the one side ESA/ESTEC, ERNO and the other firms involved and on the other NASA. The intertwined relationships between these three layers created the extraordinarily intricate structure of the Spacelab programme.

Economically, the 1970s were a critical period. They started with the crumbling of the fixed currency exchange system that had guaranteed, since 1945, the stability of international commerce. The exceptionally high level of industrial production attained by the developed countries by 1972-73, was soon counterbalanced by the oil crisis, and subsequent oil price increases, which struck Western countries in the last months of 1973. In four months the price of a barrel of oil increased by a factor of four (from 3 to 12 dollars). This was paralleled by a sustained increase in the prices, on the international markets, of primary commodities. Due to this economic and financial turmoil, inflation rates, which had been increasing since 1968, exploded and reached their highest levels since the war. From 1974 to 1980, inflation rates rose to 9.2% in the US, 11.1% in France, 15.9% in the UK and 16.8% in Italy. The Federal Republic of Germany was the only exception to this general increase: however, it scored a remarkable (for its post-war standards) 4.7%.[1768] Spacelab, whose original price of 308 MAU was calculated in 1973 prices, was severely hit by these circumstances (much more than Ariane, whose reference price was in 1974 currency).[1769] And, among participating states, those with the highest rate of inflation, such as Italy, were obviously exposed to the greatest increase in

[1765] See the observations by H. Hoffmann, Spacelab Workshop, Noordwijk, 23 April 1997; also E. Vallerani, *op. cit.*, p.30.

[1766] Interview M. Bignier by L. Sebesta, 6 December 1996, Paris.

[1767] HAEUI, ESA/IRAC (82)R/2, Annex III, Report on possible extension and/or expansion of the cooperation established between Europe and the United States of America in the Spacelab Programme, prepared by J. Arets, J.L. Collette, F. Emiliani, C. Reinhold, G. Seibert, June 1981; see also D. Lord, *op. cit.*

[1768] Pierre Milza, Serge Bernstein, *Histoire du XXe siècle. 1973 à nos jours, la recherche d'un nouveau monde* (Paris: Hatier) 1993, p.13; Alan Milward, *L'Europa in formazione*, in AAVV, *L'Europa oggi* (Torino: Einaudi) 1993, pp. 211-219.

[1769] This important consideration was suggested by M. Bignier, Interview M. Bignier by L. Sebesta, 6 December 1996, Paris.

production costs. The rises of the first two years, which brought the original estimate up to 369 MAU by the end of 1975, seem actually to have been totally due to the rates of inflation.[1770]

Within this economically unfavourable context, Europeans were confronted with yet another, more practical, problem. Spacelab and Shuttle development proceeded in parallel throughout the 1970s. Both projects had technical difficulties, delays and cost overruns. As far as Spacelab was concerned, this meant that it had to be integrated into a system whose parameters were open to refinement until the very end, whose timetable for launch was repeatedly postponed and whose pricing policy was highly uncertain. Commonality, which had been one of the focusses of discussions during the drafting of the legal instruments, had to be negotiated on an *ad hoc* basis. Discussions ranged from the prosaic choice of the measurement system (Europeans struggled to keep their metric system for Spacelab specifications, while US units (feet, pounds etc.) were kept for the Shuttle and its interfaces) to the delicate decision on the possibility of taking a docking module on board (for emergencies), which would imply a great loss of mass for Spacelab.[1771] Refinements of specifications and schedules of the Shuttle affected the cost-to-completion of the whole Spacelab.[1772] It is difficult to quantify the impact of this on the Spacelab cost overrun.[1773] Anyway, several Shuttle/Spacelab hardware and programmatic interface issues, before and after the delivery of Spacelab to the US, were still open during the integration and test phase at the end of the 1970s. NASA expected ESA to fund all make-work changes to Spacelab, including those originating from the Shuttle, up to the second Spacelab flight, while ESA was trying to limit its funding responsibility to a funding ceiling and a precise cut-off date for the new NASA requirements.[1774]

This problem was tackled using a two-way approach. On the one hand the initial ESA approach whereby any contractor in the consortium could raise an engineering change proposal and start working on it (being sure to be funded by ESA if the change required extra payments) was terminated. Changes subsequently needed prior approval by ESA. On the other hand, a "Risk Assessment Working Group" (J. Harrington and R. Pfeiffer) was set up to define ESA/NASA responsibilities as far as the post-delivery support phase was concerned.[1775] Spacelab was required to meet essential technical and scientific requirements and, at the same time, to stay within the programme constraints of schedules and funds. While ERNO, a private firm, its co and sub-contractors, were more interested in the technical success of the enterprise, with less regard for fund limitations and time constraints, ESA/ESTEC, by definition, appeared to emphasise time and financial schedules. The reconciliation of these different if not divergent aims was the challenge that Spacelab managers had to confront for a decade. The formalisation introduced by the ESA management in order to reduce the price of changes, for example, was perceived by industry as an obstacle to quick changes and efficiency in the

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1770 HAEUI, ESA, 4876, Letter, Deloffre to Lord, 28 November 1975; the exchange rate of AU into dollars changed to 1 AU being equivalent to $ 1.3.

1771 The idea was eventually discarded. See J.-P. Causse's intervention, Spacelab Workshop, Noordwijk, 22 April 1997.

1772 See, for example, D. Lord, *op. cit*., p.102.

1773 During a presentation given in 1982, Robert Pfeiffer tried to assess the causes for Spacelab cost overrun (40%) up to that date, indicating approximately the following percentage: 33% due to consortium make-work changes and higher cost for work in industry already committed, 30% due to the fact that some MOU commitments were not part of industrial baseline contracts (logistic support, depot maintenance and sustaining engineering support), 20% due to new user requirements and inadequate design, and 17% due to Spacelab/orbiter interface changes, including flight and ground operations.
See R. Pfeiffer, *Le programme Spacelab. La gestion du programme, les problèmes rencontrés et les solutions adoptées*, Paper presented at the Course on Space Technology/The management of Large Space Programmes, CNES, Toulouse, 3-14 May 1982.

1774 HAEUI, ESA, 4860, Memorandum W. Brado to J. Stiernstedt, 5 October 1979.

1775 Intervention of R. Pfeiffer, Spacelab Workshop, Noordwijk, 23 April 1997. (HAEUI) ESA Washington Office, Internal communication. Inter-office Memorandum, from D/SL (Bignier) to Mellors, 11 April 1979, Action decidée lors de la reunion DG/A du 29 March 1979; *ibidem*, Letter Frosch to Gibson, 7 May 1979; *ibidem*, Letter Gibson to Frosch, 17 May 1979.

production process.[1776] The flexibility of the structure (the Spacelab would be available in more than one configuration), the constraints imposed by the Shuttle features and their changes, and the number of companies involved caused many different concerns to managers and constructors during the programme. Spacelab characteristics such as mass, subsystems, interfaces, and its programmatic features such as operations and user requirements, changed over time and gradually diverged from those in the first document "Spacelab Guidelines and Constraints for Programme Definition, Level I",[1777] produced in March 1973 by the programme directors, Jean-Pierre Causse and Douglas Lord. The complexity of these changes has been analysed elsewhere.[1778] Progress in the programme was monitored at major milestone reviews, the list of which (see below) we take from an article by a qualified eye-witness. These reviews were catalysing milestones of the project, an essential part of the project management. Not only was industrial performance scrutinised there, but young engineers also had the opportunity to become familiar with a US managerial style developed from a need for accountability and the demands associated with the production of complex technical systems.

Some US suggestions were gladly incorporated into the practices of European engineers, such as the formalised procedures for presenting reports and proposals, implying the extensive use of graphs and tables.[1779] On the other hand, the need for written specifications down to the smallest detail was sometimes resented as an implied criticism of the personal capabilities of European engineers and technicians, who were used to operating with more autonomy.[1780] Other procedures, such as the "award fee system", were introduced and then later discarded because they were not tuned to the uncertain schedules and continuous changes of the programme.[1781] The "managerial gap" of the late 1960s between the US and Europe was (also) being closed through day-to-day exposure of European engineers to US procedures and through the creative appropriation and selective rejection of the proposed models.

1776 For the industrial point of view, see K. Berge's intervention, Spacelab Workshop, Noordwijk, 23 April 1997.

1777 HAEUI, ESA, dep. 2, 5606, 'Spacelab Guidelines and Constraints for Program Definition, Level I", by Douglas Lord and Jean-Pierre Causse, 23 March 1973; see also D. Lord, *op. cit.*, pp. 87-88 for the first document, p.91 for the last.

1778 K. Berge, *op. cit*., pp. 20-37; E. Vallerani, op. cit., pp. 31-40. Douglas Lord's book follows these milestones step by step; D. Lord, *op. cit.*

1779 See H. Hoffmann's intervention, Spacelab Workshop, Noordwijk, 23 April 1997; K. Berge, *op. cit*., pp. 20-21; E. Vallerani, *op. cit.*, p.17.

1780 For similar considerations, see K. Berge's intervention, Spacelab Workshop, Noordwijk, 23 April 1997.

1781 R. Pfeiffer's intervention, Spacelab Workshop, Noordwijk, 23 April 1997; see also K. Berge, *op. cit*., pp. 15-16.

The major milestone reviews were the following:

1 The Preliminary Requirements Review (PRR) in 1974 established a conceptual baseline for subsequent reviews and gave preliminary approval to higher level system specifications and plans.[1782]

2 The System Requirements Review (SRR) in 1975 updated the system requirements and served as a start for the final subsystem definition and design phase.

3 The Preliminary Design Review (PDR) in 1976 was a technical review of the basic design approach, to assess design versus requirement and adequacy of design in order to lead to authorisation for Engineering Model design and manufacture.[1783]

4 The Critical Design Review (CDR) in 1978 formally established the production baseline for the first flight unit.

5 The Final Acceptance Review (FAR) in 1981, at which ESA formally accepted the Spacelab Module flight unit from ERNO and NASA accepted it from ESA.

6 The Final Acceptance Review (FAR) in 1982, at which ESA formally accepted the flight units of the Spacelab igloo and pallets from ERNO and NASA accepted them from ESA.[1784]

By 1976, technical and managerial problems became serious.[1785] This was all the more disturbing because, by 1977, the emphasis within the Spacelab project team should have been changing from one of system and sub-system design to hardware manufacture, assembly and test. The most difficult managerial task involved in the Spacelab programme would be to find the right procedures to deal with two problems:

1 the implementation of technical changes;

2 the enforcement of cost-reducing steps.

This would imply quick contractual adjustments, quick communication and effectiveness of authority. The bigger the project and the greater the distribution of tasks among the co and sub-contractors, the bigger was the need for an efficient managerial control by the prime contractor. All this required stringent controls by ESA on ERNO, ERNO's improved authority over co-contractors and coordination between co-contractors having subsystem interfaces. This meant continuous supervision, coordination, flexibility, and charismatic leadership.[1786]

Among the managerial changes realised during this period, it is worth mentioning at least two which attempted to come to terms with the problem of implementing changes:

1782 M. Bignier, "Spacelab Development", cit. footnote 1739: see also; "Spacelab" (no author), *ESRO/ELDO Bulletin*, No. 27, April 1975, p.17.

1783 HAEUI, ESA, dep. 2, 5596, Spacelab Preliminary Design Review PDR-B, Minutes of ESA/ERNO Board (part II) held at ERNO, Bremen (8 December 1976), by M. Bignier and H. Hoffmann.

1784 M. Bignier, "Spacelab Development", *cit.*, p.9.

1785 HAEUI, ESA, dep. 2, 4860, Memorandum Reinhold, Meeting ESA/Spacelab Board of Directors (2 March 1976), 11 March 1976; see also E. Vallerani, *op. cit.*, pp. 37-39.

1786 For the difficulties in the management of the programme in the mid-1970s, see HAEUI, ESA, dep. 2, 5596, Fourth Report of Adelbert O. Tischler to ESA on the Spacelab Programme, based on observations made during the period May 8-21, 1976.

1 a special joint ESA/ERNO-NASA/Rockwell group was created to address the question of changes impacting the Shuttle-Spacelab interfaces. This group met twice a year and tried to establish some basic criteria to reduce changes and their financial impact.[1787]

2 the backlog of changes to be negotiated with industry was enforced through "bulk" negotiations, referred to by Gibson as "a commando type exercise aimed at dealing with the change notices in the pipeline".[1788]

Pessimism was expressed by the Americans during the PDR of December 1976.[1789] ESA's own assessment was equally critical: design deficits (that is weaknesses in design) could only be solved "without major cost or schedule impacts if correct management action (was) taken and full co-contractor cooperation achieved". Management authority and delegation of authority were considered "mandatory" to solve the problem which should be confronted "immediately".[1790] Despite these weaknesses, Gibson hoped that through modest delays, severe cuts in the deliverable hardware, disciplined resistance to future changes and continued dedicated effort by all participants the programme should be accomplished within the 120% margins.[1791]

Michel Bignier, as new Director of the Programme since November 1976, began a major analysis of the primary flaws of the programme, which he found in its growing costs and in low industrial productivity. The programme seemed to have been defined with "over-optimistic planning". Engineering changes required in the PDR were handled (in terms of costs) by reductions and cuts in the programme. A severe "scrubbing" (or "descoping") was approved by the SB Programme Board in January 1977. Cuts affected the areas of logistics, maintenance and spare parts, and the pallet-only mode.[1792] Due to the strong German support (and French backing), IPS, a potential candidate for the "descoping" exercise, was kept within the general Spacelab budget, despite the opposition of five delegations.[1793] The mood of the time was captured by Bignier's comment on this decision. "I have accepted the constraints imposed by them (the Delegations) on the Programme" he wrote to Douglas Lord "in the spirit of the TV programme 'Mission Impossible' in which the actors always succeed in carrying out their impossible task (…).[1794]

1787 Among the criteria cited by Pfeiffer in his intervention (Spacelab Workshop, Noordwijk, 23 April 1997), two seem of special interest: "Each change would be studied on both sides of the interface to find the most economical and appropriate solution; the change would be implemented on the side of interface where it was cheapest. The cost incurred was borne by the party responsible".

1788 *Ibidem*. See also Papers of James Fletcher, Manuscript Division, University of Utah Marriot Library, Salt Lake City, box 43, Letter Gibson to Fletcher, 8 July 1976.

1789 Papers of James Fletcher, Manuscript Division, University of Utah Marriot Library, Salt Lake City, box 43, Letter Fletcher to Gibson, 16 August 1976; "Documentation was inadequate, schedules were slipping, the budget could not be held, the contractor team was out of control, and the team morale was at an all-time low": D. Lord, *op. cit*., p.143.

1790 HAEUI, ESA, dep. 2, 5596, Spacelab Preliminary Design Review PDR-B, Minutes of ESA/ERNO Board (part II) held at ERNO, Bremen (8 December 1976), by M. Bignier and H. Hoffmann.

1791 *Ibid.*

1792 E. Vallerani, *op. cit*., pp. 39-40.

1793 From Belgium, Denmark, Italy, The Netherlands and Spain; for a summary of IPS evolution in this period, see HAEUI, ESA/PB-SL(77)8, 26 May 1977, Status of the Development Project; see also HAEUI, ESA/PB-SL/MIN/10, 9 March 1977. Dornier contract for IPS C/D phases would be finally signed in June 1977 for a total of 19 MAU (at December 1976 prices -that was a fixed price plus incentive with a price escalation clause in order to limit costs overruns); HAEUI, ESA/PB-SL(77)13, 8 September 1977.

1794 HAEUI, ESA, 4872, Letter Bignier to Lord, 18 March 1977.

With "new blood"[1795] injected in the management of Spacelab, both at the Director level and at the programme manager level (Stöwer, as we have seen, was replaced by Pfeiffer), a continued presence of ESA at ERNO, to provide, in the Director General's words "the daily guidance, encouragement and firm orders which they need"[1796] and, finally with a tightened contact between ERNO and its co-contractors through the Board of Directors, the project could confront the crucial transition between the "paper" phase dedicated to the drawing up of specifications, schedules and contracts and the hardware phase of manufacture, assembly, test, verification and check-out.

In the meantime, new areas of possible disagreement between European members, and between them and the US, had to be confronted. The integration contract was given, through the Marshall Space Flight Center, to McDonnell Douglas (MCDAC): it amounted to $ 43.5 million in 1977 prices.[1797] The Wall Street Journal of 11 March 1977 reported the letting by NASA of the contract for "a scientific unit of the Space Shuttle", avoiding any reference to either Spacelab or Europe.[1798]

In Summer 1977, under German pressure, the Council was confronted with the problem of the financing of the first payload. Its updated cost (13.9 MAU in 1976 prices) compared to the charge of the Spacelab development was forecast to be low.[1799]. Considering the difficulties Bignier was trying to overcome in order to remain below the ceiling of 120%, however, it was difficult to think that it could be funded out of the development programme,[1800] A general resolution on the willingness to adopt a new optional programme called the Spacelab Utilisation Programme, including the FSLP and two demonstration missions, was eventually approved in October.[1801]

At the same time, in order keep below the 120% ceiling, Bignier obtained from the Americans an extension of their financial responsibility in order to cover the whole tunnel being built by a NASA contractor and originally financed partly under the Shuttle development effort and partly under the Spacelab programme.[1802] Soon after, in the Summer of 1977, it was the USA's time to ask for cooperative behaviour. It then became clear that NASA wished to postpone the Spacelab-1 flight, which should originally be flown in the first operational Shuttle, because of their wish to launch the Tracking and Data Relay Satellite System (TDRSS) 1 & 2 with the Shuttle before Spacelab-l.[1803] Fortunately, slippage in production and flight plans of the Shuttle, despite having some bad repercussions on the cost side of Spacelab, matched the European need for expanded production time: it would in fact have been nearly impossible for Europe to produce Spacelab in time for the 1980 launch which had been planned in 1977.

During the ESA Council of July 1978 it became clear that there would be difficulties in keeping the development costs within the 120% limit. The German delegation explained the need to increase national contributions for Spacelab with the fact "that the programme had not been originally

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1795 HAEUI, ESA, dep. 2, 5580, Letter M. Bignier to J. Yardley (Associate Administrator for Space Flight, NASA) 22 December 1976.

1796 HAEUI, ESA, dep. 2, 5580, Letter R. Gibson to J. Fletcher, 2 February 1977.

1797 HAEUI, ESA, dep. 2, 5596, Compte rendu de la mission de D/SL à Washington du 21 au 23 mars 1977, 25 March 1977.

1798 As press briefings and TV broadcasts began to be programmed in the US, ESA Spacelab representative at NASA wrote an alarmed report to his HQ on what he perceived as a tendency, albeit not extendable to all sectors of NASA, to Americanise the programme; HAEUI, ESA, dep. 2, 5580, Rapifax message from Jan Bijvoet (ESA Spacelab Representative at NASA) to Pfeiffer, 14 March 1977.

1799 HAEUI, ESA/SPAG (77)23 (2716/1977), Annex III, Projet de declaration des participants au programme d'utilisation du Spacelab.

1800 HAEUI, ESA/C/MIN/18 (30 June 1977 to 1 July 1977), 18 July 1977.

1801 HAEUI, ESA/C/XX/Res.l, 4 October 1977; for more information on the FSLP, see chapter 14.

1802 Interview M. Bignier, 6 December 1996, Paris. For the original setting, see Papers of James Fletcher, Manuscript Division, University of Utah Marriot Library, Salt Lake City, box 43, Spacelab issue paper, by Douglas Lord, 23 May 1975.

1803 HAEUI, ESA, 4876, Letter Bignier to Yardley, 13 June 1977; HAEUI, ESA, 5580, Telex M. Bignier to W. Mellors, 22 July 1977.

sufficiently precisely defined and that major design modifications had to be made, while appreciable technical difficulties subsisted". Everything should be done, in Germany's view, to avoid a further cost overrun "which meant that the Agency should in particular adopt an extremely firm attitude towards NASA's demands, at the risk of accepting some deterioration of the good relations with NASA". Both the Director General and the Spacelab Programme director pointed to the inevitability of overruns, due to the early stages of design of both Spacelab and the Shuttle when the MOU was signed, to the novelty of the task for European industries, to the number of firms involved and to the constraints affecting the distribution of work. However, in front of the Member States, they defended their position *vis-à-vis* NASA, a position that, in the Spacelab Programme Directors' words "could never have been regarded as 'easy-going', but rather the opposite.[1804]

13.9 Beyond the "sacred limit" of 120%[1805]

Actually, in June 1978, just a few weeks before the Council, Gibson had sent to NASA a diplomatic yet firm assessment of the Spacelab programme as seen from Europe. The price for a Shuttle flight (which had been finally communicated by NASA the year before) seemed to go well beyond the first tentative American forecast of 1973; no convenient solution for Europe was in sight as far as the procurement of a second Spacelab was concerned (discussions being focussed at the time on the "barter agreement"[1806]); suggestions were being aired about a possible development by the USA of a sortie system which would substantially duplicate Spacelab. On the other hand, the Spacelab programme had demanded from Europe much more than initially foreseen and "the large number of interface modifications needed and the delivery to NASA of more hardware than initially foreseen, greatly contributed to this increase in expenditure".[1807]

Gibson's letter was received with what he later described as "hurt incomprehension". Frosch being out of the country, it was Lovelace, as Deputy Administrator, who harshly retorted to Gibson that "many of the complaints cited reflected misunderstandings, both of the current situation and of the basic Spacelab agreements".[1808] We already hinted in the introduction to this part of the chapter, how Lovelace's attitude could have been affected by his hierarchical position within NASA; Gibson's letter, on the other hand, was probably linked to the necessity to rebuke the critics of Spacelab and of what was increasingly interpreted by European members as a "soft" attitude *vis-à-vis* NASA, in parallel with the prospect of yet another rise in national contributions. One substantial result of Gibson's move was the US decision to proceed with the procurement of a second Spacelab, a decision we will soon examine in depth.[1809]

In the following autumn, during the annual review between the agencies' directors, Gibson "pointed out that in its approach to Member States ESA (had) to assume end-1981 as the termination date for European funding of the sustaining engineering support. ESA (would) not be able to provide funding beyond that date". NASA's Administrator retorted that, as with all development programmes, the indicated target dates should be refined "as they are affected by technical progress and the availability of necessary funding".[1810] NASA expected ESA to fund all changes of Spacelab including those originating from the Space Shuttle, up to the second Spacelab flight which was then scheduled for October 1982. ESA tried to limit its funding responsibility to a ceiling value and to a precise cut-off

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1804 HAEUI, ESA/C/MIN/26 (26-27 July 1978), 14 September 1978.
1805 The expression is used in Gibson's letter we refer to in the text; HAEUI, ESA, 4876, Letter Gibson to Frosch, 28 June 1978
1806 See the section on FOP.
1807 HAEUI, ESA, 4876, Letter Gibson to Frosch, 28 June 1978.
1808 HAEUI, ESA, 4876, Letter Lovelace to Gibson, 10 July 1978
1809 HAEUI, ESA, 5580, Letter Frosch to Gibson, 4 December 1978.
1810 (HAEUI) ESA Washington Office, 020-2C DG/A, Meeting of ESA Director General and NASA Administrator, 7 October 1978.

date for new NASA requirements.[1811] NASA's European representative James Morrison, writing to Michel Bignier in May 1979, saw "a clear inconsistency in ESA's strongly held position of not wanting to be treated like a contractor by NASA but as a partner in a development programme and then, on the other hand, wanting to set a date, the sooner the better, after which all programmatic risk is assumed by NASA. In my view" commented Morrison "the latter position does not admit the former. Risk is a natural part of the business and he who does not wish to share the risk cannot really be called a partner. It seems to me" he further went on "that, once the step is taken of setting such a date, ESA is giving NASA a fundamental message which NASA would have difficulty in ignoring in future discussions involving international cooperation".[1812] Morrison's zeal to defend the US position seems to be a typical case of the tendency, in lower echelons of NASA, to assume stiffer positions *vis-à-vis* international partners, for internal purposes, which Bignier had so aptly stigmatised since 1977.[1813] Yet, due to the heavy financial situation of the programme, Europe resented the fact that NASA expected "ESA to fund all make-work Spacelab changes, including those originating from the Space Shuttle up to the second Spacelab flight".[1814]

As far as the post delivery support responsibility was concerned, the solution was arrived at by the turn of the decade. Gibson and Frosch, meeting in March 1979, decided to create a special joint ESA/NASA "Risk Assessment Working Group", to which we already referred, in order to set mutually agreed ESA and NASA responsibilities. By the beginning of 1980, ESA's Director-General and NASA's Administrator accepted the final report of the group, with the understanding that ESA would "be responsible for correction of all obvious and hidden deficiencies necessary to meet the Spacelab requirements" as they existed on September 30, 1979. These responsibilities would continue throughout the first flight of a component, but no later than completion of the second Spacelab flight.[1815]

Not until 1980, could the decision to go beyond the upward limit, as originally anticipated in ESRO-member states arrangement of 1973, be formalised. Continuation of the programme beyond the original 120% schedule (i.e. beyond 369.6 MAU at 1973 price levels) was enforced through the adoption of an appropriate resolution at the 30th meeting of the SPB, in March 1980. The new increase brought the total cost to 140% of the original price (431.2 MAU at 1973 price levels). Every participant waived the use of the right to withdraw ex Article 6 of the original arrangement. The part of the programme above the 120% of the overall financial envelope would be funded in accordance with a scale of contribution in which Italy's share was significantly reduced (from the 18% of the original agreement to 1%) and the German share significantly increased (from 52.55% to 64.40%). Small adjustments also occurred in the contributions of the other countries -notably the French raised their contribution from 10% to 12.07%.[1816]

The diminution of the Italian share needs some explanation: at the opening of the production phase, Italy began to protest against the poor geographical return to Italian industry within the development programme, which it considered to have been settled by the Spacelab Arrangement between ESRO and Member States at 100% of the contribution. Many explanations could be found for the low Italian industrial return. First of all, it had appeared that the cost increase of the programme had a limited impact on the Italian share because the changes only partly affected the fields in which Italy was

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1811 HAEUI, ESA, 4860, Inter-office Memorandum, W. Brado to Stiernstedt, 5 October 1979; see also (HAEUI) ESA Washington Office, 020-2B. *Communication interne, Inter-office Memorandum, de D/SL (Bignier) to Mellors*, 11 avril 1979, Actions decidée lors de la reunion DG/A du 29 mars 1979; *ibidem* DG/A, Letter Frosch to Gibson, 7 May 1979; ibidem, Letter Gibson to Frosch 17 May 1979.

1812 HAEUI, ESA, dep.2, 5580, Letter J. Morrison, to M. Bignier, 8 May 1979.

1813 HAEUI, ESA, dep.2, 5596, *Compte rendu de la mission de D/SL B Washington du 21 au 23 mars 1977*, by M. Bignier, 25 March 1977.

1814 HAEUI, CAB/INT/1-31/VH/EP/13188, Communication Interne, from H/CAB to J. Stiernstedt, 5 October 1979; HAEUI, PB-SL(79)3 1, 6 September 1979.

1815 (HAEUI) ESA Washington Office, Minutes of the meeting of ESA DG and NASA Administrator, 14 February 1980.

1816 HAEUI, ESA/PB-SL/XXVIII/Res. 1, adopted at the 30th meeting of the SPB (12 March 1980).

working. In other words, the "correspondence" between contributions and contracts mentioned in the Arrangement worked for the industrial proposal which, as we have seen in the chapter on industrial involvement, only applied to about 70% of the work, allowances being made for technical contingencies. The imbalance in Italy's position arose in connection with the remaining 30%, as well as with the work which had necessitated commitment of the 20% margin (above the original 100%).[1817] Exchange rates were also objectively unfavourable to the Italian currency[1818] and its firms, which were working in a fixed price environment, in a much less favourable situation, therefore, than those working under costs plus contracts. The Italian share, fixed in 1973 MAU, was in the meanwhile increasing due to the devaluation of the Lira vis-à-vis the European currency. On the other hand, a certain "lack of aggressivity and the poor competitiveness of Italian firms leading to the transfer of work to other countries (windows/viewport,...)" had been noted.[1819]

Among the many question raised by the Italian protest, at least one needs to be remembered, because it would take so long to settle; it was in this context that the Director General commissioned the Council to decide whether the problem posed by an industrial return shortfall of a participant should be dealt with exclusively within the framework of that programme or whether this should be examined in the context of the geographical distribution in respect of the Agency's programmes as a whole.[1820] Other discussions were raised by a German proposal to solve the Italian problem in either of two ways: to forego certain contributions due from Italy or make efforts, on the occasion of starting up a new programme, to redress the Italian shortfall.

By 1980, Spacelab had entered the system qualification tests of the Engineering Model and integration (assembly) and testing of the Flight Unit.[1821] These phases involved more technical difficulties and took more time than anticipated. According to ERNO, although "it would be [wrong] to say that there were no problems, this impacted mainly on schedule and costs, not on the technical content and quality".[1822] ERNO's technical competence was unanimously recognised, as was the absence of major programmatic technical issues. Despite that, ERNO had experienced "many detail and interface problems", causing one part of the schedule delay.[1823]

In 1981 a further delay was announced in the launch of Spacelab, from September 1983 to the beginning of 1984. This delay would imply both an overrun of ESA's cost-to-completion ceiling for the two Spacelab developments and a bad psychological impact on experimenters and Member States who would refrain to take any decision regarding future utilisation of Spacelab and its follow-on development programme. The Spacelab Programme Board sadly defined its "mood" as being "tempered by the many postponements already suffered by the Spacelab-1 experimenters". The

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1817 HAEUI, ESA/C/MIN/35 (10-11 October 1979), Intervention Bignier, 6 November 1979.

1818 Italy had to pay in 1973 MAU and, the Lira being strongly devaluated, had to pay what resulted to be a much larger amount of money than expected.

1819 HAEUI, ESA, dep. 2, 5580, Letter M. Bignier to ERNO, 13 July 1978.

1820 HAEUI, ESA/C/MIN/32 (28-29 June 1979), 19 July 1979.

1821 (HAEUI) ESA Washington office, 020, Spacelab, VFW-Fokker/ERNO, Spacelab. Presentation, by Ants Kutzer, Spacelab Project Manager, to W. Mellors, ESA Representatives at NASA, 15 February 1980.

1822 *Ibidem.*

1823 *Ibidem.*

shadow of the ISPM affair loomed large: the Board expressed concern about the long-term impact of this unfortunate decision on US-European relations in general.[1824]

Another development related to the Shuttle would affect Spacelab in 1982. As we have seen at the very beginning, a first Shuttle Reimbursement Policy for commercial and foreign customers had been published by NASA in 1977. It established a fixed flat rate for the first three years of operation (FY 1983-84-85) based on best estimates of the number of flights available in that period. The standard price for a dedicated Shuttle mission was established at $18 million (FY 1975 dollars). Due to cost increases in Shuttle operations, significant reductions in projected flight rates and the effects of inflation, NASA had to revise the previous estimate upwards. In June 1982, the new price for a dedicated launch performed during the period 1986 to 1988 amounted to $71 million (FY 1982 dollars). When compared on an equal basis (using FY 1982 rates), the new price amounted to an 85% increase. That was indeed higher that the charging price of most American expendable launch vehicles.[1825] This escalation, which was to be followed by yet another (smaller) one in 1985, had obvious repercussions on Spacelab, because a non-negligible percentage of the cost of each mission was determined by the price of the launch.

13.10 Duplication avoidance

After the signature of the Spacelab agreements, ESA became aware of certain development activities, in the USA, of systems which could be installed in the Shuttle Orbiter cargo bay.[1826] Could they be considered duplications of the ESA Spacelab? The Memorandum of Understanding and the Intergovernmental Agreement both required the USA to refrain from separate and independent development of any Spacelab "substantially duplicating" the design and capabilities of the first Spacelab, unless Europe were to fail to produce such Spacelab components in accordance with agreed specifications and schedules at reasonable prices. From the formal point of view, the adverb "substantially" left much room for subjective definition. New ideas for Shuttle utilisation emerged during the decade, leading to changed technological requirements which could not be met by Spacelab. That is why Gibson, ESA Director General and Frosch, NASA Administrator, at their meeting of 29 March 1979 decided to establish a working group, the Duplication Avoidance Working Group (DAWG), to give technical form to what the diplomatic agreements had purposefully left vague, i.e. to examine in practical terms what "substantially duplicating" meant.[1827] The first meeting of ESA/NASA Duplication avoidance WG (DAWG) took place in Washington on July 18/19 1979;

[1824] HAEUI, ESA, dep. 2 5580, Telegram J. Ortner, chairman SL-PB, to J. Beggs, NASA Administrator, 5 May 1981; *ibidem*, dep 2, 5580, Inter-office memorandum M. Bignier to DG, 7 March 1981. The International Solar Polar mission (ISPM) was a dual scientific solar mission, to be carried out by two spacecraft, one from NASA and the other from ESA, with different technical characteristics, hosting scientific experiments, of European or American origin, to be accommodated impartially after competitive selection. The two spacecraft should be launched in 1983 by the Shuttle, and subsequently inserted into an interplanetary orbit by an inertial upper stage. An MOU with the classic escape clause making reference to the availability of appropriate funds was signed in 1979. Early in 1981 however, the Europeans were informed that NASA had to cancel the mission due to budgetary constraints imposed by the incoming Reagan administration. See Joan Johnson-Freese, "Cancelling the US solar-polar spacecraft", in *Space Policy*, vol. 3, No. l, February 1984, pp. 24-37; see also Roger Bonnet and Vittorio Manno, *International Cooperation in space* (Cambridge; Harvard University Press) 1994, pp. 98-108.

[1825] (HAEUI) ESA Washington Office, A Report to the Committee on Appropriations, US House of Representatives on the Cost Comparison and related issues of operating the Space Shuttle and various foreign and US expendable launch vehicles, Surveys and Investigations Staff, April 1985.

[1826] W.M. Thiebaut, "Legal Status of Memoranda of Understanding in the United States", *ESA Bulletin*, No. 38, May 1984, pp. 99-104; Thiebaut indicates that ESA was first informed of the Air Force desire to procure an SSS in 1973; the documents we have found, as we shall see from the text, refer to a later date.

[1827] (HAEUI) ESA Washington Office, 020-2B. Communication interne, Inter-office Memorandum, de D/SL (Bignier) to Mellors, Actions decidées lors de la réunion DG/A du 29 mars 1979, 11 April 1979; *ibidem,* Letter Frosch to Gibson, 7 May 1979; *ibidem*, Letter Gibson to Frosch 17 May 1979.

Michel Bignier, Director Spacelab Programme, ESA and Philip E. Culbertson, Deputy Associate Administrator, NASA Headquarters, chaired the delegations.

The cases discussed included the Rack Integration Aids, Pallet of Opportunity, DoD pallet and pointing systems. One of the systems under scrutiny by the group was the "Sortie Support System" (SSS), a pallet-type structure to support DoD payloads. In ESA's opinion, several components of the SSS substantially duplicated the design and capabilities of Spacelab pallet-only configuration. NASA partly agreed and asked for a detailed clarification from DoD. "Where and if substantial duplication in the design and capabilities of components exists" noted the WG, Article 5 of the IGA reserved to the European partner the first opportunity (a prior right to bid) to produce the components subject to availability, schedules and reasonable prices.[1828] A meeting was held with ESA, NASA , USAF and the Department of State to discuss the SSS RFQ and the applicability of the Spacelab IGA. The US position was that procurement laws, i.e. the DoD Appropriation Act of 1973 (known as the Bayh Amendment) prevented the award of research and development contracts outside the US if a satisfactory US source was available at a lower cost. The problem could be solved, in the USAF's view, by choosing an American prime contractor procuring from European sources.

In December of the same year a guideline was approved by the WG whereby it would be the responsibility of NASA to communicate to ESA any new requirement which might possibly lead to a system to be considered as substantially duplicating Spacelab. The Joint NASA/ESA Spacelab Working Group would discuss NASA requirements and how to satisfy them and would determine if that was a case of duplication. A system would be deemed to duplicate Spacelab if Spacelab hardware and/or software:

1 had similar capabilities to the proposed system;

2 were of a similar design or had similar interfaces to the proposed system;

3 could, with minor modifications, if necessary, substitute for the proposed system or its components.

If the JSL WG determined such a duplication, NASA should refrain from the development and procure the system in Europe unless it could not be made available in accordance with the agreed schedules and at reasonable prices. If not, NASA should provide, upon ESA request, an opportunity to make proposals and NASA would treat European and US proposals on an equal basis.[1829] A directive was then written by Frosch on avoiding duplication. It stated that all NASA studies and plans envisioning development of new Spacelab-type systems should be made known to NASA HQ in sufficient time that an effective decision on ESA involvement could be made. This included possible or planned development of any multi-use payload carrier systems that would be used in the Shuttle, whether such developments were done in-house or under NASA contract.[1830] As stressed by C. Reinhold from Spacelab, ESA HQ, what became apparent in the discussions was that "two specific interests would govern the shaping of these criteria and procedures. ESA's emphasis on protecting the investment and technical know-how of European industry in the development of the Spacelab system for future cooperative projects and NASA's emphasis on cost-effective, efficient utilisation of the

[1828] (HAEUI) ESA Washington Office, 021-2, Spacelab MOU Compliance, ESA/NASA Duplication Avoidance Working Group, Minutes of Meeting, (18-19 July 1979) and attachments; HAEUI, CAB/INT/I-31/VH/EP/13188, Communication Interne, from H/CAB to J. Stiernstedt, 5 October 1979.

[1829] (HAEUI) ESA Washington Office, 021-2. Spacelab MOU Compliance, Procedure for Disposing of Future Cases which may Imply Substantial Duplication of the design and Capabilities of the First Spacelab, 6 December 1979 (revised on 21 December 1979 and agreed by DAWG chairmen).

[1830] (HAEUI) ESA Washington Office, 021-2. Spacelab MOU Compliance, From Administrator for distribution, on NASA Development of Spacelab - Type Equipment, 14 May 1980.

STS".[1831] The problem was later solved, after pressure put by Wilfred Mellors, Head of the ESA Washington Office from 1973 to 1983, on Philip Culbertson and by him "at fairly high level within the USAF by general Frank Simokaitis" (NASA's Director of DoD Affairs). DoD accepted to send RFP's directly (without letting US private firms do it privately) to interested European firms.[1832]

13.11 Follow-on production (FOP)[1833]: the second Spacelab

The ESRO/NASA MOU of 1973 provided for the procurement by NASA of at least one further Spacelab, no later than two years before the delivery of the first, provided that it was "available to the agreed specifications and schedules and at reasonable prices to be agreed" (Art. VIII). NASA's Administrator later argued, however, that NASA would not consider substantial follow-on activity for the second Spacelab until the usefulness of the first Spacelab had been demonstrated. This echoed a paragraph of the article we have already analysed, whereby "the desirability of gaining operational experience with the first flight unit before ordering additional units" (Art. VIII) was clearly expressed – but originally intended to be the criterion whereby Spacelab units beyond the second one would be ordered. European requirements diverged, quite understandably, from the American ones: they were linked to the major aim of preventing costly gaps in industrial production or unsuitable overlaps between the first and the second Spacelab.[1834] Europeans also experienced a major difficulty in providing to NASA reliable financial estimates about the cost of a laboratory whose technical requirements were subject to frequent modifications. On the other hand, an early starting date for the industrial work would be of the utmost importance, especially for costs reasons, and ESA needed for that purpose a sufficient commitment to go to Member States for the FOP activity approval.[1835]

Because of these conflicting aims, a start was made on the FOP in 1976, but it was not until the end of the decade, after eliminating alternative solutions, that ESA negotiations, with NASA on the one side and ERNO (as the prime contractor) on the other, were completed. Of special interest is the fact that discussions had initially been focussed on a "barter agreement", i.e. the marginal cost of the second Spacelab to be credited to ESA for the purchase of Shuttle flights: after the escalation of the Spacelab costs above the 120% ceiling in mid 1978, the Europeans asked and obtained from NASA the acceptance of an alternative solution, which implied a real payment by NASA.[1836]

Even from the strictly legal point of view, one major obstacle stood in the way of a fruitful agreement. In accordance with American procurement practices, the contract between ESA and NASA should commit the US agency for the then-current fiscal year and should contain a "subject to availability of funds" clause for the following fiscal years. The US budgetary system provides mainly for yearly appropriations and no governmental agency is allowed to commit funds in absence of a specific Congressional authority or appropriation. This had been recognised in the Spacelab agreements where the need to respect "the respective funding procedures" had been incorporated (Art. 8 and Art. VII). The amount required by industry and ESA and the sum provided for in NASA's 1980 budget and earmarked in the financial planning for future years left a cash flow deficit in 1980-81 and 1981-82 which could be covered only in 1983-84. The difference needed therefore to be covered temporarily by a commercial bank loan. The ESA Council initially guaranteed the commercial loan necessary to

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1831 (HAEUI) ESA Washington Office, 021-2. Spacelab MOU Compliance, From C. Reinhold to James Harrington, NASA Headquarters, 31 January 1980.

1832 (HAEUI) ESA Washington Office, 021-2B. SSS, telex Mellors for D/SL, 15 April 1980; for Mellors' pressure on Philip Culbertson (NASA HQ), *ibidem*, Letter Mellors to Culbertson, 10 April 1980.

1833 The second Spacelab was defined as "follow-on procurement" by the US: the use of the acronym FOP solved the discrepancy in terminology.

1834 HAEUI, ESA/PB-SL/MIN/14 (23 November 1977), Programme Director Intervention, 22 December 1977; in general, see J. Marchant, "The Spacelab Production Programme", *ESA Bulletin*, August 1980, n.23, pp. 55-57.

1835 (HAEUI) ESA Washington Office, 020-2C DG/A, Meeting of ESA Director General and NASA Administrator,
7 October 1978.

1836 HAEUI, ESA, 4876, Letter Gibson to Frutkin, 20 September 1978.

fill up this gap. But NASA, even if it did not have, in principle, the equivalent of ESA contract authority, made special arrangements with the Congress and thereby assured ESA that it would take over this guarantee by the end of 1981.

The Director General was therefore entitled to take out such loans as might be necessary to cover the shortfall then existing in the NASA budgets during the years from 1980 to 1983, on the understanding that the cost of the loans and their reimbursement should be borne exclusively by NASA and entail no commitment by Member States.[1837] In other words, the Agency was entitled to act as a contractor *vis-à-vis* NASA and would take out the necessary loans, it being understood that all the financial charges and costs of the commercial bank loan would be covered by NASA only. NASA's "political commitment" to arrive at a full legal guarantee of repayment at the earliest date was considered as a "sufficient guarantee" to activate the project.[1838] In January 1980, therefore, the procurement contracts between NASA and ESA on the one hand, and ESA and European industry represented by ERNO (the prime contractor) on the other were signed, with an agreement on the price, the clauses and conditions applicable to both NASA/ESA and the ESA/ERNO contract and the work statement.[1839] The NASA/ESA contract covered the costs of the industrial effort necessary to manufacture, assemble, test and deliver to NASA a second Spacelab flight unit plus the reimbursement of ESA's management costs; it amounted to a total of 117.1 MAU (at mid-1979 prices) for the industrial element (95% of which was fixed-price with an escalation clause) and an estimated 12.2 MAU to cover the Agency's internal costs, to which the financial charges for the loan should be added. The contract was established in the national currencies of the participating firms.[1840]

Even though we cannot fail to notice the difference between how much ESA paid for the development and production of the first unit, to be given for "unrestricted use" to the NASA "free of cost" (Art. 7 MOU and IX IGA), and how much NASA was charged for the procurement of the second, we have to stress that NASA did fulfil its promises. Political willingness, associated to practical and legal flexibility and imagination, allowed the FOP to survive the problems that would, early in 1981, have forced the cancellation of NASA's participation in ISPM – which was equally subject to the "availability of appropriate funds" escape clause. A duplicate of the first flight unit, including the IPS and operational spares, was provided under the 1980 arrangement. By the mid-1980s almost everything was delivered to the US; the German D-1 mission was the first to use FOP materials.[1841] By January 1986, NASA, ESA and MBB/ERNO agreed to convert the remaining FOP commitments under the NASA/ESA FOP contract into a direct agreement between NASA and MBB/ERNO.[1842]

1837 HAEUI, ESA/C/XXXV, Res. 3 (Final), Council Resolution concerning the supply to NASA of a second Spacelab, 11 October 1979; HAEUI, ESA/C (79)112, add. l, 14 December 1979, Supply of a Second Spacelab to NASA; HAEUI, ESA/C(80)6, Bridging financing for the Spacelab Follow-on Production, 9 January 1980.

1838 HAEUI, ESA/C/MIN/39 (23-24 January 1980), 31 January 1980.

1839 HAEUI, ESA/C/XXXV/Res.3 (final), Council Resolution concerning the supply to NASA of a second Spacelab, adopted on 11 October 1979.

1840 J. Marchal, "The Spacelab Production Programme", *cit.*, p.57; "Spacelab", (no author), *ESA Bulletin*, May 1980, p.57. ESA decided to make the contracts payable in local currencies, considering that devaluation of the dollar would be the most plausible scenario for the future. The European choice was made at a moment of high instability in exchange rates, which made any kind of forecast extremely difficult. By the 1980s, the dollar actually begun recovering until 1985, when it devalued again until 1992. Giuseppe Mammarella, *Imparare l'Europa* (Bologna; Il Mulino) 1994, p.52.
See also interview M. Bignier by L. Sebesta, 6 December 1996, Paris.

1841 *Rapport Annuel de l'ESA*, 1985, p.66; see also D. Lord, *op. cit.*, p.105.

1842 *ESA Bulletin*, No. 46, May 1986; the last IPS activities to be undertaken by ESA under the MOU with NASA were concluded by the beginning of 1988; see *ESA Bulletin*, No.52, November 1987, p.53.

13.12 The Spacelab follow-on development (FOD) programme: Spacelab improvements and the start of Eureca

Judgements on the future of Spacelab were far from uniform at the end of the decade. In June 1978 the Executive submitted to the Spacelab Programme Board and the Council an overall concept of a Spacelab Follow-on Development Programme and, some months later, a detailed proposal for the first phase of the programme. No positive reaction to this proposal was received from delegations. Definition studies, financed under the General Studies budget, were soon completed in 1979 and the matter seemed to have reached a dead end. In September, the Executive vigorously underlined the negative consequences of this uncertain attitude. Discontinuing "the most important cooperative programme with the US" would be harmful to the political interests of Europe; besides, public opinion would interpret this unwillingness as an evidence of the abandonment of any European effort in manned space systems.[1843] The momentum created with the first Spacelab would be inevitably lost. Many reasons lay behind Europe's hesitation. The decision on FOD activities was to be framed within the broader question of European priorities in space for the future decade. Ariane and Spacelab were on the verge of being operational; telecommunication satellites and the Space Station seemed to be the two pillars around which to construct the future of European activities in space. Yet it was still unclear if Ariane and Spacelab would and could be the foci around which to expand European activities in these two fields.[1844] Not least, it was still impossible for Europe to divine US future pricing policy for the Space Shuttle and its potential evolution (upwards, as we have seen, by 1982), with a view to expanding cooperation beyond the Spacelab agreement and to giving Europe the opportunity to make proposals to meet new requirements.[1845] Moreover, it was difficult to go beyond the study phase of any future programme without knowing how the first Spacelab users had fared and without having exploited the results of the first flight.[1846] Before taking any definite step, initial utilisation experience had to be acquired and the system flight testing successfully concluded. In the meantime, the user community was consulted and its views filtered through the ESA/NASA Joint User Requirements Group (JURG), which suggested some possible improvements to increase:

1 the electrical power;

2 the mission duration;

3 the size of the on-board computer memory.[1847]

Despite these efforts, the Council, while approving the execution of the initial phase of the programme within the framework of the Agency, could only invite the interested members to commit themselves towards supporting studies.[1848] The threshold of 80% decided for starting-up the work was not reached, Italy being unable to put a figure on its level of participation.[1849] In general terms, by the end of 1981, it appeared clear that there was a widespread preference among European delegations to divide the FOD programme in two parts:

1 the limited improvement of Spacelab to make it better matched to users' requirements, to achieve greater cost-effectiveness of Spacelab utilisation and to adapt it to Shuttle developments;

[1843] HAEUI, ESA/C(79) 109, Annex, Analysis of the consequences of the absence of a decision to undertake the Spacelab Follow-on Development Programme, 4 September 1979.

[1844] Ariane had prospective customers, but the Shuttle was deemed to be operational very soon, changing the terms of competition in the launchers fields.

[1845] Ex Art. VIII of ESA/NASA MOU and Art. 5 of US/European IGA.

[1846] As pointed out repeatedly by the German delegation; see HAEUI, ESA/C/MIN/39 (23-24 January 1980), 31 January 1980; *ibidem*, ESA/C/MIN/41 (20 May 1980), 6 June 1980.

[1847] HAEUI, ESA/C(79) 109, Annex I, Description of the initial steps of the Spacelab FOD programme, 11 September 1979; see also E. Vallerani, *op. cit.*, p.113.

[1848] HAEUI, ESA/C/XXXIX/Res. 4, 24 January 1980.

[1849] HAEUI, ESA/C(81)101, Spacelab Follow-on Development Programme, 7 December 1981.

2 the definition and development of a retrievable instrument carrier, or free flyer, (to be called Eureca, from the initials of EUropean REtrievable CArrier).

The importance of this last element within the global STS programme was becoming increasingly felt and discussions on the FOD programme came to be more and more focussed on the opportunity to extend European competence in the field of platforms.[1850] After a protracted discussion in which the Federal Republic of Germany was the main promoter, Italy and the UK the least positive, this last "in view of the doubts, stemming from NASA's uncertainty, that still surround the form of the programme and its interfaces with the other programme", the ESA Council accepted the resolution with nine votes to one (Italy) and one abstention (the Netherlands).[1851] ESA would create an optional programme for "Spacelab improvements and for developments and experiments on retrievable orbital systems".

Eureca was conceived as a reusable payload carrier, or "free flyer", to weigh approximately 4000 kg at launch including 1000 kg of payload. It would optimise the length-to-mass ratio (4000 kg, not more than 2.5 m length) in order to minimise the launch charges and maximise the mounting flexibility – it could fit comfortably into the 4.6 m diameter cargo bay. It would provide essential services for its payload, including high electrical power, heat-rejection capabilities, attitude control and data handling. After being deployed in space, an on-board propulsion unit would move the carrier to a higher orbit of about 500 km altitude, where the drag on its large solar arrays would be low and it would be therefore easier to reduce gravitational accelerations to near zero, offering a perfect environment for microgravity experiments. The high altitude would also help minimise the use of fuel for altitude control. Once in its operational orbit, the payload would be switched on and operated by remote control. The experiments, highly automated, would be monitored on ground. At the end of each mission Eureca would return to low orbit, be recovered by the Shuttle orbiter and brought back to Earth. After refurbishing and re-equipping, it could be re-used, up to five times in ten years, its expected lifetime.[1852] The new system should be more economical to build and operate than the classical non-recoverable satellite systems in low orbit and should offer to users a flight duration beyond the 7 to 10 days of Spacelab. It would incorporate, at the same time, the most attractive features of Spacelab, such as high mass and power capability and recovery. It should enable Europe to accumulate the technological and operational experience needed to develop and operate large, autonomous European retrievable platform systems for both commercial and scientific experiments.[1853] It should be user friendly by providing standardised structural attachments as well as standardised power and data interfaces; based on the "ship and shoot" concept, it could be shipped as a fully integrated system, requiring only a minimum of Shuttle interface and safety check at the launch site.[1854]

At the same time, Eureca had growth capabilities "either because existing designs and hardware could be re-used or because the design of existing hardware would be flexible enough to allow increases in performance without major redesign". That is why Eureca was also conceived as contributing eventually, in several ways, to the future Space Station scenario.

[1850] HAEUI, ESA/PB-SL/XXXVII/Dec. (Final), Annex A., Programme de développement ulterieur du Spacelab. Declaration relative à un programme d'amélioration du Spacelab, de développement et d'expérimentation de systèmes orbitaux récuperables, 10 December 1981;
HAEUI, ESA/C/MIN/50 (27-28 October 1981), Intervention German delegation, 10 December 1981.

[1851] HAEUI, ESA/C/MIN/50 (27-28 October 1981), 30 November 1981; *Ibidem*, ESA/C/L/Res. 6 (Final), 30 October 1981.

[1852] "Eureca", *ESA Bulletin*, No.31 August 1982, p.73; W. Nellessen (Columbus System and Projects Department, ESA Space Station and Platform Directorate, ESTEC), "The Eureca Design Concept", *ESA Bulletin*, No.47, August 1986, pp. 7-14.

[1853] W. Nellessen (Columbus System and Projects Department, ESA Space Station and Platform Directorate, ESTEC), "The Eureca Design Concept", *ESA Bulletin*, No. 47, August 1986, pp. 7-14;
R. Mory, "Spacelab and Eureca as a Basis for European Involvement in the Space Station", *ESA Bulletin*, No. 42, May 1985, pp. 30-38.

[1854] R.D. Andresen and W. Nellessen, "The Eureca concept and its importance in preparing the Columbus programme", *ESA Bulletin,* No. 52, November 1987, pp. 57-67.

1 once qualified on Eureca flights, the capabilities in terms of support operations (power generation, heat rejection, orbit-to-ground communication, attitude control, orbital transfer, data handling) could be applied, with the necessary scaling factors, to space-station elements;

2 Eureca represented an ideal test bed for demonstrating, in-flight, essential technologies for a future space station, such as assembly, inter-orbit communication, rendezvous and docking, in-orbit servicing and maintenance of systems in space;

3 it could represent a demonstration mission in the field of ground processing of data, launch, retrieval and in-orbit operations, all of which would be needed for the space station;

4 Eureca was conceived as being the first step towards a future co-orbiting Space Station element, able to provide the advantages of an unmanned automatic platform.[1855]

Commenting on the broader strategic goals of Eureca, the Spacelab Programme Board suggested in 1981:

> *"En particulier, il permettra de poursuivre la coopération avec les Etats-Unis dans le domaine de 1'évolution de la navette et du Spacelab, ce qui facilitera 1'accès de l'Europe aux missions de pointe, élargira son expérience des vols spatiaux habités et lui permettra d'obtenir une compensation partielle sous forme de services de lancement. Ce programme permettra de répondre en outre à l'évo1ution des besoins de l'Europe dans les domains de la microgravité, (fabrication de matériaux, sciences de la vie); d'autres expériences ne demandant pas un changement des spécifications peuvent être embarquées à titre accessoire".*

The envisaged cost was 118.8 MAU (mid-1980 price level), 101.6 MAU of which were to be devoted to "external" expenditures, i.e., mainly, expenses for development, personnel and operations. After the definition phase and the definition of instruments to be carried, a review should be executed before beginning the development phase of the retrievable platform.[1856] By April 1982 contributions reached 80.8% of the above mentioned envelope – 80% having being considered, under German pressure, as a minimum for the start of the programme.[1857] Therefore, the programme could start immediately.[1858]

[1855] R. Mory, "Spacelab and Eureca as a Basis for European Involvement in the Space Station", *ESA Bulletin,* No. 42, May 1985, pp. 30-38.

[1856] HAEUI, ESA/PB-SL/XXXVII/Dec. (Final), Programme de développement ulterieur du Spacelab. Declaration relative à un programme d'amélioration du Spacelab de développement et d'expérimentation de systèmes orbitaux récuperables, 10 December 1981, Annex A.

[1857] HAEUI, ESA/C/MIN/51 (9-10/12/1981), Intervention German Delegation, 18 January 1982.

[1858] HAEUI, ESA/C (81)101, add. 4, 16 April 1982.

C: Concluding Remarks

As soberly explained by the Spacelab European resident team members at the Kennedy Space Center, Florida, Spacelab was a "complicated" device and took "a lot of understanding".[1859] This was always clear to all people involved in the programme, and became ever more evident in the post-delivery phase, i.e. when the Engineering Model and, later, the Flight Units (in the two configurations) were brought to the United States to be tested at subsystem and system level, to be checked for Spacelab/payload compatibility and to be finally integrated with the Shuttle Orbiter. The Spacelab Engineering Model reached the Kennedy Space Center in December 1980. Post-delivery organisation, assembly and testing were established and performed.[1860] The first Flight Unit Configuration I (a long module and one pallet) was accepted by NASA in February 1982 at a ceremony held at the Kennedy Space Center and attended by George Bush, then Vice-President of the USA.[1861] Problems encountered during this period were faced and solved within the deadlines. The most dramatic appears to have been the major design deficiency and box failures of the Command and Data Management System, discovered after the test performed in September 1982. Despite the quick remedies provided for this, the computers (along with the pointing system) were considered by some US engineers as being "of marginal, if not obsolete, technology compared to what they used on board American missions".[1862] Problems due to NASA's need to postpone the launch were also resolved.[1863]

Spacelab-l was launched on board the Shuttle Columbia, from the Kennedy Space Center, Florida, on 28 November 1983. The mission lasted until 8 December 1983. Six astronauts were on board: John Young (commander), Brewster Shaw (pilot), Owen Garriott and Robert Parker (mission specialists), Ulf Merbold and Byron Lichtenberg (payload specialists). One of the three ESA astronauts trained for the mission, the German citizen Ulf Merbold, was the first non-American to fly on the Shuttle and the second European citizen to fly in space - the first being J.L. Chrétien flying on Soyuz in 1982. This "outsized thermos bottle", as popularly characterised by *Time* magazine at the time, performed its tasks remarkably well. The Verification Flight Instrumentation (VFI, housed in the core segment at the front end of the module) consisting of 264 environmental, mechanical and electrical sensors and the associated control, monitoring and recording system, showed the high engineering and functional quality of Spacelab. Some 72 investigations in different scientific disciplines were performed, the results of which have been evaluated elsewhere.[1864] "The mission" in the words of the Spacelab European resident team members at Kennedy Space Center "showed not only that the requirements were met but also that there [was] an inherent in-orbit operational flexibility built into Spacelab which [had] only just begun to be understood".[1865]

Spacelab was conceived, developed and produced in a period of high inflation. Inflation, technical changes and deadlines slippages, had a large impact on its price, as they did on the Shuttle programme as a whole and, what was more devastating for European partners, on the Shuttle pricing policy. Despite some weaknesses in the area of management coordination in the initial period of the

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1859 A. Thirkettle, F. Di Mauro and R. Stephens, 'Spacelab - From Early Integration to First Flight; Part 2" *cit.*, p.84.

1860 *Ibidem*, pp. 70-73.

1861 M. Bignier, "Spacelab Development", *cit.,* p.10.. Flight Unit configuration II (an igloo and pallets) was delivered in the Summer of the same year.

1862 Roger Bonnet and Vittorio Manno, *op. cit.*, p.79.

1863 A. Thirkettle, F. Di Mauro and R. Stephens, "Spacelab - From Early Integration to First Flight: Part 2", *cit.*, pp. 70-84.

1864 D. Shapland and M. Rycroft, *op cit.*

1865 A. Thirkettle, F. Di Mauro and R. Stephens, "Spacelab - From Early Integration to First Flight: Part 2", *cit.,* p.82.

manufacture phase and despite an overrun of 140% of the original price and the problems experienced during the post-delivery phase, the Spacelab programme was a remarkable cooperative endeavour, achieved by Europeans in close collaboration with the US. Spacelab- 1, however, was to be the only flight programmed in common by ESA and NASA. There would not be any *a priori* sharing of space in subsequent Spacelab payloads (Spacelab-2, 29 July to 6 August, 1985, when the Igloo-Pallet-IPS configuration was flown; Spacelab-3, 29 April to 6 May 1985), while D-1 and D-2 would be German flights paid by the German Ministry of Research and Technology, although they hosted experiments from other ESA members and from NASA.[1866]

"By the time Spacelab was ready for use" noticed an American scholar some years ago "its development costs had risen to almost $1 billion [at the then current rate], rather than the approximately $250 million originally estimated. Projections on Shuttle usage had dramatically shrunk, and the United States decided to purchase only the one additional Spacelab it was obligated to buy, at a cost of $128 million. Any chance for ESA to recoup some of its development costs through Spacelab production thus vanished. The agreement provided for one joint US-ESA Spacelab mission at no launch cost to ESA. After that, ESA would have to pay launch costs for any Spacelab missions it wanted to undertake. By the early 1980s, the combined costs of preparing the experiments for a Spacelab mission and paying Shuttle launch fees, exceeded ESA's resources, and the Agency was left in a position of not being able to afford the use of the system it had developed (...)".[1867]

Criticism was occasionally aired of the principle whereby the first unit of Spacelab was handed over to NASA with no tangible return in terms of privileged access for Europeans to subsequent payloads. This eventually led to its partial abandonment by the Agency -although this did not prevent national German missions and an extended number of US missions, with or without European participation, from being performed.[1868] This criticism, albeit in a diplomatic form, was officially expressed by ESA Director General Reimar Lüst in 1987, in a crucial phase of Space Station negotiations. More recently, it has been revived by Roger Bonnet and Vittorio Manno in their book on ESA.[1869] Some years after his 1987 speech, Lüst completed his previous comment with some considerations of *realpolitik*. The Director General declared that:

1 "international cooperation does indeed depend a lot on the actual balance of power"

2 due to the limited European expertise, Europe had to pay an entrance fee (the first Spacelab) to acquire "the basics of manned spaceflight".[1870]

Manno and Bonnet also agreed on that, as they concurred with Lüst's emphasis on previous American generosity (in cooperation during the 1960s), interpreting Spacelab as a way to reciprocate it.[1871] Another point made by some European officials, dealt with the unwillingness of the US to share technology. Fréderic d'Allest, then Director General of CNES, talking in 1985 about the prospective agreement on Space Station, declared:

1866 D. Shapland & M. Rycroft, *op. cit.*; D. Shapland, "Spacelab" in *Le Grand Atlas de l'Espace* (Paris: Encyclopaedia Universalis) 1987, pp. 278-281.

1867 John Logsdon, "Together in Orbit: The Origins of International Participation in Space Station Freedom", NASA Contract NASW-4237, December 1991, pp. 12-13.

1868 R. Fraysse (Bureau de Coordination et de Contrôle des Projets), "Retour sur le passé: la decision de l'Europe de participer au programme post-Apollo", *ESA Bulletin*, No. 40, November 1984, pp. 61-65; Reimar Lüst, "Cooperation between Europe and the United States in Space", [The Fulbright 40th Anniversary Lecture, 6 April 1987, Washington DC] *ESA Bulletin*, No. 50, May 1987, pp. 98-104, spec. p.101.

1869 R. Bonnet and V. Manno, *op. cit*., pp. 78-80.

1870 R. Lüst, "US Cooperation in Space", *European Affairs*, 3, 1989, quoted in R. Bonnet & V. Manno, *op. cit.*, p 79.

1871 R. Bonnet and V. Manno, *op. cit*., pp. 78-80.

> *"the bitter experience of cooperation in the Spacelab programme and finally the declared policy of limiting transfers of technology and technical information to the minimum needed to ensure compatibility of peripheral European elements, demonstrates unambiguously the limits of cooperation with the USA in a strategic sector".*[1872]

Despite numerous dispersed European texts about Spacelab, the comprehensive Spacelab story was first told to the public in 1983, by Douglas Lord, who wrote a rather detailed account of his experience as NASA's Director of Spacelab throughout the programme. There, he candidly admitted: "it was as if NASA had hired a development contractor, only in this case the contractor was in Europe and would use its own money".[1873] Yet, the simple existence of this book, a book written by an American about a European developed programme, whose title is about a dignified "success story" in international cooperation, seems to prove, on the contrary, that there was indeed something more than a contractual agreement in the Spacelab story. The reasons for this apparent inconsistency are probably to be found in the American mentality, more than in a deliberately "patronising" attitude. In order to find its roots, we have to sympathise for a moment with an entire generation of US officials who had come to adulthood after the second world war. They had seen the USA go to the rescue of Europe against Nazism, help Europe to recover from war damage through an impressive programme of economic aid and help it to set up a common defence through NATO. They had later witnessed Europe stand on its own feet again and become prosperous; they had further observed the successes of the European Community, created in 1957 with their own strong encouragement, and the gradual transformation of Europe into a dangerous competitor in the international market by the end of the 1960s and into a recalcitrant ally in the military field (failure of the Multilateral Force and the exit of France from NATO in 1966). This assertiveness, translated into the space field, had contributed to the European decision in 1973 to try to develop an independent expendable launcher.

At the same time the USA had been busy, among other things, in preparing one of the (if not the) most exciting adventures in space, the 1969 manned landing on the Moon, which had consecrated what was generally perceived as a "victory" over their cold war enemy, the USSR. It goes without saying that the effort in terms of financial and human resources, emotional and political commitment put into this enterprise, and the sense of pride built around it, were unique and in no way comparable to what was happening on this side of the Atlantic in space policy. American behaviour *vis-à-vis* their European partners can only be understood against this rather complex historical background of extraordinary achievements in space and a yet undefined but growing anxiety about future European competition.

An assessment of the programme, beyond the successful, purely technical and scientific, aspects can only be political and will inevitably change with time. During the negotiating phases of the Space Station, when the Europeans struggled to earn the status of "equal partners", what were perceived as weak aspects of the Spacelab Agreements were emphasised in order to reinforce European requests, to accentuate what was presented as US bad will in previous times and, on the other hand, to stress the supposed European generosity.

Politicians have the freedom "to use" history as a tool, as they frequently do, but we, as historians, must try to make clear what are the assumptions underlying our work, what are the real facts throughout and what are our opinions. In this case, our assumption has been that cooperation is, under certain circumstances, indeed advantageous for all – i.e. it is not a zero-sum game, an "either or" game in which there is only one prize at stake. Many different advantages are on the table and, through negotiations, these advantages are distributed. A good deal, must be a good deal for every partner: their aims must not only be compatible but, possibly, mutually reinforcing. The bargain must fulfil two requirements. It has to be "feasible" in the short term and it has to create a longstanding attitude conducive to a continuity in effective cooperation. Mutual trust is the base for a healthy partnership.

1872 *Interavia*, December 1985.

1873 D. Lord, *op. cit.*, p.31

Beyond these general assumptions, which were satisfied during the Spacelab programme, one major flaw must be noticed. Due to the early stage of both the Spacelab and the Shuttle design, European assessment was based on poor estimates on future costs of both the laboratory and the Shuttle flights. Inflation did the rest. In this situation it was very difficult to produce a reliable cost/benefit analysis between European investment and future technological and scientific returns, as it was difficult for users to judge the real opportunities which Spacelab offered them. Spacelab became a sort of political challenge to test the efficiency of ESA managerial and industrial capacities in confronting this major hindrance. Competence, flexibility and imagination helped ESA to confront this challenge.[1874]. Actors could thereby find their way out of the most apparently insoluble problems: for example, partners had to keep to the US procurement practice whereby any contract stipulated by a US agency is only committing for the running fiscal year and contains a "subject to availability of funds" clause for the following fiscal years – expressed in the Spacelab agreements by the need to comply to the "respective funding procedures" (Art. 8 and Art. VII). Yet, despite budget difficulties, the US honoured its obligations through the 1980 contract for a second Spacelab (FOP) – although it was on this same basis that NASA's participation in ISPM was unilaterally cancelled in early 1981.

Creative behaviour was also found, on the European industrial and ESA side, during the solution of the crises which affected the main development contract during the years 1976-77 and in 1980 Regaining control of the situation (that is, of the performance and changes introduced by industry) and restoring the morale of the groups involved, was a delicate task. It implied, as we have seen, innovative measures as far as the staff and the practices were concerned, but it also required to maintain a sense of continuity with the past, in order to save the global credibility of the management – *vis-à-vis* the subordinates and *vis-à-vis* the American partner. In 1980, when the Member States were requested to support yet another augmentation in the Spacelab budget, they had to be reassured against indefinite extension of ESA financial responsibility; they also had to be reassured about the reliability of the US partner as far as the order of the second Spacelab was concerned. It is not by coincidence that these problems were worked out, as we have seen, in the same time-frame, as a sort of informal package-deal.

It is through the analysis of this kind of past circumstance and of the successes and failures encountered, that it will be possible to establish for the future, more realistic patterns of open or tacit rules for allocating the advantages of cooperation. Here we stop, having tried to establish a plausible, yet surely uncompleted, plot of this extraordinarily complex and fascinating technical, scientific and human collaborative venture in space.

[1874] We obviously cannot assess the technical and scientific aspects, which we leave to more expert judges.

Chapter 14: The European use of Spacelab

A. Russo

On 5 January 1972, the American President Richard Nixon announced his decision to "proceed at once with the development of an entirely new type of space transportation system designed to help transform the space frontier of the 1970s into familiar territory, easily accessible for human endeavor in the 1980s and 1990s". This new system, Nixon explained, "will center on a reusable vehicle that could shuttle repeatedly from Earth to orbit and back".[1875] The commitment of the United States to the development of the Space Shuttle heralded a revolution in space activities. Since the early Sputniks and Explorers up to the Apollo missions to the Moon, the launch of every spacecraft into space required a vehicle whose cost and technical sophistication was generally much higher than that of the spacecraft itself, and which would ultimately be lost in the launch. It was, some NASA officials used to say, like operating a railroad and throwing away the locomotive after every trip. A reusable vehicle would make the trip much more cost effective, they claimed, bringing the cost of space launches down by a factor of ten.[1876]

In the new era of space exploration, the Shuttle would replace expendable boosters for launching satellites into low Earth orbits and, in conjunction with upper stages, for sending spacecraft towards geosynchronous orbit or deep space. Other uses of the Shuttle were possible, however, taking advantage of its unique capabilities. In particular, the large cargo bay of the Orbiter could be used to support standard services and laboratory facilities for performing experiments in space. In this perspective, NASA studied the so-called Sortie Lab, a pressurised module fitting in the Shuttle cargo bay for the conduct of experimental activity in several scientific and technological fields. This was eventually called Spacelab, a manned space laboratory which could be used in different configurations on Shuttle sortie missions.

In the Summer of 1973, as we have discussed in the previous chapter, an agreement was reached between NASA and the European Space Research Organisation (ESRO) by which the latter would be responsible for the design, development, and manufacture in Europe, of Spacelab and its associated equipment. More specifically, the ESRO/NASA Memorandum of Understanding (signed on 14 August 1973) and the Joint Programme Plan (signed on 26 September 1974) stated that ESRO would deliver to NASA one Spacelab flight unit, one engineering model and two sets of ground support equipment. The European space organisation would also provide sustaining engineering support through the first two Spacelab flights. In May 1975 the Spacelab Programme was taken over by the newly created European Space Agency (ESA), the organisation which replaced ESRO in the management of the joint European space effort. The first Spacelab mission, originally planned for early 1980, was launched on 28 November 1983; three other missions followed in 1985, two supported by NASA and one by Germany. After the Shuttle *Challenger* accident of 28 January 1986, Spacelab flights were resumed in December 1990.

Spacelab was one of the most important and most expensive space programmes in Europe. For the first time since its beginnings in the early 1960s, the European space effort confronted the challenge of manned spaceflight, in the framework of the largest space collaboration ever undertaken by Europe and the United States. This cooperative venture posed unprecedented management problems, and many important technical and industrial difficulties had to be solved in Europe. The total cost of the Spacelab Programme was of the order of $ 800 million, about 40% higher than the original estimate. All ESA Member States except Ireland and Sweden participated, and the relative financial contributions were arranged according to their political and industrial interest in the Programme.

1875 "The White House, Statement by the President", 5 January 1972, in Launius (1994), p. 232. On this decision, see Logsdon (1986) and McCurdy (1990), pp. 22-33.

1876 Launius (1994), p. 107; McCurdy (1993), p. 87.

Germany paid the largest share, about 55%, the other main contributions coming from Italy (15.6%), France (10.3%) and the United Kingdom (6.5%). The industrial team was led by the German company ERNO, supported by ten co-contractors. More than forty companies in ESA Member States were involved in the development of the Spacelab system.[1877]

Although important from the technical and industrial point of view, Spacelab could not be considered as an end in itself. It was a large facility for carrying out experimental activities in a wide range of scientific fields and applications. The ultimate aim of the programme was to develop a system characterised by low-cost operations, versatility, good laboratory facilities and rapid user access, that could be used by as wide a community as possible. When Spacelab was conceived, however, no such user community yet existed. As often happens in "big science and technology" fields, a large technological facility was developed and offered as a solution in search of a scientific problem. The supporters of the new facility had to convince the potential users of the benefit that they could derive from its use and to lead them to plan their future objectives accordingly.[1878]

The aim of this chapter is to review the history of the Spacelab Programme from the point of view of a specific user community, namely the European space science community. The interest of such a viewpoint is twofold. Firstly, Europe was the birthplace of Spacelab and therefore a special responsibility was incumbent on European space scientists and policymakers *vis-à-vis* its utilisation. Secondly, the ESRO/ESA Scientific Programme suffered from severe budgetary constraints which had been imposed in the pre-Spacelab period and not revised after the decision to undertake this project. Scientists were therefore called upon to accommodate the new mission opportunities within the established budget, in a very competitive framework. The analysis is divided into four main parts. In the first we will briefly describe the main features of the Spacelab system and the early reactions of scientists to the appeal of a scientific laboratory in space. In the next part, we will analyse the role of potential Spacelab missions in the planning of ESA's Scientific Programme for the 1980s. The third part, the most important one, is devoted to the European instrumentation on the first Spacelab mission, jointly realised by ESA and NASA in the framework of the Spacelab development programme. Finally, we will briefly discuss ESA plans for Spacelab utilisation after the first mission.

14.1 The appeal of a scientific laboratory in space

The Spacelab concept consisted of a modular structure composed of two basic elements: a cylindrical pressurised module and an unpressurised U-shaped structure (pallet) (Figures 14-1 and 14-2). The module provided a shirt-sleeve laboratory environment for the experimenters and their equipment. It was connected to the Orbiter cabin by a crew transfer tunnel. The pallet acted as a platform where telescopes, antennas and other instruments which needed direct exposure to space could be mounted. A sophisticated Instrument Pointing System (IPS) was also developed in Europe in the framework of the Spacelab programme, for use with pallet-mounted equipment which required a high degree of pointing accuracy. The pallet instruments could be operated remotely from the module, from the Orbiter cabin or by command link from the ground. A flight time of 7 days was envisaged for a standard Spacelab mission and the facility was designed for at least 50 flights or a ten-year lifetime.

Several configurations were possible, according to the specific objectives of each mission. The pressurised module could be composed of one or two segments, while pallet segments could be mounted either individually or in series of up to five segments. Spacelab's modular concept offered considerable flexibility for adaptation to a wide range of missions. By changing the number of module and pallet segments, one could obtain variations on the three basic flight configurations: module-only,

[1877] Shapland & Rycroft (1984). ESA comprised eleven Member States in the Spacelab period: Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom. Austria was eventually associated in the Spacelab programme. The history of the Spacelab development programme is dealt with in the previous chapter. A historical account from the American side was provided by the former NASA director of the programme, D. Lord (1987).

[1878] Another example is discussed in Russo (1996).

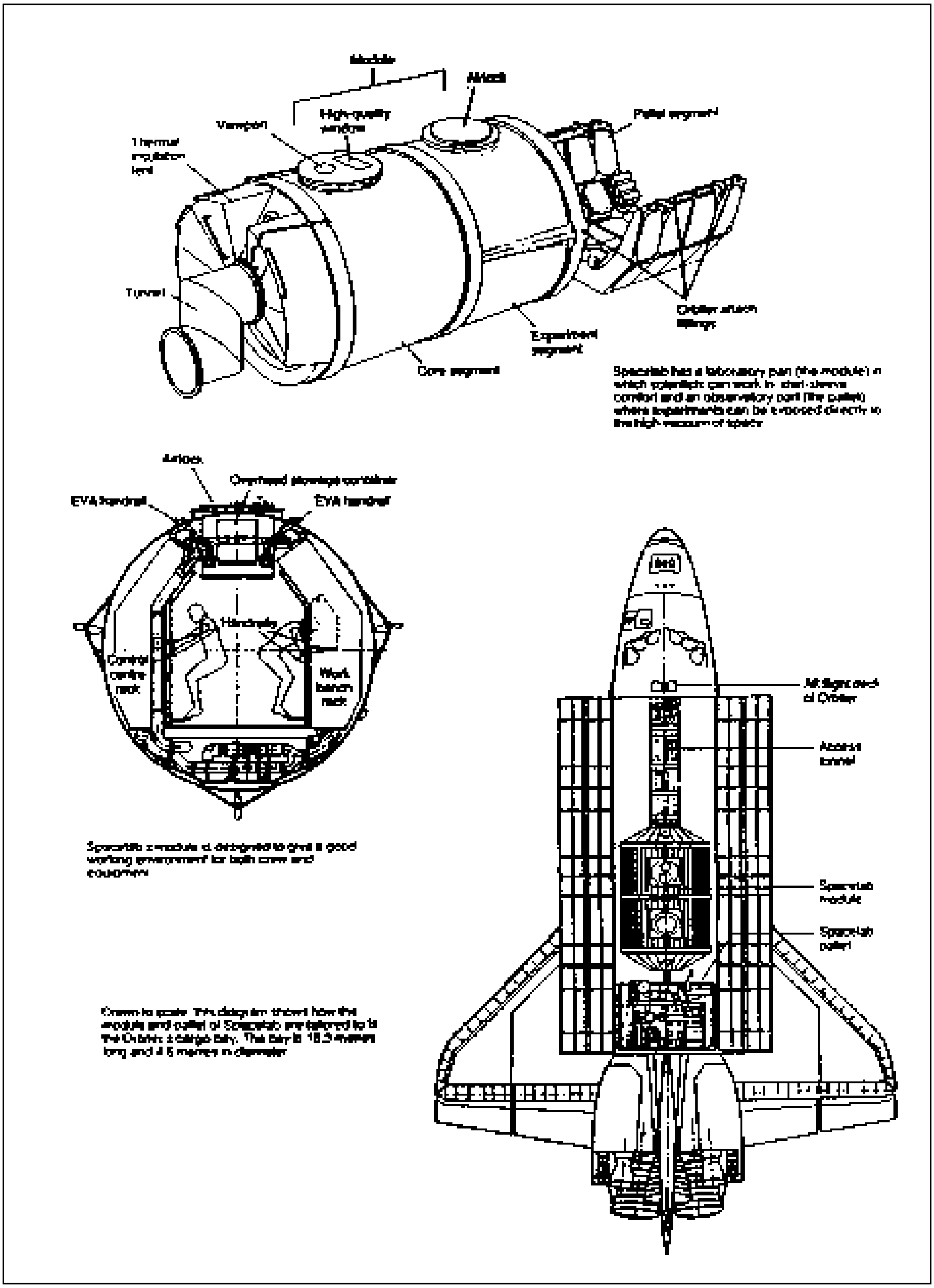

Figure 14-1: The Spacelab Concept [Shapland & Rycroft (1984)]

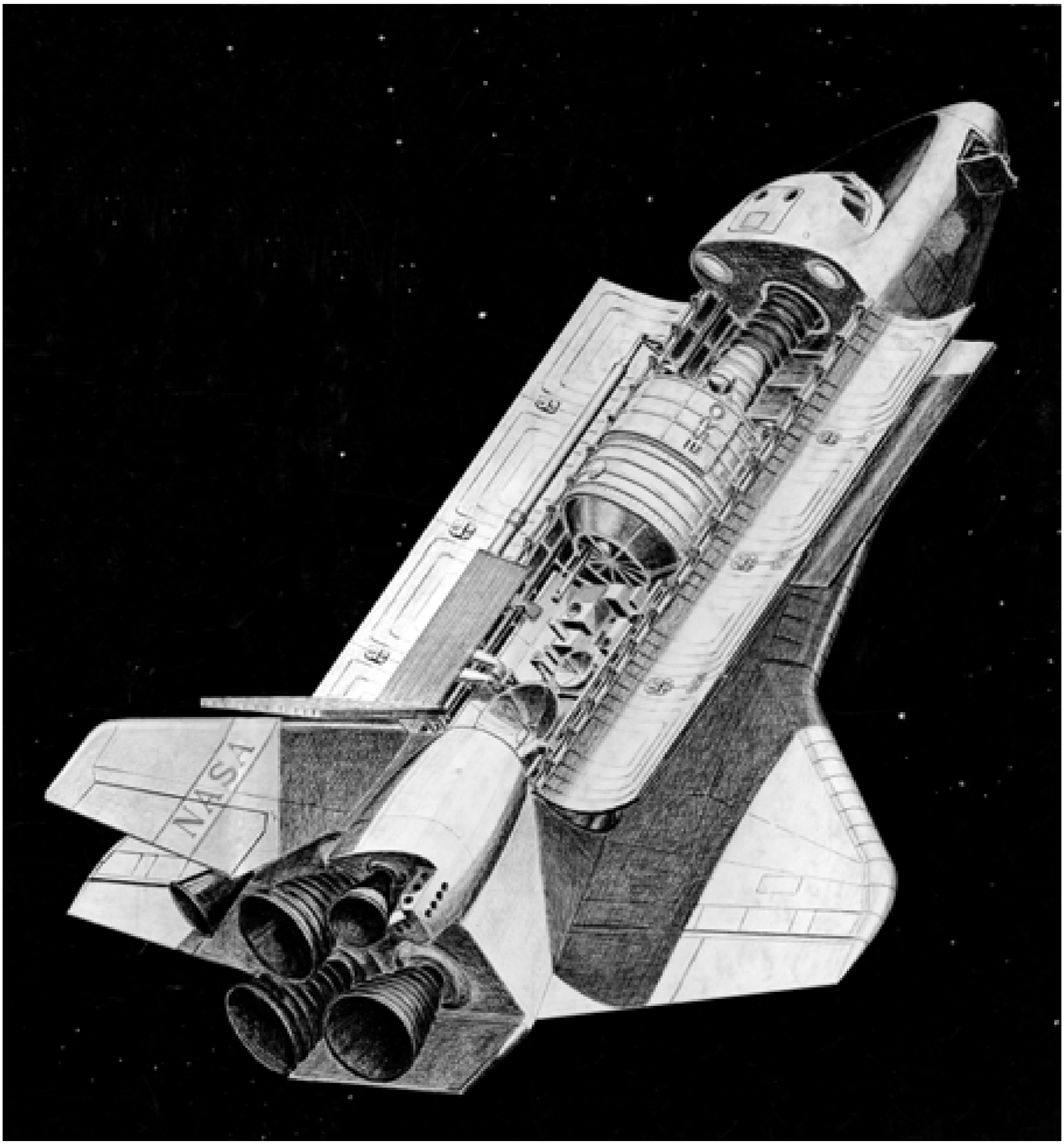

Figure 14-2: Artist's Impression of Spacelab in the Shuttle Cargo Bay [Lord (1987) p. 485],

module-and-pallet, and pallet-only (Figure 14-3). The flight unit that ESA delivered to NASA consisted of a long (two-segment) module plus five pallet segments. The first Spacelab mission was realised with the module and one pallet segment. A pallet-only configuration with three pallet segments and the IPS facility was used in the Spacelab 2 (SL-2) mission, actually the third to be launched, on 29 July 1985. Spacelab 3 (SL-3), launched on 29 April 1985, used a module-only configuration with the addition of a simple support structure to hold two experiments needing exposure to space. A similar configuration was also adopted for the German D-1 mission, on 30 October 1985, the last Spacelab flight before the Challenger accident. By that time, the manifest of

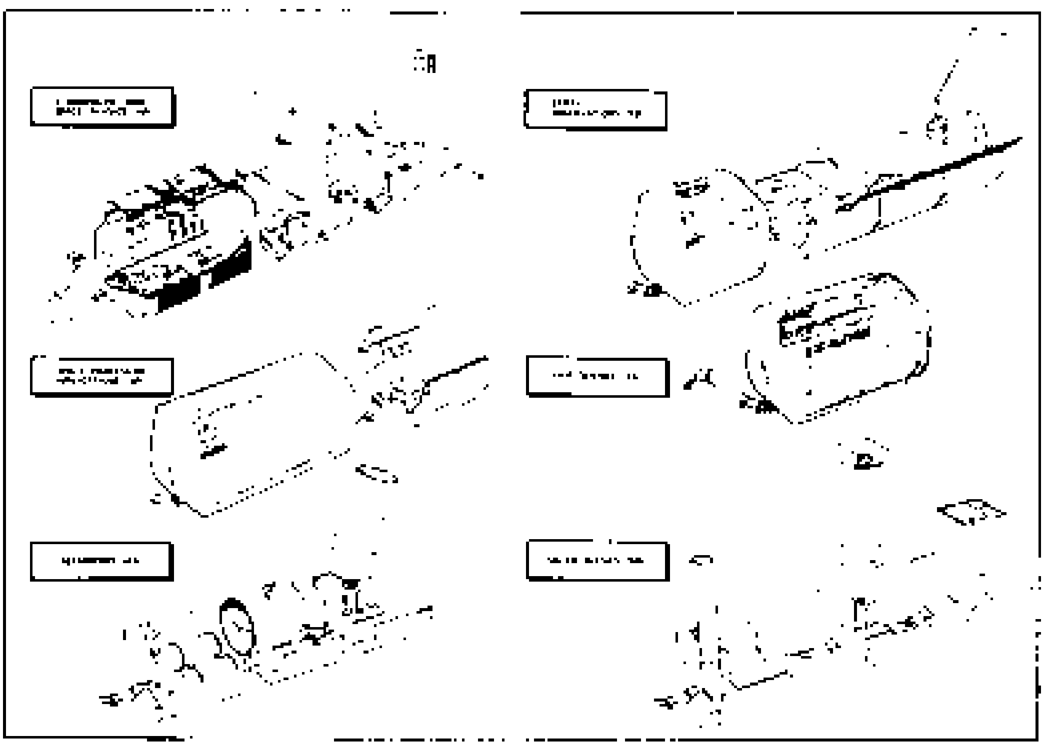

Figure 14-3: Scientific and Application areas for Spacelab Utilisation
[ESRO Annual Report (1974), p. 143]

Spacelab missions included 11 flights, in various configurations, between March 1986 and July 1988.[1879]

Spacelab was heralded by its proponents as a new and exciting way to do research beyond the atmosphere (Figure 14-4). New opportunities would be offered to traditional space science disciplines and new fields would be opened up. In the field of astronomy, for example, it became possible to explore the spectral regions of infrared through the use of large, cryogenically cooled telescopes. Microgravity experiments in life sciences and material sciences would provide important results in view of a foreseeable future in which human communities would live and work in large space stations. "Spacelab is the indispensable element to transform the Shuttle into a first generation space station", ESRO's Director General claimed in 1973, adding that according to the NASA mission plans about 40% of Shuttle flights would be devoted to Spacelab missions.[1880]

Five aspects were pointed out as the main advantages to the users over conventional spacecraft. Firstly, the large weight and volume available for experimentation, i.e. from about 4 tonnes of payload in the module-only configuration to 9 tonnes in the pallet-only configuration. Secondly, the possibility of reusing equipment on subsequent flights, which allowed the repetition and modification of experiments. Thirdly, the availability of a laboratory-like environment in which scientists and other specialists could supervise the experiments and, if necessary, adjust and repair the instruments. Fourthly, the short experiment gestation time deriving from the frequent Shuttle/Spacelab flights and the re-use of standard equipment and basic services (laboratory facilities, instrument racks, work benches, power supply, thermal control, data management, etc.). Finally, the low cost of Spacelab experiments compared to "traditional" spacecraft as a consequence of two main factors: (a) the relatively low cost of Shuttle launches associated with the large mass capability, which made the cost per kilogram of experiment mass small; (b) the less demanding standard on reliability of

1879 *ESA Bulletin*, 46 (May 1986), p. 103.
1880 ESRO/C(73)49, 13 July 1973, pp. 1-2.

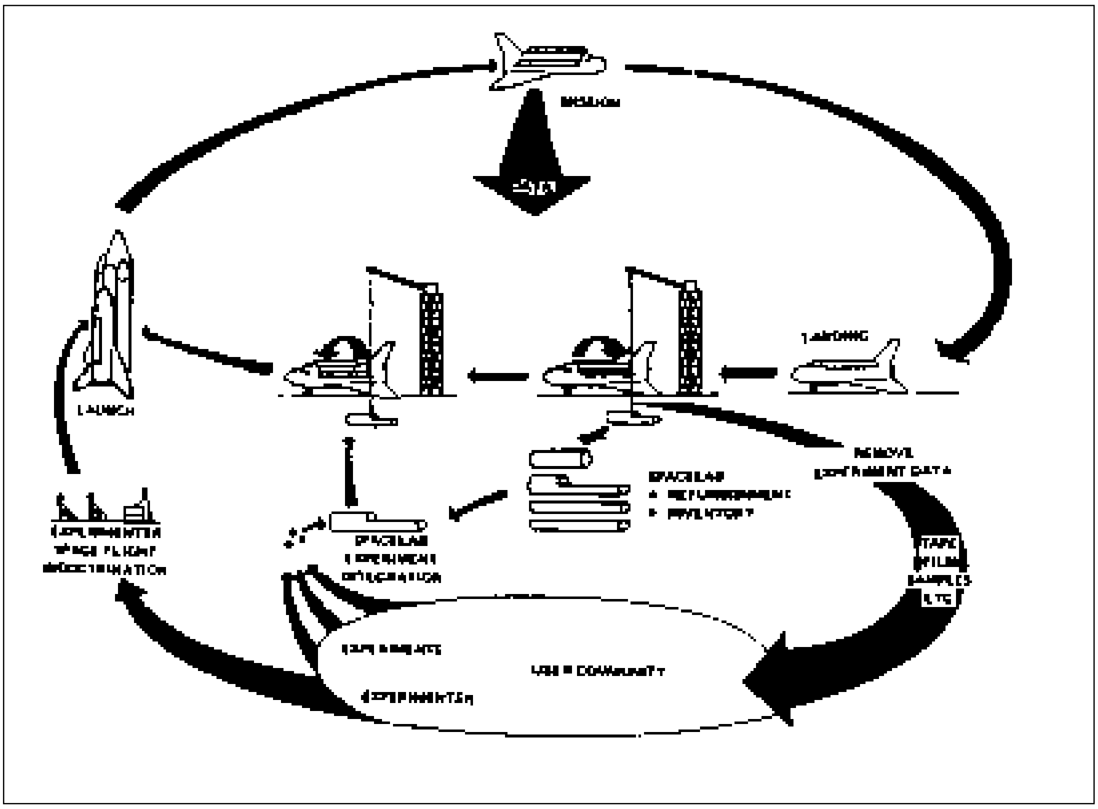

Figure 14-4: Shuttle-Spacelab Flight Profile [Lord (1984), p 489]

instrumentation because of the laboratory-type equipment and the presence of the experimenter for check-out and minor repair.

14.1.1 The reactions of scientists

While the Spacelab concept was being studied by NASA and ESRO, both space agencies took a number of initiatives to inform the scientific community about the capabilities of the Shuttle/Spacelab system, to assess the impact of the new facility on the different scientific and application fields, and to define the requirements of the potential users. In the summer of 1972 NASA organised a Space Shuttle Sortie Workshop, followed by the establishment of fifteen working groups to address questions relating to as many scientific, technological and application fields. ESRO, for its part, set up ten "Spacelab Payload Groups" to assist the Executive in defining the interfaces between Spacelab and the experiments and evaluating the Spacelab design *vis-à-vis* the users' requirements in the various scientific and technical disciplines.[1881]

The reaction of scientists to the Spacelab advocates' arguments was far from being enthusiastic, however. According to the former NASA Director of the Spacelab programme:

> *Many of the potential experimenters were more than content with their unmanned satellites and sounding rockets and had no strong desire to become involved in the new*

[1881] Lord (1987), pp. 7-8; ESRO/PB-S(73)14, 10 September 1973. The topics dealt with by the ESRO Spacelab payload groups were: infrared astronomy, stellar astronomy, solar astronomy, high energy astronomy, atmospheric and ionospheric sciences, life sciences, material sciences, Earth resources, communications, and space electrophoresis. The results of the first six groups, specifically devoted to scientific fields, were published in the report *Spacelab programme. Views of the ESRO Spacelab payload groups: utilisation of the Spacelab for science*, ESA: OSP/45, 30 May 1973.

manned systems. They could see nothing but loss of control of their experimental destinies and increased costs to make their instruments man-rated.[1882]

The lukewarm attitude of scientists towards the Shuttle/Spacelab system was evident on two important occasions at which the utilisation of the new facility was discussed by the community at large. The first was a symposium organised by ESRO in Frascati, Italy, in January 1973, attended by some 250 scientists and technologists. Then, in July that year, a two-week Summer Study was organised by the U. S. National Academy of Science at Woods Hole, Massachusetts.

The scientists who participated in the Frascati meeting discussed the possible benefit of Spacelab for their disciplines in five scientific sessions whose results were presented by their chairpersons, all of whom were recognised spokesmen of the European space science community.[1883] They did not hide the diffuse scepticism of the community itself regarding Spacelab. Two main disadvantages were pointed out, in particular. The first was the short duration of Spacelab missions. For Cornelis de Jager, who spoke on behalf of the solar physics community, "[Spacelab] is not the most appropriate spacecraft for any instrument intended for continual solar monitoring during long periods". The rapporteur for the high energy astrophysics session, Giuseppe Occhialini, echoed de Jager's statement: "Spacelab can be considered equivalent to a super rocket for X-rays or a super balloon for gamma and cosmic rays. [...] This type of mission cannot supersede, not even replace free flying missions in our field, not even small satellites". The only way to compensate for the short duration of Spacelab missions was to have frequent flights of the same instrument. This, however, called for a clarification of the financial aspects with NASA. The obvious question was bluntly asked by Hendrik van de Hulst, the spokesman of the astronomer community: "On what principle will the cost per launch be determined and what is the present estimate?". Nobody was in a position to answer this question yet.[1884]

The second disadvantage of Spacelab was precisely what some considered its main attraction, i.e. the presence of the experimenter directly supervising the performance of its instruments. Two major drawbacks of manned scientific missions were pointed out: the contamination caused by gases from the life-support equipment and the attitude instability caused by the crew. Another cause of concern was, of course, the high cost and complexity of man-rated space transportation systems, which risked jeopardising the vaunted attraction of the reduced time and cost in comparison with conventional space experiments.

In conclusion, most European space scientists were quite sceptical, or even suspicious, regarding Spacelab’s performance in their fields of interest. Occhialini probably expressed the feelings of many participants in his conclusion: "We would not have chosen this particular type of vehicle in our field, but being there, it can be used".[1885] There could be a place for Spacelab in the ESRO Scientific Programme, they argued, provided that Spacelab missions did not supersede the ongoing automatic spacecraft programmes and that certain conditions were fulfilled. In particular, it was deemed necessary to assure a frequent repetition of flights and it was recommended to give preference to pallet-only missions so that it would not be necessary to pay the performance penalty associated with manned flights.

1882 Lord (1987), p. 7. The negative attitude of American space scientists towards the continuation of important manned spaceflight activity after their "distasteful experience" with the Apollo programme is discussed by Newell (1980), pp. 389-392.

1883 LPAC(73)4, 31 January 1973. The five scientific sessions and their chairpersons were: solar astronomy (H. Elliot and C. de Jager), infrared and ultra-violet astronomy (H.C. van de Hulst and G. Courtès), high energy astrophysics (G. Occhialini and C. Dilworth), space and plasma physics (J. Geiss and G. Haerendel), life sciences (P. Lindop). The life sciences session was a novelty in the European space science framework.

1884 The three quotations are from LPAC(73)4, *cit.*, Annex 2, pp. 4, 7 and 6, respectively.

1885 LPAC(73)4, *cit.*, Annex 2, p. 7.

The American space science community did not hold the scientific potential of Spacelab in any higher esteem, as was evident at the N.A.S. Summer Study:

> *The Sortie Lab was not the most popular programme presented to this group of scientists. With the exception of the life scientists present, most of the attendees felt their resources could be better placed on automated systems in the conventional space science disciplines. Once faced with the fact that a Sortie Lab would probably be provided by a European cooperative effort, they grudgingly conceded that there were some ways in which it could be useful to all disciplines.*[1886]

Most American space scientists could see little use for Spacelab at that time and "wondered if they were going to be pressured into using it simply to keep man-in-space in the picture".[1887] They were not even convinced of the usefulness of the Shuttle itself as a vehicle to carry scientific payloads into space. Firstly, it did not appear to be appropriate for small near-Earth satellites of the kinds that were being launched by Scout rockets, both because they would hardly be accommodated within the Shuttle cost structure and because they often had to go into unusual orbits. Secondly, there were payloads headed for geosynchronous or other high-altitude orbits, or for escape trajectories to interplanetary space; if the Shuttle were to be used for the initial boost, suitable upper stages had to be developed to carry these payloads beyond the Shuttle's low-altitude orbit.

In conclusion, scientists on both sides of the Atlantic considered the Shuttle/Spacelab system of very little scientific interest, at least those involved in "traditional" space science disciplines. Against the obvious advantages of return capability, large payload availability, and on-board adjustment of experiments, there were serious disadvantages, such as the short duration of missions, the limitation of attainable orbits, contamination and man-induced attitude changes. Moreover, the cost of Spacelab missions was still an open question which dramatically depended on the eventual performance of the Shuttle. However, in spite of the poor scientific arguments which could be made in favour of the Shuttle/Spacelab programme, the scientists could not ignore it. They could not control the technical development of launch vehicles, which actually depended on wider political and economic factors. The Shuttle appeared as the space transportation system of the following decades and they had to adjust their future plans accordingly.

For the European space science community, in particular, the political importance of Spacelab was dominant. It was a key element of the "package deal" which, in 1973, solved a long-standing crisis in the European collaborative effort in space and paved the way for the creation of the European Space Agency. It also represented the start of a new era in US-European space cooperation, indeed the ticket for Europe to participate in the American Space Shuttle programme. Space policy, not space science, was the main rationale for the development of Spacelab in Europe and European scientists had to cope with this fact.

14.2 Planning ESA's Scientific Programmes in the 1980s and the role of Spacelab

By the time the Spacelab development programme was started, the European space science community was involved in the decision-making process to select ESRO/ESA's scientific missions to be flown in the early 1980s, the final decision being scheduled for the autumn 1976. The role of the Shuttle/Spacelab system in space research was central in these discussions, which brought into focus the delicate transition period through which the European space effort was going. Three main aspects deserve to be mentioned.[1888] Firstly, the ESRO/ESA Scientific Programme suffered from a severe financial constraint. The so-called "first package deal" between ESRO Member States had fixed at 27 MAU (in 1971 prices) the annual level of resources for this programme, the only one which was

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1886 Lord (1987), p. 11.

1887 Newell (1980), p. 391.

1888 For a more detailed account, see chapter 3 in this volume.

mandatory for all Member States according to a GNP contribution scale.[1889] This ceiling was confirmed, apart from adjustments for inflation, in the second package deal (1973) and after the creation of ESA (1975), despite the dramatic increase in the total financial resources made available by Member States for the joint space effort (from 75 MAU in 1974 to 462.4 MAU in 1976). More precisely, after taking into account inflation and ESA's new budget structure, the annual level of the Scientific Programme was set at 58.7 MAU in 1975-prices from 1977 onwards.[1890] The steady financial envelope gave great stability to the Scientific Programme, but the budget was now becoming critically low when compared to the increasing size of the scientific community calling on ESA and to the demands for more ambitious research projects in the new decade.

In this framework, and this is the second aspect, the advent of the Shuttle/Spacelab system posed a major problem. The new facility, in fact, not only offered new opportunities in the traditional space science disciplines, but also opened up research fields not covered by former ESRO/ESA activities, in particular zero-gravity research in bio-medical and material sciences. When the first package deal had established the financial envelope for the scientific budget, Spacelab was not yet in sight; when the latter was approved, in the framework of the second package deal, no special provision was foreseen for developing experimental payloads for Spacelab missions. Consequently, Spacelab scientific experiments should either be developed by groups of Member States as optional programmes or funded out of the Scientific Programme. In the former case, the mandatory and cooperative character of the Scientific Programme would be undermined; in the latter, new disciplines and scientific groups would compete for funding with the traditional ones. The space science community advocated the need to endorse the mandatory character of the Scientific Programme and then insisted that its budget should be increased in order to support new research fields as well as old ones, Spacelab missions as well as unmanned spacecraft. Member state governments, on the contrary, were adamantly against any increase of the mandatory budget, and their space policymakers held different views about the future of ESRO/ESA's scientific policy. Some argued that the Organisation should undertake large projects based on the use of the new space technologies and funded on an optional basis by interested Member States; others felt that the mandatory character of the Scientific Programme should not be jeopardised and the new opportunities offered by the Shuttle/Spacelab system should compete with established research fields and space science technologies.

This brings us to the third aspect, i.e. the place of science in the new institutional framework. The two package deals and the transformation of ESRO into ESA had certainly left the Scientific Programme, because of its mandatory character, at the core of the joint European space effort, but also in a very weak position from the political point of view. In the early 1960s, space research had been the main rationale for west European countries undertaking a cooperative effort in space, and the space science community played a major role in defining ESRO’s institutional framework and scientific policy. The situation was quite different in the 1970s. Practical objectives such as commercial telecommunications, air traffic control and weather forecast had replaced scientific research as the principal aim of ESRO’s and ESA’s undertakings. Economic and commercial interests, technological innovation and industrial policy were the driving force that shaped the European space effort, and science had to accommodate its objectives and priorities accordingly. Even in science itself, national interests and programmes often entered the competitive game for selecting ESA scientific projects, jeopardising the scientists' claim to base their judgement on purely scientific arguments.

It is against this background that discussions on ESRO/ESA’s future Scientific Programmes started in 1973 within the Launching Programme Advisory Committee (LPAC) and the two specialised working

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[1889] It must be remembered that MAU stood for Million Accounting Units, a conventional monetary unit used from the early 1960s in the framework of the joint European space effort. From 1975 the AU was defined in terms of a "standard basket" of the EEC currencies weighted according to the average over five years of the gross national product and the intra-European trade of each state. In 1976, the value of the AU in terms of the main currencies was 1.30 US$; 3.05 DM; 5.22 FF; 0.57 GB£; 815 LIT. See *Frank (1976)*.

[1890] ESA/SPC(76)18, 25 May 1976.

groups: the Astrophysics Working Group (AWG) and the Solar System Working Group (SSWG).[1891] The most important conclusion was the abandonment of the policy statement that the LPAC had adopted in June 1970, by which priority had been given to magnetospheric studies and high energy astrophysics, while optical astronomy, solar physics and planetary missions had been excluded from ESRO's Scientific Programme, both for financial reasons and because of NASA's strong effort in these fields.[1892] In the new situation created by the advent of the Shuttle/Spacelab system and the prospects of large-scale collaborative ventures with NASA, a new policy had to be established for scientific missions to be flown in the 1980s.

Many proposals were discussed in the second half of 1973 and early 1974, but no guidelines were defined at this stage, either regarding priorities between the various research fields or regarding preference for specific kinds of mission (e.g. automatic satellite or Spacelab missions, small or large spacecraft, purely European or co-operative projects). In the event, following the LPAC's recommendations, the ESRO Scientific Programme Board (SPB) decided in April 1974 that as many as thirteen missions should be studied at "mission definition" level, six of them foreseeing the utilisation of Spacelab.[1893] All fields of space research were covered: infrared astronomy and planetary exploration, solar physics and astrometry, atmospheric studies and high energy astrophysics, ultra-violet astronomy and cosmic rays. This decision reflected the rather uncertain perspectives for space science in the following decade as well as the need to find a compromise between conflicting scientific and political options. On the one hand, the appeal of new space technologies such as reusable transportation systems, space laboratories, cryogenic telescopes for infrared astronomy, large optical telescopes, electric propulsion and so on, stimulated plans for ambitious large-scale projects. On the other hand, there were persisting uncertainties regarding such important matters as technical and financial feasibility, political approval, time schedules, ESA's new institutional framework, international legal arrangements and so on. Moreover, not all research fields required big science: medium-size satellites and proven technologies could be successfully used for atmospheric and magnetospheric studies or X- and gamma-ray astronomy. And many scientists would prefer to keep control over small, scientifically interesting projects rather than become entrapped in large, politically important ventures.

The results of the mission definition studies were discussed by the Working Groups and the LPAC in February 1975 and finally, following the latter's recommendations, the SPB selected five projects for feasibility (Phase-A) studies, from which the final choice would eventually be made one year later. All of them required the Shuttle as the space transportation vehicle and three, in particular, foresaw the use of Spacelab. The two most important projects involved close cooperation with NASA, i.e. the Large Space Telescope (eventually renamed Hubble Space Telescope) and the Out-of-Ecliptic mission (OOE). In the former, ESA would provide one of the focal-plane instruments (the Faint Object Camera) and the solar array for the NASA-built telescope. The OOE mission consisted of the simultaneous launch of two spacecraft, one built in Europe and the other in the United States, into an escape orbit outside the ecliptic plane, for solar wind investigations and stereoscopic observation of the sun. Both Hubble and the OOE twin spacecraft were to be launched by the Shuttle.[1894]

1891 Since the early days of ESRO, the LPAC was a body of five independent scientists whose task was to advise ESRO's Director General on all scientific matters. The chairmen of the two working groups usually participated in LPAC meetings. In 1974 a Life Sciences Working Group (LSWG) was also set up. With the advent of ESA, the LPAC was replaced by the six-member Science Advisory Committee (SAC), which also included a life science expert.

1892 See chapter 8 in Volume 1. On the basis of the LPAC's 1970 policy statement, the ISEE-2 and EXOSAT missions had been selected in spring 1973.

1893 The SPB was the Council's delegate body for the Scientific Programme and comprised delegates from all Member States. After the creation of ESA, its functions were taken over by the Science Programme Committee (SPC).

1894 A detailed historical account of the Hubble Space Telscope can be found in *Smith (1989*). For the origin of the OOE mission, see *Hufbauer (1993)*.

The three other projects were a Large Infrared Telescope (LIRTS), an X-ray spectropolarimeter (EXSPOS), and a European contribution to the NASA programme for atmospheric, magnetospheric and plasma studies (AMPS). All of them involved extensive use of Spacelab; indeed they required many flights of the Shuttle-borne laboratory over several years in order to fulfil their scientific objectives. As to the LIRTS (Figure 3-2), scientists stressed that a viable programme required one 7-day mission per year, four such missions being required to cover the whole celestial sphere. Should this condition not be fulfilled, they warned, a reconsideration of the project and of its desirability would be necessary. In the case of EXSPOS, it was also assumed that one flight per year represented a reasonable time scale, eight flights being required to cover all X-ray sources. Finally, the AMPS programme aimed at exploring the Earth's atmosphere and its plasma environment by the use of sophisticated instrumentation on Spacelab over a 5 to 10 year programme of flights. The European contribution would be a laser facility for active atmospheric sounding (LIDAR) and a number of sub-satellites to be put into orbit from the Shuttle by special launching devices. In conclusion, whatever good scientific reasons existed for selecting these three projects for feasibility study, the choice was essentially based on highly optimistic expectations about the performance of the Shuttle/Spacelab system. Indeed, it was foreseen at that time that more than 20 NASA missions with European participation and 7 all-European missions would be performed in the period 1980 to 1985.[1895]

In June 1976 the results of the feasibility studies were available and ESA's advisory committees and decision making bodies were finally called upon to select the projects to be adopted within the Agency's Scientific Programme. The uncertainty regarding Spacelab was now the main concern. Two questions were on the table. Firstly, the AMPS programme was under critical review within NASA and it looked as if European scientists would not gain admittance to it for some years (in fact, it was eventually abandoned). Consequently, AMPS could no longer be proposed as a realistic context for the LIDAR and the sub-satellites, which had now to be considered as independent projects within the framework of a possible fully-European programme of Spacelab missions. Secondly, some estimates of the operating costs of Spacelab projects were available (Table 14-1) and the earlier optimism could no longer be justified.[1896]

Table 14-1: Summary table of financial aspects of major new projects (1977-1983) (in MAU at mid-1976 price levels and 1977 exchange rates)

Project	Total cost	Remarks
Space Telescope	60.1	ESA contribution until 1983. Post-1983 costs estimated at ± 20 MAU.
OOE	71.0	ESA contribution until launch (1983).
LIRTS	40.3	Including first 7-day mission. Following missions estimated at about 23 MAU.
EXSPOS	25.4	Including first 7-day mission. Following missions estimated at about 11 MAU.

In the case of the LIRTS, for example, the cost of a complete observation programme (four Spacelab missions) was estimated at about 109 MAU; as to EXSPOS, the cost of the required eight Spacelab missions was estimated at about 102 MAU. In addition, the Executive warned that a clear charging policy for the use of the Shuttle/Spacelab system had not yet been defined by NASA, and therefore the

1895 ESA, *Annual Report 1975*, p. 71. It is worth recalling that this optimistic vision had driven ESRO's scientific advisory bodies to discard an infrared astronomy satellite (Cires) and a gamma-ray satellite (Logos) in favour of LIRTS and EXSPOS, in part because of their higher estimated cost compared with the competing Spacelab projects.

1896 ESA/SPC(76)33, 1 September 1976.

cost of reflights was not under ESA's control and might be inaccurate by rather large amounts. These figures had to be compared with the estimated costs for ESA of the Space Telescope and the OOE projects, i.e. about 80 and 70 MAU, respectively. In this situation, it is hardly surprising that none of the Spacelab projects was eventually selected, in spite of the great interest many scientists had expressed for the infrared telescope. Following the recommendations of the Science Advisory Committee (SAC), in October 1976 the Science Programme Committee (SPC) definitively approved the European participation in the Space Telescope project and the European spacecraft in OOE mission, later renamed the International Solar Polar Mission (ISPM). Spacelab thus left the main stream of ESA's Scientific Programme. More precisely, one Spacelab project did remain under study as a candidate for the selection of new scientific missions scheduled for early 1980, namely a grazing-incidence X-ray solar telescope (GRIST), originally intended as the European contribution to an envisaged ESA/NASA four-telescope Spacelab payload for solar physics studies. Owing to the uncertainty of the NASA planning for a dedicated solar physics mission, GRIST had been discarded as a candidate for the 1976 selection but kept under study as a pure ESA project for the next selection. It was eventually abandoned in early 1979 because of the estimated high operational costs, and therefore all candidate projects for the 1980 selection were satellite missions, in particular the astrometry satellite *Hipparcos* and the cometary probe *Giotto* which were finally selected.[1897]

14.3 The first Spacelab mission

In parallel with the developments described above, ESA's scientific advisory bodies were discussing the experimental objectives of the first Spacelab flight. The primary goal of this mission was the verification of the performance of the Shuttle-borne laboratory and its subsystems in the framework of the Spacelab development programme, but half of the Spacelab resources would still be available for independent experimental activity. According to the Memorandum of Understanding, this part of the mission was to be jointly planned by ESA and NASA, each agency taking about half of the available resources for European and US experiments, respectively. It was also contemplated that a European payload specialist would be on board. In this section we will review the first initiatives undertaken by ESA in order to define the European participation in the first Spacelab mission and to establish a suitable legal and financial framework to support it. In the following one, we will discuss the final definition of the European experiments in the first Spacelab payload.

14.3.1 The definition of a European model payload

Guidelines for the First Spacelab Payload (FSLP) were worked out by an ESRO/NASA Joint Planning Group (JPG) in April 1974 and eventually endorsed by the ESRO Director General and the NASA Administrator at their first annual review of the Spacelab programme on 20 May. The main elements were: (a) that the payload should be "complementary and consistent with future Spacelab missions," i.e. it should use as much as possible elements and techniques that could be used in future missions; and (b) that "the experiments should take advantage of the unique capability of Spacelab", in particular capitalising on "the capability of man to perform in the Spacelab environment".[1898] The JPG also defined the technical constraints for the first Spacelab mission, the principal being:

a the flight configuration would consist of a long pressurised module plus one platform for scientific instruments ("pallet");

b a seven-day mission would be accomplished with up to 100 man-hours available for experiment operations;

c a total mass of 3000 to 4000 kg and a power of 1.5 to 2.5 kW would be available for experiments, equally divided between European and American experiments;

d the instrument pointing system would not be available.

1897 See chapters 3 and 4 in this volume.

1898 ESRO/PB-S(74)27, 5 June 1974, quotation from annex, p. 3. See also ESRO/C(74)45, 23 July 1974; ESRO/JPPC(74)37, 12 November 1974; and *Lord (1987),* pp. 121-127.

Following this agreement, the ESRO Executive circulated a "Call for Ideas" for the FSLP among the potential Spacelab user community in Europe, from which 241 replies were received. Most of them came from Germany (103 proposals), other main contributions coming from Britain (55 proposals) and France (42 proposals). About half of the proposed experiments concerned scientific disciplines still absent from European space activities, such as material sciences (80), life sciences (32) and Earth resources surveys (35). Less than one quarter fell within the traditional fields of space research: atmospheric, magnetospheric and plasma physics (23); high energy astrophysics and cosmic rays (20); astronomy (10); solar physics (3). The others proposals concerned telecommunications (19), technology (15) and "others" (4).[1899]

The proposals were thoroughly analysed by ESRO engineers and assessed in the light of the technical constraints of the first Spacelab flight. Various mission options were considered, divided into two different flight profiles: one Earth-oriented, mainly devoted to atmospheric physics and remote sensing of Earth resources; the other space-oriented, with priority given to astronomy, astrophysics and cosmic-ray observations. Experiments in material sciences and life sciences, which did not require a particular orientation, were foreseen in both cases. These mission options were first discussed within the ESRO scientific advisory system and then presented at the JPG meeting of 5-6 November 1974, together with the parallel proposals coming from NASA. As a result of these discussions, it was agreed that priority should be given to an Earth-oriented mission, for two main reasons. Firstly, major astronomy instrumentation was particularly sensitive to contamination and the long-module configuration was not suited to providing a clean environment on the pallet; secondly, a mission with scientific objectives in the field of astronomy and astrophysics would better take advantage of the fine-pointing capability available on later flights.[1900] This conclusion was endorsed by ESRO's Scientific Programme Board (SPB) and Spacelab Programme Board (SLPB), and finally approved by the Council's Joint Programmes and Policy Committee (JPPC).[1901]

Following these preliminary discussions and decisions, a list of experimental objectives for the first Spacelab mission was recommended by the JPG and eventually approved by the Heads of the two space agencies at their meeting of 4 June 1975 (Table 14-2).[1902] Subsequently, the ESRO Executive defined a model payload for the European complement of the FSLP (Table 14-3).[1903] The basic elements in the scientific fields were the laser instrument for the atmospheric studies discussed above (LIDAR) and a Sled facility for studying the behaviour of the vestibular system of astronauts under weightless conditions (Figures 14-5 and 14-6). Material science experiments were also well represented, particularly in the fields of electrophoretic separation, crystal growth, metallurgy and fluid physics.

1899 ESRO/JPPC(74)28, 20 September 1974 (also attached to ESRO/PB-S(74)33, 7 October 1974). The small number of proposals in astronomy and solar physics was essentially due to the fact that a pointing capability would not be available on the first mission.

1900 ESRO/JPPC(74)37, 12 November 1974. NASA plans are described in ESRO/JPPC(74)41, 19 November 1974. The scientific aspects of the Executive's options were discussed by the AWG, SSWG and LSWG and by the LPAC; the technology and application objectives were discussed by the newly established Technology Advisory Group, Remote Sensing Ad Hoc Group, and Material Sciences Consulting Group. All advisory groups' recommendations are reported in ESRO/JPPC(74)37, annex 2, appendices 1 to 7.

1901 SPB, 10th meeting (20 November 1974), ESRO/PB-S/MIN/10, 20 January 1975; SLPB, 17th meeting (25 November 1974), ESRO/PB-SL/MIN/17, 14 January 1975; JPPC, 10th meeting (27-28 November 1974), ESRO/JPPC/MIN/17, 15 January 1975. The complex procedure for arriving at the definition of the European complement for the first Spacelab payload is described in ESRO/JPPC(74)30, 9 October 1974.

1902 ESRO/JPPC(75)9, 20 March 1975; ESA/FSLP(75)1, 28 July 1975. By this time the European Space Agency had replaced ESRO. Director General Roy Gibson represented ESA while NASA was represented by its Adminitrator James Fletcher. The JPG was formally dissolved after this meeting.

1903 ESRO/FSLP(75)3, 18 April 1975. Unless otherwise specified, the acronym FSLP will be used henceforth to represent the European complement for the first Spacelab payload.

Table 14-2: Experimental objectives for the first Spacelab mission[1904]

Experimental objectives for the first Spacelab mission recommended on 16 January 1975 by the two co-chairmen of the ESRO/NASA Joint Planning Group, J. Collet and G.W. Sharp, to the ESA Director General and the NASA Administrator:

- To demonstrate the capability to investigate the fundamental science in vapour, liquid and solid-phase interaction under gravity-free conditions, observing among other things:
  - crystal growth, metallurgical phenomena and separation of biological material;
  - cloud microphysics;
  - drop dynamics.
- To investigate key natural cause and effect relationships that exist in the near-Earth environment by performing active and interactive experiments on and in the Earth's atmosphere and magnetosphere.
- To conduct investigations on the effects of the space environment (zero gravity and/or hard radiation-HZE) on body fluid redistribution, vestibular function, growth, development and organisation on living systems such as man, animals, plants, cells and tissues.
- To demonstrate the capability to monitor the atmosphere and its effect on environmental quality by surveying the atmosphere for trace constituents, identifying their sources, flow patterns and decay mechanisms.
- To demonstrate the capability to observe and monitor the Earth's surface, in particular to obtain high-resolution, metric-quality images, and to develop spaceborne all-weather remote-sensing methods.
- To observe extended sources of radiation in the visible, ultraviolet, and infrared spectra too faint for Earth-based observations and possibly evaluate the effect of the Shuttle/Spacelab environment on such astronomical studies.
- To demonstrate and use the capability of Spacelab as a technology development and test facility to perform experiments in the space environment in areas such as tribology and heat transfer.
- In the field of communications, to conduct investigations that will provide a basis for the efficient utilisation of orbital spacing and frequency spectrum, including:
  - studies of effects and anomalies of propagation from Earth and space, and
  - measurements of terrestrial RFI sources;
  - to demonstrate the performance and operational capabilities of advanced satellite communications and navigation subsystems.

[1904] ESRO/JPPC(75)9, 20 March 1975.

Table 14-3: List of elements in the European model payload for the first Spacelab mission[1905]

	Estimated cost (MAU)
Atmospheric research and astronomy	
Laser sounder (LIDAR)	4.0
Passive atmospheric sounder	0.8
Astronomy add-on experiment	1.2
Life sciences	
Sled for vestibular studies	1.0
Human performance research support unit Radiobiology unit Plant holding and support unit Cells and tissue research support unit	0.5
Material sciences	
Isothermal furnace 1250°	0.5
Vacuum furnace 1250°	0.25
Gradient furnace 1200°	0.35
Gradient furnace 2000° (O_2 atmosphere)	0.30
Acoustic positioning and stirring equipment	0.30
Electromagnetic positioning facility	0.30
Electromagnetic positioning facility	0.30
Free-flow electrophoresis facility	1.3
Fundamental floating zone experiment	0.4
Material science integrated test facility	0.3
Various material science experiments	1.5
Earth observation	
Microwave scatterometer	1.8
Metric camera	0.4
Technology	
Advanced heat-pipe system	0.3

1905 ESRO/FSLP(75)3, 18 April 1975.

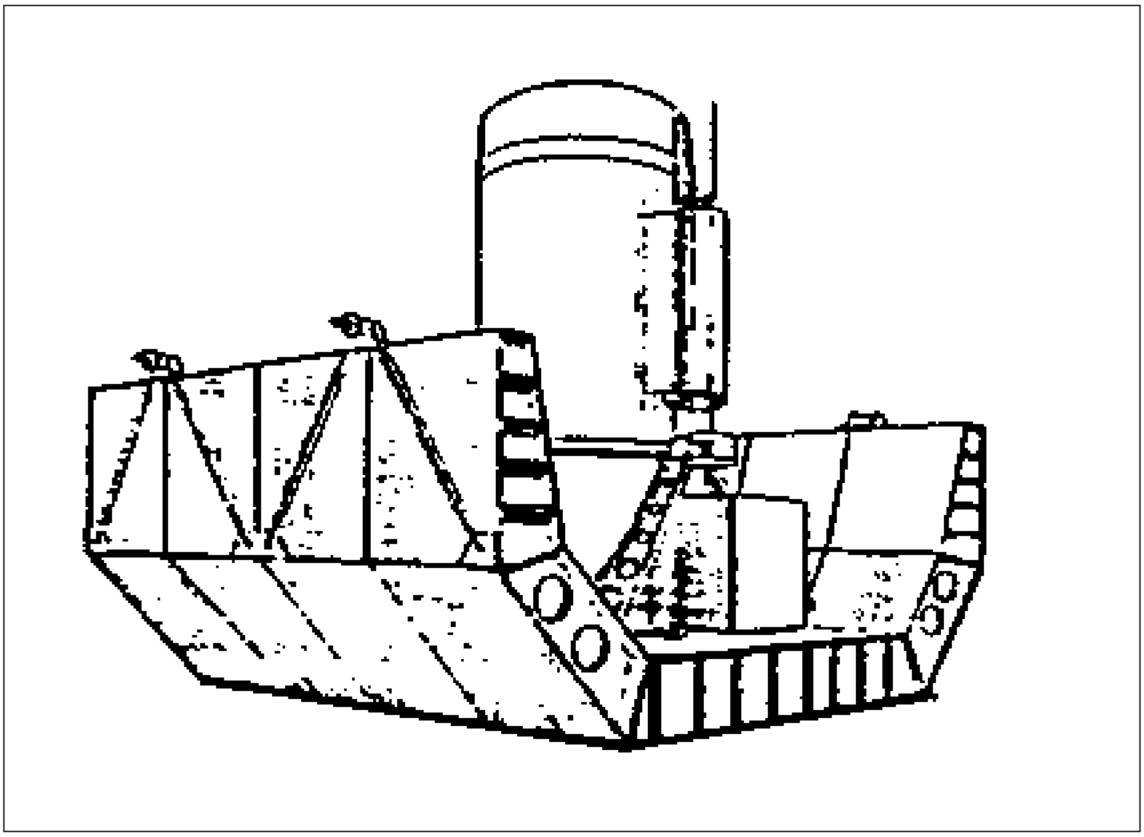

Figure 14-5: The LIDAR Configuration [ESA Annual Report (1977), p. 31]

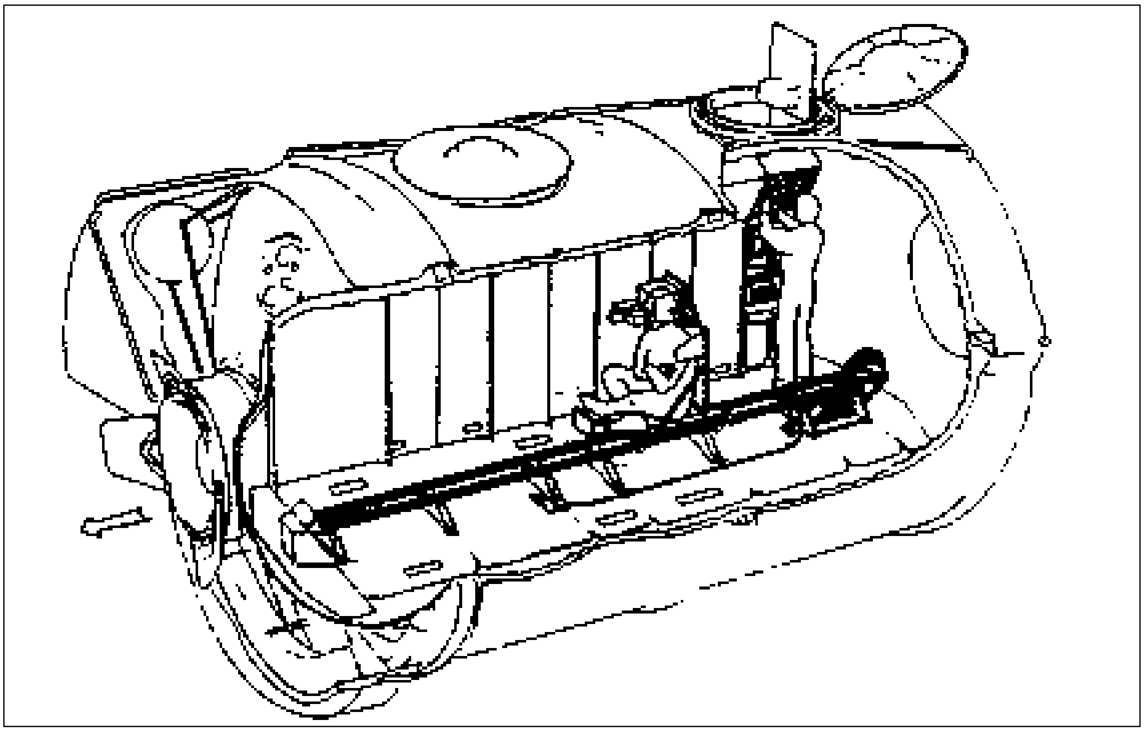

Figure 14-6: The Sled for Vestibular Studies [Steinz (1980), p. 60]

Finally, a significant fraction of the payload resources was allocated to Earth observations by means of a metric camera and a microwave sensor. The LIDAR was by far the most important instrument, requiring about half of the 1500 kg payload available to European experiments and accounting for a quarter of its cost. This was justified by the decision that the mission should be mainly devoted to atmospheric studies, as well as by the interest in testing the LIDAR facility in view of its possible use in the long-term AMPS programme. The main concern about the FSLP, however, was less the choice of its objectives and instrumentation than the question of funding, to which we now turn our attention.

14.3.2 The problem of funding

The legal arrangement between ESRO/ESA and the Member States participating in the Spacelab programme covered the development of the laboratory and the services needed during its first two flights, but it did not cover the experimental payload for the first mission, let alone subsequent ones. In principle, the participating states in the FSLP could be different from those participating in the Spacelab development programme itself. Moreover, the re-usability of Spacelab implied that some instrumentation could be flown on subsequent missions, with different participating states, not to mention the possibility of private or commercially-funded experiments. All this posed legal and institutional problems concerning funding, ownership and user rights which, according to the ESRO Executive, could only be solved by establishing a special (optional) FSLP programme, i.e. a specific arrangement between a group of participating states and ESRO. The Organisation itself could possibly contribute to the financing of the programme out of its general (mandatory) budget.[1906]

When the issue was discussed in the JPPC, in November 1974, the idea of developing the FSLP as a special project was opposed by most smaller member states (Belgium, Denmark, the Netherlands and Switzerland) as well as by the French and Italian delegations. Three main arguments were put forward. Firstly, a further reduction in the importance of the mandatory programme would result in less cohesion among Member States; secondly, participation in a new optional programme required parliamentary approval in some Member States, which would entail greater risk for such a programme than for one which was part of the Organisation's ongoing activities; finally, although developed as an optional programme, Spacelab was conceived as a general facility for the European space effort and its use should become more or less mandatory for all Member States in the 1980s (this was also the case of Ariane, the French insisted). Contrary to this position, the special project concept was supported for different reasons by the other delegations. Sweden did not participate in the Spacelab programme and therefore it could not accept the inclusion of the FSLP in ESRO's mandatory activities. Spain, which did participate in the Spacelab programme, made it clear that it had neither the financial resources nor the scientific interest to contribute to its first mission. The UK warned that the special project principle was "the only way in which Member States would retain the safeguards regarding the maximum payment they make to ESRO in one year". Finally, Germany was the strongest advocate of the special project and stated that its national authorities were in principle willing to finance up to 54% of the FSLP cost, i.e. the same percentage as in the Spacelab programme itself. This offer, the German delegation stressed, "was not a bid for power, but was intended to ensure that the first Spacelab would not fly empty".[1907]

Following this discussion, the Executive worked out, in spring 1975, a funding scheme for the FSLP based on the assumption that the various elements of the model payload described in Table 14-3 could be divided into two categories:

1 General experimental facilities and instrumentation of common interest, e.g.:

- the laser sounder (LIDAR);
- the Sled for vestibular studies;

1906 ESRO/JPPC(74)40, 12 November 1974; also attached to ESRO/PB-SL(74)14, 14 November 1974.

1907 JPPC, 10th meeting (27-28 November 1974), ESRO/JPPC/MIN/10, 15 January 1975, pp. 4-6. For the German position, see also ESRO/PB-SL(74)14, add. 1, 22 November 1974.

- the metric camera;
- the microwave scatterometer;
- the material science equipment;

2 Specific instrumentation of interest only to the group proposing its inclusion and providing the experiment hardware, e.g.:

- passive atmospheric sounding instruments;
- astronomy experiments;
- human performance research support unit;
- cells and tissue research support unit;
- material science experiments;
- technology experiments.

The estimated total cost of the FSLP project was then broken down as in Table 14-4. On this basis, the Executive proposed that the cost of the specific instrumentation should be covered by national funding, the ownership and utilisation rights of each item remaining with the funding institution. As regards the general instrumentation, it suggested that the scientific part (i.e. the LIDAR and Sled) be supported by the Organisation's Scientific Programme while the various items of the non-scientific part should be developed either within the framework of a special project or by individual Member States, and delivered to ESRO/ESA under suitable conditions regarding their utilisation. The Scientific Programme would also cover a part of the management and integration cost proportional to the weight of the scientific part of the payload, thus bringing the share of the FSLP cost to be borne by the scientific budget to 7.4 MAU.[1908]

Table 14-4: Estimated costs of the FSLP in 1975 (MAU)

General instrumentation	11.5
- *pure science*	*5.0*
- *Earth observation*	*2.2*
- *material science*	*4.3*
Specific instrumentation	4.3
- *pure science*	*2.5*
- *material science*	*1.5*
- *technology*	*0.3*
Management and integration	5.8
Total	**21.6**

The Executive's proposal was not endorsed, however, as France and Germany still had diverging opinions regarding the inclusion of part of the FSLP in the mandatory budget. The former, supported by Switzerland and Belgium, insisted that non-scientific elements should also be included in the mandatory budget. The latter, on the contrary, argued that only the astronomy experiments should be supported by the Scientific Programme; that the LIDAR, the Sled and the Earth-observation instruments should be carried out as special projects; and that the material sciences instrumentation (which had an obvious application interest) should remain under national funding.[1909] Pending a

[1908] ESRO/FSLP(75)3, 18 April 1975. Following further consultations with national delegations, this document was rewritten as ESA/FSLP(75)3, 9 September 1975.

[1909] The Executive's proposal was discussed at the 2nd meeting (7 May 1975) of a First Spacelab Payload Working Group set up by the JPPC, ESRO/FSLP/MIN/2, 13 June 1975. The German position is presented in ESRO/FSLP(75)3, add. 1, 6 May 1975.

clarification of the political aspects of the FSLP funding, the Executive turned to the space science community in order to ascertain their reaction to the idea of funding the laser facility and the Sled for vestibular studies out of the Scientific Programme financial envelope. No surprise the reaction was negative.

14.3.3 The scientists' concern

There were two main reasons why the Executive was so anxious to have the principle of funding the two most important FSLP instruments out of the scientific budget approved as soon as possible. Firstly, it was necessary to give a firmer basis to the ESRO/NASA discussions about the European participation in the first Spacelab mission; secondly, the source of funding for the scientific facilities in the FSLP was an important aspect to be clarified in order to prepare the 1976 Scientific Programme budget. There were good arguments, in the Executive's opinion, for funding the LIDAR and Sled out of the scientific budget. The former was already under study as a possible European contribution to the future AMPS missions, and therefore its inclusion in the FSLP was coherent with the Organisation's long-term scientific planning. The LIDAR experiments "must essentially be considered as a purely Scientific Programme", the Executive argued. Moreover, "the LIDAR is the only major scientific facility that could be developed on time by ESRO/ESA for the first Spacelab payload. Besides the Sled for vestibular studies, ESRO/ESA has no alternative plans for the scientific contribution to that payload".[1910] As to the Sled, the newly created Life Sciences Working Group had strongly recommended this device, stressing the importance of vestibular studies for the comprehension of human performance in a zero-gravity environment. It was expected that a large number of life scientists on both sides of the Atlantic would benefit from such a device, designed to be flown on several Spacelab flights.

The LPAC could not accept the Executive's arguments, however. Three main reasons were put forward for its opposition. Firstly, both instruments resulted from an outside initiative, contrary to the established ESRO tradition of experiment proposals emerging from widespread discussions within the European space science community; they were not supported by a consensus publicly expressed by the interested scientists nor had preliminary technical studies yet been completed. Secondly, contrary to the Executive’s argument, the fact that the LIDAR was under study in the framework of the future AMPS programme spoke against any urgency to approve its inclusion in the FSLP. As we have explained in the previous section, the European participation in this programme was only one of five candidate projects for adoption in the future Scientific Programme, and a decision was only expected in autumn 1976, after the completion of the Phase-A studies. An earlier positive recommendation on the inclusion of the LIDAR in the FSLP would give AMPS an undue advantage in the eventual competition. Finally, the LPAC could not accept that such a significant fraction of the management and integration costs should be charged to the scientific budget as they represented costs necessarily incurred in gaining experience in the use of Spacelab. The Committee was very sensitive to the budget issue, both because the programme suffered from the strictly enforced ceiling established at the time of the first package deal, and because the severe financial situation in the ESRO-ESA transition period was having dramatic effects on the development of ongoing projects, the most painful being a delay in the Exosat satellite, which risked jeopardising the very validity of this mission. Why could the funds, which it was proposed should be allocated to the FSLP, not be used instead to prevent such a delay, was the obvious question raised by one of the LPAC members, the Italian physicist G. Pizzella. No answer to this point was reported.[1911]

Notwithstanding these reservations, the LPAC grudgingly expressed the opinion that the LIDAR and the Sled might be valid experiments for inclusion in the FSLP, but it also stressed that this judgement was not based on any kind of competitive assessment and did not imply a positive recommendation on their funding out of the scientific budget. "The LPAC did not have the elements to decide whether they should have priority over other ways in which the Scientific Programme money be spent", the chairman H. van de Hulst reported to the SPB. Here the divergence in opinion between France and

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1910 ESRO/PB-S(75)11, 16 May 1975, p. 2.

1911 LPAC, 59th meeting (23 May 1975), LPAC(75)7, 8 July 1975.

Germany emerged again, the former endorsing the Executive's proposal and the latter opposing it. As a consequence, the Board was unable to take a decision and the question was put off indefinitely, pending a clarification of its scientific and political aspects.[1912]

A few remarks are called for regarding these first debates on the utilisation of Spacelab. Firstly, the lack of provision for the FSLP was becoming critically important in determining the course of events for European users of Spacelab. Like the European satellite launcher developed by ESRO's sister organisation ELDO, Spacelab was conceived as a political object on the negotiating table for European space policy and a technical challenge for European space industry. It was assumed that it would become the main facility for all space activities in the Shuttle era, but a utilisation policy was never really discussed. When it was, the conclusions were not encouraging. On the one hand, scientists involved in traditional space science disciplines did not like it and did not miss the opportunity to stress that manned spaceflight should not jeopardise automatic spacecraft in space research. They were hardly ready to accept that part of the meagre resources of ESA's science programme should be diverted towards Spacelab experiments without very good scientific motivations. On the other hand, the new Spacelab disciplines (e.g. life and material sciences) lacked a strong constituency in the established space science community and could hardly win support for their projects. Finally, regarding applications, the use of Spacelab could only make sense against the perspective of large space stations, a very uncertain future indeed in the mid-1970s. It being there, it can be used, many said, offering proposals for instrumentation and experiments as well; but when the problem of funding came to the fore, governments were very reluctant to invest resources in Spacelab utilisation in addition to their normal contribution to the ESA budget, with the obvious exception of Germany and, in part, France. These two countries, however, had different visions of Spacelab. For Germany, by far the largest contributor to the programme, Spacelab was intended as a facility dedicated mainly to application fields with potential commercial implications, such as manufacturing and processing materials in microgravity conditions. With this perspective, the German authorities wanted to retain as much control as possible in the users' hands, from the very first mission. They announced that Germany was developing the material science equipment for the FSLP and stressed that "the executing country in this case is the holder of the utilisation right and the owner".[1913] France, on the contrary, saw Spacelab and Ariane as the two legs of the European space effort in the 1980s and wanted to bind ESA Member States to mandatory utilisation of both, in scientific as well as application fields. We shall see in the following sections how this ambiguity regarding Spacelab in the context of European space activities, as well as the escalating costs of the programme, would eventually lead to the failure to establish a sizeable Spacelab utilisation effort.

14.4 The definition of the first Spacelab payload

On 15 April 1975, at the last ministerial meeting of the European Space Conference, in Brussels, the Convention of the European Space Agency was finally approved. The new Agency came into *de facto* operation on 31 May, pending the ratification process in its eleven Member States (Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden, Switzerland and United Kingdom).[1914] In the new framework, responsibility for the Spacelab programme remained with the Spacelab Programme Board (SLPB), comprising delegates from all participating states. The organisation of the FSLP project was entrusted by the ESA Council to a Working Group (FSLPWG) including delegates from all Member States, chaired by the Dutch delegate in the SLPB, J. Flinterman. In July 1976, it was renamed the Spacelab Payloads Advisory Group (SPAG), its tasks being enlarged to cover all Spacelab missions. Finally, in March 1979, the SPAG itself was disbanded and its functions were taken over by the SLPB. All aspects related to the scientific part of the payload and any expenditure that might come from the Scientific Programme budget, however, had to be discussed and endorsed by the Science Programme Committee (SPC), the delegate body that had replaced ESRO's

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1912 SPB, 13th meeting (23 May 1975), ESRO/PB-S/MIN/13, 19 June 1975, p. 11.
1913 ESRO/FSLP(75)3, add. 1, 6 May 1975, p. 2.
1914 Ireland, the only state which was not a member of ESRO, joined ESA at the end of 1975. The Convention officially came into force on 30 October 1980.

Scientific Programme Board. The role of the old-standing LPAC was taken over by the new Science Advisory Committee (SAC), whose membership was increased to six in order to include an expert in life sciences.[1915] The definition of the FSLP experiments, together with the selection of future scientific projects discussed above, were the first important decisions to be taken within the new Agency's decision-making structure.

14.4.1 A new proposal for the FSLP project

In February 1976, in view of the ESA/NASA decision on the final payload for the first Spacelab mission, scheduled for the middle of that year, the Executive prepared a new proposal for the FSLP project.[1916] Having discarded the idea of an optional programme for the development of the payload or part of it, the proposal confirmed that the specific experiments should be supported by national funding and suggested the following arrangement for the financing of the general instrumentation and the management and integration activities:

- the development of the LIDAR telescope and the Sled should be funded out of the scientific budget, at an estimated cost of 5 MAU and 1 MAU, respectively;
- the material science equipment should be developed within the framework of the Spacelab programme, after suitable extension of its legal arrangement, at an estimated cost of 5 MAU;
- the remote sensing instrumentation for Earth observation should be supported by the (mandatory) general budget, at an estimated cost of 2.4 MAU;
- the management and integration activities should be performed by a small ESA group, called Spacelab Payload Integration & Coordination in Europe (SPICE), to be located at the German Aerospace Research Establishment (DFVLR) in Porz-Wahn; their cost, estimated at 6.28 MAU, should also be charged to the general budget.

The FSLP Working Group had no objection to the principle that the LIDAR telescope and the Sled should be funded out of the Scientific Programme financial envelope, and invited the SPC to approve it. [1917] The rest of the Executive's proposal was only partially accepted, however, both because most Member States opposed the idea of funding the non-scientific elements of the FSLP on a GNP-based contribution scale, and because Germany wanted to keep control of FSLP hardware development. In the event, the Working Group recommended that, "in order to avoid duplication of investment", the possibility be envisaged of having the remote sensing and material sciences general facilities developed by interested Member States under national funding and made available for common use during the first and subsequent Spacelab missions (in fact both facilities were provided by Germany, as we shall discuss below). The question of the financing of SPICE remained pending, as most delegations thought that the management, integration and operational activities should be funded by the users, but no clear criteria could be identified for how this expenditure could be shared out in such a way. On a provisional basis, it was agreed that SPICE operations should be supported by the Spacelab programme, with the proviso that the latter would be reimbursed after a solution was worked out. The main question, however, remained whether the principle of financing the LIDAR and the Sled from the Scientific Programme budget would be endorsed by the SAC and finally approved by the SPC. It was to these bodies that the Executive now presented its new proposal.[1918]

1915 ESA/C(75)52, 7 November 1975 and ESA/PB-SL(75)8, 26 November 1975, both annex to ESA/FSLP(75)5, 2 December 1975.

1916 ESA/FSLP(76)1, rev. 1, 13 February 1976.

1917 FSLPWG, 1st meeting (18 February 1976), ESA/FSLP/MIN/1, 8 March 1976. The resolution approved at the meeting, from which the following quotation comes, is in Annex II.

1918 ESA/SPC(76)3, 10 February 1976.

14.4.2 The unhappy end of the LIDAR

The two instruments were on a slightly different footing. The Sled, in fact, was much less expensive than the LIDAR and it had been recommended by both the Life Science Working Group and outside experts. A general consensus existed within the European bio-medical community about the validity of the vestibular experiments foreseen on the Sled and of other physiological studies which could be performed using this device. The situation was much more controversial for the LIDAR, as important scientific and political questions were involved in the discussions. The inclusion of a laser facility in the FSLP had in fact been used as a working hypothesis since the very beginning of Spacelab planning and this instrument represented the largest and most sophisticated technical device onboard the first mission, the main scientific objective of which, it should be remembered, was the study of atmospheric phenomena. The LIDAR, as we have discussed, was also designed for use in the framework of the envisaged ESA/NASA cooperation in the AMPS programme; indeed it was a means for European scientists to gain access to such a programme. The AMPS programme, however, had not been included as a "new start" in the NASA budget for fiscal year 1977 and the prospects for US-European cooperation in atmospheric and magnetospheric research with Spacelab instrumentation were now very uncertain. The implication was that the use of the LIDAR after the first (cooperative) mission would only be possible for European scientists on a reimbursable basis. This posed a major problem. The LIDAR was, in fact, a facility-class instrument whose scientific potential could only be fully realised by several Spacelab flights over many years. Its development for inclusion in the FSLP then implied: (a) that the European space science community would be willing to support a long-term programme in atmospheric physics based on laser sounding, to the detriment of other scientific projects and experimental techniques; (b) that national funding would be provided for the supplementary equipment (i.e. lasers and detectors) necessary to operate the LIDAR telescope; (c) that the costs of refurbishing and reflying the LIDAR instruments would be acceptable; and (d) that NASA would hopefully be interested in cooperating with ESA in the future, so that better conditions for the use of the Shuttle/Spacelab system could be obtained. Against this background, neither the SAC nor the SPC could be reassured about the future of the LIDAR after the first Spacelab mission, nor did they have elements for making a scientific case for its use in a single seven-day mission. Nor could they could easily discard it, for the LIDAR took such a large fraction of the resources allocated to European instruments that its exclusion from the FSLP could prevent Europe from maintaining its 50% of the payload capacity.

The SAC was requested to discuss the LIDAR issue at its first meeting, in February 1976 and, like the LPAC nine months earlier, it was very hesitant to state an opinion before the scientific potential of the instrument had been discussed within the community at large, and quantitative information on its performance became available. After "an extensive discussion", the Committee agreed at this stage to endorse the principle of financing the LIDAR out of the scientific budget, but reserved the right to return to this question after the Solar System Working Group had made a scientific assessment of this instrument and the results of Phase-A studies were available. The SAC also recommended that, in addition to the LIDAR experiments, complementary atmospheric physics experiments should be performed on the first Spacelab mission using passive instruments.[1919]

No less embarrassing was the discussion in the SPC two weeks later. Introducing the subject, the ESA Director of Planning and Future Programmes, A. Lebeau, "expressed regret that alternative solutions for the constitution of the first payload could no longer be proposed" and pointed out that, "in view of the uncertainties that subsisted in respect of the scientific merits and the cost of the LIDAR", the decision the SPC was invited to take was "merely one of principle", a formal decision being requested only after the completion of Phase-A studies. Lacking alternatives, most delegations were prepared to endorse the Executive's proposal, but all expressed reservations about the unusual procedure, and concern about the impact of the LIDAR financing on the future development of the Scientific Programme. The Dutch delegation, of which H. van de Hulst was an influential member, noted that

[1919] SAC, 1st meeting (24 February 1976), SAC(76)4, 7 April 1976. The final resolution is reported in SAC(76)5, 3 March 1976.

there was "no evidence supporting the [Executive's] statement that the LIDAR met with great scientific interest on the part of several delegations" and then brought up the sore point:

> *On the subject of scientific instrumentation for Spacelab generally, the delegation felt that more should be done to honour the earlier claim of rapid access with cheap experiments. It asked in what time a 'general facility' would become obsolete and how this time compared with a satellite life time.*[1920]

In the event, the SPC agreed that financing of the FSLP LIDAR out of the scientific budget was "not precluded", but it requested the Executive to issue a preliminary call for experiment proposals on the FSLP in order to have better information about the interest and intentions of the European space science community.[1921]

In the following months, the LIDAR could no longer escape from a thorough scientific assessment. The Solar System Working Group discussed the matter at length at its 27 April meeting, in which all SAC members participated (with the exception of the biology expert H.S. Wolff) together with three invited experts. In its final resolution, the SSWG recognised that "valuable new scientific results could be obtained through the use of the LIDAR on the first Spacelab flight and that the long-term potential of the observations justified the interest in this facility". Two important qualifications were added, however. Firstly, that the inclusion of the LIDAR in the FSLP should not prevent the inclusion of passive instruments for complementary atmospheric experiments. Secondly, that "future development and re-flight of the LIDAR [should] be considered in the same way as other competitive projects".[1922]

The SSWG recommendation was endorsed the following day by the SAC, but the discomfort of its members was again quite evident. The claim that valuable new scientific results could be obtained from the use of the LIDAR on the first Spacelab mission was explicitly contested by some members, and doubts were expressed regarding its scientific capability compared with other techniques. Moreover, it was pointed out that very little information existed about the costs to be borne by experimenters for building the lasers and detectors and for eventual re-flights of the instrument. The conclusion is a wonderful example of ambiguity, wishful thinking and powerlessness: contrary to the SSWG's opinion, the SAC stated that the first flight of the LIDAR would not yield a high scientific return but accepted that it be supported by the scientific budget in consideration of the possibility that the "ratio of scientific output to 'scientific' costs would increase in future flights". In fact, no one knew whether future flights would ever occur or who would pay for them.[1923]

By early July, when the SSWG and the SAC were called to issue their final recommendation to the SPC, the situation had changed dramatically, as three new elements had come to the fore. Firstly, the development cost of the LIDAR was now estimated at 8.4 MAU, i.e. much higher than previous estimates. Were it adopted in the Scientific Programme, then no additional activities could begin in 1977 and very few in 1978. Moreover, lacking definite information from NASA about the charging policy for the use of the Shuttle/Spacelab system, the cost of later flights was still unpredictable and only a tentative 1.4 to 2.7 MAU range was given by the Executive.[1924] Secondly, the response to the preliminary call for experiment proposals for the FSLP showed that the LIDAR hardly met with great scientific interest on the part of the European space science community. Only fifteen proposals out of 74 concerned the LIDAR, some of them related not to atmospheric research but rather to geodetic and oceanographic measurements. Moreover, of all the experiments proposed in atmospheric physics, two thirds required passive techniques rather than active laser sounding.[1925] Finally, the scientific case for

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1920 SPC, 3rd meeting (11 March 1976), ESA/SPC/MIN/3, 13 April 1976, p. 6 and add. 2, 18 June 1976.
1921 ESA/SPC/III/Res. 1, 9 April 1976, attached to ESA/SPC/MIN/3, *cit.*
1922 SSWG, 18th meeting (27-28 April 1976), SOL(76)8, 2 July 1976. The final resolution is reported in SOL(76)7, 29 April 1976.
1923 SAC, 2nd meeting (28 April 1976), SAC(76)8, 4 June 1976, p. 6.
1924 ESA/SPC(76)17, add. 1, 16 July 1976.
1925 ESA/SPC(76)16, 13 May 1976.

the LIDAR had been discussed *vis-à-vis* other research fields and experimental techniques at a scientific symposium, and it was clear that the majority of European space scientists did not like such a large fraction of the FSLP resources being taken by the LIDAR. On the basis of this new information, the political importance of the LIDAR (i.e. the fact that it had been studied from the very beginning of the Spacelab programme and it was the main European instrument on the first Spacelab mission) could no longer counterbalance its poor scientific merit. The SSWG reversed its April decision, stating that "the scientific return [from the FSLP] would be greater from a passive sounding package than from the LIDAR".[1926] Within the SAC, only G. Colombo kept supporting the LIDAR, and even though a formal recommendation was not voted the Chairman's final statement was unequivocal:

> *In previous meetings, the SAC had assessed the LIDAR outside of a competitive framework. The Committee now had more information about the other opportunities that could be provided on Spacelab and [...] about the kind of science that could be done on the FSLP. From this [...] the LIDAR seemed to have a more negative position than it had at the last meeting when the SAC had recommended the funding of the LIDAR for the FSLP from the mandatory Scientific Programme budget.*[1927]

The final decision was up to the Science Programme Committee. Here, the Italian delegation was particularly resolute in defending the LIDAR, "which represented Italy's only possibility of being present on the first Spacelab payload". It warned that the Italian parliament might not ratify the ESA Convention if the country was excluded from a programme to which Italy was contributing 18% of the budget (Italy's contribution to the Spacelab budget according to the 1973 "package deal"). The delegation insisted that, besides atmospheric research, "the LIDAR would have great potential for many disciplines such as oceanography, geography and geodesy", and argued that "with a reasonable design it would be possible to include both the LIDAR and the sounding passive experiments".[1928] These argument did not convince the other delegations, however, and the Italian "ultimatum" position remained isolated. The French delegation supported the inclusion of the LIDAR in the FSLP, but in a much less sanguine way than the Italians, as it acknowledged that the scientific value of this facility could only be guaranteed over a ten-year period of flights. A similar position was held by Germany, which was less concerned about the inclusion of the LIDAR in the FSLP than in keeping this facility under study in view of its eventual use in the long-term Spacelab flight programme. The British scientific community, on the contrary, was convinced that passive sounding experiments, possibly mounted on a stabilised platform, would provide more interesting results than active laser sounding for atmospheric studies.[1929] Finally, the smaller Member States did not have strong feelings for or against the LIDAR, but all expressed a concern that its funding out of the scientific budget could impair the other projects under study. In the event, by a controversial majority vote, the SPC decided against the inclusion of the LIDAR in the FSLP, but agreed that a Phase-B study should be carried out in view of the possibility of it being flown on a subsequent flight.[1930]

1926 SSWG, 19th meeting (1 July 1976), SOL(76)14, 15 September 1976, p. 3.

1927 SAC, 3rd meeting (2 July 1976), SAC(76)11, p. 6. For Colombo's dissenting opinion about the SAC policy, see chapter 3.

1928 SPC, 5th meeting (30 July 1976), ESA/SPC/MIN/5, 30 August 1976, p. 8.

1929 ESA/SPC(76)31, 22 July 1976. A study on an integrated set of various passive instruments for atmospheric research in the FSLP was being performed under ESA contract by the Science Research Council at its Appleton Laboratory, Slough.

1930 Belgium, Denmark, Spain, Sweden, Switzerland and the UK voted against the LIDAR in the FSLP. Denmark, France, Germany, Italy, Sweden, Switzerland and the UK voted for a feasibility study. It should be mentioned that the SPC recommended a Phase-A study on a simple stabilised platform for passive sounding experiments, as advocated by the British delegation. When completed, the study showed that this coarse pointing system would be much more expensive (about 8 MAU) than expected, the time schedule for its development would be extremely tight, and not many of the proposed experiments would really need it (ESA/SPC(76), 6 December 1976). On this basis, the SSWG and the SAC did not recommend its inclusion in the FSLP and the SPC eventually cancelled it.

Following this decision, a LIDAR Facility Team was set up by ESA to review the Phase-A study from two standpoints: (a) the re-assessment of the LIDAR facility for atmospheric studies in the light of new technical developments, and (b) the possible use of this facility in other disciplines, such as geodesy, geodynamics and oceanography.[1931] On the basis of the Team's conclusions, a Phase-B study started with MATRA in June 1978 and was completed one year later. Two different missions were considered, with development costs estimated at approximately 18.4 MAU, not including the procurement of the laser devices.[1932] The results of the study were given to the newly created Earth-Oriented Research Group to consider possible applications in the framework of the ESA Earth Observation Programme. In the event, the programme concentrated on the envisaged ERS satellite project, and the LIDAR disappeared.

14.4.3 The controversial approval of the Sled

The approval of the Sled for vestibular studies on the FSLP did not present as many problems as the LIDAR. The cost was not very high and the facility enjoyed strong support from the interested scientific community. The main problem was the question of the eventual inclusion of life sciences in ESA's Scientific Programme, which put further strain on the programme's budget. Pending a revision of the whole budgetary question, the SAC recommended that the Sled be flown on the FSLP in the framework of the Scientific Programme. The final SPC decision was more controversial, however, both because the estimated development cost of the Sled had increased to 1.8 MAU and for the stress the LIDAR question had caused among SPC delegations. In fact, only five delegations voted in favour (France, Germany, Netherlands, Sweden and Switzerland), the others abstaining.[1933]

After the LIDAR had definitively been discarded, the 150 kg Sled (Figure 14-6) remained the only experimental facility on the FSLP supported by the Scientific Programme budget. The design and development programme was initiated with the German company ERNO in September 1977. At the end of the design phase, however, it became evident that the programme could not be realised within the original constraints of cost, mass and schedule. To the dismay of the Executive, in October 1978 ERNO submitted a revised proposal for the development of the Sled, from which emerged:

- a cost increase of nearly 300% compared to the baseline price (5.8 MAU at 1977 price level);
- a design exceeding by about 35 kg the mass allocated to the Sled on the FSLP;
- a delivery date showing an incompatibility of 6 months with the FSLP schedule;
- reservations on compliance with the FSLP interface requirements which might result in a further cost increase.[1934]

A rather nervous discussion followed in the SPC, in which "several delegations expressed disquiet at the general cost increases in the Spacelab experiments, which augured badly for future Spacelab utilisation".[1935] ERNO was then instructed to stop work on the contract and a meeting was called between the Executive, the Sled Science Team and some members of the Life Sciences Working Group in order to investigate ways and means of salvaging the project. As a result, a significant

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1931 ESA/SPC(78)3, 12 April 1978.

1932 SPC, 21st meeting, ESA/SPC/MIN/21, 25 October 1979, p. 8.

1933 SPC, 5th meeting (30 July 1976), ESA/SPC/MIN/5, 30 August 1976. A favourable recommendation was expressed by the SAC at its first meeting (24 February 1976), SAC(76)5, 3 March 1976, and confirmed at the following two meetings. The new estimated cost of the Sled is in ESA/SPC(76)17, add. 1, 16 July 1976.

1934 ESA/SPC(78)33, 8 November 1978.

1935 SPC, 17th meeting (14 November 1978), ESA/SPC/MIN/17, 5 December 1978, p. 7; ESA/SPC(79)3, 22 January 1979. The French delegation noted that the French experiments on the FSLP were experiencing overruns of 200 and 300%. See also Steinz (1980).

relaxation of the initial specifications was agreed and a new Sled concept proposed which could be developed in-house, at a lower cost and within a tight schedule. The increase in the estimated cost-to-completion was relatively limited in absolute terms, additional resources being requested to the amount of 2.7 MAU.

The SAC endorsed the new plan, as it considered that cancellation of the Sled would endanger the future of European biomedical research in space, a field which would presumably benefit most from the use of Spacelab in the future. The Committee refrained from discussing the budgetary implications of the continuation of the Sled programme as this was a political matter for the SPC, but it stated clearly that "the scientists should not be penalised for cost increases for which they were not responsible and therefore new funds had to be provided by Member States in order to keep the Sled programme alive".[1936] When the matter came to be discussed in the SPC, however, most delegations were firmly opposed to any increase in the Sled budget. The SPC then reserved the right to take a decision only after the Executive had investigated the possibility of cancelling the Sled and carrying out alternative biomedical experiments on the FSLP with the money still available in the Sled budget. Pending a final decision among the various options – agree to the Sled budget increase, use the available resources to carry out some biology experiments without the Sled, or eliminate the life sciences activities altogether and divert the remaining funds to other programmes – it was made clear "that the possibilities of obtaining the additional 2.7 MAU for the Sled were extremely slight".[1937]

In this situation, the European life science community took a strong line in order to salvage its first chance to enter space research. The Sled Science Team stated that "the cancellation of Sled would be viewed as a major disaster by the life science community, both in scientific and political terms". The LSWG, for its part, argued that "the abandonment of Sled [...] would be regarded as a breach of faith by ESA, which by offering experiment opportunities on Sled had caused teams in a number of member countries to expend considerable time, laboratory resources and money on the construction of experiments which are heavily dependent on Sled".[1938] In a letter to the ESA Director General, the principal investigator of the Sled Vestibular Experiment, the German physiologist R. von Baumgarten, recalled that ESA had made firm statements to the European scientists and to NASA that the Sled would be built: "Relying on this, the European and American experimenters devoted several years of highly qualified manpower to the preparation of the Sled experiments and spent millions in the belief that ESA would make this facility available".[1939] NASA also added its arguments in a letter from the director of its life science programmes, G.A. Soffen, to the chairman of the LSWG: "NASA and our scientific advisors consider vestibular experimentation as number one in priority for both scientific and operational reasons", Soffen wrote, "thus we feel strongly that ESA should continue to honor their commitment to develop the Sled facility for [the first Spacelab mission]". He went on to remind the European space policymakers of the commitments the US and Canada had made to the Sled programme after the NASA Administrator and the ESA Director General had formally agreed that the first Spacelab mission would include in-flight vestibular experiments with a Sled facility provided by ESA: one million dollars already expended on experiment hardware development, including three ground-based Sled simulators; two years of dedicated work from qualified technical manpower; and a long-term research programme on the space-motion-sickness problem, for which the Sled experiments on the first Spacelab flight represented the first step.[1940] Finally, the SAC advised that "failure to grant the 2.7 MAU would cause an amount of damage quite disproportionate to the sum involved", but warned that a decision to continue the Sled within the established financial envelope for the Scientific Programme "will reflect itself in a reduction of science plans in other areas".[1941]

1936 SAC, 16th meeting (22-23 January 1979), SAC(79)4, 9 March 1979, p. 9.

1937 SPC, 18th meeting (23-24 January 1979), ESA/SPC/MIN/18, 22 February 1979, p. 9.

1938 The quotations are, respectively, from LIFE(79)5, 21 February 1979 and LIFE(79)4, 21 February 1979, both attached to ESA/SPC(79)8, 28 February 1979.

1939 ESA/SPC(79)8, add. 1, 19 March 1979, annex 1.

1940 ESA/SPC(79)8, add. 1, 19 March 1979, annex 2.

1941 SAC, 17th meeting (16 March 1979), SAC(79)10, 3 May 1979, annex 1. Also in ESA/SPC(79)8, add. 2.

The pressure on the SPC to approve the new Sled plan was strong indeed, and the meeting at which the decision was to be taken was attended by the chairmen of the SAC and the LSWG, and by the NASA representative in Europe. Most delegations felt a moral obligation towards the scientists involved in the Sled experiments, but all were adamantly against any increase in the Scientific Programme budget. Approving the higher cost of Sled within the limits of the financial envelope of the Scientific Programme, however, implied coping with an important over-run in the 1980 budget (about 7% of the total budget), with the risk of jeopardising other parts of the Scientific Programme. The plain truth was that the inclusion of life sciences in the Scientific Programme would either be at the expense of classical disciplines, which the established space science community could hardly accept, or implied an increase in the mandatory budget, which member state governments were not willing at all to comply with. In the event, the moral obligations prevailed and the addition of 2.7 MAU to the Sled budget was finally approved, with Germany, Italy and the United Kingdom voting against.[1942] However, this was not the end of the Sled story, as we shall see in a moment.

14.4.4 The final definition of the FSLP ... and the Sled slips out

Besides the Sled, the most important facility in the FSLP was a 500 kg double rack for material science instrumentation, including several types of heating furnaces, a fluid physics module and other equipment for about 40 space-processing experiments. Following its proposal for the FSLP project, the Executive argued that these instruments should be considered as "the first elements of a material science equipment pool, which could be extended for later missions", and suggested that the Agency be responsible for the management, development and integration of the material science package, or at least of its major part.[1943] This approach, however, was not accepted by Germany, which was developing a strong effort in the material science field (an all-German Spacelab mission dedicated to material science experiments was already being prepared) and wanted to maintain direct control over this part of the payload.[1944] Germany offered to develop, integrate and test the whole of the material science package, and to deliver it to ESA for inclusion in the FSLP, with the proviso that it remained the property of the Bundesministerium für Forschung und Technologie and the latter retained the right of disposal for the package itself for later missions. This solution was eventually approved by the FSLP Working Group, but the problem remained of defining suitable rules for the use by individual experimenters of these and other instruments provided by national agencies.[1945]

This was the object of long and complex discussions, the main actors being the Executive and the German delegation in the SPAG.[1946] The former wanted to establish a general legal framework governing access to and use of a European instrument pool for the first and subsequent Spacelab missions; in other words, it considered the FSLP as a basis for a medium-term policy for Spacelab utilisation under the aegis of ESA. Germany, on the contrary, insisted that the instruments intended for the first flight should remain the property of the countries that had supported their development, and that the arrangement for the FSLP should not set a precedent for any future policy for Spacelab use; in other words it considered that the Shuttle-borne laboratory would mainly be used by national agencies or industrial companies for commercially valuable experimental activity. In the event, the German view prevailed. Following a meeting between the Executive and the German delegation, the latter drafted its own text on the rules concerning the general instrumentation on the first Spacelab mission

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1942 SPC, 19th meeting (22-23 March 1979, ESA/SPC/MIN/19, 26 April 1979.

1943 ESA/FSLP(76)5, 16 March 1976, p. 1; ESA/FSLP(76)7, 16 March 1976.

1944 FSLPWG, 2nd meeting (31 March 1976), ESA/FSLP/MIN/2, 4 May 1976.

1945 ESA/FSLP(76)10, 11 June 1976; FSLPWG, 3rd meeting (24 June 1976), ESA/FSLP/MIN/3, 3 August 1976. It was foreseen that Germany would integrate into the material science double rack two gradient furnaces procured from France and the fluid physics module procured from Italy.

1946 The evolution of these discussions is reported in the series of documents ESA/SPAG(76)8, 24 August 1976, with revisions 1 to 5. The rules under discussion regarded in general all Spacelab instrumentation, but in fact the main questions were related to the material science package.

and insisted that this be taken as a basis for discussion instead of the text proposed by the Executive. It was eventually approved by the SPAG in January 1977.[1947]

At the same meeting, the SPAG approved the final composition of the FSLP, which was eventually endorsed two weeks later by the ESA Council.[1948] Besides the Sled for vestibular studies and the material science double rack, it included a 155 kg metric camera and a 166 kg microwave sensor for Earth observations, both provided by the German Aerospace Research Establishment (DFVLR), and about twenty nationally funded experiments in astronomy and solar physics, atmospheric and plasma physics, and life sciences. The most important instruments were a 137 kg grille spectrometer for atmospheric research, jointly provided by the Institut d'Aéronomie Spatiale de Belgique and the French Office National d'Etudes at de Recherches Aéronautiques (ONERA), and a 100 kg very-wide-field camera for astronomy observations provided by the Laboratoire d'Astronomie Spatiale in Marseille, France. All of these facilities and experiments were complemented by approximately equivalent NASA equipment, whose main elements were two large instruments for active plasma-physics experiments (including a 400 kg electron gun provided by the University of Tokyo), a complex spectrometer for atmospheric studies and a *minilab* for life science experiments.[1949]

The Sled had remained the only FSLP hardware supported by ESA. This facility, however, did not survive the dramatic crisis originated by the stricter weight constraints imposed by NASA at the beginning of 1980. On 14 January that year the ESA Director General received a formal request from the NASA Administrator to reduce the European portion of the FSLP to the original mass allocation of 1392 kg, along with a parallel effort by NASA. "Our current assessment of the Shuttle performance indicates that we must continue to assume that the original payload allocations will not be increased", the head of the American space agency wrote, "consequently, we must jointly agree to take the necessary steps to assure that the ESA and NASA complement of investigations do not exceed the original commitments when they are delivered for [final] integration".[1950] He added that NASA would guarantee a free flight on subsequent missions with equivalent characteristics of the instruments that had to be removed from the FSLP because of the imposed weight constraints.

The mass estimate for the European portion of the FSLP exceeded the prescribed allocation by 122 kg but, considering a requested mass margin to cover the later payload increase, the necessary mass saving amounted to about 220 kg.[1951] The Executive then elaborated a set of criteria and procedures for "descoping" the FSLP by removing experiments and/or facilities from the payload. Four options were identified, each of which foresaw the removal of one or two heavy experiments:

1 the metric camera plus the very wide field camera (VWFC);

2 the Sled and its experiments;

3 the microwave remote sensing experiment plus the VWFC;

4 the grille spectrometer plus the VWFC.

[1947] SPAG, 3rd meeting (11 January 1976), ESA/SPAG/MIN/3, 8 February 1977. The German text is ESA/SPAG(76)8, rev. 4, 3 January 1977; the Executive's is ESA/SPAG(76)8, rev. 3, 29 November 1976. The final text, essentially identical to the German one, is ESA/SPAG(76)8, rev. 5, 14 February 1977.

[1948] Council, 14th meeting (28 January 1977), ESA/C/MIN/14, 17 February 1977. The complete payload as approved at this stage is described in ESA/SPAG(76)22, 28 December 1976, complemented by the guidelines given by the SPAG in ESA/SPAG(77)2, 12 January 1977. Both of these documents were submitted to the Council under the cover ESA/C(77)8, 12 January 1977.

[1949] *Shapland & Rycroft (1984)*, pp. 181-187, and *Lord (1986),* pp. 347-349.

[1950] ESA/SAC(80)6, 31 January 1980, annex.

[1951] ESA/SAC(80)6, 31 January 1980.

In all cases, the descoped experiments would be flown on subsequent Spacelab missions planned by NASA, over a period of time ranging from 11 months for the grille spectrometer to 29 months for the Sled.

On the basis of its analysis of the scientific aspects of the various options, and taking into account the NASA position, the Executive recommended that option 4 be selected, namely the transfer of the grille spectrometer and the VWFC to later flights.[1952] The main reasons for this recommendation can be grouped into three main categories:

a Both the metric camera or the microwave experiment (options 1 and 3) were general facilities with a pioneering character in the new field of Earth-oriented research; a wide interest in this kind of investigation had been demonstrated by the response to the call for experiment proposals, 103 of which had been accepted for the metric camera and 45 for the microwave experiment; finally, both instruments were being developed by DFVLR, by far the main player in all Spacelab matters.

b The Sled (option 2) could not be accommodated on the first NASA mission devoted to life sciences (SL-4) for technical reasons, and therefore it could only be flown on the subsequent life science mission (SL-10), with a launch delay of about 2.5 years. Such a long postponement was unacceptable for the experimenters' team; NASA attached highest priority to the Sled, due both to the importance of vestibular studies for the man-in-space programme and because half of the Sled experiments were from US and Canadian scientists, and it insisted that this facility should remain in the FSLP.

c NASA had offered the earliest possible flight opportunity (SL-3) for the grille spectrometer, less than one year after the first mission, with a technical arrangement which promised a probably larger scientific return; two flight opportunities were offered for the VWFC, on SL-4 or SL-5, which implied a relatively short launch delay (16 to 18 months) and an undiminished scientific return.

The Executive's position aimed at keeping all of the major experimental facilities in the FSLP, in particular the one supported by ESA. It was hardly a surprise, when the matter came to be discussed in the SPC, that the French and Belgian delegations (the latter being represented by the principal investigator of the grille spectrometer, M. Ackerman) "protested very strongly" against the Executive's proposal and invited the Committee to reject it. "By descoping [the grille spectrometer experiment] one of the main scientific objectives of FSLP would be deleted", the Belgian delegation argued, stating that if this instrument were to be accommodated on the SL-3 mission, "it would lose much of its value since it would be flown together with a similar United States experiment". The French warned that "if either the grille spectrometer or the very wide focal [sic] camera were to be descoped, France would probably have to abandon those experiments completely".[1953]

Notwithstanding these positions, the SPC finally decided (with France and Belgium voting against, and Switzerland abstaining) to recommend that the Spacelab Programme Board accept to retain the Sled on the FSLP and to transfer the grille spectrometer and the VWFC to later flights. The Board did not concur, however. In a very strong written statement circulated at the meeting, the French delegation warned that the consequences of holding back the two major French and Belgian experiments "are not of a minor nature":

It would be an illusion to imagine that such a measure specifically affecting those investigators who have most directly invested in the scientific use of Spacelab and mutilating the results expected from

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1952 ESA/PB-SL(80)4., 25 February 1980. The Executive's proposal was endorsed by the majority of the SAC members, after consultations during a teleconference on 28 February 1980: cf. ESA/SPC(80)8, 26 February 1980 and ESA/PB-SL(80)4, add. 1, 3 March 1980.

1953 SPC, 23rd meeting (4-5 March 1980), ESA/SPC/MIN/23, 3 April 1980, pp. 10-11.

half the human and financial investment by the French scientific community, should be without impact on the subsequent participation that may be expected from the same community. The catastrophic situation that would be brought about for France by the adoption of option 4 proposed by the Executive could not be without consequence to its future use of Spacelab under the auspices of the European Space Agency.[1954]

After a nervous discussion and two divisive votes, the Board finally decided to remove the Sled from the FSLP, four delegations voting in favour (Belgium, Denmark, France and Netherlands), two against (Germany and UK) and four abstaining (Austria, Italy, Spain and Switzerland).[1955] ESA's Scientific Programme was thus definitely excluded from the first Spacelab mission and no ESA experimental facility was on board the laboratory on its maiden flight. In a sense, the Sled was sacrificed just because, being an ESA facility, Member States would not be as embarrassed by its removal from the payload as in the case of national facilities or experiments. It was an essentially political decision which caused much frustration among the many life scientists from ten scientific institutes and universities in France, Germany, Canada and the United States who were preparing the vestibular experiments to be performed with the Sled. Their hopes now rested on the possibility of having a new flight opportunity as early as possible.

14.5 A later mission for the Sled

Following the SLPB decision, NASA offered to include the Sled on its dedicated life science mission SL-4 (scheduled for May 1984) and to take over all responsibility for the experiments as well, including integration activities; Germany, for its part, insisted that the Sled be accommodated on the German D-1 mission (scheduled for August 1984), in order to maintain the European character of this facility. The NASA option was less expensive by far, the two options requiring additional expenditure of 1 MAU and 3.6 MAU for the American and German solutions, respectively, but, as the Executive put it, "accepting that all integration activities of European experiments and coordination with European experimenters be done in the US would mean, in practice, abandoning all future Sled use for European purposes and make the European development of the Sled meaningless".[1956] The scientists in the Sled Science Team and the Life Science Working Group, on the contrary, recommended that the American offer should be accepted, both for the shorter delay in the flight schedule and because SL-4 was a dedicated life science mission, while D-1 would mainly be devoted to material science experiments. Opinions were much divided among national delegations in the SLPB: Austria, Belgium, Italy and the UK favoured the SL-4 option; Denmark, Germany and Spain expressed their preference for the D-1 mission; France advocated SL-4, but felt that the German proposal should not ruled out and hoped that, "the Programme Board would, in a spirit of solidarity, decide that Sled should fly on D-1 if this were at all possible".[1957]

In the event, it was agreed that a decision should be unanimously taken by the participants in the FSLP project in December 1980. The choice implied political as well as scientific and financial considerations. On the one hand, by offering to fly the Sled free of charge on the next available flight, NASA considered that it had fulfilled its obligations after the off-loading from the first mission, and it refrained from making any explicit statement about the possibility of a free flight for the Sled on a subsequent NASA mission in case ESA decided to fly this device on D-1. The German offer, on the other hand, was very generous as it foresaw that all flight and mission costs, including payload integration, transportation to the US and back, launch and payload operations, would be borne by Germany in order to keep the ESA costs as low as possible. The German authorities underlined the

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1954 ESA/PB-SL(80)4, add. 3, 11 March 1980, p. 3.

1955 SLPB, 30th meeting, part I (12 March 1980), ESA/PB-SL/MIN/30/I, 26 March 1980.

1956 ESA/PB-SL(80)28, 1 September 1980, p. 2.

1957 PBSL, 32nd meeting (17-18 September 1980), ESA/PB-SL/MIN/32, 23 October 1980, p. 10. The possibility was also contemplated of flying the Sled on both SL-4 and D-1, but it had to be discarded because only one flight unit was available and the scheduled time separation between the two mission was not sufficient for refurbishment.

"European" character of the D-1 mission, in fact the only foreseeable European mission after the failure to reach an agreement on a cooperative Spacelab utilisation programme (as discussed in the following section). The D-1 payload would include the material science equipment developed for the FSLP (with facilities provided by France and Italy), and scientists from other European countries were invited to participate in the experimental activities. Moreover, Germany had offered a flight opportunity on D-1 for the envisaged ESA-developed Biorack facility for life science experiments.[1958]

At the December meeting of the SLPB, unanimous agreement could not be reached, despite the impassioned arguments put forward by the German delegation in favour of "the first truly European Spacelab flight". Austria, Belgium, Italy and UK persisted in supporting SL-4, which was also preferred by the Netherlands. Denmark, France, Germany, Spain and Switzerland, on the other hand, advocated D-1. As a consequence, the matter had to be deferred to the Council meeting scheduled for a few days later.[1959] Here the stalemate was finally overcome in a spirit of European solidarity. The German and French pressure for an important European use of Spacelab prevailed over the economic and scientific arguments of the two other major Member States (Italy and the UK) and of the interested scientific community. In fact, after receiving formal assurance that 3.6 MAU was a realistic estimate for flying the Sled on D-1, all delegations declared their willingness to join in a unanimous vote in favour of this solution.[1960] With hindsight, it was a good decision from the scientists' viewpoint also. In fact, NASA's first life science mission had to be postponed and, at the time of the launch of the first Spacelab mission, it was scheduled for January 1986, i.e. two months after D-1. Owing to the Challenger accident, it was eventually launched on 5 June 1991, almost six years after the Sled had successfully flown on the German Spacelab mission.[1961]

14.6 The Spacelab Utilisation Programme and the funding of the FSLP

When the first Spacelab mission was finally launched, on 28 November 1983, it was already evident that no dedicated ESA missions would be flown in the foreseeable future. The German D-1 mission, scheduled for autumn 1985, was at that time the only firm flight opportunity for ESA-developed instruments, i.e. the Sled and the Biorack, a multi-user facility for studying the effects of microgravity and cosmic radiation on living organisms developed within the newly established ESA Microgravity Programme. For the longer term, a reflight of the Biorack facility was foreseen on the joint ESA/NASA International Microgravity Laboratory (IML-1), in May 1987. As we shall see in this section, all initiatives by the ESA Executive to define long-term plans for Spacelab utilisation were frustrated by the concurrence of two main difficulties. Firstly, as was to be expected, there was the problem of funding. NASA's charging policy for the use of the Spacelab/Shuttle system did not in fact consider any preferential treatment for European missions and therefore, facing the escalating costs of the Spacelab programme, Member State governments became more and more reluctant to commit further resources for Spacelab utilisation. Secondly, there was the relationship between the envisaged ESA Spacelab utilisation programme and the very important German activity in this field. Germany, in fact, wished to benefit as much as possible from the project in which it had invested so much, and wanted to keep control over European Spacelab missions whether they carried the ESA flag or that of the German Federal Republic. It is against this background that we will briefly discuss the origin and early development of the Spacelab Utilisation Programme (SLUP), an optional programme financed by most ESA Member States, in whose framework the FSLP itself was also accommodated.

The question of Spacelab utilisation had two different aspects. On the one hand, there was the still pending problem of the support to the management and integration activities for the FSLP performed by SPICE; on the other, it was necessary to outline long-term plans for the European utilisation of Spacelab after the first mission, and to define the role of ESA accordingly. In the Executive's view, these two facets were strictly intertwined. In fact, the degree of financial support to SPICE,

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1958 ESA/PB-SL(80)43, 25 November 1980, with add. 1, 8 December 1980, and add. 2, 9 December 1980.

1959 SLPB, 33rd meeting (10 December 1980), ESA/PB-SL/MIN/33, 20 January 1981, p. 9.

1960 Council, 45th meeting (14-15 December 1980), ESA/C/MIN/45, 27 January 1981, pp. 10-12.

1961 *Wedde-Mühlhausen et al. (1987).*

particularly regarding the investments in technical equipment and infrastructure, critically depended both on the level of FSLP integration to be performed in Europe and on the envisaged role of ESA/SPICE in the framework of future European Spacelab missions.

In early 1977, the Executive worked out a proposal for the FSLP in which three main options were suggested as regards the integration activities in Europe.[1962] Option A foresaw a minimum level of European effort (pre-Level IV integration): SPICE activities would be limited to support instrument development, then the instruments would be sent to NASA for all four levels of integration, with the exception of the material science double rack which would be pre-integrated in Europe in all three alternatives. In option B, most of the European part of the payload would be physically pre-integrated and functionally tested at a central establishment in Europe (possibly SPICE) endowed with the necessary ground support equipment (Level IV integration). The complete package could be dispatched either to NASA's Marshall Space Flight Center (option B1) for completing Level IV integration or directly to the launch site at Kennedy Space Center (option B2). Finally, option C foresaw a maximum level of integration and testing in Europe, including pre-Level III activities with a complete set of ground support equipment. The estimated costs for the various options (at 1976 price levels) were 10.83 MAU for option A; 13.42 and 13.14 MAU for options B1 and B2, respectively; and 17.63 MAU for option C. The differences stemmed mainly from the expenditure required by the investments for the ground support equipment.(0.19 and 7.21 MAU for the extreme options, respectively). While the various alternatives were strictly applicable only to the FSLP, the Executive insisted that this had to be considered in the context of a long-term Spacelab utilisation programme involving several flights over a period of years:

> *In the search for a cost effective solution it is worth noting that, although the initial investment requirement of option C is the largest, this option also exhibits the lowest recurring costs. It follows that, over a period of years, the initial investment is recouped. In fact, studies indicate that the amortisation of the cost of the pre-Level III [ground support equipment] would be complete within about 10 missions – or by 1983 if the current utilisation model applies.*[1963]

Three possible contribution schemes for the financing of the FSLP were suggested: the first foresaw the same contribution scale as in the Spacelab development programme; the second foresaw that the activities related to the scientific part of the payload would be financed out of the ESA scientific budget and the rest divided among Member States in proportion to the weight of their instrumentation; the third foresaw that the FSLP would be developed in the framework of the long-term Spacelab utilisation programme that the Executive was working out in parallel with the FSLP cost study, according to the contribution scale eventually agreed on by the participating states.[1964]

The principle that significant FSLP integration tasks (i.e. an option intermediate between B2 and C) should be performed in Europe was generally endorsed by the SPAG, but with two important qualifications. Firstly, that this should be achieved in the framework of the general budgetary constraints, which called for a reduction in the estimated costs, e.g. by performing the physical integration in industry. Secondly, that the decision on the FSLP should not be binding for future

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1962 ESA/SPAG(77)6, 11 February 1977. A preliminary version of this document is ESA/SPAG(76)23, 5 January 1977. Four integration levels were foreseen in the Spacelab Programme Requirements defined in an ESA/NASA document of 24 September 1975: Levels I and II were to take place at the launch site; Level III integration could be performed in technical centres but required important Spacelab-dedicated technical facilities; Level IV integration was possible at user home facilities with minimum Spacelab support equipment. See also *Lord (1986)*, p. 514-516.

1963 ESA/SPAG(77)6, *cit.*, p. 4. At that time the first Spacelab mission was scheduled for 1980 and the latter statement gives an idea of how optimistic the expectations were about the Spacelab flight schedule.

1964 ESA/SPAG(77)7, 18 February 1977. The general outlines of the Spacelab utilisation programme were anticipated in a document prepared for the first meeting of the ESA Council at Ministerial Level, on 14-15 February 1977: ESA/SPAG(77)1, 11 January 1977, with annex ESA/C-M(77)14. The meeting expressed general consensus on the idea of establishing such a programme within the framework of ESA missions. The German delegation, in particular, argued that ESA should not become involved in large-scale investment when it was responsible for only a small part of the payload: "there should be no attempt to transform SPICE into a comprehensive space-flight centre", they said, insisting that most of integration work should be performed in a industrial establishment (possibly in Germany) rather than in an ESA centre. In the German view, a clear distinction had to be made between the first and subsequent missions. The former could be financed according to the Spacelab programme contribution scale, and Germany was prepared to contribute more than 50% of the budget; the latter should be carried out in the form of optional individual missions in which Member States would participate according to their interests, and ESA's role should be limited to providing SPICE services financed on a GNP basis.[1965]

In April 1977, the Executive finally submitted to the SPAG and the Council its ambitious proposal for a Spacelab Utilisation Programme (SLUP), also including the FSLP project.[1966] The aim of the programme was to promote a rapid growth of Spacelab utilisation in Europe, both in the traditional space disciplines and in the new fields opened up by the advent of the space laboratory. In this framework, the Agency's role would be twofold. On the one hand, it would provide services to European users, such as assisting the experimenters in preparing and testing their instruments, planning Spacelab missions, coordinating with NASA activities, training mission specialists, procuring ground support equipment and Spacelab subsystems, collecting and distributing data, and so on. On the other, ESA would also design and implement a number of dedicated European missions to be developed in the form of optional programmes by interested Member States. In order to estimate the required effort, three utilisation models were considered, which foresaw European participation to as much as 13 to 23 Spacelab missions in the period 1980-1985, including a number of fully dedicated European missions ranging from 2 in the lowest option to 7 in the highest. The total cost of Spacelab utilisation in the period 1977-1985 was estimated at about 255, 330 and 485 MAU (at 1976 price levels), for the three models, respectively; the fraction to be paid to NASA for access to the Space Transportation System (Shuttle) was estimated at 54%, 59% and 64%, respectively.[1967]

In order to define a charging policy determining the part of the Spacelab utilisation costs to be charged to the users and the part to be funded by ESA out of the SLUP budget, three phases were distinguished in the programme: an initial phase (1977 to about 1981), in which ESA would have to fund the basic investments in order to permit the integration and flight of the FSLP, and to set up the capability for implementing a complete payload in Europe; a consolidation phase (1982 to 1985, approximately), the objective of which would be to ensure that the funding was taken over progressively by the users, according to a specified set of principles; and a permanent regime phase (after about 1985) during which it was reasonable to foresee that the ESA subsidy would cover only the operation of SPICE and its equipment. The result of this exercise was the SLUP budget level for the years 1977 to 1985, in each of the three utilisation models. The total budget for the entire period was estimated at about 202, 155 and 347 MAU, respectively. According to the Executive, the low utilisation model was not sufficient to satisfy the user community, and it therefore proposed that the medium model be taken as the reference for elaborating the programme.

The Council did not endorse this ambitious plan.[1968] In fact, there were several reasons for ESA Member States' negative attitude towards the SLUP concept as proposed by the ESA Executive.

1965 SPAG, 4th meeting (24 February 1977), ESA/SPAG/MIN/4, 24 March 1977, p. 4. The resolution approved was reported in ESA/SPAG(77)12, 4 March 1977. The German position was spelled out in a written document reported in ESA/SPAG(77)11, 25 February 1977.

1966 ESA/EXEC(77)4, April 1977, annex to ESA/SPAG(77)13, 3 May 1977. A summary of this document, intended for presentation to the Council, is in ESA/C(77)32, 16 May 1977.

1967 These figures did not include the cost of experiments, which would be charged to the users. Approximate figures for these costs were given for the three models, i.e. about 117, 153 and 233 MAU.

1968 Council, 17th meeting (25-26 May 1977), ESA/C/MIN/17, 16 June 1977. See also SPAG, 5th meeting (18 May 1977), ESA/SPAG/MIN/5, 15 June 1977, and 6th meeting (23 June 1977), ESA/SPAG/MIN/6, 1 July 1977.

Firstly, as a matter of principle, all delegations insisted that the question of the financing of the FSLP and related SPICE activities should be dealt with separately from any long-term utilisation programme. While a rapid decision was requested on the former, in order to give the FSLP project a proper institutional and financial framework, the European participation in subsequent Spacelab missions still suffered from too many uncertainties and difficulties, particularly regarding the utilisation costs of the Shuttle/Spacelab system. In this situation, the Council felt that all mission models presented in the Executive's proposal were far too ambitious and that, in any case, it was still premature to enter into any commitment. Secondly, and more generally, the ESA Member States were negotiating at that time a new package deal on a group of the Agency's activities, including the Ariane production and the telecommunication programmes, and some argued that the Spacelab utilisation programme should be discussed and agreed on within the package deal framework. Thirdly, and more specifically, some delegations, notably Germany, opposed the idea that ESA should assume a role of mandatory intermediary between NASA and European users. In their opinion, national space authorities, research laboratories and industries should maintain the right to approach NASA directly for having access to the Shuttle/Spacelab system and they insisted that the Agency should not have a monopoly of the facilities required for high level testing and integration of Spacelab instruments in Europe. Finally, there was the problem of FSLP funding. While Germany had stated its willingness to pay 53% of the costs of the FSLP programme, as it did for Spacelab, no agreement could be reached on the way in which the remaining 47% should be divided among the other participants. For France, the costs should be apportioned in accordance with the Spacelab agreement, but this was strongly opposed by Belgium and Italy, which did not want to maintain their high rates of contribution to the Spacelab development programme for the FSLP activities.

After many negotiations, extending over several meetings of the SPAG, the Administrative and Finance Committee (AFC) and the Council, it was finally agreed that "the Agency be used as a framework for the execution of a new optional programme, called the Spacelab Utilisation Programme, intended to promote and facilitate utilisation of the Spacelab by European users". The programme objectives included two different tasks. Firstly, the setting-up of a Spacelab-access service, managed by SPICE, "comprising all the auxiliary means that are necessary for the execution of the different missions and that the user cannot provide himself". It was assumed that the costs of this service would be charged to the users. Secondly, the preparation and execution of ESA-funded missions, "in which the participating states may take part if they wish". More specifically, this task comprised the FSLP mission and two "demonstration missions" to be launched in the period 1981-1983.[1969] All Member States participating in the Spacelab programme eventually accepted to participate in the new programme (including Austria, a non-Member State participating in the Spacelab programme), but funds were only committed to the FSLP, at a level of 12 MAU (at 1976 price level), with Germany contributing 56.3%, France 12.8%, Italy 9.3% and the UK 8.4%. It was agreed that the objectives, cost and contribution scheme for the demonstration missions would be determined in the future by a unanimous agreement of the States wishing to participate in each of these missions. As regards subsequent missions, it was simply stated that their cost would be borne by the users concerned, with some support eventually provided by ESA.[1970]

14.6.1 The abandonment of the demonstration mission concept

Once the long-standing question of the financing of the FSLP had been settled, the ESA Executive started the definition studies to prepare the two demonstration missions foreseen in the SLUP plan.

[1969] ESA/C/MIN/XX/Res. 1, 4 October 1977, attached to the minutes of the 20th Council meeting (3-4 October 1977), ESA/C/MIN/20, 17 October 1977. This Council decision, which approved the SLUP principle, followed the recommendation adopted at the 7th SPAG meeting (11 July 1977), ESA/SPAG/MIN/7, 27 July 1977.

[1970] Council 22nd meeting (12-14 December 1977), ESA/C/MIN/22, 4 January 1978, and annex ESA/C/XXII/Dec. 2, 12 December 1977. A preliminary budgetary proposal was presented by the Executive in ESA/SPAG(77)20, 27 June 1977 and its evolution is reported in the series of documents ESA/C(77)81, 8 September 1977, with subsequent additions and revisions. All Council resolutions related to the approval of the SLUP are attached to ESA/SPAG(77)35, 16 December 1977.

These missions were to be devoted to microgravity research (material sciences and life sciences) and Earth-oriented disciplines (atmospheric sciences, Earth resources and geodesy), respectively. Their twofold objective was to demonstrate the full versatility of Spacelab in many scientific and application fields, and the low-cost, easy-access concept of Spacelab payloads.[1971]

Two problem areas emerged in this phase. Firstly, apart from Germany and, to a certain extent, France, the other Member States were very reluctant to invest resources in Spacelab utilisation. The cost escalation of the Spacelab programme and the persisting uncertainty regarding the NASA charging policy prevented European governments and industry from committing to an important utilisation programme in which most of the money would certainly go to NASA for Shuttle operations. Secondly, Germany informed its partners that it was preparing two national Spacelab missions whose objectives were essentially the same as those of the envisaged ESA missions and which were scheduled for launch in the same period.[1972] After many discussions between the ESA Executive and the German authorities, a compromise was worked out. The four ESA and German missions would be jointly planned, and the Earth-oriented German mission would be replaced by an astronomy mission. Germany confirmed its willingness to contribute important instrumentation and manpower to the ESA payloads, and stated that its national missions were open to complementary participation by other European groups.[1973] The German authorities did not hide, however, their desire to secure a leading role in the performance of demonstration missions and stressed that they would hold fast to their schedule. The first German mission was firmly planned for June 1982, and they declared that, "although the other Member States were invited to join, there is no intention of slowing down the planning of the mission". Similarly, it was assumed that the ESA Earth-oriented mission would take place in spring or autumn 1982 and "if the mission takes place later, the German interest in it would decrease".[1974]

The hard reality soon became evident. Following a preliminary call for experimental proposals, more than 200 proposals were received by June 1978, but no Member State delegation, with the obvious exception of Germany, was in a position to give any firm indication about the financing of the national experiments.[1975] In the next year, the dramatic financial situation of the whole Spacelab programme prevented the ESA Council from adopting any important decision on the demonstration missions. Firstly, new technical problems with the Shuttle development programme resulted in further slippages of the scheduled date of the first Spacelab flight, from July to December 1980, then to June 1981 and finally to April 1982. Secondly, it became clear that the development cost could not be kept within 120% of the original estimate and therefore new arrangements had to be negotiated by the participants in the programme to exceed this ceiling. Finally, the projected costs of the FSLP itself had almost doubled when compared to the initial estimate. By October 1978, with a launch still scheduled for June 1981, the cost-to-completion was estimated at 26.3 MAU (at 1978 price levels, corresponding to 22.3 MAU at 1976 price levels), with no reserve or contingency for unforeseen factors such as a new launch slippage. This increase was considered "unacceptable" by the Executive, which urged the SPAG to suggest "a change in philosophy [...] taking into account the effects such a change would have upon the industrial policy".[1976] In the event, following a complex cost-reduction exercise and some heated discussions among SPAG delegations, it was decided to drastically simplify the integration

1971 ESA/SPAG(77)24, 27 June 1977. The Executive had originally suggested (ESA/SPAG(77)21, 14 June 1977) three demonstration missions, devoted to microgravity, Earth-oriented and space-oriented disciplines, respectively.

1972 ESA/SPAG(77)28, 6 December 1977; SPAG, 8th meeting (20 December 1977), ESA/SPAG/MIN/8, 25 January 1978.

1973 ESA/SPAG(78)4, 16 February 1978; ESA/SPAG(78)8, 17 February 1978.

1974 SPAG, 10th meeting (29 June 1978), ESA/SPAG/MIN/10, 31 July 1978, p. 4.

1975 ESA/SPAG(78)12, 19 June 1978; ESA/SPAG/MIN/10, *cit.*

1976 ESA/SPAG(78)22, 18 October 1978, p. 7.

activities in Europe, with all physical integration carried out at ERNO's establishments. The new cost estimate was 21.7 MAU (at 1978 price levels, corresponding to 15.8 MAU at 1976 price levels).[1977]

To shorten a long story, in September 1979 the Council decided to stop planning the dedicated ESA demonstration missions and to search for participation in NASA missions with a full pallet or an experiment rack. It became evident that any European programme for the utilisation of Spacelab after the FSLP would not include dedicated ESA missions until after the mid-1980s. As we have anticipated, it was eventually agreed in 1981 to participate in the German D-1 mission by providing the Sled and the Biorack facilities, and one of the payload specialists. The ESA Council also agreed to undertake an optional Microgravity Programme with the objective of developing advanced Spacelab facilities and ensuring the necessary flight opportunities on future NASA and German missions. The first phase of the programme was approved in February 1982 with ten participating states; the programme elements were the Biorack, an Improved Fluid Physics Module (IFPM), and a series of rocket experiments. After the Challenger accident on 28 January 1986, all Shuttle activities were stopped and Phase 2 of the Microgravity Programme was delayed accordingly. In the event, the Biorack facility was included in the first flight of the International Microgravity Laboratory (IML-1), in January 1992. Other ESA-developed facilities were flown on the German D-2 mission, in April 1993, and on the IML-2 mission, in July 1994. The former carried a sophisticated facility for experiments in human physiology (Anthrorack) and an Advanced Fluid Physics facility. The latter carried four multi-user facilities: the Biorack, a Bubble Drop and Particle Unit (BDPU) and a Critical-Point Facility (CPF) for the study of transparent fluids, and an Advanced Protein Crystallisation Facility (APCF) for studying the growth of single protein crystals. In more recent times, we can recall that the APCF was carried on the USML-2 Spacelab flight in October 1995, while five ESA multi-user facilities were included in the Life and Microgravity Spacelab (LMS) mission in June 1996: BDPU, APCF, the Advanced Gradient Heating Facility (AGHF), the Torque Velocity Dynamometer (TVD), and the Microgravity Measurement Assembly (MMA).

14.7 Epilogue

A few months after the successful accomplishment of the first Spacelab mission, a member of the ESA staff who had been associated with the Spacelab programme since its very beginning could not conceal his disenchantment:

> *The aim was to make space readily accessible to all experimenters [...] Many of our early dreams have been dispelled by such things as high launch costs, the high standards of safety needed by a manned system, and the large amount of documentation that must be handled by scientists and engineers alike. A significant high-cost factor arises from the sheer size of Spacelab. It takes over 4 tonnes of experiment equipment to use its capability fully. Although the cost per kilogram of experiment put into orbit is low, the total mission cost is quite high.*[1978]

Such disillusionment was probably widespread in many quarters, with the former NASA director of the Spacelab programme resenting "the comments from dissidents in the public and scientific press"

1977 ESA/SPAG(78)28, 30 November 1978; ESA/SPAG(79)1, 12 February 1979. SPAG, 11th meeting (26 October 1978), ESA/SPAG/MIN/11, 22 November 1978; 12th meeting (7 December 1978), ESA/SPAG/MIN/12, 11 January 1979, and 13th meeting (21 February 1979), ESA/SPAG/MIN/13, 23 March 1979. The main controversial issue was whether integration should be performed in German industry or in the US or at a non-industrial European centre (ESTEC or CNES). Owing to further launch slippage of the first Spacelab mission, a new cost figure had to be approved in 1980 at 28.9 MAU with a contingency of 1.5 MAU (both at 1978 prices): *ESA Annual Report 1980*, p. 54.

1978 D.J. Shapland's preface (June 1984) to Shapland & Rycroft (1984), p. 7.

and blaming the scientists, "who were still insisting that man was unnecessary for space research [...] and received far more recognition from the news media than they deserved".[1979]

For the European scientific community, the last word on Spacelab was spelled out in a report on the development of space science in the 1980s, prepared by the SAC during 1978 in consultation with the community at large and published in December that year.[1980] "Spacelab [...] represents a good vehicle for such disciplines as the microgravity sciences and astronomy", the SAC wrote when the first mission was being delayed from mid-1981 to spring 1982, ESA's planned demonstration missions were about to be definitely jeopardised, and the Spacelab development programme was entering its most dramatic financial crisis. "But even for these [disciplines]", the SAC went on, "high cost is a major obstacle to its use, and this has been the determining factor in the rejection of excellent candidate projects". For the SAC as well as for most space scientists, the launch cost per kilogram of experiment mass was not a good indicator for assessing the worth of Spacelab in space research. Firstly, the cost of small experiments turned out to be as high as on unmanned satellites, particularly because of the stringent safety requirements; secondly, the short duration of flights made Spacelab uncompetitive with conventional spacecraft on a cost/observation-day basis.[1981] "What was supposed to be a platform to carry, in particular, rocket-type experiments into space for seven days has turned out to be a platform to carry the most expensive type of satellite experiments for this same period of time", the SAC members insisted, echoing the criticism that had been voiced from various parts of the scientific community. Furthermore, the Spacelab payload-integration scheme had not met the original promise of short lead times, again because of the manned-safety requirements, and the reflight time would not be as short as initially advertised. In conclusion, only a drastic reduction in the 'effective' cost to science of Spacelab launches could stimulate a significant utilisation programme, "which will represent a dividend for the European initiatives and investments involved in the creation of Spacelab". The SAC's position, in any case, left no room for indulgence:

> *Regarding the future utilisation of Spacelab, the SAC is of the opinion that the scientific community should consider itself a* potential user *of this means of transportation, and not a* promoter *of it. In no way should the community and the Working Groups themselves undertake the task of programming the utilisation of Spacelab [emphasis added].*

High operation costs and lack of a sufficiently large, motivated and influential user community were the two main aspects of Spacelab's shortcomings. Two others can be pointed out in order to understand ESA's failure to establish a sizeable Spacelab utilisation effort. Firstly, the unequal partnership between NASA and ESA was felt in Europe to be unduly penalising for European interests in this joint venture. Such issues as the poor transfer of technology, the lack of significant contracts for Europe in the Spacelab operational phase, the pricing policy for user access to the Shuttle/Spacelab system, and the fact that only one other Spacelab was procured by NASA after the first unit, were the main areas of controversy. In this situation, and facing the cost escalation of the programme, European governments became more and more disenchanted with the future of Spacelab. European industry, for its part, could hardly be excited about a large utilisation programme for Spacelab when most of the money would go to NASA for Shuttle operations.Secondly, ESA's multinational structure and the different interests of its Member States made it impossible to build a strong and unitary direction as regards Spacelab utilisation. It is striking to observe that the Spacelab Programme Board, the delegate body responsible since 1973 for directing the Spacelab development programme on behalf of the participating states, was not responsible for planning its first mission (let alone subsequent ones) until spring 1979. In the

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1979 Lord, *Spacelab* (1987), p. 389.

1980 SAC, *Recommendations on the development of space science in the 1980s*, ESA SP-1015, December 1978; also referenced as SAC(78)17 and circulated under cover ESA/SPC(79)2, 3 January 1979. The following quotations are from pp. 47-48 and 57-58. For a more detailed discussion of this document, see chapter 4 in this volume.

1981 The cost/ kg of experiment mass was the main argument in the Executive's document SAC(79)12, 26 April 1979, but it was strongly criticised by the SAC at its 18th meeting (9-10 May 1979), SAC(79)16, 25 June 1979, and 19th meeting (26 September 1979), SAC(79)25, 8 November 1979.

ESRO framework, this task was first assigned to the Scientific Programme Board (for scientific projects) and the Joint Programmes and Policy Committee (for the other projects). Subsequently, the First Spacelab Payload Working Group was set up, whose main task, however, was to find a solution to the hot question of FSLP funding. In late 1976, it was replaced by the Spacelab Payloads Advisory Group (SPAG), with wider terms of reference, but the scientific projects, including the new field of life sciences, remained under the competence of the Science Programme Committee. An advisory group made up of national delegates was also created to deal with the remote-sensing (RESPAG), and a Material Science Consultant Croup of independent experts was added to the SAC and the Astrophysics, Solar System and Life Science working groups. Each of these boards, committees and advisory groups intervened in the decision-making process, with the Council retaining responsibility for all final decisions.

The decision-making process was long and complex, and the ESA Executive lamented that "in the area of the Spacelab utilisation programme ESA suffered from the absence of a policy and a mission clearly defined by the Member States".[1982] For Germany, Spacelab was essentially like a national programme, in view of the country's large effort. It could not do it alone, however, and its European partners did not like to leave too much control in German hands. "[Italy is] not prepared to subsidise the acquisition of experience by German industry", the Italian delegation declared when it was proposed to integrate the FSLP in ERNO in order to reduce costs. The German delegation retorted pointing out that Germany was paying 56% of the cost of the FSLP, "to say nothing of the equipment and manpower which was made available free of charge to the programme". It blamed the larger Member States for not showing "a greater interest in using the Spacelab", and the Science Programme Committee for not showing "sufficient enthusiasm for the facilities offered by Spacelab".[1983]

Indeed, one can hardly find any enthusiasm in the records of discussions on Spacelab utilisation. Whether because of doubts regarding its real scientific value or concern about its costs, the initial optimism about the potential of the Shuttle/Spacelab system vanished soon. The Spacelab programme was criticised in Europe as being a 1 billion dollar gift to the US Space Shuttle programme: "Europe's most expensive gift to the people of the United States since the statue of Liberty", the head of the German delegation in the ESA Council remarked.[1984] In fact, the Europeans agreed to build Spacelab with their own money and ship it to the United States, and "all ESA received overtly in return was the free use of half of the payload bay on the first flight", as the first ESA Director General, Roy Gibson, put it with hindsight.[1985] European governments were greatly disappointed by NASA's pricing policy, which did not consider any "preferred access" to the Shuttle/Spacelab system for European users, and they hardly appreciated the fact that the US procured only one additional flight unit, barely complying with the requirements of the Memorandum of Understanding. We can perhaps fairly conclude by quoting the former NASA director of the Spacelab programme from the conclusion of his long historical account: "since the end of the [...] program, the attitude of European and US representatives toward future cooperation has become increasingly suspicious or combative".[1986]

1982 SPAG, 2nd meeting (30 November 1976), ESA/SPAG/MIN/2, 28 December 1976, p. 13.
1983 SPAG, 13th meeting (21 February 1979), ESA/SPAG/MIN/13, 23 March 1979, pp. 5 and 9.
1984 W. Finke, quoted in *McCurdy (1990),* p. 102.
1985 *Gibson (1992)*, p. 42.
1986 *Lord (1987)*, p. 400.

Chapter 15: The Space Station

L. Sebesta

A: The European Background

15.1 Introduction

Space Station does not only represent an upgrade in US-European cooperation, it is the most ambitious international cooperative programme in space ever started. As with every project implying a quantum jump into new, manifold, high-technology areas, the Space Station project has been characterised by several changes in its configuration and time schedules, and by related uncertainties about the operational costs and final performance of the station: moreover, it has been conceived, developed and built in a rapidly evolving international context; this has brought about a major change in the configuration of partnership and a modification of the goals being pursued through the Space Station project.

Last but not least, beyond uncertainties related to the cost and the long duration, there has been a major problem linked to the controversial rationale of the project: NASA as well as ESA and the other international partners have been constantly facing severe criticism from scientists, engineers, sectors of the government and the public at large, who consider the Station too expensive compared to the expected scientific and technological return[1987]. As a general remark, it must be stressed that the Space Station, more than any other space project, is based on the assumption that the human presence in space is “an important factor in learning how to use space for scientific and applications purposes”. The “learning factor” is therefore considered an essential asset of the programme, more than any specific scientific or technological immediate return[1988]. In this sense, what is perceived by some as the weakness of the Space Station – i.e. the difficulty to envisage cost/effective experiments to repay the investments made – is considered by others as its strength. It is thought that the Space Station will offer unforeseen opportunities which would be impossible to envisage from Earth[1989].

The people involved in Space Station have learnt how to live with constant criticism. Actually, it is sometimes felt that the original American programme was indeed inspired by the necessity to appease as broad as possible a constituency, more than by the ambition to make a workable plan. This "over-committed system" had to be downsized in the following years in order to confront serious technical problems and financial constraints[1990]. This increased the instability of the project, which culminated in the early 1990s.

"Differences over space policy" says another author who dealt with the Space Station "were not resolved by the space station decision; they were merely postponed."[1991] In order to be able to postpone these difficulties, and not to take any definite stand over questions of overall goals, NASA supposedly used

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1987 W.D.Kay, "Where No Nation Has Gone Before: Domestic Politics and the First International Space Science Mission", *Journal of Policy History*, vol. 5, n.4, 1993, p. 448.

1988 Van Reeth Papers, Gaiole in Chianti (Siena), Italy, Space Station, Space Station, 1, ESA/C-M(85)3, Principles and guidelines for the negotiations with the US on participation in the development, operation and use of a Space Station, 17 December 1984.

1989 See for example, "Face to Face with Ian Pryke", *Aerospace America*, August 1991, pp.7-8.

1990 W.D.Kay, *Can Democracies Fly in Space. The Challenge of Revitalising the US Space Program* (Westport: Praeger) 1995, p. 88 and p. 94.

1991 Howard E.McCurdy, *The Space Station Decision: Incremental Political and Technological Choice* (Baltimore:Johns Hopkins University Press) 1990, p. 224.

"incremental techniques" , whereby it did not try to create long-term legal obligations for the Congress. If this seemed, at the time, to be the only way to gain sufficient public support, it entailed a weak commitment by the Congress and opened the programme to endless revisions – with no clear-cut long-term goal to help in the redefinitions[1992].

Whatever were the techniques used to make the programme acceptable at the start, its flexibility allowed not only significant changes in the structural model and features of the Station, but, fifteen years after the launching of the project, its complete re-orientation in order to accommodate new political goals connected with the end of the Cold War and the need (or political will) to take on board Russia. What was before perceived as a weakness of the programme by some commentators actually became one of its strengths.

The "evolutionary character" of the Station was legally sanctioned in the international agreement which ruled the programme (art 1.4, IGA 1988). Rules were worked out in order to cope with this possibility either by means of amendments or by separate new agreements (art. 14) – this was the road actually chosen in 1997, which led to the new agreement of 29 January 1998.

The existence of a web of international contacts and agreements provoked a complex effort of negotiations to coordinate the development and operation of the Space Station; on the other hand, international participation contributed effectively to the stabilisation of the programme in its most difficult phases. Cooperation, characterised by a very high political profile, safeguarded the Space Station from defection of its partners. More than once, the possible abandonment of the project was perceived by the partners involved as an intolerable break of faith *vis-à-vis* the others and therefore discarded.

Originally, the Space Station was presented to "friends and allies" as a political, scientific and technological enterprise to provide "a highly positive centerpiece for demonstrating Free World unity, goodwill and technological progress"[1993]. This happened in early 1984, at the height of the so-called second Cold War period, opened by the election of President Reagan in November 1980. His "evil empire" speech, recommending prayers "for the salvation of all those who live in totalitarian darkness" (8 March 1983) was followed by his speech on the "Strategic Defense Initiative" (SDI) in which he announced that he was "directing a comprehensive and intensive effort to define long-term research and development programmes to begin to achieve our ultimate goal of eliminating the threat posed by strategic nuclear weapons", through a sort of "speed-of-light" defence umbrella to shield the US from nuclear missile attacks (23 March 1983). Through SDI, the American President instigated an astonishing quantum jump in the arms race spiral, a jump whose cost, by the most conservative estimates, would be up to 30 to 40 billion dollars over the following ten years[1994].

Space Station, on the other hand, was supposed be less ambitious as far as the financial estimates were concerned, and civilian in character. Its peaceful purposes were emphasised since the beginning: even in private meetings with their European counterparts, American representatives were keen to underline that "there was no intention to use it [the Space Station] to further President Reagan's Star War initiative"[1995].

Reagan's strategy seemed therefore to be twofold. On the one hand, the US were unilaterally challenging the USSR in the military field with SDI, while reassuring allies about their enduring support in the defence of their territories through missiles. The Pershing and Cruise deployment in response to the

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1992 *Ibid*, pp.224-235. As one reviewer of McCurdy's book quite rightly put it it is actually difficult to think how, realistically, the decision could have been reached if not due to this kind of approach; see Kenneth Pedersen, "In defence of the incremental art", *Space Policy*, August 1991, pp. 268-273.

1993 Van Reeth Papers, Space Station, 1, Letter NASA Administrator James Beggs to ESA Director General Erik Quistgaard, 6 April 1984. Beggs' letter formalised a general invitation forwarded by President Ronald Reagan during his State of the Union Address of 25 January 1984.

1994 For the estimate, H.McCurdy, *op. cit.*, p. 161.

1995 Van Reeth papers, Space Station, 1, K.Barbance, Inter-office Memorandum, Mr Beggs' visit to London (5 March 1984), 6 March 1984 [Beggs is speaking].

increase of Russian SS-20s during the 1970s was approved by NATO and discussed in European Parliaments in November-December 1983, just a few months before the Reagan's announcement about the Space Station.

On the other hand, the Space Station was conceived as a "demonstration of free world leadership" and, as had happened at the time of the Apollo programme, it should be a tangible symbol of the superiority of American democracy – hence the name, *Freedom*,eventually chosen for the project[1996]. It was not by chance that, when announcing the Space Station programme, President Reagan used a sentence structure familiar to the American public, announcing that he was directing NASA "to develop a permanently manned space station and to do it within a decade"[1997]. While the Congress had, back in the 1960s, quickly accepted Kennedy's call for a huge supplement in NASA's budget, Space Station would be always struggling for funds. Equally interestingly, before extending the offer of cooperation to America's allies, Reagan, in a typical condensed version, clarified the starting point of this cooperation: "We are first: we are best: we are so because we're free".[1998]

Yet this two-fold presidential strategy was substantially weakened in 1986-87 when, under heavy pressure from the Department of Defense, the concept of peaceful use was put in danger; as we shall see later, DoD intervened heavily in US-European negotiations and was able to guarantee a free hand for itself on the Station [1999].

In the original offer, the Space Station was conceived as an American enterprise, which could be expanded by external intervention. Despite the use of the term international Space Station since the very early stages of negotiations, it was clear that the US had planned to build "a $8 billion dollar fully functional Space Station to be operational by the early 1990s, but [had] also set the stage for working together to develop a more expensive international Space Station"[2000].

[1996] A special "Space Station Name Committee" was created in 1988, with representatives of various NASA offices and programs as well as of ESA (Ian Pryke), Canada and Japan. Ian Pryke, Head of the ESA Washington Office, did not carry any official ESA mandate as far as the name selection. The name Freedom was chosen from a list of 600 proposals, all of US origin, which was reduced with the intervention of NASA Administrator Flecther, by June 1988, to a list of three (Freedom, Orion and Aurora). President Reagan made the final choice; Van Reeth Papers, Space Station, 11, Fax Ian Pryke to DG, Name of the International Space Station, with Annexes, 18 May 1988; *Ibid*, 12, Fax Ian Pryke to DG, Naming of Space Station, 9 June 1988.See also Gabriel Lafferranderie, "Les accords relatifs à la station spatiale internationale", in *Revue Générale de Droit International Public*, avril-juin 1989, n.2, p.344, note 14.

[1997] Those with historical flair will be reminded of Kennedy's statement on 25 May 1961 (calling for "landing a man on the moon and return him safely to Earth", "before this decade is out") in which the President justified the future Apollo programme with the need "to win the battle" "between freedom and tyranny". "We go into space" Kennedy went on in a rather cryptic style "because whatever mankind must undertake, free man must fully share". For the text of Kennedy's speech, see John Logsdon (ed.) with Linda Lear, Jannelle Warren-Findley, Ray Williamson and Dwayne Day, *Exploring the Unknown. Selected Documents in the History of the US Civil Space Program. Vol. 1. Organising for Exploration* (Washington: NASA) 1995, pp.453-454. For Reagan's speech, see *20 Weekly Compilation Presidential Documents*, 61, "The State of the Union Address", Delivered by President Ronald Reagan before a Joint Session of Congress, 25 January 1984.

[1998] *Ibid*.

[1999] Already in his 1982 National Space Policy speech, released by the White House after the successful achievement of the last pre-operational space shuttle flight (Columbia), Reagan had announced that "the United States program [would] be comprised of two separate, distinct and strongly interacting programs - national security and civil. Close coordination" he added "cooperation and information exchange [would] be maintained among these programs to avoid unnecessary duplication". The White House statement, released on the 4 July 1982, is entirely reprinted as Appendix F in Theodore R. Simpson, *The Space Station. An Idea whose time has come* (New York: IEEE Press) 1985, pp. 273-279, p. 274 for quotation.

[2000] Van Reeth Papers, Space Station,1, Letter NASA Administrator James Beggs to ESA Director General Erik Quistgaard, 6 April 1984 [underlined by the author.].

Cooperation between Europe, the US, Canada and Japan was formalised, as we shall see later, through various inter-agency and intergovernmental legal agreements signed in 1985 (for Phase-B) and in 1988 (for Phases-C/D/E).

At the same time, from 1984 to 1989 the programme underwent eleven major reviews [2001]. Beginning in 1986 (after the Challenger accident) major redesigns of the Space Station were accompanied by severe blows launched by the American Congress to the project and to NASA altogether – the agency was headed by four different administrators from 1984 up to 1992 (Beggs, Fletcher, Truly and Goldin). Cuts in funds and redesign processes, conducted under the Reagan and Bush administrations, became particularly severe during Clinton's tenure (January 1993 onwards).

The international component of the project became more and more relevant in political, financial and technological terms; the original thrust towards an independent station that would *also* accommodate external partners was therefore reversed and international partners became more and more essential for the functioning of the station[2002].

The American Space Station concept and funding was submitted to a (unilateral) severe "scrub-down" exercise in 1989 (the so-called "Scrub '89"), which strongly affected not only the design of the American Space Station, but the quality and timing of the European, Canadian and Japanese contributions. Some facilities were then dropped altogether, among which were the astronomical observatory in 1989 and those for Earth observation in 1990. Freedom was then *saved* a first time "after heavy lobbying by the international partners and the Bush administration"[2003]. In 1991, "NASA essentially started over, proposing a much smaller, simpler and less ambitious facility"[2004].

Reshaping and scaling down procedures, in consultation with the partners this time, were revived during Clinton's Presidency, until the late complete redesign of June 1993, which undermined the original concept of "core station"-the project actually survived in the House by a single vote[2005]. This setback, coming at a time when European industry was ready to enter the developing phase of its hardware, was indeed dramatic for all the partners[2006].

At the same time, after the Soviet political turmoil of 1991-92 and the creation of a Russian Space Agency (RKA), new perspectives seemed to be opened for an enlargement of the cooperation, to include Russia. In the Fall of 1993 it was decided to merge Freedom with the MIR 2 then under development[2007]. The new programme was eventually renamed Alpha. By matching efforts with Russia, Alpha would become the first big technological cooperative project for almost forty years with the *new* American friend and ally, Russia, its past strongest competitor in the field.

Russia was experiencing political and economic catastrophe; in the space field, where its record of man-hours in space was higher than that of the US and could be of great value, a whole set of technical and scientific competence in in-orbit infrastructure and launching services risked to be lost and the results of sustained investments over the years were seriously jeopardised[2008].

2001 W.D.Kay, *op. cit.*, p. 91.

2002 Lynn Cline, "Space Station politics: the International dimension", presented at the 1996 Annual Meeting of the Western Political Science Association, San Francisco, 1996, cited by Eligar Sadeh, James Lester and Willy Sadeh, "Modeling international cooperation for space exploration", *Space Policy*, August 1996, pp. 207-223: for the quotation, see p. 220.

2003 W.D.Kay, *op. cit.*, p.91; see also Roger Bonnet and Vittorio Manno, *International Cooperation in Space. The Example of the European Space Agency* (Cambridge: Harvard University Press) 1994, pp. 114-115.

2004 W.D.Kay, *op. cit.*, p.91.

2005 Kevin Madders, *A New Force at a New Frontier* (Cambridge: Cambridge University Press) 1997, pp. 464-467; W.D.Kay, *op. cit.*, p.91.

2006 R.Bonnet and V.Manno, *op. cit.*, p. 116.

2007 W.D.Kay, *op. cit.*, p.93.

2008 K. Madders, *op. cit.*, pp.467-469.

The merge of MIR 2 and Freedom could be a means to rescue both the American and the Russian projects. With increasing foreign contribution to the major infrastructure of the Station, though, the meaning of "core station" became even more controversial and European participation had to be reoriented yet another time[2009]. Russian participation was finally sanctioned through the signature in January 1998 of new intergovernmental and inter-agency agreements.

In order to deal with this complex subject, we will focus our analysis on the evolution of the European participation, highlighting at the same time the major development on the other side of the Atlantic.

A special emphasis will be put on:

- the significant stages of the European involvement in the Space Station programme: origins and implementation of the Preparatory Programme for Long-Term Space Transportation Systems (STS-LTPP) and Columbus. Linkages between the evolution of Columbus and the other two elements of the European "triad" (Ariane-5 and Hermes) will be also taken into account, placing European participation in the Space Station in the context of the first ESA Long-Term Space Programme, approved in January 1985, and its evolution.

- the international negotiations, from the original American offer of 1984 to the MOU of 1985 and the legal texts signed in 1988. Some major controversial issues will be analysed in this context, such as the management and operational control, the access to use, the transfer of technology, the military use and the legal form of the final agreement.

15.2 The ESA context

As early as 1976 the ESA Council, making reference to art. 4.2. of the agreement between the Agency and certain Member States on Spacelab, considering NASA's Space Station study programme and "noting the impact of, and relationship between" the Spacelab and the future Space Station projects, invited the Spacelab Programme Board to examine the possibility of European participation in the programme[2010].

Eight years would elapse before a decision could be taken on the subject, eight years of comprehensive debates on the future of the newly-born European Space Agency. The problem of STSs was only one of the questions facing the Agency.

From a functional point of view, there were divergent views "as to whether the Agency's role should be limited to development or should extend to commercialisation"[2011], that is which role should ESA assume in the management of the satellite-based operational systems that were now beginning to leave the experimental stage.

On the structural side, much thought was given to the attempt to establish a comprehensive rule governing the relationship between the Agency's programmes and national activities[2012]; everyone seemed to accept *complementarity,* but each government interpreted this notion in its own way. Bearing in mind that ESA was based on intergovernmental cooperation, not on integration, it is not difficult to understand why such a comprehensive rule was never established and governments were left free to prioritise their national interests – either by national or by cooperative means.

[2009] K.Madders, *op. cit.*, p. 469.

[2010] Historical Archives, European University Institute, Florence, Italy, (HAEUI), ESA/C/MIN/X, Res. 2, 8 October 1976.

[2011] HAEUI, Intervention by the Chairman (Curien), ESA/C/MIN/50 (27-28 October 1981), 30 November 1981.

[2012] HAEUI, Intervention Director General, during the discussion on ESA/C(81)27, ESA/C/MIN/47 (29 April 1981), 11 June 1981.

Nor did it seem possible to strike a compromise between the contradicting national views on what European future space policy should be, beyond the traditional field of space science which was an undiscussed heritage of the original period[2013].

The UK, historically the most user-oriented among the agency's members, was in favour of increasing the responsibilities of industry for management and funding, continuing telecommunication programmes and opening the way to the new Earth observation programmes, including terrestrial applications. Germany favoured the increase of the core Scientific Programme supported by mandatory expenditures and the addition of another basic activity, i.e. the remote sensing programme, of which ERS was the first link in an hopefully long chain, finally providing a welcome connection between science and applications. The attention of the French government was mainly concentrated on its pet project, Ariane, and the means to increase European competitiveness in the field of launchers to both geostationary and low-Earth-orbits; as far as satellites were concerned, telecommunication and Earth observation were considered two strategic fields for expansion. Italy was traditionally less inclined to indulge in strategies for the long-term future, preferring to focus on the problem of industrial returns, considered as the main factor in judging the viability of any future programme. The so-called small countries generally kept a low profile in their interventions. Under these conditions it seemed difficult for the Executive to strike a deal and get to a unified long-term programme[2014].

Even cooperation with the US, which had been a baseline for Europe in space since the early days, seemed to become a controversial concept. Collaboration, it was felt, needed to be redefined on more assertive terms, in the light of the expansion of the realm of collaboration from scientific to technological enterprises and due to recent controversial experiences (Spacelab and ISPM).

Hence, the Agency seemed to be still "digesting" the innovations introduced by the package deal of July 1973 whereby Europe had decided to build its autonomous launching system in order to have access to the communication satellites' market (Ariane), to enter the manned system area in cooperation with the US (Spacelab) and to pursue the trend towards applications using satellites in geostationary orbit (Marots).

A substantial portion of the Agency's funds had been managed, since those days, through optional programmes, whose legal and budgetary status was inevitably leading each of them to a tendency to live an independent life. On the one hand, the proliferation of optional programmes had brought about a dispersion of interest and a weaker control by the Agency of the direction of the European effort; on the other hand, the development phases of both Spacelab and Ariane were absorbing a large part of the effort of the Agency and of the Member States' contracting firms during the late 1970s.

Despite a Council at Ministerial level in 1977, "nothing really was elaborated on the long-term aspect" from the Brussels Ministerial Council of July 1973 up to the Rome Ministerial Council of January 1985[2015].

On the top of that, a major restructuring of ESA took place after the arrival of the new Director General Quistgaard in mid May 1980. The restructuring is to be interpreted with reference to the long-term strategy of curtailing general expenditure and, in the short term, as a way to cope with the failure of the second Ariane flight on May 23 1980. After the first successful flight of Ariane L01 at Kourou

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2013 We are excluding from our present discussion the question on how space science should be best pursued through the agency. On this topic, see chapter 14.

2014 HAEUI, ESA/C/MIN/50 (27-28 October 1981), 30 November 1981.

2015 Gabriel Lafferranderie, *European Space Agency* (The Hague: Kluwer Law International) 1996, p.28.

on Christmas Eve of 1979, the May 1980 failure of L02 came as "something of a shock for the teams involved and the observers"[2016]. At a time when Arianespace was being created as an industrial company made up of contributing firms, banks and CNES for the manufacturing, marketing and launching of Ariane after the completion of the ESA managed promotion series, ESA, one of the major prospective users of the European launcher, did not want to lose complete control of the project.

In May 1980, it was therefore decided to create an Ariane Directorate which would eventually merge with the Spacelab Directorate and that of Microgravity to form the Directorate of Space Transportation Systems. Michel Bignier was called to direct the newly-created body[2017]; his past experience in both Ariane and Spacelab made him a natural candidate to lead this fundamental directorate, which managed more than half of the ESA budget by the beginning of the decade. His Directorate also took over the functions of future planning, which had been decentralised after the suppression of the Directorate for Future Planning under the responsibility of André Lebeau, who left the agency in June 1980 and the dispersion of the future planning units within the various directorates[2018].

Yet, after the coming into force of the ESA Convention in October 1980, the major programmes which emerged from the 1973 package deal began to come to fruition. This was clearly reflected by the diminishing curve of financial commitments. The effectiveness of European cooperation in space technology, under the new institutional framework of ESA, seemed remarkable. The year 1981 was indeed defined as "a vintage year for Europe" in the ESA Annual Report[2019]; while, two years later, 1983 would be defined as a "year of harvest" by the Executive[2020]. After Ariane's successful maiden flight on Christmas Eve of 1979, Meteosat-2 flew on the third Ariane launch in June 1981[2021] and Marecs-A, the first European-built maritime communication satellite, was launched on board Ariane L04 in December 1981; the satellite entered operational service with INMARSAT for ship-to-shore communication over the Atlantic in May 1982. This launch completed the qualification of the launcher: in January 1982, Ariane-1 was qualified operational by its Programme Board. Despite the loss of the Marecs-B mission due to a failure in the third stage propulsion system of Ariane L05 in September, ECS-1 , the first of the five satellites which would provide Europe with its first civil operational telecommunication service, was successfully launched in June 1983.[2022]

At the same time, ESA had begun to provide hardware for worldwide organisations based on space systems such as INTELSAT, which had been previously reticent in giving contracts to Europe; it also set up or was on the verge of establishing regional organisations using European-developed operational satellites, such as EUTELSAT and EUMETSAT. Arianespace, set up in 1980, represented a world-wide innovation in the field of production and commercial management of launchers. Finally, the Spacelab engineering model reached the Kennedy Space Center in December 1980, while the first flight unit Configuration-I was accepted by NASA in February 1982; Spacelab would be successfully launched on board of the Shuttle Columbia in November 1983.

2016 *ESA Annual Report 1980*, p. 51.

2017 Michel Bignier, as CNES Director General from 1971 to 1976 negotiated with ESA the Europeanisation of Ariane. He was later called to take over the post of Spacelab Programme Director in ESA in 1976, at a very delicate phase of the programme; he was both responsible for SL and FSLP.

2018 *ESA Annual Report, 1980*, p. 51 and p. 135.

2019 *ESA Annual Report 1981*.

2020 HQ Paris, ESA/C(84)R/6, Conseil, Note de couverture, Examen préliminaire des objectifs d'une politique spatiale européenne à long terme, 10 February 1984.

2021 Meteosat-1 was launched on board of a Delta 2914 rocket in November 1977; on the Meteosat programme, see chapter 7.

2022 On these programmes, see related chapters in this book.

The gap between American and European funds and performances in space seemed reduced: money spent in the US on space (both in the civil and military sectors) was ten times the equivalent (in ESA and national terms) of that in Europe (17 billion AU versus 1.7 billion AU in 1983) -compared to the 20 to 1 ratio of the 1960s[2023].

15.3 European interest in-orbit infrastructures

What were the terms of reference for the new Directorate of Space Transportation systems? Where to go next in the field of space transportation systems, i.e. means of transport and in-orbit structures?

1. As far as *launchers* were concerned, it was forecast that telecommunication missions would continue to develop, increasing the number of services provided, of users envisaged, of traffic in high and low orbit. However, foreseeable requirements of users did not necessarily imply an increase in mass so large as to require a capability exceeding that of the European launcher under development at the time, Ariane IV. The mass and volume of the payloads were increasing less rapidly than their performance (due to miniaturisation); also, the value of very long satellite lifetime, and hence an increase in mass (to accommodate more propellant for example) was limited by the mission obsolescence of the payload. On the other hand, Europeans should be ready, in the medium and long-term, to cope with the operational start of the Shuttle, which would imply a loss of competitiveness by Ariane. If, in 1982, both the cost and mass performance of the future Ariane-IV were considered to be close to those of the Shuttle plus Inertial Upper Stage (IUS), in the medium term, technological progress in the shuttle propulsion could create a serious cost competitor for Ariane[2024]. It was then indeed forecast that, from the mid 1980s onwards, Ariane would not be able to match the Shuttle's reliability, payload envelope and mass capability, at least for LEO. If the Shuttle were to win the market, satellite designs would be reoriented towards Shuttle requirements and be incompatible with Ariane.

   This future development could be confronted either with an effort to achieve reduction of cost per kg in orbit or, in the long-term, with a fundamental change in the type of launcher. The document on the Long-term Space Transportation Systems Preparatory Programme presented by the Executive to the Council in November 1981 made explicit reference to the need to develop a launcher "for the most part re-usable" if, in the long term, competitiveness with the US should be attained[2025]. This potential development would open a major debate within the Agency and have important, even if indirect, repercussions on the debate over in-orbit structures.

2. Microgravity research, remote sensing and, in the long term future, telecommunications, could be based, or take advantage of, *low-Earth orbital infrastructures*, i.e. platforms where satellites could be assembled, "plugged in" and/or added in accordance with new missions, the platform having a much longer life than the individual payloads[2026].

   Among the future developments, the most unpredictable was microgravity. Industrial companies, particularly pharmaceutical ones, had shown interest in the possibilities offered by production under microgravity conditions. Space processing activities, despite being in their infancy, already opened a scenario in which the one who had the monopoly in Earth-return capability would monopolise the whole sector[2027]. Wasn't this situation similar to what had happened in the telecommunication field? The telecommunication field had been structured through the identification and mobilisation of expertise since the 1960s, mainly by the US. Energy and money had been spent well into the 1970s, mainly in the US, to convince potential users that satellites

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[2023] For 1983 figures, see ESA/C(84)R/6, 10 February 1984.
[2024] HAEUI, ESA/C(81)84, Long-term space transportation systems. Preparatory programme proposal, 25 November 1981.
[2025] *Ibid*, p.3.
[2026] HAEUI, ESA/C(81)84, *cit.*
[2027] HAEUI, ESA/C(81)58, Space Transportation Systems Long-Term Preparatory Programme, 7 October 1981.

were convenient compared to wires and to organise and regulate their functioning (via INTELSAT).

The parameters of "user interest", however, was more difficult to apply in the orbital systems field. Here any estimate of future utilisation was only a guess and future users were not public companies (the PTTs), but scientists and commercial companies. It was still unclear if the field was rewarding at all because it had not been sufficiently developed in order to assess its potential benefits in commercial terms.

An orbital system, though weak from the "users" point of view, had other appreciated qualities:

a) it was a system which *could be built in stages*, progressively, by tackling one element at a time, in order both to phase expenditures over time and to master one technology before developing the next[2028].

b) it *could take profit of the results already obtained during Spacelab and EURECA*[2029]. Through Spacelab, European industry had, without doubt, acquired new competence in high tech fields connected to manned systems, and experience in the managerial techniques needed for complex technological systems. For a part of the scientific community, however, the technical characteristic of the laboratory, the programme's slippage and rising costs, made the positive assessment of the programme less straightforward. In addition, for the use of the laboratory, the Europeans had to rely on their American partner and the dramatic revision upwards of the Shuttle's flight costs had made this dependence very inconvenient.

The Director of Space Transportation Systems showed no hypocrisy when speaking about his past experience: "The Spacelab development" he wrote in October 1981 "could not be justified from the utilisation standpoint, the access to new space activities (e.g. microgravity) with the Shuttle/Spacelab system would have been as well possible to Europe even if it would not have undertaken the Spacelab development programme. This programme has to be considered as the entry of Europe into manned-technology systems and could only find its full justification in the participation of Europe in a permanent manned system. Whether Europe wants to pursue the participation is one of the key question for defining Europe's long-term space transportation activities"[2030].

Spacelab's main rationale was to be found, therefore, in its pioneering character; in order to make it a valuable asset, Spacelab should be considered as only the first step of the European entrance into the field of more ambitious manned orbital infrastructures.

3) last but not least, working in orbital infrastructures *opened the path to a renewed and upgraded cooperation with the US*. American plans, though still in an embryonic form, were pointing definitely towards a manned base (then called Space Operations Center) permanently in orbit, serviced by the shuttle.

2028 HAEUI, ESA/C(81)84, *cit.*

2029 Eureca, the European Retrievable Carrier, was a first element of the Spacelab Follow-on Development (FOD) Programme. It was conceived as a free-flying and reusable platform launched and retrieved by the American Space Shuttle system. The system was designed as a multipurpose carrier for orbital flight durations of up to nine months. While Eureca's first missions were primarily microgravity missions, Eureca was considered to be of use for other space sciences, such as astronomy, solar physics and Earth observation as well as a test bed for in-orbit communication, rendezvous and docking, in-orbit servicing, robotics and operational methodologies essential to deploy future platforms in space; cf. R.Mory, "Spacelab and Eureca as a Basis for European Involvement in the Space Station", *ESA Bulletin*, No.42, May 1985, pp. 30-38; *ESA Annual Report. 1984*, pp. 66-67. See also chapter 13 of this volume.

2030 HAEUI, ESA/C(81)58, Space Transportation Systems Long-Term Preparatory Programme, 7 October 1981. On the scientific debate surrounding the use of Spacelab, see chapter 14.

Cooperation with the US, from a political and a technological point of view, had always been considered an asset and long-term priorityt[2031]. This appeared to be all the more true, as we shall see, if European wanted to have a say, in the short term, in the field of manned activities in space.

As anticipated by Quistgaard during a meeting with his NASA counterpart in November 1981, there was, therefore, at high political level, a strong willingness not to let the ISPM affair spoil the overall rewarding record of a cooperation[2032].

US behaviour in the ISPM affair, however, was judged by Quistgaard not to be "up to the normal standard for international relations"; in general, as we shall see later, it left in heritage a strong European sensitivity on the clause making reference to "availability of funds" and on the legal form of agreements[2033].

On the other hand, in the light of the Spacelab experience, some features of the international agreement which retrospectively appeared as "major inconsistencies" should be avoided. A report presented to IRAC at the beginning of 1982 grouped them around two major items:

- lack of clarity on the precise definitions of the commitments and responsibilities, and ambiguities with regards to the content of the deliverable items and the post-delivery phase of the programme;
- the fact that after delivery, Spacelab remained the property of ESA, which enjoyed no rights but carried considerable responsibilities throughout the Spacelab flights, whether European experiments were carried or not – questions of ownership, liability and intellectual property rights.[2034]

Spacelab and ISMP legacies induced Europeans to be more assertive *vis-à-vis* their hegemonic partner: trying to avoid repeating old patterns, Europeans strove for legal guarantees and respect for their own rights in the rules governing the development and operational phase of any future cooperative programme. Generally speaking, their enthusiasm towards cooperation became more qualified[2035].

That is why both Germany and France seemed determined to make sure that studies on future multi-purpose platforms retain a sufficiently independent and original nature. France insisted on the need "to achieve a measure of independence" meaning independence on both platforms and the means to reach them, i.e. launchers. In this context the French Delegation reminded its partners of an official statement by NASA's Director of International Affairs, Kenneth Pedersen, "warning the Council of the limitation involved for Europe of pursuing a policy based too narrowly on cooperation with the United States". The UK shared this cautious attitude, while Italy stressed the interest in taking advantage of the efforts devoted to Spacelab and made clear that, should ESA abandon plans for in-orbit structures,

2031 See, for example, Pfeffer Papers, ESA HQ, Paris, France, ESA/LTT-PC(84)3, Long-Term Space Transportation Systems Preparatory Programme Committee, 16 March 1984.

2032 HQ ESA, Lafferranderie Papers, Space Station Negotiations Meetings, Notes on Meeting between James Beggs and Erik Quistgaard, 3 November 1981.

2033 For a lively account of the ISPM affair, as seen from the European perspective, Roger Bonnet and Vittorio Manno, *op. cit.*, pp.89-108.

2034 HAEUI, ESA/IRAC(82)R/2, 15 January 1982, Annex III, Report on possible extension and/or expansion of the cooperation established between Europe and the United States of America in the Spacelab programme, June 1981. The report was prepared by a remarkable working group consisting of J.Arets, J.L.Collette, F.Emiliani, R.Reinhold, G.Seibert.

2035 *Ibid*.

Italy would probably incorporate any such programme in the Italian national effort and look forward to cooperating on bilateral terms with NASA[2036].

The need to keep the door open for both possibilities – autonomous and cooperative tracks – induced a certain flexibility in European attitudes, which from time to time seemed to border on ambiguity. As remembered by the Director of Space Transportation Systems in 1983 "it was necessary for Europe to carry out studies over a sufficiently wide area to avoid being outflanked by NASA, and to proceed empirically while keeping itself informed about the progress of studies in the United States"[2037].

While the development of an independent and competitive launcher system could be said to be a clear-cut policy of ESA by the beginning of the 1980s (though the nature of this competitive launcher, reusable or expendable, was unclear), policy on the space station seemed unresolved. Should Europe participate in the US Space Station as an intermediate step towards acquiring an independent manned spaceflight capability? Should it participate in the station by means of autonomous elements, eventually to be flown independently?

For the moment, Europe was determined to proceed with a vast array of independent studies on in-orbit infrastructures and manned modules. At the same time, as observed by the French delegation during a Council meeting of June 1982, the Europeans should seek to "establish the list of principles that should govern any transatlantic cooperation"; they should, in other words, have a say in the formal arrangements leading to a future cooperation. "Europe's situation" as seen from the same delegation "was indeed better than it had been at the time of the post-Apollo discussions"[2038]: would ESA be able to exploit its better position in order to extract more favourable terms for cooperation?

15.4 The Preparatory Programme for Long-Term Space Transportation Systems (STS-LTPP).

A first draft of a document proposing a preparatory programme for the long-term space transportation systems was presented by the Executive as part of the ESA Medium Term Plan in June 1981 and then, in a revised form, in October 1981[2039]. The aim of the preparatory programme was to study, evaluate and assess the possible different paths of action for a future Space Transportation System, which would encompass both launchers and orbital infrastructures. It was therefore to be "paper work" for devising a comprehensive scenario to orient the future development programme to be started in the mid 1980s, when the successor of Ariane IV might be decided and when the US Space Station would probably start.

Preliminary studies, according to the Director of Space Transportation Systems, Michel Bignier, were required to ensure that the programme take account of the evolving space missions and have sound technical and economic bases in order to avoid possible financial overruns. The themes to be explored were the following:

- Maintain competitiveness with the US Space Transportation Systems for geostationary orbit and acquire it for low-Earth-orbit if needed for industrial exploitation.

- Continue a strong cooperation with NASA in the field of manned systems.

2036 HAEUI, ESA/C/MIN/53, Minutes ESA Council Meeting of 27-28 April 1982, 26 May 1982.

2037 Pfeffer Papers, ESA/LTT-PC/MIN/2, Long-term Space Transportation Systems Preparatory Programme Committee, 2nd meeting, 10 November 1983.

2038 HAEUI, ESA/C/MIN/54 (22-23 June 1982), 29 July 1982.

2039 HAEUI, ESA/C(81)58, Space Transportation Systems Long-Term Preparatory Programme, 7 October 1981.

- Develop an independent in-orbit capability which would permit Europe to acquire an autonomy for operation in-orbit, including return- to-Earth capability"[2040].

An agreement could not be reached at the Council meeting of October 1981, while an important development on a related topic, the Spacelab Follow-on Development (FOD) Programme, was accomplished: it was decided, under German pressure, to divide the FOD programme in two, proceeding, on the one hand, to Spacelab improvements and, on the other hand, to the development and experiments on retrievable orbital platforms, the future EURECA [2041].

In view of the urgency of the matter, and in the absence of specific financing, the Executive announced in April that advance financing had been taken from the general studies budget, so that work could begin in the three areas identified[2042]

In June 1982 the Council finally approved an "enabling" resolution concerning the Space Transportation Systems Long-Term Preparatory Programme (STS LTPP)[2043].

During the debate preceding the approval of the resolution, the German delegation emphasised the need to keep a balance between a "certain will for independence on Europe's part and the need for transatlantic cooperation". France suggested to pursue independent preparatory studies before embarking on negotiations with the US, in order to be better placed to discuss principles which should govern such cooperation. The UK was apparently the only country to favour an immediate start of transatlantic cooperation; this was justified by "a number of political, economic and psychological factors that provided grounds for thinking that a major cooperation programme with the United States could be embarked on in circumstances particularly favourable to Europe" at the time.

The UK delegation further "emphasised the opportunity that Europe could thus be given to advance in new fields such as robotics and it invited the Executive to provide for the next meeting of the Council the necessary information to enable it to assess more accurately the advantages that Europe might derive from cooperation in such a field".

With a slight modification compared to the document prepared by the Executive in October 1981, the STS-LTPP approved in June 1982 was centred around three directives:

1 maintenance of the competitiveness of European *launchers* for geostationary orbit (by increasing the overall cost-effectiveness) and extension of their competitiveness to the low

[2040] HAEUI, ESA/C/50 (27-28 October 1981), 30 November 1981.

[2041] Italy being the only opposing vote (for questions connected with industrial return, and The Netherlands abstaining); *cf.* HAEUI, ESA/C/L/Res. 6(Final), Resolution on a programme for Spacelab improvements, and for development of and experiments on retrievable orbital systems, adopted on 28 October 1981, Att. to ESA/C/MIN/50 (27-28/20/1981), 30 November 1981.

[2042] HAEUI, ESA/C(82)47, 27 April 1982.

[2043] HAEUI, ESA/C/LIV/Res. 1(Final), Resolution concerning the Space Transportation Systems Long-Term Preparatory Programme, approved on 22 June 1982, Annex to ESA/C/MIN/54 (22-23 June 1982), 29 July 1982. It should be noted that, from a legal point of view, this preparatory programme followed the normal process of any ESA optional programme (set out in Annex III of the ESA Convention), whereby, upon the submittal of a programme proposal by the executive, the Council, by simple majority of all member states, adopts an "enabling" resolution. This kind of resolution does not provide for a financial covering, nor does it oblige states to participate to the programme; it is just a judgement on the consistency of the programme with the aims of the Agency. A declaration must be then adopted by the Participating States with a unanimity vote, setting out "the content, technical and financial, the schedule of the programme and specific management rules" and the level of contribution of the participants. The programme can be sliced and during each phase, as defined in the declaration, the Council can, by two-thirds majority of all participating states, adopt annual budgets. See Gabriel Lafferranderie, *European Space Agency*, (The Hague: Kluwer Law International) 1996, p. 47.

orbit. The way to obtain this competitiveness – by expendable or partially reusable launchers – was not clarified and would be a source of quarrels in the years to come[2044].

2 development of an *orbital infrastructure* providing Europe with its own system for orbital operations, including return-to-Earth capability. Studies on the orbital system should be conducted, according to the German delegation, "bearing in mind the possible consequence of cooperation with NASA, i.e. the risk of becoming dependent"[2045].

3 analysis of solutions implying European access to *manned orbital systems*, either independently or in cooperation with the US[2046].The participation in the US space station programme, which would be the subject of the Phase-B studies, was considered as a step towards "the acquisition of a full autonomous manned capability by Europe, the aim being for Europe to have a full operational capability in the 21st century allowing to conduct particular industrial space activities"[2047].

The preparatory programme would be an optional programme, even if the resolution suggested that, in the future, it would be possible to incorporate it within ESA's mandatory activities[2048]; it would be started once the threshold of 80% of the financial support was reached.

Despite the approval of the "enabling" resolution, the programme did not take definite technical and financial shape for many months. European governments showed a prudent attitude towards it; by the end of 1982, only the UK, Germany, Sweden and Belgium gave their financial support[2049]. The minimum necessary to start the programme was lowered from 80% to 75% and the deadline to notify acceptance prolonged to 15 January 1983[2050].

The entrance into force was then unexpectedly delayed, due to the lowering of the Spanish contribution on consideration of what it considered to be a low industrial return; after lowering the threshold yet again to 73%, the programme finally started in February 1984, more than eighteen months after the approval by the Council of the enabling resolution.[2051]

Meanwhile, from September 1982 onwards studies on the hardware of the future space station had been conducted by European industry. These covered a number of major European candidates for participation in the American Space Station, comprising elements derived from Spacelab (Spacelab-derived laboratory modules, logistic modules, pallets and the common space station module) and EURECA (co-orbiting platforms), as well as a new system, i.e. a tele-operated service vehicle (TSV) or servicing element. The studies, completed by April 1983, were presented to both ESA delegates and NASA.[2052]

2044 See, for example, the discussion held at the LTT-PC of 3-4 April 1984, where Pfeffer's idea about the opportunity to continue a technological studies programme to test the feasibility of a reusable or partially reusable launcher was opposed by many delegations; *cf* Pfeffer Papers, ESA-LTT-PC/MIN/3, *cit.*

2045 HAEUI, ESA/C/MIN/51, Minutes of the Council Meeting held on 9-10 December 1981, 18 January 1982.

2046 In the earlier version, this last point made only reference to the "continuation of substantial cooperation with the United States regarding manned systems", see HAEUI, ESA/C(81)84, Long-term space transportation systems Preparatory programme proposal, 25 November 1981.

2047 Pfeffer Papers, ESA/LTT-PC(84), rev.1, *cit.*

2048 The executive had proposed that the programme be financed through the budget for general studies, in which contributions were decided on a GNP basis, but the proposal was dismissed for the time being.

2049 HAEUI, ESA/C(82)92, Preparatory Programme for Long-Term STS, Declaration on Status Report on Subscriptions, 7 October 1982; ESA/C(82)92, rev.2, Idem, 22 November 1982.

2050 HAEUI, ESA/C(82)92, Rev.1, 27 October 1982.

2051 HAEUI, ESA/C(82)92, rev.2, att. to ESA/C/LV/Dec. (Final) rev.2, Declaration on the Preparatory Programme for Long-Term Space Transportation Systems, amended 23 February 1984; ESA/C(83)5, PP LTSTS Entry into force, 17 January 1983.

2052 Pfeffer Papers, ESA/LTT-PC(83)4, Status Report on programme execution, 16 September 1983; see also *ESA Annual Report* 1985, p.68.

Because NASA was then following an approach whereby the Space Station should be built from common sub assemblies and components, ESA studies emphasised that Spacelab-derived modules were suited to fulfil this commonality requirement, due to existing designs, qualified equipment and available manufacturing tools and could lead to cost reductions compared to new designs.

From April 1983, European preparatory studies were coordinated by the newly established Long-term Space Transportation Preparatory Programme Committee (LTT-PC), under the chairmanship of F.W. Olivier (from the Netherlands)[2053]. Once the Directorate of Space Transportation System divided in two (1985), this committee would establish "a functional link across existing programme divisions", the one on launchers and the one on space platforms. From a managerial point of view, both the Spacelab and Ariane Programme Boards would follow the STS-LTPP's work closely [2054].

15.5 Columbus up to its presentation to the European partners.

ESA-sponsored space station work was paralleled by bilateral German-Italian efforts, which up to 1984were performed outside the ESA framework.

Industrially, this initiative was born out of the desire to further build on the knowledge acquired in inhabited modules by the two leading firms, MBB/ERNO and Aeritalia, during the 1970s. "Having developed Spacelab and SPAS" declared Gerhard Blechert, Assistant Head, Space Technique Division, for the German Ministry for Research and Technology "and being in the development phase for Eureca, it would be unwise not to take this hardware into account"[2055]

Strategically, the effort was viewed as "an effort by the two countries to secure a lead role in ESA's future space station activities"[2056]. Political and industrial control of what was seen as a major, yet undecided, cornerstone of a long-term European space policy and major focus of cooperation with the US was a palatable aim for both countries.

Italian socialist leader Bettino Craxi seemed especially prone to look for an international legitimisation of his newly-formed government (formed in August 1983) – the first to be directed by a socialist since the end of the war – and to assure American support.

In the Federal Republic of Germany, the Christian Democrat parties, the CDU of Helmut Kohl and the CSU of Franz Josef Strauss, won the elections of March 1983, in a period of industrial recession. The traditional Atlanticism of the CDU, reinstated by Kohl, was coupled with Strauss's long-term policy aimed at strengthening the German position in high-technology industry[2057].

Tactically, it was a low-key modular approach, i.e. an evolutionary method envisaging an "incremental route" which might be "an easier sale to the politicians" [2058].

Bilateral contacts between MBB/ERNO and Aeritalia, ERNO and Aeritalia being the two leading partners in the construction of Spacelab, had intensified since the end of 1982 in order to set up a joint

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[2053] Pfeffer Papers, ESA/LTT-PC(83)4, Status Report on programme execution, 16 September 1983.
[2054] K.Madders, *op. cit.*, p. 293.
[2055] Cited in Jeffrey Lenorovitz, "ESA Pursuing Space Station Role", *Aviation Week and Space Technology*, December 5, 1983, pp. 16-17.
[2056] *Ibid*, p. 17.
[2057] For the Italian and German cases, see Giuseppe Mammarella, *Storia d'Europa dal 1945 ad oggi* (Bari:Laterza) 1992, pp. 501-504 and 513-516.
[2058] William Gregory, "Space Station. European Style", *Aviation Week and Space Technology,* December 19, 1983, p.13.

project to exploit the experience acquired in inhabited systems and to use, in a modified version, the hardware developed for Spacelab[2059].

From the very beginning, they thought to create a group of companies acting as a mediator between the scientific communities and corporate laboratories committed to microgravity research on the one hand, and providers of facilities (Spacelab, Eureca, Columbus) on the other – the European company *Intospace* was eventually established in October 1985 and became active in 1986, promoting the utilisation of space laboratories and flight opportunities.[2060] "The hope was originally", one commentator has noted, "that a regular stream of Spacelab flight opportunities, at reasonable costs, would then in a few years give way to long-term, long-duration experimental facilities on the International Space Station". Actually, the soaring costs of the Shuttle flights, the Challenger's accident and the uncertainties of the Space Station made coalition building extremely difficult.[2061]

The Italian Ministry of Research and its German counterpart were contacted by their respective firms and gave their support to the idea of a joint project. Manfred Fuchs, responsible for the future activities of ERNO, went together with Ernesto Vallerani, manager of Aeritalia, to Dr Greger of the BMFT, in charge of space-related activities. "In the professor's office" recalls Vallerani "we had to make room on his desk to lay out a large sheet of paper on which I illustrated our collaboration project in the form of blocks. There was one module attached to the space station and a laboratory on the same orbit for more sophisticated experiments, which would link up with the station from time to time. The former would first see the light of day in Italy and the second in Germany".[2062]

By the end of 1983, the project had developed into a pressurised module, Columbus, derived from Spacelab, capable of docking with the station for long-duration missions – the module would be compatible with the Shuttle orbiter's payload bay, since it retained the sizing for equivalent modules developed for Spacelab; a free-flying service module as a support/link vehicle to the space station, provided with a solar array to provide electrical power during free flight to and from the station; crew transfer could be handled by a manned Columbus unit derived from the pressurised module.[2063] Hoffmann and D'Emiliano were put in charge of the project, in ERNO and in Aeritalia, and it was decided to name it after the Italian explorer Columbus, following a suggestion of Fuchs.[2064]

Bilateral contacts between each of these two governments and the US were also progressing. They were probably facilitated by the parallel negotiations that the two governments were separately conducting with the US for the installation of intermediate-range nuclear missiles on their soil. Shortly after the two Parliaments approved deployment, arousing vast public protest, in November 1983, delivery began of Cruise Missiles to Italy and of Pershing-2s to the Federal Republic of Germany.[2065]

The Federal Republic of Germany took the political lead in approaching the US on the subject of a future collaboration on the Space Station. The German Minister for Research and Technology, Heinz Riesenhuber, visited Washington in May 1983, met Beggs and discussed with him the prospects of collaboration in a space station programme. The visit was followed by a letter sent by Riesenhuber to Beggs in which the Minister expressed his deep interest in coordinating "as early as possible, even

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2059 When not specified, information is taken from Ernesto Vallerani (edited by Giovanni Caprara), *Italy and Space. Habitat Modules* (Milano:McGraw-Hill Libri Italia), 1995.

2060 Intospace is owned by 66 shareholders.Its services include "the provision of flight opportunities and experiment facilities as well as the elaboration and carrying out of research concepts for industrial and academic researchers", *European Space Directory 1997*, p. 196

2061 K.Madders, *op. cit.*, p. 528.

2062 Ernesto Vallerani (edited by Giovanni Caprara), *Italy and Space. Habitat Modules*, *cit.*, p. 137

2063 *Ibid*, see the Appendix. The configuration of Columbus was due to change in later years; see E.Vallerani, *op. cit.*, p.141 and Jeffrey Lenorovitz, "Germany, Italy Propose Space Station", *Aviation Week and Space Technology*, 20 June 1984, pp. 55-56.

2064 E.Vallerani, *op. cit.*, p. 138.

2065 "Missiles delivered to Italian, German Bases", *Aviation Week and Space Technology*, 5 December 1983, p. 17.

prior to the final decision, the possibilities of a European participation in a space station in the now ongoing preparatory phase". Building upon the experience acquired during the Spacelab programme, Germany could guarantee, continued the Minister, "the necessary political and programmatic prerequisites for a European participation in the space station"[2066].

The formal involvement of ESA in the Columbus programme started with the presentation of the Columbus paper ESA/PB-SL(84)13 dated 19 January 1984 – a few days before Reagan's offer about the internationalisation of the Space Station.

In January 1984, Aeritalia entered an industrial grouping with Boeing and Rocketdyne, for a call for tender for studies on the Orbital Maneuvering Vehicle (OMV), for transferring payloads between the Station and orbiting platforms[2067]. This initiative was "totally uncoordinated" with ESA's policy *vis-à-vis* the question of the Space Station[2068]. In March the Italian Prime Minister Bettino Craxi, very pugnacious and active at the time on many different fronts, informed the American President that the Italian Cabinet had already given the green light to the study of the terms of significant cooperation in the space station[2069].

15.6 Getting users aboard. A missed opportunity?

The *identification of potential users* was high on the agenda of the ESA leaders since the start of the programme. The question of how to guarantee substantial returns for their space investments was a controversial matter: everyone agreed it was important, but no own knew how to to proceed with an effective strategy.

This was all the more true in the case of in-orbit manned infrastructure. "In Europe" wrote Michel Bignier, Director of Space Transportation Systems at the time, "the user community, and particularly the scientific community, has been a little disappointed with European participation in manned systems because mainly of the delay of Spacelab flight and the high utilisation cost of the Shuttle and thus of Spacelab flight. Therefore, we should be extremely careful in approaching them with the idea of participation in another even larger manned programme". Users' support was therefore seen as an essential precondition in Europe, as it had been in the US. In order to gain their support, users had to be involved in the evaluation of the programme from an early stage [2070].

The Eureca programme for the construction of a European Retrievable Carrier, launched as an ESA optional project in April 1982, was indeed developed not only to keep the expertise acquired in the domain of unpressurised platforms, but as a tool to "to pursue the effort of building up the user community's interest for the immense capacities of the Space Station". Users should be attracted from both sides of the Atlantic. To this end, ESA maintained close contacts with NASA, in order to monitor and assess their parallel studies in the sector of utilisation [2071].

A study on the "European utilisation aspects of a manned space station" (EUA-I) was set up in September 1982 by DFVLR, together with a number of European industrial sub-contractors, and

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2066 On Germany, see John Logsdon, *Together in orbit: the origins of the international participation in Space Station Freedom,* unpublished paper supported by NASA under contract number NASW-4237, December 1991, pp. 87-91; see also Letter Riesenhuber to Beggs, 27 October 1983, quoted in J.Logsdon, *op. cit.*, p. 88.

2067 The bid being publicised on 3 January 1984, the industrial response came on 14 February 1984; see Pierre Langereux, "Project Boeing-Alitalia de remorqueur interorbital (OMV)", *Air et COSMOS*, n.995, 31 March 1984.

2068 Van Reeth Papers, Space Station,1, Inter-office Memorandum Dattner to DG, 10 April 1984.

2069 The letter is quoted in J.Logsdon, *Together in Orbit*, *cit.*, p. 65.

2070 (HAEUI) ESA Washington office, Michel Bignier, Director of Space Transportation Systems, to B.I. Edelson, Associate administrator for Space Science and Applications, 25 August 1982.

2071 ESA HQ, Paris, France, CAB/INT/I.31/KB/MTL/11303, Letter Lüst to Jim Beggs, 20 November 1986.

lasted until April 1983[2072]. Based on a series of questionnaires sent out to scientists and industries, the study identified a number of potential users and requirements, covering a vast range of scientific and technological disciplines, from basic and applied research in materials processing and in life science to astronomy, from Earth observation to technology demonstration and testing. In order to specify the preliminary results of the first phase, which established the general interest for many potential users of both manned systems and orbital platforms, a second phase of the study on "European utilisation aspects of a manned space station" (EUA-II) was set up in September 1983 (lasting until July 1984) in order to prosecute the identification of potential users of the Space Station and to establish a preliminary definition of their requirements through the development of model payloads[2073].

As a general result, attitudes developed at the time of Spacelab were confirmed[2074]:

1 the classical space science disciplines, such as astrophysics and solar system exploration, did not see a need for a Space Station in the next 10 years. On the contrary, they were concerned that a participation in Space Station development might reduce the funds available to their discipline;

2 strong support for the programme of manned systems came from the life science community, especially human physiology and medicine; man was considered an irreplaceable "experiment interface" in most other areas such as gravitation biology, animal and plant experimentation, biotechnology and processing;

3 unmanned platforms were strongly supported by the material science and processing community, especially those interested in microgravity payloads. The most important advantages perceived were unconstrained mission duration, abundant resources in term of electrical power and crew time and new services offered to experimenters. Because of the experimental stage of these disciplines, it was forecast that experiments should be performed in iteration in order to establish a scientific base for microgravity applications. Therefore, in most instances, the use of occasional astronaut intervention was advocated, as least in a first phase.

4 unmanned platforms were also strongly supported by Earth observation disciplines, in order to carry their large and sophisticated instrumentation. As a particular requirement, scientists stressed the necessity for orbits with high inclinations, whereas most microgravity platforms were expected to fly in low inclination orbits. Equally important, in order to experiment new technologies, they tended to prefer dedicated satellites [2075].

The response to the questionnaires helped to signal that it was difficult to establish effective contacts with commercial firms outside the established space community, which had however a product range that might benefit from the exploration of microgravity. Metallurgical industries, semi-conductor manufacturers and pharmaceutical companies seemed to have difficulties in fully understanding the opportunities offered by the Space Station or, alternatively, they were not disposed to invest money in order to identify them.

2072 Under ESA contract n. 5243/82, during the period September 1982-April 1983, then extended from September 1983 to June 1984; Pfeffer Papers, ESA/LTT-PC(84)3, Long Term Space Transportation Systems Preparatory Programme Committee. Results of the first study phase, 16 March 1984.

2073 Pfeffer Papers, ESA/LTT-PC(84)3, cited; see also: (HAEUI) ESA Washington Office, Space Station System Study, ESA, STS/LTPO/GP/fm/7502, 2 August 1983; (HAEUI) ESA Washington office, European utilisation aspects of low Earth orbit Space Station elements, phase III, prepared by K.K.Reinhartz, System Studies Division, 19 July 1984.

2074 See chapter 14.

2075 The paragraph on users draws on Pfeffer Papers, ESA/LTT-PC(84)3, cited and *Ibid*, ESA/LTT-PC(83)4, Status Report on programme execution, 16 September 1983.

In addition, in most areas, a considerable amount of basic and applied research in space would be needed before a real commercial exploitation could be expected. Spacelab and EURECA should therefore be used extensively in order to prepare the basis for an optimum utilisation of the Space Station.

Additionally, there were not, as in the case of telecommunication, entities who would offer services and make profits by intermediating between private citizens and the providers of technical support; there were only clients, who would use, for their direct benefit, the opportunities offered by the Station.

As a further step to increase effectiveness in the area of soliciting users to consider possible use of the Space Station, a scientific advisory group, named the Space Station User Panel (SSUP), was set up at the end of 1983, under the chairmanship of Professor Schnopper from the Danish Research Institute; it was formed by members designated by ESA user advisory bodies in order to link the executive and the various scientific advisory groups of the agency on matters related to the use of the space station. SSUP also interacted with ESA LTPP space station user study (EUA) carried out by DFVLR.

Unfortunately, SSUP lamented from 1984 what it considered an inadequate financial support within the Phase-B Columbus preparatory programme, from which its funds were made available, and unclear guidelines as for its specific powers *vis-à-vis* industries[2076]

The British Delegation, traditionally the most sensitive to the need to attract users to increase the legitimacy of space projects, suggested, with no luck, that COPA should not limit itself to choosing between experimenters, but instead build up an extended coalition of users from ESA and non-ESA areas, allocating funds to encourage them[2077].

The decision taken by the Columbus Board in 1987 to include the Columbus Utilisation Preparation Programme as an integral part of the Columbus Development Programme did not seem to reverse this trend[2078].

Looking back at this period, one feels that these efforts were made to assess the reaction of the scientific and industrial community, rather than to build up an extended consensus or to create new users for a new opportunity. Moreover, as a well-placed British observer later suggested, the user community seemed to be discouraged "with excessive and expensive procedures implemented by heavyweight managements"[2079].

Whether this was due to lack of vision and financial investment from the Agency, or to scarce away interest from private firms, remains a question to be investigated and assessed.

[2076] See HQ Paris, Lafferranderie cabinet [provisional], Inter-office memorandum, Roger M.Bonnet to DG, 26 April 1984; *Ibid*, ESA/PB-SL(84)wp/10, 25 October 1984; *Ibid*, Letter Herbert W.Schnopper to Michel Bignier, 17 April 1985.

[2077] ESA/PB-Columbus/MIN/3 (23-24 September 1985), 11 October 1985.

[2078] *ESA Annual Report, 1987*, p.72.

[2079] E.S.Rothery (Assistant managing Director, British Aerospace, Space and Communications Division), "Technical co-operation problems and procedures", Paper presented at the Eurospace 8th US-European Conference on "Co-operation in the international space station system", 22-24 April 1986.

B: The American offer and European reactions. 1984-1985

15.7 The American decision to build a Space Station.

References to a future space station rotating in low orbit can be found in NASA's documents, from the very beginning, as a goal of US long-term space policy [2080]. The Space Station programme endured a false start in the late 1960s, as a cornerstone of the ambitious post-Apollo programme, whose long-term objective was planetary exploration. The programme was later squeezed and focussed on a new reusable launcher, the Shuttle, which had been originally conceived as a transportation system to set up and support the Space Station.

In parallel, the goal of living and working in space was partially fulfilled by NASA using a dedicated system with limited evolutionary capability, Skylab, launched on 14 May 1973[2081]. Skylab, however, seemed more a technical by-product of Apollo and Gemini than a departure towards new paths in space exploration.

The interest in the Space Station was revived during 1981, after the election of the new President Ronald Reagan (November 1980). In April, NASA tested the Shuttle Columbia, the first ever reusable spacecraft. Columbia would be fully operational by the following year and "ready to provide economic and routine access to space for scientific exploration, commercial ventures and for tasks related to the national security"[2082].

In July 1982, Ronald Reagan launched a three-fold space programme embracing civilian and commercial programmes as well as national security; in this context, the President referred to the necessity of looking "aggressively to the future by demonstrating the potential of the Shuttle and establishing a more permanent presence in space"[2083].

The process leading from these first manifestations of interest into a comprehensive programme was long and difficult. The Space Station was not greeted with universal enthusiasm in the US administration and in scientific circles. Since the first discussions, criticism spread over a number of different considerations. The Office of Management and Budget and the House Appropriations Subcommittee were against the project for budgetary reasons. The Office of Technological Assessment of the Congress, at first a charitable supporter, became after 1985 pessimist about the possible application activities to be performed on the Station[2084].

[2080] Howard McCurdy, "The decision to build the Space Station. Too weak a commitment?", *Space Policy*, November 1988, pp 297-306; as a starting point, McCurdy cites a long range plan of NASA dating back to December 1959, see *art. cit.*, p. 298. More generally, on the decision to build the Space Station see Howard McCurdy, *The Space Station Decision: Incremental Politics and Technological Choice*, (Baltimore, Johns Hopkins University Press), 1990.

[2081] After hosting three scientific missions, Skylab dropped into the atmosphere and disintegrated on an inhabited area outside Perth, Australia, on 11 July 1980.

[2082] Speech of Ronald Reagan at Dryden Flight Research Facility, 4 July 1982, partially reprinted in LG82-1732 (1), NASA HQ, 9 March 1982.

[2083] The speech was given during the landing of the fourth Space Shuttle mission on 4 July 1982; cited in Hans Mark, *The Space Station. A Personal Journey* (Durham: Duke University Press) 1987, p.249.

[2084] H.McCurdy, *art. cit.*, p. 300; see also by the same author, *The Space Station Decision: Incremental Political and Technological Choice*, *cit.*, pp. 1-2 and pp. 157-168.

The National Security Council and the Presidential Science Advisor were against the project in part because they prioritised the concurrent SDI, in part because they wanted to reserve NASA's money to make the Shuttle operational. Presidential Science Adviser George A. Keyworth criticised the idea of men in space altogether, preferring robots and automated means; on the other hand, he accused NASA of not providing President Reagan with a range of visionary options for expansion of the space programme, which should involve a new view of man's ability to range throughout the solar system[2085].

The DoD and its Secretary Caspar Weinberger were equally vigorous in opposing any foreign participation, for security reasons and technology transfer concerns and, during the final stages of the elaboration of Reagan's proposal, they opposed the civilian Space Station altogether, as competing with the SDI in a context of constrained financial support[2086].

Some high level officials of the State Department, as well as some Presidential advisors, shared the DOD's point of view and were instrumental in delaying high-level approval of the concept[2087]. Indeed, as one commentator noted, "the absence of an inter-agency consensus in support of the programme portended future instabilities" from the very beginning[2088].

Technically, the choice of a Space Station programme, to be assembled in orbit, clearly emphasised NASA's interest in fostering the manned aspect of its programme. Financially, the Space Shuttle development beginning to wind down, NASA was in search of a challenging new start in space which should build upon the opportunities offered by the newly developed reusable Shuttle and the optimal use of NASA’s resources. As noted by the Office of Technological Assessment in 1984, it was fairly clear that, as the Shuttle development programme was coming to a close, "thousands of in-house engineers and technical support staff and, in principle, as much as $ 2 billion (1984$) per year in contract funds under its present $ 7 billion (1984$) 'budget envelope'" would be freed up to be applied in new programmes[2089].

As for the international involvement in the Space Station programme, as early as 1974, Arnold Frutkin, who had been responsible for cooperation with the Europeans almost since the inception of NASA and who was then Assistant Administrator for International Affairs, suggested that "it would be easier to get domestic clearance to explore a space station internationally than to get domestic approval for a space station *per se* before inviting international participation". It was therefore necessary, in his opinion, to find an approach "in which all elements of the project would be attacked on an international basis: justification, definition, design, construction, operation and use". A single "strawman" concept should be formulated from the very inception of the programme, i.e. Phase-A [2090].

The two pillars identified by Frutkin were therefore early international involvement and joint work; we will see how they would be alternatively adopted or discarded by the different branches of the administration during the early phases of negotiations with Europe, ten years later.

2085 "Reagan urges NASA to be more visionary", *Aviation Week and Space Technology*, 24 October 1983, p. 25; see also H.McCurdy, *art. cit.*, p. 299.

2086 Caspar Weinberger to James Beggs, 16 January 1984, reproduced in John Logsdon (ed.) with Dwayne Day and Roger Launius, *Exploring the Unknown. Selected Documents in the History of the US Civilian Space Program. Vol II: External Relationships* (Washington DC: NASA), 1996 , pp. 600-601.

2087 John Logsdon, *Together in orbit: the origins of the international participation in Space Station Freedom*, cit., pp. 39-40 and pp. 42-43.

2088 *ibidem*, pp.134-135.

2089 Congress of the United States, Office of Technology Assessment, *Civilian Space Stations and the US Future in Space*, Summary, OTA-STI-242, November 1984, p.9.

2090 Rensselaer Polytechnic Institute, Troy, George Low Papers, Arnold Frutkin, Memorandum to Deputy Administrator, "International Space Station Approach", 7 June 1974, reproduced in John Logsdon (ed.) with Dwayne Day and Roger Launius, *cit. Vol II*, pp. 87-90:87.

International involvement was presented by NASA since November 1981 as an essential feature of the future programme. Cost sharing, access to others' valuable expertise and improvement in the linking of foreign programmes to the utilisation of the American shuttle and future Space Station were seen as its prominent goals.[2091]

International cooperation was also internally "sold" as a way to divert foreign money from competition. If the US could attract international cooperation, said Beggs in mid-1983, "then other nations will be cooperating with us in the resources that they spend, rather than competing with us"[2092]. The broader the enterprise into which allies would be tied, the less would be the money available to them to begin potentially competing programmes.[2093] Quite understandably, this was a way to sell the programme to the President and his entourage more than to prospective partners.

Cooperation, however, should be "properly structured and controlled". As a first rule, planning should proceed as if the Space Station were an autonomous national enterprise; potential partners should be invited to prepare studies for an eventual future participation[2094] (in this sense, Frutkin's original concept was altogether altered).

A first official meeting to inform potential partners was convened by NASA's International Affairs Chief Kenneth Pedersen at the Johnson Space Center in Houston, Texas, in January 1982, i.e. two years before the Presidential endorsement of the Station [2095]. A study group to discuss the internationalisation of the Space Station was later jointly set up by NASA and ESA. It was chaired by Ivan Bekey and Robert Freitag of the NASA's office of Manned Space Flight and Jacques Collet, Head of the Long-term Programme Office of the Directorate for Space Transportation Systems[2096].

Despite opposition, the idea did get through on the American side and a constituency of high level officials from NASA, the State Department (Undersecretary for Political Affairs and Bureau of European and Canadian Affairs), the CIA and Presidential advisors was successful in getting the idea of internationalisation through the Presidency at the beginning of 1984.

If it is clear by now which tactics were adopted by the proponents of foreign intervention to sustain their point of view, it is unclear why the promoters eventually won and why, after an apparently hurried intervention, the issue of international participation was added to the State of the Union address delivered by President Reagan on January 25 1984, which we have already referred to in the introduction[2097].

The speech was indeed focussed on glorifying "America's pioneer spirit" and, building over it, to spur modern expansion towards space as one element of American power. In this context, the offer to American "friends" and the invitation to other countries "to participate so we can strengthen peace,

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2091 See the report of the workshop on Space Station planning convened by NASA in November 1981, cited in John Logsdon, *Together in orbit*, *cit.*, p.20. The paper is the best and most accurate account of the origin of the international involvement in the Space Station programme up to the Presidential address of 1984. On the early phase of negotiations, see also Joan Johnson-Freese, *Changing Patterns of International Cooperation in Space* (Malabar: Orbit Book Company) 1990. More generally, see J. Logsdon, "International Cooperation in the Space Station Programme", *Space Policy*, 1991, pp. 35-45.

2092 Quoted in Mireille Gerard and Pamela Edwards (eds), *Space Station: Policy, Planning and Utilisation* (New York: American Institute of Aeronautics and Astronautics) 1983, p. 4, *cit.* in J.Logsdon, *Together in Orbit*, *cit.*, p. 35.

2093 K.Madders, *op. cit.*, p. 456.

2094 *Ibid*.

2095 J.Logsdon, *Together in Orbit*, *cit.*, pp. 22-23.

2096 J.Logsdon, *Together in Orbit*, *cit.*, p. 20, footnote 17.

2097 Van Reeth Papers, Space Station, 1, Telex Beggs to Quistgaard, 25 January 1984; *Ibid*, Telex Quistgaard to Beggs, 26 January 1984. It is maybe worth noting that the passages referring to the "pioneer spirit" were accompanied by laughter fromy the joint session of Congress. An extract of the State of the Union Address is reprinted in *Weekly Compilation of Presidential Documents*, vol. 20.

build prosperity, and expand freedom for all who share our goals" was clearly subordinated to the acceptance of American leadership by future allies.

How did the station NASA was thinking about look? Its modular elements would be launched and tended by the Shuttle and assembled in low orbit. The station would provide work space, utilities (electricity, data processing, thermal control), docking ports and living quarters for a crew of six to eight that would rotate every three to six months; it would consist of both attached pressurised operations modules and free-flying unpressurised platforms. It would be used for scientific and technological research and commercial manufacturing of critical materials and pharmaceutical, assembly, service and repair of satellites and other large space structures and, finally, research focussed on extending man's capacity to stay in space. The price of the enterprise was approximately assessed as $ 8 billion. Participation from partners could range from use of the completed space station facility all the way to participation in its development[2098]. Participation was initially assessed at about 10% of the total sum, i.e. about $ 800 million, a participation of the same order as Spacelab, which was said to have cost a final amount of $ 1 billion[2099].

In the NASA follow-up to the speech, it was also clarified that the station would be "a national facility", and the national security community would possibly use it "should such uses be identified"; linkages with SDI were however discarded[2100].

15.8 European early reactions

President Reagan's offer did not catch the European partners unprepared. As we have seen in the first part of this chapter, ESA had, since September 1982, carried out numerous studies on the definition of the most promising candidates for participation in the Space Station. At the same time, outside the ESA framework, bilateral German-Italian studies had been conducted on a pressurised laboratory, later to be called Columbus, and its applicability as a common module of the Space Station.

Member States found understandable difficulties however in coming rapidly to a common position. The bigger the enterprise, the bigger the financial risks involved and the more uncertain its economic returns, the more difficult it appeared to be to obtain the acceptance of eleven members (and two associate members, Austria and Norway), whose governments would have to promote the project in Parliament to get financial support. This was all the more true at a time of economic crises and the rising success of concepts like "liberalism", "free market" and "consumer interest".

If we add to that the fact that, despite official denials, the question of the potential military uses of the Space Station had always attracted the attention of the media and that elements of public opinion in Europe were by no means happy about Reagan's enthusiasm for Star Wars, we can understand under which unfavorable political constraints ESA governments were discussing the US offer.

On the top of that, in February 1984, just two weeks after the American offer, European leaders, as well as members of the French Government, seemed to be caught unprepared by President

2098 (HAEUI) ESA Washington Office, Washington DC, *The US Space Station. Background questions and answers*, NASA follow-up to the State of the Union Address; message sent by I.Pryke to ESA HQ on 2 February 1984.

2099 Pierre Langereux, "La NASA propose à l'Europe de coopérer à la 'Space Station'", *Air et COSMOS*, No. 993, 17 March 1984, pp. 50-51.

2100 *The US Space Station. Background questions and answers,* NASA follow-up to the State of the Union Address, *cit*.

Mitterrand's unexpected announcement in favour of a European space station with both civilian and military aims[2101]. Mitterrand wished publicly that "l'Europe soit capable de lancer dans l'éspace une station habitée qui lui permettra d'observer, de transmettre et de contrarier toute menace éventuelle, et elle aura fait un grand pas vers sa propre défense. Sans omettre les progrès du calcul électronique et de la mémoire artificielle, ainsi que la capacité déjà connue de tirer des projectiles qui se déplacent à la vitesse de la lumière"[2102].

As cautiously noted by the Executive few days later, this initiative, if pursued, would have changed the whole perspective of the European space programme[2103] – indeed ESA's purpose, as clarified in art.II of the Convention, was "to provide for and promote, for exclusively peaceful purposes, cooperation among European states (...)", not to speak about the possible repercussions of such a project for the Atlantic military partnership. As a matter of fact, Mitterrand's call never materialised and attention focussed soon again on the American offer.

Less than a month after Reagan's speech, ESA's Director General presented Council members with a draft text of a response in which the ESA Council should declare "immediately its interest in making a detailed study of the NASA proposals and in studying the possibility of European participation in the space station programme, having regard to Europe's long-term interests". The recent request for "Europeanisation" of Columbus and the STS-LTTPP studies were among the most important considerations leading the Executive to suggest an early acceptance [2104].

Member countries, however, felt that this declaration would be a much too formal engagement, waiting for further reflection on the Space Station relationship with their future long-term space plan and further clarification by NASA about the form and content of Space Station.

All but one thing was therefore clear by the first months of 1984: Europe wished "to be engaged in a genuine cooperative venture", which should form at the same time an "integral part of the overall European long term programme"[2105].

15.9 Towards a Long-Term Space Programme. Setting the stage for a new package deal in ESA.

The first purpose of ESA, according to its Convention, is to promote cooperation among member states "by elaborating and implementing a long-term European space policy, by recommending space objectives to the Member States, and by concerting the policies of the Member States with respect to other national and international organisations and institutions" (art II.a).

2101 President Mitterrand's speech was given at The Hague, on 7 February 1984, in front of the Parliament; the previous month, France had assumed the presidency of the European Council. Robert Walgate, "French vision of Europe and space", *Nature*, vol. 307, 16 February, 1984. It obviously elicited reactions and curiosity also in the US; see, *Hearings before the Subcommittee on Science, Technology, and Space of the Committee on Commerce, Science, and Transportation,* US Senate, 98th Congr., II Session 28 February and 1, 8 and 29 March 1984, serial no. 98-72, Statement of Ian Pryke, Head of the Washington Office, ESA, and intervention Senator Gorto, pp. 103-104.

2102 Quoted in P.L.[Pierre Langereux], "Le Président Mitterrand propose un nouveau défi à l'Europe", *Air et COSMOS*, n. 989, 18 February 1984, p.57; see also *Keesing's Contemporary Archives*, London, Longman, 1984.

2103 HQ Paris, ESA/C(84)R/6, Examen préliminaire des objectifs d'une politique spatiale européenne à long terme, 10 February 1984.

2104 HQ Paris, ESA/C(84)R/5 (23-24 February 1984), add.1, Annex,Cooperation between Europe and the United States in a Space Station programme, 13 February 1984.

2105 Van Reeth Papers, Space Station, 1, Memorandum, Space Station, CAB/INT/KB/DB, 7 March 1984.

Yet, in the struggle for development programmes, the strategic role of the Agency seemed to be somehow forgotten in the early 1980s. The Agency's activity orientation was still oriented towards the "old" package deal of 1973.

Internal and external elements provided a new impetus to reconsider the global role of the Agency as provider of a strategic view for the future. We already mentioned how the major programmes came to fruition by mid-1980s. This had a worrying repercussion on the financial side: ESA's future expenditure profile seemed gloomy, indicating a sharp decrease – of the order of 50% – in ESA expenditure by 1986. On the other hand, the American decision to build a space station seemed to be entering a crucial stage, while the German-Italian Columbus initiative had been presented to partners, as we have seen, in January 1984.

By the beginning of 1984, therefore, the time was ripe to begin exploring new directions for space development and the executive took the leadership in proposing new ventures to member countries. The new rationale proposed concentrated on some *buzzwords*, among which "coherence" seemed to be the most prominent:

- there should be "coherence" between the economic objectives and profitability of space adventures, in both new (Space Station) and traditional (Ariane) fields. The development of an orbital structure should go hand in hand with the planning of its future exploitation, in both commercial and scientific terms. Ariane should improve its commercial competitiveness by increasing its reliability and its power, possibly through a new large cryogenic engine,. The European plan should "closely link the development of the infrastructure, i.e. launchers and orbital infrastructures, to the users' requirements".

- institutional "coherence" should be reached between the various optional projects within a single rationale through the setting up of "an overall management scheme (within the Executive) and an institutional scheme (at Council level)" "to monitor and coordinate the various parts of the programme in which all Member States would be committed to participate". As a matter of fact, optional programmes, if they served to overcome the impasse of unanimity, tended to fragment the image of an integrated space effort. The insistence on a "coherent plan", on a strategic view encompassing a balanced development of science, applications and infrastructures (launchers and orbital infrastructures) was considered a necessity by the Executive.

- "coherence" between national and ESA programmes was a third requirement. Programmes should be integrated into a coherent plan, which would be organised around "phases", each having "intermediate objectives reached through progressive steps", leaving the possibility of schedule modifications or technical changes.

In this context, cooperation with the US should be incorporated within the overall goals, and not considered as "an objective *per se*, but as a way for Europe to reach its own objectives in less time and at less cost"[2106].

The document was presented and discussed by Member States during the restricted session of the Council meeting which took place on 23 February 1984. This was an important meeting because, for the first time, discussions on European participation in the Space Station and on long-term European planning came together. As we have seen, ESA members decided to postpone an official reply to the American offer; they decided, at the same time, to convene, after an interlude of nine years, a new Conference at Ministerial level, "to which a package of well prepared decisions should be submitted, together with budgetary consequences"[2107]. The way was open for a revival of European ambitions and for a new assertiveness *vis-à-vis* the American partner. In the concluding remarks, the Chairman noted

2106 ESA/C(84)R/6, 10 February 1984.
2107 ESA/C(84)R/8 (23 February 1984), 10 April 1984.

the common intention "to show firmness during the discussions with NASA" and the common desire to be considered "as an interlocutor and not as a client"[2108].

15.10 Clarifying American offer and European position.

Despite "the lukewarm Congressional reaction to the station program during 1984"[2109], however, NASA Administrator James Beggs, in his capacity of President's personal envoy, gave details of the invitation to Europe first to the Head of the ESA Washington Office, Ian Pryke, then during a visit to Europe in March[2110]. In this context, he visited London, Bonn, Rome and Paris; in this last city he met not only French representatives, but also the ESA Executive and a group of ESA member state delegations. The Canadian and Japanese Governments were also contacted at the time.

The space station, in Beggs words, had "high priority for President Reagan for political reasons", such as "demonstration of free world leadership", and would be "wholly civilian"[2111]. As was clarified in a subsequent meeting, the orbit of the Space Station, in general terms, did not meet the needs of the military; at most, one could foresee them "carrying out on-board experiments, which would be agreed to by NASA, provided that they were in line with the commitments entered into in the UN"[2112]. It was up to the participants to bid for the part they wished to develop; this contribution could be additional to the core station or directly part of it. This ambiguity entailed another one – on the conditions for Europe's use of the facilities, which were left undecided[2113]. Of equal relevance was the European request for technologically significant transfers, which the American representative considered "a guarded and sensitive area"[2114]. Despite the unclear status of the project, Beggs expected an indication of interest by Europe in six months and a commitment to go ahead with Phase-B studies in twelve months[2115]. As later clarified by him, the anticipated proportion of European financial involvement was set at 20-25% of the whole project, i.e. twice what had been expected initially.[2116]

At the same time, in March 1984, the NASA Space Station Task Force begun to publish a reference document, i.e. an official publication for the Space Station Programme (Activity Schedules). These schedules would be revised each month and would comprise both control milestone schedules and expected configurations.[2117]

At the political level, American position was further clarified in a letter sent by Beggs to the ESA Director General on 6 April 1984. The political nature of the project was again underlined ("the President believes that international participation in the manned Space Station program can provide a

2108 *Ibid*.
2109 J.Logsdon, *Together in orbit*, *cit.*, p. 135.
2110 The meeting with Pryke took place on 12 February 1984: see (HAEUI) ESA Washington Office, Fax Ian Pryke to DG, Luncheon Meeting with Mr. Beggs, 17 February 1984.
2111 Van Reeth Papers, Space Station,1, Inter-office Memorandum by K.Barbance, Mr Beggs' visit to London (5 March 1984), 6 March 1984.
2112 Pfeffer Papers, ESA/C(84)43, Space Station Programme, 20 April 1984, Annex, Account of the meeting between ESA Council delegates and the NASA Administrator. Mr Culbertson was also present on the American side.
2113 Van Reeth Papers, Space Station, 1, Draft Aide memoire for the visit to ESA of Mr Beggs, Administrator of NASA, 9 March 1984.
2114 "According to another source", specifies the report, "Mr Beggs answer was unforthcoming and gave no assurance on transfer relevant to non US participants"; Van Reeth Papers, Space Station,1, Inter-office Memorandum by K.Barbance, Mr Beggs' visit to London (5 March 1984), 6 March 1984.
2115 *Ibid*.
2116 Van Reeth Papers, Space Station, 1, Draft Aide memoire for the visit to ESA of Mr Beggs, Administrator of NASA, 9 March 1984.
2117 NASA, Space Station Task Force, *Activity Schedules*, March 21, 1984. John D.Hodge was responsible for the Task Force.

highly positive centerpiece for demonstrating Free World unity, goodwill and technological progress"), hence the exclusion of the Defense Department from the project ("While the Defense Department worked with NASA in the early planning for Space Station by reviewing their near and long-term requirements for space, they concluded they had no requirements for a manned Space Station").

Beggs also reiterated the idea by which international cooperation would be an addition, to be worked out by the partners, to the autonomous American Space Station. "[...] President Reagan" wrote Beggs "has committed the US to building an $ 8 billion fully functional Space Station to be operational by the early 1990s, but has also set the stage for working together to develop a more expensive international Space Station with even greater benefits and capabilities for us all to use". Beggs therefore invited Europe "to take a close look at our plans and concepts and then, based on your long-term interests and goals, share with us your ideas for cooperation that will expand the capabilities of the Space Station"[2118].

The "core" element of it should be made up of an habitation module, two laboratories, plus all basic facilities to support these. NASA would be conducting during the following two years an extended definition effort in order to minimise programme risk and maximise space station capabilities. By the end of this time, NASA expected to have a firm and responsive design, and be in a position to proceed towards hardware development. Europe should use this interval for intensive definition work (Phase-B) on its possible participation.

In plain words, Beggs' discourse seemed to suggest that NASA intended to entrust to US industry all the studies related to the various elements of the core station -and it would do so whatever the decision made by international partners as to their own involvement. In other words, "if Europe undertook to carry out certain Phase-B studies, this would not stop NASA carrying out the same studies". This was due both to the unwillingness to become dependent on Europe for certain elements of the Station and the intention to reserve, at least at the beginning, the totality of industrial work to American firms. If US firms intended to place contracts abroad during this stage, they would do so on their own responsibility[2119].

ESA, on the other hand, wished NASA to refrain from duplicating ESA studies from Phase-B and proposed that if "at completion of Phase-B, the Europeans [did] not undertake the development of part of [the] items they [had] studied, the results of their studies should be give free of charge to NASA".[2120]

Another area of controversy emerged during this first period, and related to the so-called "condominium scheme" proposed by NASA, whereby "ESA/Europe would become co-owner of the Space Station" against its contribution to the investments and to the basic exploitation costs of the station, i.e. those costs related to launches and services related to the operation of the space station.[2121] Who would guarantee Europe against spending billions of dollars in the US to pay its share of the operation costs, for which there was no clear prediction at the time [2122]?

Guidelines by the Executive on the principles which should guide Europe in its negotiations with the US focussed on some priorities such as:

[2118] Van Reeth Papers, Space Station, 1, Letter NASA Administrator James Beggs to ESA Director General Erik Quistgaard, 6 April 1984.

[2119] Pfeffer Papers, ESA/C(84)31, Status Report of the space station programme proposed by NASA, 24 April 1984.

[2120] Van Reeth Papers, Space Station, 1, Draft Aide memoire for the visit to ESA of Mr Beggs Administrator of NASA, 9 March 1984.

[2121] After some misunderstanding on the content of the expression, the expression "condominium scheme" was discarded; see Howard McCurdy, *The Space Station decision. Incremental Politics and Technological Choice* (Baltimore and London: The Johns Hopkins University Press), 1990, p. 203.

[2122] Van Reeth Papers, Space Station, 1, R.Fraysse, *Cooperation with NASA. A few critical problems*, attached to letter A.Dattner to DG, 10 April 1984.

1 "turning to account what has already been achieved and demonstrated through past programmes (Spacelab, seen as Europe's entrance ticket to manned space activities and the precursor of the modules constituting the space station);

2 increasing technological know-how of manned systems;

3 participating in the design, development, management and technical operation of an international station".

Europe's aim was "to arrive at autonomy in this area in the long term". In the view of the Executive, NASA's approach did not reflect European objectives. NASA, in fact, expected Europe to build a peripheral element of the station, e.g. an additional laboratory, and, at the same time, expected Europe to contribute substantially to the operating costs of the station (costs of the order of 10 to 20% of ESA's annual budget) through the "condominium scheme", so deeply influencing the future of Europe's long-term ambitions.

A choice had to be made between two alternatives:

1 either Europe decided to participate in the whole programme (development of a substantial element, utilisation of the station and participation in its operating costs) and "the United States treats Europe as a partner";

2 or Europe would limit itself to be a user of the system set up the US and might possibly make a peripheral contribution later on, participating in the operating costs in proportion to the use made of it [2123].

15.11 European contribution to the Space Station: from STS-LTPP to the Columbus Preparatory Programme

The broader rationale of European policy for Space Transportation Systems (launchers and in-orbit structures) beyond Ariane-4 and Spacelab FOD was summarised in these terms by the Director of Space Transportation Systems, Michel Bignier:

> *Preserving Europe's access to manned systems opened up by Spacelab by taking part in American space-station activities and giving thought to the evolution of European orbital infrastructures;*
>
> *The provision of a European capability to conduct orbital operations (including a return to Earth) by means of an orbital infrastructure developed independently or in cooperation with NASA within the framework of American space-station activities.*
>
> *The maintenance in Europe of an independent launch capability to meet the foreseeable requirements of European and other users which will be competitive with the transportation systems existing or planned elsewhere*[2124].

At the time of the US offer to Europe, therefore, the form of Europe's approach to the idea of a space station was still unclear. Technically, Europe should be able to choose either an autonomous scenario based on automated platforms or a participation to the US programme – the so-called "double option". The "double option" had been at the basis of the Long-Term Space Transportation Systems Preparatory Programme Committee (LTT-PC) since 1983, as we saw in Part A of this chapter. Still in

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2123 Pfeffer Papers, ESA/C(84)31, Status of the space station programme proposed by NASA, 24 April 1984.

2124 Michel Bignier, "Spacelab's Development", *ESA Bulletin*, No.36, November 1983, p.11.

1984, the Committee deemed important "to keep open the "non-participation" option"[2125]. Uncertainties regarding the concept of the Space Station, its development, its operating costs and the conditions for its use were widespread, while disagreements were already emerging on some critical points. That is why it was still deemed important to define an alternative path on the road to long-term European autonomy in manned systems.

At the same time, in case of cooperation with the US, it was suggested to develop an autonomous element (e.g. a laboratory), eventually to be docked to the station or a more integrated one, in the form of a subsystem , e.g. for electrical power generation or heat rejection[2126]. From a legal point of view, it would be wise to split the arrangement in two and wait until the Space Station's contents, operations and costs were better understood, through Phase-B, before embarking on a definite cooperative project[2127].

Studies based on the hypothesis of an "autonomous European scenario" were conducted as well as studies on the applicability of European knowledge to the future US Space Station. In the context of in-orbit infrastructure, IOI, what was even referred to as the "autonomous European scenario" – two parallel systems studies were eventually conducted by two industrial teams led, initially by Aérospatiale and Matra with its co-contractor MBB-ERNO[2128]. Important IOI elements in the automated scenario, controlled automatically from the ground, were considered to be the capability for automated rendezvous, docking and servicing of a platform by means of an *Orbit Transfer and Servicing Vehicle* (OTSV). This could be used either for transferring unprocessed material to the space processing facilities at a platform located in Low Earth Orbit (LEO) or for transferring material for Earth observation (LEO) or for transferring material to telecommunication platforms in geostationary orbit (GEO).[2129] Eureca could be used as one mission element within the perspective of a rendezvous and docking mission.

In April 1984, after the mid-term review, the Committee proposed a study plan for the continuation of this first phase of studies. Three meetings of the LTT-PC (3 April, 8 June and 9 July 1984) were devoted to review the proposals put forward by the executive for the second phase of the STS-LTPP.

The LTT-PC proposed a reorientation of the programme to directly support both the launcher studies for a future European launcher after Ariane-4 and the preparation of the strategy for approaching the US partner on the question of the Space Station [2130].

As far as this last point was concerned, the executive suggested:

1 a study to establish a mission model and a semi-reusable vehicle to test the possibility to perform rendezvous and docking missions in space as a prerequisite for advanced space operations such as assembly of spacecraft into larger units and the servicing of spacecraft in orbit[2131];

2125 Pfeffer Papers, ESA/C(84)5, 25 April 1984, Annex 1, Long-term Space Transportation Systems Preparatory Programme Committee, Concept of a long-term space transportation system programme -proposed approach, 20 March 1983 (quotation underlined in the original).

2126 Pfeffer Papers, ESA/LTT-PC(84)3, Long-Term Space Transportation Systems Preparatory Programme Committee, Results of the first study phase, 16 March 1984.

2127 Van Reeth Papers, Space Station, 1, Memorandum, Space Station, CAB/INT/KB/DB, 7 March 1984.

2128 *Ibid*.

2129 Pfeffer Papers, ESA/LTT-PC(84)6, rev.2, *cit.*

2130 Pfeffer Papers, ESA/LTT-PC(85)4, Situation of the STS - long term preparatory programme in the light of the Ministerial Conference in Rome, 9 October 1985.

2131 In particular, the IOI Part-2 study and the Advanced System and Technology Programme (ASTP) study on "GEO rendezvous and docking and its demonstration in low Earth orbit"; Pfeffer Papers, ESA/LTT-PC(84)6, rev.1, Long-term Space Transportation Systems Preparatory Programme Committee. Plan for 1984/1985 LTPP studies, 30 May 1984, p.7.

2 an advanced study on users (EUA III);

3 a transition study to get to Phase-B of the space station.

An "astonished" (consterné) Director of Space Transportation Systems had to confront the rejection by a majority of member states (Germany, Belgium, Spain, France and Italy) of the programme proposed – with Denmark, the Netherlands, Great Britain and Sweden favouring the programme[2132].

First of all, waiting to submit the Columbus programme for Europeanisation to the Council of June 1984, the German and Italian Delegations were cautious about embarking on a European programme which could compete with their pet project. Further studies on in-orbit infrastructures and the Space Station within the joint framework of the preparatory programme were therefore considered premature by the two delegations[2133].

Columbus would not only ensure a substantial industrial return to governments that had initiated it; it could also function as part of a package deal on which to base the future of the European Space Transportation System at large. Since April 1984, the German delegation predicted a future package deal between a decision on a Phase-B based on Columbus and the programme HM60, i.e. the cryogenic engine with powerful thrust which would be one of the elements of the future Ariane-5.[2134]

Disagreements on this option seem actually to be at the core of the rejection of the LTT-PC proposal. In particular, while it suggested that “the man-rating of a semi-reusable launcher should be much more straightforward than that of a fully expendable launcher, because of the high reliability already built into the reusable first stage", and therefore supported a technology programme in this direction, CNES wanted to freeze the Ariane-5 design to that of A5P, which did not allow a later evolution towards reusability. LTPP studies, carried out by Aérospatiale for ESA had, on the contrary, pointed out the benefits implied in the solution which provided for the direct development of a semi-reusable launcher after Ariane-4. The development cost of this alternative would not exceed that of A5P and it would have a lower recurrent cost. On the other hand, as we have seen, the semi-reusable concept appeared more straightforward than the Hermes space plane proposed by CNES, because of the high reliability already built into the reusable first stage. CNES, however, insisted on the development of A5P and Hermes, proposing the launch of Hermes in 1996/97 as an overriding justification for developing A5P[2135].

While the LTT-PC was favourable towards beginning a study on the long-term evolution of manned systems leading to European autonomous systems in the long term (including re-entry, unmanned and manned), supported, in various forms, by Great Britain, the Netherlands, Denmark and Sweden, France indicated that "in its view the future European launcher (after Ariane-4) would be expendable

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[2132] Pfeffer Papers, ESA/LTT-PC/MIN/3, Comité du programme préparatoire des systèmes de transport spatial à long terme, troisième réunion tenue à Paris les 3 et 4 avril 1984, 26 April 1984.

[2133] Pfeffer Papers, ESA/C(84)40, Long-Term Space Transportation Systems Preparatory Programme, Report by the LTT-PC Chairman following the LTT-PC meeting of 3 and 4 April 1984, 25 April 1984, Annex 1, The situation of the Long-Term Space Transportation Systems Preparatory Programme.

[2134] Pfeffer Papers, ESA/LTT-PC/MIN/3, Comité du programme préparatoire des systèmes de transport spatial à long terme, troisième réunion tenue à Paris les 3 et 4 avril 1984, 26 April 1984.

[2135] Pfeffer Papers, Inter-office Memorandum, Pfeffer to DG, ESA position on A5. Notes for the meeting of 24 October 1984, 24 October 1984.

and that further studies by the Executive and industry on semi reusable and interim expendable launchers [were] superfluous".[2136]

Finally, at the July meeting of LTT-PC, the Committee decided to reorient the second part of the LTPP: the allocation of money was concentrated on two programmes, Columbus and Ariane-5 (whose configuration had been selected by France in June 1984), 1.1 MAU being earmarked for each programme. The Space Station studies were therefore continued with the aim of preparing for the start of the Columbus Phase-B in as smooth a way as possible[2137].

The package deal which would be formalised in Rome some months later was born, showing, once more, that technology and technological assessment is just a part of the decision-making process. Final decisions, especially in an international context where everyone has to get rewards, follow a much more complicated pattern of considerations. In this case, we had a three-fold programme in which each large member state could find the fulfillment of a national aim: the French objectives were self evident, i.e., to take the leadership in the manned and unmanned launcher field; Germany saw its agreement on A5P as the price to get French consent to Columbus and to cooperation with the US (however, they seemed reluctant to see France assuming the same role for Hermes as for Ariane); Italy was interested in the solid propulsion work linked to A5P (even though it wanted prime contractorship in this area that CNES did not want to concede).

15.12 Columbus gets European

As we have seen in the first part, the Columbus proposal had been presented to the European partners in January 1984. During the following months, in order to get a better understanding of the content of the proposals, two co-ordination meetings and two further working level discussions were held between ESA representatives and DFVLR.[2138]

The proposal was further submitted to the review of LTT-PC and IRAC (International Relations Consultative Committee) in June 1984. IRAC noted the absence of any long-term philosophy to clarify the relationship between Columbus and the Space Station. In particular, it seemed that the FRG and Italy were thinking in terms of a customer role, i.e. as interpreted by LTT-PC, Columbus was to be seen "as a US STS/space station customer programme which (did) not contain the typical elements required for inclusion in a co-operative programme"[2139]. If this was the case, Columbus would be used by the Europeans, possibly dock to the Space Station and be submitted to any technical and financial requirement established by NASA.

IRAC, on the contrary, would prefer to see Columbus as being an integral part of the Station, open for use to any user; in this case ESA should accept some obligations, such as, for example, commonality, and should suffer the risks of the future cost of the station upkeep. On the other hand, it could be entrusted work connected with the common module and forecast returns for it in terms of a barter. This option would entail more difficult negotiations and higher costs, but would also guarantee a higher return in term of technological benefit and political prestige.[2140]

2136 Pfeffer Papers, ESA/C(84)40, Long-Term Space Transportation Systems Preparatory Programme Report by the LTT-PC Chairman following the LTT-PC meeting of 3 and 4 April 1984, 25 April 1984, Annex 1, The situation of the Long-Term Space Transportation Systems Preparatory Programme; *Ibid*, ESA/LTT-PC(84)6, rev.2, *cit.*; *Ibid*, ESA/LTT-PC/MIN/5, Cinquième réunion tenue à Paris le 9 juillet 1984, Projet de procès-verbal, 3 August 1984.

2137 Pfeffer Papers, ESA/PB-SL(84)31, Status Report of LTPP, 24 September 1984.

2138 The last working level discussion was held at ERNO; Pfeffer Papers, ESA/LTT-PC(84)12, Columbus Programme - Assessment by the Executive, 7 June 1984.

2139 Pfeffer Papers, ESA/LTT-PC(84)12, Columbus Programme. Assessment by the Executive, 7 June 1984.

2140 Pfeffer Papers, ESA/IRAC(84)32, Coopération avec les Etats-Unis. Programme de Station Spatiale, 14 September 1984.

Finally, an enabling resolution was voted on 28 June 1984, whereby it was suggested that the Columbus programme should be defined. The Council was therefore able to approve two formal enabling resolutions. One called for “the execution of a Space Station related preparatory programme Columbus" (unanimity), to be defined "with the view to ensure progressively the European autonomy in the field of [a] manned-space station mutually compatible with the future European launching systems". The other, for the large cryogenic engine HM60 preparatory programs (unanimity with abstention of Spain). Declarations would be subsequently issued in order to formally endorse the optional programs.[2141]

Columbus could be envisaged both as a part of the international Space Station and as a starting point for a self-sufficient space station; HM60 would be used to equip the new Ariane-5 in order for it to orbit Space Station elements and transport European crew on board the newly-envisaged French mini-shuttle vehicle, Hermes (which was to be placed on the top of the launcher).[2142]

Within this context, the Council approved the examination of the invitation received by the President of the United States to participate to the Space Station programme.

The execution of the programme was assumed by the Spacelab Programme Board.[2143] German and Italian studies done by DFVLR and MRST on Columbus would from now on be integrated with studies on the Space Station and the IOI, within the STS-LTPP.

The declaration which established the effective start of the Columbus Preparatory Programme, drawn up on 28 November 1984, was opened to subscription on December and took effect on January 30, 1985. It provided for a financial envelope of 80 MAU, which was, from the beginning, over financed.[2144] The original members (Belgium, Denmark, the Federal Republic of Germany, France, Italy, the Netherlands and the UK) were joined by Austria in February 1985, by Switzerland in July and by Norway in September of the same year.

The Columbus programme would be based on the preliminary work done by Germany and Italy and made available to the Agency, making use, at the same time, of the work done by ESA within the STS-LTPP. It would comprise several elements:

1 one or more pressurised modules (PM), "envisaged as derivatives of Spacelab, manned and/or man-tended and capable of becoming in the long term the core of a European orbital system";

2 one or more payload carriers (PC), for low orbit or polar orbit, "envisaged as derivatives of hardware already [available] or being developed or studied in Europe";

3 one or more resource modules (RM), providing the PMs and, if appropriate, PCs with logistics such as power supply, communication, data management, heat rejection, attitude control. This element "could be envisaged as a further development of Eureca-type hardware";

4 a Servicing Module (SM) for in-orbit transfer of payload, equipment and eventually crew;

5 the corresponding ground segment -in particular crew training and integration facilities and the Operations Control Centre for the European elements.

2141 ESA/C/LXIV/Res.4/Final, 28 June 1984. See also: *ESA Annual Report, 1984*. For the vote see ESA/C/MIN/64; the minutes are unclear on whether Spanish abstention was on Columbus(as stated in the paragraph on the vote) or HM60 resolution (as stated in a further declaration by theSpanish representative).

2142 ESA/C/CXIV/Res.4 (Final), 28 June 1984; see also Jeffrey Lenorovitz, "ESA approves two studies for future space presence", *Aviation Week and Space Technology*, July 9, 1984, pp.17-18.

2143 Pfeffer Papers, ESA/PB-SL(84)33, Résolution relative à l'execution d'un programme préparatoire Columbus se rapportant à une station spatiale, 24 August 1984.

2144 At the mid-1983 price level and 1984 conversion rate.

6 a user support programme and initial demonstration missions;

7 an advanced technology programme[2145].

The preparatory programme would be divided into two: Phase-B1, which should last from April to December 1985 (and was eventually performed from July 1985 to March 1986 and then extended for three months), was devoted to the study of the double option – attached module and free-flying polar platform. The aim was to identify among the Space Station elements, which one ESA would propose for development under a cooperative arrangement. At the end of Phase-B1, a time when the configuration of the US Space Station should be closed, Europeans would immediately move on to Phase-B2 in order to complete definition of the space station element or elements retained in agreement with NASA for development, subject to satisfactory negotiations of the terms and conditions for a subsequent programme[2146].

At the same time, negotiations were opened between NASA and ESA's Executive to draw up a draft MOU covering the definition and preliminary design studies phase (Phase-B).

A working group was set up by Director General Quistgaard in order to undertake bilateral discussions and presentations of the plan to Member States and to review the coherence of the Columbus/US Space Station/Long-term plan concepts.[2147] Conditions for cooperation set out in the June 1984 documents were further specified in this working group basic document on "participation in the development and use of a Space Station".[2148]

The drafting of the MOU did not pose any major problem; its first version was presented to IRAC on 27 November 1984 and then to the potential participants in the Columbus preparatory programme the day after.[2149]

On this basis, members would eventually approve in Rome the resolution on participation in the space station programme.

15.13 The Ministerial Council meeting of Rome (January 1985).

The Ministerial meeting of Rome was the outcome of a comprehensive process of negotiations and discussions on STS, which took into account both STS-LTPP and Columbus studies within the broader framework of the "Outline of a long-term European space plan", presented by the Executive to delegations in June 1984.[2150]

Throughout that document, the rationale for an in-orbit infrastructure was thoroughly presented and deserves an extensive quotation. There were three objectives to be pursued through human exploration via in-orbit infrastructures:

2145 HQ ESA, Lafferranderie Papers, Space Station Negotiations Meetings, ESA/C(85)21, att. ESA/PB-SL/XLIX/Dec. (Final), rev., Columbus Preparatory Programme, Declaration (drawn up on 28 November 1984), 13 February 1985, Annex A, Objectives and contents of the preparatory programme.

2146 *Ibid*. See also Pfeffer Papers, ESA/PB-SL(84)32, Etat d'avancement du programme Station Spatiale/Columbus, 14 septembre 1984.

2147 ESA HQ, Paris, Interoffice Memorandum Quistgaard to All Members of the Management Board, 29 June 1984.

2148 ESA/C(84)WG/9, Note on the main principles for the negotiations with the United States on participation in the development and use of a Space Station, 13 September 1994.

2149 ESA/PB-SL(84)4, add.3.

2150 ESA/C(84)46, Outline of a long-term European space plan, 12 June 1984.

1. *to take advantage of the unique capability of man to perform complex tasks in space, especially of a non-repetitive nature requiring a high degree of initiative (experimental research, repair, assembly);*

2. *to improve cost-effectiveness of many missions through the installation of permanent facilities in orbit and the performance of a variety of automated interventions in orbit (refuelling, repair, payload replacement);*

3. *to a lesser extent, to capitalise on the prestige of manned flights as a symbol of European achievement*

"Unfortunately" the executive continued "the very high cost of manned flight and the relatively limited scope of orbital activities make it difficult to reconcile the first two motivations; the issue is thus complex and controversial". The basic elements of the questions, as they existed in the 1980s, and as they still exist today, were clearly set.

To these considerations had to be added a series of uncertainties which made impossible the specific formulation of future milestones. Among them, it was difficult to anticipate the future scale of activities in LEO, these "being largely related to the prospects of microgravity applications in space, and of military activities".

Independence, which was not an absolute requirement at the moment, could become one. On the other hand independence would be extremely costly. That is why, participation in NASA' space station was seen as the preferred course of action rebus sic stantibus to enter the field of in-orbit infrastructures. The choice of manned and unmanned platforms was confirmed (the manned module to be launched in 1992/93 and the serviceable platform in 1994), as well as the use of the ESA Data Relay System to perform tasks related to operation and control. Estimates were given about the milestone and financial envelope of the forecast in-orbit infrastructure.

Participation in Space Station, however, was submitted, by the Executive, to stringent conditions:

1 freedom of access, meaning that Europe should have the possibility of using the Space Station facilities without being committed to using the entire American system (e.g. TDRSS or the Shuttle);

2 freedom of utilisation, intended as the freedom to use the Station on a non-discriminatory basis, i.e. with the same rights as American users;

3 Europe should be free to have its experiments conducted by a European crew;

4 the financial conditions for the use of the Station should be defined before any final commitment be made; they should be related to the actual use of the space station resources and a commitment to pay a certain percentage of the total running costs, irrespective of the actual utilisation, would not be acceptable.

The demanding tone of the document was probably to be put in the context of a shared wish for assertiveness *vis-à-vis* the stronger ally. Even in the Federal Republic of Germany, historically the strongest supporter of transatlantic cooperation, some key personalities seemed at least unconvinced about the prospective partnership. The Finance Minister Gerhard Stoltenberg and the Research

Minister Heinz Riesenhuber were indeed extremely preoccupied about the financial repercussions of the project on the already strained state budget; while Erhard Keppler, technical director at Max-Planck Institute for Aeronomy, simply questioned the value of astronauts at all for scientific progress in space.[2151]

However, as one senior official at the West German Research Ministry convincingly argued, the project was important "for transatlantic technical cooperation and for relations within the NATO alliance". "That, in a way," added the official "is almost better than any possible scientific gain"[2152].

That is why, despite agreeing on the general elements of ESA's plan, Germany suggested to moderate the references to "European autonomy", even if everyone agreed internally on the objective.[2153]

A common position on the Long-Term Space Programme and on US-European cooperation was reached thanks to bilateral meetings between the Executive and the national delegations and through the creation, during the Summer 1984, of a Delegate Council Working Group to define the text of the resolutions to be adopted at the ESA Ministerial Council Meeting.[2154]

The meeting took place in Rome, on 30-31 January 1985; the Minister of Research of the hosting country, Granelli, played a leading role in support of participation in the American Space Station and in finding a suitable compromise among Member States.[2155]

The Council resolution on the "Long-Term European Space Plan" called for a balanced long-term European Space Plan for the following decade "leading to a comprehensive autonomous European capability in space and containing the following major elements: an in-orbit infrastructure programme, a space transportation systems programme and programmes for Earth observation [meteorology and remote sensing], telecommunications, microgravity, space science and technology".[2156]

As had always happened at crucial times in ESA's history, and before that in ESRO and ELDO, an agreement was found through a package deal, a solution which gave to any member satisfaction on some element of a broader architecture. As in 1973, the Federal Republic of Germany and France were at the core of this deal. German Minister of Research Riesenhuber and French Minister of Research Hubert Curien agreed to support reciprocally their own space programmes: Germany would support Ariane-5 and France Columbus, if their government would respectively provide the needed increase of funds.[2157] Germany would at the same time not oppose the "Europeanisation" of the French programme Hermes, while opposing its immediate introduction in the "package" under discussion in Rome.[2158]

2151 Peter Gumbel, "A wary Europe moves to help US build manned space station", *The Wall Street Journal*, 28 November 1984.

2152 *Ibid*.

2153 Van Reeth Papers, C-M Roma (2), Meeting with the German Delegation, by R.Fraysse, 10 September 1984.

2154 ESA HQ, Paris, Inter-office Memorandum, Quistgaard to all members of the Management Board, Preparation of the Ministerial Conference, 29 June 1984.

2155 E.Vallerani, *op. cit.*, pp. 140-141.

2156 The Text of the Resolution on "Long-Term European Space Plan" is reproduced in *ESA Annual Report. 1985*, pp. 13-15; see also Van Reeth Papers, C-M Roma,2, ESA/C-M/LXVII/Res.2(Final), Resolution on participation in the Space Station Programme, adopted on 31 January 1985; the document appears as an attachment to ESA/C-M(85)/1 (30-31 January 1985), rev.1, 25 September 1985. Agreement on the Horizon 2000 plan for space science and on a planned increase in science at a rate of 5% annually up to 1990 (later extended), expanded activity in Earth observation and microgravity programmmes was also endorsed. See also K.Madders, *op. cit*. pp. 296-297.

2157 J.Logsdon, *Together in Orbit*, pp. 88-89.

2158 See text of the resolution below this.

The UK was drawn into negotiation once British Aerospace, the leading UK space firm, found a viable role in the framework of the Columbus programme: it would build one of the automated platforms provided for by the Columbus programme, in particular an Earth-observing platform in polar orbit[2159].

The Resolution on the long-term European Space Plan, therefore, called for a comprehensive programme covering ESA's activities for the next decade, based on the strategic aim "to maintain and build on the achievements of the first two decades of European space cooperation and to expand Europe's autonomous capability and Europe's competitiveness in all sectors of space activity". As far as in-orbit structures were concerned, the main objective was "to prepare autonomous European facilities for the support of man in space, for the transport of equipment and crews and for making use of low Earth orbits".

Getting from strategies to programmes to fulfil them, the Council approved the parallel endorsement of two optional programmes of identical cost per decade, 2.600 MAU (in 1984 currency): Columbus and the Ariane-5 launcher, equipped with the large cryogenic engine HM60. The decision by Member States to engage fully into both programmes was planned for April 1987.

The Columbus programme was to be considered "as a significant part of an international Space Station programme". Therefore, its detailed content would be defined in the course of its preparatory phase and it also depended on the terms and conditions of the agreements to be signed with the US to rule this Phase-B. Basic elements, indicated in the resolution, should be in any case "a fully independent Columbus complex including polar orbiting platforms and an operational data relay system [DRSS](…)".

As for the transport of crews into low orbit, the Council "took note with interest" (without endorsing any proposal) "of the French decision to undertake the Hermes manned spaceplane programme and the proposal by France to associate her European partners interested in this programme, in detailed studies(…)" with a view "to including this programme, as soon as feasible, in the optional programmes of the Agency"[2160]. Hermes[2161], under study by CNES since 1978, had been put on the ESA agenda since 1983 as a winged vehicle for manned missions, with no systematic payload launching function. There had been always an interaction between its mass, originally forecast to be below 10 tons, and the launch capability of Ariane-5.[2162]

Other fundamental elements of the long-term plan were programmes for Earth-observation, telecommunications, microgravity, space science and technology.

The resolution on future collaboration with the US (Res. n.2), making reference to the need "to continuing and strengthening a genuine partnership", stipulated as a condition for participation in the Space Station that Europe retain responsibility for "the design, development, exploitation and evolution of one or several identifiable elements of the Space Station together with the responsibility for their management with the aim of increasing overall capability of the space station" – in legal terms, this requirement would be referred to during the negotiations as equivalent to retaining "full jurisdiction and control" over European "space objects".

[2159] J.Logsdon, *Together in Orbit*, *cit.* p. 82.

[2160] ESA/C-M/LXVII/Res.1(Final), Resolution on the long-term European space plan, adopted on 31 January 1985.

[2161] The messenger of the Greek gods!

[2162] Van Reeth Papers, C-M Roma (2), Inter-office Memorandum, D/STS/LTPO to Management Board, An ESA strategy for Hermes, 30 November 1984.

Access and use, on a non-discriminatory basis, of the full capability of the Space Station on terms "as favourable as those granted to the most-favoured users and on a reciprocal basis"was equally required.

A satisfactory agreement on the share of the operations costs of the station and on the level and condition for the transfer of technology was also requested. Supplies and services from the US, such as transportation and communication facilities, should be granted by the US and offset through European supplies and services. In line with the position expressed since 1984, Europeans asked to ensure "maximum legal security and an identical level of commitments" by the partners involved[2163].

These issues clearly reflected past experiences within the Spacelab programme. Spacelab was indeed instrumental in strengthening European negotiating position in two ways: both as a technical and industrial asset, which placed Europe on a much more equitable footing *vis-à-vis* the US, and as a teaching experience for what should be asked, or not given away, in future cooperation[2164].

Spacelab was consciously used as a negotiating device."(...) now that Europe has demonstrated its competence with Spacelab and with the success of Ariane" declared Reimar Lüst, who had replaced Erik Quistgaard as ESA's Director General in mid-1984, in his Fulbright Anniversary Lecture of 1987 "it will not again accept an Agreement on a cooperative project in which the terms would be similar to those applicable to the Spacelab agreement. European States now feel very strongly" he continued "that any future Agreement must be based on the principle of partnership"[2165].

What did this mean from a practical point of view? As we shall see better in the next part, the critics seemed to be targeted, first of all, against the old provision that provided for the control and jurisdiction of the Spacelab to be transferred to the US after the end of the construction phase. They were equally aimed at preventing (as it had happened with Spacelab) that Europe, forced to rely on the shuttle as means of transport, should be forced to pay increasing fares to put their element in orbit. European partners also wanted to limit dramatic repercussions on their share of work coming from changes in the "core station" structure and from rising operation costs. Last but not least, indirectly recalling the recent ISPM quarrel, they asked for legal commitments by the partners involved[2166].

These would be the main points under discussions in the future negotiations with the US.

The resolution of the Rome meeting was transmitted to President Reagan in a letter of 12 February 1985 from G.M.V. Van Aardenne, Minister of Economic Affairs of the Netherlands, in his capacity of Chairman of the Rome Ministerial Council[2167].

In order to cope with the decentralised character of ESA and the new requirements emerging from the long-term programme, an internal reorganisation of the Agency took place under the leadership of the new Director General, Reimar Lüst, in Spring 1985, soon after Rome.[2168]

2163 ESA/C-M/LXVII/Res.2(Final), Resolution on participation in the Space Station Programme, adopted on 31 January 1985.

2164 "Europe's participation [to the Space Station] should be based on the achievements obtained through the Spacelab programme, and the possibility to draw heavily on the experience thus gained should be an essential criteria when selecting its possible participation"; Van Reeth Papers, Space Station, 1, ESA/C(84), Council, Cooperation between Europe and the United States in a space station programme, no author, no date [the document is probably a preparatory paper for the Rome Council of Ministers meeting of January 1985].

2165 Reimar Lüst, "Cooperation between Europe and the United States in Space", [The Fulbright 40th Anniversary Lecture, 6 April 1987, Washington DC] *ESA Bulletin*, n.50, May 1987, pp. 98-104, p.101 for the quotation.

2166 Van Reeth Papers, C-M Roma, 2 , ESA/C-M/LXVII/Res.2(Final), Resolution on participation in the Space Station Programme, adopted on 31 January 1985.

2167 The text of the letter is in Van Reeth Papers, Space Station, 1, Letter Van Aardenne to the President of the USA, 12 February 1985.

2168 Van Reeth Papers, ESA/C(85)R/12, The Director General's statement on the structure and management methods of the agency, 16 April 1985; ESA/C(85)R/18 (24 April 1985), 23 May 1985.

Among the various innovations, the old Directorate of Space Transportation Systems, created in 1980 by the merger of Ariane and Spacelab activities, and managed by Michel Bignier, was divided in two. After being linked together for five years, launchers and in-orbit infrastructures separated again as was the case for Ariane and Spacelab before 1980.

This division was driven first of all by the awareness that, with the approval of the Columbus and Ariane-5 programmes, the Directorate had accumulated responsibilities over an excessively large part of the ESA budget. From 1985 onwards, therefore,

1 The tasks of the new Directorate of Space Transportation Systems should be limited to launchers and Michel Bignier would be confirmed in his role as Director until October 1986;

2 a new Directorate of Space Station and Platforms was created, under the responsibility of Fredrik Engström[2169].

With a new programme and a new organisation at hand, ESA was ready to better articulate its participation in the Space Station in order to approach common negotiations with a solid and credible proposal.

15.14 Columbus as the core of the European participation to the Space Station.

After official endorsement of collaboration with the US by the Rome Council meeting, three joint PB-SL/AFC/IRAC meetings were held in January, February and March to consider successive versions of the draft of the US-European memorandum for Phase-B. Negotiations were conducted by Engström, with the support of Emiliani; and a satisfactory US-European draft was soon arrived at[2170]. The final text was unanimously approved by the Council on 24-25 April 1985[2171].

On 8 May 1985 the Columbus Programme Board was created; it was directed by the Italian De Leo, who would be replaced from 1 July 1987 onwards by Daniel Sacotte (France)[2172]. Aeritalia, ERNO (which was being reorganised into the new MBB/ERNO) and British Aerospace participated in the Columbus Board with a rotating presidency[2173]. The programme was managed by ESTEC through a small group of engineers, led by G. Altmann.

On 3 June 1985 three Memoranda of Understanding for governing parallel Phase-B studies (definition and preliminary design studies) were signed between NASA and its prospective partners, i.e. ESA, the Government of Japan and the Canadian Ministry of State for Science and Technology (MOSST) and entered into force on the same date. The MOU on ESA's participation was signed in Paris by James Beggs and Reimar Lüst[2174].

2169 These and other senior management decisions were taken during a rather stormy session of the Council; ESA/C(85)R/22 (11-12 June 1985), 16 July 1985. In 1986, J.Feustel-Büechl would replace Bignier as Director of Space Transportation Systems.

2170 E.Vallerani, *op. cit.*, p.150.

2171 ESA/C(85)34, ESA/PB-SL(84)WP/4, add.9. See also ESA/LEG/73, Memorandum of Understanding, 4 July 1985.

2172 At the same date, De Leo became chairman of the Ariane Launcher Programme Board. Sacotte was substituted by Traiset (France) in September 1988 and was called back to his functions one year later, in September 1989. Michel Praet (Belgium) took up the job in September 1990 and Bernard Haine (Belgium) replaced him in January 1993.

2173 E.Vallerani, *op. cit.*, p.150.

2174 ESA/C(85)34, ESA/PB-SL(84)WP/4, add.9; see also ESA/LEG/73, Memorandum of Understanding, 4 July 1985.

The MOU aimed to allow NASA to define the configuration of the US Station and ESA to choose, in agreement with NASA, the form of its future contribution. At the same time, it provided for a presentation by ESA of its candidate elements for preliminary design at SRR - 90 days (90 days before the System Requirements Review, due to be performed at the end of Phase-B1, scheduled for Spring 1986) and the beginning of discussions between NASA and ESA on the legal aspects of their future collaboration to identify and assess basic principles related to phases C/D/E.

When discussions on the ESA candidate elements for Phase-C/D/E began (December 1985), the US reference configuration had been modified compared to the original reference configuration for the preliminary design phase (the "power tower" concept). The Space Station was now conceived as a composite structure ("the figure of eight" or "dual keel"), constituted of 4 modules with integrated junction points for human passages and connections [2175]. It included:

- Two habitat modules
- One science laboratory module (life and general science)
- One materials technology laboratory (material processing)
- One servicing bay
- Two platforms (one polar, one co-orbiter)
- One OMV and related accommodations plus smart front-end
- Two logistic modules.

The Space Station configuration, which was to be revised several times, had to take into account both structural criteria (overall controllability, asseambleability, compatibility with the Shuttle, cost and payload accommodations), functional criteria (such as safety of the crew and facilities, commonality and maintenance), and, last but not least, financial criteria.

Within this configuration, ESA had to accommodate its participation, which was discussed for the first time in Washington DC in December 1985, on the basis of the decision taken by the Columbus Programme Board.

Elements retained by ESA for further studies during the so-called Phase-B2 were:

- A pressurised laboratory essentially dedicated to microgravity disciplines, able to operate either attached or in a free-flying mode, in order to provide quieter environmental conditions for these disciplines;
- A resource module to support the laboratory during its free-flying mode operations;

[2175] When not footnoted, information is taken from Van Reeth Papers, Space Station, 2, Situation of the Columbus/Space Station Programme in the light of recent discussion with NASA, no author, January 1986; see also *Ibid*, ESA/C-WG/Space Station (85)12, Results of the last Programme Coordination Committee (PCC) meeting held in Washington DC (17/18 December 1985), 20 December 1985 and ESA/C-WG/Space Station (85)12, add.1 (Document delivered by NASA at the occasion of the PCC meeting).

- An unmanned Eureca-derived co-orbiting payload platform;
- A polar platform primarily for Earth observation and meteorology[2176].

The US, while accepting the proposal of a polar platform and "showing interest" for a possible co-orbiting platform, "reacted in a very negative way to the ESA proposal to develop a pressurised module which would be mainly devoted to microgravity and would work also in a man-tended free-flying (MTFF) mode". This solution, which represented a fulfillment of the "double option" solution (autonomy and cooperation), because it could be either attached or detached from the Space Station, did not please NASA which, arguably for technical reasons, preferred a permanently attached laboratory, "preferably integrated in the 'figure of eight'". NASA regarded the Columbus laboratory as a permanent feature of the station and, should Europe insist on supporting a MTFF concept, that would imply the provision of a second pressurised module. Last but not least, NASA objected to the assignment of function in the functional allocation scheme, stating that "they were under strong pressure to retain the microgravity laboratory function for the US". ESA, on the other hand, stated that retaining this specific function was mandatory for ESA [2177].

Between the end of 1985 and the beginning of 1986, under NASA's pressure, the pressurised module programme was descoped: there would be a first pressurised module permanently attached to the Station (Columbus), and a second smaller pressurised module, baselined for Ariane-5, outfitted with equipment for crystal growth experiments or other experiments which need long duration super-quiet conditions.[2178]

Later on, the baseline for convergence activities was once more partly revised to encompass, by March 1986, three major elements: a polar orbiting platform, a co-orbiting platform and a pressurised module which would form a permanent part of the manned base, with facilities for materials and life science payloads.

Europe had not yet abandoned the idea of a double option, though: in a letter to W.Graham, ESA Director General Reimar Lüst, wrote "the one open question which I hope can be clarified in Europe very soon, is the possibility of detaching the permanently attached module for certain short periods in conjunction with a resource module"[2179].

Finally, NASA agreed to the establishment of a common study , to be completed in 1987, which would provide the basis for determining the utilisation of MTFF within the Space Station system[2180].

Phase-B2 studies were conducted from November 1986 to May 1987 (followed by a seven months' extension period), under MBB/ERNO as prime contractor. Aeritalia studied the possibilities for a pressurised module, Dornier for a resource module, British Aerospace for the polar platform; Matra, Logica and MBB/ERNO were in charge with common subsystems such as data management, software and electrical ground equipment.[2181]

2176 Van Reeth Papers, C-M, München, 1, ESA/C(87)3, Annex 5, Space Station and Platform. Man-tended meant that man was not a passenger in the free-flying mode, but only when the module was connected to the station; Van Reeth Papers, Space Station, 2, Inter-office Memorandum, D/SSP (F.Engström)to DG, Possibilities to meet German Requirements in present ESA/NASA Negotiations, 25 February 1986.

2177 Van Reeth Papers, ESA/C-WG/Space Station (85)12, Results of the last Programme Coordination Committee (PCC) meeting held in Washington DC (17/18 December 1985), 20 December 1985.

2178 Van Reeth Papers, Space Station, 2, Inter-office Memorandum, D/SSP (F.Engström)to DG, Possibilities to meet German Requirements in present ESA/NASA Negotiations, 25 February 1986.

2179 Van Reeth Papers, Space Station, 2, Letter Lüst to Graham, 24 March 1986.

2180 *ESA Annual Report. 1986*, p. 88.

2181 E.Vallerani, *op. cit.*, p. 144; *ESA Annual Report. 1986*, p. 86.

Aeritalia invited thirteen European companies from the six nations who had decided to join the programme; five of them were Italian (Fiat, Laben, Microtecnica, Selenia and Telespazio). ESA obligeded Aeritalia to adopt a double option, providing studies for a permanently integrated module and for a free flying element, which would be visited at regular intervals by the station crew – the Man-tended Free Flyer (MTFF)[2182].

[2182] E.Vallerani, *op. cit.*, pp. 144-146.

C: The Space Station as an international enterprise: 1985 up to the 1990s

In order to grasp the full meaning of the Space Station initiative, and understand the challenge Europe was confronted with at the time it entered negotiations with the US, it is worthwhile remembering that the Space Station was primarily conceived, in the US, not as a Scientific Programme (indeed it was criticised by a large constituency of space scientists), but as a part of an overall industrial strategy which aimed, through space, to keep the competitive edge compared to that of political enemies, such as the USSR, as well as to that of its allies. In this context, its development was therefore not totally disconnected, as we recalled in the first chapter, from the development of the Space Defense Initiative, which was part and parcel of the same strategy.

Discussions on SDI intensified in Europe in 1984-1885. The *New York Times* of December 12, 1984, reported that Margaret Thatcher, the British Prime Minister, Helmut Kohl, the West German Federal Chancellor, and President Mitterrand of France had all "made statements interpreted as critical of the project"[2183]. Not only was SDI considered to dangerously destabilise the existing nuclear balance and leading to a "decoupling" of the US from the European defence. The substantial military subsidies it offered to high technology firms, to promote leading technologies, were perceived in Europe as "a *de facto* industrial policy" on a huge scale[2184]. Europe was trying to find an overall and coordinated answer to the challenge coming from the US in the field of high technology *via* the European Union (in which research and technology would be legalised as a field of communitarian policy by the Single European Act, eventually ratified in 1987). There was, however, in the European Union's policy, a tension between the trend towards the Single Market (the White Paper of the Commission on that dates from 1985), which was rooted in a liberal logic of free competition and privatisation, and the progress towards the public support of policies of research and technological developments to reinforce the competitiveness of European industry. This was done through the adoption of specialised programs of industrial development, such as *Esprit*, the first one (1983), dealing with information technologies, and the definition of long-term framework programmes (the first one covering the period 1984-1987)[2185].

After the withdrawal of President Mitterrand's proposal for a European military space station (February 1984), which we referred to in section 15.8, the French President, warning that SDI would reduce the Europeans to sucontractors for the less technologically advanced areas of the project (May 1985), proposed a European high-technology cooperation civilian programme in response to Reagan's SDI[2186]. In the conference he assembled in July 1985 to launch the programme, he presented a document emphatically called "EUREKA, the technological renaissance of Europe". EUREKA was an attempt to foster European expertise in areas of research, such as information technology, robotics, communications, and new materials, which might be otherwise dominated by the US SDI programme[2187] .

Mitterrand's attempts to find an autonomous European path was only partly successful. A few months after the inception of EUREKA, responding to an invitation extended by the US Secretary of Defense Caspar (Cap) Weinberger on March 26, 1985, the first bilateral memoranda of understanding between

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2183 *New York Times*, 12 December 1984.

2184 Margaret Sharp and Keith Pavitt, "Technology Policy in the 1990s: Old Trends and New Realities", *Journal of Common Market Studies*, Vol. 31, n.2, June 1993, p.136.

2185 A clear discussion on the trends of scientific research in Western Europe can be found in Antonio Ruberti and Michel André, *Uno spazio europeo della scienza* (Firenze: Giunti) 1995. Antonio Ruberti was European Commissioner for Science, Research, Development and Education from 1993 to 1995. See also, Luca Guzzetti, *A Brief history of European Union research policy* (Brussels: European Commission) 1995, p. 117.

2186 *Keesing's Contemporary Records* (London: Longman) 1987, pp. 35482-35483.

2187 French document referred to a fifth area of research to be developed, i.e. biotechnology; see Luca Guzzetti, *op. cit.* p. 117.

European countries and the US on SDI research was signed. British and German leaders, after long negotiations, shifted their original position "in an apparent attempt not to undermine [the] US bargaining position" (during the talks on strategic arms reductions with the USSR). Building up on a long-standing tradition of bilateral cooperation in the military field, Michael Heseltine, British Secretary of State for Defense, was the first European leader to sign a MOU for the participation of British firms and research institutes in SDI research (6 December 1985); it was followed, three months later, by two agreements signed by the Western German Economics Minister, Martin Bangemann, which provided for general guidelines for cooperation in the area of technological transfer and for creating a basis for participation by West German firms and research centres in the SDI (27 March 1986). An agreement on SDI was then signed with Italy (19 September 1986)[2188].

15.15 Negotiating the final agreements on the Space Station (1985 to 1988).

Negotiations spanned a long period, from 26 November 1985 (the first round of negotiations) to 29 September 1988, when both the IGA and MOU were signed. While discussions on the MOU of 1985 on Phase-B had been relatively smooth, this second round of negotiations, dealing with development, operation and utilisation the (phases C/D/E) of the International Space Station, proved laborious and argumentative.[2189]

The work of the legal experts was demanding, because of the need to devise new rules for unprecedented circumstances and to establish a fixed legal framework for work in progress, whose technical content and temporal limits were not fixed at the time of negotiations. Beyond the need to cope with the technological complexity and the frequent modifications of baseline, the negotiators had to solve another fundamental issue: they needed to translate into legal terms the will of Europe not to be treated as a sub-contractor, but as an equal partner.

Not only the form (technical and legal), but the perceived value of the Space Station for all the partners involved changed during the time of negotiations, as it would change after them, leading to a reappraisal of the Space Station design ("scrub 89"), just after signature of the IGA and, later, to the opening of yet another round of discussions in order to involve Russia in the enterprise.

Therefore, negotiations repeatedly met stumbling blocks, phases of deceleration followed by acceleration, which were not only linked to the context of the negotiations, but to what was happening around them. If, for ESA Member States, a clear settlement of the IGA with the US became *a priori*ty after the Rome ministerial Council, leading European partners to ask for an early opening of talks, for the US they lost some importance after the first approval of the Station in Congress and, most importantly, after the Challenger accident, which caused a two-year long reorientation of NASA towards the problem of the reliability of reusable launchers.

Our aim in this section is therefore to highlight the history of the development of negotiations, leaving for the next a discussion on the major legal and political points at issue. It must be remembered, though, that anexhaustive analysis of the legal content of the 1988 IGA has alreadybeen made by legal

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2188 *Keesing's Contemporary Records* (London: Longman) 1986, p. 34082 and p. 34273; *Ibid*, 1987, p. 35482. On the two German agreements, see Bernd Kubbing, "The SDI agreement between Bonn and Washington. Review of the first four years", *Space Policy*, August 1990, pp. 231-247.

2189 For an overview, see John Logsdon, "International Cooperation in the Space Station Programme: Assessing the Experience to Date", *Space Policy*, February 1991, pp. 35-45.

experts and can be found in the secondary literature; we will not try to follow the same pattern of analysis.[2190]

In May 1985, the Director General proposed that a Council Working Group be set up to “clear the ground” with regard to the basic issues related to Resolution No.2 approved in Rome, i.e. participation in the Space Station programme. The Working Group should, first of all, prepare the negotiating position and ensure political and diplomatic support from participating governments; it should also open discussions with the US in order “to make sure that we are talking of the same realities” and make the US aware of what Europe perceived as the most important issues at stake. Despite the fact that the term of the Phase-B MOU provided for the start of negotiations at the end of Phase-B1 or, in the MOU’s terms, at the time of the Systems Requirements Review (SRR), scheduled for Spring 1986, Europeans thought it useful to make contact with prospective partners and try to find “original solutions” for what appeared to be a challenging jump into the dark, from the legal no less than the technical point of view[2191]. Chaired by Reinhard Loosch, the Working Group was set up the following month with the task of preparing and monitoring the elaboration of the Space Station IGA concerning detailed design, development, operation and utilisation of the International Space Station (Phases C/D/E).

By Autumn 1985, the Council Working Group prepared some position papers on issues of special importance, which should represent the initial negotiating position of Europe – such as the form of the international agreement, control and jurisdiction, access and use of the Space Station, operational costs, pricing policy and transfer of technology. The attention was not so much focussed on single articles, but on a draft which should contain “[a] simple expression of some basic ideas on which consensus could be reached with the Americans”[2192]. The idea was to separate as far as possible the discussions on the legal issues from those on the “mechanics”; the legal issues could in this way have been approached while waiting for the technical choices on the structure of the station[2193].

As it was later explained to the American counterparts, the basic purpose of this exercise was to complement existing international space law, wherever it could not be invoked, in the management of the future enterprise. Outer space agreements, such as the 1967 Outer Space Treaty, did not always provided adequate answers to a wide range of legal issues which were forecast to arise during the development and operation of the Space Station[2194].

[2190] See, for example, in chronological order: Gabriel Lafferranderie, "Aspects juridiques de la station spatiale", in *Annales de l'Université des Sciences sociales de Toulouse*, tôme XXXVI, 1988, pp.169-188; *Les Stations spatiales habitées -Aspects juridiques*, Actes du Colloque, Paris 7-8 novembre 1989, ESA SP-305 (ESA) 1990; Gabriel Lafferranderie, "Les accords relatifs à la station spatiale internationale. Analyse et commentaire", *Revue générale de droit international public*, avril-juin 1989, n.2, pp.318-382; *Les Stations spatiales habitées: Aspects juridiques*, ESA SP-305; André Farand, *La station spatiale et son régime juridique*, in Nicolas Mateesco Matte (ed.), *Annales de droit aérien et spatial*, vol. XV (Montreal: McGill) 1990, pp. 309-329; Brigitta Staudt, *Die transatlantische Raumstationskooperation. Der rechtliche Rahmen einer langfristigen multinationalen Zusammenarbeit* (Frankfurt am Main: Peter Lang) 1992; André Farand, *Space station cooperation legal arrangements*, in Gabriel Lafferranderie and Daphné Crowther (eds), *Outlook on Space Law over the next 30 years. Essays published for the 30th anniversary of the Outer Space Treaty* (The Hague:Kluwer Law International) 1997, pp. 125-133.

[2191] Van Reeth Papers, ESA/C(85)16, Space Station-Starting of dicussions with the United States for preparing the Phase-C/D/E negotiations, 20 May 1985.

[2192] Van Reeth Papers, Space Station, Doc (1), ESA/C-WG/Space Station(85)3, Space Station Working Group, Note from the Executive, 2 October 1985 and Annexes 1-8.

[2193] Van Reeth Papers, Space Station, 1, Letter Lafferranderie to DA, Space Station Negotiations, 8 November 1985; *Ibid*, Memorandum Van Reeth to Loosch, 11 November 1985.

[2194] Van Reeth Papers, Space Station, Doc, 1, ESA/C-WG/Space Station(86)1, 2nd negotiation meeting (Paris, 21 January 1986), Preliminary views on some legal issues, 28 January 1986.

In October 1985, the European negotiating group took the initiative of inviting the US government to start discussions in the following month.[2195] While accepting the anticipation proposed by their partners, the US suggested to stick to the terms of the 1985 MOU (which provided for a beginning of negotiations after the Space Station baseline had been defined, i.e. in Spring 1986) for formal talks.[2196]

During the IGA negotiations, the US were mainly represented by officials coming from the State Department and NASA; Otho Eskin, Director, Office of Advanced Technology, and Ralph Brabanti, who were the principal negotiators on behalf of the State Department in the very first phases, left more space during later stages to Richard (Dick) Smith, who became the main actor from the State Department, while Philip Culbertson, Richard Barnes and Margaret (Peggy) Finarelli would be the most active on the NASA side in both the IGA and MOU negotiations.

The European delegation for the IGA negotiations was mixed. While Denmark and Spain were represented by ambassadorial counselors, Switzerland and France sent representatives from the Ministry of Foreign Affairs, Italy and Germany representatives from the Ministries for Research and Technology (BMFT for the FRG) , the British delegate came from the National Space Centre and the Belgian from the Prime Ministerial Service for Scientific Research. ESA was represented by the Director of Administration, George Van Reeth, the Director of Space Platforms, Frederik Engström, the Head of International Affairs Branch, Jean Arets, the Legal Adviser, Gabriel Lafferranderie and the ESA representative in Washington, Ian Pryke, while the European spokesman in the intergovernmental negotiations, as we have seen, was Reinhard Loosch.

At the third meeting (10-11 March 1986), the articulation of the agreement began to be discussed and drafts of the various articles were exchanged between the two delegations[2197].

The Challenger disaster of the Summer 1986 represented a severe blow not only to the credibility of American space effort, but to the Space Station project and, consequently, to the negotiations. On the one hand, NASA, under the new Administrator James Fletcher (returned to the Agency for a second tour of duty after Beggs had left in the wake of the Challenger tragedy) would be focussed on the investigations and the ways to answer the challenge posed by the questions they raised, for at least two years. To people involved in the Space Station project, the Shuttle disaster highlighted how dangerous could be the reliance of the Space Station on a single means of transport. This was true for everyone, including Europeans, who planned to use the Shuttle to send up the modules of their Columbus programme.

Notwithstanding, the first drafts of IGA articles were introduced during 1986, though they did not yet constitute complete IGA texts. Concurrently, the negotiations between representatives of ESA and NASA began on the draft of a new ESA-NASA MOU, covering the technical aspects of the C/D/E phases. In this context, a major milestone was achieved in April 1987, when, as a result of a joint technical feasibility investigation, as we saw previously, the MTFF was included in the Space Station programme. Europe acquired therefore the right to dock the MTFF at the manned base at regular intervals for servicing purposes

In December 1986, the US delegation called for a pause in the negotiations and, after completeing a thorough policy review, it produced a new, still incomplete, IGA draft containing provisions on the utilisation of the Space Station for national security purposes. At the same time, in early 1987, under the pressure of soaring budgetary estimates, James Fletcher was compelled to scale back the programme. "He did it 'by the yard'" one commentator notes "cutting out (NASA officials preferred

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2195 Van Reeth Papers, Space Station, 1, Letter Reinhard Loosch to John Negroponte (Assistant Secretary for Oceans, International Environmental and Scientific Affairs), 17 October 1985.

2196 Van Reeth Papers, Space Station, 1, Letter Negroponte to Loosch, 6 November 1985.

2197 Van Reeth Papers, Space Station, Docs, 1, ESA/C-WG/Space Station(86)7, Third Negotiation meeting (Washington, 10-11 March 1986), 17 March 1986.

the term 'deferring') one of the co-orbiting platforms, the satellite servicing bay, and the two vertical keels on the central facility and their instrument attachment points".[2198]

European positions were elaborated in formal and informal meetings of the ESA Council Space Station Working Group, in several ESA Council meetings, in sessions of the Columbus Programme Board and in a number of meetings of legal experts.[2199]

A new ministerial meeting, the third in the whole history of ESA, took place on 9-10 November 1987 in The Hague. The meeting was intended, *inter alia,* to formalise Member States' involvement in the development programmes of the projects related to Space Transportation and In-orbit Infrastructure discussed in Rome (Ariane-5, Columbus, Hermes and the Data Relay Satellite System, DRSS). Due to the different conditions of implementation, these programmes received different kinds of endorsement. In particular, while the start up of the Ariane development programme as a whole was fixed (January 1988), in the case of Columbus a phased development programme was approved, pending the conclusion of negotiations with the US and the end of the Phase-B2. In this context, only phase I, dealing with the pre-development of the project, was endorsed: the decision to embark on phase II, related to the full development work, would not be taken for three years, that is not before the end of phase I. It would require a double two-thirds majority, as stated in art II.2 of Annex III of the ESA Convention, governing optional programmes[2200].

The resolution endorsing, *inter alia*, these decisions (Resolution on the long-Term Space Plan and Programmes), was approved by twelve votes and one abstention (the UK).[2201] The UK opposed the DG's proposal in favour of the preparation of autonomous facilities for the support of man in space, with the aim of men living and working in space; it criticised Columbus, Hermes, and Ariane-5, the first for having neglected efforts to attract potential users and the second for being too expensive for what it offered, a manned capability in a limited and peripheral form. In general, British reproaches went in the direction of a generalised attack against what was perceived as a wrong all-out strategy, aiming at "catching up with the US and the Russians, even [in cases] where, as with [the] Shuttle, it is now acknowledged that the US made a mistake in putting too many eggs into one basket". Whereas the supporting infrastructure and transportation programmes were tailored, in Rome, to the needs of future applications, the UK said, they had now become the focus of future ESA's activities, thereby disrupting the original balance between means and aims, STS and applications.[2202].

With the UK abstaining, but with the assent of all the other Delegations, the Council voted for Resolution No.2 on the participation in the Space Station programme, whereby members confirmed their interest in participating with the US in the international Space Station, provided that:

2198 See H.McCurdy, *art. cit.*, pp. 304-305. According to 1987 OMB estimates, the cost of the Space Station had grown from $ 8 to $ 14.5 billion.

2199 HQ ESA, Lafferranderie Papers, Space Station -Policy, ESA/C-M(87)3, 5 November 1987, Negotiations with the USA on the space station programme. Report of the Chairman of the Council Working Group.

2200 A two-thirds majority of all participating states was required, provided that this majority represented at least two-thirds of the contributions to the programme. For the resolution, see ESA/C-M/LXXX/Res.1 (final), Resolution on the European Long-Term Space Plan and Programmes (adopted on 10 November 1987), 10 November 1987.

2201 The British delegation, according to the minutes, "stressed that although it did not wish to vote against the draft Resolution, it did not want its abstention to be interpreted as supporting a 'unanimous' decision"; Van Reeth Papers, Space Station, C.M.den Haag, 5, ESA/C-M/MIN/80, 13 December 1988, p.11. Minutes were produced more than one year after the Council, which took place from 9 to 10 November 1987.

2202 Van Reeth Papers, Space Station, ESA/C-M/MIN/80, 13 December 1988, Statement by the United Kingdom.

- the principles fixed in Rome be respected;
- a satisfactory solution be elaborated to the problem raised by the US for recognition by other partners of the right to interpret the notion of peaceful purposes;
- an adequate provision for the settlement of disputes be found;
- a legal regime safeguarding the interests of ESA's members be achieved.

In the event of failure to fulfil these aims, member states were ready "to adapt the content of the Columbus development programme (...) to the new situation, while seeking other forms of cooperation with the United States regarding the respective manned space programme".[2203]

On 25 January 1988, President Reagan gave an important speech on the National Space Policy: it was a long and bold reassessment of the US quest for leadership in space. The first clear aim of the speech was to reassert US leadership in space (both civilian and military); there was almost an obsessive reference to "leadership", "preeminence", "the lead role" throughout the document. The second pillar was the support of earlier presidential policy about the commercialisation of the civilian space sector. There were indeed in the US "two strongly interacting governmental sectors (Civil and National Security) and a separate, non-governmental commercial sector" which needed to be maintained and promoted. "Leadership in an increasingly competitive international environment" clarified Reagan "does not require United States preeminence in all areas and disciplines of space enterprise. It does require" he continued "United States preeminence in key areas of space activity critical to achieving our national security, scientific, technical, economic, and foreign policy goals". One wonders what this broad definition left out for supposed competitors!

Not surprisingly, international cooperation was the last of the six main goals for civil space policy devised by the President. Even more disturbing from the European point of view was the explanation given by the directive of the leading elements that would inform such cooperation, because they were entirely focussed on the question of technology transfer and the protection of commercial interests developed with Federal funds.[2204]

It would be difficult to appreciate the meaning of this speech without reference to the situation of the US space effort at the time. Reagan needed to answer the apprehensions of the public and the users as far as the reliability of the shuttle was concerned and of the entire launcher policy and Arianspace commercial successes in the field of launchings. Without entering a complex story which has been already told, we just have to remember that:

- Profiting from the abandoning of ELVs before the Challenger tragedy, Ariane had acquired in the first half of the 1980s a remarkable proportion of the commercial market for civilian launchers.
- during the TCI affair many aspects of governmental subsidy practices of both Europe and the US had emerged. In particular, the US seemed caught in a real dilemma: if they were to favour the use of the Shuttle (*vis-à-vis* national ELVs) to make it profitable (the more frequent the launches, the

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2203 ESA/C.M/LXXX/Res.2 (final), Resolution on Participation in the Space Station Programme (adopted on 10 November 1987), 10 November 1987.

2204 The three paragraphs devoted to international cooperation are worth mentioning. International cooperation should: "Be consistent with United States technology transfer laws, regulations, executive orders and presidential directives. Support the public, nondiscrimatory direct readout of data from Federal civil systems to foreign ground stations and provision of data to foreign users under specified conditions. …Be conducted in such a way as to protect the commerical value of intellectual property developed with Federal support. Such cooperation will not preclude or deter commercial space activities by the United States private sector, except as required by national security or public safety". Van Reeth Papers, Space Station, 10, the White House, Fact Sheet, National Space Policy, 25 January 1988.

less the cost of a flight), they would indirectly give a boost to the European alternative to US military ELVs, Ariane. In order to favour the use of the Shuttle, the government should support the shuttle financially, alienating the producers of ELVs (even more so if they were going to be commercial companies, as requested by Reagan), and giving rise to European criticism.[2205]

- The US President, seemed no longer to be thinking in terms of friends and allies, but rather of international competitors.

Meanwhile, on 1 February 1988, in line with the The Hague Resolution and with suggestions made by several delegations at the meeting of the ESA Council Space Station Working Group (26 January 1988), a restricted European delegation, headed by the German Minister Riesenhuber, Chairman of the Ministerial Council, went to Washington to meet Secretary of State George Schultz and Undersecretary of State responsible for technology affairs, Derwinski, in order to solve the last issues left open by negotiations. There were three points of major concern for the Europeans:

- The exchange of letters on national security uses;
- The settlements of disputes;
- The transit of objects to and from the Station through another partner's territory.

On the first issue, Europeans thought the idea of the exchange of letters "unnecessary and, indeed, rather creating doubts than eliminating any". They were however ready to accommodate American wishes, provided that the letters make clear that the Partners had the "right to interpret, in good faith, the terms of [the] IGA, consistent with its whole contents (and spirit), not a right to change the terms of the IGA or to inflect its perceptions".

On the second point, the European insisted on the need, for "Western democracies", to apply, whenever possible, a due process of law, implying the resort to arbitration. When it would be impossible to arrive at a common position through *bona fide* consultations, the IGA should therefore provide for arbitration or similar forms of dispute settlements that the US, more pragmatic and inclined to guarantee their freedom from external constraints during the implementation of the IGA, refused to accept.[2206] Compulsory arbitration had been perceived by European partners since the beginning not only as an instrument for settling disputes, but "even more importantly, as an inducement to reach amicable solutions before any resort is made to arbitration".[2207]

A third and last point of consultation was a more technical aspect, aiming at protecting material or equipment *in transit* from any risk of using temporary jurisdiction over it to withhold such hardware or software from the partner or the user community to which it belonged. Europeans hoped for a "fair solution, an amicable compromise on these major issues" which would open the way to solve "all

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[2205] See John Krige, *Space Transportation Systems. An overview,* paper presented at the Conference "The History of the European Space Agency", London 11-13 November 1998, ESA SP_436.

[2206] Van Reeth Papers, Space Station, 10, Fax R. Loosch to DG, with Annexes (especially "Talking Points"), 2 February 1988.

[2207] Van Reeth Papers, Space Station, 8, ESA/C-MIN WG(87)WP, Report of the Space Station Working Group Chairman on the Current State of Negotiations with the US on an International Space Station, 12 August 1987.

other questions still open on the IGA (especially on the legal regime) and on the MOU to implement the IGA".[2208]

15.16 The 1988 IGA

On 29 September 1988, a multilateral intergovernmental agreement (IGA) was signed by the Government of the United States of America, the governments of nine Member States of the European Space Agency, the Government of Japan, and the Government of Canada on "cooperation in the detailed design, development, operation and utilisation of the permanently manned civil space station".[2209] An Arrangement concerning the application of the IGA pending its entry into force was signed by the partners, except Japan (for constitutional reasons) on the same date.[2210] The IGA would eventually enter into force in 1991.

The IGA was coupled by a Memorandum of Understanding (MOU) between NASA, as the US cooperating agency, and the cooperating agencies of the other partners, ESA among them. The NASA-ESA MOU was signed on the same day as the other two legal instruments and entered into force on 14 November 1988.

The Space Station as devised in the original 1988 IGA was made up of elements provided by the US, Europe, Japan and Canada through their cooperating agencies.

The US would provide both flight elements and ground elements:

1 the Space Station infrastructure elements, including a habitation module;

2 a laboratory module for the manned base, the attached payload accommodation equipment and a polar platform;

3 Space Station-unique ground elements

The European governments through ESA and the Columbus programme would provide:

1 the Attached Pressurised Module (APM) for the manned base, dedicated to material and life experiments;

2 a Man-Tended Free Flyer (MTFF), for microgravity experiments, to be serviced either by Hermes or by the US Shuttle;

3 a polar platform dedicated to the study of the Earth and its environment

4 ground elements unique to the Space Station-

2208 Van Reeth Papers, Space Station, 10, Fax R. Loosch to DG, with Annexes (especially "Talking Points"), 2 February 1988.

2209 The nine European partner states were Belgium, Denmark, the Federal Republic of Germany, France, Italy, the Netherlands, Norway, Spain and the United Kingdom. Austria, Ireland, Switzerland and Sweden abstained from signature. See André Farand, *Space station cooperation legal arrangements*, in Gabriel Lafferranderie and Daphné Crowther (eds), *Outlook on Space Law over the next 30 years. Essays published for the 30th anniversary of the Outer Space Treaty* (The Hague:Kluwer Law International) 1997, pp. 125-133.

2210 K.Madders, *op. cit.*, p. 458.

The Government of Japan would provide the Japanese Experiment Module as well as the Exposed Facility and the Experiment Logistic Modules for the manned base and Space Station-unique ground elements, while Canada would provide the Mobile Servicing Center (MSC), the MSC Maintenance Depot and the Special Purpose Dexterous Manipulator as Space Station infrastructure elements and Space Station-unique ground elements.

15.17 Some interpretative issues.

15.17.1 The legal form of the agreement and the settlement of disputes

Within Resolution No.2 of Rome (January 1985), the Council had subordinated its acceptance of the US offer to the assurance of "maximum legal security and an identical level of the commitments entered into by the European Governments and the United States Government"[2211]. This was indeed the first requirement raised during the first meeting on IGA, held on 26 November 1985.[2212]

The sour Aerosat and ISPM experiences had opened the path to a long series of European recriminations *vis-à-vis* the reliability of their American partner in the implementation of international programmes based on MOUs or agreements without binding value as in Europe. The legal instruments regulating both partnerships, in fact, had not guaranteed ESA against unilateral US withdrawal. The Federal Aviation Administration in the case of Aerosat and NASA in the case of ISPM had justified their withdrawal on the grounds of Congressional cuts in annual funding. Both texts provided for a clause of "non-availability of funds", whereby US agencies made the continuation of cooperation conditional on the availability of funds yearly voted by the Congress in the context of the Federal Budget. If the 1977 decision on Aerosat had been accepted "more in sorrow than in anger", the same could not be said for ISPM.[2213]

As clarified by Resolution No.2 approved in Rome, the Europeans had two main preoccupations: "to ensure maximum legal security and an identical level of commitment". Because the IGA would be ratified by European Parliaments and take precedence over subsequent national laws, providing a legally binding framework for future governments, Europeans wanted an identical level of commitment on both sides of the Atlantic, that is, as a first choice, a Treaty for the US.[2214] A Treaty, they thought, would have solved the formal problem because it would require the assent of the US Senate (while an Executive agreement would have exempted the US from requiring the ratification of the Senate).

However, a Treaty would not have avoided the key question of the intervention by the Congress with regard to allocation of funds. According to the Anti-Deficiency Act, no international agreement whatsoever can commit the resources of the US without Congressional assent[2215]. The American funding procedure provides for an annual budget appropriation process and the Congress has been

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2211 ESA/C-M/LXVII/Res.2(Final), *cit.*

2212 HQ Paris, ESA/C(85)R/36, 4 December 1985, Annex, 1st US/European meeting on a government-to-government agreement on the space station, Washington (26 November 1985).

2213 HAEUI, ESA/PB-AERO(77)7, Future of the Aerosat Programme, Report on the 8th Meeting of the Aerosat Council, 7 October 1977; see also chapter 8 for European reaction to ISPM cancellation, see Joan Johnson-Freese, "Canceling the US solar-polar spacecraft. Implications for international cooperation in space", *Space Policy*, February 1984, pp. 24-37; Roger Bonnet and Vittorio Manno, *International Cooperation in Space. The Example of the European Space Agency*, Cambridge, Harvard University Press, 1994,
pp.98-108. The most insightful and balanced account is W.D.Kay, "Where No Nation Has Gone Before: Domestic Politics and the First International Space Science Mission", *Journal of Policy History*, vol.5, n.4, 1993, pp, 435-452.

2214 Van Reeth Papers, C-M Rome, 1, ESA/C(84)WG/9, Note on the main principles for the negotiations with the US on participation in the development and use of a Space Station, 13 September 1984.
See also K.Madders, *op. cit.*, pp. 457-458.

2215 Van Reeth Papers, Space Station, Doc (1), ESA/C-WG/Space Station(85)4, Space Station Working Group, International Agreements in US Constitutional Law, 30 September 1985.

extremely reluctant to make multiyear financial commitments except for exceptional case -such as the replacement orbiter following the Challenger accident[2216].

This prerogative not only limits the ability of NASA or any other institution (we have seen the FAA in the case of Aerosat) to comply with international agreements, it also prevents NASA from having a stable, reliable, long-term policy of its own – as the historical record of the Space Station programme clearly shows.[2217] As NASA Administrator James Fletcher sadly said in 1986: "There simply is no way, in our system of government, to get a long-term national commitment".[2218]

At the end, the IGA was approved by the US Department of State in the form of an "executive agreement". As for the financial responsibility of each partner, it would be "subject to its funding procedures and the availability of appropriated funds". However, "recognising the importance of Space Station cooperation, each Partner [undertook] to make its best efforts to obtain approval for funds to meet its obligations, consistent with its respective funding procedures" (Arts.15.1 and 15.2 IGA).

In a resolute effort to avoid any legal prosecution related to the Agreement, US representatives also opposed the European desire for "adequate provisions for settlement of disputes that might arise during this long-term cooperation in an environment which is, frankly speaking, unknown yet to you (the US) and to us (Europe) and to everybody else". "Obligatory arbitration in any possible case would be ideal" in ESA's view, but it would be "perhaps not achievable because sensitive policy issues as well as effective management could be put at risk". Therefore, they limited their request to a formula referring to "resort to arbitration or similar forms of dispute settlement whenever agreeable to the Partners concerned – a clear statement of intent to make use of that possibility whenever consultations do not reveal major political obstacles against such recourse".[2219]

The rationale of the European request seemed to imply the possibility of retaining, as an *extrema ratio*, a means of proper legal recourse against, for example, the "availability of funds clause", in case the partner's withdrawal would imply financial or other kind of losses or against an increase of costs due, for example, to changes in the design of the station negatively affecting the European part of the project. This is probably why the US were so vigorous in their refusal of the European position. As in the case of the legal form of the Agreement, no satisfaction could be obtained on this point. Dispute settlement as ruled by art. 23 of the IGA was in fact left to the political level, whereby any partner might "request that government-level consultations be held with another partner on matters arising out of Space Station cooperation"; when it was impossible to reach agreement on this level, the concerned Partners might "submit that issue to an agreed form of dispute resolution such as conciliation, mediation, or arbitration".

2216 Richard Barnes, "Letter to the Editor. Treaties are not the answer", *Space Policy*, May 1991, p. 168.

2217 It is not by chance that the Augustine Committee, submitting its report on the future of the US Space Programme in 1991, saw in the "provision of predictable and stable funding" an essential element of any "successful civil space program" in the US. See Richard Barnes, "Letter to the Editor. Treaties are not the answer", *Space Policy*, May 1991, pp. 167-168. Barnes, former NASA European Representative (1981-85) and NASA Director of International Relations (1985-1990), answered in this letter criticisms advanced by a former ESA legal adviser, Michel Bourély, in a much quoted article "The Legal Hazards of transatlantic cooperation in space", *Space Policy*, November 1990, pp. 323-331. Against the legal requirement advanced by Bourély, Barnes retorted that "there appears to be no substitute for national political will": *Ibid*, p. 168. For strong criticism of American behaviour in this context, see also Peter Creola, "European.US space cooperation at the crossroads. Can the lessons from the past guide us into the future?", *Space Policy*, May 1990, pp. 97-104

2218 James Fletcher, "Space Shuttle development", *Science*, Letters, 18 July 1986, p.263, quoted by H. McCurdy, art. *cit.*, p.305.

2219 (HAEUI) ESA Washington office, Talking Points, Confidential, attached to unsigned and undated letter on European-US meeting on 1 February 1988, attached to message Loosch to DG, 2 February 1988 (underlined in the original).

15.17.2 Genuine partnership"

"Genuine partnership" was one of the most used (and abused) terms during the IGA 1988 negotiations. The origins of the terms are uncertain. A *Note verbale* sent by the Director General to the NASA Administrator in November 1986 states that it "was introduced in the presentation made by Administrator Beggs to the European delegations and in his letter to the ESA Director General of 6 April 1984 as well as in various economic summit declarations".[2220]

This interpretation seems to be confirmed by the declaration on the 40th anniversary of the end of the second world war made by Helmut Kohl at the Bundestag on 3 May 1985, during the Bonn Economic Summit. The Chancellor, in fact, made reference to the positive responses of ESA, Canada and Japan to the invitation forwarded by "the President of the United States to co-operate in the United States Manned Space Station Programme on the basis of a genuine partnership and a fair and appropriate exchange of information, experience and technologies"[2221].

On the other hand, already in March 1984, the term "genuine" can be found in an ESA internal document dealing with Space Station, which stated that "Europe wishes to be engaged in a genuine cooperative venture".[2222]

If it is difficult to draw a definite conclusion on the origin of the terms, it is easier to trace what was the meaning of the term for the partners involved in the Space Station programme. Following the first US-European meeting on Space Station negotiations held in Washington DC on 26 November 1985, the European delegation put on paper its views on the subject. The definition recalled, in an amplified version, the basic tenets already exposed in the Rome Resolution on cooperation with the US. On the other hand, the meaning of the term was, in European eyes, quite specific. According to this document, "genuine partnership" encompassed, "*inter alia*":

> *Europe's participation on [an] equal footing in all decision-making affecting its contribution and financial commitment.*
>
> *Retention by each partner on the basis of jointly agreed standards of his responsibility for the design, development, exploitation and evolution of identifiable elements of the Space Station together with the responsibility for their management with the aim of increasing [the] overall capability of the Space Station.*
>
> *Joint identification of the overall operations costs and of those to be apportioned between partners, as well as of the method of apportionment.*
>
> *Definition of common policy guidelines vis-à-vis users of Space Station to permit fair terms in commercial utilisation.*
>
> *[The] right of both partners to decide, after consulting with each other, upon mission aims and their implementation including part-time free-flyer missions by certain European elements without affecting overall commitments of [the] European side not impairing utilisation options of the US side.*

2220 HQ ESA, Lafferranderie Papers, Space Station, (also Van Reeth Papers, Space Station, 5), *Note verbale*, no date (but November 1986).

2221 *Weekly Compilation of Presidential Documents*, vol. 21, No.19, 13 May 1985, pp. 573-578.

2222 Van Reeth Papers, Space Station, 1, CAB/INT/KB/DB/7.3.1984.

Mutual guarantees for the provision of transportation and other services within the abilities of one partner upon request by the other.

Cooperation to lead to equal opportunities for the partners in the future use of space.[2223]

What did the US negotiators object to in this version of genuine partnership? The American vision was never apparently expounded in a similarly extended form, even if the term was frequently used in official texts; *genuine partnership* was more of a rhetorical expression, which alluded to a more balanced partnership compared to the ones developed before. The need for a "partnership" grew out of an objective increase in European efforts and capabilities in space; it was also a response to what had been for a long time perceived (by Europeans) as a hegemonic attitude, only partly to be attributed to technological advances and managerial requirements. The way cooperation on Spacelab and, more importantly, the cancellation of ISPM, had been managed on the American side were sometimes seen as examples of excessive self-reliance and disregard for the partners' legitimate interests. "Genuine partnership" was to mean, first of all, a fresh new start in the way of looking at European allies (partners) and in the way to manage co-operation (genuine).

However, it was clear from the beginning that the US negotiators found themselves in a very delicate situation. They had not only to cope with their international counterparts, but with the internal "watchdogs" of their work, such as the DoD and the DoT. The committees handling NASA appropriations were also prominent in checking their behaviour. It is interesting to review a letter sent to the NASA Acting Administrator from the Chairman and the ranking minority member of the House of Representatives Committee on Appropriation, stressing the need for NASA to ensure "that the US be the dominant developer, outfitter, and user of the space station" and keep the "primary role in developing the station".[2224]

Even more eloquent would be, some time later, on the specific issue of the military use of the space station, the Secretary of Defense's call to George Schultz (Secretary of State) not to "accede to multilateral decision-making on matters of Space Station management, utilisation, or operation" and not to "allow the concept of 'equal partnership' to displace either the reality or the symbol of US leadership in the Space Station program".[2225] Discussions over the introduction of the term "leadership" (next to the term "genuine partnership") in the first article of the last (expanded) agreement of 1998 shows how painful it is still for the US government to choose between two concepts of international co-operation which do not seem to be totally compatible.[2226]

Without an inward look into the American political system it is therefore difficult to understand what was not seldom perceived on the European side as an ambiguous behaviour over a term that the US themselves had, if not invented, substantially contributed to publicise as one of the revolutionary novelties of the Space Station cooperation.

2223 ESA HQ, Paris, Lafferranderie Papers, Space Station Negotiations Meetings, ESA/C-WG/Space Station(86)1, 28 January 1986, Annex, European Delegation's preliminary views on partnership, 21 January 1986
[also in Van Reeth Papers, Space Station, Docs, 1] .

2224 ESA HQ, Paris, Lafferranderie Papers, Space Station Negotiations Meetings, Letter from Edward Boland, Chairman, and Bill Green, Ranking Minority Member, House of Representatives Committee on Appropriations, forwarded by Ian Pryke to HQ Paris, on 4 February 1986, to William Graham, Acting Administrator, NASA, 14 January 1986 (underlined in the original text).

2225 On this topic, see section 15.17.4.

2226 The agreement refers, to the "basis of genuine partnership" on which international cooperation must be based (paragraph 1 of article 1); however, after much discussion, paragraph 2 of the last version of article 1 states that "the Partners will join their efforts, under the lead role of the United States for overall management and coordination, to create an integrated international Space Station". See "Agreement among the Government of Canada, Governments of member States of the European Space Agency, the Government of Japan, the Government of Rusian Federation, and the Government of the United States of America concerning Cooperation on the Civil International Space Station", 29 January 1998.

15.17.3 Control and jurisdiction

After considerable pressure, the US accepted the European proposal that each Partner should register as space objects the flight elements it provided, in accordance with the Registration Convention of 1976 (art. II), and therefore retain jurisdiction and control over, and ownership, of these elements in accordance with the "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies" (Outer Space Treaty) of 1967 (art.VIII) which provided that the State of Registry retains jurisdiction and control.[2227] Legally speaking, therefore, genuine partnership was embodied first of all in the concepts of ownership (art.6), jurisdiction and control (art. 5.2) granted by the IGA to each Partner over its own elements and personnel throughout the various phase of the programme -which meant substantially to preserve the norm of respective sovereignty[2228].

Without getting into the detail of a highly complex and controversial legal question, we will only remind the reader that while the meaning of jurisdiction in international law is quite clear, i.e. it is the recognised power of a government to prescribe and enforce the rule of law, the meaning of control is not equally defined in specified terms. Control in space law is generally supposed to mean that the state of registry "has the right to require other states to refrain from interfering with the direction and supervision of the object or with any of the technical arrangements necessary for the fulfillment of its mission of exploration and use of outer space".[2229]

The issue of jurisdiction and, more importantly, of control and use of the results, interferes therefore with the broader question of management over the different phase of the project (design, development, operation and utilisation). In order to guarantee an efficient overall management of the Station, i.e. of the various elements furnished by Partners, NASA insisted that the exercise of jurisdiction and control would be, therefore, "subject to any relevant provisions of this agreement, the MOU's, and implementing arrangements, including relevant procedural mechanisms established therein" (art.5.2). This formula, as noted by Europeans from the start, substantially weakened the effective meaning of jurisdiction and control over the various national elements, for the sake of a broader operational requirement.[2230]

The establishment of bodies responsible for the control of the Station was, therefore, a delicate exercise of checks and balances, in which legal, technical and political elements got intermingled.

As a general comment, it must be stressed that the European request for an overall institutional mechanism for regular intergovernmental exchanges, for reaching common positions on relevant political matters, was denied by the US Partners, who preferred to focus on a set of managerial bodies[2231]. There would be, however, "beginning 1989, and every three years thereafter", Space Station Cooperation Reviews, a method which had been informally inaugurated with success during the Spacelab programme, where the partners would meet "to deal with matters involved in their cooperation and to review and promote Space Station cooperation" (art.24).

2227 HQ ESA, Lafferranderie Papers, Space Station -Policy, ESA/C-M(87)3, 5 November 1987, Negotiations with the USA on the space station programme. Report of the Chairman of the Council Working Group.

2228 For European protest upon US initial denial of this important right, see HQ ESA, Lafferranderie Papers, Space Station -Policy, ESA/C-WG/Space Station (86)19, 3 July 1986, Annex, "The European position as regards the form and substance of an intergovernmental agreement/treaty", 2 July 1986. More generally, on the Outer Space Treaty, see Carl Christol, *The Modern International Law of Outer Space* (New York: Pergamon Press) 1982, pp. 12-58; Carl Christol, *Space Law. Past, Present, and Future* (Deventer: Kluwer Law) 1991, esp. pp. 3-66.

2229 Manfred Lachs, *The Law of Outer Space* (Leiden: Sijthoff) 1972, pp. 69- 70

2230 For the European point of view, Van Reeth Papers, Space Station, 8, ESA/C-MIN WG(87)WP, Report of the Space Station Working Group Chairman on the Current State of Negotiations with the US on an International Space Station, 12 August 1987.

2231 *Ibid*.

The US would have to provide all the station utilities such as living space, energy, waste disposal, transportation and logistics, and were bearing over 80% of the costs of the overall project: therefore, they felt entitled to ask for the responsibility for the "overall program coordination and direction", for the "overall system engineering and integration" and for "overall planning for and direction of the day-to-day operation of the manned base and the US polar platform" (art.7 IGA). As a general rule, the various decision-making bodies would be ruled by the principle of consensus (embodied in art. 7.5. of the IGA), failing which, according to the MOU, NASA was to take the final decision.

Consistent with the American overall responsibility, the other Partners were deemed responsible "for management and direction of their own programs, for system engineering and integration of the elements" they provided (art. 7.2.).

In particular, there would be a differentiation of the various Columbus elements with respect to this issue. MTFF and Polar Platform would be designed, developed and operated under full autonomy, except that, insofar as their servicing at the manned base (for the MTFF) or by the STS (for the Polar Platform, which should exit the Polar orbit in order to get refurbished) they would have to comply with NASA safety, operational, and interface requirements; on the other hand, NASA would keep ultimate responsibility for decisions on APM operations. All system command and monitoring functions would be performed at the Space Station Control Center in Houston[2232].

1. *Design and development*. NASA's right to play a primary role in the Space Station baseline configuration was recognised by Europe. While recognising a system level "design authority" of NASA, the evolution of the baseline configuration should be closely coordinated and interface specifications defined by common agreement: ESA would object to bearing costs of important changes, as had been the case during the Spacelab development. ESA would remain responsible for the design and development of the elements it would provide.

As specified in the MOU, two management bodies would supervise this phase: the PCC, a bilateral body co-chaired by ESA and NASA and the SSCB, a bilateral body chaired by NASA. The SSCB would take the decisions concerning design and development of the Space Station – which, as far as ESA was concerned, were limited to the APM and to certain interface aspects concerning the servicing of MTFF and PFF. If a decision of the SSCB was not accepted by ESA, the issue would be brought to the PCC for resolution (a sort of "appeal mechanism" that, as we shall see, did not exist for operations and utilisation).[2233]

2. *Use of transportation and communications means*. It was agreed that European means would be the baseline for servicing the MTFF and the PPF, whereas the US means would be the baseline for the manned base and the elements attached to it, such as APM. Each party should be free to use its own system and these should be mutually available – the Shuttle and NASA's Tracking and Data Relay Satellite System, TDRSS, for the US and Ariane/Hermes and ESA's Data Relay Satellite System, DRS, for Europe. This freedom of access was one of the strong requests advanced by European negotiators, under the special pressure of France.[2234] It was spurred by two concerns: to ensure autonomy from US launcher services, to guarantee users for the future Ariane-5, and to make use of article 15 of the IGA which provided for the "use of barter" for compensating common costs of the station (Ariane-5 flights could be offered in exchange for services obtained by the core station).

Neither the use of European means of transport nor of its own communication system (DRS) were anticipated in NASA's original plans and its introduction was thus to be considered an achievement by Europeans. Inasmuch as the rising cost of the means of access provided by the US had been one of the

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[2232] Van Reeth Papers, Space Station, 10, no author, Assessment Report on the negotiations for the Space Station MOU (confidential), 5 January 1988; see also, *ESA Annual Report. 1987*, p.70.

[2233] Van Reeth Papers, Space Station, C-R, 6, ESA/C(88)R/5, 11 March 1988, Annex 2, Management and Technical Comments.

[2234] Van Reeth Papers, C-R, 5, ESA/C(86)R/23, Annex 1, ESA/C(86)R/18, rev.1, Session restreinte tenue au cours de la 75ème réunion (22 Octobre 1986), 10 December 1986.

big problems of Spacelab cooperation, one cannot underestimate the result obtained by ESA on this point.[2235]

3. *Access and utilisation*. Generally speaking, NASA and ESA agreed from the beginning that all partners would enjoy a right of access, on a non-discriminatory basis, to all elements of the space station.[2236] Originally, however, NASA asked to retain the final say on the utilisation of all elements, including those of its partners, introducing what was termed as an "asymmetrical veto right".[2237] Moreover, according to NASA's initial scheme, each partner would receive an allocation of use of each element exclusively commensurate with its share in the total investment (cost of build-up launches being included in this computation); it should therefore be a fixed percentage identical for each element. The said percentage would be defined at the end of the Phase-C/D. Everyone agreed on the fact that there should be a relation between investment and utilisation, but Europeans disagreed with the concept of identical percentage and suggested that there should be a guaranteed percentage of use for each partner element by element; in any case, each partner should retain the final say on outfitting its elements.[2238]

At the end, according to the MOU, ESA retained 51% of the user accommodations of its module (the same percentage was retained by Japan for its own), 49% could be "bartered" with the US and Canada against provision of infrastructure and services. ESA would further retain 100% of its rights on the MTFF, NASA being offered 25% of its capacity; the use of the Polar Platform would be mutually agreed.[2239]

If we consider that, according to the agreement ruling Spacelab, all European users had obtained was free access to one half of the first payload, this new rule can only be considered a step forward in European assertiveness.

4. *Operations* – that is the technical action of controlling and managing the station. Decision-making in this context was managed through a Multilateral Coordination Board (MCB) (art. 8.1.b MOU), which was a body "constituted by all partners for coordinating the activities that [would] take place once the station [would be] running".[2240] In case consensus could not be reached, each partner should retain its rights on its own elements and take appropriate decisions so as to safeguard its fundamental interests, but the chair person (NASA) would have the final say, with no possibility of an "appeal mechanism" as in the SSCB, ruling the design and development phase.

Basic operations planning and responsibility for individual elements, while fully coordinated, should remain with partners providing them in all the phases of the programme (C/D/E). Day-to day decision-making, however, would be left to the Commander of the Station on board and to the ground operations centres. The APM, as already recalled, would be under NASA management.

5. *Operations and utilisation costs*. According to the MOU, each partner would be financially responsible for the operations and utilisation costs of its elements. ESA, in its relations with NASA, would have to support STS costs, communications costs (when using TDRSS), and astronaut training costs, according to the use it made of the relevant facility.

2235 HQ ESA, Lafferranderie Papers, Space Station -Policy, ESA/C-WG/Space Station (86)19, 3 July 1986, Annex, "The European position as regards to the form and substance of an intergovernmental agreement/treaty", 2 July 1986. For the initial American requests on these points, see Pierre Langereux, "Divergences profondes Europe-NASA sur la Station", *Air and COSMOS*, n. 1140, 25 avril 1987, pp. 36-37.

2236 HQ ESA, Lafferranderie Papers, Space Station - Policy, *Note verbale*, no date (but November 1986).

2237 HQ ESA, Lafferranderie Papers, Space Station, Briefing Note on Space Station, IGA Negotiations, no date.

2238 *Ibid*. See also Pierre Langereux, "Divergences profondes Europe-USA sur la Station", *Air and COSMOS*, No. 1140, 25 avril 1987, p. 36.

2239 K.Madders, *op. cit.*, p. 461; R.Bonnet and V.Manno, *op. cit.*, p.111.

2240 K.Madders, *op. cit.*, p. 461.

In addition, the MOU fixed, at European request, the so-called common costs, which could be modified only by agreement between the partners. They did not include either transportation nor communication, and were limited to operation (excluding therefore utilisation). The MOU provided for the SOP (acting by consensus) to identify the detailed content to be included in each cost category. They would be covered by partners' contributions in proportion to the percentage of resources allocated to them (NASA, 71.4%, ESA and Japan, 12.8% respectively, Canada 3%). Everyone agreed on the necessity to bear specific costs associated with its own elements – either directly or by providing services – and to provide a sharing of the overall running costs. The overall cost estimate profile appeared stable during 1987.[2241] The best guarantee that NASA would try to keep these costs as limited as possible was the high apportionment attributed to the Agency by the agreement.

During the negotiations, each of these points was re-elaborated several times. European requests were sometimes satisfied. For example, the rule whereby access could take place with both US and European means. In some instances, Europeans insisted up to the end, and without obtaining satisfaction, on criticism of the text. For example, European negotiators saw the request of NASA to have the final say on any controversial matter, though through different decision mechanisms, on both the design and development phase and the operations and utilisation matters as "a blank cheque" signed by ESA to NASA.[2242]

15.17.4 The "peaceful use".

Reagan's speech of January 1984 announced that NASA would "invite other countries to participate [to the Space Station] so we can strengthen peace, build prosperity and expand freedom for all who share our goals".[2243] As we recalled in the first part of this chapter, the Presidential call for peace though space came less than one year after the announcement of the Strategic Defense Initiative, which envisaged, on the contrary, a massive militarisation of space. Since September 1982, a Space Command had been established in Colorado Springs, following a defence guidance approved by the Secretary of Defense Weinberger, in order to expand military operations in space. The new Command should assume the control of surveillance and warning systems and of space-based weapon systems to be developed in the future.[2244]

A few days before Reagan's announcement on the Space Station, Weinberger was asked to support the project and advanced serious reservations on the ability of the nation to support the Strategic Defense Initiative and the civilian Space Station at the same time, in a "constrained fiscal environment". Therefore he regretted "not being able to endorse the modified thrust of the proposed Space Station, but the national security implications are too extensive and are not mitigated by calling it a civil program"[2245].

There seemed to exist two lines of interpretation about the relationship between the Space Station and the military. On one side, the Space Station had been publicised to show (as had been the case with the "Atoms for peace" programme of the 1950s) that the US were open to collaborate on the civilian utilisation of space. On the other hand, for US officials, it was rather clear that, due to the existence of an overall strategy for the military exploitation of space, the Space Station was to be conceived within that. It is probably not by chance that the first Director of the Strategic Defense Initiative Organisation,

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2241 HQ ESA, Lafferranderie Papers, Space Station -Policy, ESA/PB-Columbus (88)2, 22 January 1988, Annex, Presentation to International Partners on Space Station Annual Operations Costs, by Andrew Stofan, Associate Administrator, Office of Space Station; Van Reeth Papers, Space Station, C-R, 6, ESA/C(88)R/5, 11 March 1988, Annex 2, Management and technical comments .

2242 HQ ESA, Lafferranderie Papers, Space Station, *Note verbale*, no date (but November 1986).

2243 An extract of the State of the Union Address, delivered by President Ronald Reagan on January 25, 1984, is reprinted in *20 Weekly Compilation of Presidential Documents,* No. 61, p. 17.

2244 *Keesing's Contemporary Archives*, London, Longman, 1983, p. 32473.

2245 Caspar Weinberger to James Beggs, 16 January 1984, reproduced in John Logsdon (ed.) with Dwayne Day and Roger Launius, *Exploring the Unknown*, *Selected Documents in the History of the US Civilian Space Program. Vol II: External Relationships* (Washington DC: NASA) 1996, pp. 600-601: 601.

Maj-Gen. James Abrahamson, nominated in April 1984, had previously been responsible for NASA's manned space program.[2246]

As an example of the first behaviour, in April 1984, Beggs described the station to US prospective European partners with these words: "The US Space Station is a civil program which will be funded entirely out of NASA's budget, with no national security funds to be used. While the Defense Department worked with NASA in the early planning for Space Station by reviewing their near -and long-term requirements for space, they concluded they had no requirements for a manned Space Station. NASA, therefore, constructed its proposal to the President on the basis of civil and commercial requirements. The Space Station that the President directed NASA to build is a civil Space Station. Of course, like the Shuttle, the Space Station will be available for users. If there are any national security users, like national and international users, they will be able to pay to use the facility. As provided in the Outer Space Treaty, however, all activity on the Space Station will be limited to peaceful, non-aggressive functions".[2247]

As a matter of fact, since the 1967 Outer Space Treaty, the meaning of "exclusively peaceful purposes" (which is used in the above-mentioned Treaty, art. IV, as well as in the ESA Convention, art. II) has given rise to recurrent debates, in that "there are so many capabilities inherent in uses of space systems that is consistently difficult to distinguish military from civil uses of outer space based upon consideration of technology alone"[2248]. Indeed, as far as the technological content, many space systems meet all criteria to qualify as civilian systems (telecommunication, Earth observation, meteorological, navigation systems, for example). However, if we consider the same activities from the point of view of the goals pursued (functional definition), we can define them either as military or civilian, depending on the context in which they are used. They are, indeed, part of the broad area of dual-use technology.

Despite these difficulties, "it is generally recognised" as a legal expert put it "that the Space Treaty, in combination with the UN Charter, does not contain any *absolute* prohibition of military activities in outer space. The crucial provision on military uses of space is *Article IV, Paragraph 1* (which) does contain an absolute prohibition of stationing *nuclear* weapons and *other* weapons of '*mass destruction'* in an Earth orbit or on celestial bodies or in outer space".[2249]

A few months after Beggs' reassurances, however, Kenneth Pedersen, Director of International Affairs, warned John Hodge, Director of NASA's Space Station Task Force, that "the question of how military involvement would infringe on access rights to the station (was) a vital issue -probably in the end the single most important factor influencing foreign participation"[2250].

2246 *Keesing's Contemporary Archives* (London: Longman) 1984, p. 32954.

2247 Van Reeth Papers, Space Station, 2, Letter Beggs to Quistgaard, 6 April 1984, attached to ESA/C-WG/Space Station(87)15, Background documents related to the notion of "peaceful purposes", 26 June 1987.

2248 Stephen Doyle, *Civilian Space Systems* (Aldershot: UNIDIR, Dartmouth) 1994, p..81; on ESA's civilian role, see K.Madders, *op. cit.*, pp. 184-187.

2249 The author further continues "Apart from nuclear weapons and other weapons of "mass destruction", the military use of outer space is *not* prohibited; *however*, this use must be in accordance with international law and the UN Charter (as stated by Article III of the Outer Space Treaty). Article 2.4 of this Charter prohibits the *use of force*. This article applies to outer space, as has been said. Another article of the UN Charter, which applies to outer space is Article 51, containing the right of *self-defence*". Underlined in the original text. Tanja L. Zwaan, "The (il)legality of the military use of outer space", in *International Colloquium on the Militarisation of Outer Space* (Bruxelles: Editions Bruylant) 1988, pp. 301-309:303.

2250 NASA History Office, Washington DC, NASA Historical Reference Collection, Kenneth Pedersen, "Strategy for International Cooperation in Space Station Planning", no date [August 1984], reproduced in John Logsdon (ed.), *op. cit.*, pp. 91-100:97.

Because of this two-track tactic, it is not surprising that nothing was heard about the possible military uses of the Space Station until negotiations entered the final stage. In fact, it was only during mid 1986, when severe cuts were announced for SDI, that DoD begun to express "serious concerns about the course of negotiations"[2251] and information filtered through about DoD plans for using part of the Space Station for military research linked to the SDI project.

A meeting between ESA's Director General and the NASA Administrator was organised in the same months to dispel Europe's concerns. While Professor Lüst conceded that the performance of "DOD funded basic research was not likely to be a problem", he stressed that "certain members were concerned as regards to SDI" and its relation with the Space Station.[2252]

The ESA Director General was probably referring to studies being conducted by the US Air Force and the Army, which tended to confirm the possible use of the space station as a maintenance and logistic base for anti-satellite and anti-missile platforms equipped with high-energy lasers, which were part of the SDI project.[2253] The discussion on this point was stopped by Fletcher's rather dismissive attitude[2254].

At the end, article 1.1 of 1988 IGA described the station as a "civil Space Station for peaceful purposes, in accordance with international law". All national security uses ought therefore to be in conformity with this expression. It was decided, however, to leave the final determination, whether a contemplated use of an element was for peaceful purposes or not, to the partner having provided that element. It was its duty to "determine whether a contemplated use of that element is for peaceful purposes" (art. 9.8 IGA)[2255].

The US demanded that no agreed minute be produced on this point, but bilateral exchanges of letters between the heads of negotiating delegations of the US and each of the Partners were to be placed on the record before the IGA signature.[2256]

European representatives initially objected to this; confronted with a firm attitude on this point by the US, they required, at least, that the text of the letter "make it absolutely clear that any partner's right to determine for his element what is permitted and what is not <u>is a right to interpret, in good faith</u>, the terms of <u>the IGA, consistent with its whole contents</u> (and spirit), not a right to change the terms of the IGA or to inflect its perception".[2257]

The exchange of letters eventually took place, its goal probably being to reassure internally the DoD. An official letter was sent by the US chief negotiator Richard Smith to the European delegation leader, Reinhard Loosch; it was placed on record on the 19 September 1988. The US reserved to themselves "the right to use its elements, as well as its allocations of resources derived from the Space Station

2251 Kenneth Pedersen, "In defence of the incremental art", *Space Policy*, August 1991, p. 270. Pedersen continues: "Conversations I had with DoD representatives made it clear that their actions were motivated, at least in part, by a lingering sense that they had not been properly consulted in connection with the President's original, and in their view misguided, decision to invite international participation"; ivi.

2252 ESA HQ Paris, File 31 (provisional number), Aide-memoire from Ian Pryke to DG, Meeting between DG and NASA Administration on Space Station negotiation status, NASA HQ, 3 April 1987.

2253 Pierre Langereux, "Le Pentagon veut utiliser la Space Station de la NASA", *Air and COSMOS*, n. 1140, 25 avril 1987, p. 37.

2254 "Fletcher claimed he had never heard of the US Army plan to study the use of space station in battle field control!". ESA HQ Paris, File 31 (provisional number), Aide-memoire from Ian Pryke to DG, Meeting between DG and NASA Administration on Space Station negotiation status, NASA HQ, 3 April 1987.

2255 The full text reads: "The Partner providing an element shall determine whether a contemplated use of that element is for peaceful purposes, except that this subparagraph shall not be invoked to prevent any partner from using resources derived from the Space Station structure".

2256 Van Reeth Papers, C-R,6, ESA/C(88)R/7, Report of the Space Station Working Group Chairman on Intergovernamental Space Station Agreement Negotiations, 14 March 1988.

2257 Underlined in the original: (HAEUI) ESA Washington office, Talking Points,Confidential, attached to unsigned and undated letter on European-US meeting on 1 February 1988, attached to message Loosch to DG, 2 February 1988.

infrastructure, for national security purposes". Loosch, in his reply, recognised American freedom to decide “whether contemplated uses of its elements and its allocations of resources derived from the Space Station infrastructure” might be carried out under the agreement. The European representative further confirmed that, “with respect to the use of elements of the permanently manned Space Station, the European Partner [would] be guided by article II of the Convention establishing the European Space Agency”.[2258]

15.17.5 Other points

Many other points were discussed during the negotiations. Rules regulating the provision of crew and its code of conduct, the cross-waiver of liability, intellectual property (where to file a patent application and under which national law), technology transfer, the transit through another Partner's territory of anything developed or produced in the Space Station.

As far as technology is concerned, the American attitude was, not surprisingly, prudent. Despite some initial protests which were echoed in the mass media in 1985, this did not apparently represent a real stumbling block. No one could really expect the US to provide technical assistance in areas of space technology in which the ESA members were lagging behind – such as propulsion, construction of large solar arrays, docking techniques or computer control systems. US officials justified their reserved attitude with the fear that American-developed technology in such pioneering fields as computers and electronics could "leak" via Western Europe to the Soviet Union, which "could use such techniques in military projects".[2259] The US, however, had a long historical record of preventing technology transfer not so much for fear of "leaks", but to protect its own technological superiority in commercially and militarily sensitive fields *vis-à-vis* its European partners. And no partner in good faith could be really surprised about this.

Not surprisingly, therefore, the IGA provided for the transfer to be subject to national regulations. In the event of classified data, extra guarantees were required; they could take the form of "a security of information agreement or arrangement which sets forth the conditions for transferring and protecting such technical data or goods". More importantly, a transfer would not be conducted "if the receiving partner state does not provide for the protection of the secrecy of patent applications containing information that is classified or otherwise held in secrecy for national security purposes" (art.19.3 (c)).

15.18 Focussing on the European laboratory

With the final resolution on the European Long-Term Space Plan and programmes, unanimously approved at The Hague, with the abstention of the UK, in November 1987, the Council had called for the execution of the Columbus development programme according to a phased approached, starting on 1 January 1988. The total estimated cost of the programme, as we have seen, was 3.713 MAU (figure expressed in 1986 terms). The first phase would last three years and would determine whether the programme objectives could be met within the overall financial envelope and within the framework established at the end of the negotiations with the United States on the Space Station. During this phase, studies should be undertaken in order “to secure user or private sector co-funding for the flight hardware and its operations and to evaluate modified design approaches for ensuring the

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[2258] Van Reeth Papers, Letter Loosch to Smith, 20 September 1988, attached to ESA/C(88)R/25, add.1, 17 October 1988. See also G.Lafferranderie, “Aspects juridiques de la station spatiale”, in *Annales de l’Université des Science sSociales de Toulouse,* tome XXXVI, 1988, pp. 186-188; K.Madders, *op. cit.*, p. 462 and footnote 69 at p. 480. Art. II of the ESA Convention says, *inter alia*, “The purpose of the Agency shall be to provide for and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems”.

[2259] Peter Marsh, "Technology transfer threat to space base", *Financial Times,* 26 February 1985. Peter Marsh, "US concerns over technology transfer may ground joint space project with Europe", *Christian Science Monitor*, 6 March 1985. For a French point of view on that, see Frederic D'Allest's declarations in *Interavia*, December 1985, p. 1291. D'Allest was then Director General of CNES.

mission objectives in a cost-effective manner". Before the end of Phase I, it should be decided whether to embark on Phase II related to the full development work[2260]. The existence of the programme should be guaranteed even in case negotiations with the US would not succeed; in this case, the content of the development programme should be adapted to the new situation and coherence among the elements of the European in-orbit infrastructure should be maintained in order to keep "in line with the financial commitment of Member States concerned, the present level of their responsibilities and industrial involvement in the development programme".[2261]

On 15 December 1987, the Declaration on the Columbus development programme was drawn up – after the conclusion of Phase-B2 (May 1987) and its seven months extension period. It would be updated on 1 March 1988 and again on 28 June 1988 to include participation of the United Kingdom subscribing 5.5%. It provided for "the manufacture and the delivery to orbit of the space segment elements, the build up of the associated ground infrastructure, and the preparation of initial preparations and utilisation".[2262]

The financial envelope of 3713 MAU was distributed between the construction of the space segment (2400 MAU), the initial launches of the space elements (287 MAU), the initial operation preparation (186 MAU) and the utilisation preparatory activities (205 MAU). The envelope assumed that the integration preparation activities for the space elements, would be funded under the future Columbus exploitation programme.

The space segment was composed of:

- an attached pressurised module, launched by the space shuttle and permanently attached to the space station;
- a platform in a polar orbit, launched by Ariane-5;
- a man-tended free-flyer, consisting of a resource module and a pressurised module, launched by Ariane-5, capable of automatic operations and of man-tended servicing at the Space Station or in combination with Hermes.

The targeted launch dates were: last quarter 1996 for the Attached Pressurised Module, first quarter 1997 for the Polar Platform; first quarter 1998 for the MTFF.

As we have seen, the programme had been divided in The Hague in two phases; before the end of the first three-year period of initial development, on the basis of the results achieved and the industrial plans approved by the Executive, governments would be invited to decide whether to embark in the full development phase.

This was one of the questions discussed during the Ministerial Council of Munich (November 1991). The Council met at a very delicate time: on the one hand, the very rapid process of political and economic dissolution of the Soviet "empire" had led, among other things, to the reunification of Germany (3 October 1990), whose costs were being sustained by the Federal Republic. On the other hand, in order to contain the devastating effect of rising political and economic disorder in Europe, the Western European countries had decided to increase integration among themselves through the signature of a new Treaty (adopted by the European Council re-united in Maastricht on

[2260] ESA/C-M/LXXX/Res. 1(final), Resolution on the European Long-Term Space Plan and Programmes (adopted on 10 November 1987), 10 November 1987.

[2261] ESA/C-M/LXXX/Res.2 (final), Resolution on Participation in the Space Station Programme (adopted on 10 November 1987), 10 November 1987.

[2262] ESA/PB-Columbus/XVIII/Dec.1 (Final), Declaration on the Columbus Development Programme, 15 December 1987.

9-10 December 1991), modifying the European Community and creating a new European Union, enlarged in scope and fortified in its institutional setting.

Germany was at the core of both processes, caught between the need to enforce financial savings in order to support the burden of reunification and the need to show its eagerness for European integration. Despite the iron-clad alliance between Mitterrand and Kohl, embodied in the bilateral summit of Bonn (14-15 November 1991), reunited to find a viable compromise on a vast series of questions encompassing Europe (the Treaty of Maastricht) and space (the Ministerial Council of Munich), it was impossible to keep the entirety of the Columbus programme alive.

The Ministerial Council meeting of Munich (18-20 November 1991), reaffirming "in their entirety" the objectives of The Hague, required an "evaluation" of the new situation, with a particular emphasis on the opportunities offered by "the possibilities for widened international cooperation with other space powers, in the first instances in Europe", meaning Russia first of all.[2263] In the meantime, it decided to limit the scope of the Columbus programme in order to reduce its financial envelope and consolidate its design; activities connected with the MTFF were postponed.[2264]

This process of reduction of the Columbus programme progressed in Granada (9 November 1992), when the MTFF, which had for a long time symbolised the European wish to leave open the option of an autonomous presence in inhabited space platforms, was abandoned altogether. The Polar Platform was "descoped" from the programme, and reduced to two satellites (Envisat, dedicated to the understanding and monitoring of the environment and the provision of radar data; and Metop, to provide operational meteorological observation). The Polar Platform should be implemented, from now onwards, through a separate programme and managed by the Earth Observation Programme Board rather than the Columbus Programme Board.[2265]

In 1993, in view of the redesign required by President Clinton in March and the pending invitation to Russia to become a Partner of the Space Station, the Columbus programme was further modified in order to achieve technical simplification and overall cost reduction and a "bridging phase", instead of a complete Phase-2, was approved.[2266]

Finally, at the Ministerial Council meeting in Toulouse (20 October 1995), ten of ESA's member states subscribed to a new European Space Station development programme (1996-2003) whereby European efforts should concentrate on the development of the Columbus Orbital Facility (COF) and the Automated Transfer Vehicle (ATV), a cargo vessel to be launched by Ariane-5 for re-supplying missions.[2267]

15.19 The implementation of the Space Station Programme

Following the signature of the IGA and the MOUs, the initial effort of the partners were concentrated on the establishment of joint management bodies and the reinforcement of the liaison mechanism, by increasing the staffing and enlarging the facilities of the Columbus Liaison Office in Reston, Virginia,

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2263 Quotations from K.Madders, *op. cit.*, p. 317 and p. 318.

2264 The "Resolution on the European Long-Term Space Plan 1992-2005 and Programmes" adopted on 20 November 1991 is reproduced in full in *ESA Bulletin*, No. 68, November 1991, pp14-24.

2265 The "Resolution on the Implementation of the European Long-TermSpace Plan and Programmes" adopted on 10 November 1992 is reproduced in full in *ESA Bulletin*, No. 72, November 1992, pp. 14-32. For an overview on the two ESA Ministerial Council meetings, see R.Bonnet and V.Manno, *op. cit.*, pp.128-133; K.Madders, *op. cit.*, pp312-331. It should be remembered that, since 1989, the difference of logic embodied in the Space Station and the Polar Platform had been noted, and the idea of keeping them linked in a single project criticised; see Peter Creola, "European-US space cooperation at the crossroads. Can lessons from the past guide us into the future?", *Space Policy*, May 1990, p.101.

2266 K.Madders, *op. cit.*, p. 331.

2267 André Farand, "Signing of new Agreements on the International Space Station", *ECSL News*, No. 17, February 1998, pp. 1-2.

and by accommodating NASA representatives at the Columbus Project team in ESTEC. The Programme Coordination Committee (PCC) met in February 1989 and reached agreement on:

1 appointing staff to be responsible for interfaces, covering engineering and integration aspects, safety and product assurance, utilisation and operations;

2 establishing procedures to handle the requirements applicable to Hermes for access to the Space Station;

3 defining clear criteria for applicability of NASA technical requirements to the development of Columbus.

A Joint Programme Definition and Requirement Document applicable to the Attached Pressurised Module was signed in June 1989, while Sweden acceded to the Columbus programme – and would eventually enter the IGA.

In the meanwhile, as a first approach to the questions of operations and utilisation, basic responsibilities were defined as far as the ground segment was concerned, while multinational utilisation studies were conducted.

During the Summer, in order to face potential reductions in FY 1990 budget, the NASA Langley Research Center was required to perform a review exercise of the programme. The results of this investigation were then communicated to American partners.

The descoping implied a lower-functionality, but still viable base at the Permanent Manned Capability milestone. It must be remembered that the Station Freedom was, *de facto*, structured on two parts, corresponding to the achievement of the Permanent Manned Capability (PMC) and of the Assembly Complete (AC). Absolute priority was given, in the "scrub 89", to maintaining the PMC phase, which included neither international laboratories (Columbus, for example) nor international utilisation. The performance and capability of the station in this phase were reduced and could only support the US utilisation elements. No clear planning related to the completion of the station assembly existed, even though NASA proposed to launch Columbus in June 1998 and to outfit it for utilisation in February 1999. The rendezvous and servicing capability for the MTFF, on the other hand, needed "technical confirmation" and was not "nominally offered before mid 1999.[2268] This meant, among other things, that, within the PMC phase, it would be impossible to logistically support the Space Station with transportation systems other than the Shuttle.

The "scrub 89" was the main topic of the first Space Station Cooperation Review (ex art. 24). ESA was very critical, not only ofr not being involved in the restructuring from the beginning: it also observed that US attention seemed to focus on what was considered an "arbitrary milestone", the PMC, "rather than on the Assembly Complete (AC)" on which no dates or other details were available. However, it was exactly in this phase that all the tasks and resource-allocation related to the non-US elements would fall. NASA's strategy seemed to be born out of the attempt to postpone front-end costs to later parts of the programme; if this could be understandable in terms of the short-term viability of the project, it however left European contributions extremely vulnerable to future US budget cuts.

On the other hand, the US side felt that "once parts of the Station were in space, increased budgets would be easier to obtain". Moreover, to the European suggestion to include the Columbus APM in

[2268] Van Reeth Papers, Space Station, C-R, 7, ESA/C(89)R/21, Report on International Space Station Cooperation, 27 November 1989; see also Letter F.Engström (Director, Space Station and Platform) to William Lenoir (Associate Administrator for Space Station), 1 September 1989.

the PMC, instead of the US, very similar, US laboratory, US representatives claimed that APM would not be ready and, anyway, “political” factors were involved too”.

The European perception was that AC might never be achieved as planned and that contributions by Europe and Japan were seen as “dispensable add-ons”. On the other hand, the NASA Associate Administrator for the Space Station, William Lenoir objected that “the full plate [i.e. the agreed configuration] was never real”.[2269]

During the following decade, progress on the Space Station was mainly linked to three different kinds of development:

1. the redesign of the project;
2. the resilient opposition from the Congress;
3. the prospective of Russian participation following the events of 1989 and the need for Russia to join international cooperative projects in order to retain its space capacities, once the national space budget were severely cut

Confronted with rising costs and wide protest from powerful scientific circles, the Space Station came once more under severe scrutiny by the Congress. Only two years after the “scrub-89” exercise, in April 1991, the permanently manned capability (PMC) was cut by half and accompanied by a 25% reduction of power capacity. Beginning in Spring, the House threatened to cancel the programme altogether. This time, ESA was involved in the guidelines for the restructuring and its representatives testified to the House Space and Technology Committee in order to strengthen NASA’s position[2270]. In public discourses and private letters, ESA Director General Jean-Marie Luton, strongly protested against the threat of cancellation , warning about its negative consequences for the “credibility in US international cooperation commitments”.[2271]

In February 1993, the newly-elected President Bill Clinton, in order to induce savings, directed NASA to redesign Space Station Freedom yet again and, at the same time, instructed the Agency to consider Russian participation in the cooperative programme and using its space hardware for the building up of the Station. During the discussions over the budget for FY 1994, which took place in Congress in the Summer 1993, the Space Station escaped cancellation altogether by only one vote in the House of Representatives.[2272] The following year, while discussing the FY 1995 budget, the President and Vice-President personally got involved at an earlier stage than usual in supporting the project and convincing reluctant Congressmen. The full amount of more than $ 2 billion was eventually authorised at the end of a rather distressing process.

The new, slimmer, configuration developed by NASA in the Summer of 1993, and now called Space Station Alpha, included Russian hardware to be purchased in Russia. On September 2 1993 US Vice-President Al Gore and Russian Prime Minister Chernomyrdin signed a US-Russian agreement on cooperation on human space flight; it was followed by an agreement between the two national space agencies (November 1993). By December of the same year all current Space Station partners extended

2269 Parenthesis in the text; Van Reeth Papers, Space Station, C-R, 7, ESA/IGA-CC(89)2, Coordinating Committee for Implementation of the ISS IGA, Salient Points of the 1st Government Review (5 September, US Department, Washington DC; Agenda and List of Partecipants attached), 2 October 1989.

2270 “Face to Face with Ian Pryke”, *Aerospace America,* August 1991, p.8.

2271 From a letter sent by Luton to US Vice-President Dan Quayle, on May 21 1991, Douglas Isbell and Andrew Lawler, “NASA to run out of Station money in June”, *Space News*, May 27-June 2, 1991, p. 3 and p. 29 (For the quote); see also R.Bonnet and V.Manno, *op. cit.*, p. 114..

2272 K.Madders, *op. cit.*, p. 467.

an invitation to Russia to become part of the project and to begin negotiations; the invitation was promptly accepted.[2273]

The negotiations on the International Space Station Alpha (ISSA) between Russia and the four original partners started in April 1994 and lasted two and a half years. At the end of the period a new IGA replaced the old one. The Agreement between the Government of Canada, Governments of Member States of the European Space Agency, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America concerning cooperation on the civil international space station was approved *ad referendum* on 14 December 1996.

On 29 January 1998, the representatives of fifteen states (eleven from Europe, Canada, Japan, Russia and the United States[2274]) signed the IGA on Space Station cooperation, establishing the legal framework for their cooperation in the design, development, operation and utilisation of the station and defining the rights and obligations of each of them and the jurisdiction and control of their elements. The space agencies of four partners (the eleven European countries being represented by ESA) also signed MOUs with NASA, describing the steps, the roles and responsibilities to be taken during the assembly of all permanently attached elements of the station (1998-2003), its operations and utilisation for the following ten years. As far as the flight elements were concerned, ESA was due to provide:

- one pressurised laboratory permanently attached to the station;
- logistic carriers to provide system operations support, user logistics and in-orbit supply;
- orbital transfer vehicles to provide thrust capability for orbit adjustments (reboost).[2275]

Despite delays and financial problems on the Russian side, the first component of the Space Station, the Russian-built and US-owned control module Zarya, to serve as a space propulsion engine and power station in the early stages of the project to provide propulsion, power and communications, was actually sent into orbit by a Proton launcher, from the Russian cosmodrome at Baikonur in Kazakhstan, on 20 November 1998.[2276] This was the first element of the Station, which is due to be completed by 2004, with the help of small crews of astronauts who will soon begin to co-operate in the assembly phase; from that date onwards, larger crews would live on board the station, for periods up to several months.

Yet, European participation to the Space Station remains controversial. In 1998, the newly designated French Minister of Research and Education, Claude Allègre, took up again the question by labelling station Alpha, with a contemptuous literary vein, as a "very expensive emotion" ("La station, c'est de

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[2273] *Ibid*, pp. 331-332.

[2274] Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom.

[2275] "Memorandum of Understanding between the European Space Agency and the National Aeronautics and Space Administration of the United States of America Concerning Cooperation on the Civil International Space Station", 29 January 1998, *ESA Press Release*, n. 4-98, 29 January 1998; André Farand, "Signing of the new Agreements on the International Space Station", *ECSL News*, n.17, February 1998, pp. 1-2. Minister Allègre signed the agreement commenting: "La parole de la France a été donnée. Je suis donc venu signer cet accord sur la Station Spatiale Internationale, même si je ne crois pas pour ma part que les vols habités dans l'espace soient une priorité"; cited in *Libération,* 3 February 1998, p.30.

[2276] *ESA Press Release*, n.50-98, 18 November 1998; *ESA Press Release*, n.51-98, 20 November 1998; Stefano Citati, "L'Aurora nella casa spaziale", *La Repubblica*, 20 November 1998.

l'émotion très chère")[2277]. How far we appear to be from the emphatic declaration given at the Ministerial Council meeting of The Hague in 1987, when the views held by the Minister of Industry, P.T. and Tourism, Alain Madelin, seemed to be diametrically opposed. "We want to go forward in the conquest of space" declared the French representative "not just because we are hoping for various forms of spin-off that will benefit our economies generally but also because, deep down, we feel one and all that the best answer to the talk of Europe's so-called decline, the best way to demonstrate that Europe is taking on a new lease of life, is to play a leading role in the conquest of space, the symbol of the future, the symbol of human aspirations".[2278]

The Space Station, involving a tremendous financial effort spanning a long and protracted period, finds itself in a very peculiar situation: it has survived its sponsors. It is a costly legacy that not every new government (and new Congress) is ready to accept.

ESA's Director General, Antonio Rodotà, in a sober effort to reaffirm the rationality of the European choice to join the Space Station, declared that its mission is threefold:

1 "space for people", that is work on everything that can improve human life on Earth – from navigation systems to the discovery of new materials and pharmaceutical products;

2 "from the infinitesimally big to the infinitesimally little", that is research on the frontier between cosmic physics and particle physics;

3 to find an answer to two not minor questions which have haunted humanity since the beginning: is there life outside Earth? Can we live there?.[2279]

The floor is open to debate, while astronauts are preparing to reach towards the first "man-made star".

[2277] Cited in "La station spatiale internationale définitivement sur orbite", no author., *Les Echos*, 30 janvier 1998, p.13. Minister Allègre is supported by a group of scientific experts, officials and managers; see André Lebeau, "La Station Spatiale est une erreur", *La Recherche*, n. 299, juin 1997; Roger Lesgards, *Conquête spatiale et démocratie* (Paris: Presses de Sciences Politiques) 1998.

[2278] Van Reeth Papers, Space Station, C-M den Haag, 5, ESA/C-M/MIN/80 (9/10 November 1987), 13 December 1988, Annex XIV, Statement by the French Delegation.

[2279] Arnaldo D'Amico, "2003, Terra chiama Alpha", *La Repubblica*, 20 January 1998, p. 18.

Epilogue

L. Sebesta

The deadline of our historical account is 1987. However, because of the developments and changes which have occurred in the years from 1987 up to now (Summer 1999), it would be misleading to draw some general conclusions from what was then the "state of the art" in European space policy. It would be impossible, on the other hand, to synthesise in a few pages more than ten years of extraordinary transformations in three intermingled fields: European space policy, with its scientific, technological, institutional and industrial developments, European integration, and the international system at large.

The Ministerial Council of The Hague was a major watershed in European space history, because of the wide range of questions tackled and because of the importance of the decisions taken. In order to solve what were generally perceived as ordinary difficulties paving the way towards extraordinary goals, package deals were struck and a phased approach was enforced for two major programmes, Columbus and Hermes.[2280] The package deal and the phased approach eased the finding of a compromise, but represented a shadow for the future: package deals are difficult to downsize, because of the need to keep all the parts in balance, while a phased approach always risks to open the programme to future weaknesses, because it postpones crucial financial decisions. It is also true that, leaving space for "agonising reappraisals", the phased approach gives to the overall programme the flexibility that the package deal does not guarantee.

Whatever the opinion one has about the means with which the decisions taken in The Hague were enforced, they were considered as a price to be paid in order to achieve a quantum jump of European ambitions in space. These ambitions were rooted in the political assumption (the validity of which could not be found in any cost-effectiveness analysis) that in order to be a credible and powerful actor on the international stage, Europe should gain autonomy in space and its space programmes should be comprehensive (that is, should cover all sectors), coherent (that is, should be tailored to the activities to be performed and favour the best synergy among programmes) and balanced. As we have noticed elsewhere, "autonomy" and "autonomous" were used with a striking frequency in both the Rome and The Hague resolutions. Retrospectively, one of its the main architects, the then Director General Reimar Lüst, would define this concept quite unambiguously, stating that "Whenever necessary, European autonomous capability in space should be expanded – not for its own sake, but rather to

[2280] The ESA Convention provides strict rules for phased programmes. In particular, as stated in Annex III, article II, "Decisions on the start of a new phase shall be taken by a two-thirds majority of all participating states, provided that this majority represents at least two-thirds of the contributions to the programme". This provision is generally referred to as the "double two-thirds majority rule". While the overall cost of the Columbus and Hermes programmes was noted in the resolution (3713 MAU for Columbus, including the cost of launching the Columbus elements and the Columbus utilisation preparation; 4429.4 MAU for Hermes, including two qualification flights), each programme was funded for "a three-year period of initial development", with a specific financial sub-envelope of 669 MAU for Columbus and 530 MAU for Hermes . Before the end of this period, after reviewing the results of phase 1 in order to judge whether the programme objectives could be achieved within the overall financial development, governments would be invited to decide, with a double two-thirds majority, whether to embark on phase 2 (the development phase). Columbus and Hermes were then perceived as intimately linked, i.e. the complete package had to be promoted at the same time, the first to accommodate German and Italian ambitions, the other to satisfy those of France. That is why, despite their different timing (Columbus was presented by the FRG and Italy for Europeanisation in January 1984, while France indicated its intention to internationalise Hermes at the Council meeting of December 1984 and Ministers took note of the French proposal to Europeanise Hermes in Rome,1985), they were treated even-handedly in The Hague. ESA/C-M/LXXX/Res.1 (final), Resolution on the European Long-Term Space Plan and programmes, 10 November 1987; see also "The Space Station", part II, paragraphs 6 and 7; part III, paragraph 2 avoid dependence on critical elements outside Europe and thereby to become a competent partner in international co-operation".[2281]

Autonomy in space had to be defined by the standards of the leading space power, the USA. It therefore meant following a complex strategy of innovative and conservative elements in relation to the Agency's history, and of cooperation and competition *vis-à-vis* the US. MTFF and Hermes symbolised the wish for an autonomous presence in inhabited space platforms, Columbus represented the wish to build on past experience (Spacelab) and to cooperate with the US, Ariane-5 was aimed at keeping the competitive edge in the field of expendable launchers, serving the additional function of carrying Hermes into orbit. These differentiated plans were strategically rooted in a convergence and parallelism of three major long-term infrastructure programmes: Columbus (with MTFF and DRS), Hermes, and Ariane-5 which, taken together, accounted for almost 50% of the 1988 ESA budget. This convergence, in its turn, emerged from an equilibrium reached among the three major contributors, France, Germany and Italy, whose joint financial support represented almost 70% of the Agency's total budget in the same year. Everything was wrapped up as a single all-encompassing strategic plan.

Ministers, reunited in The Hague, did not forget user programmes, whose importance had been repeatedly stressed during the meeting by the British representative, Kenneth Clarke, Trade and Industry Minister, who refused to vote for the long term programme on the grounds of what he perceived as being technical over-ambition and disregard for viable applications.[2282] Ministers endorsed an extension of the Earth observation programme (made up of the ERS-1 project, the proposal for an ERS-2 programme, the continuation of work on a new generation of meteorological satellites, and the preparation of the Earth observation payloads for the polar platform), of microgravity (i.e. an enhanced programme of utilisation of Spacelab and Eureca, and preparation for the Space Station), and of space telecommunications, through Olympus, the experimental satellite which had been developed to qualify a large multipurpose platform and demonstrate new applications for communication services. Taken together, the three programmes represented 25% of the overall budget in 1988.

From a strategic point of view, however, the three user programmes forecast in The Hague seemed to be somehow squeezed in between the three main pillars of activity of the Agency. On the one hand, there was the In-orbit Infrastructure, which represented the passport for international cooperation and the blueprint for the future presence of man in space. Built upon optional programmes, it required a constant political monitoring and balance between each member's (changing) interests and it was weakened by its reliance on the volatile US core station.

On the other hand, there was the Ariane programme, the symbol of the international competitiveness of Europe in space; relying on European industrial and commercial skills, as well as indirect subsidies by European governments, Ariane had overcome the "ordeal" of the petition filed by the American firm Transpace Carriers Inc. (TCI) in 1984, during which it had been shown that government support for the launch service industry was an accepted practice on both sides of the Atlantic Ocean. The conclusion of the TCI affair and the declared US willingness to reach a mutually-agreeable *modus vivendi* for future launching activities, had given added impetus to the programme and to its legitimacy as a pillar of European involvement in space.[2283]

Last but not least, there was the "historical" mandatory Scientific Programme, on which the identity and stability of ESA was rooted – despite its modest budget share (13% of the 1988 budget). Horizon 2000 was endorsed in Rome as the first comprehensive long-term programme to direct the future scientific effort of ESA; this effort should be sustained by a constant yearly increase above inflation of

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2281 Reimar Lüst, "Where is Europe's place in space?", *Space Policy*, November 1991, pp. 295-299 (p. 296 for the quotation).

2282 K.Madders, *op. cit.*, pp. 304-305.

2283 John Krige, "The commercial challenge to Arianspace: the TCI affair", *Space policy*, 15, 1999, pp. 87-94.

five per cent for five years (this rule was eventually extended to another five-year period in December 1988).[2284] Horizon 2000 was mainly focussed on "classic" space sciences such as astronomy/astrophysics (the high-throughput X-ray spectroscopy mission XMM and the Far-Infrared Space Telescope, FIRST) and solar system sciences (the Solar Terrestrial Science Programme, STSP, with SOHO and Cluster and the Rosetta mission), quite apart from what had long been considered sciences "at the borderline of applications"[2285], such as Earth observation and microgravity.

Compared to these three programmes, space applications seemed to lack established and visible lobbying groups, first of all because of the segmentation of market and demand.[2286] Secondly, ESA's role in their management appeared to be unclear: ESA was supposed to endorse the R and D part of a system, whose future role and rules of exploitation were left undecided by the Convention. As a matter of fact, despite discussions on the topic which had gone on since the early days of ESA, no common rules had emerged about how to operate commercial satellites, which were only partially included in the legal coverage of the Convention. Established at a time when legal experts could not benefit from the insight of practical experience, the ESA Convention had been cautious in defining the responsibilities in this sector.[2287] Despite the definitory efforts of the so-called "Operations Resolution" of 1977 ("The Agency and Operational Systems"), which mainly dealt, however, with the pre-operational systems, the legal vacuum had given rise to an extended "*ad-hocery*".[2288] This was all the more complicated for the telecommunication sector, the one with the greatest likelihood of being profitable at the time, which had been revolutionised since the early 1980s by the policies of deregulation adopted by the Reagan administration, translated into European terms by the British Prime Minister Margaret Thatcher in 1981 and, a decade later, by the European Commission.

Under these conditions, what return, in terms not only of visibility but of financial profitability, could ESA and its Member States expect from expenditure on the experimental phases of such projects? The experience with the EUTELSAT Convention, signed in 1982 and which entered into force in 1985, in order to manage a European operational telecommunication system, did not seem to anticipate a future involving easy relations between ESA and the operating agencies for commercial satellites on such fundamental topics as the procurement of satellites. Moreover, with the entry into force of new Commission directives to enforce competition law in the realm of satellite services and equipment, EUTELSAT had to redefine its public service role.[2289]

The European Union entered the picture of space policy in this very same period: in 1987, with the ratification of the Single European Act, the Single European Market received an official endorsement

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2284 See chapter 5 of this volume and R. Bonnet and V. Manno, *op. cit.*,, pp. 38-39.

2285 R.Bonnet and V.Manno, *op. cit.*, p. 39 (the authors refers here to Earth Observation).

2286 On both aspects, see Euroconsult, "Earth observations in Europe. Growth and Prospects", *Space Policy*, February 1992, pp. 70-81.

2287 Article II states that "The purpose of the Agency shall be to provide for and promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space application systems". As far as the problem of the operator is concerned, art. V provides that the Agency "may, should the occasion arise, carry out operational activities", but, in doing so, the Agency should rely on "operating agencies", placing at their disposal "its own facilities" and ensure as required "the launching, placing in orbit and control of operational satellites". The conditions of this task should be defined by the Council by a majority of member states, provided that "the cost of such operational activities shall be born by the users concerned".

2288 In managing ESA's disvestment of operational capabilities, "Member States that have contributed to the development of a space programme [are] to be equitably associated with the follow-up operational activities resulting from the programme in question, taking due account of any commercial constraints"; in K.Madders.*op. cit*., p. 503.

2289 *Ibidem*, pp. 502-514; see chapter 6 of this volume. An attempt to solve some of the questions highlighted by EUTELSAT experience is represented by the new Meteosat Transition Programme (MTP), whereby ESA manages satellite procurement, while EUMETSAT is responsible for the ground segment, launch and operations; Andrew Wilson, *ESA Achievements. More than Thirty Years of Pioneering Space Activities,* ESA BR-142, 1999, p. 56; on Meteosat, see chapter 7 of this volume.

by the governments and a tight time schedule (it had to be implemented by 1992); the Act, moreover, enlarged the Community's field of competence to "Research and technological development", which became a new title to Part Three of the Treaty of Rome ("Policy of the Community"). Therefore, by the second half of the 1980s, the Community's enlarged range of competence included not only research and technology, but a vast array of fields concerning space and space firms, such as public procurement, competition, rules on mergers and state support, norms and standards, the protection of intellectual property, customs arrangements, trade and external relations, education and training. Prospective benefits of the Single European Market in terms of scale factor of business volume (increased by the progressive enlargement of the Community) were coupled by the opportunity to reduce the fragmentation of the industrial effort.

As pointed out by Roy Gibson (then special adviser to the Director General of Inmarsat) in 1987, "Working out the appropriate arrangements to bring in the private sector will need the imaginative help of governments, not only in the form of some pump-priming funding, but also in creating the right regulatory environment".[2290] Following the road traced by the White Paper on the Single European Market drafted by the Commission in 1985, the European Union as well as the national governments shared the power to elaborate and enforce the future regulatory environment for public and privatised activities that Gibson was referring to, as well as for the future European industrial policy. As would become clear in the following decade, this task was one of the main and most difficult questions to be solved in order to safeguard, if not to increase, Europe's share in the global aerospace market.

It is therefore not surprising that the first document of the European Union Commission signalling its interest in space dates back to 1988. The document suggested a strategy for setting up a coherent European approach to space. Two elements are of special relevance here. On the one hand, the Commission called the attention of the Council to the fact that no comprehensive space policy whatsoever existed in Europe, incorporating economic, social, industrial and security dimensions with the aim of taking advantage and making valuable use of the technological capability, both within Europe and outside. Such a policy, in the words of the Vice-President of the European Commission, should be designed "to achieve greater consistency between the development of technologies and their application, between space segment and ground segment, and between collaborative ventures and national activities". On the other hand, it stressed how ESA and the other European organisations set up to exploit operational satellites should act in conformity with European Union norms in areas such as competition and financial aids.[2291]

Institutionally, following a meeting between Reimar Lüst, Director General of ESA, and Jacques Delors, President of the European Commission, on 7 February 1989, it was decided to focus cooperation on three key areas: Earth observation, telecommunications and microgravity. Joint working groups were established to discuss and suggest future options on such relevant topics as external relations, competition, research and technology, telecommunications, environment and Earth observation, while the Community approved action lines to provide a coherent framework for its future involvement in space activities.[2292]

In 1991, a panel of experts, chaired by Roy Gibson, former ESA Director General, was called by the European Commission to elaborate on this last point. Among the recommendations offered, the Group suggested that the Community concentrate its efforts on a major field of activities instead of diluting

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[2290] Roy Gibson, "Governments Must Strive to Make Private Enterprise Work in Space", *Aviation Week and Space Technology*, November 2, 1987, pp. 91-92.

[2291] Karl-Heinz Narjes, "Space and the European Community", in *Space Policy*, February 1989, pp. 59-64 (p. 60 for the quotation); see also K.J.Madders et W.M.Thiebaut, "Deux Europes pour un seul espace: évolution des relations entre l'Agence Spatiale Européenne et la Communauté européenne dans le domaine spatial", *Revue française de droit aérien et spatial*, n.2, 1992, pp. 234-237.

[2292] Karl-Heinz Narjes, "Space and the European Community", in *Space Policy*, February 1989, pp. 62-63; see also K.J.Madders et W.M.Thiebaut, "Deux Europes pour un seul espace: évolution des relations entre l'Agence Spatiale Européenne et la Communauté européenne dans le domaine spatial", *Revue française de droit aérien et spatial*, n.2, 1992, pp. 240-241.

resources, and put money on a "flagship project" in Earth Observation.[2293] The Council of European Union Research Ministers of April 1993 finally tackled the problem, calling for an extension of EU research responsibilities towards space science and for a coordination in the field of management of operational satellites; the Council focussed on the possibilities of Earth Observation satellites in such vast areas as environmental monitoring, management of natural resources, inventory and survey of forestry and agricultural activities, urban planning etc. The EU needed space techniques for a series of control and verification procedures connected with its specific tasks in areas such as agriculture, fisheries, transport, regional development, and the environment. The EU could, thus, be a user and help co-ordinate links with both firms and customers, were they public organisations (intergovernmental development agencies like FAO or national administrations, both civilian and military), or private operators (insurance companies, consulting firms, airlines etc.), whose collaboration would be crucial in the passage between the experimental and the operational phases of these programmes.[2294]

The European Union's attempt to have a say in space affairs did not seem altogether exempt from potentially disruptive side-effects: in particular, the Commission's activity on such fundamental topics as industrial policy and, inside that, rules on mergers and state subventions, was to impact on ESA's own industrial policy, which was made up of giving out contracts through the rules of "juste retour". Under this respect, decisions taken in The Hague seemed to be rooted in the past, more than projected into the future. How to reconcile this increasingly tight rule with that of free competition on the international market?[2295] Moreover, the spread of institutional actors involved in the definition and carrying out of European space policy risked diluting the previously unified approach of ESA.

Meanwhile, history had entered into ESA's plan in Munich, where the Ministers of Member States and representatives of the Commission of the European Community, Eutelsat and Eumetsat (having been granted the status of observers) met in November 1991 to match the ambitious long-term goals of The Hague to the short-term unwillingness of Member States to follow the growth profile foreseen in 1987.[2296] In the opening of the "Resolution on the European Long-Term Space plan 1992-2005 and Programmes", Ministers recognised "the need for a careful, ongoing, analysis of the changing geopolitical context, in order to assess its impact on European space activities".[2297] What were the main impacts of this changing geopolitical context on European space policy? On the one hand, with the economic and political crises in Russia, its accumulated scientific and industrial knowledge in space risked becoming lost. This was particularly true in fields such as launchers and inhabited space platforms, where the record of Russian presence was particularly striking. Russia, it was thought by some, could offer technology to the West and receive much needed hard currency for it.[2298] At the same time, the country needed to be helped not only to save its technical competence in some specific fields, but for the strategic importance of its stabilising role in the whole area of Eastern Europe. The dismemberment of Yugoslavia, already going on since 1989, officially began in the Summer of 1991, with the declarations of independence of Slovenia and Croatia, and became irreversible by the end of that year, with the first formal recognition of the two countries by the Federal Republic of Germany

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2293 Roy Gibson, "Exending the EC's role in space", *Space policy*, February 1992, p. 82.

2294 Karl-Heinz Narjes, "Space and the European Community", in *Space Policy*, February 1989, pp. 59-64, spec. p. 61.

2295 In order to accommodate the wish of Italy, which felt deprived by a long record of weak "juste retour" and lack of prime-contractor responsibilities, Ministers in The Hague decided to revise the rule of the overall return coefficient. It should not only be "as near as possible to the ideal value of 1 for all countries", but should be guaranteed up to a level of 90% within each optional programme; see ESA/C-M/LXXX/Res.1 (final), Resolution on the European Long-Term Space Plan and Programmes, 10 November 1987.

2296 ESA Press Release, "Council at Ministerial Level, Munich, 18.19 and 20 November 1991, in *ESA Bulletin* , No. 68, November 1991, p. 39.

2297 Resolution on the European Long-Term Space Plan 1992-2005 and Programmes, Adopted on 20 November 1991 (repoduced in full text in *Ibid*, pp. 14-27; p. 14 for the citation)

2298 Peter Creola, "ESA ministerial meeting: consensus or confrontation?", *Space Policy*, November 1991, p.293.

and the start of military operations by the Serbian leader Milosevic. Because of the historic ties between Serbia and Russia as well as its geographical position, Russia, were it not for the political turmoil experienced in August, would be the best placed actor to moderate and mediate in the incipient crises. As far as the space field was concerned, these changes had many effects. Among them, one of the most outstanding was the need to rethink the whole architecture of the Space Station which represented, for European countries, a substantial amount of their space budget. On the other hand, European countries were struggling against the economic recession of the beginning of the 1990s. This task turned out to be particularly dramatic for a country such as the Federal Republic of Germany which, despite its political stability, confirmed during the first elections of the reunified country (December 1990), under the undiscussed leadership of Helmut Kohl, had to foot the bill for the reconstruction of the five newly attached Länder. More to the point, the new country needed to merge two different space policies into a coherent one.[2299] It is not surprising to see that, under these conditions, despite reaffirmation of the country's all-out effort in space cooperation, Germany tried to limit its financial participation in ESA optional programmes, concentrating on the one which had been living the most difficult life from a technical and financial point of view, Hermes. This was all the more predictable if one remembers that, since the meeting at The Hague, the German Research Minister, Riesenhuber, had asked for a reduction of 15-20% in the total budget[2300]. The situation did not seem to be much more positive for countries such as France, Great Britain and Italy, which had been hit by the international financial crises and internal political turmoil.

It has to be noted that the European countries were in the very same period struggling through the text of the Maastricht Treaty, the new step forward in European integration, setting the phases and rules for the achievement of the Economic and Monetary Union. The Treaty was eventually signed, among much criticism, in February 1992 and its ratification in French and British parliaments was not smooth, while Germany, carrying the burden of reunification since October 1990, showed itself to be more reluctant than before in getting rid of its fiscal prerogatives in favour of a single currency. In fact, the Treaty would not enter into force before November 1993. The impossibility to reach a final decision during the Ministerial Council of Munich has therefore to be interpreted in the light of these major and sudden changes in the geopolitical balance in Europe, changes that had a strong, albeit indirect, relationship to ESA's policies.

The geopolitical context, however, would not be enough to understand the complexity of the challenge ESA was confronted with in Munich, a challenge which was also linked to the *tempo* of European choices in space. From 1987 to the early 1990s important satellite programmes had been completed (Olympus was launched in 1989, ERS-1 in 1991), while ESA spending for Earth observation and telecommunications correspondingly levelled off. Programmes had to be revitalised if ESA's involvement in these areas was deemed sufficiently important to deserve further action. At the same time, Ariane-4 entered the operational stage in 1988; its expenditures began to drop rapidly, while funding for Ariane-5 entered a phase of sustained increase, reaching a peak in both absolute and percentage terms in 1992, when its expenditures, 1064 MECU in 1998 terms, represented no less than 35% of the total budget.[2301]

Where to go next, in order to "(…) remain an effective instrument of innovation"?[2302] How to do that with the financial limitations and within the rapidly evolving landscape of space technology of the early 1990s? In order to be such an effective instrument, the Agency had to know where space technology at large was heading, but the pattern of this evolution was scarcely discernible. The abused rhetoric by which the US would present each new space programme as "the next logical step" in an ideal expansion of the human presence into space seemed to have vanished with the end of the Cold

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2299 Stephan Hobe and Mathias Spude, "Impact of unification on German space activities", *Space Policy*, November 1991, pp. 323-327.

2300 See Reimar Lüst, "Where is Europe's place in space?", in *Space Policy*, November 1991, p. 295.

2301 See table and *World Space Markets Survey. Ten year outlook. 1994 Edition*, *cit.*, p. 82. MECU stands for millions of ECU; one ECU is almost equivalent to one EURO, i.e. $1.29 in 1997.

2302 Jean-Marie Luton, "The Agency's Current and Future Policy", *ESA Bulletin*, No.66, May 1991, pp. 9-12 (p.9 for the quotation).

War, when the rationale of American space policy came under severe public scrutiny and NASA seemed to lose its central position as mediator between firms and government in devising a coherent public policy for space.[2303] There appeared not to be such a concept as "the next logical step", because it was clear that technology does not define the evolution of projects: it is up to politics to do that. And, as far as politics is concerned, "the loss of the Soviet threat deprive[d] the US civilian space programme of arguably its single most vital propelling force".[2304] This was extremely disorienting for Europe, whose space programmes had been strongly linked, during the Cold War, to the American strategy for space – through cooperation, subsidiarity or competition with US choices.

As far as US-European relations in space were concerned, "The Cold War's conclusion had perceptibly moved the centre of gravity in the West away from containing the Communist expansion to winning and preserving market shares, especially in high-technology sectors. In this race the successor states to the former USSR [were] seen as no immediate threat to US interests at all. Rather it [was] the marketplace ambitions and actions of America's G-7 colleagues that trouble[d] and weigh[ed] heavily on the American mind".[2305]

It is interesting to note that the Committee set up by President Bush to define the future of American space, the Advisory Committee on the Future of US Space Programs, was chaired by Norman Augustine, neither a scientist nor a politician, but the Chief Executive Officer of Martin Marietta. Was it surprising to see that the document called for a "faster, better, cheaper" philosophy which seemed to go in the opposite direction to the long-term strategic programmes followed by NASA during the previous decades? How should Europe react to this change of mind which also risked to affect directly US-European co-operation, as one of its first spillovers appeared to be the approaching cancellation of the US Space Station?

"Wait and see" was the answer. Waiting for a clearer view of the direction of space policies, the second resolution of the Council of Munich concentrated on the adaptation of the European in-orbit infrastructure to the rising concerns of Europe, first of all Earth observation, a field in which ESA had been able to produce an outstanding success, with the start of operation of ERS 1, a sophisticated satellite carrying a synthetic aperture radar (SAR) sensor, just a few months before the meeting (July 1991). The Ministers, therefore, called for the execution of the first Polar-Orbiting Earth Observation Mission (POEM-1), using the Columbus Polar Platform as a technical basis, and exploiting the Data Relay System in order to acquire global data coverage. In this context, the Director General was invited "to establish a fruitful cooperation with Eumetsat, with the European Community and its Environmental Agency, as well as with other European organisations, and to seek appropriate international arrangements for involving such organisations in the development of the future European Earth-observation systems".[2306]

Despite divergences on how, everyone seemed to agree on the necessity to reduce the space plan approved in the Hague and to do it as soon as possible. This is why the next Ministerial Meeting was planned for November 1992, just one year after Munich. Agreement was reached in Granada (9 November 1992) on a cut in the two programmes whose development phases had been approved in The Hague. Columbus was reduced by suppressing the Man-Tended Free Flyer, which had symbolised for many years the European will to leave open the option for an autonomous presence in manned

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2303 On the "paradigm" of "the next logical step", see Alex Roland, "Priorities in space for the USA", *Space Policy*, May 1987, pp. 104-114.

2304 Kenneth Pedersen, "Thoughts on international space cooperation and interests in the post-Cold War world", *Space policy*, August 1992, p. 210.

2305 *Ibid*, p. 213.

2306 "Resolution on Programmes for Observation of the Earth and Its Environment", in *ESA Bulletin* , No. 68, November 1991, pp. 28-37 (p. 30 for the quotation).

space.[2307] In the context of Columbus reorientation, the Polar Platform component was soon to be transferred to the responsibility of the Earth Observation Programme Board.[2308]

In Resolutions No.2 and No.3, international collaboration seemed to be proposed as a compensating measure for the lowering of ESA's own space expenditures. The Ministers called for a new collaborative effort with the Russian Federation (res. 3) and "recognised the importance of achieving a greater synergy between the efforts of the Agency and those of the Commission of the European Community in using and exploiting the Agency's products, while preserving their respective roles, and between the Agency and other European space organisations such as Eutelsat and Eumetsat" (res.2).[2309] The time had come for ESA to fulfil one of its mandates as expressed by Article II of the Convention, i.e. to concert "the policies of the Member States with respect to other national and international organisations and institutions". This seemed to be especially true for fields such as telecommunications and Earth observation.

The Agency was presenting itself as a sort of "honest broker" between the various actors playing in this field. The POEM programme can be considered, in this respect, as test ground. It is important to note that with the assignment to Roger Bonnet, ESA's Scientific Director, of the task to reinvent ESA's Earth observation policy, under the new attractive name of the "Living Planet Programme", full scientific dignity was given to the programme (which had been excluded, as we have recalled, from Horizon 2000), The Science Directorate's missions now include Earth Explorer (focussed on Earth sciences) and Earth Watch (focussed on commercial remote-sensing missions, due to be at least partly sponsored by private industry).[2310]

Meanwhile, beginning in 1993, ESA's budget began to decline, a decline which has not yet stopped. This trend is to be interpreted in the context of a general slackening of space budgets – NASA's total direct obligations began a similar negative trend at the very same time.[2311] At the same time, by the end of 1993, Russia was formally invited by all the Space Station partners to join the programme; a process of redesign and renegotiation of the IGAs and MOUs for the newly-denominated International Space Station Alpha (ISSA) started – which eventually led to the signature of new international legal instruments in January 1998.[2312]

In this context, it is not surprising to see how the Ministerial Council of Toulouse (1995) felt obliged to rethink European participation to the Space Station, deleting DRS altogether, and descoping Columbus within a stretched timescale and a new "consolidated scenario". It consisted of a simplified Columbus Orbital Facility (COF), the provision of logistics services using Ariane 5 and the Automated Transport Vehicle (ATV), and of orbital manoeuvring capabilities by the ATV. A decision on the continuation of activities concerning the development of a Crew Transport Vehicle (CTV) was

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[2307] POEM encompassed two elements: the Envisat mission, mainly dedicated to the understanding and monitoring of the environment and to the provision of radar data; the Metop-1 mission, to provide operational meteorological observation to be carried out under the terms of the future agreement with Eumetsat, which had confirmed its intention to contribute to the mission. Resolutions 1, 2 and 3 of the Granada Ministerial Conference are reproduced in *ESA Bulletin*, No. 72, November 1992, pp. 14-36.

[2308] K.Madders, *op. cit.*, p.331.

[2309] "Final declaration of the ESA Council meeting at Ministerial level", reproduced in *ESA Bulletin*, No. 72, November 1992, pp. 41-42.

[2310] Peter de Selding, "ESA Divisions Persist; Hopes For Ministers' Meeting Fade", *Space News* , 20 March-5 April 1998 p.4 and p.20. The "Living Planet Programme" was officially endorsed by the Ministerial Council Meeting of Brussels in May of this year (1999). Lord Sainsbury declared to journalists that "The agreement to embark on the Living Planet Programme is the first step towards providing an assured long-term programme of research which looks at the Earth and its environment from space. We are putting Earth sciences on a more equal footing with ESA's traditional strengths in scientific research". *ESA Press Release*, n. 17-99, 12 May 1999.

[2311] *NASA Pocket Statistics. 1995 Edition*, Washington DC, NASA, 1995, p. C-17

[2312] See chapter 15.

postponed in time.[2313] New ideas for future programmes (such as lunar exploration and a future launch system beyond Ariane-5) as well as Horizon 2000 Plus were visible steps towards getting out of the doldrums of the beginning of the decade, towards new paths of activities in space.[2314]

In the framework of today's conditions (1999), with an unemployment level reaching 20% in some regions of the European Union and public funding still representing up to 75% of European space expenditures, ESA is called on not only to update its programmes, but to rethink its responsibilities in general.[2315] As the newly-elected Director General of ESA, Antonio Rodotà, told a press conference in January 1998: "ESA's role in the beginning was to develop a space sector in Europe. Increasingly that role is to support European industry to keep up with market developments and to generate jobs". During the press conference Rodotà and ESA's Director of Administration, Daniel Sacotte, often referred to European government ministers as the Agency's "shareholders".[2316]

On the same line, referring on the outcomes of the Council at Ministerial level held in Brussels on 11 and 12 May 1999, the new designated ESA Ministerial Council Chairman, Lord Sainsbury, UK Space Minister, told journalists that "The new investments agreed will underpin the development of new jobs in multi-billion Euro knowledge-based industries in the next decade"[2317]. In this respect, it is expected that ESA, through its R and D and contracts policy, will be able to direct the industrial sector to the most promising opportunities of economic growth in space, in the area of services, whose users are both civilian and military entities. If the European Union is going to extend its prerogative to the field of external relations and security, as appears feasible and opportune in the light of recent developments, this orientation will become compelling. ESA ought to be ready to provide satellites for these functions. This would not impinge on the rationale of ESA's activities as expounded in the Convention, as being to provide and promote co-operation "for exclusively peaceful purposes", neither from the legal point of view nor in respect to more substantial standards.[2318] Crisis management and verification of arms control agreements are meant to be preventive actions on the road to a more peaceful European society.[2319]

Therefore, there seems to be a drive towards an homogeneity of the structural and financial conditions of Member States, as well as increasing functional links between ESA and the EU. Cooperation between ESA and the EU is nowadays easier due to the developments in the memberships of the two organisations. After the accession of Austria, Norway and Finland to ESA and, more recently, those of Austria, Sweden and Finland to the European Union, they seem slowly but surely moving towards a significant homogeneity in membership.[2320]

Within this homogeneous formal framework, ESA is the best placed agency to set strategic goals, providing for and promoting, as stated in Article II of the Convention, "co-operation among European

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2313 Resolution concerning decisions on agency programmes and finances (adopted 20 October 1995), reproduced in *Space Policy*, February 1996, p. 79.

2314 K. Madders, *op. cit*., pp. 333-336.

2315 For the figure, see Eurospace, "Space: a challenge for Europe", *Space Policy*, November 1995, p. 227.

2316 These are Rodota's words cited in Arnaldo D'Amico, "2003, Terra chiama Alpha", *La Repubblica*, 20 January 1998, p.18.

2317 *ESA Press Release*, No. 17-99, 12 May 1999.

2318 See chapter 15.

2319 Alasdair McLean, "Integrating European security through space", *Space Policy*, November 1995, pp. 239-248. It is important to stress that ever since 1984 the Assembly of the Western European Union has stressed how space capability would be the key determinant of the future European security and "the difference in potential between the space-capable nations and the others will be almost as great as the current difference between nuclear and non-nuclear nations"; Recommendation 410 of 21 June 1984, cited in Stephan F. von Welck, "Dominance in space – a new means of exercising global power?", *Space Policy*, November 1988, p. 326.

2320 ESA members are: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, The Netherlands, Norway, Portugal (from mid-2000), Spain, Sweden, Switzerland and the United Kingdom. All of them except Norway and Switzerland are EU members. On the other hand two EU members: Greece and Luxembourg do not (yet) participate to ESA.

states in space research and technology and their applications, with a view to their being used for scientific purposes and for operational space application systems". European day-to-day behaviour will continue to be the result of the tugs of war between different national and other interest groups (consumers, airliners, PTTs etc) in the same way as democracy is the mechanism which accommodates and regulates the conflicts within civil society.

Within these strategic goals, Member States are not required to abandon their national policies, but to co-ordinate them. Differences in national interests, expressed through the existence of national space budgets, are not, *per se*, a threat to European space policy, provided that they are compatible and stay within an overall international strategy. The existence of an inversely proportional relationship between the extent of national expenditures and the degree of 'affection' towards ESA's policies is still a disputable question.[2321]

The problem here does not seem to be quantitative, but qualitative: what should be the kind of expenditures sustained directly by national states? Which should be "handed over" to ESA (and, eventually, the EU). Because of its nature and long term planning, ESA seems to offer more guarantees of continuity compared to national policies, subject to the vagaries of frequent government changes. It would therefore be logical to think that the Agency be accorded responsibility for the pursuit of long-term, high profile space programmes (be they in the scientific, transport, in-orbit infrastructure or commercial), while national governments care for the maintenance of infrastructures. This for two reasons: because infrastructures, by their very nature, are more likely (than programmes) to be protected from sudden "changes of mind" of national governments; because in order to reach the financial critical mass for big projects, co-operation seems to be an absolute necessity. The last is equally true for small and large countries. If we consider that the new *Ariane plus 5* rocket is budgeted at a figure which varies from 1.5 to 2.8 billion Euros and that the costs of the newly approved global navigation satellite system Galileo (including the cost of building and launching a 24-satellite constellation into medium Earth orbit, plus the cost of related ground stations) is estimated by the EU Commission at about 2.2. billion Euros, we easily understand that cooperation is a compelling need.[2322] In this context, more than focussing on the ratio between national and ESA expenditures, it is important to point out how the overall ratio between European global space expenditures (national and ESA) and US expenditures (both including military expenditures) has stabilised in this last decade at an average of 1 to 5, which compares remarkably well with the ratios of previous times, but is still low by absolute standards.[2323]

As the example of Galileo clearly shows, there appear to be high expectations about the profitability of the market for services offered by satellites and their ground sectors (such as Earth observation, telecommunication and navigation). The four companies forming the consortium working on the feasibility studies for Galileo have recently informed the EU Ministers about their willingness to finance part of the global satellite navigation service. The consortium estimates that the market for Galileo user terminals will be more than 120 billion Euros over the next 18 years and the market for Galileo-related services could reach 113 billion over the same period, with an additional 50 billion from export of Galileo hardware and services outside Europe. What industries ask is a legal structure and commercialisation system that can make profitable a service that, for many reasons, has to be given basically for free![2324]

2321 André Lebeau argues that this has not been the case for France; André Lebeau, "La Convention de l'ESA à l'épreuve du temps", *Twenty Years of the ESA Convention*, ESA SP-387, Noordwijk, ESA, 1995, p.133.

2322 Thierry Gadault, "Ariane-5 nécessite de gros investissement", *La Tribune*, 10 May 1999; Peter de Selding, "Firms Want to Invest in EU Navigation System", *Space News*, 10 May 1999.

2323 *European Space Directory. 1999*, Paris, A SEVIG Press Publication (endorsed by Eurospace), 1999; on Galileo, see also Michel Alberganti, "L'Europe va briser le monopole américaine des satellites de navigation", *Le Monde*, 11 February 1999..

2324 The four companies are: Daimler-Chrysler Aerospace AG (Dasa) of Munich, Alcatel Paris-based, Matra Marconi Space of Velizy, and Alenia Aerospazio of Rome; Peter de Selding, "Firms Want to Invest in EU Navigation System", *Space News*, 10 May 1999.

This is not to say that ESA is less interested than before in scientific excellence: ESA was born to be an R & D agency and science has been giving it visibility, representing its historical roots and the undisputed core of its architecture. Scientific research done together in space "from the infinitely large to the infinitesimally small", that is from cosmic physics to particle physics, is the added value of ESA compared to other international organisations; it is what makes ESA not only and not so much an agency or an organisation, but a laboratory for new questions and new answers about human destiny.[2325]

[2325] These are Rodotà's words cited in Arnaldo D'Amico, "2003, Terra chiama Alpha", *La Repubblica*, 20 January 1998, p.18.

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