The implementation of satellite technology in the Eurovision network

W. Potter (EBU)

An essential feature of the Eurovision system, enabling the network to retain its lead in the provision of television distribution services across Europe, has been the implementation of satellite technology in support of the long-established network of terrestrial relays.

This article retraces the history of satellite operations within Eurovision, from the first experiments with the Orbital Test Satellite in the 1970s, to the establishment of transmit/receive earth stations at broadcasters' premises in all the major centres of Europe - East and West.

Against a backdrop of engineering, the author explains that there is much more to satellite transmission than G/T and rain-fades; tact, diplomacy, a keen awareness of European politics, and above all patience are essential attributes contributing to the successful installation of earth stations at the places where broadcasters need them most.

1. Early days - OTS and Eutelsat I

1.1. Flirting with satellite technology

The Members of the EBU were amongst the first customers of the Eutelsat organization. This was after many years of planning and consultation with several international bodies, from the time when European communications satellites were still at the stage of paper exercises, some pessimistic, some optimistic. From the outset, it was recognised that an important element in the requirements for the design of a regional European communications satellite system would be the particular needs of the EBU for the exchange of programmes in Eurovision between the Members of the Union.

Through Working Party N of the EBU Technical Committee, later succeeded by Sub-group T7 of Working Party T, there was close collaboration at all stages of the development programme known as the European Communications Satellite (ECS) with the European Conference of Posts and Telecommunications (CEPT), the European Space Agency (ESA) and its predecessors. This included participation in the tests with the Orbital Test Satellite (OTS), which was the experimental forerunner of what was to become the Eutelsat I

Original language: English.
Manuscript received 24/10/94.

series of satellites. Some of these satellites are still in orbit, and in use. The culmination of this activity in the late 1970s and early 1980s, was the signature of a contract in Paris early in January 1982, between the EBU and the (then) Interim Eutelsat for the lease of two transponders in the first Eutelsat satellites.

Having a contract for the use of two satellite transponders was one thing: obtaining facilities at earth stations to operate with the transponders was another. The main mission of the ECS satellites was for public telecommunications, notably for time division multiple access (TDMA) telephony traffic. The PTT Administrations were in the process of setting up earth stations for ECS with antenna diameters of the order of 15 metres and upwards. In general, such stations were located at existing earth station sites deep in the country, usually several hundred kilometres from the broadcasting studios of EBU Members. At that time, it was necessary to lease the earth segments from the PTTs in countries which were Signatories to the Interim Eutelsat Agreement.

Although the EBU was able to contract direct with Interim Eutelsat on behalf of its Members for the lease of the two transponders, individual negotiations between the EBU Members and their national Administrations had to be undertaken to lease the earth segments, including the terrestrial extensions between the earth stations and the broadcasters' premises. In Europe, the PTTs were still very insistent on maintaining their communications monopoly.

The rental costs for the lease of transmit and receive chains for television at the main earth stations were very high. They were so high, in fact, that the earth station contracts between the EBU Members and their PTTs were for the lease of a single transmit chain and a single receive chain in most of the nine countries in which stations became available during the first two years of operations. In some countries, the outgoing traffic was insufficient to justify the lease of transmission facilities, and three countries were served by a single receive-only chain for television.

The overall cost of transferring part of the Eurovision traffic from terrestrial circuits to the satellite system was so high, that such a move was hardly economically justified. The EBU rightly maintained that its annual network costs using terrestrial circuits for Eurovision operations should not be increased by the change to a mixed satellite/terrestrial network. After many studies and calculated simulations, it was decided to proceed on the basis that the costs would work out to be about the same over a ten-year period, taking account of the expected traffic growth and the probable need to extend the leased terrestrial network.

It was a contractual condition with Interim Eutelsat, that the Agreement could only come into force when two satellites were in orbit, and at least five earth stations were available. During the first two years, the satellite rental was proportional to the number of earth stations available, up to a maximum of twelve. The first ECS satellite was launched in June 1983, to be immediately renamed Eutelsat I - Flight 1 when it was taken into service in October. In October 1984 the second satellite was taken over from ESA by Eutelsat, and the full commercial exploitation of the system could begin. Even then, fewer than five earth stations were available, and it was only later, in November 1984, that the EBU was able to start transferring Eurovision traffic to the Eutelsat I - Flight 2 satellite, using five earth stations in Austria, Belgium, France, Germany, and Sweden. Thus 1994 represents not only the fortieth anniversary of Eurovision: it also marks the tenth anniversary of the introduction of satellite transmission in the EBU's leased network.

1.2. The first earth stations

At the main telephony stations where the EBU Members had rented transmit and receive chains, a certain amount of technical innovation was necessary. Of more significance, was the need to overcome the psychological barrier of remote switching. Since 1968, the Eurovision permanent leased vision network (PNV) had been in operation. By the time the change- over to satellite operations took place in 1984, the Eurovision network operators had for many years enjoyed the complete flexibility and improved quality achieved through daily monitoring of the leased terrestrial circuits of the PNV.

Switching at the nodal points of the terrestrial network was under the direct control of the broadcasters from their national technical control centres (CNCT), and no orders had to be placed, nor advance notice given to the PTT Administrations, for each and every transmission. This is still the case for the use of occasional circuits. There was no question of stepping back into history in terms of operational flexibility with the change to satellite transmission. Most PTTs displayed a distinct reluctance to permit the broadcasters to have direct control of the earth stations, but it was a *sin qua non* for the EBU that the earth stations be under the control of the CNCT operators from the point of view of channel changing and transmitter

switching. This was finally achieved at most transmitting stations, using a specification jointly drawn up by the EBU, Eutelsat, and the CEPT. Satellite remote switching (SRS) was carried out using 1200 bit/s synchronous data circuits rented from the PTTs.

The EBU had always maintained that the main PTT earth stations were over-dimensioned for the transmission and reception of television signals in the Eutelsat system. Furthermore, the terrestrial links between the earth stations and the broadcasters' premises considerably increased the costs, in addition to reducing the overall transmission quality which was available over the satellite. The satellite network was very inflexible if any expansion in the numbers of channels in the satellite were to be contemplated (an early development), mainly due to the large distances separating earth stations from the end-users requiring additional terrestrial links. It was somewhat paradoxical that a transmission between London and Paris, say, remained on terrestrial links for a far greater distance when the satellite path was being used, compared with the shorter distance over the direct London-Paris terrestrial link.

The technical specification of the requirements at the main earth stations had been drawn up jointly in 1983 by the EBU and Eutelsat (ECS/C 7-19 rev 3). By February 1985, EBU Sub-group T7 had established a specification for the minimum requirements at television receive-only stations (EBU document Tech. 3248) and, by July 1987, the Sub-group had also drawn up the specification for transmit stations (EBU document SPB 277). Taking advantage of the improved potential quality for stations without terrestrial extensions, antenna diameters of the order of 7 to 9 metres could be used. It was envisaged that these stations would be set up at the broadcasters' premises.

1.3. *Earth stations at the broadcasting centres*

Once the EBU leased transponders had been brought into service - that is to say, once a satellite network with an adequate number of earth stations had already been paid for - it soon became evident that the cost of adding an earth station to the network was very attractive from the financial point-of-view, if it was situated at the broadcasters' studios. Even the Administrations were persuaded that this was the way to go, and as early as May 1985, the German broadcaster ARD was renting a 9-metre receive-only station from the Deutches BundesPoste. The station is located at the ARD news hub at the Hamburg studios. The annual rental cost was competitive compared with the lease of the single terrestrial vision circuit between Frankfurt and Hamburg which had been abandoned by the EBU with the change-over to satellite.

Figure 1
The first transmit/receive station at the Member's studios in Copenhagen. An ideal situation for a Eurovision earth station.

Originally, the overall plan for the Eutelsat system included a main earth station situated at Aagesta near Stockholm to serve not only Sweden, but the other Scandinavian countries and Finland as well. This was one of only two stations where the EBU was able to justify simultaneous access to both leased transponders. The Members dependent on the Swedish station still had to lease terrestrial extension circuits from Stockholm for access to the satellite. In the particular case of Denmark, the circuit from Stockholm to Copenhagen was of inferior quality to the more expensive PNV circuit which had previously been leased from Hamburg. Not unnaturally, DR was not particularly happy with one of the consequences of the switch to the partial satellite distribution of Eurovision transmissions. Before long (in fact, in June 1987), the Danish Administration had set up a transmit/receive earth station "just outside the front-door", so to speak, at the premises of Danmarks Radio (DR) at Soberg. In *Fig. 1*, the part of the building immediately behind the antenna houses the CNCT. The earth station equipment is contained in a room immediately adjacent to the CNCT.

The Copenhagen station represented the first fully operational transmit/receive earth station situated at an EBU Member's broadcasting centre.

Mainly due to local circumstances, it has rarely been possible over the years to emulate the ideal situation represented by the Copenhagen station. Setting up a relatively large antenna in an urban environment, rather than way out in the country, brings to light new problems such as adequate geostationary arc visibility, planning permission, non-ionising radiation hazards, etc., not to mention higher interference levels. However, this negative side of the balance sheet is far outweighed by the advantages of multiple channel access, flexibility (even to the extent of installing temporary ad-hoc facilities for particular events), and much lower costs. The only major drawback was the continued need to rent the station from the Administration, although the rental costs were much more reasonable than under the original contracts for the use of the main stations.

The need to lease earth station facilities from the Eutelsat Signatories did not apply outside the CEPT area in the Middle East and in North Africa. It was not long before projects were under weigh in Member-countries in this area. The Copenhagen station was joined on the network in July 1987 by a receive-only station at the Member's premises in Cairo. This was the first earth station to be owned and operated by an EBU Member. The first Member-owned 7-metre transmit/receive station came into service in Tunis in April 1988, to be joined by 9-metre receive- only stations in Israel and Jordan in time for the Summer Olympic Games from Seoul in 1988. Both Middle East stations are owned by the Members and they have now been up-graded to be able to transmit, using temporary installations. The whole of North Africa is now served through the Members' transmit/receive earth stations, with the most recent station in Libya coming into service in autumn 1994.

Another advantage of the introduction of the satellite network, for some Members having their own earth stations, was direct access for the first time to the main Eurovision network. This was in addition to the financial savings to themselves and to all the other Members taking part in Eurovision, through the mechanism of network cost clearing. For many years, the Members in countries in the Middle East, Egypt, Cyprus, and Iceland had to depend on expensive block bookings using the INTELSAT system for their participation. The change to a mixed satellite/terrestrial network using earth stations at their premises, or even when leased from the Administrations, gave these Members direct access to the same network which their continental fellow-Members had enjoyed through the years.

1.4. Intervision

In the days of the Cold War, it sometimes came as a surprise to the uninformed that no Iron Curtain existed between the Members of the EBU and those of its sister-Union, the OIRT. Collaboration between Members was particularly close for daily operations in the Eurovision and Intervision networks. Frequent exchanges of news and other programmes took place between the participating Members of the two Unions, using the Eurovision and Intervision terrestrial networks. From the point of view of satellite transmission, the Intervision network had already been operating a satellite news exchange since 1982/83, using the Intersputnik system, some months before the Eurovision change to satellite operations in November 1984.

Traffic between the two Unions had reached such an extent by the mid-80s that the EBU had leased a permanent terrestrial circuit from Prague to Vienna, and there was a leased circuit in the other direction for Eurovision to Intervision traffic. As early as November 1983, before the EBU change-over to satellite, the possibility of linking the Intervision network to the Eurovision network using the EBU leased transponders had been examined at meeting of the Eurovision and Intervision Contact Engineers in Prague. An earth station situated close to the TKCI in Prague - the equivalent of the Eurovision Control Centre (EVC) - would have been an interface between the two networks. Apart from the usual increase in flexibility, substantial cost savings could have been made on both sides.

With the usual administrative delays in seeking the necessary permissions and agreements, little progress had been made towards the establishment of the Prague station by the autumn of 1989, when the profound political changes were taking place in the countries of Eastern and Central Europe. In fact, the Velvet Revolution in the former Czechoslovakia was taking place at the time of the following meeting of Contact Engineers in Prague in November 1989, when the need for such a station had become even more evident. The necessary agreements in principle for setting up the Prague station were obtained during the course of 1991. A new factor was the increase in Eurovision traffic from the former Soviet Union, which had grown to such an extent by the end of 1991, that an expensive direct satellite connection over Intersputnik had been leased from the PTTs to link Moscow to the Eurovision network at Hilversum in the Netherlands. It had also become necessary, for economic reasons, to try to establish an EBU earth station in Moscow.

2. Building on experience

2.1. Eutelsat II and earth stations for new EBU Members

By the end of 1991, Sub-group T7 had established the specifications for EBU earth stations to be used with the Eutelsat II generation of satellites, which were due to come into service in 1993. The EBU Permanent Services had drawn up a Request for Proposals (RFP) for circulation to potential suppliers, for the earth stations in Prague and Moscow, taking into account the need to convert the stations for digital transmission at a later date. By this stage, plans were also afoot for the unification of the two Unions, and it became evident that the Prague station would have to be located not at the Intervision headquarters, but at the studio premises of the Czechoslovak Television (CST) at Kavchi Hory in Prague. Furthermore, with the unification of the two Unions being brought forward to a target date of January 1993, the original RFP was extended to cover stations in the countries of the OIRT Members. In fact, with the break-up of the Soviet Union, stations were also likely to be required in the new republics of the Commonwealth of Independent States (CIS) situated in the European Broadcasting Area, which extends beyond Moscow to the 40°E meridian.

Resulting from the RFP to industry, eleven potential suppliers had submitted proposals by February 1992. A Selection Board, including Members' representatives from both the EBU and the OIRT and from the Permanent Services, selected the United States company Scientific Atlanta as a suitable source of supply for earth stations meeting the EBU requirements. During the assessment period, and in the time leading up to the final negotiations, this company had also won contracts from several other EBU Members and PTTs for the replacement earth stations to be installed in Western Europe in time for the change to the Eutelsat II satellites in January 1993. The company was in close touch with the Permanent Services and its customers concerning the design reviews for these stations, intended to streamline the technical facilities at the earth stations and to meet the exact needs for Eurovision operations including, in particular, the requirements for remote control from the CNCTs. Although this cooperation with the manufacturer did not weigh very heavily on the final selection of this company, the experience gained in meeting the other Members' requirements was useful for incorporation in the final design and specification of what has become known as the "standard" EBU earth station.

By the time final Agreement had been signed between Scientific Atlanta and the EBU in June 1992 time was running short, if plans to equip the OIRT Members with earth stations by the date of EBU/OIRT unification in January 1993 were to be met. The first series of site visits to Bulgaria, Romania, Czechoslovakia, Hungary and Poland in August resulted in tacit agreements to purchase earth stations, but various complications were setting in, and hopes to meet the target date in a period of about four months began to fade.

Not the least of the problems in setting up stations in Eastern and Central Europe was locating a source of funds. With many of the national economies in very bad shape, the problem of finding sums of the order of one million dollars to finance the construction of an earth station was of great consequence to the new EBU Members.

Towards the end of 1991, the EBU had entered into discussion with the European Bank for Reconstruction and Development (EBRD) with a view to providing loans to EBU Members in Eastern and Central Europe. This Bank had been specifically set up to provide financial support for projects in the new democracies, but it is usually involved in large-scale projects costing many millions of dollars. By considering the new EBU Members' requirements as a single project involving the construction of up to 15 stations, the Eurovision Network Expansion Project was born in an Agreement between the Bank and the EBU in November 1992. The individual loans would be guaranteed by the EBU, with repayments by the Members scheduled over eight years.

One problem which arose during the negotiations with the Bank was the question of procurement. Normally, the Bank will only finance projects which have been subject to open public tender according to the Bank's own procurement rules. Serious progress towards the final Agreement with the EBU only occurred after the EBU's Selection Board had already chosen a supplier from the results of the RFP issued in November 1991. A dispensation was written into the individual Members' Loan Agreements, such that the first six stations could be financed by the Bank under the EBU procedures, provided that the orders were placed, or at least a letter of intent existed, before the end of 1992.

There was the time constraint imposed by the foreseen Unification of the Unions and there was the need to prepare the change of the whole Eurovision network to operations with the Eutelsat II satellite in January 1993, using new earth stations to replace the original PTT main stations. This

added need to complete the contracts for the procurement of six stations for the new Members, and to negotiate individual loan agreements before the end of the year, led to a period of intense activity within the Permanent Services, for which an additional member of staff had to be recruited.

By the autumn of 1992, the prospect of earth stations in the countries of the former Yugoslavia had also come into view. Although the former EBU Member, JRT, had set up a station in Zagreb in May 1990 to serve all JRT Members, it would be more economic to install earth stations in Slovenia, in Bosnia-Herzegovina, and in the former Yugoslav Republic of Macedonia rather than to interconnect the new Members in these countries by terrestrial leased circuits. The Bank was prepared to include some of these stations in the Eurovision Network Expansion Project.

As has been mentioned, the first tour of sites in the OIRT countries resulted in progress on five stations. However, only in Romania and in Bulgaria did the Members decide to finance the stations through EBRD loans. This left a shortfall of projects which could benefit from the EBRD loans, without the need to proceed to a second tender.

A second series of site visits was undertaken during October, November, and December 1992 to Russia, Ukraine, Belarus, Moldova and Slovenia. Various uncertainties prevented progress in Russia, but completion of the early paper work for the construction of earth stations in the four other countries meant that the Bank deadline was met before the end of the year.

Although the targets had been met on paper, it was quite evident by December 1992, that setting up permanent earth stations in the countries of the new EBU Members in time for the Unification in January 1993 had become a physical impossibility. This opened the probability of the Eurovision cost clearing having to support high terrestrial circuit costs to feed the new Members taking transmissions as full participants from 1st. January. Urgent steps were required to reduce the network costs arising from feeds to the new Members.

In consultation with Eutelsat, it was agreed that one of the four transponders in Eutelsat II could be operated in extra-high gain as a temporary measure. This meant that the channel G which would become available in January 1993 after the change-over could be received in Eastern and Central Europe with antenna diameters of the order of 4 to 5 metres. It may be recalled that the satellite to be used for Eurovision had the antennas modified to give improved coverage in Eastern Europe, particularly towards Moscow.

As a stop-gap measure, a survey was carried out in the new Members' countries, and it was established that all but five of the OIRT Members had suitable stations available, or which could be modified for this temporary solution. A rush project was implemented to equip the new Members in the three Baltic countries - Estonia, Latvia, and Lithuania - and also the new Members in Belarus and in Moldova with cheap temporary receiving stations which were very rudimentary in form, but suitable as interim measures while awaiting more permanent solutions.

A crash programme of acquisition was initiated for these 5-metre stations, with a two-month delivery time. It was also necessary to organise the dispatch of sound-in-syncs (SIS) equipment to enable as many new Members as possible to participate in the Eurovision exchanges from January 1993.

The transfer of Eurovision traffic from Eutelsat I, Flight 5 at 21.5°E to Eutelsat II, Flight 4 at 7°E took place overnight from 13/14 January 1993. This was also the occasion to bring into service the new earth stations at Frankfurt, Mainz, Stockholm, and Vienna. Several existing Eutelsat I earth station contracts were prolonged using other earth stations. Since the main public communications services were still being carried on the previous satellite, the change-over to Eutelsat II resulted in the physical separation of the telephony services and the Eurovision services. The majority of television-only earth stations now in service are situated at the Members' premises, and most are owned by the Members.

2.2. Unification of the Unions

On 1st January 1993, all of the former OIRT Members from countries in the European Broadcasting Area, with the exception of DFF, became Active Members of the EBU. Although the new Members in Bulgaria, Czechoslovakia, Hungary, Poland, Romania, Russia, and Ukraine were able to take part in Eurovision satellite operations at least from the time of the change-over to Eutelsat II using the Channel G, those dependent on completion of the 5-metre temporary project had to wait until mid-March 1993 before having access to the satellite.

Nevertheless, the saving in costs once the new Members were able to receive from the EBU leased transponders, albeit on a temporary basis, was considerable, compared with the costs of the

terrestrial circuits used for the short period before the satellite change-over. Some 5-metre stations were amortised through savings in terrestrial circuit costs in a period of a few weeks.

3. Eurovision Network Expansion.

3.1. Phase I

Meanwhile, the Eurovision Network Expansion Project was well into the manufacture and delivery process. However, with the inevitable transport/customs and other delays, the first station resulting from the first site visits in August 1992 only became available from early March 1993. This was the Prague station. It may be recalled that the idea of this station was first mooted in November 1983. This illustrates the most striking requirement for setting up the earth stations on the Eurovision network - not only in the new Members' countries, but also in the old Members' countries too - patience!

Progress continued during 1993, with the stations in Bucharest, Sofia, Warsaw and Budapest becoming available during the year. Two more stations came on the air early in 1994: at Ljubljana in January and at Kishinev (Moldova) in April. The 5-metre temporary station at Kishinev had been well and truly amortised by that time. The Kiev station, which will be the fifth station to be financed under the EBU/EBRD Agreement, is due for testing in November, and it should be operational by the end of 1994. Construction of the sixth station to be financed under the EBRD Agreement, namely in Minsk, had to be postponed to Phase 2 of the Project. The station had arrived in Europe in mid-1993, and was placed in storage in Germany. Despite all efforts being made to obtain the necessary administrative paper-work from the Member in Belarus, it became evident that the high storage costs for the station could not be supported indefinitely, and the station was shipped elsewhere.

A feature of the Eurovision Network Expansion Project has been the rapidity with which new countries in Europe have grown from the ashes of the former Socialist countries. There was no problem to find a suitable destination for the station originally destined for Minsk: the former Czechoslovakia had in the meantime split into two independent republics. The new Member in Slovakia was keen to establish full operations in the Eurovision network, and the station in question was shipped to Bratislava, to become fully operational

Figure 2
The earth station at Sofia (Bulgaria) where, fortunately, the urban development was behind the antenna.

in July 1994, although it had been available for reception of the Lillehammer Winter Olympic Games since February.

Mention has been made of the Kiev station being ready before the end of 1994. Another important station has completed its tests before the winter and it should also be operational before the end of the year to complete the initial project. The modest project envisaged in the original RFP concerned earth stations in Prague and in Moscow for the particular requirements of the EBU as it was then. It proved to be impossible to set up a station at the Member's premises in Moscow, particularly since an antenna diameter of 13 metres was required. The Member, RTR, was also particularly concerned about the radiation hazard in the densely-populated suburb of Moscow where the studios are located, surrounded by high buildings. The elevation angle from Moscow for a satellite at 7°E is just over 20°. Several alternative sites were inspected during visits by EBU and Scientific Atlanta personnel, but none was suitable.

The Member was very keen to have the station located at a site at Klin, some 80 kilometres north-east of Moscow. By government decree, RTR had been granted use of the site for the establishment of a teleport, and the Member proposed that this site be used for the station. The site will be linked to the studio premises in Moscow over 140 Mbit/s digital microwave links, using 34 Mbit/s for the television signals. Over existing glass-fibre links, the other Member in Russia, RTO, located at the Ostankino studio complex, will also be served by

the station, taking a feed from the RTR CNCT, as will the EBU News Bureau in the Rossia Hotel.

Perhaps the location of the Klin antenna and shelter is symbolic as a closing chapter to the initial project in the new era which began with the demise of the Cold War. The site granted to RTR for their teleport had been an intercontinental ballistic missile launch site. Under the terms of the SALT Treaties, the rockets had been destroyed, and many of the installations had been blown up. The site is surrounded by former missile tracking stations. A Director of the EBU Technical Centre expressing the conviviality of an after-dinner speech during a courtesy visit to the OIRT during the pre-glastnost days once remarked that it was fortunate that the technical discussions between the two Unions revolved around Megabits, rather than Megatons. It may be an extension of this same sentiment that during the site survey at Klin, it was unanimously agreed that the best location for the station was right on top of a former missile launch pad. The Member's earth station at Klin will soon be launching its Megabits westwards rather than Megatons, once the change to digital transmission takes place.

3.2. Phase 2

The installation of earth stations for the new Members is still not complete. A call for tenders for Phase 2 of the Eurovision Network Expansion project was launched by the EBU in November 1993. Future stations to be financed by an EBRD loan have to be purchased from a manufacturer selected after the Bank's procurement rules have been followed. This time, seven proposals were received by the closing date in March 1994, after a pre-qualification stage which required candidates to be prime manufacturers of at least half of the equipment proposed. A second Selection Board, similar in composition to that for Phase 1, chose the Japanese Company NEC as a suitable supplier. This company had already constructed nine stations on the network for Members and PTTs during the Eutelsat I years.

The likely order of construction will be in Macedonia, Estonia, Latvia, and Belarus. Preliminary site visits have been made to these countries pending completion of the Bank procedures. Progress will depend on how soon the paper-work can be cleared up. It may be possible at a later stage to include stations in Belgrade and Tiranë in the project. As with the Scientific Atlanta project, the NEC project is also expected to include stations in Western Europe, either where no station yet exists, or where a replacement for an existing PTT station is required. The same terms of NEC's final proposal will also apply to both new Members and old Members.

Since the Member in Lithuania was able to finance an earth station from its own resources, an earth station in Vilnius came into service early in October 1994. A special project to meet the particular needs of the Member in Bosnia-Herzegovina is being studied. Several other projects are under study for Members in Western Europe.

4. Earth stations for Eutelsat II

And the earth stations themselves? Perhaps some answers in reply to the typical questions asked by the Members, particularly by the non-engineering executives responsible for such a relatively important investment, is a good starting point:

4.1. Why so large?

The immediate question always refers to the reason why an antenna with a diameter of up to 9 metres and more is necessary, when good pictures from other satellite channels can be received from a 3- or 4-metre antenna, sometimes from the same satellite as that used by the EBU. The easy answer is that the contract between the EBU and Eutelsat sets down the minimum values for the satellite parameters in the direction of a given location. Stations with a foreseen lifetime of ten years and more must be constructed to meet the constraints imposed by these contractual values. The main parameter which determines the antenna diameter is the minimum saturated power (EIRP) of the satellite towards the earth station. This statement contains two nuances: it means that the power will be maintained by Eutelsat from any satellite, from any orbital location for the entire duration of the contract; and it is the power from such a satellite, when going "flat out", so to speak.

The antennas of the present satellite have been modified compared with those of the first three satellites to give better coverage towards the eastern part of the footprint, and the saturated EIRP towards a given location usually exceeds the minimum value, sometimes by a large margin. However, Eutelsat cannot guarantee that the EBU service will always be provided from the present satellite. In fact, Flight 4 will be the only Eutelsat II satellite to carry the modified antennas. At any time, the Eurovision transponders may be relocated in any other satellite, even in one from which the initial lower power has dropped off by

ageing. Although the design of the Eutelsat II satellites reduces the probability of a complete transponder failure through the availability of redundant travelling wave tubes (TWT), the possibility is still there. In any case, a complete satellite failure is not unthinkable. Even human error can lead to the loss of a satellite service, since although it is commonly believed that geostationary satellites just sit there once placed in orbit, this is not so. The satellite has to be "driven" throughout its lifetime by frequent manoeuvres to keep it in the correct place and facing in the right direction. Past experience has shown that satellite transmission is still a vulnerable operation, and the EBU cannot take the risk of losing a large part of its network should the worst happen.

The second point concerning satellite EIRP is contained in the adjective *saturated*. The EBU channels are not operated with the transponder saturated. To maximise the use of the wideband 72 MHz transponders, two analogue television carriers are carried in each transponder, plus up to two 2 Mbit/s digital carriers for stereo sound in the EURORADIO service. More recent changes to the frequency plan have introduced two additional channels at 8 Mbit/s for digital television carriers together with many two-way coordination channels. With inadequate antenna diameters, such evolutions in the use of the transponders would not be possible, and who knows what the future will hold.

The maximum power available from a satellite is its saturated power. The more carriers there are in the channel, the more the available power must be shared between them. For example, the difference in down-link power when a single analogue television carrier is present, compared with the case where two are present, is 3.2 dB. This is less than half the power, and represents about 3 metres difference in antenna diameter for satisfactory service under "clear sky" conditions. Occasions have arisen when the second channel had to be abandoned when using under-dimensioned stations.

The Eurovision network is not a fair weather operation. It provides a high-quality broadcast-quality service night and day, and in all weathers. The types of climate enjoyed by the Members varies from the desert heat and dryness of North Africa, through torrential Mediterranean rainstorms, to temperatures 40°C below zero in Russia. The precipitation characteristics at a given location also determine the diameter of the antenna required. It is impossible to guarantee service in all weathers, but Sub-group T7 has determined that the target should be to maintain adequate availability of service for 99 per-cent of the worst month of fading. Using a worst case up-link from the Mediterranean area, an overall fade of up to 5 dB can be tolerated in the satellite link with a receiving station meeting the EBU requirements. This 5 dB margin for fading can also be translated into an antenna diameter difference of about 4 metres.

4.2. Why so complicated?

To some extent, station complexity is determined by the need to prepare for future digital transmission. Over the years, the cost of earth stations for analogue transmission has fallen considerably: the antenna costs have fallen; much lower low-noise amplifier temperatures are available at lower cost; down-conversion, up-conversion, demodulator and modulator costs have fallen. This reduction in cost is probably a spin-off from the penetration of satellite reception into the home and cable markets. A cablehead operator, faced with the need to receive up to eight analogue channels, would no doubt install eight chains for the purpose. Had only analogue transmission been envisaged, the same philosophy might have been adopted for the EBU stations. However, the need to have highly stable, low phase noise up- and down-conversion (particularly for the low bit-rates now being envisaged in some circumstances), with flexibility in channel selection, automatically increases the cost of the chains. It could be argued that one day, the cost of digital coding and decoding will fall, and that eight receive chains could be fitted. However, the installation of eight transmit chains, using the same logic, would be unthinkable in terms of cost, and the number of simultaneous transmissions envisaged.

It was decided by an EBU group that simultaneous reception of four of the eight 34 Mbit/s digital channels foreseen at that time for Eutelsat II and simultaneous transmission to two channels would be the requirement in terms of predicted traffic growth. Oh for a crystal ball! Traffic patterns have changed in an unpredictable manner, and some of the frequency plans being considered could end up with as many as 32 channels in the satellite in the extreme. The earth station design must take account of future changes to the greatest extent possible, without too much additional cost.

4.3. What about system reliability?

In discussion with manufacturers, and sometimes with the Members, the question arises: what about redundancy? The same group which decided to provide the stations with two transmit chains and four receive chains also decided that no redundant chains were required. From past experience, redundancy systems are usually a source of problem in themselves: throughout the life of the system, annoying anomalies arise and are a source of trouble through the added complication of redundancy switching, and on the day when there is a chain failure, the redundancy provision is also likely to fail. Furthermore, the broadcasting services, careful of their financial resources, feel that an investment in equipment means that the equipment will be used – and not be sitting doing nothing for the greater part of its life, just in case an active chain fails. In any case, within a week of a station with redundant chains going into operation, the technicians would be in there with a sol-

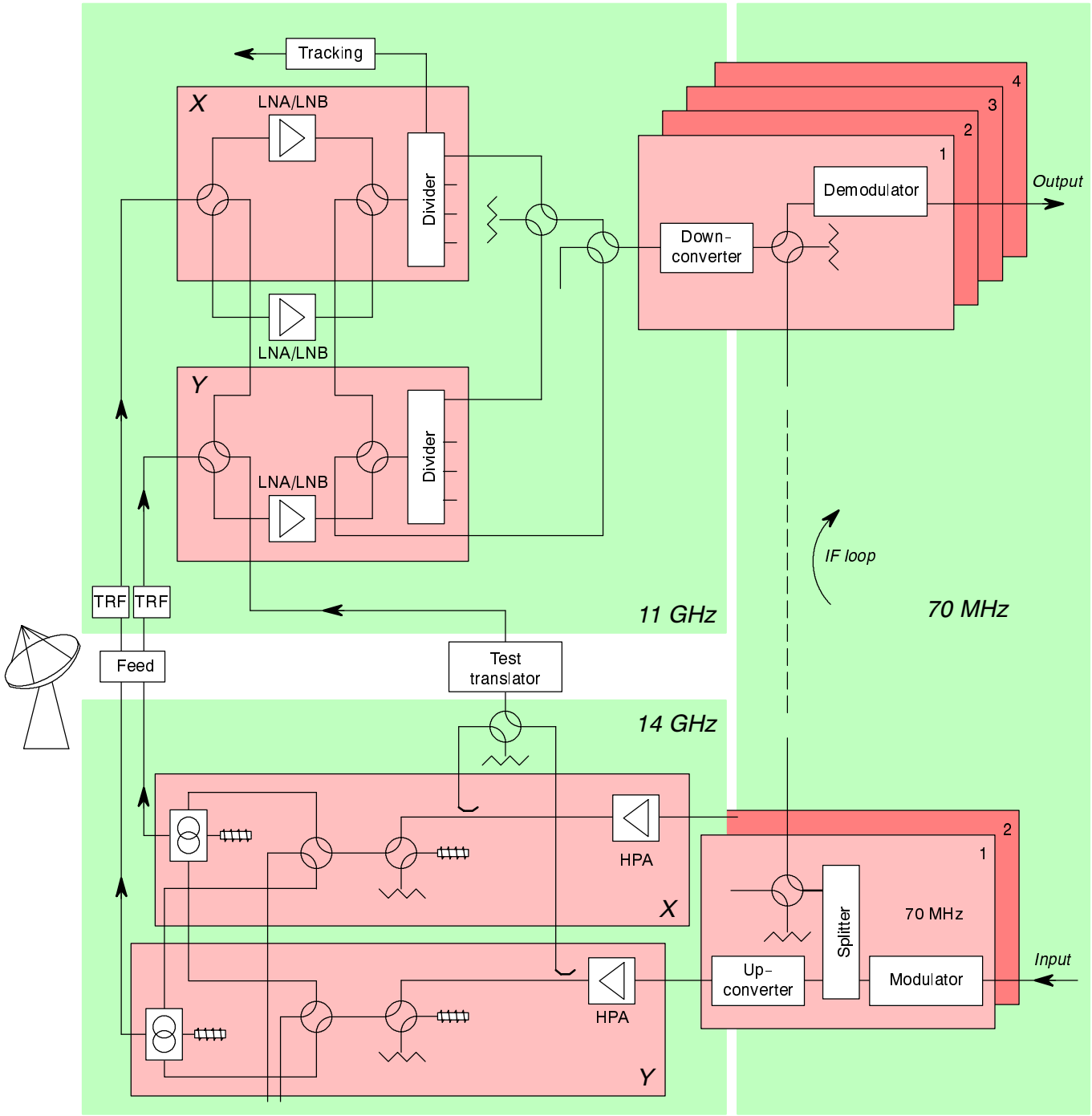

Figure 3
Block diagram of the "standard" EBU earth station.

dering iron, to permit immediate use of the redundant chain. Even shelf spares, when provided, get wired into the system to provide added capacity within days of the station being handed over. Redundancy is, however, provided in antenna-mounted low-noise equipment on the receive side. It would be unrealistic to expect the technical staff to fit a shelf spare in the middle of the night in a raging snow storm.

A block diagram of the "standard" EBU station is shown in *Fig. 3*. The stations built by Scientific Atlanta and those to be supplied by NEC are basically very similar in design. Existing earth stations for Eutelsat I, and those built by other manufacturers conform to the same pattern to differing degrees.

On the receive side, an 11 GHz divider for each polarization presents outputs through a bank of switches, such that each receive chain input may be selected from either polarization. A second bank of switches permits a feed from either divider for on-air reception, or from the output of the test translator via the inactive low noise unit in the antenna. In the Scientific Atlanta stations low-noise amplifiers (LNA) are used, while low-noise blocks will be used in the NEC stations for a first down-conversion to 1 GHz in the antenna hub. Transmit reject filters (TRF) protect the low-noise front end.

At the 70 MHz intermediate-frequency (IF) level, the demodulators, which can be either analogue or digital, can be switched to receive on-air signals, or to complete an IF Loop. The number of receive chains can be easily increased, by providing the additional switches and equipment.

For transmission, two chains are provided initially, but rack space is provided to accommodate a third transmit chain with ease. A third transmit chain could also be provided on a temporary basis, using transportable equipment connected into the available port. The modulator outputs, which may be either analogue or digital, are split in a divider to provide the possibility of IF loops. The outputs from the 600W/500W high-power amplifiers (HPA) are fed via switching to dual combiners. The dual combiners permit totally independent operation of the two (or three) transmit chains, without the need to de-power when a chain is being switched to the other polarization.

Figure 4
A typical monitoring and control unit (M&C) for remote control of an earth station from a Member's CNCT.

The only limitation is when three transmitters are installed, in that only two chains can feed to the same polarization simultaneously. Couplers feed the transmit chain outputs via switching to the loop test translator to provide an RF loop test facility. The transmit chains may feed either the antenna, or high-power loads. This permits RF loops to be made, either when a chain is on-air, or when feeding the load. In fact, the normal

Bill Potter *spent seven years as a Marine Radio Officer before joining the BBC, where he was with the Transmitter Department in operations and maintenance.*

He was seconded to the EBU in 1968, where he was a supervisor in the EVC for several years. He was Project Leader for the "new" EVC in Brussels, which was taken into service in April 1979.

In 1982, following a period as Senior Assistant in the Eurovision Operations Division, he was charged with the task of coordinating the introduction of the Eurovision mixed terrestrial/satellite network. Since then, in collaboration with the EBU Members, he has been responsible for setting up the earth stations on the network, particularly those at Members' premises.

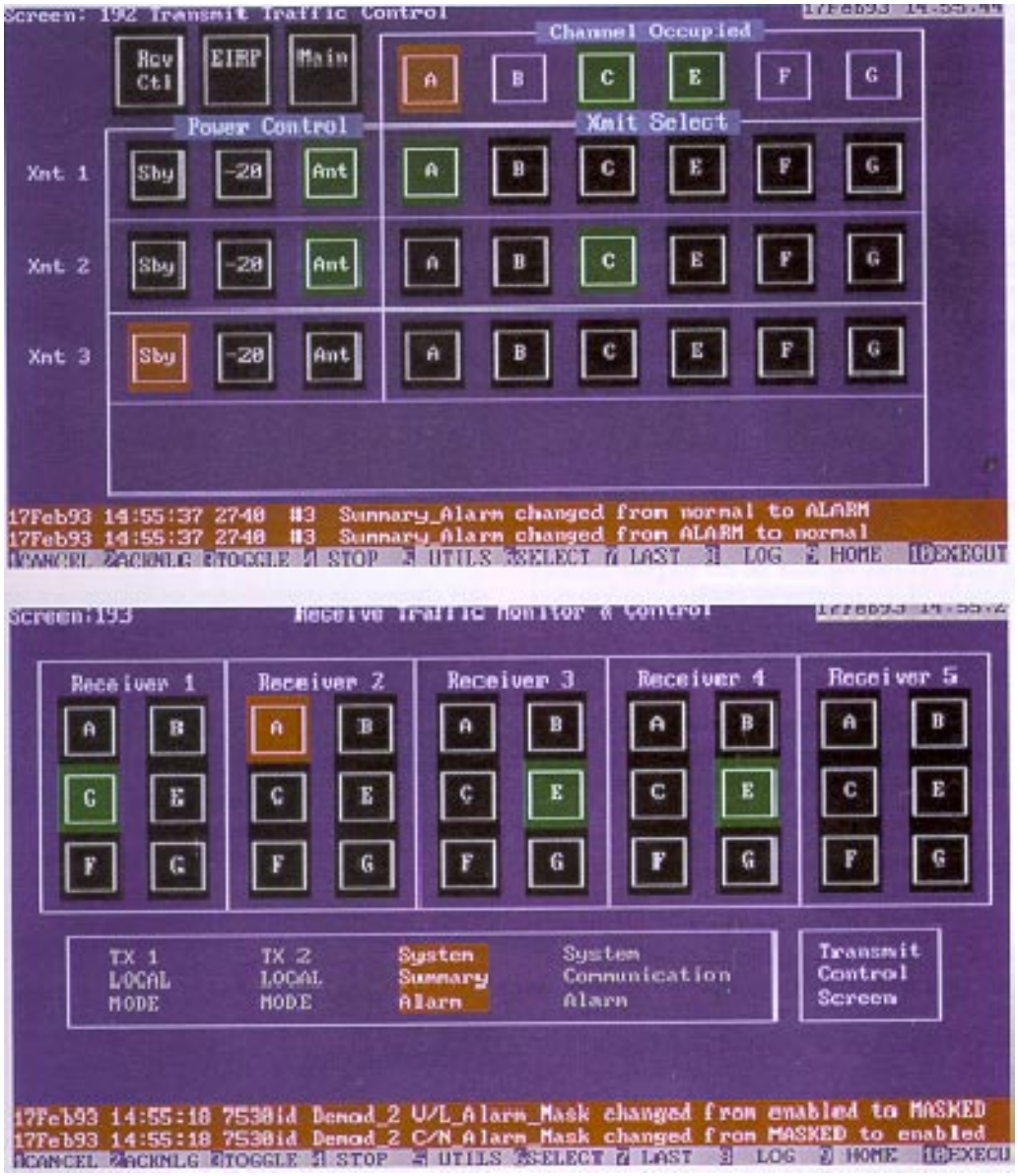

Figure 5
Typical screen displays presented to CNCT operators for routine operational control of an earth station.

stand-by situation is when the transmit chain is feeding to the load with low drive. This helps to prolong tube life, and to ensure that the transmitter is ready for instant use. A feature of the Eutelsat II satellites is that the satellite G/T can vary by as much as 2 dB/K between the X and Y polarizations. The transmitter power output is adjusted automatically to meet the different G/T of the satellite as the polarization is changed.

The equipment is usually housed in an air-conditioned shelter, equipped with an uninterruptable power supply (UPS) which can maintain the station on the air for several minutes on full load, until the emergency electricity supplies become available. Power ratings and air-conditioning loads are dimensioned to meet a three-transmitter configuration. Antenna de-icing is provided where necessary, and a sophisticated self-learn programme step-track system controls the antenna movement, such that inclined orbit working is possible.

The main EBU requirement for the earth stations, which are supplied on a turn-key basis, can be summed up rather simply in a phrase often used in discussions with the manufacturers: to the greatest extent possible, the network operations staff in the CNCT should hardly be aware that there is an earth station out in the grounds. In other words, the shelter door should normally be locked, and the station left completely unattended, except for routine maintenance visits. The entire operation of the station is carried out as a switching routine from the CNCT (*Fig. 4*).

Earth stations from EUTELSAT I (in service)

Country	Earth station	Owner	Country	Earth station	Owner
Algeria	**Algiers**	TDA	Israel	**Jerusalem**	IBA
Croatia	**Zagreb**	HRT	Jordan	**Amman**	JRTV
Cyprus	Makarios	PTT/CY	Morocco	**Rabat**	RTM
Denmark	**Copenhagen**	PTT/DK	Netherlands	**Hilversum**	PTT/NL
	Odense	TV2-DK	Norway	**Bergen**	TV2-NO
Egypt	**Cairo**	ERTU		Nittedal	PTT/NO
Finland	Helsinki	PTT/FI	Switzerland	**Lugano**	RTSI
France	Bercenay-sur-Othe	PTT/FR		**Zürich**	SF DRS
	Romainville	TDF	Tunisia	**Tunis**	ONT
Germany	**Hamburg**	PTT/DE	United Kingdom	London	PTT/GB
Iceland	**Reykjavik**	PTT/IS			

EUTELSAT II stations (in service)

Austria	**Vienna**	PTT/AT	Libya	**Tripoli**	LJB
Belgium	**Brussels**	BRTN	Portugal	**Lisbon**	RTP
Ireland	**Dublin**	RTE	Spain	**Madrid**	Retevision
Italy	**Roma**	PTT/IT	Sweden	**Stockholm**	STR/STV
Germany	**Frankfurt**	ARD	Switzerland	Geneva	PTT/CH
	Mainz	ZDF	Turkey	**Ankara**	PTT/TR

EUTELSAT II stations (planned)

Cyprus	**Nicosia**	CyBC	Malta	**Valetta**	PBM
Greece	**Athens**	ERT	Monaco	**Monte Carlo**	TMC
Finland	**Helsinki**	YLE	Norway	**Oslo**	NRK
Luxemburg	**Luxemburg**	CLT			

New Members' stations (in service)

Bulgaria	**Sofia**	BNT	Russia	**Klin**	RTR
Hungary	**Budapest**	MTV	Slovakia	**Bratislava**	STV-SK
Lithuania	**Vilnius**	LRT	Slovenia	**Ljubljana**	RTVSLO
Moldova	**Kishinev**	TNM	Ukraine	**Kiev**	DTRU
Poland	**Warsaw**	TVP	Czech Republic	**Prague**	CT
Romania	**Bucharest**	RTVR			

New Members' stations (planned)

Albania	**Tiranë**	RTVSH	Fyrom	**Skopje**	MKRTV
Belarus	**Minsk**	BTRC	Latvia	**Riga**	LT
Estonia	**Tallinn**	ETV	Bosnia-Herzegovina	**Sarajevo**	RTVBH

Earth stations printed in **bold** type are located at broadcasters' premises.
The list of earth stations does not take account of temporary receive-only stations in service, pending the installation of a permanent station.

Table 1
Earth stations in the Eurovision network.

For unattended and transparent operation from the CNCT, the monitoring and control (M & C) system is of great importance. The normal presentations of the control screens in the CNCT for transmit and receive chains at Scientific Atlanta stations are illustrated in *Fig. 5*. Except for the transmitter power on/power off feature, it will be seen that the presentation is similar to that of any other routing matrix, as used in many other control room applications. The transmit chains may be switched for full power to the antenna (Ant) or to standby, with low power to the load (Sby). When radiating from the antenna, the power can be immediately reduced for checking purposes (-20). Selection of the "buttons", which change colour with status, is made with a mouse or a roller ball. All information concerning the channel frequencies, polarization, allocated EIRP, etc, is contained in the software. Of course, other screens concerning the state of the station are available if required, as are the look-up tables for pre-setting the channel parameters. The NEC stations will have a very similar presentation, with the same facilities.

From the control screens, using an inactive receive chain, the operator can make IF and RF loops, either on-air or off-air. This presents the operator with every opportunity, when his output is queried, to state with full authority in the time-honoured phrase: "It's all right leaving me".

5. The experience

The overall project for installing new earth stations throughout the network for Eutelsat II, including the stations in the countries of the new Members, has resulted in a large number of stations with either identical, or basically similar facilities. This is a great improvement compared with the initial network, where the facilities were installed in an uncoordinated manner, except for conformity with the bare requirements of the specification.

Although much work still remains to be done, particularly to prepare existing Eutelsat I stations for future digital transmissions, the experience which has been gained during Phase I of the programme of stations for the new Members will be put to good use for Phase 2. Of the problems to be overcome, very few have been of an engineering nature.

Delays in individual projects must be accepted as almost inevitable. The difficulties of dealing with transportation, customs formalities, and financial transactions in the emerging democracies used to central control and planned economies vary from country to country. Tales of vital elements or other items, such as easily-lost antenna anchor bolts, or pots of touch-up paint disappearing for days, sometimes weeks on end, are legend. Sworn testimony that the packet marked "grease" really does contain grease may be a slight exaggeration, but the EBU personnel, the ex-OIRT staff, and the supplier's representatives who have been involved in the project have a full stock of after-dinner stories. Tribute must also be paid to Eutelsat for scheduling tests when several stations are coming on line at virtually the same time. Meeting the test schedule deadline, or arranging to reschedule at short notice when the test equipment is in the wrong place, are just a few of the problems to be shouldered in such a project, where coordination, as in all Eurovision operations, is the essence.

Perhaps the most satisfying experience of the project has been the human contact which has resulted. The inevitable language difficulties are often at the root of a given problem, but even these can be smoothed out when a meeting is adjourned to a local restaurant. The extension of Eurovision activities into new areas, almost as large as the existing part of Europe before Unification, has opened many new doors and cemented many new friendships between the people involved.

The present stations on the network, or expected at some time in the future, are listed in *Table 1*.