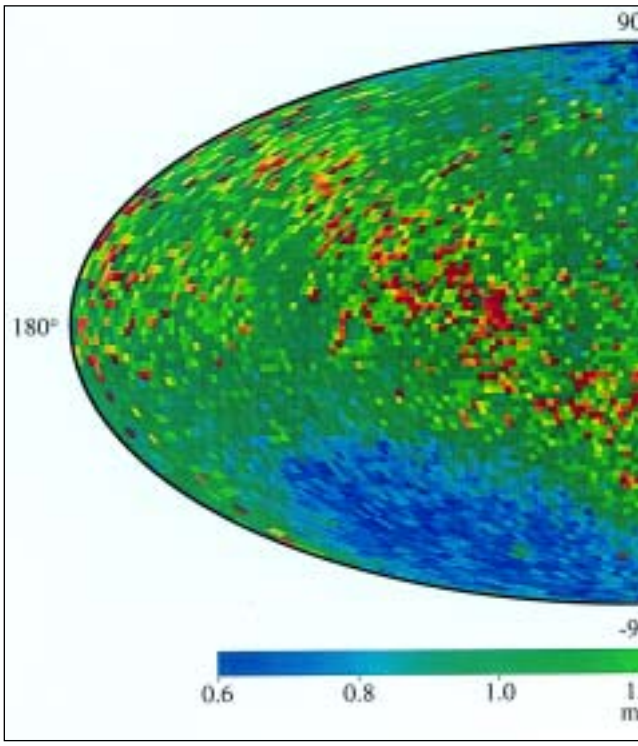
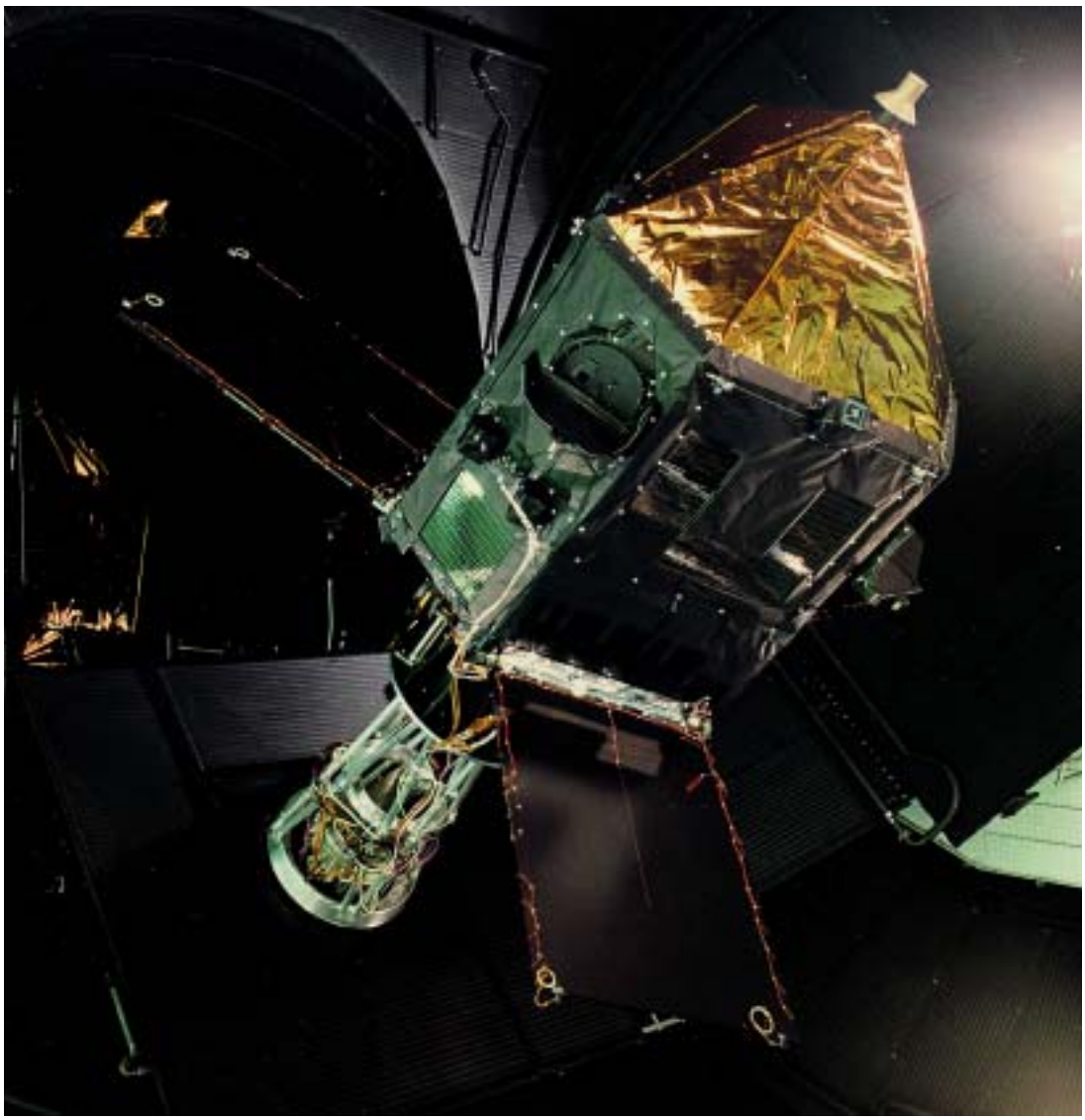
Hipparcos

Achievements: first space-based astrometric survey
Launch date: 8 August 1989 (design life 30 months)
Science operations began/ended: November 1989/March 1993. Communications ended 15 August 1993
Launch vehicle/site: Ariane-44LP from CSG/Kourou, French Guiana
Launch mass: 1140 kg (including 215 kg science payload)
Orbit: boost motor failure left Hipparcos in 200x35 896 km, 6.9° instead of placing it in geostationary orbit at 12°W. Thrusters raised it to 526x35 900 km for revised science operations
Principal contractors: Matra Marconi Space (satellite prime, payload development), Alenia Spazio (co-prime: spacecraft procurement & AIT)

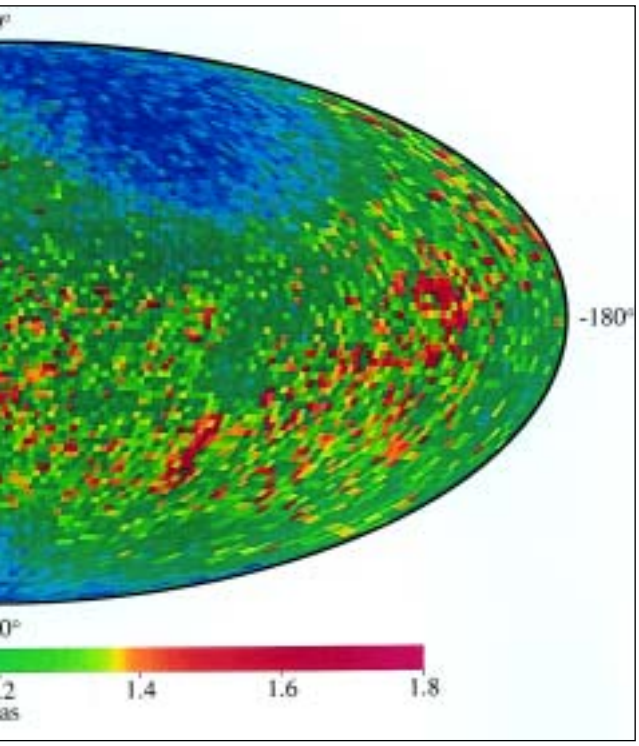
Hipparcos ('High Precision Parallax Collecting Satellite') had the single goal of producing the most accurate positional survey of more than 100 000 stars, in the process determining their distances, their motions and other characteristics such as their variability and binary nature. Improving on ground-based accuracies by a factor of 10-100, Hipparcos is fundamentally affecting every branch of astronomy, from the Solar System to the history of the Universe, and especially on theories of stars and their evolution.

The mission was a major technical challenge for European industry in building the satellite and the European astronomical community in generating the resulting star catalogues. The satellite design required extreme thermal stability to maintain optical precision, smooth jitter-free motion, realtime attitude determination to within 1 arcsec, and fast realtime data downlinking to handle the information generated by the scanning. 1000 Gbit were returned during the 4 years of operations, making the production of the catalogues the largest data analysis problem ever undertaken in astronomy. The approach was simple: measure the angles between selected pairs of stars as Hipparcos' rotation scanned its telescope across the sky. Covering the whole celestial sphere allowed these 118 000 target stars to be precisely located to within about 0.001 arcsec. Simultaneously, redundant star mappers of the satellite's attitude determination system performed the less accurate 'Tycho' survey of 1 million stars. The Hipparcos Catalogue (118 218 entries) and the Tycho Catalogue (1 058 332 entries) were both declared final on 8 August 1996, and the 17-volume set was published by ESA in 1997.





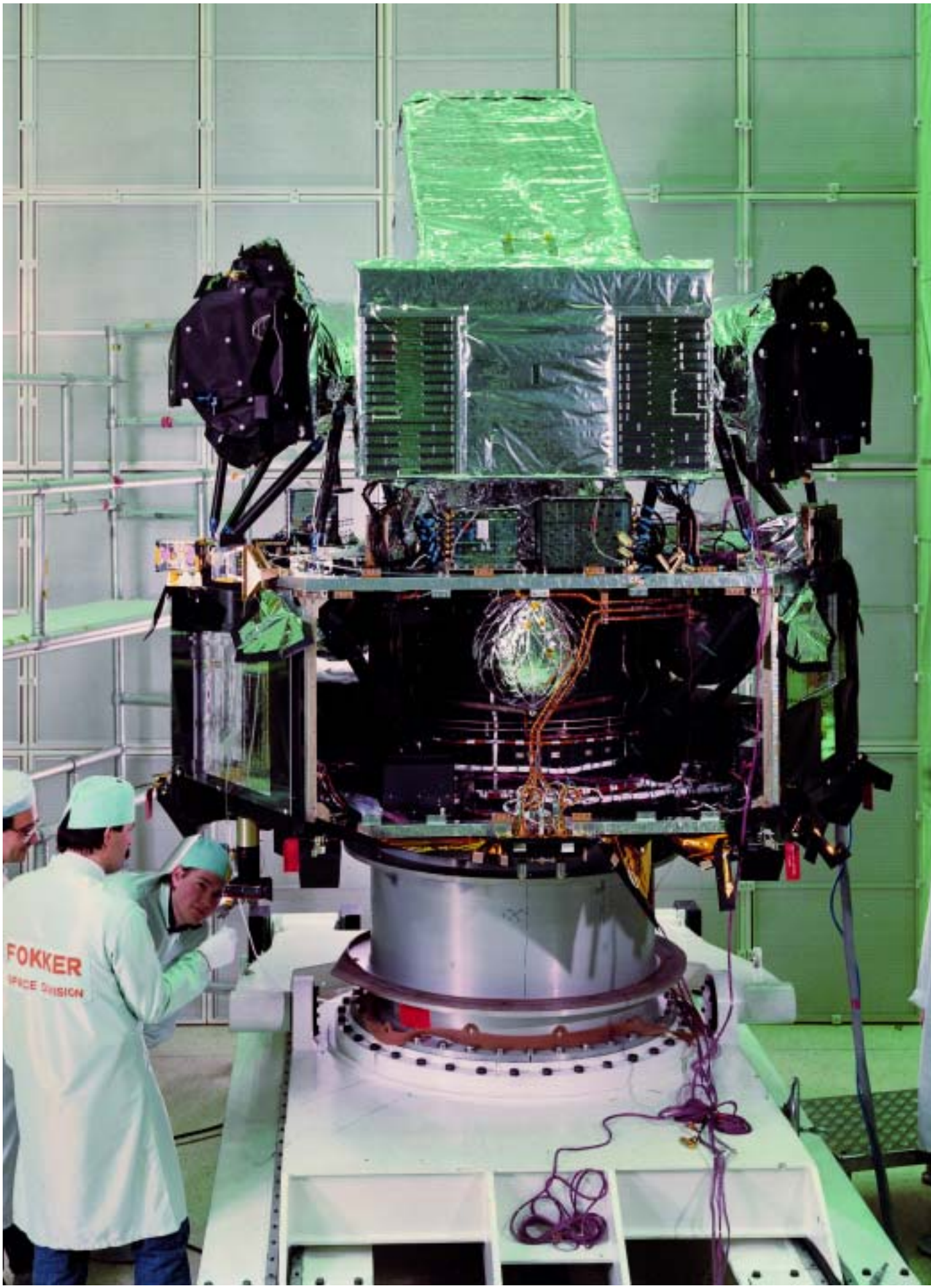
Hipparcos final qualification testing in the Large Space Simulator at ESTEC. One of the telescope's two semi-circular apertures is seen closed; the other is side-on at far right.



Astronomers continue to analyse the data: the Tycho-2 catalogue covering 2 539 913 stars (99% of all stars down to 11th magnitude) was issued in 2000. Hipparcos pioneered techniques that will be used by ESA's GAIA mission (see separate entry) to analyse the composition, formation and evolution of our Galaxy by mapping 1000 million stars.

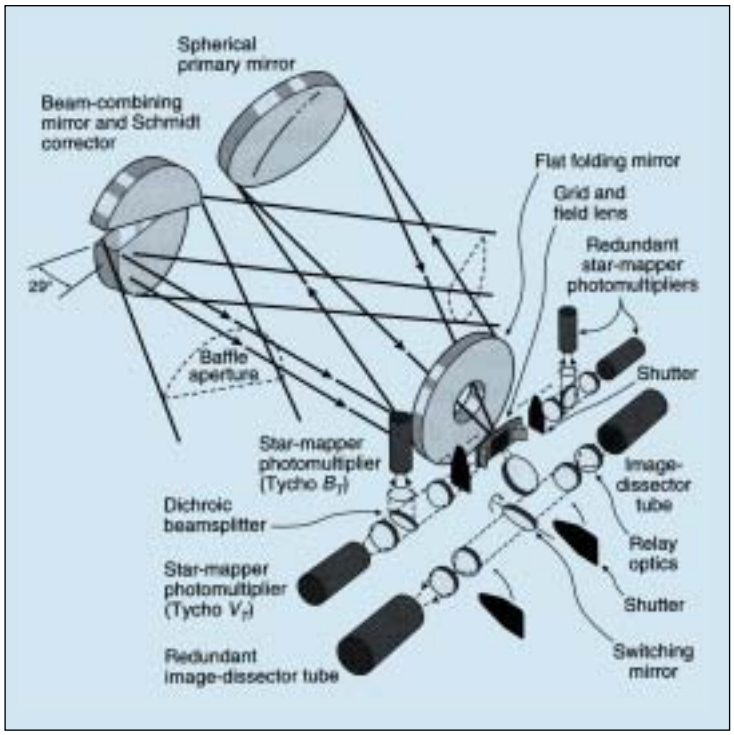
The resounding success of Hipparcos is even more remarkable considering its dramatic problems soon after

Accuracy of Hipparcos stellar distances. The data obtained by Hipparcos is of unprecendented accuracy and is being used to tackle many issues in astronomy, such as the structure of the Galaxy, the evolution of stars, and the age the Universe. The map is in equatorial coordinates; mas = milliarcsecond. (From the Hipparcos and Tycho Catalogues, ESA SP-1200 - Volume 1.)



The Hipparcos Engineering Model is displayed at the Noordwijk Space Expo at ESTEC.

The Hipparcos flight model being prepared for testing in the Large Space Simulator at ESTEC, April 1988. The payload module is mounted on the bus before installation of the Sunshield. The two telescope aperatures are covered at top.



Hipparcos' optical system measured the angular separations of stars by timing their passages over a modulating grid, combining fields of view 58° apart on the sky. Processing the voluminous data required a very accurate knowledge of the satellite's orientation at all times. These data, along with data for the million-star Tycho Catalogue, came from separate detectors and a star-mapper grid on one side of the main grating.

launch. The satellite was destined for geostationary orbit, but it was stranded in the transfer orbit when its solid-propellant boost motor failed to fire. Using 26 kg of its 32 kg hydrazine supply allowed its small thrusters to lift the 200 km perigee away from atmospheric drag, but that still left severe operational problems. The solar panels and spacecraft electronics were not designed for repeated passage through the harsh Van Allen radiation belts, and unexpected periods in Earth's shadow threatened battery breakdown. Also, the torrent of realtime data could no longer be collected by the single Odenwald station in Germany as Hipparcos swung around the Earth – stations in Kourou, Perth and Goldstone had to be added, increasing costs. Despite these problems, the goal of 30 months' observations was comfortably achieved before the electronics succumbed to the bombarding radiation in 1993.

The mission's scientific aspects were conducted by four consortia, altogether comprising some 200 scientists, responsible for constructing, documenting and publishing the final catalogues.

Satellite configuration: bus was an irregular hexagonal prism of conventional aluminium design with central thrust tube. Payload module mounted on top; CFRP structure required for thermal stability. Topped by Sunshade. Total height 3 m; body diameter 1.8 m.

Attitude/orbit control: 6x20 mN nitrogen thrusters (9.3 kg supply in two tanks, 285 bar) maintained smooth spin stabilisation at 11.25 revolutions daily for scanning. Supported by 4x5 N hydrazine thrusters (32 kg supply in two tanks, 22-5.5 bar blowdown). Mage-2 Apogee Boost Motor to circularise GTO into GEO (failed).

Power system: three 119x169 cm deployed Si solar panels generated 380 W at 50 Vdc (payload requirement 110 W); 2x10 Ah nickel cadmium batteries.

Communications/data: 2.5 W 2.24 GHz S-band omni transmitter provided 24 kbit/s realtime science data downlink.

Hipparcos Scientific Payload

1.400 m-focal length 29.0 cm-diameter Schmidt telescope simultaneously observed two 0.9° star fields separated by 58°. Combining mirror focused the two fields on a 2.5x2.5 cm detector carrying 2688 3.2 mm-wide parallel slits 8.2 mm apart for the modulated light over a 38 arcsec field to be sampled by a redundant image dissector tube at 1200 Hz. As Hipparcos' spin axis changed by 4.415° daily, the whole sky was scanned several times. An average star crossed the detector in 20 s and was observed 80 times during the mission. This allowed the positions, proper motions and parallaxes of 118 000 programmed stars to be measured with 0.001 arcsec accuracy. Also, two star mappers used primarily for attitude determination produced the Tycho catalogue of position (0.015 arcsec) and photometric (0.01m) data on 1 million other stars.