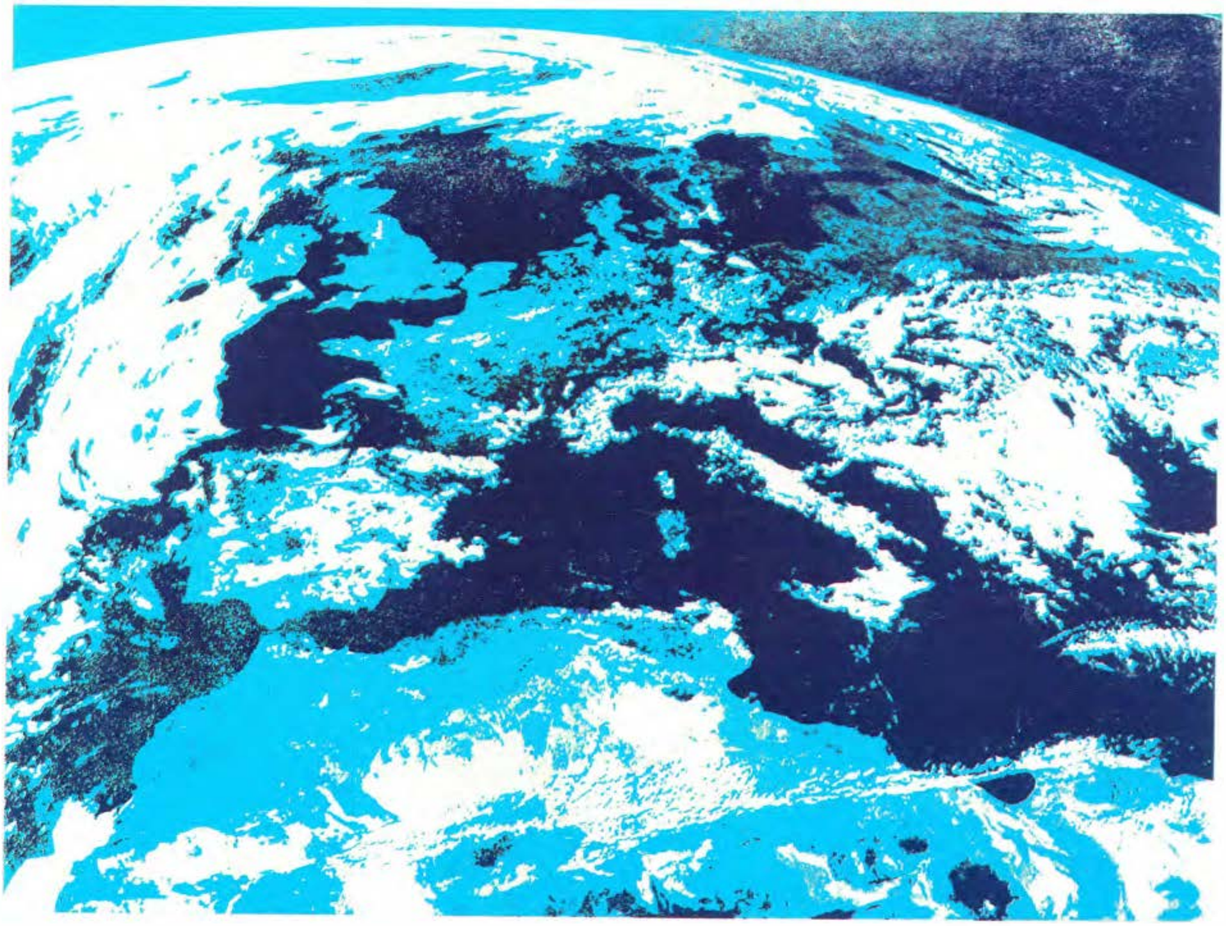
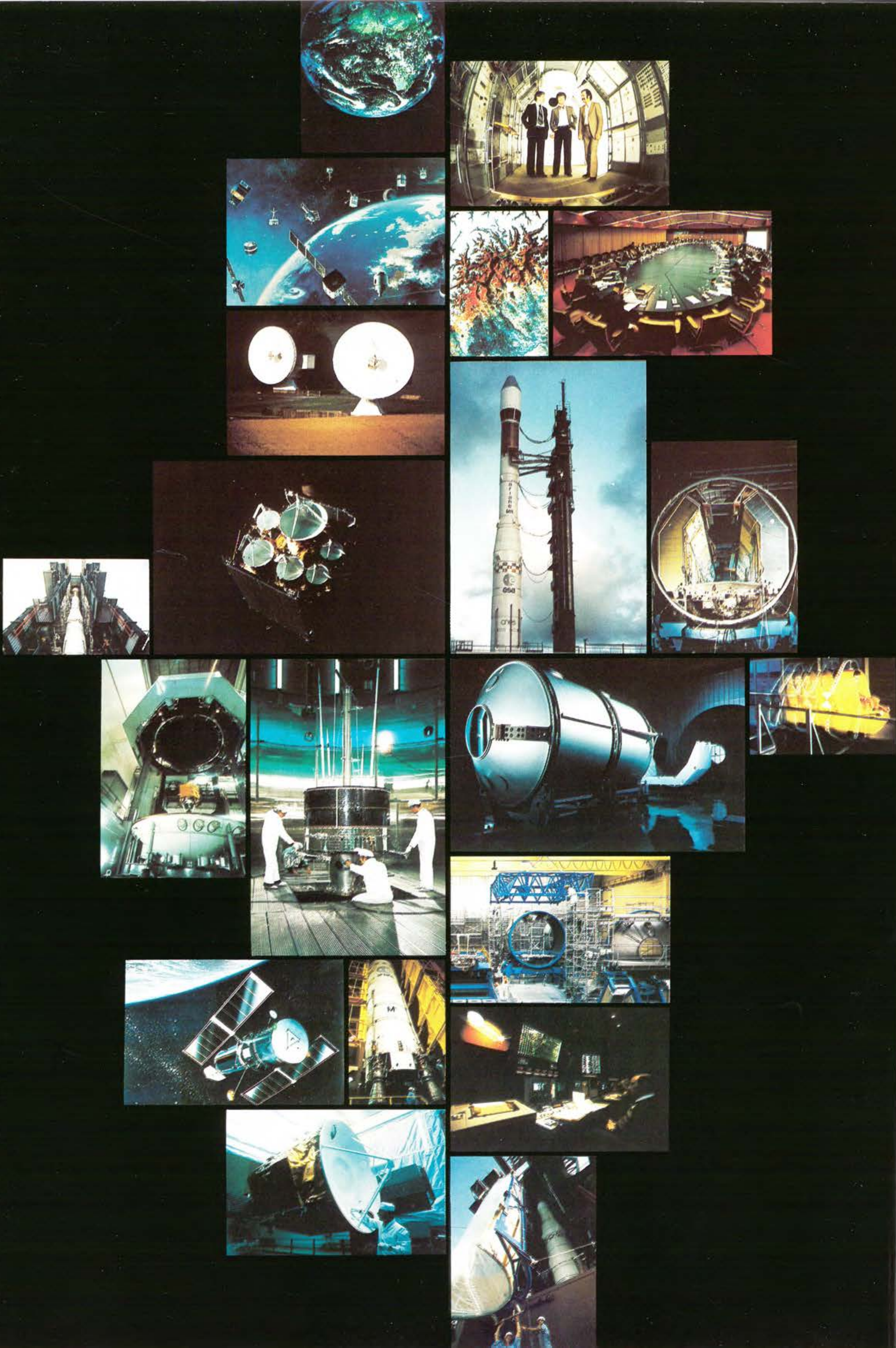
Space-part of Europe's environment

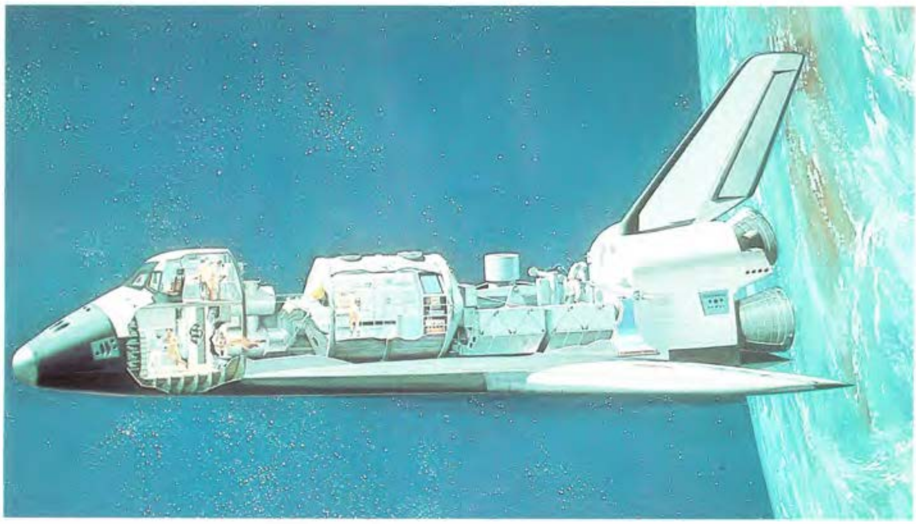
esa

european space agency



SUMMARY





Spacelab carried on the NASA Space Shuttle

The age of maturity

The European space effort has today reached the age of maturity. When the European Space Research Organisation (ESRO) — which in 1975 became the European Space Agency (ESA) — was in its early days it was quite natural that its activities should be devoted primarily to basic research.

The use of application satellites — as communication relay stations or observation posts, for example — could not be envisaged until precise knowledge had been acquired of the medium in which they would be operating. It was therefore necessary to conquer the unknown: only experience could open the highway of space to the service of man.

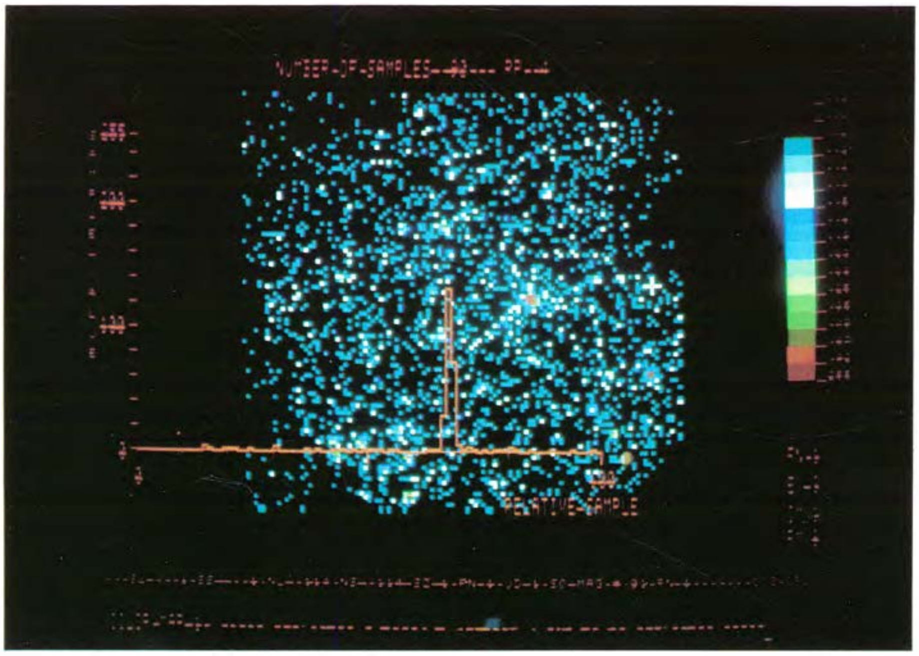
In fifteen years twelve ESRO/ESA scientific satellites have been placed in orbit. They have largely contributed to a better understanding of the Earth's upper atmosphere and identification of the various phenomena that occur in it.

In addition to satisfying human curiosity, scientific satellites have also helped to bring about improvements in space telecommunications techniques, communications with ships at sea, weather forecasting, and management of the Earth's resources. Thanks to the experience thus gained, Europe's first application satellites are already in orbit. Meteosat provides images of the Earth every thirty minutes, and as part of a world-wide meteorological network will enable more accurate long-term weather forecasting to be achieved. OTS provides telephone, telegraph and telex links, and transmits radio and television programmes. The setting-up of these two satellite systems does not constitute an end in itself; they are just initial models of the future operational systems with which Europe will be equipped during the next decade.
Thus have Europe's ambitions in the space field taken form and substance. Implementing the wishes of its eleven Member States, the European Space Agency's programme harmoniously combines scientific projects and application projects, satellites and launchers — undertakings that will help to ensure that Europe has a place in the major international projects and greater independence.

The new paths of science

In 1978, in its twenty-first report to the Committee on Space Research (COSPAR), the Agency stressed the very lively interest of the European scientific community in astronomical research. This discipline has recently made spectacular progress, thanks to the radio-astronomy techniques that have led, in particular, to the discovery of quasars and pulsars. But even more is expected of the use of space techniques. The satellite is, in fact, the only means by which one can more clearly observe the full radiation spectra of the celestial bodies, because it enables the observer to break free of the thick atmospheric «fog» in which our planet is steeped. A major contribution to the exploration of the sky in the ultraviolet was made by the European TD-1 satellite, launched in 1972. Even more striking results in the field of gamma astronomy are being achieved with the COS-B satellite, launched in 1975. COS-B was expected to have a lifetime of two years, but nearly four years after entering orbit it is still faithfully transmitting its observations. Looking to the early future, large space telescopes — the first of which is scheduled to be placed in orbit in 1983 — and deep space probes will dominate astronomical research up to the end of the century, observing regions that are today out of reach.
Spacelab, the European manned space laboratory that during the next decade will be repeatedly taken into orbit and brought back to Earth by the American Space Shuttle, opens up new research horizons. New materials processing techniques will be tried out by taking advantage of two characteristics of space: vacuum and weightlessness. In orbit it is, for instance, possible to mix together liquids of different densities, manipulating them without using a receptacle and consequently eliminating the risk of contamination. It is also possible to grow crystals that are virtually free of defects, and to obtain perfect spheres by solidification of molten metal. The potential applications are numerous: fabrication of materials, creation of hitherto unknown alloys, production of perfect crystals for use, in particular, in electronics. In the field of biology particular attention will be devoted to the impact of weightlessness on the behaviour and development in space of living beings. It is also thought that it will be possible to separate biological substances and obtain cell preparations for transplant purposes, as well as concentrated antibodies and pure vaccines for use in the treatment of certain diseases.

There is currently a whole series of efforts converging on the various disciplines associated with observation of the Earth. These efforts bear not only on the now conventional areas like remote sensing, but also on a relatively new discipline — climatology — on which the world's economic activities depend. Here, too, space techniques have a fundamental role to play in arriving at an understanding of the changes and variations in climates and foreseeing their repercussions on human activities. It is thought that climatic variations stem from periodical astronomical phenomena that modify the quantity and distribution of solar energy received by the Earth. But this hypothesis has yet to be verified by means of satellites that will measure the radiation budget in the Earth's atmosphere.



Part of the sky viewed by the IUE satellite and as seen by astronomers on the consoles of the Villafranca station in Spain.

The Earth as seen by Europe's satellite Meteosat

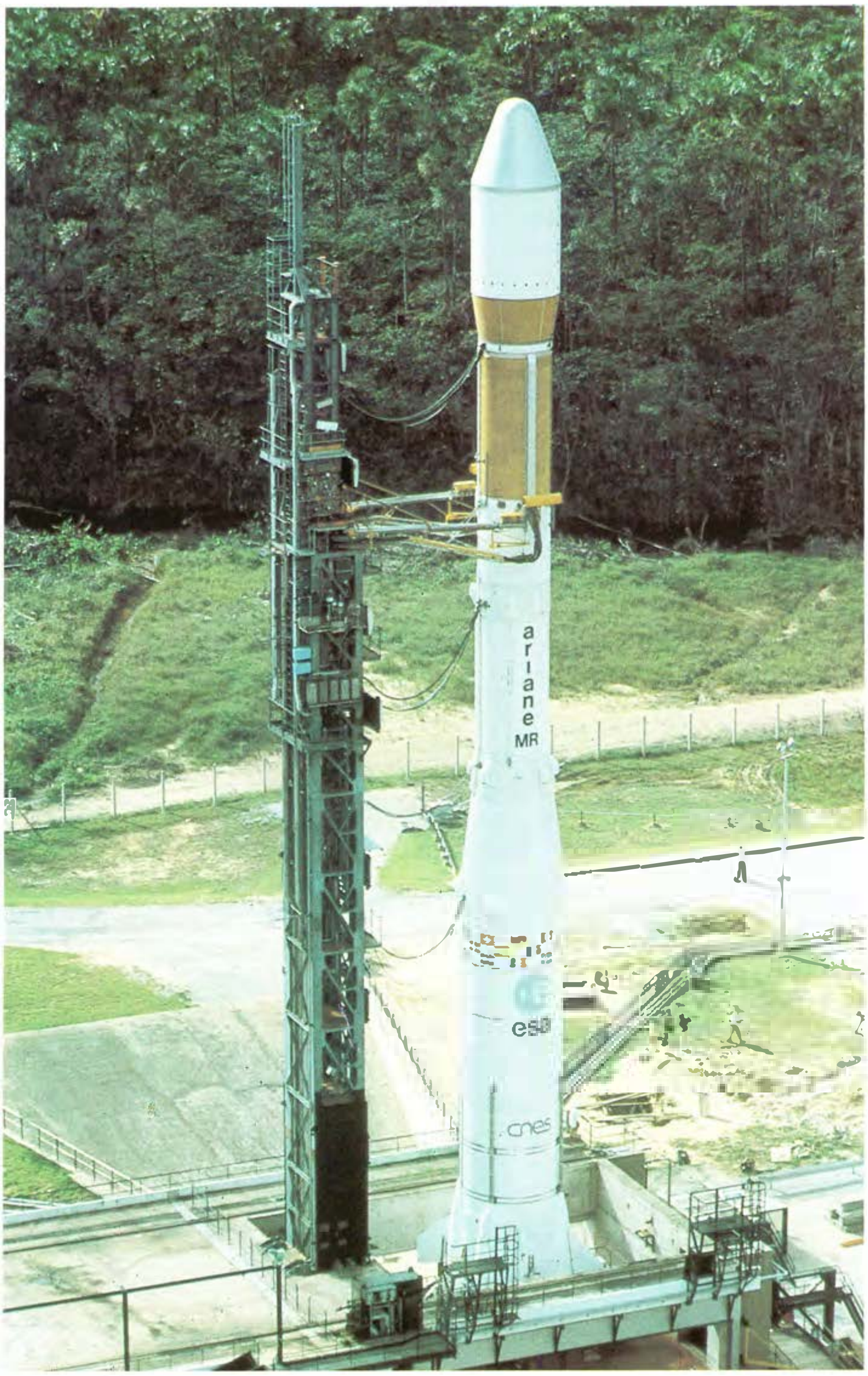
The requirements explosion

The space policy of the Agency has, under the inspiration of its Member States, followed the paths of independence. Faced with a veritable explosion of requirements, which was foreseen at the outset of the 1970s and which related particularly to the telecommunications field, it was evident that a choice would have to be made to ensure that Europe secured autonomy in the space field by developing its technological and industrial capabilities.

The European communications satellite programme was designed to make available to the postal, telecommunications and broadcasting administrations, from the 1980s onwards, satellite links capable of carrying a large share of the intra-European telephone, telegraph and telex traffic and of transmitting Eurovision programmes.

Already, the OTS-2 satellite launched in May 1978 is being used experimentally in Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom. From 1981 onwards the ECS satellites will provide long-distance (over 800 km) operational links and will constitute the European regional system whose operation will be entrusted to the user organisation, Interim EUTELSAT.
In the field of navigation, the Agency will put maritime communication satellites (Marecs) into service from 1981 onwards, as part of a world-wide telecommunications network whose management will be entrusted to the international INMARSAT organisation.

Independence in satellite technology, then, but also independence in the field of launch systems, where the Ariane launcher constitutes the spearhead. During the next decade Ariane will provide the geostationary transfer orbit injection capability for all the



The Ariane launcher

of other countries that ask for its services.

The Agency has thus played a decisive role by successfully matching the ambitions and requirements of its eleven Member States and by enabling European firms to develop and demonstrate their space technology.

Although the European space capability may have developed slowly, and at the cost of much effort over the past fifteen years, it has now become a reality. It is based on the know-how and skills of the specialised industries, on the « think tanks » represented by the national institutions and the Agency's technical centres, and on an extensive space infrastructure. Scientific research is following a now well-traced path, while operational telecommunications, meteorological and Earth observation systems of regional or national scope are taking shape. Europe really has established itself in space.

Europe's space agency

The European Space Agency (ESA), which succeeded two earlier European space organisations — ESRO for the development of satellites, and ELDO for the construction of launchers — came into operation on 31 May 1975, consolidating in a single body the complete range of European space activities. Its Convention describes the Agency's purpose as being 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 applications systems. The Agency fulfils this mission by:

(a) elaborating and implementing a long-term European space policy, recommending space objectives to the Member States, and concerting the policies of the Member States with respect to other national and international organisations and institutions;

(b) elaborating and implementing activities and programmes in the space field;

(c) coordinating the European space programme and national programmes, and integrating the latter progressively and as completely as possible in the European space programme, in particular as regards the development of application satellites;

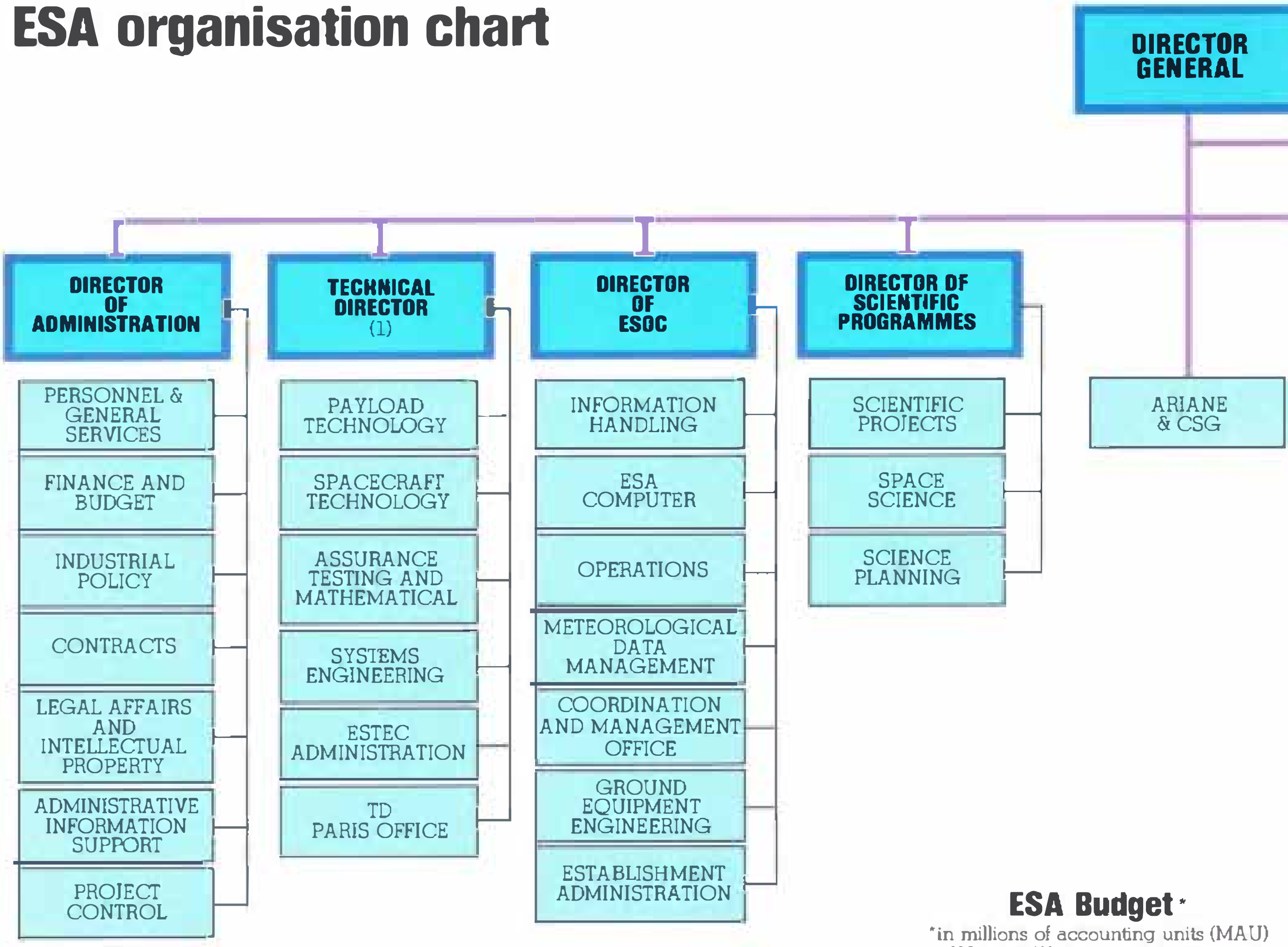
(d) elaborating and implementing an industrial policy appropriate to its programme, and recommending a coherent industrial policy to the Member States.

Eleven European countries are Member States of ESA, namely Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom. Three other countries — Austria, Canada and Norway — also participate in certain of the Agency's programmes.

A meeting of the ESA Council.

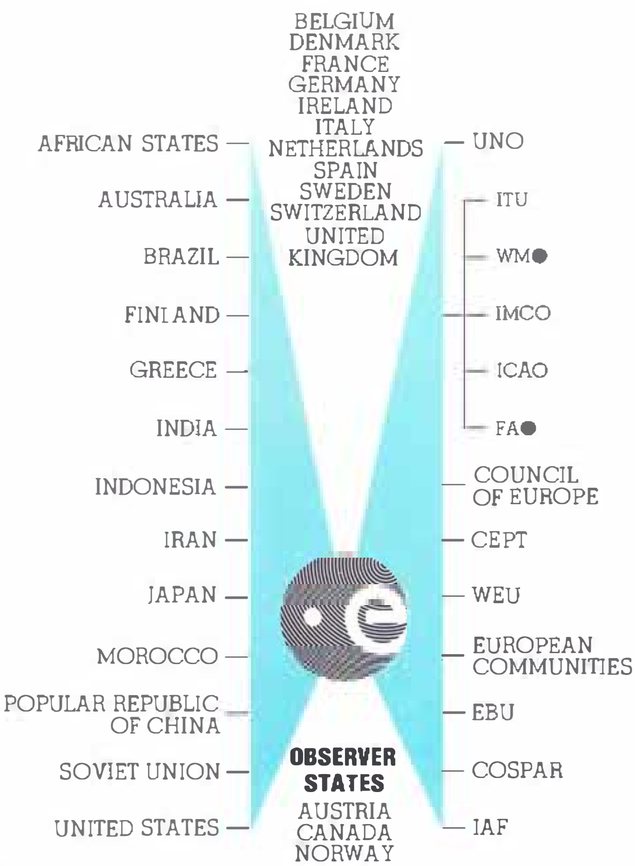
ESA Headquarters in Paris.

ESA organisation chart



(1) Also Director of ESTEC Establishment
(2) Spacelab Payload Integration Centre
(3) Deputy Director General

International Relations



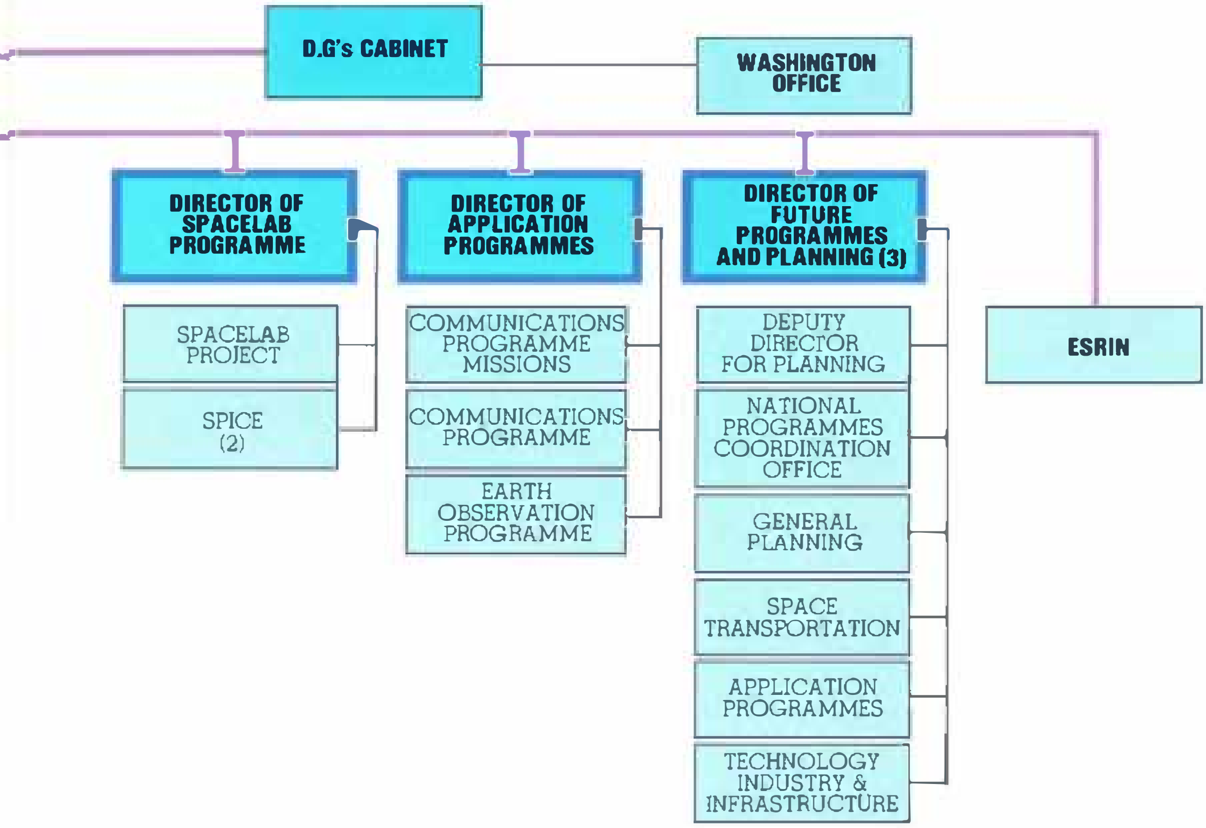
ESA Budget*

*in millions of accounting units (MAU)
1 UC = 1.2 US $

Programme	1977	1978	1979
General Budget (including Technological Research and CSG Kourou)	60	72	72
Scientific programmes	68	75	78
Earthnet	3	3	5
Meteosat 1 and 2 (including exploitation)	34	30	23
Sirio 2	—	—	7
OTS	35	38	14
ECS 1 and 2 (+ 1 launcher)	3	20	32
Marecs A and B	34	29	28
Other telecommunications programmes	3	9	5
Spacelab (development and first payload)	103	125	123
Ariane (development and user support)	133	147	163
Programmes not yet approved	—	—	24
Total	476	548	574

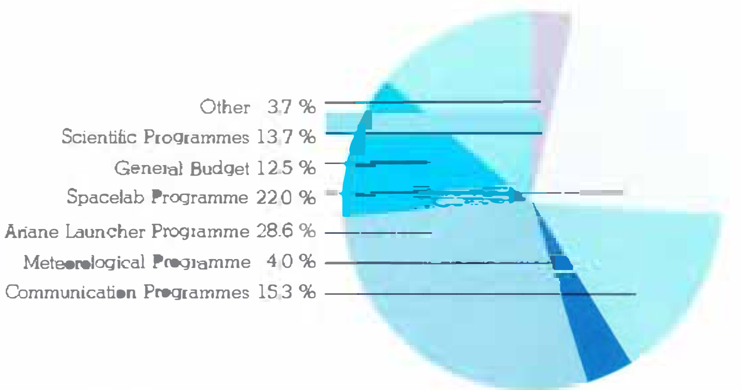
Cost-to-completion of the principal ongoing programmes

Programme	MAU
Exosat	139
Space Telescope	71
International Solar Polar Mission	73
ECS	147
MARECS (A and B)	218
Meteosat 1 & 2	206
Spacelab	680
Ariane	790



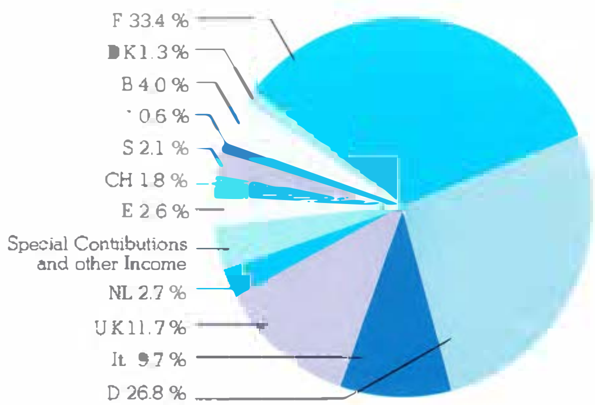
ESA budget for 1979

Approximately 570 MAU (700 M $)



ESA budget for 1979
Income from Member States and other sources

Approximately 570 MAU (700 M $)



*Ireland-Austria-Canada-Norway

Contributions of the Member States to the principal ESA programmes (expressed in terms of percentages)

	Gen. Budget* and Scient. Progr.	Meteosat	OTS	ECS	MARECS	SPACELAB	ARIANE**
Germany	25.27	25.66	25.89	31.57	19.08	53.34	11.28
Belgium	4.29	4.06	4.83	3.39	0.95	4.20	4.82
Denmark	2.29	2.41	2.58	0.40		1.50	0.52
Spain	4.73			0.16	0.95	2.80	2.54
France	21.07	23.70	23.74	25.88	11.92	10.00	69.28
Ireland	0.54						
Italy	12.19	15.07	13.74	13.99	2.20	18.00	2.05
Netherlands	5.60		2.50	0.85	4.63	2.10	1.65
United Kingdom	15.35	20.60	17.30	20.91	55.81	6.30	***
Sweden	4.41	5.02	4.96	1.59	2.96		1.09
Switzerland	3.96	3.48	4.46	1.26		1.00	0.72
Other income					Norway 1.50	Austria 0.76	6.05

*for 1979 and 1980
**for 1979 only.

***The United Kingdom participates in the programme under a bilateral agreement with France.

Establishments and staff complements

At the beginning of 1979 ESA's total staff complements numbered approximately 1450 persons from the Member States, distributed between the Headquarters and the various Establishments.

- The Headquarters is in Paris and has a staff of about 290;
- ESTEC (European Space Research and Technology Centre) is located at Noordwijk, in the Netherlands, and is responsible, in liaison with the Programme Directors, for the study, design, development and testing of spacecraft in collaboration with industry and the scientific community. ESTEC is also responsible for applied research in space technology. It has a staff of 800;
- ESOC (European Space Operations Centre) is located at Darmstadt, in Germany, and is responsible for satellite orbital operations and tracking, as well as data acquisition and processing. ESOC controls a network of four ground stations, located in Belgium (Redu), Germany (Michelstadt), Italy (Fucino) and Spain (Villafranca del Castillo). It has a staff of 250;
- IRS (Information Retrieval Service) is located at Frascati, near Rome. It is responsible for the operation of the most powerful automated documentation system in Europe, with a file of more than twelve million bibliographic references. It has a staff of 55.

In addition, there are a number of technical teams (totalling some 50 persons) located in national establishments in France and Germany. The Agency also has a liaison office in Washington.

ESTEC in Noordwijk, Netherlands.

The main control room at ESOC, Darmstadt, Germany

The Information Retrieval Service, Frascati, Italy

Organisation and Functioning

The Agency's policy-making body is the ESA Council, composed of representatives of the Member States. Delegations from the Member States also sit on various Committees and Programme Boards. The chief executive and legal representative of the Agency is its Director General, who is assisted by seven Directors responsible, respectively, for the Scientific Programme, Application Programmes, Planning and Future Programmes, the Spacelab Programme, the Technical Directorate (including the activities of ESTEC), ESOC, and Administration.

Finance

The Agency is financed by its Member States. They contribute to the mandatory programmes (Scientific Programme and activities covered by the General Budget) on the basis of national income, and to the budgets relating to the optional programmes on an « à la carte » basis whereby each participating State decides at the outset what percentage it will contribute. The non-member States that participate in certain of the ESA programmes (Austria in the Spacelab Programme, Canada in the General Studies relating to future projects, and Norway in the Marecs Programme) contribute to the financing of the activities in question. The overall level of expenditure for 1979 is approximately 570 MAU(*).

Economic spin-off

The Agency, one of whose missions is to improve the competitiveness of European industry, wondered whether it might be possible to quantify the economic usefulness of expenditure devoted to space research. The idea was to catalogue and quantify the positive benefits that can accrue to industrial firms participating in the European space programme, and so obtain a qualitative and quantitative picture of the economic spin-off outside the field of space that is generated in European industry by ESA contracts.

The diversity of the information collected from the 77 contractors consulted in the course of the study enabled 171 specific cases of benefit to be identified. Examples were the sale of new products, increased turnover, the maintenance of a production team, the reduction of production costs, the reduction of research and development costs, and the amortisation of equipment. The study bore on 81.5 % of the total value of contracts placed by ESA in its Member States between 1964 and the end of 1975.

As regards the quantitative aspect, the total net benefit in respect of the sample was 2260 MAU derived from contracts of a total value of 840MAU in terms of payments received by the contractors, i.e. an overall ratio of 2.7. This means that an ESA outlay of 100 units resulted in a net amount of benefit of 270 units for its contractors.

This qualitative and quantitative picture of the secondary economic effects generated by ESA contracts confirms the Agency's success in its mission of promoting European industry world-wide. Moreover, the economic benefit ratios in respect of the individual countries that result from the study provide grounds for thinking that the consolidated advantages and benefits secured are greater than the amounts the governments have invested in space research.

(*) 1 MAU = 1 million accounting units, equivalent in 1979 to $ US 1.23 million.

Sirio-2 undergoing tests in the vacuum chamber at ESTEC.

International relations

In conformity with the terms of a Resolution adopted by its Council, meeting at ministerial level, the Agency is developing its relations with non-member States, and with international organisations, so as to make known Europe's achievements in the space field and encourage international cooperation.

In this context the Agency has concluded cooperation agreements with numerous countries. It offers technical assistance and the use of its facilities. It receives trainees in its establishments and gives demonstrations of its equipment and briefings on its programmes and activities.

Space science today

At the beginning of 1979, the European Space Agency had four scientific satellites operational: COS B, was launched in August 1975 to study the sources of extra-terrestrial gamma radiation; ISEE-2, launched in October 1977, is one of the three satellites of the international programme for studying Sun-Earth relations which ESA embarked on in cooperation with NASA; IUE, launched in January 1978, is a joint project involving ESA, NASA and the UK Science Research Council, designed for astronomical research in the ultra-violet part of the spectrum; GEOS-2, launched in July 1978, continues the magnetosphere research mission started with GEOS-1. Let us recall, incidentally, that the latter, launched in April 1977, carried out only part of its mission owing to a malfunction of its launcher.

New projects approved by the ESA Science Programme Committee are currently being prepared: Exosat, due to be launched by Ariane in 1981, will determine and examine X-ray sources with a degree of accuracy never previously attained; the Space Telescope developed jointly with NASA (1983); the International Solar Polar Mission, a joint ESA-NASA programme under which two satellites, one of them European, will be launched into deep space in 1983; the Space Sled, a piece of equipment designed for the study of space sickness; the Lidar, another Spacelab-borne device for active study of the Earth's atmosphere.

COS-B

This satellite is in fact a remotely-controlled astronomical observatory for the study of radiation emitted from known and assumed sources of gamma rays. It was designed and supplied through the collaboration of research groups from the Centre d'Etudes Nucleaires de Saclay, the Max Planck Institut für Extraterrestrische Physik, Garching-bei-München, the Universities of Leyden, Milan and Palermo, and ESA's Space Science Department.

Industry in seven ESA Member States (Belgium, Denmark, France, Germany, Italy, Spain and the United Kingdom) participated in the construction of COS-B and the prime contractor was Messerschmitt-Bölkow-Blohm.

After two years of near-perfect behaviour, the COS-B experiment had completed the most sensitive survey of the galactic plane ever made. Most of its observations (of approximately one month) were dedicated to observing targets in the galactic disc at all longitudes. Some were repeated to permit more detailed study of the brightest gamma-ray source, the pulsar Vela, and of the enigmatic Crab Nebula.

The success of this mission, which normally should have ended in August 1977, has led the experimenters to recommend extension of the observation programme.

Extension of the COS-B mission will enable the investigations to be directed at goals that were not attainable within the operational constraints of the original mission, or in respect of which insufficient data was secured. Priority will thus be given to acquiring a better understanding of the fine structure of the galactic radiation. Then, if time permits, a search will be made for extra-galactic sources. The observation programme proposed with these two objectives in mind comprises a more detailed study of the region that includes the high ridge towards the galactic centre and the Cygnus region, where astronomic phenomena of great interest occur.

High-energy gamma radiation from the Milky Way measured by COS-B.

Horsehead nebula

Geos

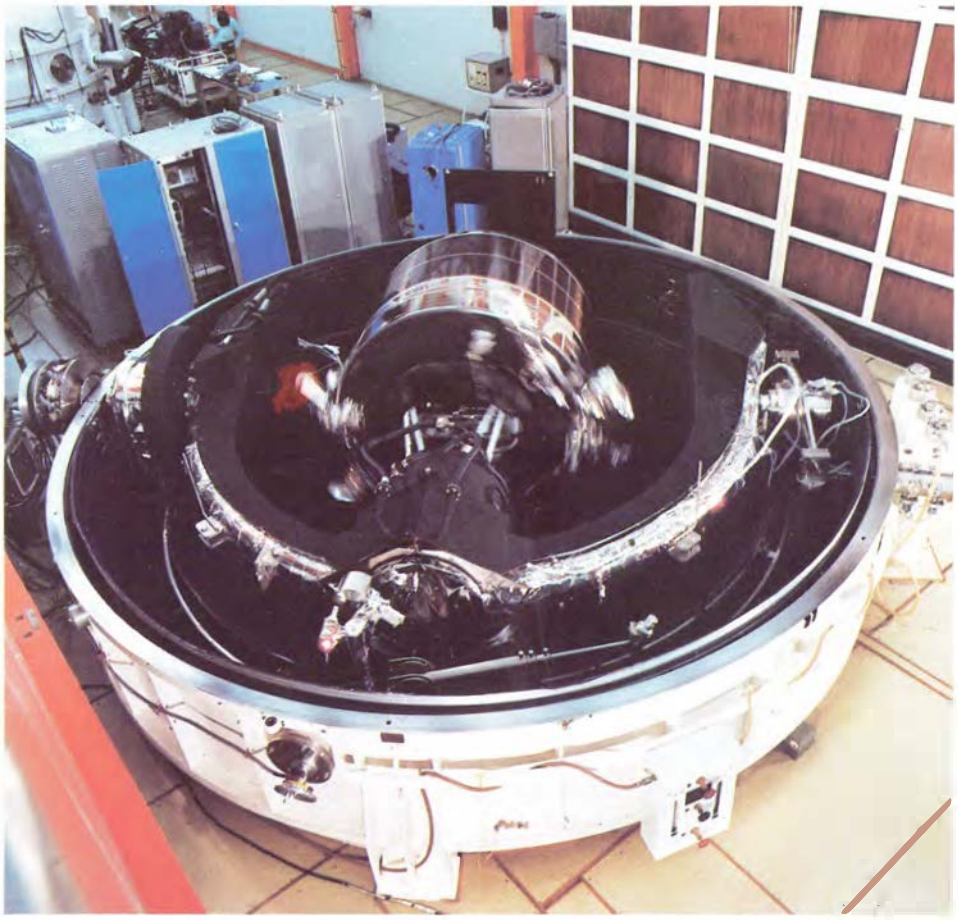
GEOS was developed to study the region of near-Earth space (the magnetosphere) where the magnetic field of the Earth still plays a dominant role.

The spacecraft was built for ESA by firms in 10 European countries (Belgium, Denmark, France, Germany, Italy, Netherlands, Spain, Sweden, Switzerland, United Kingdom), grouped in the STAR Consortium. The prime contractor was British Aerospace-Dynamics Group, under the technical management of ESTEC.

GEOS-1 was launched from the Eastern Test Range at Cape Canaveral, Florida on 20 April 1977. Owing to a malfunctioning of the American Delta 2914 launch vehicle during separation of its second and third stages, the launcher failed to place GEOS in the correct transfer orbit for subsequent injection into geostationary orbit. As soon as the launcher error was detected, ESA's Space Operations Control Centre (ESOC) at Darmstadt in Germany successfully took emergency action using the satellite's apogee boost motor to inject GEOS into a 12-hour excentric orbit with an apogee of 38 000 km and a perigee of 2 050 km.

After operating for 14 months in this orbit, results showed that GEOS-1 had made a major contribution to the International Magnetosphere Study (IMS) 1976-79. The excellent behaviour of the spacecraft and the flexibility of its payload enabled interesting and previously unknown scientific data to be obtained through this « rescue » mission which ended towards the end of June 1978.

Some months after the launch of GEOS-1, the ESA Science Programme Committee decided, in response to demand from the scientific community, to launch a second flight model. GEOS-2, the eleventh ESA scientific satellite, was successfully launched on 14 July 1978 and reached the planned geostationary orbit a few days later. The main purpose of this mission is to find out more about how the Earth's near environment reacts to phenomena occurring in outer space.



Geos 2 undergoing thermal vacuum testing at ESTEC, Noordwijk, Netherlands

The GEOS-2 payload is identical with that of GEOS-1. Seven scientific experiments comprising 16 electric field sensors and 26 particle analysers are carried on the satellite.

The region thus explored by GEOS-2 lies between the plasmapause and the inner boundary of the plasma sheet. These two areas are not fixed in space and may from time to time cross the geosynchronous orbit. The satellite thus studies the phenomena associated with these movements. In addition, in view of the satellite's position on the lines of the magnetic field linked to the two auroral zones of the Earth, a correlation is established between the GEOS-2 data and the data gathered by ground instruments in the associated auroral stations or instruments on board balloons and sounding rockets.

Other correlations are carried out between the GEOS-2 data and the results gathered from the three ISEE magnetospheric satellites, one of which is an ESA satellite. It is thus hoped to gather a large quantity of data in connection with the International Study Magnetosphere which will lead to an overall understanding of the Earth's near environment.

ISEE-2 (previously ISEE-B)

The ISEE programme (International Sun-Earth Explorer) includes three satellites two of which, ISEE-1 and ISEE-3, were supplied by NASA, the Agency being responsible for the development and operation of the ISEE-2 satellite.

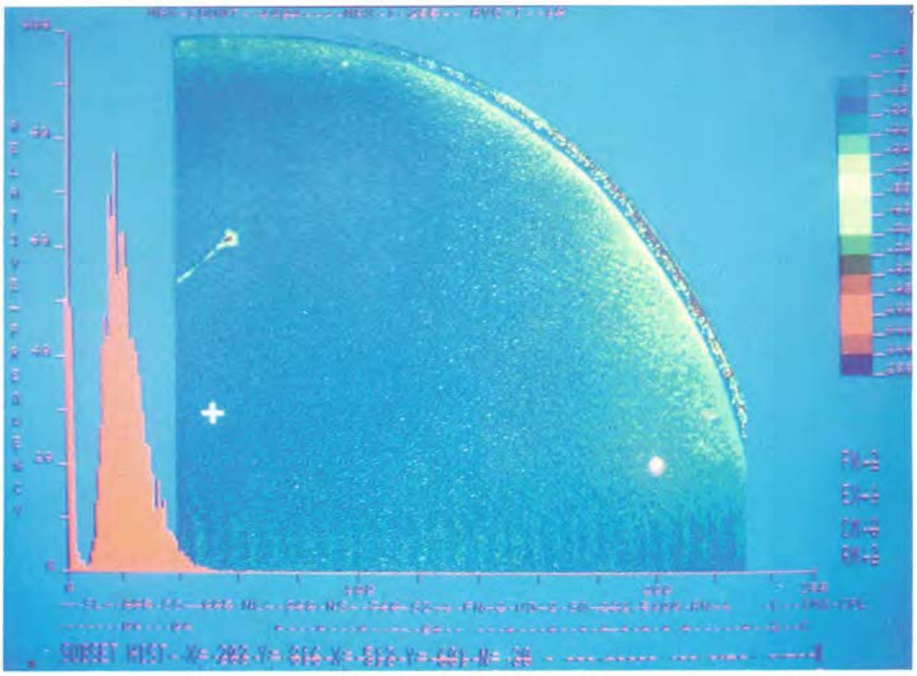
ISEE-1 and ISEE-2 were launched in tandem on a very highly excentric orbit (perigee 280 km and apogee 139000 km) where they are surveying magnetospheric phenomena, their fluctuations and their effects on the Earth's environment.

A particularly important aspect of this mission is the opportunity to correlate measurements by the two satellites in order to resolve previous ambiguities between spatial and temporal variations in the magnetosphere.

The ISEE-2 payload comprises eight experiments provided by universities and scientific institutes in France, Germany, Italy and the USA. ISEE-2 was developed for ESA by the STAR Consortium with Dornier as prime contractor.

NASA's satellite, ISEE-3, was launched on 12 August 1978 into a heliocentric orbit between the Sun and the Earth at a distance of about 1.5 million kilometers from the latter. In this position ISEE-3 carries out important interplanetary measurements and records solar wind phenomena moving towards the Earth which probably are the cause of most disturbances inside and around the magnetosphere.

The ISEE mission coincides with the International Magnetosphere Study Programme mainly centred on the GEOS programme whose aim is to provide complete understanding of the Earth's near environment.



Part of the sky seen from the IUE satellite and displayed on a console at the Villafranca station, Spain

IUE

The IUE (International Ultraviolet Explorer) programme is a joint undertaking by NASA, the United Kingdom Science Research Council and ESA. Its purpose is to provide an observatory in geosynchronous earth orbit which can be operated by observers as a ground station. ESA's contribution comprises the deployable solar cell array for the spacecraft and the design, construction and operation of the European ground station at Villafranca del Castillo near Madrid.

Launched successively on 26 January 1978, this orbital observatory has already proved its capabilities by obtaining ultraviolet spectra from objects ranging from planets, the interplanetary medium, stars ranging from type O to M, including stars of a particular type, planetary nebulae, supernova remnants, galaxies, objects of the BL Lac Type and quasars. With its long exposure time, IUE has been able to obtain the spectrum of a magnitude 18 quasar with a 6 Å resolution.

The operation of the satellite involves very wide international cooperation bringing in two other satellites and six ground telescopes for studying X-ray sources. This cooperation has led in particular to the discovery of variations in the ultraviolet spectrum of the Cygnus X-1 source, in phase with the orbit of the invisible companion that most astronomers believe to be a black hole (final stage of a star which has collapsed under its own weight to reach a dimension where the pressure of its internal gravity is so great that even light cannot escape).

The interest of scientists in IUE is very great. 171 proposed observations have been put forward for 1979, a figure which far exceeds the time allocated to European astronomers, i.e. 180 periods of eight hours. The operational conception of IUE, which is very similar to the one which astronomers are used to with ground telescopes offers a new and fascinating opening in space astronomy especially as the satellite, compared with a ground telescope ensures cloudless skies!

EXOSAT

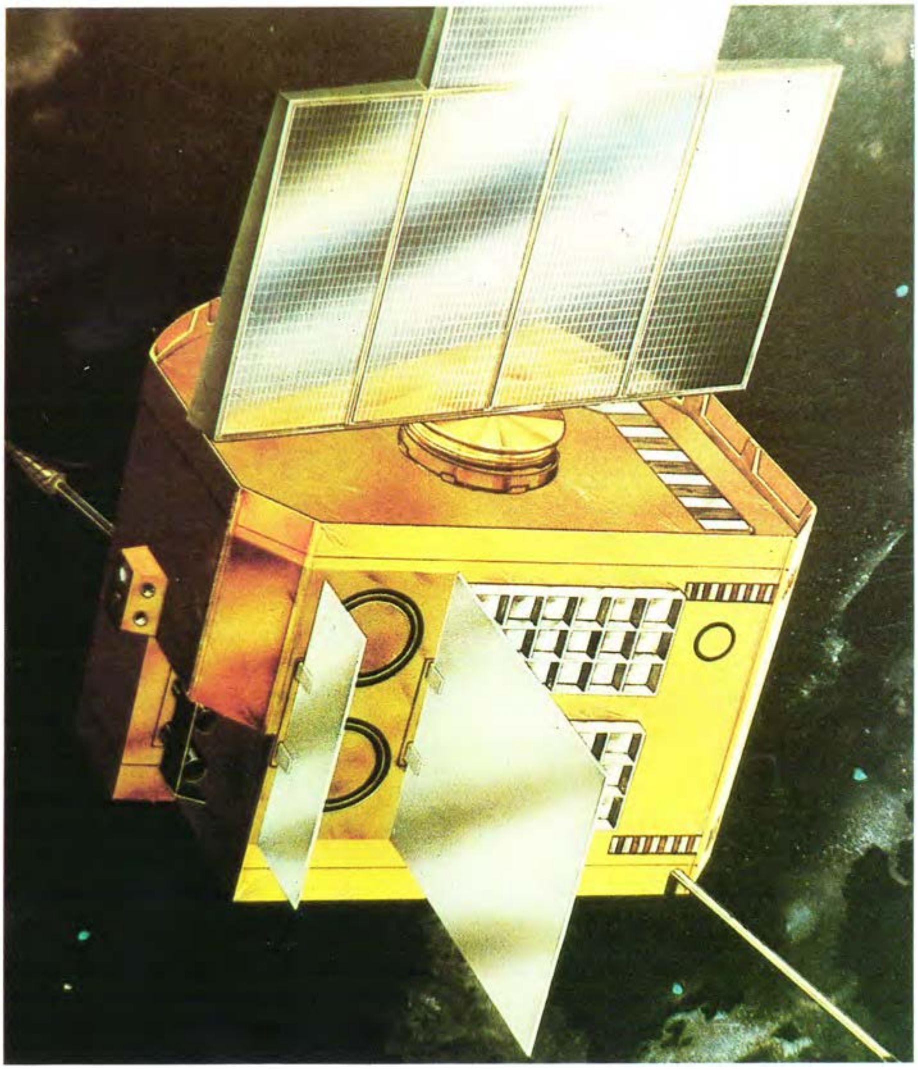
This ESA satellite will be launched in 1981 by Ariane which, on this occasion, will have a fourth stage enabling the satellite to attain an orbit with an apogee of 200 000 km and a perigee of 300 km. The Exosat observatory will determine the position and examine the structure of celestial X-ray sources. In one mode it will use lunar occultation, i.e. taking account of the time and speed of disappearance of celestial objects behind the lunar disc. This technique is very common in astronomy and is particularly interesting in view of the satellite's excentric orbit, because it will be possible to make observations of occultations over 20 % of the celestial sphere. Outside the periods of occultation, the satellite will be able to observe the sky in a given direction for about 80 hours without a break, in order to determine the regular and irregular variations in X-ray sources.

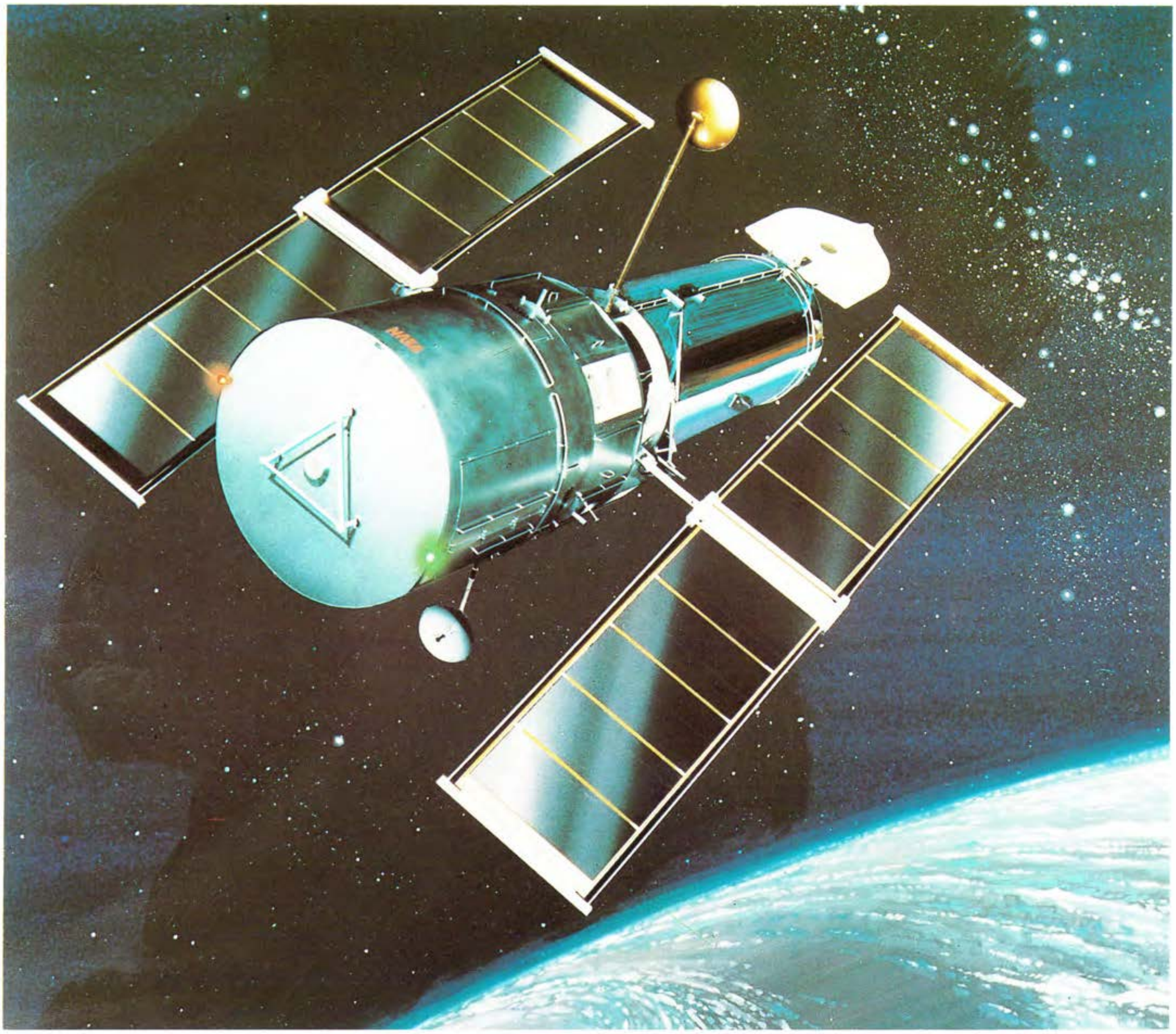
The resolution thus obtained should yield information on binary stellar systems. Many cosmologists believe one of the stars in these systems to be a «black hole» which it is hoped Exosat may finally pin down. The payload consists of four instruments: two X-ray imaging telescopes for the low energy unit, a large-area proportional counter and a high-resolution gas scintillator, the latter two being used for the study of medium-energy X-rays.

The experiments are being developed mainly by Institutes in Great Britain, Germany and the Netherlands and by European industrial firms under the supervision of the ESA Space Science Department.

The satellite currently under development is being built for ESA by firms in ten Member States (Belgium, Denmark, France, Germany, Italy, Netherlands, Spain, Sweden, Switzerland, United Kingdom) under the industrial consortium COSMOS, with Messerschmitt-Bölkow-Blohm (Germany) as prime contractor.

Exosat





The Space Telescope.

Space Telescope

NASA's 2.4m Space Telescope is the most ambitious current astronomy project. It will dominate astronomical research for the rest of the century, open up fields of research at present unattainable and contribute to cosmological studies and to our understanding of the geometry of the Universe. This project was approved by the United States Congress in autumn 1977 and the telescope is to be launched into orbit by the Space Shuttle in 1983.

The European contribution of 15 % to the Space Telescope programme includes a faint object camera and its associated detector (image photon counting system), the solar array and part of the associated activities of the Space Telescope Science Institute. European astronomers will in return be allocated not less than 15 % of the total observing time of the Space Telescope (due to operate for at least 10 years).

The Space Telescope has capabilities that are unique: it will be able to concentrate light from a star in a fraction of a tenth of an arc second and to observe celestial objects nearly 100 times fainter than those observable from the ground. It will have access to the vacuum ultraviolet region between 1000 and 3000 Å which is unobservable from the Earth, and to the visible and infrared regions.

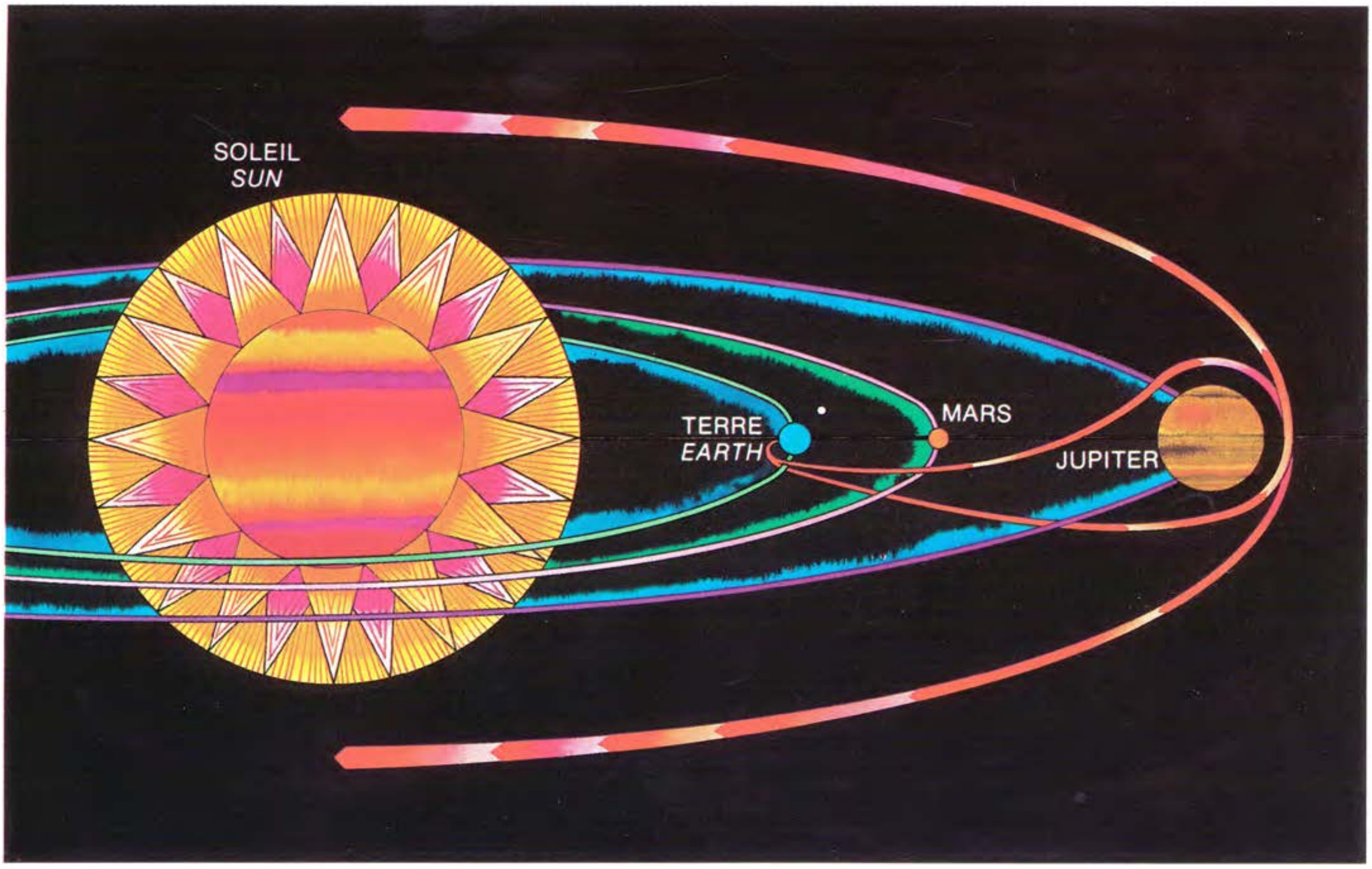
The ten-fold increase in spatial resolution of the Space Telescope coupled with spectroscopic capability will allow study of star formation and stellar and chemical evolution in near galaxies. Finally, the extension of the absolute distance scale ten times farther out than is currently possible will allow the Space Telescope to be used to tackle the classical cosmological problem of defining and tracking beyond time the expansion of the Universe to throw new light on its ultimate fate: continual expansion or eventual collapse into another primordial fireball followed by rebirth and eternal recycling?

International Solar Polar Mission

ESA will undertake jointly with NASA the International Solar Polar mission, formerly known as the Out-of-Ecliptic mission. This mission will include the launching towards Jupiter in February 1983 of two interplanetary spacecraft, one European and the other American. The originality of the mission is that each spacecraft will be sent out of the ecliptic plane (the plane in which the Earth orbits around the Sun) with the help of Jupiter's gravitational field. They will then fly over the Sun almost at its North and South poles.

At present virtually nothing is known about the solar system's third dimension and the region around the Sun into which no space vehicle has yet penetrated. The international Solar Polar Mission should provide this information by a detailed exploration of the solar environment and observations of the Sun from a large number of angles. Part of the instruments on board the two spacecraft will thus be devoted to this observation mission. Other sensors will study and analyse the properties of the solar wind, composed of charge particles, which are continuously propagated in all directions from the Sun. In addition, instruments such as a coronograph placed on board one of the spacecraft will perform solar observations which, combined with terrestrial observations, will allow a stereoscopic study of various transient phenomena in the Sun's atmosphere to be carried out.

The two spacecraft, weighing about 270 kg each, will be injected into an Earth-Jupiter transfer orbit by means of the interim upper stage of the NASA Space Shuttle. When the spacecraft are out of the ecliptic plane they will describe an elliptical solar orbit, one over the southern hemisphere and the other over the northern hemisphere. It will take almost three years in these orbits for the spacecraft to reach the points closest to the Sun. During this mission, which will last five years altogether, the two spacecraft are expected to fly respectively at least twice over the Sun's poles at a distance of approximately 255 000 000 km. This will be the first time that a spacecraft has been developed by ESA for a mission in deep space.



The two interplanetary probes, one European and one American, will fly over the polar zones of the Sun after swinging round Jupiter

Space sled

The Space sled is a piece of equipment designed to study the vestibular function which has its origin in the inner ear and is linked to the sense of equilibrium in humans and animals. This sled, to be carried by Spacelab (manned European space laboratory) will be accelerated together with its passenger at well-defined rates. By measuring the effect of these accelerations on the subject, it is hoped to achieve a better understanding of the vestibular function. In this respect, in addition to increasing our basic knowledge of one particular aspect of physiology, there is a definite attempt to solve the problem of space sickness, which of course has great relevance for the efficient use of Spacelab and the manned space stations that will succeed it. The sled is being developed with a view to its inclusion in the first Spacelab mission. Several groups of scientists from both Europe and the United States have been selected to carry out the experiments.

Lidar

The Lidar is a device that will allow the Earth's atmosphere to be studied from Spacelab.

The regions of the Earth's atmosphere between altitudes of approximately 35 and 120 km remain relatively unexplored and several physical and chemical processes of this region are still not well understood. To the intrinsic scientific interest of studying these processes must be added the fact that if we do not properly understand how the atmosphere functions we cannot assess the possibly harmful effects of man-made perturbations of its upper regions.

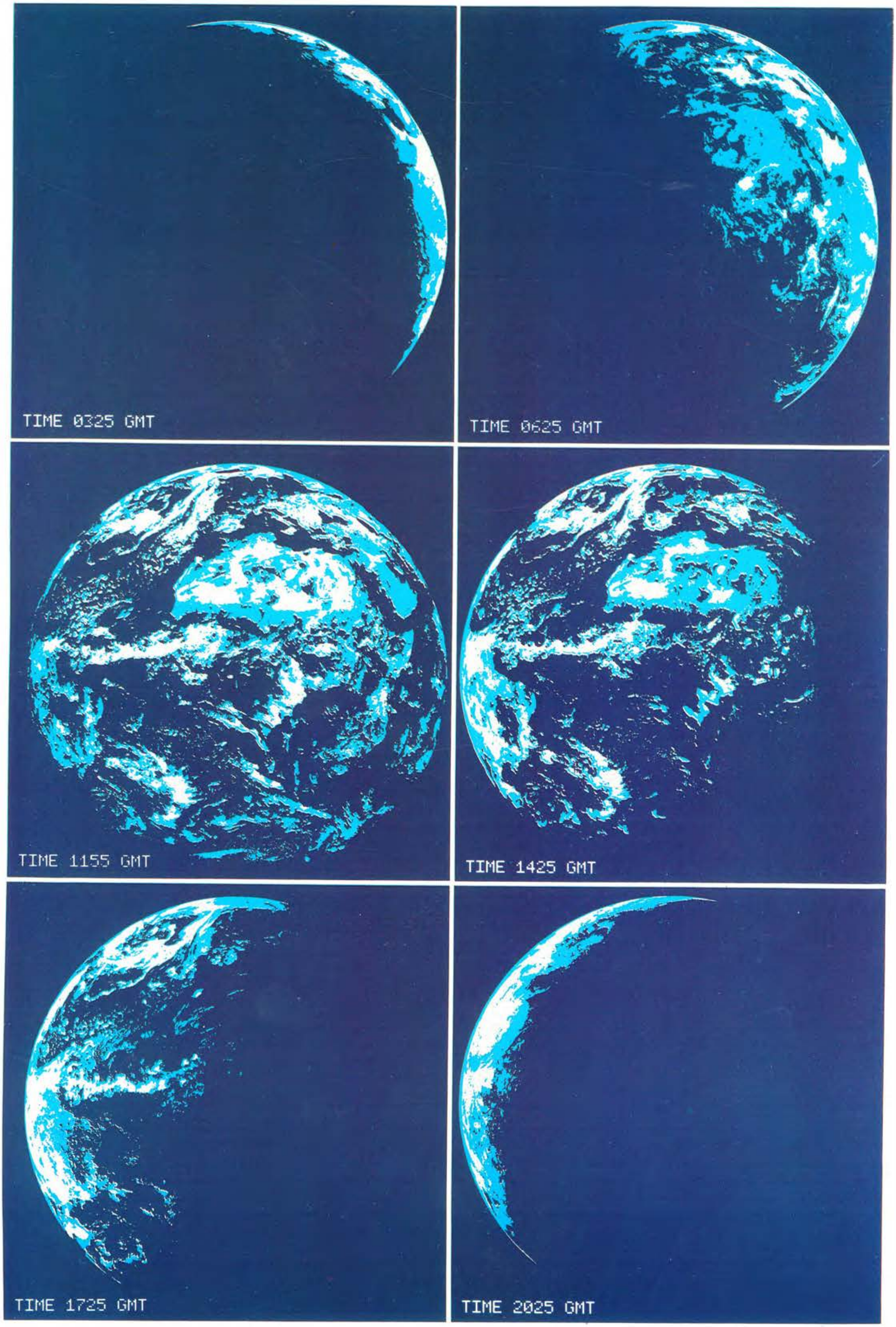
The Lidar will permit active sounding of the atmosphere with powerful laser beams, the back-scattered signals being analysed by a variety of spectrophotometric devices. As Spacelab is re-usable, the Lidar design will allow changes in the type of laser and appropriate detectors from one mission to the next.

Sounding rockets

Sounding rockets and balloon launchings are carried out by ESA member states in the auroral zone at ESRANGE, Kiruna, Sweden (67°53'N, 21°04'E) and Andoya, Norway (69°18'N, 16°01'E). The Agency plays an important part in the coordination of these activities, executed under the ESRANGE Special Project.

Sounding rockets are used to explore the Earth's upper atmosphere and provide attractive opportunities for experiments by European Scientists. They are used in a wide variety of experiments, some of which demand zero-gravity conditions.

Special Esrange project. Launching of a sounding rocket from the Andoya base in Norway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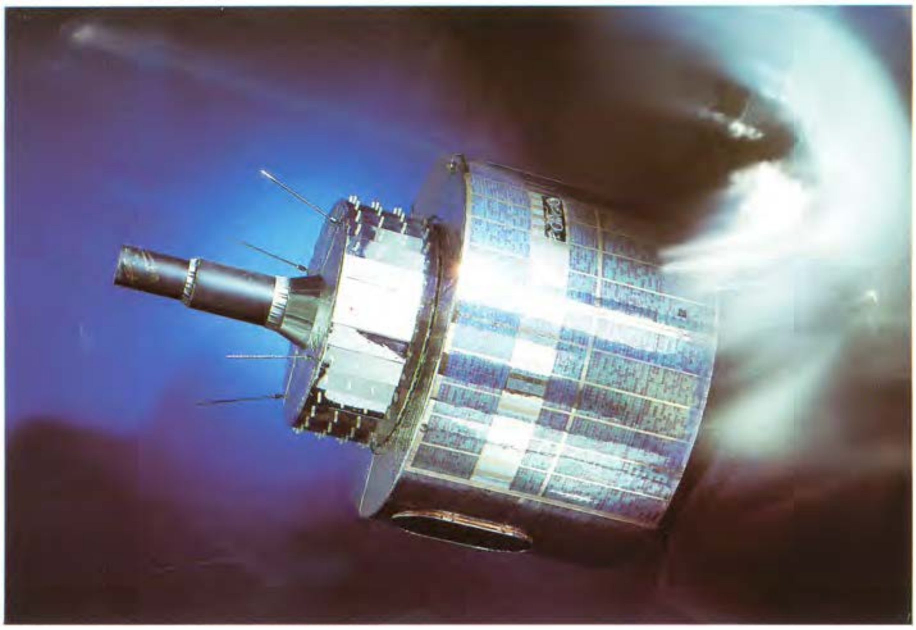
Earth observation

Satellites are increasingly used as observation platforms. Meteorological satellites study atmospheric phenomena. Remote-sensing satellites study the Earth's land surfaces and oceans



Meteosat

Meteosat and its mission

The Meteosat-1 spacecraft is 3.2 m high and 2.1. m in diameter. Its launch weight of nearly 700 kg includes a 345 kg apogee boost motor and fittings. The spacecraft was built by the European COSMOS consortium with Aérospatiale (France) as prime contractor. The satellite's image-taking radiometer was developed by Engins Matra.

Meteosat-1 was successfully launched on 23 November 1977 by an American Thor Delta launcher and placed in geostationary orbit (over the Gulf of Guinea). The images produced by this satellite mean that changes in meteorological conditions can be monitored effectively on an almost continuous basis. Meteosat-1 was designed to fulfil three main missions:

1. **Image-taking mission.** Images are taken every half hour of the surface of the Earth and the cloud masses within the area of visibility of the satellite. These images are provided by a radiometer operating in three channels, corresponding to the visible, the thermal infrared and the water vapour spectra.

2. **Dissemination mission.** The dissemination of images of the cloud cover or meteorological data obtained from these images. The aim is to provide the greatest possible number of users with access to the data produced either by Meteosat or by the American satellites GOES E and I.

3. **Data collection mission,** i.e. from automatic (or semi automatic) stations called data collection platforms. The purpose of this mission is to gather local data to complete the images transmitted by the satellite.

The raw image data from Meteosat-1 are received by the Michelstadt ground station in the Odenwald, Germany and are then transferred for processing to the Meteorological Data Management Department (MDMD), located some 50 km away at the European Space Operations Centre (ESOC) at Darmstadt.

After processing, the image data are sent back to the Michelstadt station to be retransmitted by Meteosat to the meteorology user stations. To receive these data, and depending on whether they want them in digital or analogue form, the users have a choice between two types of station:
— the Primary Data Users Station (PDUS)
— the Secondary Data Users Station (SDUS).

Through these stations the users can receive Meteosat images or data images as well as data transmitted by the U.S. satellites GOES-East (over the Atlantic) and GOES-1 (over the Indian Ocean). About ten PDUSs and eighty or so SDUSs are in service in the Meteosat coverage zone.

In addition, the MDMD performs the mathematical processing required to extract certain meteorological parameters such as wind field and velocity, sea surface temperature, cloud top altitude etc. This information is coded and injected into the terrestrial communications network of the World Meteorological Organisation (WMO).

The second Meteosat flight model will be launched on the third qualification flight of the Ariane launcher in 1980.

A day's observation of the Earth by Meteosat (on May 29, 1978).

The Meteorological Data Processing Centre at ESOC, Darmstadt, Germany.

Global system

Meteosat-1 represents Europe's contribution to the World Weather Watch and to the Global Atmospheric Research Programme (GARP) whose first experiment began in December 1978 and is due to end in November 1979. In this framework, Meteosat-1 forms part of a world-wide system of five satellites (three American — including GOES-I which is operated by the Agency — one European and one Japanese) positioned around the Equator.

Meteorological conditions in one part of the world can affect the weather many thousands of kilometres away. Only a global system of carefully planned geostationary and polar satellites can make the continuous observation of almost the entire Earth's surface and cloud cover that is necessary in order to make accurate weather forecasts and to issue reliable warnings in time to avert the danger of hurricanes, tempests and all meteorological disturbances which considerably affect many sectors of the economy.

Sirio-2

Following an offer by Italy which proposed to re-use the available platform of the Italian satellite Sirio, the Agency studied several mission objectives. In the light of the needs expressed by meteorological users and of the interest displayed by dissemination institutes, it was decided to carry out two experimental missions of interest to meteorology and geodesy:

— a meteorological data distribution mission (MDD) designed to improve meteorological data distribution on the continent of Africa.
— A second mission called LASSO (Laser Synchronisation from Stationary Orbit) is designed to improve by using laser techniques the world-wide synchronisation of atomic clocks.
Sirio-2 will be launched by Ariane in 1981 into a geosynchronous orbit along with another ESA satellite, either Marecs-B or ECS-1.

Earth resources

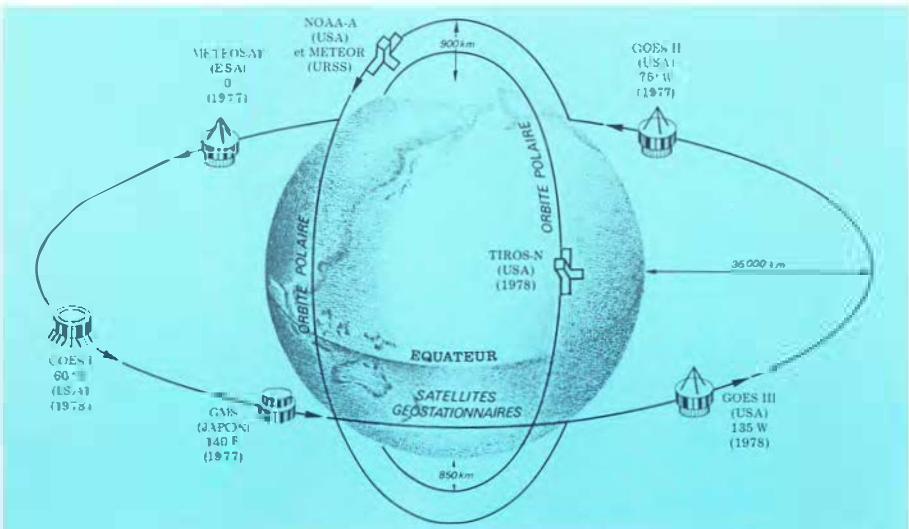
The missions of remote-sensing satellites cover a wide variety of applications, e.g. crop inventory and yield forecasts, management of water resources, soil and arable land use, shore and coastal areas surveillance, exploitation of mineral resources. Such applications are of interest not only to the industrialised countries but also to developing countries which in many cases have no fundamental information available on the state of their natural resources.

The Agency and its « Remote Sensing » Working Group studied the aims of a European mission and in 1977 defined a programme directed along the following three lines:
— a network of data collection stations « Earthnet »
— a European remote-sensing payload flown on the first Spacelab mission
— the preparation of future European remote-sensing satellite projects.

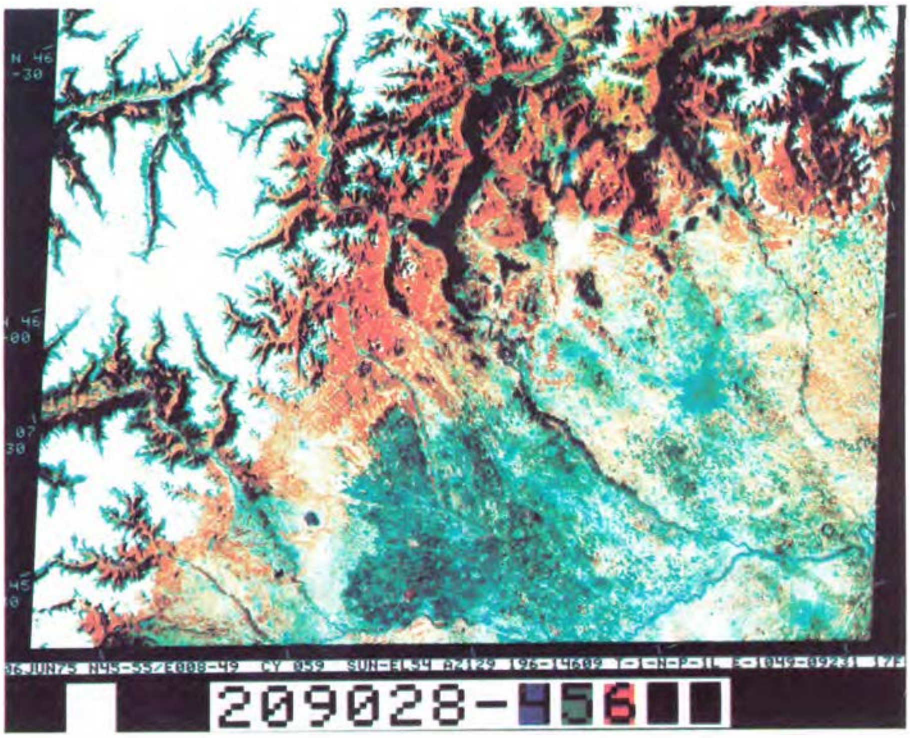
The Earthnet system

The Earthnet programme approved by the European Ministers in February 1977 covers the setting-up by ESA of a network of ground stations for collecting, preprocessing and distributing images and data from the American remotesensing satellites at present in orbit, namely Landsat-2, HCMM, Nimbus-7 and Seasat, all of which were launched between 1977 and 1978.

The Earthnet system which became operational in 1978 includes four receiving stations located at Fucino in Italy, (Landsat data), Kiruna in Sweden (Landsat data), Lannion in France (HCMM and Nimbus-7 data), Oakhanger, Great Britain, (Seasat data). A fifth station at Maspalomas in the Canary Islands will come into service in 1980 and will receive data from Nimbus-7. Data from these satellites are managed at the Earthnet Management Centre at



The meteorological satellite system set up under the World Weather Watch



Landsat image showing from left to right part of Switzerland, Lakes Maggiore, Iseo and Como. Top right Milan. Bottom centre an immense humid area, corresponding to rice fields, is clearly visible.

Frascati which organises their distribution throughout Europe. Earthnet will be modified so as to receive Landsat-D data. It also forms a fundamental element in the definition of the specification for the ground network which will be associated with future European remote-sensing satellites.

Spacelab utilisation

Two European experiments in the remote-sensing of Earth resources will be flown on the first Spacelab mission in 1981. The first of these two experiments should provide an assessment of the possibilities of using pictures taken by a very high-resolution metric camera (10 × 20m) covering a ground area of 188.5 × 188.5 km. This camera will mainly be used for mapping (scale 1/100.000) but also for a number of thematic applications such as geology and all disciplines related to land use.

The second experiment is an attempt to develop a microwave remote sensor in Europe. The instrument will have several operating modes which will enable it, whatever the cloud cover, to measure the temperature of the oceans, to study the ocean swell and take high-resolution pictures of the Earth's surface. The use of these two instruments on Spacelab provides a unique opportunity for in situ experimental research before developing future European remote-sensing satellites.

Preparatory remote-sensing programme

The Agency has undertaken a two-year preparatory programme for the study and preliminary development of systems intended for future European remote-sensing satellites to be launched in the mid-80's. The main aims of this programme are the definition and pre-development of the key elements of the optical and microwave sensors needed for these future satellites. Some of the new concepts envisaged are:

- a land applications satellite system (LASS) including a synthetic aperture radar and an optical instrument operating in the visible and infrared parts of the spectrum,
- a coastal ocean monitoring satellites system (COMSS) comprising an optical instrument, a synthetic aperture radar and a microwave radiometer.

These satellites will use the multi-mission platform currently under development in connection with the French project SPOT.

Subject to approval by the ESA Council, the European programme will include two European remote-sensing satellites, ERS-1 and ERS-2, launched with a two-year interval, the first launch (ERS-1) being scheduled for 1985-1986.

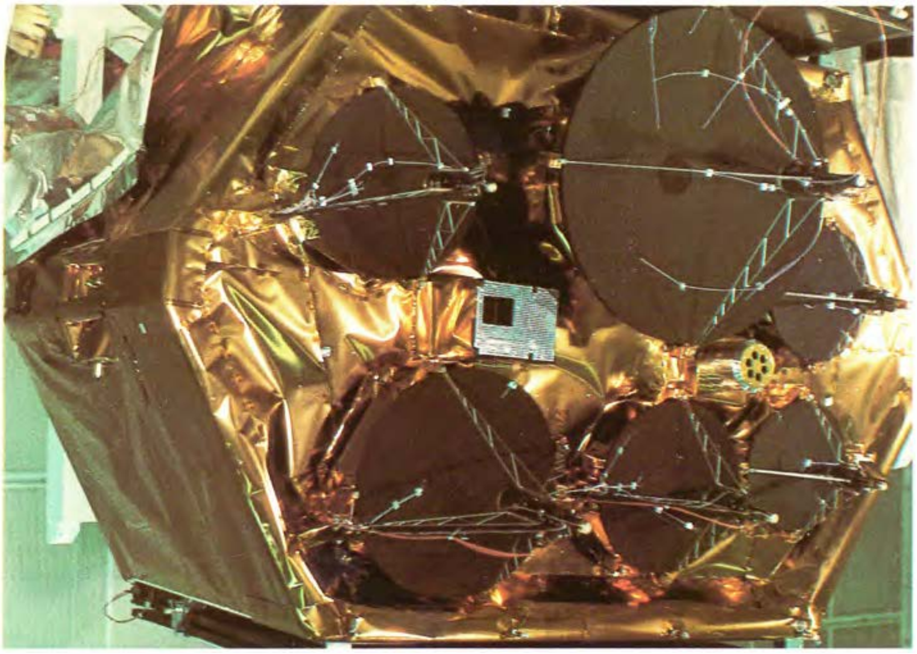
The choice of mission objectives for these satellites depends mainly on technological considerations and the relative priorities given to the various applications possible by the community of European users. This choice will be made in 1979 and a programme proposal prepared in early 1980.


Weitere im 2. Untergesc

Communications by satellite

One of ESA's communications objectives is to set up and make available to the European Post and Telecommunications and broadcasting administrations a system of satellite links capable of carrying, from 1982, a larger share of intra-European telephone, telegraph and telex traffic and of relaying Eurovision programmes. More specialised services, such as data transmission, teleconferencing and off-shore oil rig communications, are also envisaged.

According to the traffic forecasts made by European PTTs in the Interim EUTELSAT Organisation, the operational satellite system needs to carry the equivalent of some 5000telephone circuits in 1982 for traffic between points more than 800 km apart (the distance considered as a minimum), rising to about 20000 in 1990. The basic requirement for television is the permanent allocation of two wide-band repeaters capable of high-quality transmission.



OTS thermal model

The experimental programme OTS

European telecommunications activities started in 1971 with the evaluation of a European regional system. This led to the design of the Orbital Test Satellite (OTS) whose development was started in 1974, based on needs defined in consultation with the European Conference of Posts and Telecommunications (CEPT) and the European Broadcasting Union (EBU).

OTS was launched in May 1978 in order to:

— demonstrate the performance and reliability in orbit of all on-board equipment (payload, spacecraft systems and sub-systems);
— fulfil, from an experimental communication system point of view, the objectives required by a subsequent operational mission (experiments on propagation, frequency re-use, transmission impairments, time division multiple access etc.);
— provide an experimental and preoperational traffic capacity (6000 telephone circuits, or 4500 such circuits and two television channels).

OTS was the third communications satellite to be developed in Europe, after the experimental Franco-German Symphonie and Italian Sirio satellites. It is one of the first communications satellites to operate in the 11 and 14 GHz frequency bands;

OTS is a three-axis stabilised spacecraft of modular construction with two main components: a service module providing all the basic service functions and a communications module containing the payload.

Development of the OTS spacecraft was entrusted by ESA to the MESH Consortium, with British Aerospace Dynamics as the prime contractor. AEG-Telefunken was the contractor responsible for the communications payload.

The OTS Control Room at ESOC, Darmstadt, Germany

The tests programme

Under an agreement concluded on 11 January 1979 between the Interim EUTELSAT Organisation and ESA, the orbital test programme of OTS is overseen by the former. The programme has three objectives:

— helping the European PTTs and the EBU to prepare the bringing into service of the ECS (European Communications Satellite) operational system;

— increasing Europe's communications satellite design capability;

— studying possible new uses of communications satellites.

The first phase of the programme, under ESA's control, was carried out from injection into geosynchronous orbit in liaison with the Telespazio/ESA Fucino station in Italy and the ground station of the French PTT administration at Bercenay-en-Othe, south-east of Paris.

In a second phase the experiments rapidly expanded to involve many national administrations which have brought their earth stations, equipped with large 15m to 19m antennas, into the network of stations used for the test programme, viz., Usingen near Frankfurt, Germany, the Deutsche Bundespost station, and Goonhilly Downs in the United Kingdom, the station of the British Post Office. As part of the extensive propagation experiments, eight small earth stations owned by various national PTT Administrations, educational bodies and ESA have been transmitting and receiving test signals through the test satellite, and thirty small receive-only earth stations have been measuring beacon signals from the spacecraft on a regular basis.

In addition to these experiments solely within Western Europe, a number of demonstrations of the capability and versatility of OTS have been made to the international community. They include experimental transmissions of TV from Europe to both Cairo and Rabat. A regularly scheduled use of the satellite to transmit TV from France to Tunisia is envisaged.

The concepts and equipment used on OTS have demonstrated, through their satisfactory in-orbit performance, that they are directly applicable for use on the future operational ECS system. The present status of the OTS on-board subsystems allows one to expect a longer lifetime than the design objective; furthermore, the spacecraft has sufficient fuel to maintain itself at the correct geostationary position with the proper orientation of the satellite for another five years. During this period, it is expected that the data from the satellite and the uses to which it can be put will continue to

Stations at Bercenay-en-Othe, France (top) and Fucino, Italy (bottom)

provide a clear demonstration of Europe's advanced capabilities in the field of space communications.

Forward-looking studies of new applications focus on two main areas. The first is the transmission of data at ultra-rapid rates in real time between computers, the transfer of data between computer centres or data banks, and the transmission of information (remote printing of newspapers). The second relates to communications with North Sea off-shore oil rigs. Teleprocessing experiments are included in the test programme; for example, an experimental link will be established between the European Nuclear Research Centre (CERN) in Geneva and a number of high energy physics centres in the United Kingdom, Federal Germany, France and Italy; the use of OTS is also envisaged for linking the various establishments of ESA and the Royal Aircraft Establishment at Farnborough.

Lastly, OTS offers interesting prospects for direct television broadcasting. It is planned to explore this possibility, which will enable several kinds of equipment for individual and community reception to be tested, the respective merits of various transmission techniques to be examined, and progress to be made in the definition of future European television broadcasting systems.

1. ECS

Mission

The European Communications Satellite System (ECS) will provide international trunk telephony circuits to complement the terrestrial network between countries of the Members of the CEPT (Conférence Européenne des Administrations des Postes et des Télécommunications). Additionally, it will provide a means of exchanging television programmes between the Member Organisations of the European Broadcasting Union (EBU).

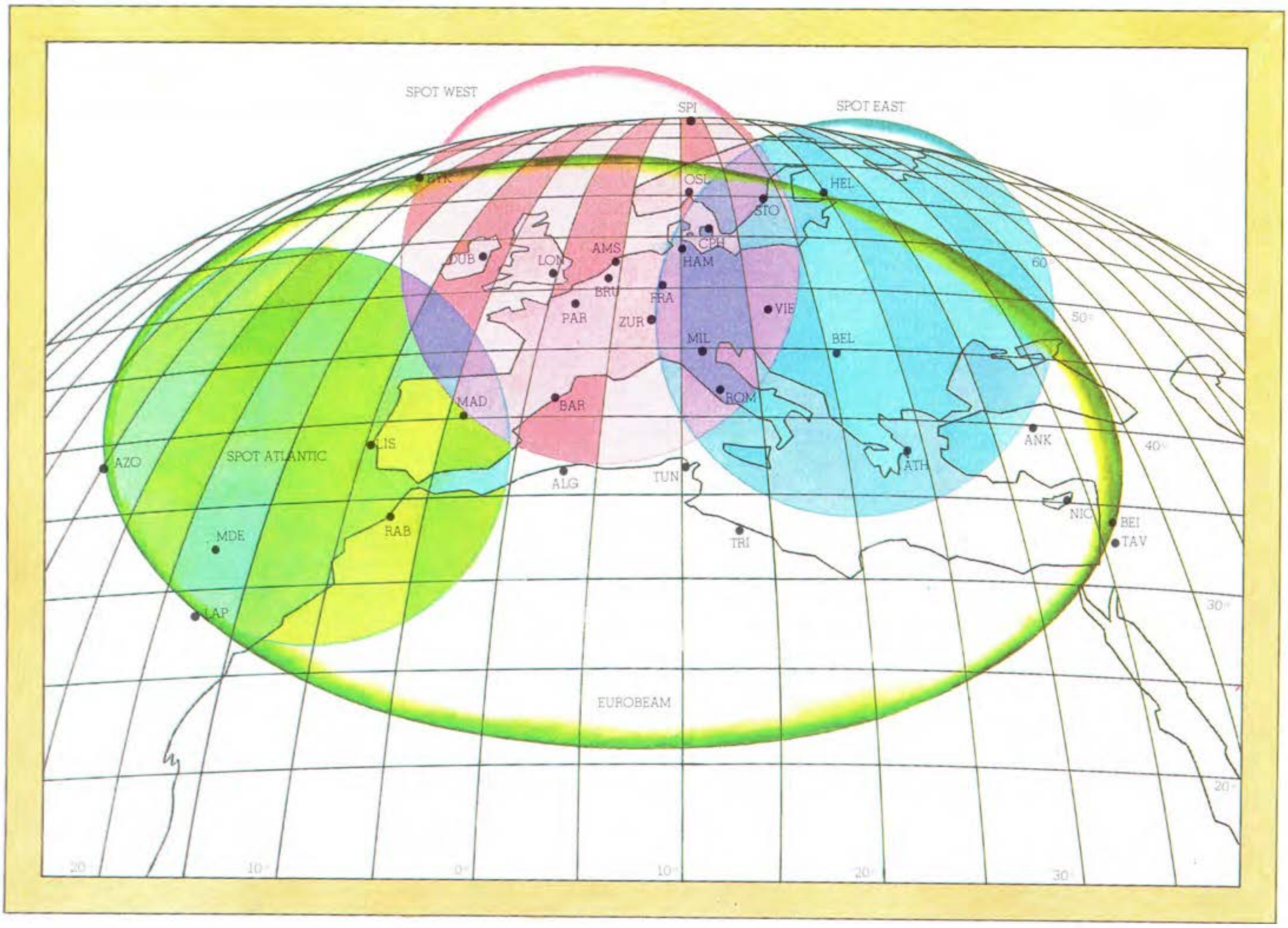
The ECS system may also be used to provide other services, such as additional television relay data transmissions or communications to off-shore oil or gas platforms. Such use is compatible with the design of the satellite and the provision of the primary telephony and television services.

General description

The European Communications Satellite System consists of a ground segment comprising initially 15 earth stations for telephony and a space segment comprising on the one hand 2 ECS satellites in orbit, one operational located at 10°E in a geostationary orbit and one spare, and on the other hand, the necessary ground facilities for satellite control.

The earth stations will be equipped with an antenna having a diameter of approximately 15 m. Two of these stations, Bercenay-en-Othe (France) and Fucino (Italy) already exist, as they have been used for the OTS programme.

European Communications Satellite



ECS coverage areas: for telephone communications, the area covers all the countries of Western and Southern Europe. For television broadcasting, the area extends to the Mediterranean countries within the EBU area.

The spacecraft

The design of the ECS spacecraft is based on that of the Orbital Test Satellite. A modular design, it consists of a communications module (payload) comprising repeater and antenna, and a service module (platform).

The spacecraft is three-axis-stabilised with 0.1°EW and NS station-keeping. Its primary power of 950 W is provided by two deployable solar arrays.

The spacecraft overall « lift-off » mass is about 1000kg and it measures about 14 m from tip to tip of the solar array. The satellite design lifetime is 7 years.

The prime contractor for the design, development and supply of the spacecraft is BAeDG, leading the MESH consortium, which comprises 14 industrial firms from 10 European countries, (Germany, Belgium, Denmark, France, United Kingdom, Italy, Netherlands, Spain, Sweden, Switzerland).

ECS will be launched by Ariane. The Agency, which is responsible for procurement of the space segment (satellites, launchers, control network) foresees the construction of 5 satellites to meet the requirements of the system over a ten year period. The first satellite will be launched at the end of 1981.

The Maritime Service

Long-distance radio links between ships and ground stations are still far from satisfactory. It is surprising but true that even today 93% of all messages to ships at sea are sent in morse code and only 7% by radiotelephone. Also, because of radio-wave propagation anomalies, the quality of communications can be very bad and it is sometimes impossible to establish the link.

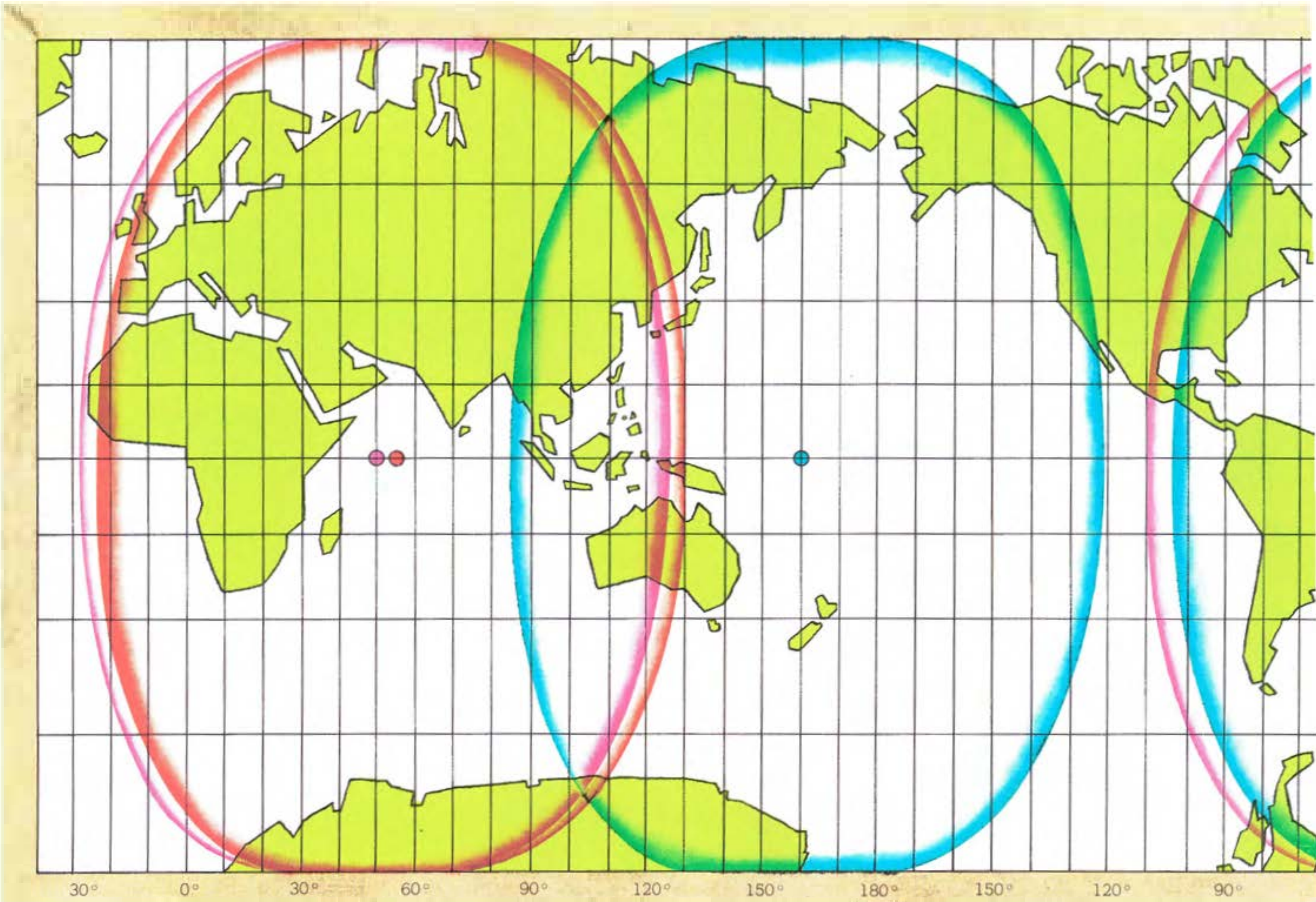
A geostationary maritime satellite communications system whose service has characteristics similar to those of the fixed service (with respect to quality, rapidity, automatic operation etc.) is the most effective way of overcoming the drawbacks of radiotelephony.

It was with this aim in mind that the ESA Member States, acting on a United Kingdom proposal, decided to undertake in 1973 a maritime satellite programme i.e. Marots, which in 1978 became the Marecs programme.

The maritime satellites programme (Marecs)

The initial Marots programme undertaken by ESA in 1974 underwent progressive changes and was then transformed into the Marecs programme. The initial concept, confined to an experimental phase, evolved in favour of an operational system using a more advanced technical design for the spacecraft, derived directly from the ECS spacecraft.

The interest of this new system stems largely from the possibility of making it the basis for a worldwide maritime satellite programme. The discussions started in 1978 on this subject in the Joint Venture, grouping 18 countries interested in participating in a world maritime satellite system, led to the definition of a system comprising three Marecs satellites associated with three Intelsat V satellites equipped with maritime payloads. Each Marecs satellite will use an antenna with terrestrial coverage and will be able to handle up to forty high-quality circuits. The international organisation INMARSAT which should come into being in the course of the summer 1979, will be responsible for managing the operational maritime communications satellites system.

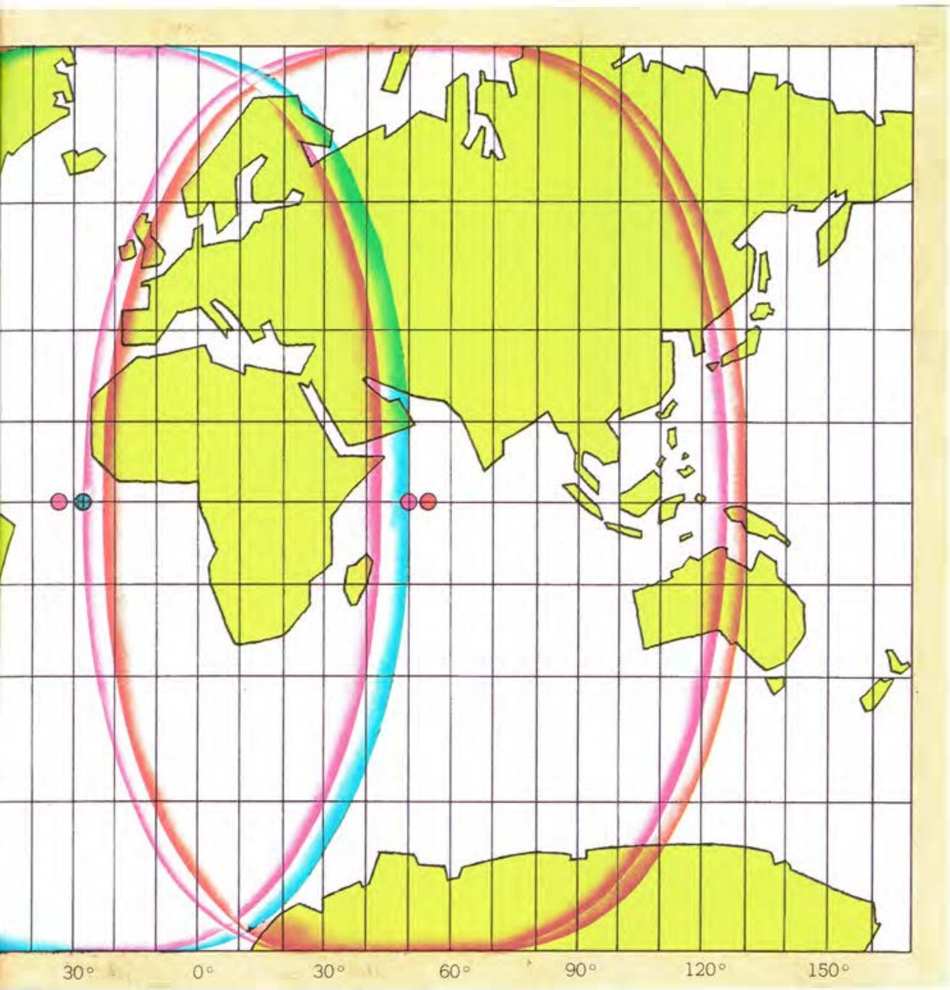


Areas covered by a world maritime satellite system. (In blue, Marecs, in red, Intelsat.)

The Marecs satellite

The Marecs spacecraft comprises two main components i.e. a service module — identical with that of ECS — providing all the essential support functions, and a communications module containing the payload. This is a horizontal platform housing the repeaters, surmounted by an antenna kept pointed towards the Earth. Two booms with three solar panels, each fixed to the sides of the spacecraft, constitute the solar array. The nominal lifetime of the satellite is 7 years.

Operating in the 4 to 6 GHz frequency bands (C to L bands), Marecs will provide a high-quality, reliable and real-time operational



maritime communications service. It will provide telephone and telex links between ships and shore stations and will be able to relay ship-to-shore search and rescue messages.

Three satellites, Marecs A, B and C, are envisaged for the world maritime communications system. Marecs A and B are in process of development and will be launched in late 1980 and early 1981 respectively. Injected into geostationary orbit, they will be positioned so that they provide coverage of the Atlantic, the Indian Ocean, and the Pacific.

Development of the spacecraft has been entrusted by ESA to British Aerospace Dynamics Group as the prime contractor; Marconi Space and Defense Systems has been chosen as contractor responsible for the communications payload.

Direct broadcasting

Since 1976, ESA has been considering a programme for a heavy platform adapted to the capabilities of the Ariane launcher, and able inter alia to carry communications payloads for direct and semi-direct broadcasting of television or radio programmes. The studies made have shown that this concept would match European requirements perfectly for improving coverage and increasing in certain countries the number of television programmes. It would also cater for differing mission requirements, such as, for example, the new services which would be needed in countries which do not have an elaborate ground infrastructure for telecommunications and radio broadcasting.

Why set up new systems when conventional communication satellites already relay from one point to another telephone conversations or television images? The radiated power of communication satellites is low and spread over a wide area. To profit from it, it has to be picked up by large antennas — 10 to 30m in diameter — whose cost is high and which are difficult to install. The trend therefore is towards a system which will permit high-power transmissions enabling television signals to be received by simple and low-cost ground facilities which the public will be able to purchase. Direct broadcasting satellites will need to provide continuous transmission at powers up to 6kW.

This being the case, broadcasts can then be received in each home by using a parabolic antenna — of less than a metre — combined with a convertor supplying a signal compatible with a conventional television set.


esa

Ariane: Europe's launcher

The Member States of the European Space Research Organisation (ESRO), now called the European Space Agency, decided in July 1973 to develop a heavy launcher to give Europe an independent launching capability for its own communications and other satellites, and also to enable it to secure a share of the large launcher market forecast for the 1980s. Something like 200 geostationary satellites are expected to be launched during that period. Most will be for space applications and a high proportion of these for communications. The share of the market that could be covered by the European launcher is estimated at between 40 and 50 launchers.

The prime contractor for the development phase of the Ariane programme was the Centre National d'Etudes Spatiales (CNES). More than 50 firms in 10 European countries participate (Belgium, Denmark, France, Germany, Italy, Netherlands, Spain, Sweden, Switzerland and United Kingdom*).

The development of the launcher will be completed by four qualification test flights. Series production has already started, with the additional participation of Ireland, and the launcher will be available as from 1981 to meet the requirements of the Agency, its Member States and outside customers.

Performance

Ariane is a three-stage launcher designed for a wide variety of missions ranging from low-orbit missions to deep-space exploration. The launcher was more particularly designed for placing geostationary satellites in transfer orbit.

With Ariane, the following masses can be placed in orbit:

(a) 1700 kg into geostationary orbit (perigee 200 km and apogee 35900 km).
Launching a one tonne satellite into geostationary orbit at 35 900 km above the equator involves placing in transfer orbit a total weight of about 1700 kg. This includes an apogee boost motor which effects the final transfer to geostationary orbit. The geostationary orbit is used in particular for communications and meteorology satellites.

(b) 4800 kg into low Earth orbit (altitude: 200 km): scientific satellites.

(c) 2500 kg into a sun-synchronous circular Earth orbit: this quasi-polar type of orbit where the sub-satellite point is always at the same local time on Earth is used mainly for Earth observation missions.

(d) 400 kg into a hyperbolic trajectory: interplanetary missions.

Proved technology

The development of Ariane is based on technology already known and proved in Europe, notably in the highly successful French Diamant launcher programme. Ariane's first and second stages are equipped with the Société Européenne de Propulsion's Viking engine, which had already reached an advanced state of development when the new launcher was undertaken. Expertise in the cryogenic propulsion used for the third stage existed in France and Germany.

Test stands for qualification of the propulsion stages were constructed for ESA at Vernon in France and at Hardthausen in Germany. Similarly, launcher and stage integration facilities were built at Les Mureaux near Paris and at Bremen in Germany. In the launcher integration site at Les Mureaux, the Industrial Architect for Ariane, Aerospatiale, carries out the assembly and acceptance of the first and third stages and of the complete launch vehicle (the second stage is assembled in Germany).

First stage test on the stand at Vernon, France.

* The United Kingdom participates in the programme under a bilateral agreement with France.

The Ariane launcher (propellants mock-up) on its launch table in Kourou, French Guiana.

Aerial view of the Ariane Launch Site at Kourou, French Guiana.

Test programme

After a number of adjustments and a long series of tests, both of the full launcher and its propulsion systems, development of Ariane has reached the final stage with the beginning of the qualification phase for the engines and stages; four development and qualification test flights, one in November 1979 and the others in March, June and October 1980 will conclude the Ariane development phase.

At the start of 1979, the launcher was, for the first time, completely erected on its launch table in Kourou. This operation was carried out in the framework of the propellant mock-up tests which are designed to check all the launcher/launch site interfaces, the launch procedures and the training of the launch team. The programme, which aims to have the launcher operational by the end of 1980, is running very close to schedule.

The launching range

Ariane will be launched from ESA's launch facilities located in the Guiana Space Centre at Kourou, French Guiana.

The near-equatorial location of the range (5.23° North) is a highly favourable factor for the launching of all types of geostationary satellites. From the Kourou site, launches can be made in any azimuth from — 10.5° through North to + 93.5°.

The launching range also comprises facilities and equipment for use by Ariane customers in preparing their satellites.

The Ariane launch site consists of:

— The launch centre — a circular underground building from which launch vehicle and satellite operations are controlled.
— A launch area which includes the launch table, on which the launcher rests, the mobile servicing tower, which is fully air-conditioned and where Ariane is erected and connected to the ground equipment by means of the umbilical mast, and the storage and propellant transfer facilities.
— An assembly zone.
— Associated installations such as a liquid oxygen and nitrogen production plant and a propellant-analysis laboratory.

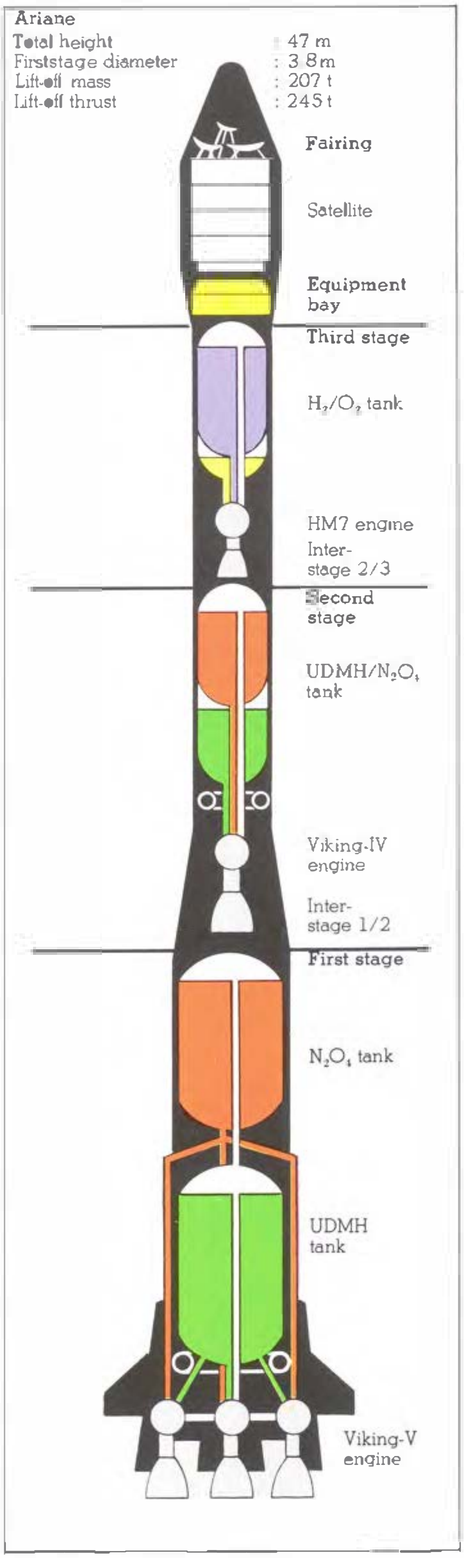
Operational use of the ELA involves the facilities and equipment of the Guiana Space Centre (CSG). The Agency contributes to the CSG operating and investment costs under an agreement concluded with the French Government in 1976.

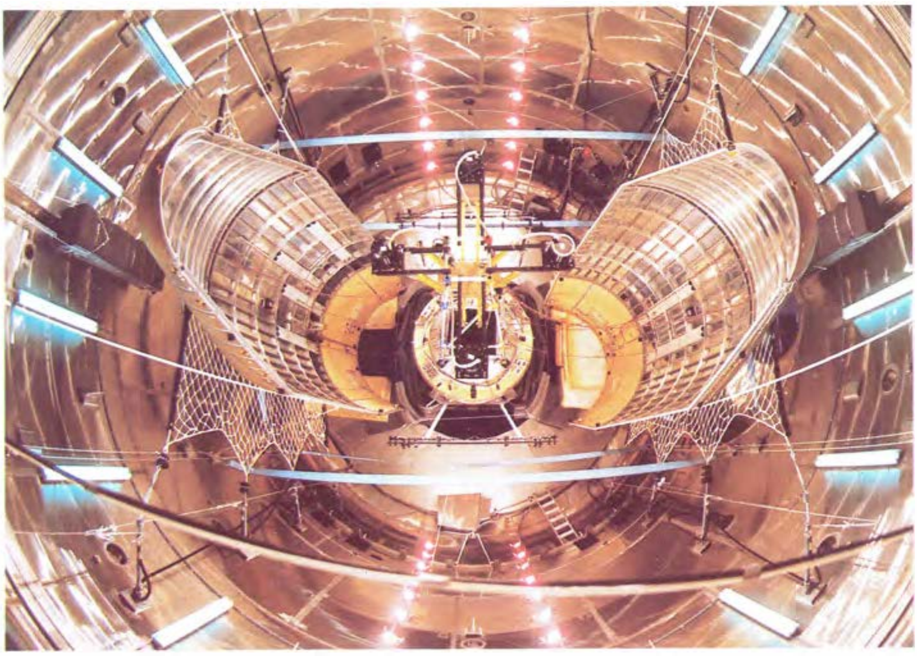
Apex programme

The Apex (Ariane passenger experiments) programme covers the launch of payloads, free-of-charge, on the last three development flights of Ariane (LO2, LO3 and LO4). Following an announcement of flight opportunities made to experimenters in 1975 for Ariane passenger capsule proposals, the following selection was made:

LO2 — March 1980.
Firewheel (scientific satellite developed by the Max Planck Institute (FRG): 1050 kg.
Oscar 9 (radio amateur satellite developed by the International Association of amateur radio operators — AMSAT): 75 kg.
LO3 — June 1980.
Meteosat-2 (ESA meteorology satellite): 700 kg.
Apple (Ariane Passenger Payload Experiment), experimental communications satellite developed by the Indian Space Research Organisation (ISRO): 630 kg.
LO4 — October 1980.
Marecs-A (European maritime communication satellite): 960 kg.

The Ariane Launch Centre at Kourou, French Guiana





Fairing opening tests at ESTEC, Noordwijk, Netherlands

Operational launches

For the operational phase, which begins in 1981, it was decided in 1978 to produce a first series of 6 launchers. This series is intended for the following programmes:

— EXOSAT (ESA scientific satellite),
— ECS 1 (European communications satellite),
— MARECS B (European maritime communications satellite launched along with Sirio 2-ESA meteorological and geodetic data distribution satellite),
— SPOT (Earth observation satellite France),
— Intelsat V (communications satellite — INTELSAT).

The lauching of this satellite was ordered from ESA by the INTELSAT Organisation which has also taken out an option for the lauching of a second satellite in the Intelsat-V series.

The last launcher will act as a backup.

The ESA communication satellites ECS 2, ECS 3 and ECS 4, to be operated by Interim EUTELSAT, will be launched by Ariane as well as the French communications satellites Telecom 1A and Telecom 1B. The production of a second series of 5 launchers will consequently be started at the end of 1979.

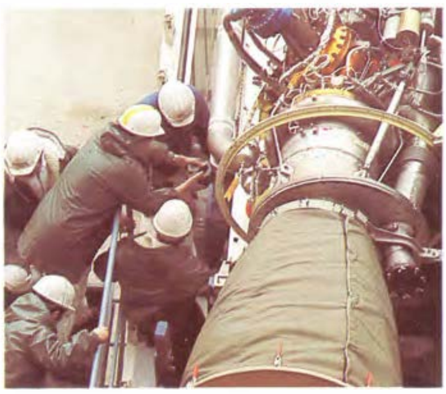
Other missions are planned for the years 1981-1983, both for European requirements and for developing national projects: a third Marecs satellite is to be launched in late '82 as well as a third Meteosat and several satellites to meet the requirements of 3 or 4 direct television broadcasting systems in Europe.

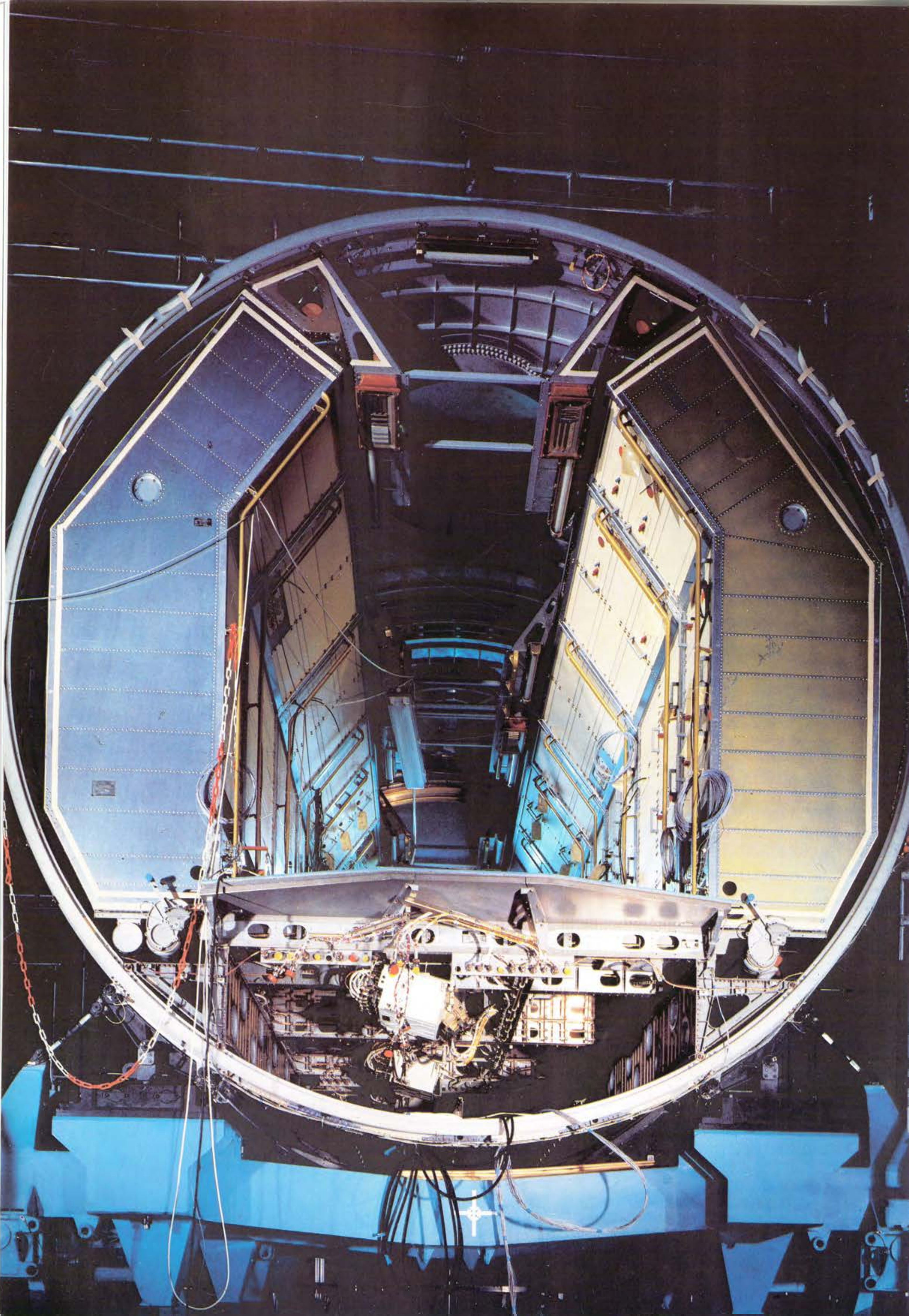
Uprating of the launcher

With a view to the world market for geostationary satellites and in order to turn to best account the dual launch capability made possible by the Sylda, the launcher's performance may be uprated so as to make it more competitive.

The payload mass in geostationary transfer orbit will first be increased from 1700 kg to about 2200 kg in late 1982 and then to 2300kg as from mid-1983.

One of the four Viking V first stage engines





Europe's manned space laboratory, Spacelab

The Spacelab is a manned space laboratory being developed by the European Space Agency in which, for the first time, scientists, engineers and technicians rather than astronauts — women as well as men — will be able to conduct experiments in Earth orbit. Unlike earlier space laboratories, Spacelab will be reusable. It consists of two main elements:

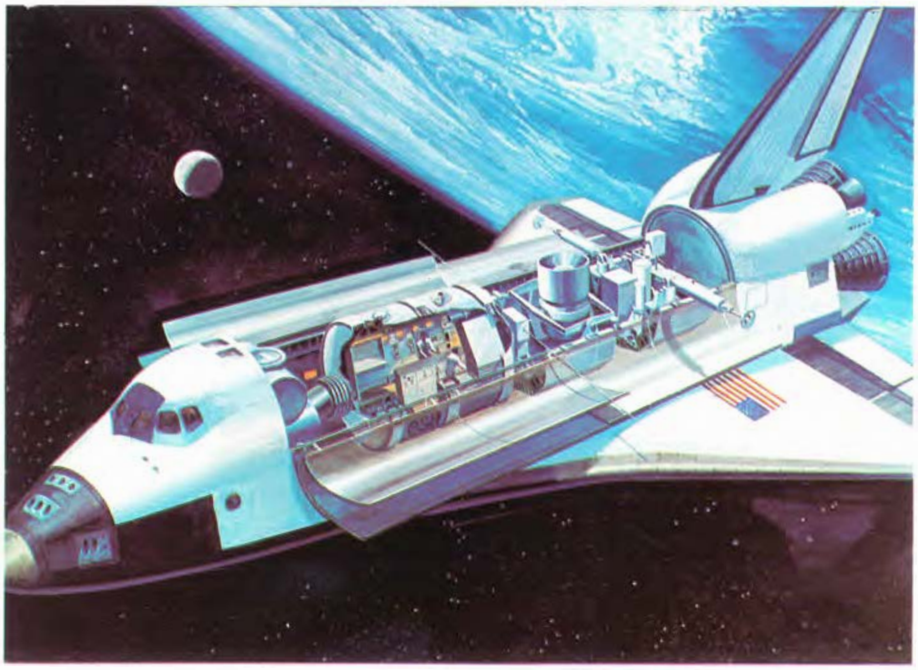
— a pressurised module
— an instrument pallet.

Spacelab will be carried to orbit by NASA's Space Transportation System and remain attached in orbit to the 4.5 m × 18 m cargo bay of the Space Shuttle's orbiter element. This resembles an aircraft and will, on completion of each mission, land back on Earth on a jet-sized airstrip.

A team of up to three people — called payload specialists — will be able to work in Spacelab for about a week. The members of this team will control, adjust and perhaps repair the experiments in orbit. They will sleep and eat in the orbiter, together with the four astronauts of the Shuttle crew. They will bring the data obtained back with them when they return to Earth. The first Spacelab mission is scheduled for 1981. On return to Earth, Spacelab will be removed from the orbiter and prepared for its next mission.

This is the most important international space project of ESA and NASA.

The Spacelab is being built for ESA by an industrial team of nearly 40 firms in 10 European countries, led by VFW-Fokker/ERNO. The Memorandum of Understanding, signed by ESA and NASA in August 1973, covers the delivery to NASA of one Spacelab engineering model and one flight unit. NASA has undertaken to buy additional Spacelabs from Europe, subject to certain conditions being met. Detailed design and development work began in June 1974. The engineering model is scheduled for delivery in mid-1980 and the first flight unit towards the end of the same year.



Spacelab transported by the NASA Space Shuttle

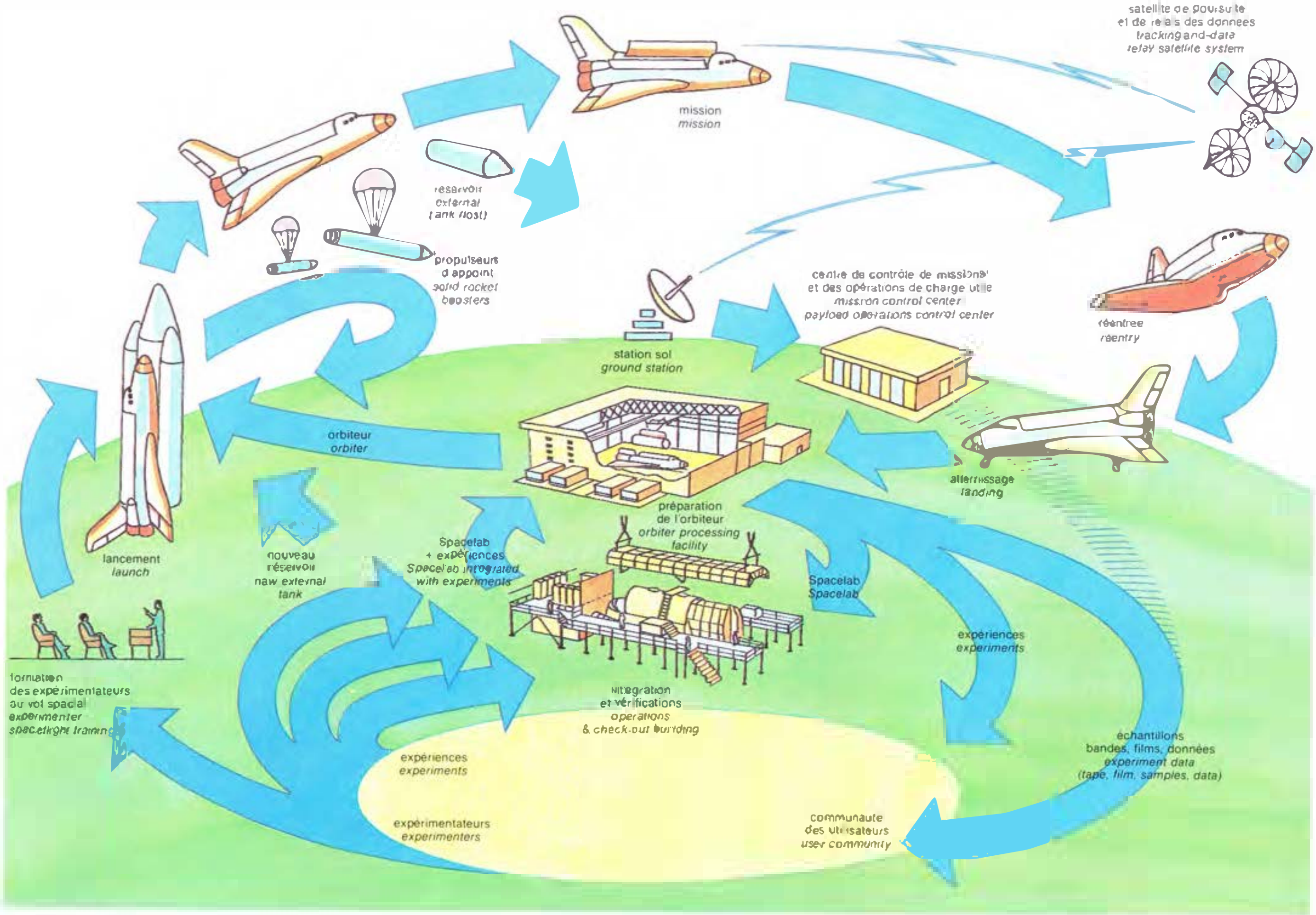
Mission flexibility

The Spacelab concept possesses flexibility in its application to a variety of missions. This very important characteristic arises from two sources. Firstly, the Space Shuttle flight parameters may be varied, so that the orbit inclination, orbit altitude (200 to 900 km) and resulting ground coverage may be selected for mission compatibility. Secondly, Spacelab mission flexibility results from the modular approach adopted in the design. The module-pallet configuration can be varied to meet the needs of each mission. Three basic configurations are found — module only, module plus pallet, and pallet only. Further flexibility is provided by the availability of the common payload support equipment.

Main uses

Spacelab will provide greatly increased opportunities in many fields of science, applications and technology. Its extremely stable and gravity-free environment will, for example, open up entirely new possibilities for separating biological materials in order to obtain pure preparations of cells for transplantation, for preparing concentrated antibodies for the treatment of certain diseases and for purifying vaccines. In conditions of weightlessness, ultra-pure metals, semi-conductors and glass can be processed, free of contact with containers, for research and applications in electronics, laser technology and optical products. New types of composite materials with improved strength at high temperatures may be processed in Spacelab, as well as perfect crystals for a variety of applications.

Engineering model of Spacelab



Profile of a Spacelab mission.

The following fields of research and applications in particular will benefit from using Spacelab:

- high-energy astrophysics;
- ultraviolet, optical infrared and X-ray stellar, planetary and solar astronomy;
- atmospheric, ionospheric (plasma), and magnetospheric physics;
- life sciences (including biology, biomedicine, behaviour);
- remote Earth-sensing (meteorology, land-use planning, resources, pollution control) etc;
- material sciences (e.g. crystal growth, pure metals and alloys, composite materials) and fluid physics;
- processing and manufacturing in space (e.g. electrophoresis, high-strength materials), communications and navigation;
- advanced technology.

Spacelab principle

At lift-off, the orbiter is secured to a metal tank much larger than itself, containing 2 000 000 litres of liquid hydrogen and oxygen for fuelling its three engines. Two solid-propellant boosters are strapped to the sides of this immense tank, and will function during the first two minutes of the flight, after which they will be recovered for reuse. As for the tank, once the propellants are exhausted, it will then be abandoned and will burn up on reentry into the atmosphere.

The crew of the Shuttle comprises a commander, a pilot and two mission specialists. The latter are responsible for managing the Shuttle's resources and the Spacelab support equipment. The Shuttle crew is housed in a split-level pressurised cabin in the nose of the orbiter: on the upper level, the cockpit; on the lower level the living accommodation, with galley, sleeping quarters and showers, which the orbiter crew shares with the payload specialists.

In the course of the complete mission operations are carried out on the ground and in flight.

The ground operations are the activities directly linked to the integration of Spacelab and the experimental equipment before the mission, and to preparations for future missions. Some of these operations — relating to European experiments — take place in Europe and are conducted by a management team known as SPICE (Spacelab Payload Integration and Coordination in Europe) located at Porz-Wahn in Germany. The remainder take place in the United States, at NASA's Kennedy Space Center, the launch base for the Space Shuttle. Each mission is controlled from two ground centres, one concerned with the Shuttle flight and the other with the operation of the payload.

The flight operations include the activities, on board or on the ground, linked to the execution of the orbital mission proper. When the chosen orbit is reached, the doors of the orbiter cargo bay open and the Spacelab systems are switched on.

The payload specialists, with the support of the Shuttle crew and the participation of the experimenters on the ground, check the Spacelab out and activate the experiments.

From this point on, data are collected and stored 24 hours a day until the Spacelab systems have been switched off and the journey back to Earth begins. The average mission lasts about seven days, but it is hoped to extend this up to a month, depending mainly on the improvement of Spacelab's energy resources.

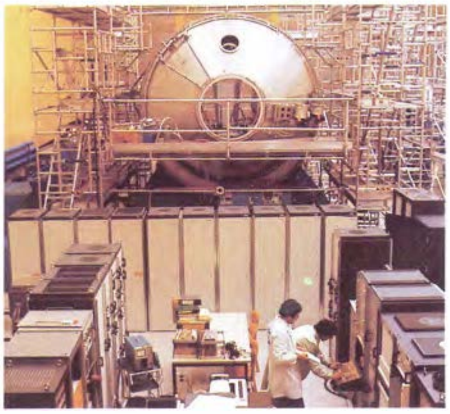
The first Spacelab mission

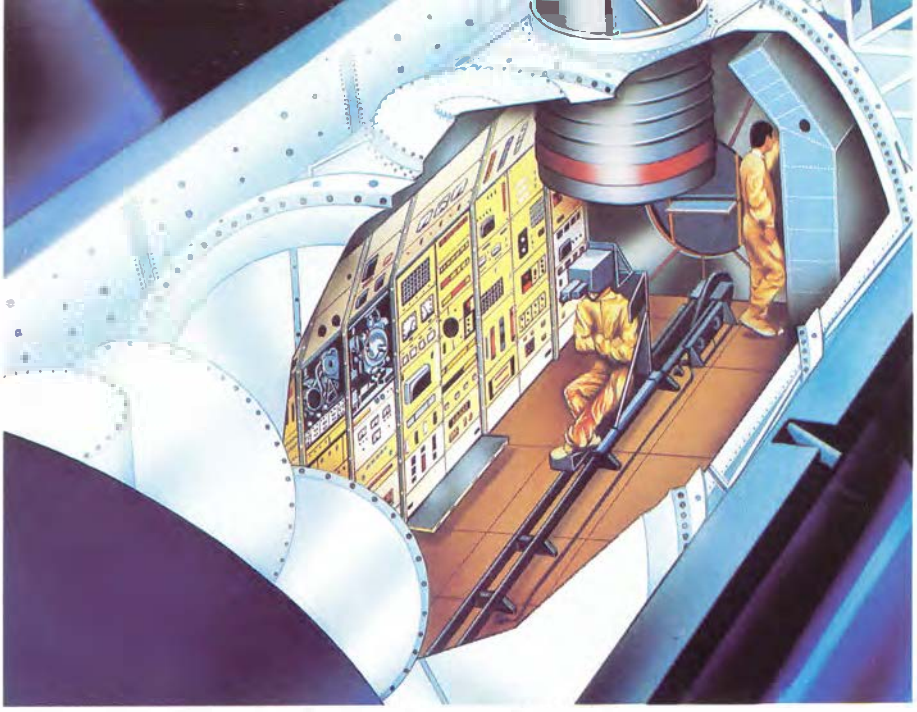
The first mission is scheduled for 1981. Its essential objective is to check the performance and the flight conditions of the Shuttle/Spacelab composite. In addition, on this mission, scientific experiments will be carried out with the aim of demonstrating the extensive possibilities offered by Spacelab for space exploration. Research into the stratosphere and the upper atmosphere will play a predominant part in this flight. Many other fields, however, will be studied: materials processing, plasma physics, biology, botany, medicine, astronomy and solar physics, as well as technological subjects such as thermodynamics and lubrication.

This first mission will last a week. The Spacelab will consist of a long pressurised module and a short instrument pallet.

ESA and NASA have jointly drawn up the plan for this first mission and will share the weight, energy and crew time allotted to the experiments on Spacelab. A total of 76 scientific and technological experiments — 60 European, 15 American and 1 Japanese — will be carried out on this occasion.

Assembly of the pressurised module (long module) at Bremen, Germany





Inside the pressurised module. In the centre, the vestibular Sled

Through these 76 experiments, 219 experimenters in 16 countries including 12 European ones (Austria, Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Sweden, Spain, Switzerland, United Kingdom) are participating in the mission.

Two payload specialists — a European and an American — will take part in this first mission. They will be chosen only a few months before the launch from among five specialists — three European and two Americans — whom ESA and NASA respectively nominated in mid-1978.

The three European specialists selected by ESA — out of more than 2000 candidates, all nationals of ESA Member States — are:

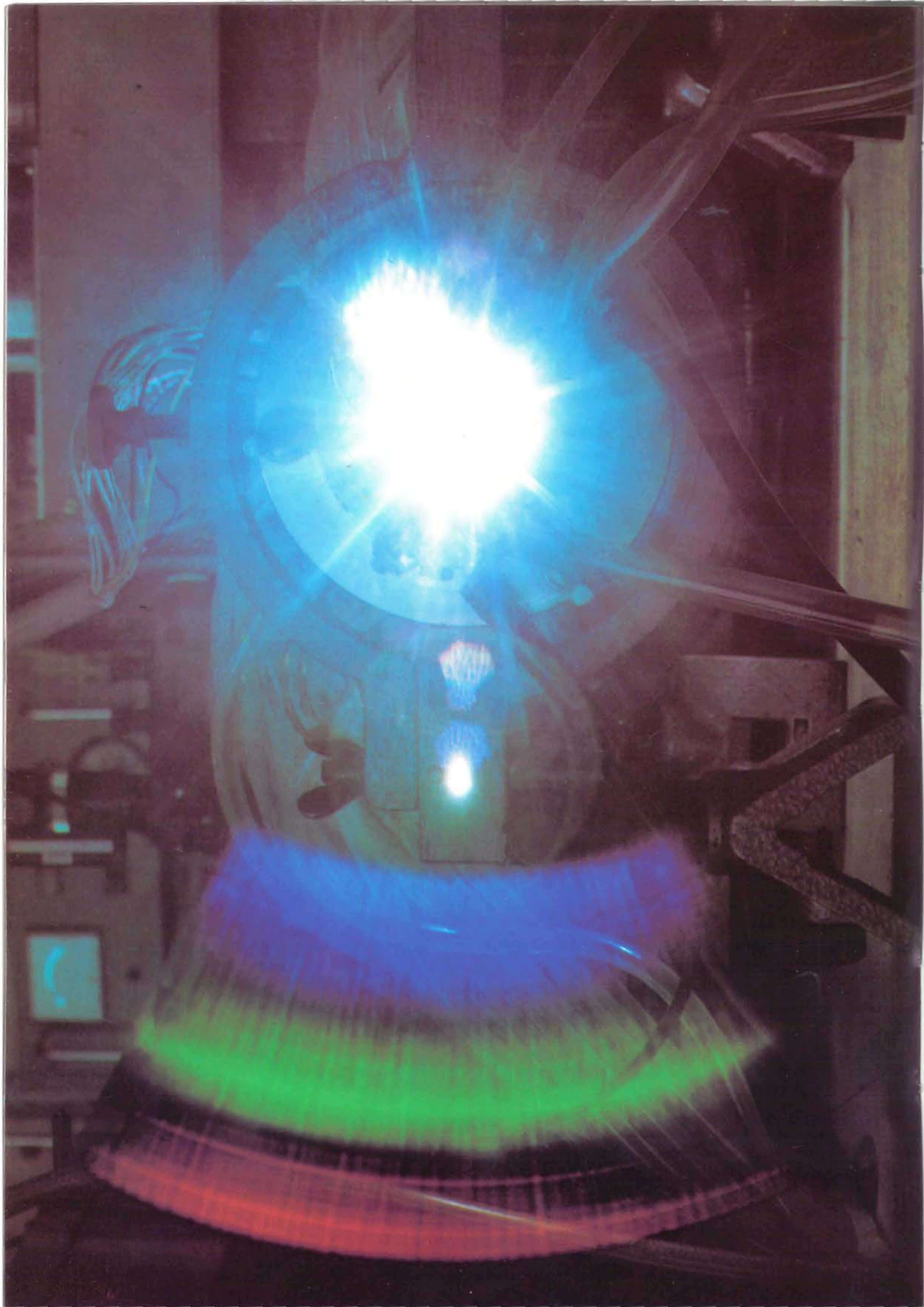
- Ulf MERBOLD, born at Greiz, Germany, in 1941 — physicist,
- Claude NICOLLIER, born at Vevey, Switzerland, in 1944 — astronomer and airline pilot,
- Wubbo OCKELS, born at Almelo, Netherlands, in 1946 - physicist.

The two specialists selected by NASA are:

- Michael L. LAMPTON, born at Williamsport (United States) in 1941, physicist
- Byron K. LICHTENBERG, born at Straudsburg (United States) in 1948, researcher.

Spacelab is not just another space project. It marks by its re-usability a completely new minimum-cost concept of space exploration and exploitation. It also opens a new era of international cooperation in this field.

From left to right, Claude Nicollier (Switzerland), Ulf Merbold (Germany) and Wubbo Ockels (Netherlands). One of them will be the first West European to travel and work in a terrestrial orbit.



The programmes of tomorrow

Space science

In 1971 the annual budget of the Agency's scientific programme was fixed at an amount that corresponds, in 1978 values, to approximately 78MAU. This is very little. It is much less than the effort devoted to space research in either the United States or the Soviet Union. It is equivalent to approximately one-third of the programme of the European Nuclear Research Centre (CERN) and is, in fact, only comparable to the amount allocated to space research in Japan. These points are made by the Agency's Science Advisory Committee in a report on the future of space science over the next decade. The Committee points out that Europe has nonetheless become the third space entity in the world, thanks largely to the great fertility of the ideas stemming from European scientists.

All the space missions envisaged over the next few years will make use either of automatic satellites launched by Ariane or of Spacelab, the latter being capable of functioning both as a space laboratory and an observation platform.

Several missions are being studied concurrently, and two of them will be chosen by the Agency's Science Programme Committee as new programmes. The first choice will be made at the beginning of 1980 and the second at the beginning of 1981.

The 1980 selection will be made from among the following projects:

- A study of the tail of the terrestrial magnetosphere, using a satellite of the GEOS series (GEOS 3 mission).
- A space astrometry mission (Hipparcos) whose purpose is to measure with a very high degree of accuracy the position of the stars and their speed of movement, in order to produce as complete a map of the sky as possible.
- A study, in the extreme ultraviolet and soft X-ray bands, of the very hot stars, which, for the most part, are still unobserved (EXUV Mission).
- A project that might be carried out in cooperation with NASA (Cometary Mission) under which measurements of the cometary environment would be made, a European-built spacecraft doing a fly-by of Halley's comet and a NASA satellite rendezvousing with the Tempel 2 comet, which is due to enter our solar system in 1988.

A large number of new proposals have been put forward for the new programme that is to be chosen in 1981. They cover the fields of astronomical and astrophysical research, study of the terrestrial environment, and the exploration of deep space.

With the entry into service of Spacelab, the range of space science disciplines will greatly expand. By using the pallet it will be possible to embark a batch of small experiments devoted to exploration of the sky, the atmosphere and space plasmas. Fluid physics, chemistry, metallurgy and monocrystals are disciplines already well represented in the first Spacelab payload, but there is no doubt that in the years to come the experiments will increase in number and diversity.

Most of the other experiments aboard Spacelab will use man as the test subject in order to study physiological modifications attributable to microgravity. The experiments will, however, also extend to the study of the behaviour of plants in the various stages of their development, the culture of cells, bacteria and protozoa in a special multipurpose facility, known as the Biorack, which will provide controlled ambience and observation conditions and permit the experiments to be extended at a later stage to fishes, reptiles and small mammals.

Is gravity a constraint to which life has had to adapt itself, or is it an essential factor without which the ability to survive diminishes? The question is one that remains completely open and it may be that the experiments carried out on Spacelab will provide an answer.

The Villafranca station. Observation of the sky from the IUE satellite.

Earth observation

Meteosat-1 is the first European satellite to gather data on the terrestrial atmosphere for the purposes of meteorological forecasting. Integrated in the Global Atmospheric Research Programme (GARP) since 1978, it constitutes Europe's contribution to the operational programme known as the World Weather Watch. Permanent monitoring of meteorological phenomena will be kept up, thanks to the Meteosat-2 satellite and to a series of satellites of the same type which may subsequently be made available to the potential users during the next decade.

The Agency and its advisory committee, the Earth Observation Research Group, attach fundamental importance to the Earth Observation discipline. They have worked out the elements of a future programme, which will complement the one already under way in the conventional sectors of space science. Encompassing the wide range of research fields linked with Earth Observation, this programme will have to cover such varied subjects as oceanography, geodynamics, seismology and geodesy.

Two climatology satellites — Seocs and Biramis — which operate according to different procedures, will enable the Earth's radiation balance to be precisely measured. Other objectives will be pursued. How, for instance, can one describe the climatic systems unless one has a sound knowledge of the interactions of the atmosphere, the hydrosphere, the cryosphere and the biosphere? Similarly, how can one forecast the behaviour of the Earth other than by conducting intensive studies on the physics of the globe? Space techniques will provide efficient and inexpensive means of research for better grappling with the problems involved in understanding the terrestrial environment.

In the field of remote sensing, the objectives of the European remote sensing programme include the following:

European regional observation:
— preparation, and updating, of an inventory of resources — arable and pasturable land, forest areas, hydrological and coastal resources;
— development of the forecasting of plant production, crops and hydrological resources;
— monitoring of the environment with special reference to thermal and chemical pollution of waters and of the atmosphere in built-up areas, and to coastal oil slicks;
— assistance to fisheries: the extension of territorial waters to 200 miles calls for systematic observation of more extensive zones in order to guide fishery operations towards the productive areas.

Assistance to developing countries:
The developing countries need the same remote-sensing information as Europe, plus assistance in map-making and the search for underground resources. Particular importance is attached by these countries to the continuous monitoring of agricultural resources, and of the sea, with a view to regulating food production.

Global monitoring programmes:
Global missions likely to interest Europe are the monitoring of oceans, the atmosphere and certain critical resources. The preparatory remote sensing programme currently under way should lead, in 1980, to the start-up of a programme of European satellites. These satellites will be devoted to both terrestrial applications and the monitoring of coastal and oceanic zones. The first two European remote sensing satellites, ERS-1 and ERS-2, will be launched around the middle of 1980.

Telecommunications

The development of communication satellites for intercontinental links (Intelsat) is open to international competition, and European firms are taking an increasingly large share of the sub-contracting in this sector. Still to be covered is the rapidly expanding market represented by the supply of individual systems to Third World countries, and Europe can hope to secure a major share of this despite the predominance of American industry.

In the light of this situation Europe's general objectives in the field of satellite communications can be summarised as follows:

— meet European domestic requirements with high-performance systems supplied by European industry;

— enable European industry to supply a satisfactory share of the systems intended for international organisations such as Intelsat and of the domestic systems intended for Third World countries.

Obviously, if European industry is to have a convincing image in the world markets it will have to prove in concrete terms that it is capable of meeting Europe's own requirements. The switch from the present programmes, which are of an experimental nature, to operational systems, and the availability of the Ariane launcher from 1981 onwards, will clearly be key elements in the attainment of Europe's objectives in the field of satellite telecommunications. Another conditioning factor will be the enhanced competitivity at industrial level which stems from the studies conducted by the Agency in the field of advanced telecommunications techniques and the development of new space applications.

Spacelab

In its mission model for the 1980s, NASA envisages some 400 flights by the Space Shuttle, 40% of which — representing about 150 flights — will be devoted to Spacelab missions.

A balance must clearly be maintained between optimum use of Spacelab, once it has become operational, and the activities devoted to its follow-on development. To this end it is necessary that thought be given, without delay, to making improvements to Spacelab that will be a natural extension of the development effort and will reinforce the possibilities of the Spacelab-Shuttle system.

It is with this in mind that ESA has prepared a programme, known as the Spacelab Utilisation Programme, under which European users will have access to the Spacelab-Shuttle system under attractive conditions of frequency and cost.

It is planned to augment the onboard power supply, extend the duration of missions, and provide for the funding, constitution and management of a common pool of equipment for the materials processing and other activities to be performed aboard Spacelab. Likewise, ESA will have to provide certain elements of Spacelab hardware to meet specifically European requirements. Future Spacelab operations in Europe need to be prepared and coordinated, and the necessary infrastructure must be set up.

These developments will enable Europe to remain associated with the American manned space programme and its long-term objectives. The future of that programme lies in the creation of the manned space stations that could follow on from the Spacelab-Shuttle system.

Space Technology

ESA's space technology programme aims at making available in good time the technologies on which the future space programmes will depend. It also seeks to ensure that resources are so organised that Europe is capable — both from an industrial viewpoint and as regards its entities and national institutions — of playing an active role in the space competition and ensuring that the ESA Member States receive a fair return on their financial contributions.

Analysis of the requirements of likely future ESA missions indicates the need for new technologies in such fields as onboard image data processing, high capacity data storage, very high accuracy attitude stabilisation, and thermal control at very low temperatures. Sensor technology for earth observation activities also needs considerable development, which could be based on the use of Spacelab as a veritable test bed.

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