esa bulletin

number 51 august 1987

european space agency

The European Space Agency was formed out of, and took over the rights and obligations of, the two earlier European Space Organisations: the European Space Research Organisation (ESRO) and the European Organisation for the Development and Construction of Space Vehicle Launchers (ELDO). The Member States are Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom. Finland is an Associate Member of the Agency. Canada is a Cooperating State.

In the words of the Convention: The purpose of the Agency shall be to provide for and to promote, for exclusively peaceful purposes, co-operation 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.

(a) by elaborating and implementing a long-term European space policy, by recommending space objectives to the Member States, and by concerting the policies of the Member States with respect to other national and international organisations and institutions;
(b) by elaborating and implementing activities and programmes in the space field;
(c) by co-ordinating the European space programme and national programmes, and by integrating the latter progressively and as completely as possible into the European space programme, in particular as regards the development of applications satellites;
(d) by elaborating and implementing the industrial policy appropriate to its programme and by recommending a coherent industrial policy to the Member States.

The Agency is directed by a Council composed of representatives of Member States. The Director General is the chief executive of the Agency and its legal representative.

The Directorate of the Agency consists of the Director General; the Inspector General; the Director of Scientific Programmes; the Director of the Earth Observation and Microgravity Programme; the Director of the Telecommunications Programme; the Director of Space Transportation Systems; the Director of the Space Station and Platforms Programme; the Director of ESTEC; the Director of Operations and the Director of Administration.

The ESA HEADQUARTERS are in Paris.

The major establishments of ESA are:

THE EUROPEAN SPACE RESEARCH AND TECHNOLOGY CENTRE (ESTEC), Noordwijk, Netherlands.

THE EUROPEAN SPACE OPERATIONS CENTRE (ESOC), Darmstadt, Germany

ESRIN, Frascati, Italy.

Chairman of the Council: Mr H. Grage.

Director General: Prof. R. Lüst.

agence spatiale européenne

L'Agence Spatiale Européenne est issue des deux Organisations spatiales européennes qui l'ont précédée — l'Organisation européenne de recherches spatiales (CERS) et l'Organisation européenne pour la mise au point et la construction de lanceurs d'engins spatiaux (CECLES) — dont elle a repris les droits et obligations. Les Etats membres en sont: l'Allemagne, l'Autriche, la Belgique, le Danemark, l'Espagne, la France, l'Irlande, l'Italie, la Norvège, les Pays-Bas, le Royaume-Uni, la Suède et la Suisse. Finlande est membre associé de l'Agence. Le Canada beneficie d'un statut d'Etat coopérant.

Selon les termes de la Convention: L'Agence a pour mission d'assurer et de développer, à des fins exclusivement pacifiques, la coopération entre Etats européens dans les domaines de la recherche et de la technologie spatiales et de leurs applications spatiales, en vue de leur utilisation à des fins scientifiques et pour des systèmes spatiaux opérationnels d'applications:

(a) en élaborant et en mettant en oeuvre une politique spatiale européenne à long terme, en recommandant aux Etats membres des objectifs en matière spatiale et en concertant les politiques des Etats membres à l'égard d'autres organisations et institutions nationales et internationales;
(b) en élaborant et en mettant en oeuvre des activités et des programmes dans le domaine spatial;
(c) en coordonnant le programme spatial européen et les programmes nationaux, et en intégrant ces derniers progressivement et aussi complètement que possible dans le programme spatial européen, notamment en ce qui concerne le développement de satellite d'applications.
(d) en élaborant et en mettant en oeuvre la politique industrielle appropriée à son programme et en recommandant aux Etats membres une politique industrielle cohérente.

L'Agence est dirigée par un Conseil, composé de représentants des Etats membres. Le Directeur général est le fonctionnaire exécutif supérieur de l'Agence et la représente dans tous ses actes.

Le Directoire de l'Agence est composé du Directeur général; de l'Inspecteur général; du Directeur des Programmes scientifiques; du Directeur des Programmes d'Observation de la Terre et de Microgravité; du Directeur du Programme de Télécommunications; du Directeur des Systèmes de Transport spatial; du Directeur du Programme Station spatiale et Plates-formes; du Directeur de l'ESTEC, du Directeur des Opérations et du Directeur de l'Administration.

Le SIEGE de l'ESA est à Paris.

Les principaux Etablissements de l'ESA sont:

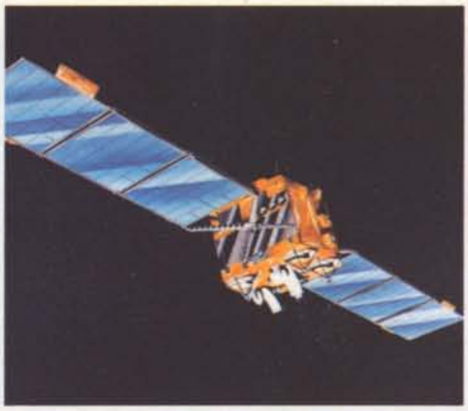
LE CENTRE EUROPEEN DE RECHERCHE ET DE TECHNOLOGIE SPATIALES (ESTEC), Noordwijk, Pays-Bas.

LE CENTRE EUROPEEN D'OPERATIONS SPATIALES (ESOC), Darmstadt, Allemagne.

ESRIN, Frascati, Italie

Président du Conseil: M H. Grage.

Directeur général: Prof. R. Lüst.



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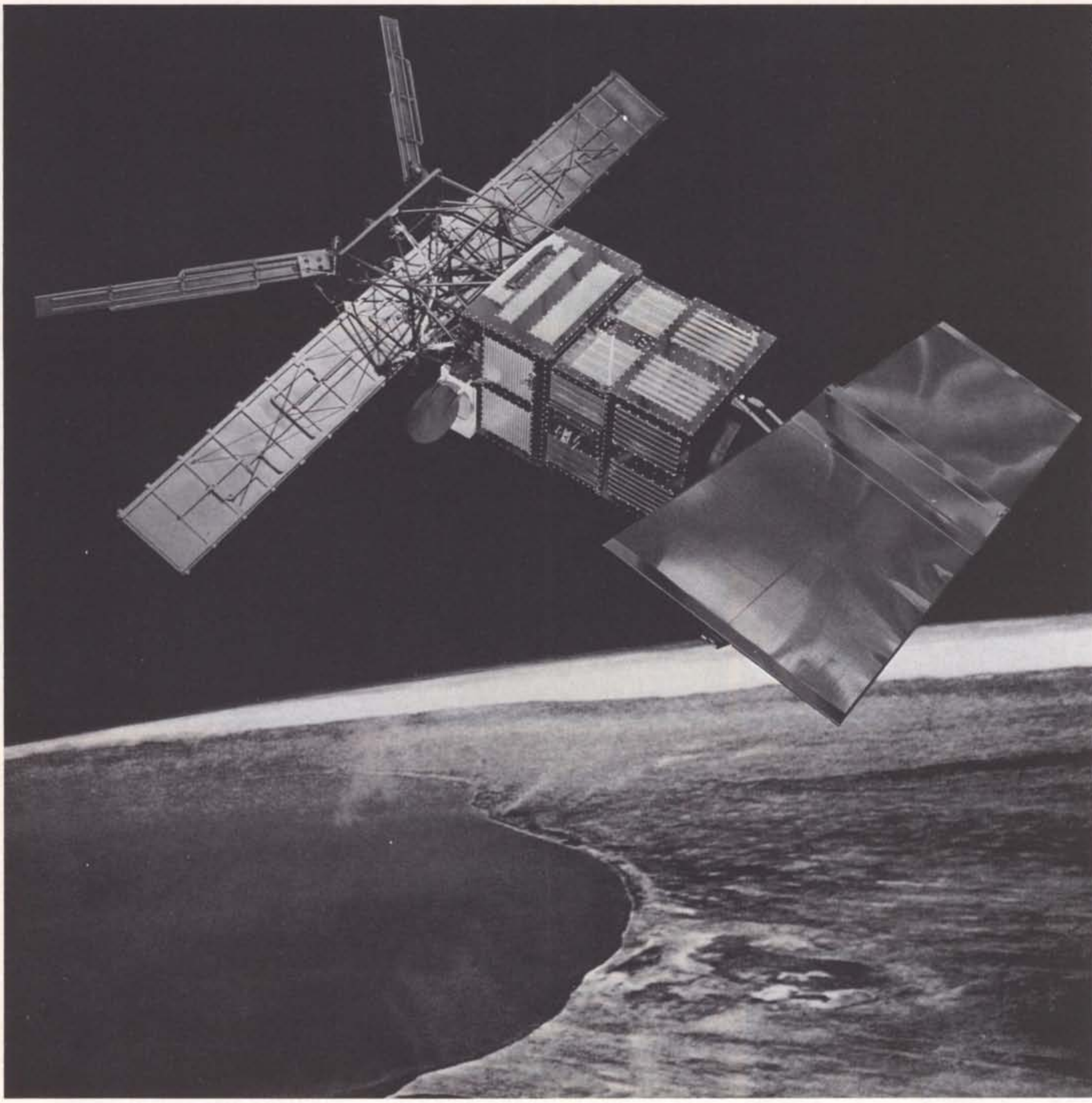

15,000 years of communication

One of the first examples of communication by man still survives and, although the pictures above are 15,000 years apart, they illustrate man's genius and quest for knowledge.

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Tel: (0705) 664966.
Fax: (0705) 690455.
Telex: 86666 MARSAT G.

Above left
Bison painting in a cave at Altamira, Spain.
Above right
Part of the earth from 36,000 km taken by ESA's Meteosat weather satellite. Photograph courtesy of the National Remote Sensing Centre, Farnborough, England.

ASTROPHYSICS – EUROPEAN SPACE AGENCY

VACANT SCIENTIFIC POSITIONS

STAFF SCIENTISTS – ASTROPHYSICS, ESTEC
ESA/VN/ESTEC(85)52 – Reference 58/85
ESA/VN/ESTEC(87)135 – Reference 150/87

Scientists with PhD or equivalent in physics or astronomy with experience in infrared detector technology and cryogenics. The scientists would be engaged in support of the *Infrared Space Observatory (ISO)* mission initially on the development and calibration of the focal plane instruments and later on preparations for and conduct of scientific operations in orbit. The scientists will be expected to undertake research in infra-red or sub-millimetre astronomy including instrument development and observational work.

STAFF SCIENTIST – ASTROPHYSICS, ESTEC
ESA/VN/ESTEC(86)25 – Reference 51/86

Scientist with PhD or equivalent in physics or astronomy with experience in sub-millimetre wave heterodyne systems. The scientist would be engaged in the definition of the sub-millimetre heterodyne spectroscopy 'cornerstone' mission *(FIRST)* and would carry out research in sub-mm heterodyne astronomy, with emphasis on instrument development and observational work.

STAFF SCIENTIST – ASTROPHYSICS, ESTEC
ESA/VN/ESTEC(87)136 – Reference 151/87

Scientist with MSc or PhD in physics, astronomy or electronics to work on the research and development and exploitation of photon counting detectors initially for ground-based astronomy but intended for space-based applications.

STAFF SCIENTISTS – STScI, Baltimore
ESA/VN/ESTEC(86)94 – Reference 115/86

Experienced astronomers with PhD or equivalent in physics or astronomy with substantial research experience. The scientists will be engaged in support of the in-orbit calibration of the Space Telescope scientific instruments and would be expected to carry out an active research programme.

STAFF SCIENTIFIC SYSTEMS ANALYST – STScI, Baltimore
ESA/VN/ESTEC(87)71 – Reference 103/87

The scientific systems analyst will be engaged in support of Space Telescope scientific operations, data processing and analysis. An MSc or PhD in physics, astronomy or computer science with experience in image processing and treatment of large data sets is required.

Send applications and curriculum vitae to Head of Personnel, ESTEC, Keplerlaan 1, 2201 AZ Noordwijk, The Netherlands. Further information may be obtained from Brian Taylor, tel. 1719-83556

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nucleus with high precision. NASA, in turn, pinpointed the positions of the Vega spacecraft, allowing the overall uncertainty to be reduced by a factor of ten (small circle around the Halley path). Giotto could then be targetted with much greater accuracy

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Scientists with PhD or equivalent
cryogenics. The scientists would be
the development and calibration of t
operations in orbit. The scientists w
including instrument development a

Inter-Agency Coordination of Solar-Terrestrial Science Projects

R. Reinhard, ESA Space Science Department, ESTEC, Noordwijk, The Netherlands*

At its sixth meeting in Padua, Italy, on 4 November 1986, the Inter-Agency Consultative Group for Space Science (IACG) decided to adopt Solar-Terrestrial Science as its next project for inter-agency coordination.
The IACG was formed in 1981 and until 1986 coordinated the six space missions to Halley's Comet undertaken by its four member agencies: Intercosmos, ISAS, NASA and ESA. During its first five years, the IACG demonstrated an ever-growing usefulness for the various Halley flight projects, as a focal point for the exchange of information, discussion of common problems, and mutual support to enhance the overall scientific return.

Introduction

Four space agencies — the Intercosmos of the USSR Academy of Sciences, the Japanese Institute of Space and Astronautical Science (ISAS), the National Aeronautics and Space Administration (NASA) and ESA — sent spacecraft to Halley's Comet and were involved with Halley observations from space during the comet's 1985/86 apparition. Intercosmos sent Vega-1 and Vega-2; ISAS sent Sakigake and Suisei; ESA sent Giotto; and NASA sent ICE and was able to mount a significant space-based observation programme using existing spacecraft and sounding rockets.

The spacecraft that encountered Halley complemented each other in flyby distance, which ranged from 600 km to 25 million km, all spacecraft passing on the sunward side (Fig. 1). The ICE spacecraft had earlier explored the anti-sunward side of Comet Giacobini-Zinner.

The flybys occurred between 6 and 14 March 1986, covering more than three comet nucleus rotations and the corresponding variations in activity. The scientific experiments on the various spacecraft together provided the full complement of experiments that can be flown on flyby spacecraft. Some

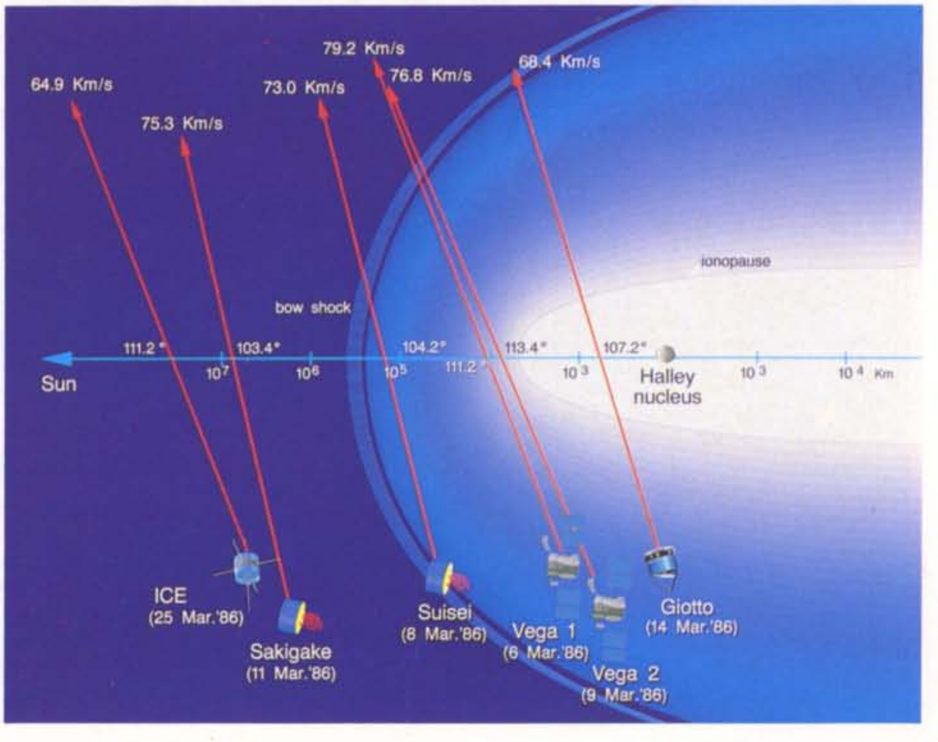
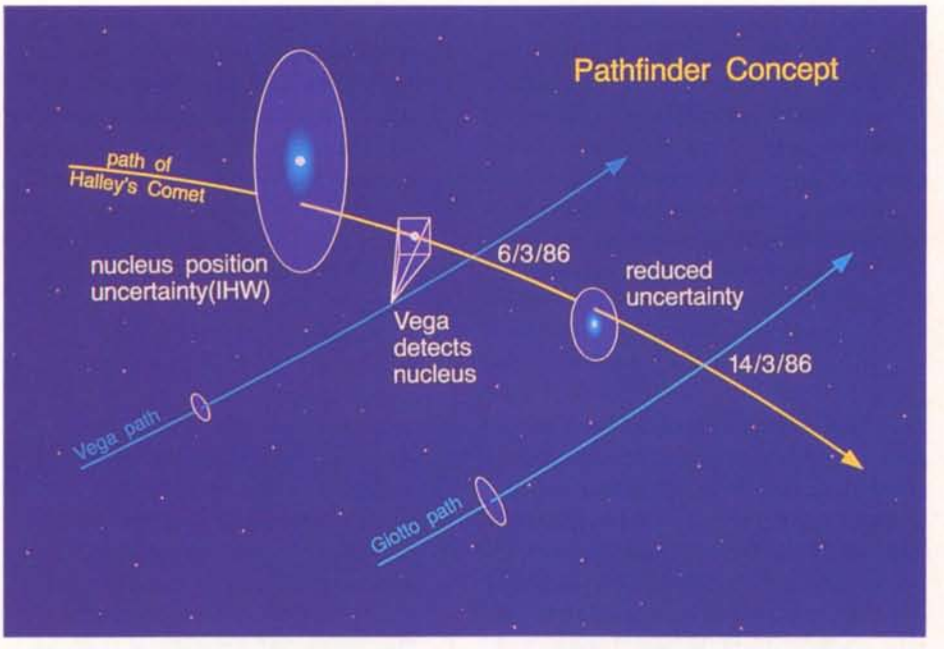


Figure 1 — The six spacecraft flying through the coma of Halley's Comet at different times and at different distances from the nucleus

* IACG Executive Secretary

Figure 2 — Principle of the 'Pathfinder Concept'. Based on astrometric observations from the ground, the position of the nucleus could only be determined with an uncertainty of 500 km (large circle around the actual path of Halley's Comet). The cameras on the Vega spacecraft, however, located the nucleus with high precision. NASA, in turn, pinpointed the positions of the Vega spacecraft, allowing the overall uncertainty to be reduced by a factor of ten (small circle around the Halley path). Giotto could then be targetted with much greater accuracy



experiments on the various spacecraft were also very similar, which provided a stimulating basis for data comparison after the encounters.

Realising that many aspects of mission planning, spacecraft and experiment design, and data evaluation were common to all missions, and that the overall scientific return could be increased through cooperation, the four agencies agreed in 1981 to form the Inter-Agency Consultative Group for Space Science (IACG). The IACG had the task of informally coordinating all matters related to the space missions to Halley's Comet and the observations of the comet from space.

At the IACG's first meeting, three Working Groups were formed in which many of the problems common to all of the space missions to Halley's Comet were discussed, resulting in recommendations to the flight projects or actions on the Working-Group members to carry out specific tasks. The three Working Groups formed were:

- the Halley Environment Working Group (WG-1)
- the Plasma-Science Working Group (WG-2)
- the Spacecraft Navigation and Mission Optimisation Working Group (WG-3)

The in-situ observations by the various experiments onboard the six flyby spacecraft were complemented by a number of remote observations from space and a very large number of observations from the ground, the latter being coordinated through the International Halley Watch (IHW). The remote observations from space were particularly useful when Halley was in solar conjunction (near its perihelion passage) and difficult or impossible to observe from the ground. The ground-based observations began with the comet's recovery in October 1982 and are expected to continue until about 1990, covering the whole apparition. The IHW, although not a space agency, has participated in all IACG meetings, just as the space agencies have been represented at all general meetings of the IHW. The communication and coordination achieved through this 'cross-representation' has turned out to be highly effective.

Since its formation in 1981, the IACG has demonstrated an ever-growing usefulness for the various flight projects, as indicated by the following list of achievements (described in more detail in ESA Bulletin No. 46, pp. 81—94):

- exchange of information on spacecraft (in particular the dust bumper shield) and experiment design
- intercalibration of experiment sensors
- implementation of the 'Pathfinder Concept' (Fig. 2)
- development and distribution of Halley gas and dust models, prediction of dust jets, determination of parameters for the nucleus
- exchange of results from models on spacecraft charging due to the dust and gas impacts on the spacecraft during the flybys
- exchange of Halley spacecraft orbital data
- exchange of information on spacecraft and experiment performance and mission planning, and in particular on experiment operation times
- use of common coordinate systems
- definition of special periods for cruise science
- near-real-time exchange of scientific data, i.e. within days of the encounters
- agreement to exchange all encounter science data within two years after the encounter
- joint publication of 'first results' just two months after the encounters (Nature, Vol.321)
- organisation of Topical Workshops and a major Halley Symposium (Heidelberg, Germany, October 1986)*
- exchange of information on post-Halley targets for the flyby spacecraft.

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*Proceedings available as ESA Special Publication SP-250 (3 volumes, 1600 pages), from ESA Publications Division.

The IACG and its counterpart on the ground, the IHW, have formed the cornerstones of a global effort to explore Halley's Comet as completely as possible during its present apparition. By the end of the 1980s, when Halley will disappear again into the outer solar system, it will be the most thoroughly studied comet ever, with more data having been collected on it than on all other comets put together.

Selection of the new IACG project

All delegations recognised the advantages stemming from the close cooperation and efficient exchange of information that the IACG organisation provided for the Comet-Halley activities and the impetus created through the work already accomplished. They therefore expressed a desire to continue working in the IACG framework beyond 1986. During an interim meeting in March 1986, three areas were identified for possible future coordination within the IACG:

- Solar-Terrestrial Science
- Planetary and Primitive Bodies
- Radio-astronomy.

Ad hoc Working Groups were formed to discuss and summarise the situation in the member agencies in these three disciplines, for consideration as the next project of the IACG.

At its meeting in Padua, Italy, in November 1986, the IACG adopted 'Solar-Terrestrial Science' as its next project, for the following reasons:

- Solar-terrestrial science is of interest and importance to all nations and all space agencies, since it is relevant both to basic space-physics processes and to the habitability of the Earth.
- Many remote measurements of the Sun and of the Earth's atmosphere require space techniques and in-situ sampling of the solar wind, magnetospheric fields and particles, and these measurements can only be carried out with space sensors.
- Each member agency of the IACG has one or more solar-terrestrial science missions approved or near approval for launch and operation in the 1989—1996 time frame, many of these missions being bilateral arrangements between IACG members.
- The scientific output of these missions will be significantly enhanced through the coordinated operations provided by the IACG and through the data sharing and the joint data analysis by the science communities associated with the IACG members.

'Radio-astronomy' is not yet at the level of approval, but could become an adopted IACG discipline area in a few years' time, while 'Planetary and Primitive Bodies' may become an IACG project further into the future.

Past and future IACG meetings

Date	Place	Host
1981, 13—15 September	Padua, Italy	ESA
1982, 21—22 November	Dobogokö, Hungary	Intercosmos
1983, 18—19 December	Kagoshima, Japan	ISAS
1984, 13—16 November	Tallinn, USSR	Intercosmos
1985, 10—12 September	Washington DC, USA	NASA
1986, 4 November	Padua, Italy	ESA
1987, 20—23 October	Kyoto, Japan	ISAS

Consequently, it was agreed to initiate the cooperation in solar-terrestrial science by forming Working Groups. Cooperative activities in the other two areas should also continue in the form of Panels.

In the area of solar-terrestrial science, two Working Groups were formed. The task of the *Solar-Terrestrial Science Working Group* is to provide recommendations to the IACG on science coordination, within the defined scope of the participating projects, including:

- definition of multi-mission science objectives
- identification of coordinated data acquisition
- intercalibration of scientific instruments
- sponsorship of Workshops and Symposia.

The task of the *Solar-Terrestrial Data Working Group* is to provide recommendations to the IACG in a number of areas, including:

- scope of data exchange and policies
- data-exchange requirements and system
- data standards and formats
- schedule and implementation.

In the areas of Radio-astronomy and Planetary and Primitive Bodies, two Panels were formed. The *Space VLBI Panel* will consider the value of scientific collaboration on approved and future space VLBI missions. This will include reporting to the IACG on the results of their studies of future scientific collaborations for missions under consideration.

The *Planetary and Primitive Bodies Panel* will consider coordination activities for:

- Comet-Halley data dissemination and any other matters remaining from the first IACG project
- comet- and asteroid-science issues
- future scientific collaboration for missions under consideration to primitive bodies, terrestrial planets and satellites.

IACG organisation and terms of reference

Since its formation, the IACG has met annually, with the task of organising the meeting, and consequently the meeting place, rotating within the four agencies. The meetings are usually chaired by a senior Director or the Director General of the hosting agency. He is supported in that task by the Executive Secretary, who prepares the meeting agenda, in consultation with the member agencies, and carries out the day-to-day work in the interim between the meetings. It was found useful to nominate also one 'point of contact' within each delegation. Information is usually distributed from the Secretary to these points of contact (NASA — D.P. Rausch; Intercosmos — B.S. Kunashev; ISAS — Y. Matogawa; ESA — R. Reinhard) for further distribution to agency delegation members.

With between five and ten delegation members from each agency attending the IACG meetings and adopting an informal approach that has allowed unhindered exchange of expertise, a new level of inter-agency collaboration has been built up. The IACG meeting agenda usually includes reports on spacecraft and experiment design and performance, and on mission planning, as well as reports by the IACG Working Groups and Panels.

Much of the work is carried out in the Working Groups and Panels, meeting on average twice per year, usually in combination with another major meeting or just prior to an IACG meeting. Their reports to the IACG often contain recommendations for consideration by the member agencies.

The sixth meeting of the IACG in Padua, Italy, on 4 November 1986 was chaired by Prof. L. van Hove, then Chairman of ESA's Science Programme Committee. The delegations of the member agencies were headed by Academician R.Z. Sagdeev (Intercosmos), Dr. B.I. Edelson (NASA), Prof. M. Oda (ISAS) and Dr. R.M. Bonnet (ESA), while the delegation of IHW representatives was headed by Dr. R.L. Newburn.

Solar-Terrestrial Science Working Group

Chairman:
S.D. Shawhan (NASA)

Deputy Chairman:
A.A. Galeev (Intercosmos)

Members:
V. Domingo (ESA)
R. Farquhar (NASA)
R.A. Kovrazhkin (Intercosmos)
T. Krimigis (NASA)
I. Nakatani (ISAS)
H. Oya (ISAS)
R. Reinhard (ESA)
F. Scarf (NASA)
R. Schmidt (ESA)
D. Southwood (ESA)
R. Tatum (NASA)
K. Tsuruda (ISAS)
K. Uesugi (ISAS)
L.M. Zeleney (Intercosmos)

Solar-Terrestrial Data Working Group

Chairman:
A. Nishida (ISAS)

Deputy Chairman:
K. Blank (ESA)

Members:
D. Baker (NASA)
R. Costa (NASA)
J. Green (NASA)
N. Head (ESA)
T. Mukai (ISAS)
R.R. Nazirov (Intercosmos)
K. Ninomiya (ISAS)
T.R. Sanderson (ESA)
M. Sugiura (ISAS)
L. Tracy (ESA)
D. Williams (NASA)

Space VLBI Panel

Chairman:
N. Kardashev (Intercosmos)

Deputy Chairman:
J.F. Jordan (NASA)

Members:
B. Burke (NASA)
U.O. Frisk (ESA)
L.I. Gurvits (Intercosmos)
T. Hayashi (ISAS)
H. Matsuo (ISAS)
L.I. Matveenko (Intercosmos)
M. Morimoto (ISAS)
T. Nishimura (ISAS)
H. Olthof (ESA)
L. Peterson (NASA)
M.P. Popov (Intercosmos)
R. Preston (NASA)
R.T. Schilizzi (ESA)
P.N. Wilkinson (ESA)

Planetary and Primitive-Bodies Panel

Chairman:
J. Rahe (NASA)

Deputy Chairman:
H. Oya (ISAS)

Members:
R. Akiba (ISAS)
S. Bauer (ESA)
J. Head (NASA)
M. Hechler (ESA)
T. Itoh (ISAS)
V.M. Linkin (Intercosmos)
D. Morrison (NASA)
V.I. Moroz (Intercosmos)
L.M. Mukhin (Intercosmos)
A. Nishida (ISAS)
D. Rea (NASA)
R. Reinhard (ESA)
G. Schwehm (ESA)
M. Shimizu (ISAS)

IACG TERMS OF REFERENCE

1. Purpose
The objective of the Inter-Agency Consultative Group for Space Science (IACG) is to maximise opportunities for multilateral scientific coordination among approved space-science missions in areas of mutual interest. The IACG is a multi-agency international forum in which space-science activities are discussed on an informal basis among representatives of the member agencies.

2. Policies
- Where mutually agreed by the participating agencies, the IACG serves as a vehicle for coordination efforts among approved space-science missions on a multi-lateral basis.
- Exchanges of information on future plans and potential science missions are desirable, and take place during periodic IACG meetings. However, the IACG does not have a formal planning role for future missions.
- The IACG does not supplant bilateral cooperative space-science activities and arrangements, nor does it serve as a substitute for existing mechanisms for managing specific multi-lateral space-science projects.
- The IACG leadership (agency delegation heads) is comprised of senior space-agency representatives in order to maintain the overall efficiency and productivity of the group.
- In addition, where appropriate, the IACG may consider the participation of organised ground-based scientific communities in order to enhance the overall benefit from such multilateral coordination (as was done, for example, with the International Halley Watch).
- The IACG will continue its role as a forum for inter-agency discussions in space science for as long as is deemed useful by the participating agencies. The IACG will review its overall effectiveness and continued need for existence at regular intervals.

3. Membership
The IACG has the following members (listed in alphabetical order):
- the European Space Agency (ESA)
- the Institute of Space and Astronautical Science (ISAS), Japan
- the Intercosmos Council, USSR Academy of Sciences (Intercosmos)
- National Aeronautics and Space Administration (NASA)

4. Discipline(s)
The IACG concentrates on a single discipline area of approved space-science projects as a focal point for a number of years, much as it did successfully with Comet Halley in the past, whilst this approach does not preclude involvement of the IACG in other important disciplines.

5. Organisation
In order to ensure the success of the IACG, a straightforward but informal organisational framework is essential:
- **Schedule of Meetings:** Regular meetings of the IACG take place on an annual basis and rotate from country to country. Special meetings are convened as required.
- **Chairmanship:** Chairmanship of the IACG is transferred from agency to agency along with the responsibility for hosting the regular meetings. Chairmanship for special meetings will be treated ad hoc.
- **Level of Participation:** Agency delegations are comprised of senior programme-management officials and mission personnel. A few key members of each Agency's scientific community can be included.
- **Working Groups:** The detailed work of the IACG is carried out in Working Groups. The IACG will decide on the aspects that require Working Groups, the scope for these groups, and their duration. Each group concentrates on a particular scientific or operational aspect of the agreed discipline area that would benefit from IACG coordination, and these groups meet both in conjunction with, and separate from, IACG meetings, as required.

  The meetings of the Working Groups are organised by the Chairmen or the Deputy Chairmen of those Working Groups, who also report to the IACG at each regular meeting on the status of their activities.

  The selection of the Chairmen and the Deputy Chairmen of the Working Groups is agreed unanimously. They are appointed by the Head of the particular IACG Delegation. Members of the Working Groups are appointed by the Head of the particular Delegation in consultation with the Working Group Chairmen. Should the need arise for broadening international participation in the various Working Groups, Working Group Chairmen may, with the consent of the Heads of Delegations, invite participation by other experts or representatives of other agencies.
- **Panels:** The IACG may also establish panels to consider potential future space-science disciplines that would benefit from inter-agency coordination. The procedures used for panels are similar to those used for the Working Groups.
- **Executive Secretary:** An Executive Secretary is designated for the organisation of the IACG meetings and the day-to-day work between meetings. Selection of the Executive Secretary requires unanimous approval of the IACG Delegation Heads. The Executive Secretary is responsible for carrying out the administrative work of the IACG. The duties of this position include: serving as a point of contact for outside enquiries, distribution of information on forthcoming IACG meetings to the agencies, liaison with agencies on matters of mutual interest, establishment of the agenda for the IACG meetings in consultation with the agencies and the Working- Group Chairmen, and preparation of IACG meeting summaries and public information.

Projects in solar-terrestrial science

Before the IACG adopted solar-terrestrial science as its next project, it had a forerunner, the trilateral ISTP Planning Group. In 1983, ESA, NASA and ISAS considered it useful to review all the solar-terrestrial physics missions then under study by the three agencies. This led to the first trilateral meeting between ESA, NASA and ISAS, which was held in Washington DC on 26—27 September 1983. In the following months, 'Guidelines for the Planning Phase of the Proposed International Solar-Terrestrial Physics (ISTP) Programme of NASA, ISAS and ESA' were worked out. The task of the Group was to coordinate the activities of the three partners during the ISTP planning phase. Between June 1984 and October 1985, the Group had four meetings.

Having completed the coordination of the space missions to Halley's Comet, the IACG was ready from 1986 onwards to continue coordination of solar-terrestrial physics activities during the implementation phase. The transition was already prepared by the ad hoc Working Group formed in the field of solar-terrestrial physics by the IACG in March 1986. At their first meeting, this Group recommended:

— bringing Intercosmos into the meetings of the ISTP Planning Group
— investigating ways to incorporate Relict-2 measurements into the ISTP database, so that all ISTP observations would be made available to all ISTP scientists
— investigating ways of instituting multi-agency Guest Investigator and Theory Investigator programmes, so that scientists from all agencies would be able to participate in the data analysis.

In early 1987, of all the projects listed in Table 1, only NASA's Wind and Polar and IKI's two Cluster-type magnetospheric spacecraft were not yet approved. It is hoped that Wind and Polar will be included in the Fiscal Year '88 budget and that the two IKI spacecraft will be approved within the next year. The trilateral planning phase, and thus the task of the ISTP Planning Group, has therefore been completed. At a fifth and last meeting of the Group in May 1987 it was concluded that for the implementation phase the IACG was a suitable forum for coordination and data exchange at inter-agency level, and that the IACG, together with bilateral agreements as foreseen in the Memoranda of Understanding (MOUs), could cover all the areas that need to be discussed.

Thirteen projects involving 20 different spacecraft (Table 1) are already approved within the four IACG member agencies or are awaiting approval shortly.

EXOS-D (ISAS)

The EXOS-D mission carried out by ISAS will make direct investigations of the particle-acceleration regions above the auroral region. Though the general features of the acceleration mechanism are gradually being clarified from the data previously obtained by satellite observations, some fundamental questions still remain, such as:

(i) What is the initial triggering mechanism for the particle acceleration? Is it caused by the fast plasma injection, or high-energy electrons, or the current?
(ii) Is the acceleration region made up of the electrostatic shock, or a double layer, or successively growing large-amplitude waves?
(iii) How is the development of the acceleration regions related to the occurrence of the magnetospheric disturbance called the 'substorm'?

To answer these three basic questions, EXOS-D carries a payload of seven plasma experiments and a visible and UV auroral imaging system. The 294 kg spin-stabilised EXOS-D spacecraft will be launched in February 1989 by an M3SII-2 rocket into an orbit with 300 km perigee and 8000 km apogee. The nominal mission duration is three years.

Ulysses (ESA/NASA)

The Ulysses project has as its primary

Table 1 — Solar-terrestrial science missions

Mission	Number of spacecraft	Agency	Envisaged launch date
Exospheric Satellite (EXOS-D)	1	ISAS	1989
Ulysses	1	ESA/NASA	1990
Interball	4	IKI	1990
Combined Release & Radiation Effects Satellite (CRRES)	1	NASA	1991
Relict-2	1	IKI	1991
Solar-A	1	ISAS	1991
Upper Atmosphere Research Satellite (UARS)	1	NASA	1991
Geotail	1	ISAS/NASA	1992
Wind*	1	NASA	1992
Polar*	1	NASA	1992
Solar & Heliospheric Observatory (SOHO)	1	ESA/NASA	1994
Cluster	4	ESA/NASA	1995
IKI-1, IKI-2*	2	IKI	1995

* In process of approval

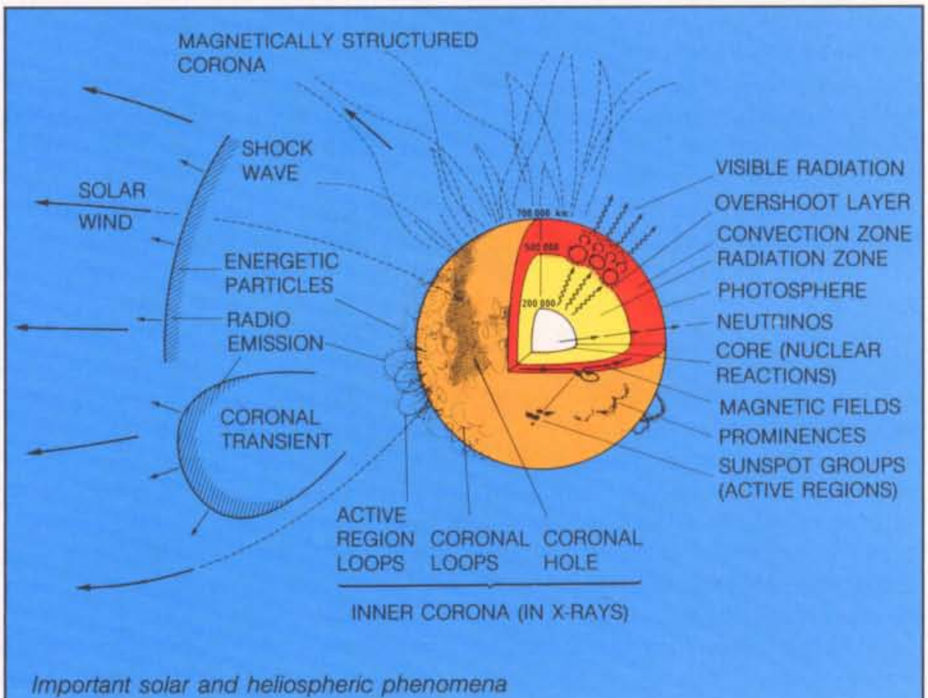
SOLAR-TERRESTRIAL

The Sun is the only star that can be studied in detail from within our solar system. It is a variable star — its activity varies with time. This variation arises because the Sun both rotates and possesses an internal convection zone that physically transports hot gas from the solar interior to its surface. The interaction of these two motions, rotational and convective, generates powerful magnetic fields through a complicated mechanism (not yet fully understood) that is generally called the 'solar dynamo process'. Furthermore, this 'dynamo' is cyclic, as demonstrated by the ebb and flow of sunspots and energetic events called 'solar flares', with roughly an 11-year period. Today, we know that many stars — indeed, perhaps most — also possess activity cycles, many of which would dwarf that of our own Sun.

Whereas its periodic activity alone makes the Sun quite an interesting astronomical object, other features make it of more practical interest to the Earth. In particular, the Sun also has an extended atmosphere — the 'solar corona', the pearly white halo of gas seen at solar eclipses, which generates the 'solar wind'. The solar wind is an invisible but hot, high-velocity solar gas (or plasma) that is constantly being expelled from the Sun and that streams out through the solar system. Just as the corona is highly irregular in shape, so is the solar wind.

That this gusty solar wind envelops the Earth and all the other planets in the solar system has been known since the discoveries by the Mariner-2 spacecraft in the early 1960s. What makes it of more than intellectual interest is the fact that our planet also possesses a magnetic field. The interaction of the structured, time-varying solar wind with the Earth's magnetic field creates a whole range of effects — aurorae, geomagnetic storms, disruptions in short-wave radio communications, power surges in long transmission lines — which are collectively called 'solar-terrestrial phenomena', and which occur in the region now known as 'geospace'.

Thus, the general subject of solar-terrestrial physics can be thought of as encompassing the Sun as a variable star, the origin and transmission of the solar wind, the interaction of this solar wind with the Earth's magnetic field, and the subsequent time-varying magnetic and atmospheric effects in the Earth's lower atmosphere. It is a subject that is breathtaking both in the scope of the physics involved — all the way from the working of the solar dynamo to the origin of the aurorae in the Earth's atmosphere — and in its potential for application to routine activities on Earth, including the increasingly routine operation of our near-Earth spacecraft.



Important solar and heliospheric phenomena

The Sun and the heliosphere — the nearest star and its sphere of influence — harbour a large number of fundamental questions that are of consequence not only for the solar system, but also for astrophysics as a whole. Mankind now has the intellectual curiosity and technical capability to investigate the many basic and interconnected questions regarding the internal structure of the Sun, the heating of the corona, and its expansion into the fast and slow streams of the solar wind.

Helio-seismology concerns the study of the Sun's internal dynamics and structure through observing oscillations of the Sun's surface, similar to the use of earthquakes to infer the interior structure of the Earth. A complete understanding of these oscillations would ultimately lead to knowledge of the interior composition of the Sun and of the dynamo processes that drive the Sun's 11-year activity cycle.

In addition, short-term decreases (of the order of a few tenths of a percent in a few days) in solar luminosity can occur with the appearance of large sunspots. Thus, it is of great interest to study systematically the mechanism by which the Sun blocks, stores, and then ultimately releases this energy, and also look for long-term trends (decreases or increases) that may be linked to the solar cycle.

Observations of the solar surface and its nebulous atmosphere — the corona — reveal a variety of features including sunspots, solar magnetic flares, polar coronal holes, coronal streamers, and plasma jets. Although these features are caused by the interaction of solar convection and magnetic fields, their interrelationship is not well established.

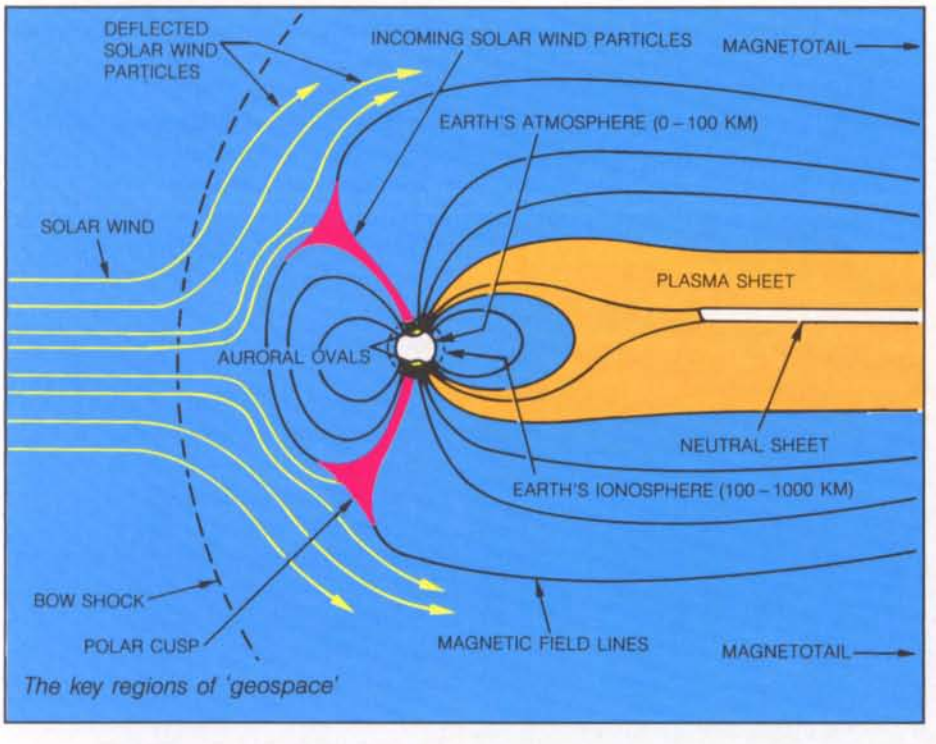
SCIENCE

Measurements reveal that the temperature of the solar atmosphere rises from 5000 K in the photosphere, to over a million Kelvin in the corona. Coordinated measurements of densities, temperatures, velocities, and magnetic fields in coronal loops are necessary as inputs to understanding just how this high coronal temperature occurs and where the solar wind is accelerated.

To advance our knowledge of Sun/Earth interactions requires that we measure the cause-and-effect relationship between the solar surface features, the coronal dynamical features, and the characteristics of the solar wind as it envelops the Earth to create the geospace.

Roughly 99% of all the matter in the Universe exists in a form called 'plasma'. Plasma is an electrically charged gas in which each atom has been stripped of one or more of its electrons, thus leaving it with a net positive electrical charge. This assemblage of charged atoms and electrons carries mass, momentum, and energy between the Sun and the planets. It pervades the region between the stars and other astrophysical entities.

Exploration of the Earth's nearby space environment has revealed a dynamic and complex system of plasmas interacting with magnetic fields and electrical currents surrounding our planet. This region, comprising the magnetised solar-wind plasma plus the perturbation in the heliosphere caused by the presence of the magnetic Earth, is the region we have defined as geospace. Solar influence shapes and links the three major regions of geospace: the magnetosphere, the ionosphere, and the Earth's neutral atmosphere, where life exists.



The key regions of 'geospace'

The magnetosphere is the volume of space dominated by the Earth's magnetism. Solar wind compresses the dayside magnetosphere and stretches the nightside into a comet-like tail millions of miles long. Some solar-wind plasma penetrates this magnetic shield and mixes turbulently with local plasmas. When these 'magnetic storms' jolt the magnetosphere, charged particles stored in the tail region hurtle towards the Earth along magnetic field lines and release their energy as aurorae.

The ionosphere is a zone of plasma created by the effect of solar radiation on gases in the Earth's upper atmosphere (60—100 km altitude). Aurorae occur at 100 km, heat the ionosphere, and temporarily alter its electrical properties. Magnetic storms and aurorae may disrupt the transmission of radio and telecommunications signals in the ionosphere. Plasma motions and electric currents in this region affect, and are affected by, processes occurring in the magnetosphere above and the atmosphere below. Thus, the ionosphere is the interface or transition zone in geospace.

The atmosphere, an envelope of electrically neutral gases, sustains life on Earth and is the theatre for terrestrial weather. Chemical reactions and wind patterns in the lower atmosphere are influenced by ionospheric currents, aurorae, and uneven solar heating at high altitudes. Events in the magnetosphere and ionosphere often simulate atmospheric emissions in X-ray, visible, and ultraviolet wavelengths. These 'footprints' of activity in geospace can be observed meaningfully only from above the filtering atmosphere.

Because geospace resembles the plasma environments that exist around distant planets and stars, plasma processes common throughout the Universe can be sampled and studied in Earth's own backyard. Geospace is an accessible natural laboratory for astrophysical investigations and for basic research in plasma physics.

Furthermore, geospace is a laboratory for the study of solar-terrestrial relationships. The aurora, for example, is part of a complex chain that links the regions of geospace and responds to solar influence.

Solar-terrestrial science also involves the assessment of human (as well as solar) influence on Earth's space environment. This environment may be as vulnerable to abuse as the planet's surface ecology. The interactive nature of geospace suggests that pollution or disruption of one region may alter the balance of the entire system. With increased understanding of the physical processes that govern geospace we can learn how to interact prudently with the Earth's vast, invisible environment.

objective the study of the interplanetary medium and the solar wind in the inner heliosphere as a function of heliographic latitude. Ulysses will permit measurements to be made for the first time in-situ, away from the plane of the ecliptic and over the polar regions of the Sun. The payload consists of nine hardware experiments, mostly addressing particle and field investigations, and two radio-science investigations.

The spin-stabilised (nominally 5 rpm) spacecraft (Fig. 3) will be launched in October 1990 using the Space Shuttle plus IUS/PAM-S upper stage. In December 1991, Ulysses will fly by Jupiter, using its gravity assist to leave the plane of the ecliptic (Fig. 4). It will pass over the solar south pole in July 1994 (80° max. latitude), crossing the ecliptic again in December 1994 and passing over the solar north pole in June 1995 (80° max. latitude). The mission nominally ends two months thereafter.

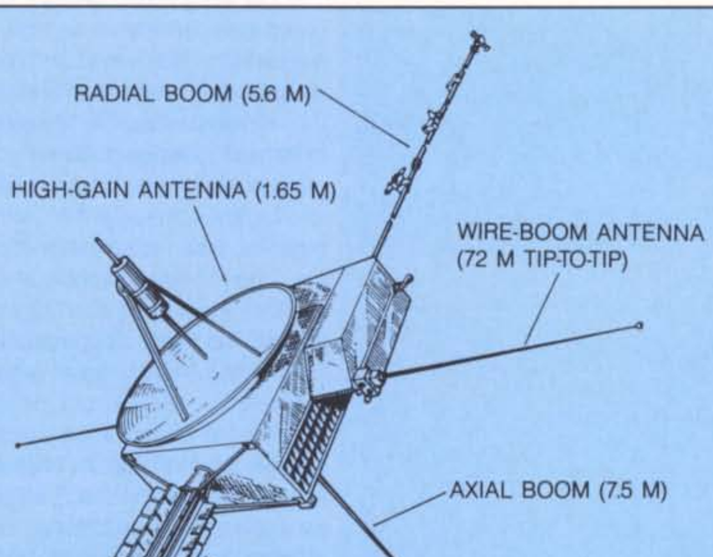


Figure 3 — The Ulysses spacecraft in flight configuration

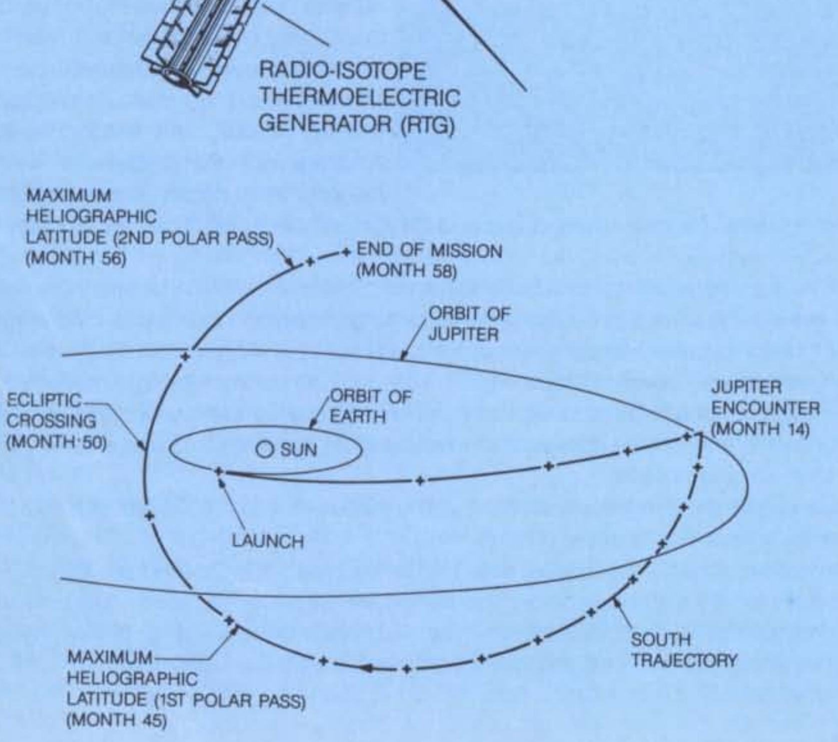


Figure 4 — Typical Ulysses spacecraft trajectory viewed from 15° above the ecliptic plane. Elapsed time is given in months after launch, with crosses at 100 d intervals

Interball (IKI)

The Interball mission is intended to study the physical mechanisms responsible for transportation of the solar-wind energy to the Earth's magnetosphere, its accumulation there, and its subsequent dissipation in the auroral regions of the magnetosphere during the magnetospheric substorm.

Two spacecraft of the Prognoz type are to be used, one for the tail region, the other for the auroral region, each spacecraft also having a subsatellite. The auroral main spacecraft (Fig. 5) carries a payload of 16 experiments, the tail spacecraft a payload of 20 experiments, addressing a very wide range of plasma particle and wave measurements. The auroral spacecraft also carries an instrument to observe line emission in the UV, and a UV imager. The two subsatellites carry experiments to measure fields, waves, plasma and energetic particles.

All four Interball spacecraft will be launched in 1990, the auroral spacecraft into an orbit with a 20 000 km apogee and 500 km perigee, the tail spacecraft into an orbit with a 200 000 km apogee and a 500 km perigee (Fig. 6). The spacecraft—subsatellite distance will be varied between 10 and 1000 km for the auroral spacecraft, and between 1000 and 10 000 km for the tail spacecraft.

CRRES (NASA)

The Combined Release and Radiation Effects Satellite (CRRES) is a joint US Air Force/NASA mission consisting of two phases: an initial low-Earth-orbit (LEO) phase and a later, more extended, geosynchronous-transfer-orbit (GTO) phase.

Figure 5 — Auroral spacecraft of the Interball project in flight configuration

Figure 6 — Trajectories of the tail satellite/subsatellite and the auroral satellite/subsatellite of the Interball project

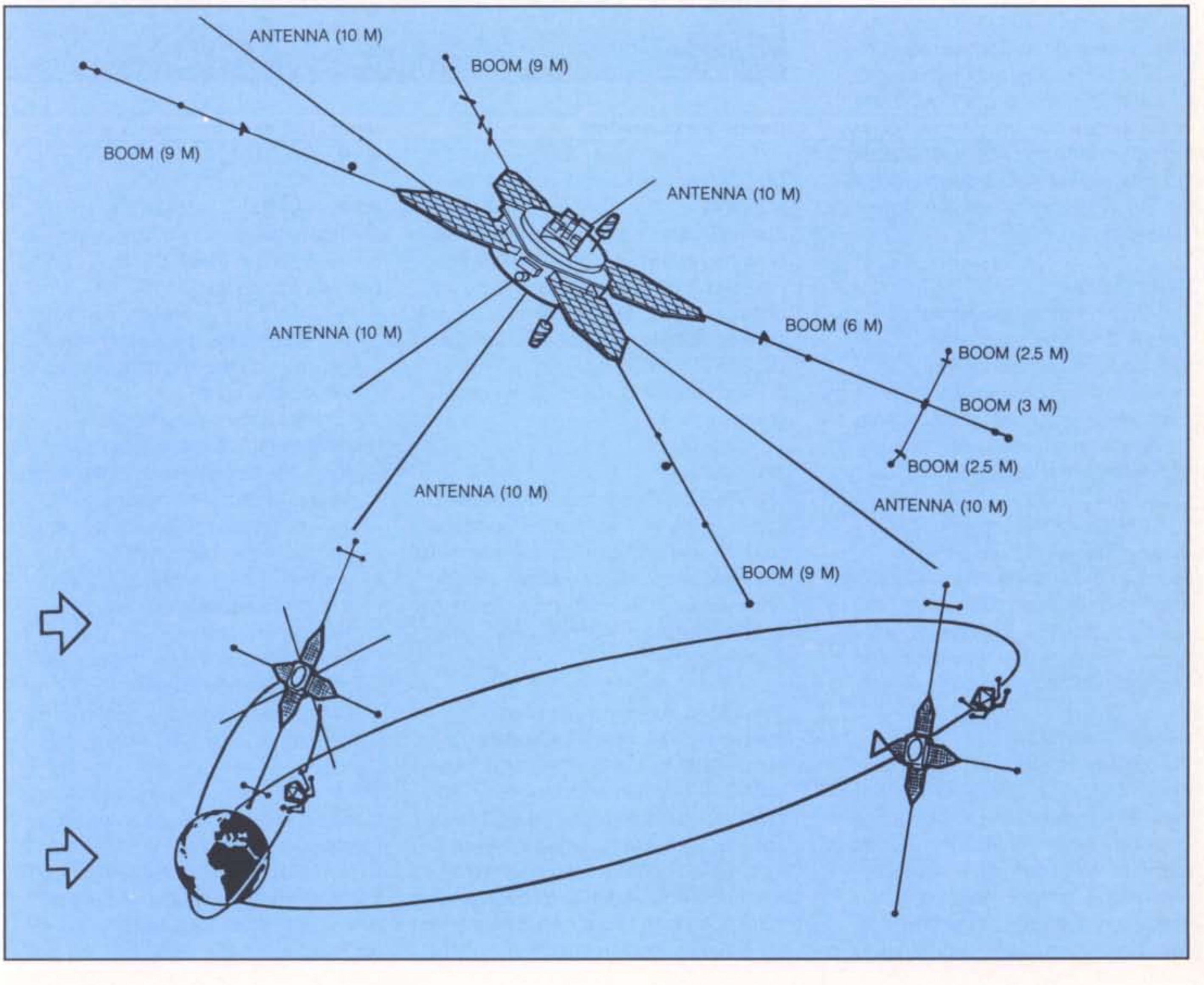
The objectives during the LEO phase are to perform active chemical-release experiments in the ionosphere, and to study the artifically produced ionospheric perturbations, along with naturally-occurring phenomena. Diagnostic instrumentation on the ground, aboard special aircraft, and onboard the CRRES spacecraft will be used in making the necessary coordinated measurements that will allow the effects of the controlled chemical-release experiments to be understood.

The objectives during the GTO phase focus on studies of the natural radiation environment, studies of the effects of the radiation environment on modern micro-electronic components, and a series of chemical releases to study the effects of artificial plasma injections on the inner and outer magnetosphere.

The CRRES payload consists of six experiments, including an 890 kg LEO and GTO chemical-release module and a 168 kg space-radiation experiment. CRRES will be launched in October 1991 by a Space Shuttle into a low circular orbit (358 km altitude). After between 45 and 90 d in this low Earth orbit, the Orbital Transfer Stage (OTS) will be used to manoeuvre CRRES into geosynchronous transfer orbit (apogee 6.6 Earth radii, perigee 1.1 Earth radii, inclination 18°).

Relict-2 (IKI)

This Prognoz-type spacecraft carries an astrophysical experiment designed to study millimetre radiation, and a plasma package of four instruments to study the physical characteristics and dynamics of the distant geotail.



Relict-2 will be launched in 1991 into a halo orbit around the second Lagrangian point L_2, which is about 220 Earth radii away from the Earth in the geotail.

SOLAR-A (ISAS)
The primary goal of the SOLAR-A mission is to investigate high-energy phenomena on the Sun via X-ray and gamma-ray observations made by a carefully coordinated set of instruments. SOLAR-A will for the first time observe the soft and the hard X-ray images of solar flares simultaneously, together with the energy spectrum over a wide energy range.

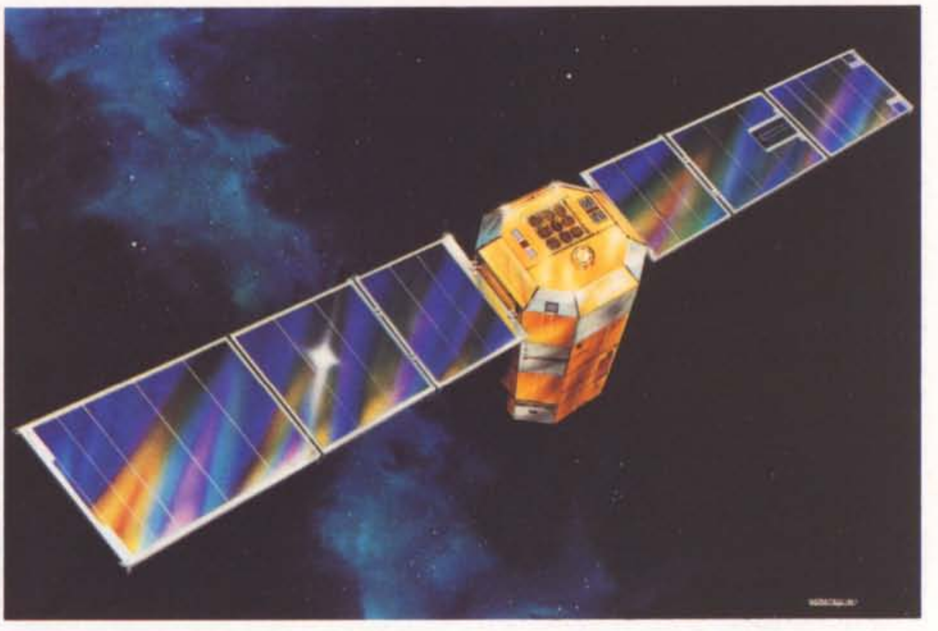
The spacecraft (Fig. 7) will carry two telescopes and two spectrometers. It will be launched in August/September 1991 by an M3SII-6 rocket into a low Earth orbit (apogee 650 km, perigee 550 km, inclination 31°). The 420 kg spacecraft will be three-axis stabilised, pointing at the Sun. The nominal mission duration is two years.

UARS (NASA)
The Upper Atmosphere Research Satellite (UARS) will perform simultaneous, comprehensive measurements of the Earth's stratosphere, mesosphere and lower thermosphere, for investigations of energetics, chemical composition and dynamics.

The UARS payload consists of ten experiments, with a total mass of 1600 kg. The spacecraft is 10.67 m long and 4.58 m wide and will weigh 7650 kg at launch. It will be launched by the Space Shuttle in 1991, into a circular orbit (altitude 600 km, inclination 57°).

Geotail (ISAS/NASA)
The primary objective of the Geotail mission is to study the dynamics of the Earth's magnetotail over a wide range of distances, extending from the near-Earth region to the distant tail. Geotail will address the transport, storage, and conversion of energy in the tail with seven instruments designed for field and particle measurements.

Figure 7 — The SOLAR-A spacecraft in flight configuration (artist's concept)



The 790 kg spacecraft (Fig. 8) will be launched towards the end of 1992 by the Space Shuttle plus PAM-D. The near-tail orbit will have an apogee of 20 Earth radii and a perigee of 8 Earth radii; the distant tail orbit, using lunar swingby, will have an apogee of 250 Earth radii and a perigee of 8 Earth radii (Fig. 9). The nominal mission duration will be three years.

Wind (NASA)
The Wind payload is made up of seven investigations that will provide complete plasma, energetic-particle, and magnetic-field data in the interplanetary medium upstream from the Earth's bow shock for magnetospheric and ionospheric studies.

The 800 kg spin-stabilised Wind spacecraft (Fig. 10) will be launched in March 1992 by the Space Shuttle plus PAM-D or ELV into an orbit with an 80 Earth radii apogee and an 8 Earth radii perigee. A double lunar swingby would extend the apogee to 250 Earth radii. Another option would be to place the Wind spacecraft into a halo orbit around the sunward libration point (Fig. 11). The design lifetime of the mission is about three years.

Polar (NASA)
The Polar spacecraft will carry a payload consisting of ten investigations, including two imagers, designed to:
- measure plasma, energetic particles and fields in the high-latitude polar regions, and the energy input through the dayside cusp
- determine the characteristics of ionospheric plasma outflow
- study the characteristics of the auroral plasma-acceleration regions
- provide global, multispectral, auroral images of the footprint of magnetospheric energy deposition into the ionosphere and upper atmosphere, and
- help determine the ionosphere's role in substorm phenomena and in the overall magnetospheric energy balance.

The 900 kg spacecraft (Fig. 12) will be launched in September 1992 by the Space Shuttle plus PAM-D or ELV into an eccentric polar orbit with a perigee of 2 Earth radii and an apogee of 9 Earth radii. The misson design lifetime is approximately three years.

Figure 8 — The Geotail spacecraft in flight configuration

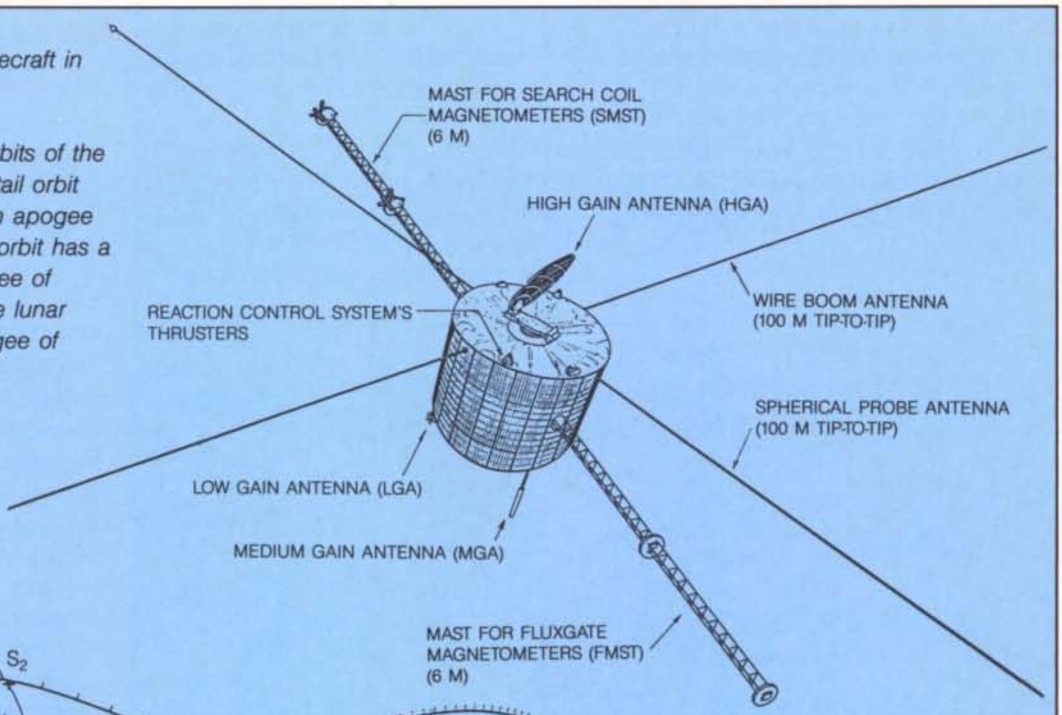
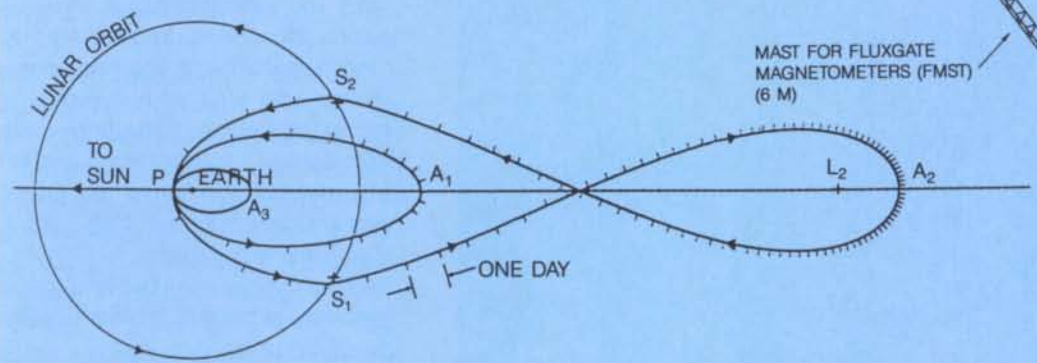
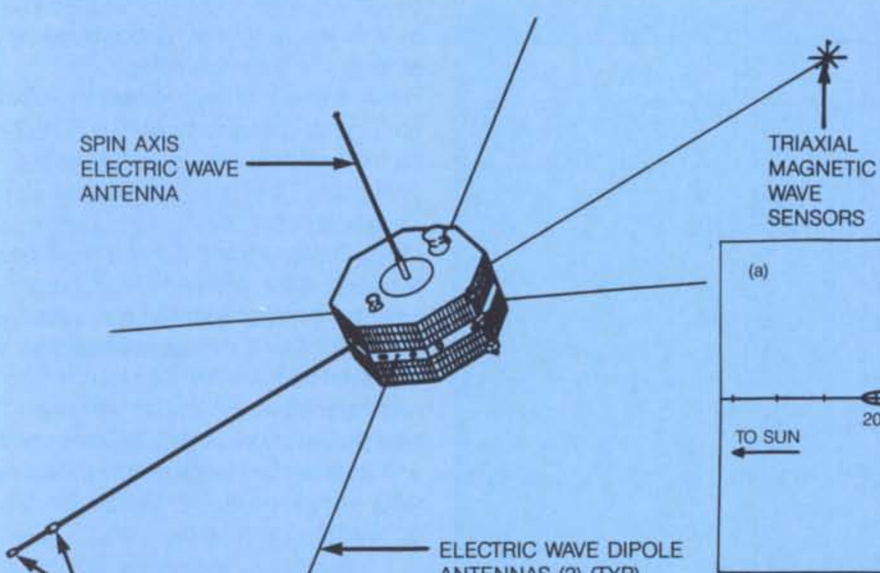


Figure 9 — Three different orbits of the Geotail spacecraft. The near-tail orbit has a perigee of 8 R_E and an apogee of 20 R_E (A_3). The distant-tail orbit has a perigee of 8 R_E and an apogee of 80 R_E (A_1). By using a double lunar swingby (S_1 and S_2), an apogee of 250 R_E (A_2) can be achieved





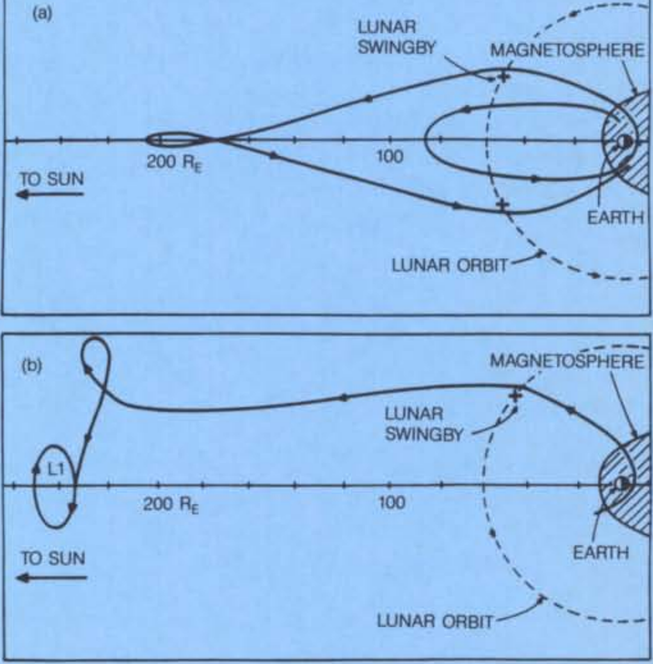


Figure 10 — One possible design for the Wind spacecraft
Figure 11 — Two different options for the orbit of the Wind spacecraft are shown.
(a) shows an orbit with a perigee of 8 R_E and an apogee of 80 R_E. By using a double lunar swingby, an apogee of 250 R_E can be achieved.
(b) shows a trajectory towards a halo orbit around the sunward libration point (L_1)

Figure 12 — A possible design for the Polar spacecraft. The spacecraft contains a despun platform to perform critical measurements along the magnetic-field direction. Polar will also have auroral imaging cameras mounted on the despun platform and a spin-axis electric-field boom

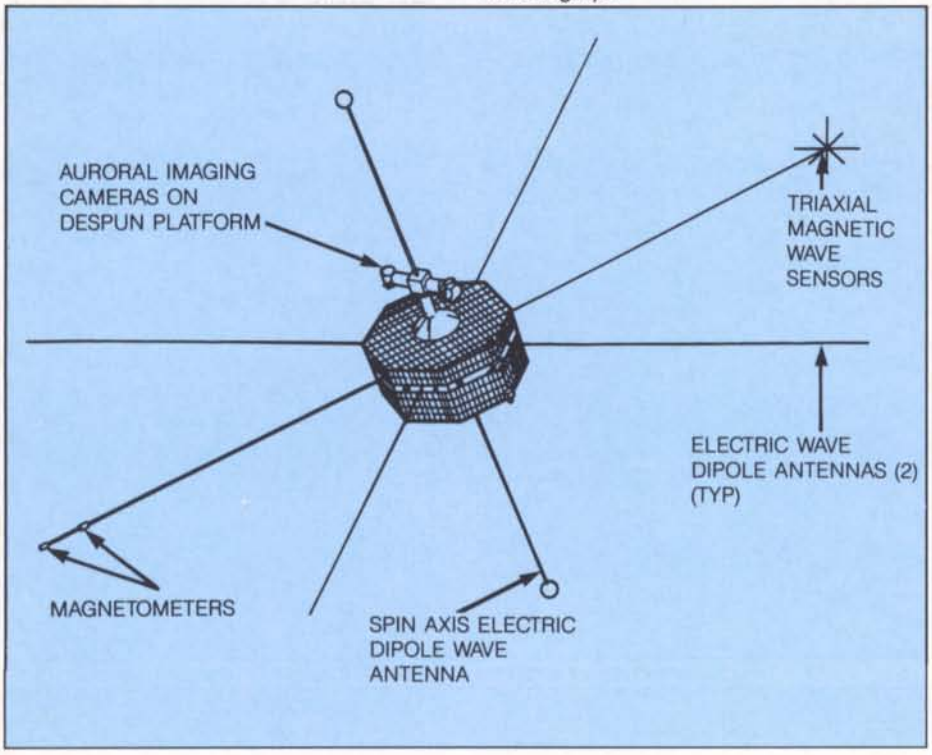
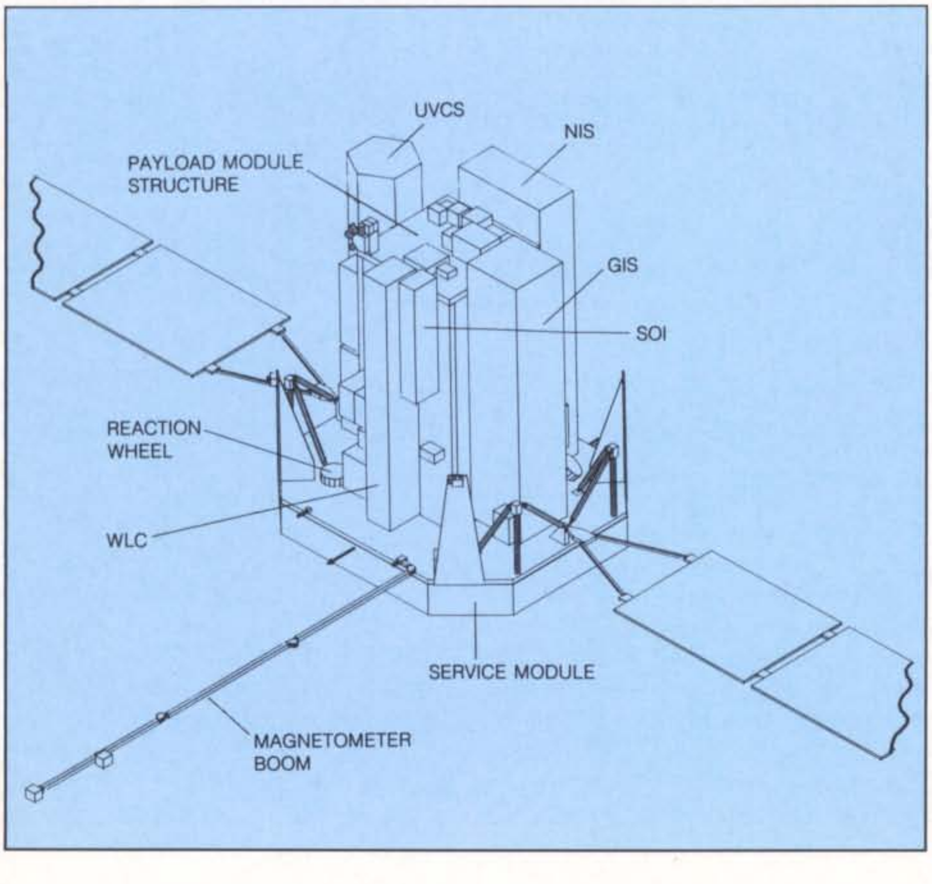


Figure 13 — The SOHO spacecraft in flight configuration. The experiments are mounted on the payload module structure. The larger experiments of the model payload are: UVCS — Ultra-Violet Coronal Spectrometer; NIS — Normal-Incidence Spectrometer; GIS — Grazing-Incidence Spectrometer; SOI — Solar-Oscillations Imager; WLC — White-Light Coronagraph



SOHO (ESA/NASA)

The Solar Heliospheric Observatory (SOHO) is a three-axis-stabilised spacecraft, which will be placed into a halo orbit around the sunward libration point (L_1) and permanently pointed at the Sun's centre. The main objectives of SOHO are:

- study and understanding of solar-corona phenomena, in particular the heating mechanisms and expansion into the solar wind, both by remote sensing of the solar atmosphere with high-resolution spectrometers and telescopes and by 'in-situ' measurement of the resulting solar-wind fields and particles
- study of the structure and interior dynamics of the Sun, from its core to the photosphere, by helio-seismological methods.

The above objectives will be addressed by a variety of solar-atmosphere remote sensing and helio-seismology investigations and experiments for solar wind in-situ measurements. The SOHO payload will be selected by the end of 1987.

The 1500 kg spacecraft (Fig. 13) will be launched at the end of 1994 or in early 1995 by the Space Shuttle plus upper stage. SOHO will be inserted into the halo orbit four months after launch. The nominal mission will last for two years after this insertion. (The SOHO mission and its scientific objectives are described more completely in ESA Bulletin No. 50, pp. 8—16).

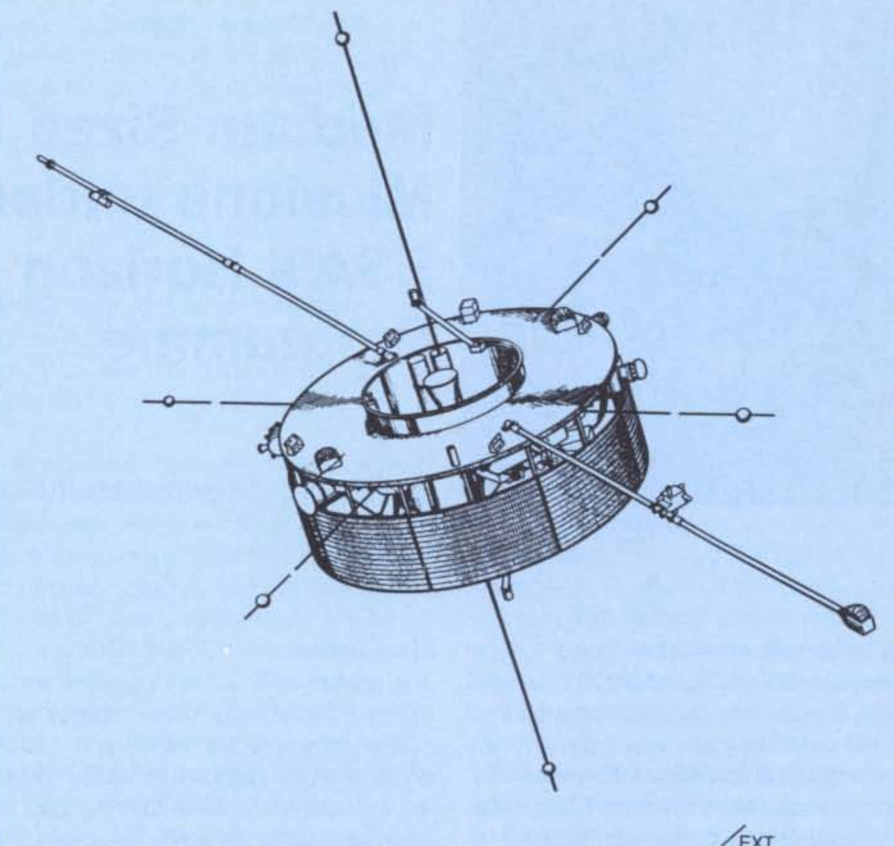
Cluster (ESA/NASA)

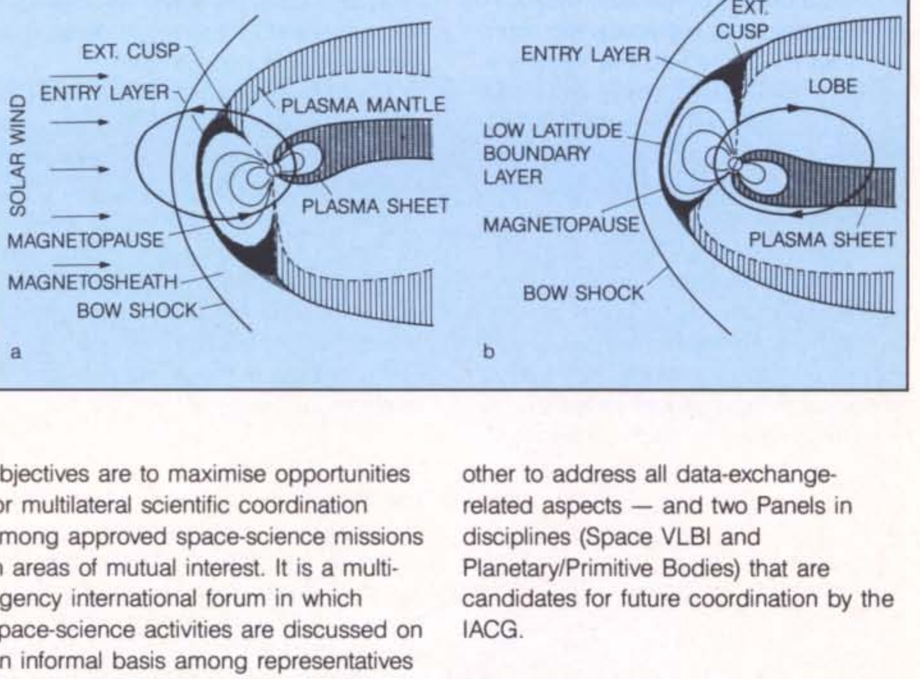
The Cluster mission consists of four satellites to be placed into a polar orbit to study plasma turbulence and small-scale structures in the Earth's magnetosphere and solar wind in three dimensions.

To facilitate this, the four spacecraft (Fig. 14) will be identically instrumented and placed into orbits that yield a tetrahedral spatial configuration. The

Figure 14 — One of the four identical Cluster spacecraft in flight configuration

Figure 15 — Cluster orbits at six-monthly intervals relative to the magnetosphere. (a) dayside orbit, and (b) nightside orbit





technique of using several closely grouped spacecraft will be exploited to diagnose fine structures and to distinguish spatial from temporal variations. For this, a minimum of four non-coplanar Cluster spacecraft making measurements with high time resolution is required. The Cluster payload will be selected by the end of 1987.

The Cluster spacecraft will be launched by an Ariane-5 vehicle in mid-1995. They will be placed in a near-polar orbit with 20 Earth radii apogee and 3 Earth radii perigee (Fig. 15). Typical separations will be in the range of a few hundred to a few thousand kilometres on the dayside and up to a few Earth radii on the nightside, where the chracteristic scale lengths are somewhat larger. The nominal mission duration is three years. (The Cluster mission and its scientific objectives are described more completely in ESA Bulletin No. 50, pp. 8—16).

IKI-1, IKI-2 (IKI)

These two spin-stabilised magnetospheric spacecraft of a novel design will be similar in performance (e.g. magnetic cleanliness) to the four ESA/NASA Cluster spacecraft. They are not yet approved, but a decision is expected within the next year. IKI-1 and IKI-2 are working names for the time being only.

IKI-1 and IKI-2 will be launched after the Cluster launches. IKI-1 will be placed into an orbit with an apogee of 32.5 Earth radii, a perigee of 3 Earth radii, and an inclination of 90°; IKI-2 will be placed into an orbit around the anti-sunward libration point. The two IKI spacecraft could be moved into Cluster-like orbits at any time and could thus provide redundancy for the Cluster mission in the event of a failure.

Conclusion

The Inter-Agency Consultative Group for Space Science (IACG) decided to adopt 'Solar-Terrestrial Science' as its next project at its sixth meeting in Padua, Italy, on 4 November 1986. The IACG's objectives are to maximise opportunities for multilateral scientific coordination among approved space-science missions in areas of mutual interest. It is a multi-agency international forum in which space-science activities are discussed on an informal basis among representatives of the member agencies. The IACG will continue to concentrate on a single discipline area of approved space-science projects, as a focal point for a number of years, much as it did so successfully with Comet Halley. This approach does not, however, preclude IACG involvement in other important areas.

With these objectives in mind, the IACG has formed two Working Groups in the area of solar-terrestrial science — one to address all science-related aspects, the other to address all data-exchange-related aspects — and two Panels in disciplines (Space VLBI and Planetary/Primitive Bodies) that are candidates for future coordination by the IACG.

In the solar-terrestrial-science domain, the IACG is now coordinating thirteen different projects originating from its four member agencies, involving a total of twenty spacecraft. This coordination activity will occupy the IACG for the next decade, as the last of the spacecraft involved will be launched only in 1995, and the nominal mission duration of most projects is about three years.

Medium-Sized Astronomy Missions under Study for ESA's Horizon 2000 Programme

S. Volonté, Directorate of Scientific Programmes, ESA, Paris

An important element of ESA's 'Space Science: Horizon 2000' Long-Term Programme consists of projects of the medium-class category, costing some 220 MAU*. Selected in open competition, after periodic calls for new mission proposals, these projects serve to introduce the required flexibility into the Agency's overall long-term planning. They are essential to permit the continuous injection of new ideas resulting from today's rapid evolution in space science.

The mission concepts presently being addressed by the Agency within the framework of the current selection cycle include candidate missions in the general fields of planetary research and astronomy.

* 1 AU = ±0.96 US$

Introduction
The present selection cycle within the Space Science Programme includes five mission concepts that will be in competition for approval in 1988. Three are astronomy missions, covering the areas of gamma-ray and ultra-violet observations ('GRASP' and 'Lyman', respectively) and space radio interferometry ('Quasat'). Both the GRASP and Lyman projects would be natural follow-ups to previous or still operating missions, such as Cos-B and IUE. Quasat, on the other hand, is a totally new mission concept and could be one of the very first space missions in radio astronomy. This article briefly outlines the scientific objectives of, and the basic concepts behind, these three potential astronomy missions.

The GRASP mission
The GRASP mission would provide a major step forward for Europe in gamma-ray astronomy. GRASP (Gamma-Ray Astronomy with Spectroscopy and Positioning) would be the first high-resolution spectral imager with accurate positioning to operate in the gamma-ray range. It would cover a wide operational bandwidth (15 keV — 100 MeV), connecting the X-ray and the gamma-ray ranges, and high-resolution spectroscopy (typically $E/\Delta E = 1000$ at 1 MeV) in the 15 keV — 1 MeV range would be provided by a position-sensitive system of germanium detectors cooled to 90 K. The use of a coded aperture mask, with the possibility of rotation to improve the detection of sources, would allow an angular resolution of about 1 arcmin within a 50° square (approx.) field of view. The system would provide high sensitivity for both extended and point sources.

The scientific objectives of the mission are numerous and varied, but the study of Active Galaxies would be one of its major features. The identification of a large number of Active Galaxies would lead directly to the compilation of a gamma-ray luminosity function for these objects. Furthermore, the detailed study of red-shifted electron-positron annihilation lines from these distant sources has fundamental cosmological implications. Precise measurements of the spectra would provide a revealing probe into the physics in the vicinity of the compact objects associated with extragalactic nuclei.

In the context of our own Galaxy, GRASP would discover new gamma-ray sources, map extended objects, locate point sources precisely ($\sim 1'$), analyse their emission spectra with high resolution and study the variability of a wide variety of spectral objects, with special emphasis on the Galactic Centre. A picture of the distribution of recent nucleosynthesis throughout the Galaxy could then be derived by mapping key emission lines such as ^{26}Al and the positron annihilation line.

During the lifetime of the mission, a significant number of transient events are expected to occur, including gamma-ray bursts. In addition, supernova events in distant galaxies could be studied over longer periods of time by occasionally re-orienting the telescope. These and

Galactic Novae are exciting targets for high-resolution spectroscopic studies, as they are potential sites of explosive nucleosynthesis.

The mission requirements call for a three-axis-stabilised spacecraft carrying a total payload weighing approximately 1000 kg and having a moderate pointing and telemetry capability. In the Assessment Study, two basic mission concepts have been considered, based on the type of carrier. The first alternative is based on a dedicated free-flyer with a mission duration of a few years, allowing up to 1000 pointings to be made in the sky, each lasting between 10^5 and 10^6 s. This would maximise the scientific return from the mission and provide a significant opportunity for beneficial spin-off for the wider astronomical community through an Associate Observer Programme.

This type of mission would be in line with the concept of medium-sized projects in the 'Space Science: Horizon 2000' Long-Term Programme. A step in this direction is the possibility of using Robus, a free-flyer platform developed for Rosat, which would require little modification. The Robus concept appears to be particularly suitable for GRASP, because the instrument can be accommodated in either section of an Ariane dual-launch and placed in a low-inclination Earth orbit that would require only one near-equatorial ground station. Figure 1 is an artist's impression of observation of the gamma-ray sky by the GRASP payload on the Robus carrier.

The other possibility for GRASP, following the recommendations of the Agency's advisory bodies, would be to accommodate it on the Eureca-B platform in the more general context of the Columbus scenario (both programmes were described in detail in the last issue of ESA Bulletin). In this case, the mission lifetime of up to a maximum of two years and the necessity of a low-Earth, Shuttle-compatible orbit, would provide some 300 pointings each lasting 10^5 s. This would be largely adequate for a rich scientific programme and a full return to the participating institutes.

It should be pointed out, however, that the uncertain future of the Eureca Programme, which is now very dependent on the resumption of Shuttle flight opportunities, could cast some doubts on such a possibility. Consequently, the Space Science Advisory Committee (SSAC) recently recommended that GRASP be the subject of a Phase-A study based on a carrier vehicle of the Robus type, although other platform concepts, like the ISO spacecraft bus, may also be considered.

Whichever platform alternative might be selected, the quality of the mission itself guarantees that, following upon the successful Cos-B mission, Europe would maintain a leading position in the field of gamma-ray astronomy.

The Lyman mission

The primary objective of the Lyman mission (Fig.2) would be to study a large variety of astronomical objects in the largely unexplored wavelength range between 900 Å and 1200 Å at high spectral resolution and with high efficiency. Both the future Hubble Space Telescope (HST) mission and the very successful IUE mission, which is still operating, have been designed to operate in the spectral region above

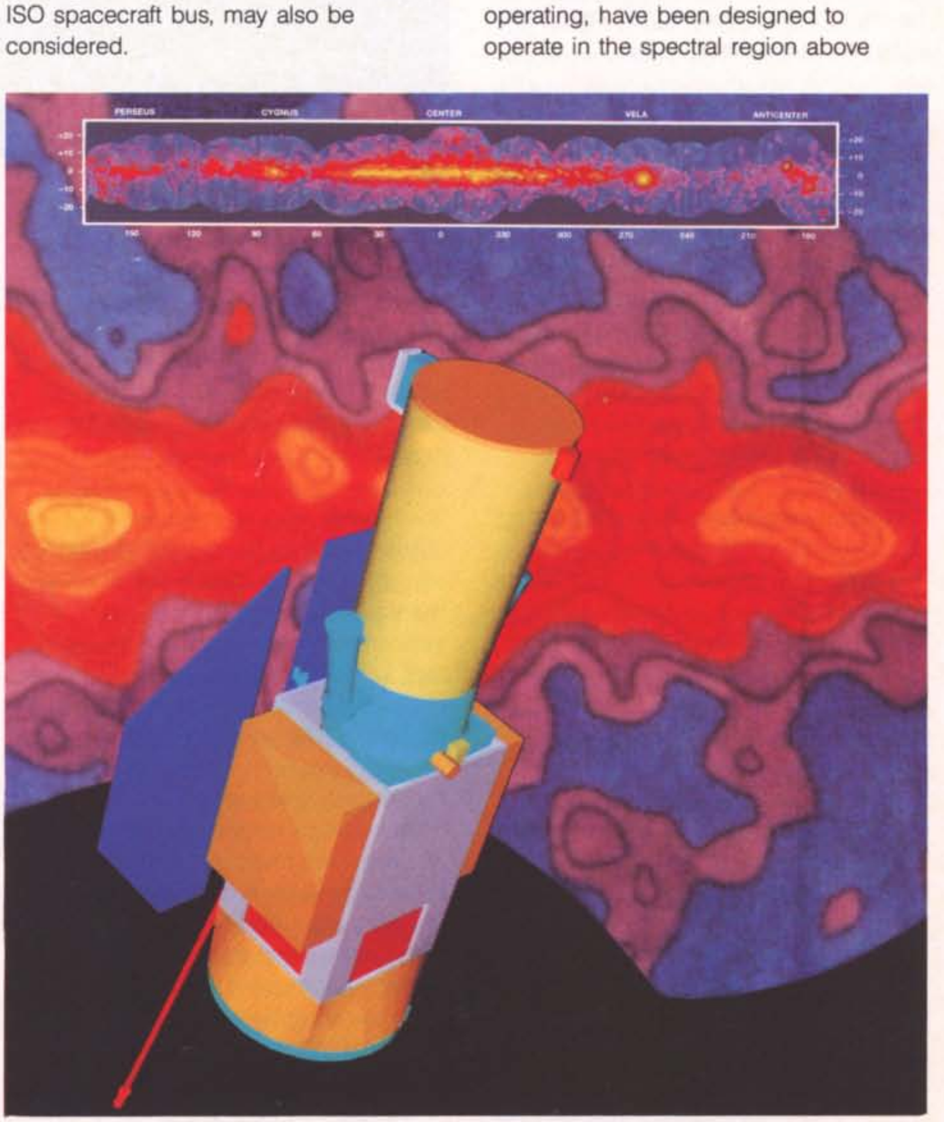


Figure 1 — Artist's impression of gamma-ray sky observations by the GRASP payload on a Robus vehicle. The insert shows the gamma-ray emission of our Galaxy as observed by ESA's pioneering Cos-B mission

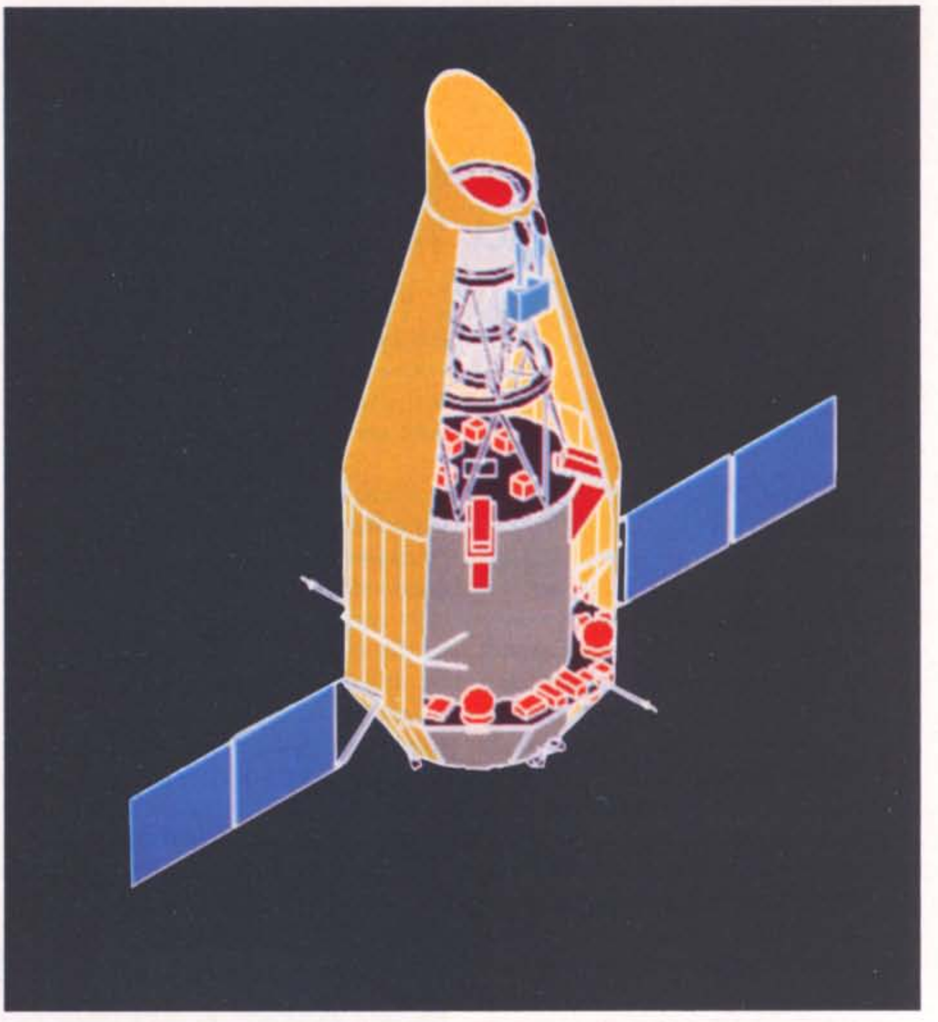


Figure 2 — Artist's impression of the Lyman spacecraft

1200 Å and are therefore inefficient at shorter wavelengths.

The key 900—1200 Å band, known as the 'Lyman domain', is of crucial interest as it contains important spectral features of the most abundant interstellar and stellar atomic species and molecules, such as the Lyman lines of atomic hydrogen and deuterium, the Lyman and Werner bands of molecular hydrogen, and the resonance transitions of key ionic species (e.g. C III, N II, O VI). As the Copernicus satellite showed during the mid-seventies, this segment of the spectrum is incredibly rich in astrophysical information on a great variety of objects covering a wide range of temperatures and densities.

Despite its low efficiency, restricting observation to the brightest objects, Copernicus contributed significantly to our understanding of stellar winds and the physical state of the interstellar medium. As an example, Figure 3 shows the Lyman spectral range of the hot star Zeta Puppis, containing a number of broad lines formed in the wind of the star. The numerous narrow absorption lines also visible in the spectrum are typical of the interstellar medium.

This clearly emphasises the need for a high-resolution, high-sensitivity spectrographic mission optimised for the 900—1200 Å range to complement the HST and IUE missions. Several mission concepts have previously been studied. Although based on different approaches, they all addressed similar scientific objectives, once again endorsing the widespread enthusiasm within the international astronomical community for a spectrographic satellite covering the crucial Lyman domain.

The concept of a cooperative Explorer-class Lyman mission was studied by ESA and NASA and then selected by ESA for a Phase-A study early in 1986. However, the delay in NASA's Explorer programme following the Challenger accident meant that ESA could no longer proceed towards mission selection in 1988 as originally envisaged. A quick re-evaluation between November 1986 and January 1987 resulted in a new, ESA-led mission, with potential participation from Australia and Canada, compatible with the concept of a medium-sized ESA project.

The revised mission envisages the Lyman spacecraft being injected into a highly efficient 120 000 km 48 h orbit from a shared Ariane launch, via an initial geostationary transfer orbit. This low-cost orbit would allow both real-time observing and uninterrupted observations exceeding 38 h at low-background level.

This choice of launch and orbit does, however, place engineering constraints on spacecraft mass and volume and, consequently, on the scientific capabilities of the mission. However, these are very broad and extend to most areas of modern astronomy, from detailed observations of solar-system objects, the interstellar medium, stars and the Galaxy, to studies of cosmological significance. The Doppler shifting of the spectra of cosmologically distant sources due to the expansion of the Universe leads to some overlap with the objectives of the HST. Consequently, the Lyman payload would be optimised to study the science goals unique to the 900—1200 Å spectral region. The more demanding of these investigations include accurate determination of the deuterium abundance in the local interstellar medium and in the intergalactic medium at low red shift, and extensive mapping of the interstellar O VI and of the interstellar molecular hydrogen in the disc and halo of the Galaxy.

These goals require high spectral resolution ($R \simeq 30\ 000$) and full 900—1200 Å wavelength coverage, in order to ensure that ambiguities in the curve-of-growth analysis due to line blending can be minimised. In particular, the 900—1200 Å region is of vital importance for the key deuterium problem in order for the higher lines of the Lyman series to be observed.

The Lyman payload currently under study thus consists of an 80 cm-aperture, f/10 glancing-incidence telescope feeding

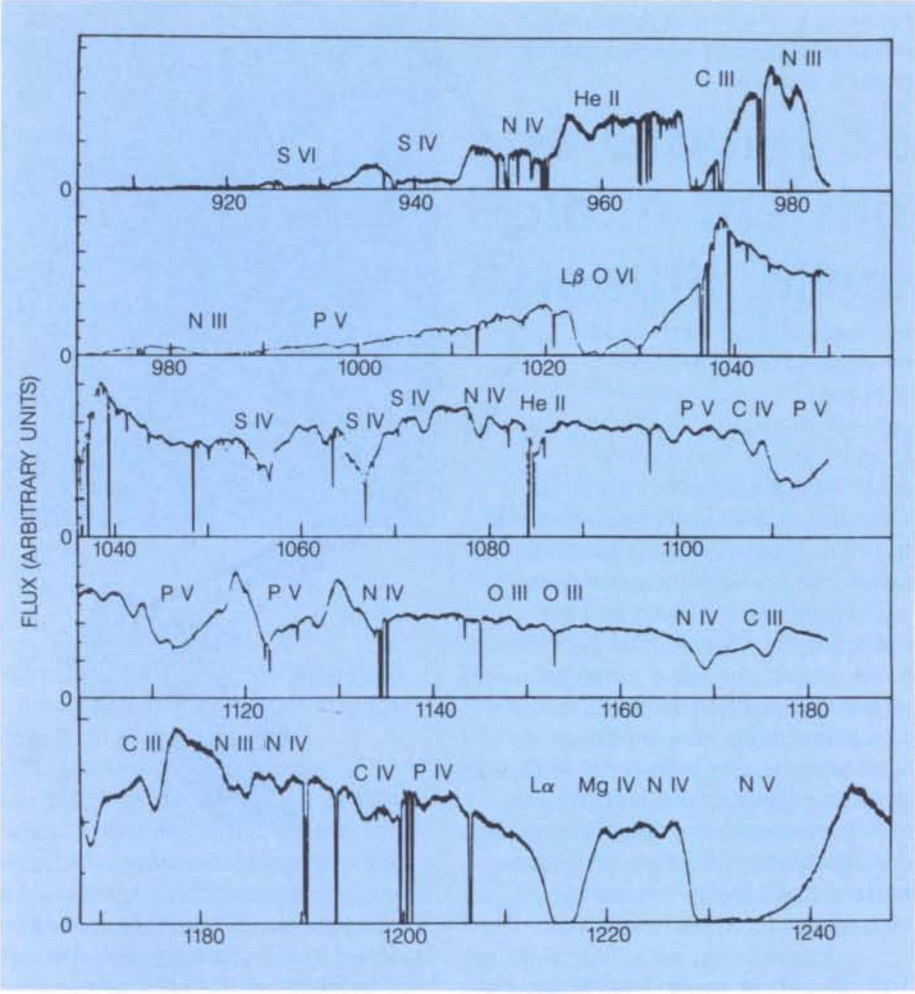


Figure 3 — The 900—1250 Å spectral range of the hot star Zeta Puppis as observed by Copernicus. Note the richness of the spectrum, showing both narrow interstellar lines and much broader stellar lines formed in the star's wind. These include features produced by various typical ionic species such as C III, N III and N IV, and O III—O VI

a high-resolution spectrograph of either Rowland, Wadsworth or Echelle design, and one or two secondary spectrographs working at longer (1200—2000 Å) and/or shorter (100—300 Å) wavelengths, respectively. The goal for the prime spectrograph is to achieve a limiting magnitude of at least $V \simeq 14^m$ in the 900—1000 Å wavelength region, probably rising to $V \simeq 16^m$ at longer wavelengths, where Al/LiF and Al/MgF_2 reflective coatings can be used.

The Lyman payload would be capable of achieving a sensitivity between one and ten thousand times better than that of the Copernicus spacecraft at twice the spectral resolution.

Lyman would be operated mainly as a guest-observer astronomical telescope in a manner following on from the IUE and Exosat missions.

The Quasat mission

The Quasat (Quasar satellite) mission concept involves operating a free-flying satellite carrying a 15 m radio telescope in an elliptical orbit around the Earth. This orbiting radio telescope would be used to make interferometer observations of radio sources in conjunction with the major Very-Long-Baseline Interferometry (VLBI) networks of ground-based radio telescopes in Europe, the USA, the USSR and Australia.

The VLBI technique is based on the combination, as one single instrument, of radio telescopes separated by distances (baselines) as large as the Earth's diameter, to provide radio observations with very high angular resolution (up to 3×10^{-4} arcsec). The obvious reason for going into space is to create interferometer baselines longer than the Earth's diameter and thereby achieve improved angular resolution. Equally important, images of improved quality can be obtained by appropriate choice of the orbit.

The Quasat mission, illustrated in Figure 4, responds to these requirements for space-based VLBI. It is designed to provide images (continuum and line) of the total intensity and polarisation emission of compact radio sources, with a combination of angular resolution and image quality unattainable on Earth.

Quasat was originally studied by ESA and NASA as a cooperative Explorer-class mission, and was selected by ESA for a Phase-A study early in 1986. However, as for the Lyman mission, the impact of the Challenger accident necessitated a re-evaluation of the project and resulted in the proposal of an ESA-led medium-class mission with potential participation from Australia and Canada.

For Quasat this meant a low-weight (<1150 kg) spacecraft to be launched by Ariane-4, in a dual-launch configuration, into a 7° inclination geostationary transfer orbit (GTO). This involved sacrificing the simultaneous dual-polarisation capability and reducing the antenna diameter. It was shown that a configuration based on a 10 m offset antenna would fit inside the lower compartment of the Ariane launcher and would allow a higher aperture efficiency.

From GTO, the spacecraft's inclination would be increased to 30° and the perigee altitude raised to 5000 km by a solid booster, the apogee altitude remaining at 36 000 km. After a certain period of operation in this orbit to provide a high resolution but poorer image quality, the orbit could be changed by lowering the altitude to 22 000 km to provide excellent imaging but with lower resolution.

The sensitivity for continuum observations would be unchanged because the full bandwidth would be used for one polarisation instead of one half per polarisation. Several factors (the two most important being the higher orbit improving resolution and the use of larger diameter telescopes on the ground) suggest, however, that the spectral-line performance of Quasat would be adequate.

The major scientific objectives of the redefined Quasat mission include study of the nuclei of Radio Galaxies and quasars with resolution scales approaching those expected for

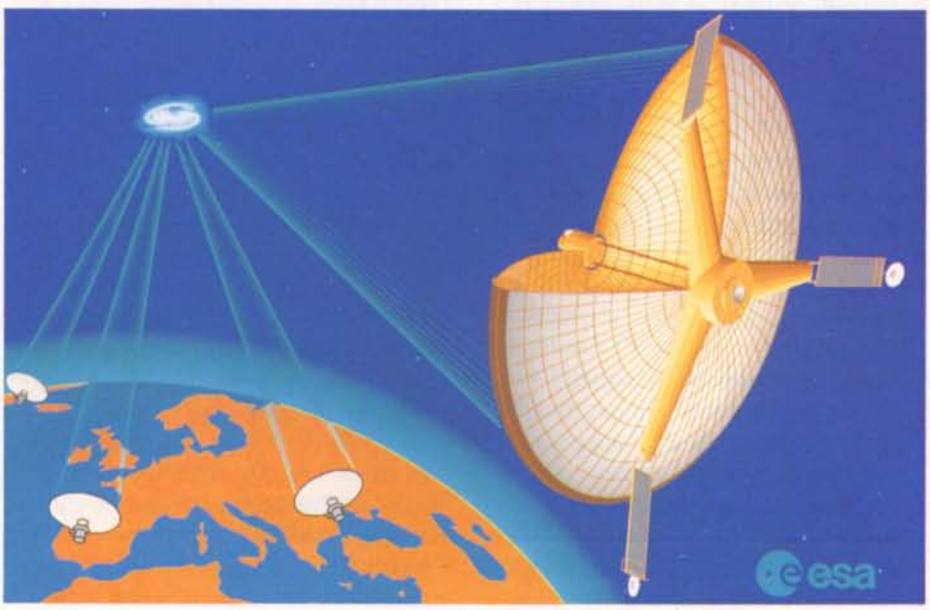


Figure 4 — Artist's impression of the orbiting Quasat radio telescope as part of a Very-Long-Baseline Interferometer (VLBI) network

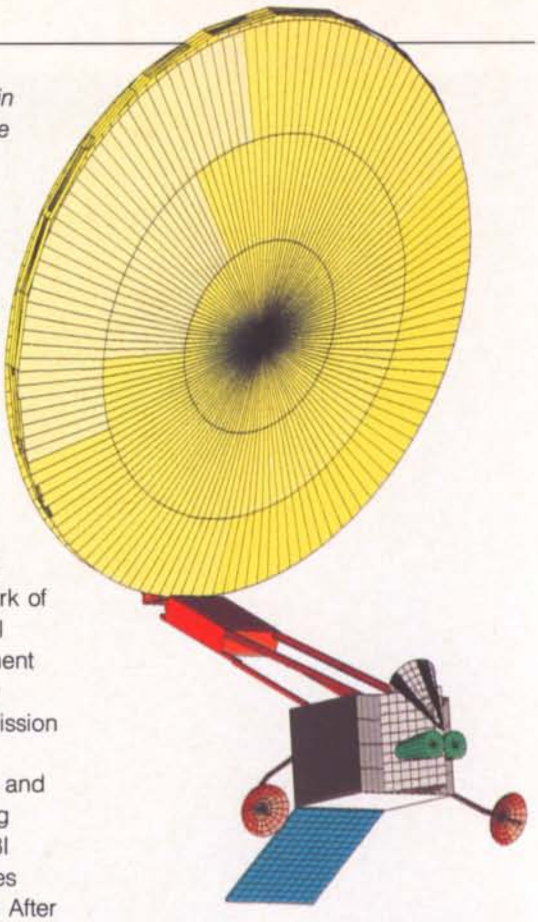


Figure 5 — The Quasat spacecraft in orbital configuration with its inflatable antenna deployed

accretion discs around massive black holes. Not only would this add to our knowledge of the physics of the central power source, but it would also throw light on the origin of the jets that transport power from the central object at relativistic speeds. The resolution available with Quasat would allow several aspects of stellar evolution to be studied, both through stellar and interstellar masers and through studies of flare stars and X-ray stars. Moreover, study of the proper motion of the point water maser features would allow measurement (through statistical parallax considerations), of the distance to the sources. Such direct measurements are of particular importance in the case of masers associated with nearby Galaxies (1—20 Mpc) because they would provide a new independent estimate of the Hubble constant.

The observing frequencies selected for Quasat cover the maser line emissions at 22 GHz for H_2O and 1.6 GHz for OH. A third frequency of 5 GHz has been chosen to fill the gap between 22 and 1.6 GHz and provide a different combination of resolution and surface-brightness sensitivity. An additional low frequency of 0.327 GHz would be included for observations of pulsars.

Quasat's spaceborne antenna would relay the signals received via an analogue link directly to a network of telemetry stations on the ground. All communication with the space element would be via one or more telemetry stations in the network. After transmission to the ground, the signal would be recorded digitally on magnetic tape and transported to the central processing facilities of the European or US VLBI array for correlation with similar tapes from the ground-based VLBI arrays. After correlation and calibration, the data would be sent to the Principal Investigators for further analysis.

The assessment studies have shown that the overall Quasat mission, which is based on current VLBI and spacecraft engineering practice, is technically feasible. This has recently been further demonstrated by a VLBI experiment involving the American TDRSS satellite and ground-based telescopes in Japan and Australia. The major new feature of the spacecraft would be its antenna concept, relying on the new Kevlar-based technology of an inflatable, space-rigidised structure. The antenna would be launched folded and then inflated to the required dimensions and made rigid in space (Fig. 5).

VLBI is already a worldwide activity into which the Quasat mission could be integrated quite naturally. We could therefore expect Quasat to be exploited by a very large and well-established community of radio astronomers.

Conclusion

The Phase-A activities for both Lyman and Quasat have now been initiated and are scheduled to be completed by the end of May 1988. The GRASP Phase-A activities will commence before the end of 1987, to be completed in September 1988. By then, model spacecraft and payloads will have been defined and good cost estimates will be available.

Together with two missions in the field of planetary research, these astronomy missions will enter competition for selection by the end of 1988. The approved mission will be subjected to a detailed industrial system-design phase (Phase-B) followed by hardware development and testing (Phase-C/D) in the 1990—1995 time frame, with launch scheduled to take place in 1996—1997.

The Ground Segment's Vital Role in the Hipparcos Scientific Mission

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ESA's astrometry satellite Hipparcos is presently at an advanced stage of integration and testing, with completion of the flight model scheduled for the beginning of 1988. Design of the dedicated ground-segment functions required to support this mission has been completed and the various support elements are now being implemented. The paper provides a global description of the important role of the ground segment in supporting the scientific mission operations and in guaranteeing the quality of the data products to be delivered to the scientific community.

Introduction

Hipparcos will be the first satellite mission with a payload primarily dedicated to global astrometry. The prime objective of the 2.5 yr mission is to produce a star catalogue containing the astrometric parameters for a set of about 100 000 pre-selected stars of magnitude down to $B=13$. The accuracy of the parameters in this catalogue will be unprecedented: star position components and parallaxes will become known to typically 2 marcsec, and the proper motions will be established to an accuracy of about 2 marcsec per year. The fundamental measurements on which these results are based will be produced by an Image Dissector Tube (IDT).

A secondary mission called 'Tycho' will use signals provided by the Hipparcos Star Mapper's Photomultiplier Tubes (PMTs) to derive additional astrometric as well as photometric characteristics for a set of about 400 000 stars down to magnitude $B=11$.

The Hipparcos and Tycho catalogues are expected to be of revolutionary importance to the astronomical sciences.

More background on the scientific objectives, the principles of the sky-scanning, as well as spacecraft and payload design aspects, has been given in an earlier article by M. Schuyer, in ESA Bulletin No. 42, and in the ESA Brochure 'Ad Astra' (ESA BR-24). This article concentrates on the ground-segment's functions in support of the scientific mission.

Early operational activities

Hipparcos will be launched into a geostationary transfer orbit by an Ariane-4 launcher in 1989. Communications between the Operations Control Centre (OCC) at ESOC and the satellite will be maintained by means of the ESA S-band transfer-orbit ground network, with stations at Malindi (Kenya), Perth (Australia) and Kourou (French Guiana). These stations will provide telemetry and telecommanding, as well as tracking support.

The operational activities during this early phase will consist mainly of monitoring the functioning of all spacecraft subsystems and commanding the necessary controls. Spin-up and attitude-reorientation manoeuvres will be performed in order to achieve optimal conditions for apogee-motor firing. Nominally, this latter event will take place around the fourth apogee of the transfer orbit. Thereafter, the satellite will be placed by orbital manoeuvering into a drift orbit in order to reach its designated position at 12°W longitude above the equator within the allocated 12 d interval. During its drift phase, the satellite will be in continuous contact with the OCC. During this phase, the Hipparcos-dedicated Odenwald ground station near Michelstadt (about 40 km southeast of ESOC) will establish contact with the satellite for the first time. This station will subsequently support all telecommanding, telemetry and tracking functions throughout the 2.5 yr mission.

After terminating the satellite's orbital drift, telecommands will be sent from the

Figure 1 — The Main Control Room at ESOC in Darmstadt

Figure 2 — Hipparcos-dedicated Odenwald ground station near Michelstadt, West Germany

ground to despin the satellite, to point its z-axis towards the Sun, and to drain the remaining (liquid) hydrazine fuel. The hydrazine expulsion will prevent sloshing effects, which would cause attitude disturbances and thereby degrade the quality of the mission's data products. From this point onwards, all attitude and orbit control will be performed by means of the satellite's cold-gas thrusters.

Initialisation of payload operations

Payload operations will be initiated during the Sun-pointing phase. The telescope shutters will be opened and the two onboard computers (one for central processing, the other for attitude-control functions) will then be operational. Light entering either of the two telescope fields of view (Fig. 3) is combined by a flat aspheric mirror and deflected onto the common modulating grid system located within the payload's focal surface. The two redundant Star Mappers (each having a vertical and an inclined slit system consisting of four individual slits) are located on either side of the main grid.

The satellite will perform a slow scanning motion at a nominal rate of 11.25 rev/d about an axis normal to the plane formed by the two telescope axes. A star crossing the Star Mapper's slits will therefore produce a modulated signal. This signal will be sampled continuously by two photomultiplier tubes measuring different (B and V) spectral ranges. The resulting data stream will be downlinked in its entirety and will form the raw input data for the Tycho experiment during the nominal mission. During the initialisation phase, however, the Star-Mapper data will be processed by ESOC to make a precise determination of the satellite's attitude (down to arcsec level).

The first stage of ESOC's processing of the Star-Mapper data stream is designed to recognise the star transits contained in the data. The transit times of a set of about ten observed star crossings are to be correlated with actual star distances taken from a Star Catalogue strip around a great circle normal to the Sun's direction. This star pattern recognition algorithm is far from straightforward, since stars from the two telescope viewing directions are mixed in the Star Mapper's output stream. Furthermore, each star crossing produces two transit signals (one for the vertical and one for the inclined Star-Mapper slit system), with varying distances, depending on the ordinate of the crossing.

Once the identities of the star crossings have been established, the satellite's three-axis attitude can be calculated to arcsec-level accuracy using the star's inertial position coordinates contained in the Star Catalogue. This is done by means of a real-time Kalman filter which estimates the attitude parameters as well as gyro drift rates from the measured star-crossing times.

The precise on-ground knowledge of the satellite's attitude will allow the construction of a so-called 'Program Star File' (PSF), which contains the nominal future crossing times of a number of catalogue stars, calculated on the basis of a nominal attitude-evolution model. The PSF data, as well as the attitude parameters determined, will be communicated to the satellite's onboard computers. Real-time attitude determination to 1 arcsec (rms) accuracy can then be performed onboard by comparing actual star crossing times over the Star-Mapper slits with the nominal times for the stars in the uplinked PSF.

Figure 5 shows a functional overview of the ground — satellite communications during the initialisation phase.

Once the onboard attitude-determination algorithm has become operational, Hipparcos' principal detector, the Image Dissector Tube (Fig. 4), can be switched on. The IDT has a small sensitive area — the 'Instantaneous Field of View' (IFOV) — covering an area with a diameter of about 35 arcsec on the celestial sphere. The IFOV can track the path of a star over the main field of view, resulting in a grid-modulated signal which is sampled at a frequency of 1200 Hz.

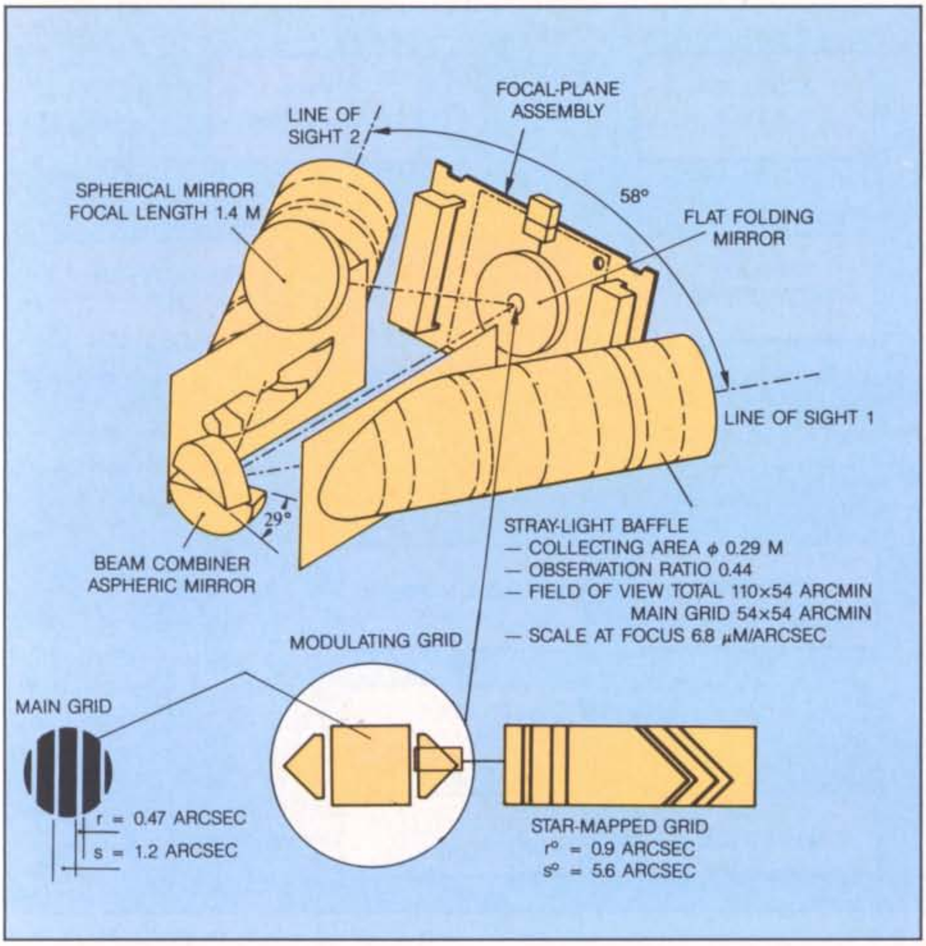


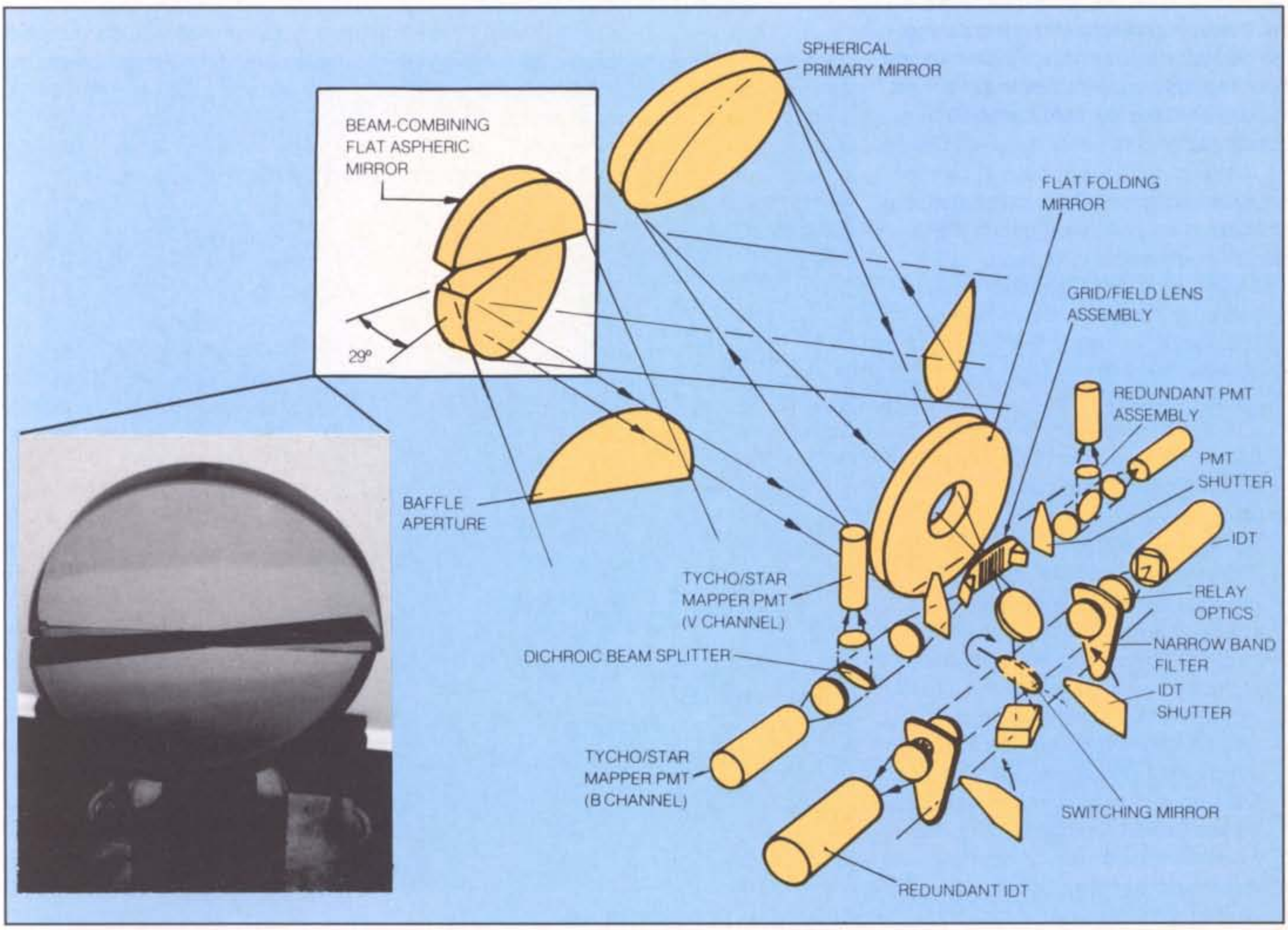
Figure 3 — Hipparcos telescope configuration

Figure 4 — Schematic of the Hipparcos optical payload

The star observation strategy implemented in the onboard computer will use uplinked PSF information to calculate the IDT currents required for piloting the IFOV from one star to the next in the main field of view, covering a 0.9°×0.9° square area on the sky. The phase differences in the modulated signals between the five or so PSF stars lying in the combined fields of view at any given time will form the fundamental entries for the scientific data processing, leading eventually to production of the Hipparcos Astrometric Catalogue.

Payload calibration operations

Achievement of the extreme accuracies imposed on the Hipparcos mission will be possible only if the payload satisfies



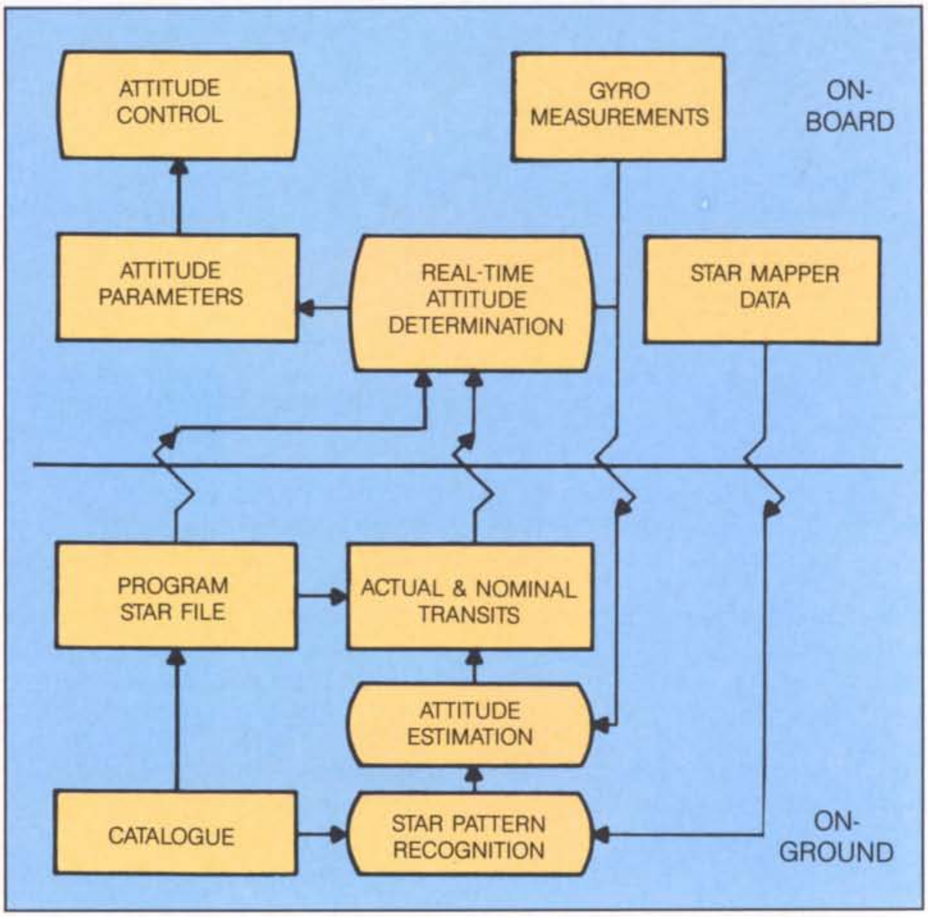


Figure 5 — Ground — satellite dialogue during the initialisation phase

stringent performance requirements. A number of payload calibration activities are therefore to be performed during the pre-launch tests. The ultimate calibration and verification of the payload's geometric and photometric performances can, however, only be done in the real operational environment.

A large part of the 40 d period dedicated to satellite commissioning is therefore reserved for payload calibration operations and associated data processing. This will involve the combined efforts of payload specialists, the project team and project scientist, the operations control team, and data-processing analysts, as well as calibration software specialists from ESOC and the scientific institutes. The payload calibrations must be conducted under the thermal conditions prevailing during the normal mission phase, which means that the satellite's z-axis has to be slewed to point at 43° away from the Sun's direction.

An overall summary of the calibration activities to be performed during the satellite commissioning phase is presented in Table 1. The three types of calibration support tasks have been categorised according to the following operational considerations:

1. Software and operational procedures must be implemented to generate the payload data to be subjected to the calibration analyses.
2. Software is needed to process the collected payload data and assess the results. This task may be the responsibility of a scientific institute or of ESOC, depending on the purpose of the particular calibration (i.e. results may be of purely scientific interest, or may be required for fast feedback into the payload operations).
3. Software and/or procedures need to be established for incorporating the results of a particular calibration activity into the operational environment.

Table 1 — Hipparcos in-orbit calibration activities

Calibration tasks	Type 1	2	3
A. Geometric calibrations			
1. Field-to-grid transformation of primary FOV:			
(i) for payload initialisation (<1 arcsec)		ESOC	X
(ii) for data reduction (<0.05 arcsec)		DRC*	X
2. Field-to-grid transformation for Star Mapper FOV		DRC	X
3. Grid-to-IDT currents transformation:			
(i) nonlinearity of transformation	X	ESOC	X
(ii) transverse offset	X	ESOC	X
(iii) IDT displacement relative to grid	X	ESOC	X
4. Chromaticity of primary FOV	X	ESOC	
5. Chromaticity of Star Mapper		DRC	
6. Attitude jitter induced by thruster actuations	X	ESOC	
B. Photometric calibrations			
1. Sensitivity of primary FOV		DRC	X
2. Modulation factors of IDT signal:			
(i) for refocussing operations	X	ESOC	X
(ii) for payload response evaluation		DRC	
3. Background count rate of primary FOV		DRC	X
4. Profile of IDT's sensitive area	X	ESOC	
5. Sensitivity of Star Mapper FOV		DRC	
6. Star Mapper single-slit response		ESOC	X
C. Stray-light calibrations			
1. Sun stray-light and light tightness	X	ESOC	
2. Stray light from Earth and Moon		ESOC	X

DRC = Data Reduction Consortia

The type-A3 geometric calibrations (Table 1) are essential for ensuring the accurate piloting of the IDT's IFOV onto the star image in the primary field of view. The IDT position relative to the grid system is to be calibrated at daily intervals. An automatic operational control loop providing a fast feedback (after validation) of the calibration results from the Hipparcos-dedicated ground computer to the onboard computer will be implemented and tested for this purpose. Most of the other calibrations will be performed only during the commissioning phase or are of an intermittent nature, allowing the data to be processed and analysed on an offline computer. The operational feedback from the geometric field-to-grid calibration and the Star Mapper's response is important for minimising possible biases in the onboard attitude determination, thereby improving the IDT piloting accuracy. Some of the photometric calibration results are to be used by ESOC as a basis for assessing the payload's performance during the normal mission.

Scientific mission support

During its nominal 2.5 yr mission, the Hipparcos satellite will perform regular scanning of the celestial sphere. Slow precession of the satellite's z-axis on a cone of 43° half-angle about the Sun's direction will provide complete and almost uniform sky coverage every six months. The 'ideal' scanning law will be achieved to within 10 arcmin at any given moment by the onboard attitude-control system.

The ground support for the payload functions during the normal mission will consist mainly of PSF-data telecommanding and telemetry-data monitoring and processing. Special support will be needed during periods of payload occultation (i.e. when one of the telescope viewing directions points close to the Earth or Moon direction), station-keeping manoeuvres, calibration operations, contingencies and re-initialisations.

Figure 6 gives a general impression of the flow of scientific data within the ground control centre, while Figure 7 shows the overall scientific data flow between the various establishments responsible for Hipparcos data processing.

The Program Star File (PSF)

Uplinked Program Star File data are required by the onboard computers for essentially two purposes:

(i) for constructing the strategy for distribution of the available observing time between the program stars in the FOV in an optimal manner;

(ii) for onboard real-time attitude determination on the basis of the observed differences between actual and nominal star crossing times over the Star-Mapper slit systems.

If the onboard PSF data were to run out, no scientific data could be acquired and the onboard attitude knowledge would degrade because of uncorrected gyro drift effects. Interruptions in scientific data of more than 20 min would seriously affect the quality of the data-reduction process. It is therefore imperative that outages in the communications link between satellite and OCC, as well as other interruptions in the real-time data acquisition, be minimised (in both duration and frequency). The strategy for uplinking PSF data has been designed to keep the onboard PSF memory space as full as possible at all times. It is expected that a PSF survival time of at least 40 min can be achieved throughout the mission.

The PSF will contain 12 bytes of information for each program star: apart from nominal crossing times (which are calculated from the imposed scanning law) and priority parameters used in the onboard observation strategy, the star's identification number, its instrumental magnitude, a (preceding or following) field-of-view identifier, as well as a few other characteristics will be provided in the PSF. The priority parameters that govern the observation time to be allocated to each star will be updated regularly during the mission to ensure

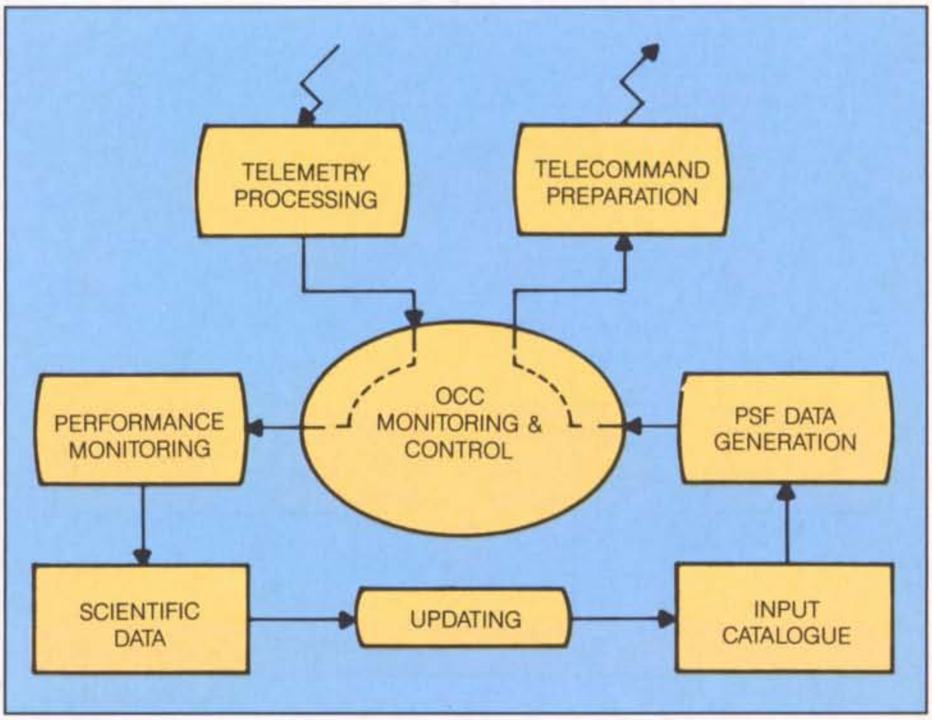


Figure 6 — Overview of scientific data flow at the Control Centre

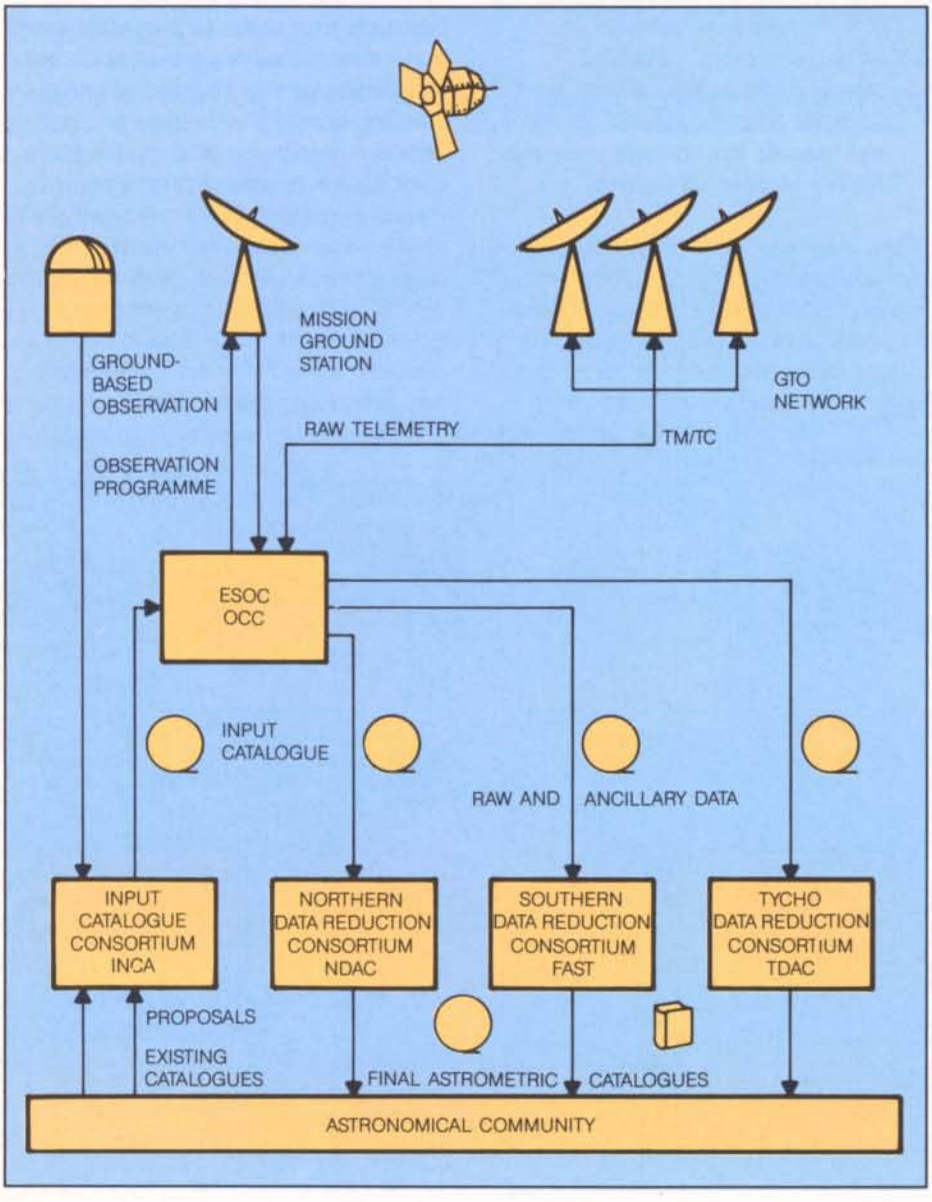
Figure 7 — Overall flow of scientific data in the Hipparcos Programme

that the actual observation history for each star is kept in balance with the projected one as far as is practically possible.

The PSF data will be prepared by ESOC using star characteristics provided in the so-called 'Input Catalogue', which is currently being compiled by the INCA Scientific Consortium. This Catalogue, which contains the characteristics of the 100 000 Hipparcos program stars, is the result of a systematic scrutiny of available catalogues, supported by extensive new ground-based observations and measurements.

Telemetry processing

The Hipparcos telemetry bit rate will be approximately 23 kbit/s. More than 80% of the telemetry data will be raw IDT and Star-Mapper photomultiplier outputs, which constitute the scientific data products. The remaining telemetry will consist of observation reports produced by the central onboard computer. These will provide the key to the 'reading' of the scientific data, as well as information on the performance of the spacecraft's subsystems. This last category of telemetry is needed by the OCC for monitoring and control purposes. On arrival at the ground station, the telemetry data will be time-tagged to within 12 μs of Universal Time (absolute datation) and to within 1 μs stability over a 5 min period (relative datation).



The telemetry data will be routed via a ground link to the Hipparcos-dedicated computer at ESOC, where they will be decommutated into various substreams in accordance with subsequent monitoring and processing needs. After proper validation, the scientific data, the supporting spacecraft telemetry products, as well as additional information generated by ESOC (e.g. orbit and monitoring results) will be written onto tapes for distribution to the three Scientific Consortia responsible for scientific data reduction:

- FAST (Fundamental Astronomy by Space Techniques), led by Prof. J. Kovalevsky at CERGA, Grasse, France;
- NDAC (Northern Data Reduction Consortium), led by Dr. E. Høg, Copenhagen University Observatory, Denmark;
- TDAC (Tycho Data Reduction Consortium), also led by Dr. E. Høg.

Each of the first two Consortia will be constructing an astrometric catalogue, so that the final results can be cross-checked. The third Consortium is responsible for the Star-Mapper data reduction.

Table 2 provides an overview of the distribution of the various data categories to these Consortia. The scale of the data-reduction process can perhaps be visualised from the fact that Hipparcos will produce about 1.5×10^{12} bits of scientific data during its nominal lifetime. It is estimated that more than

3000 magnetic tapes will be forwarded to the Consortia.

Data validation
It is essential that the final data products be completely fault-free when they are distributed to the scientific community. An important part of ESOC's support preparations therefore consists of testing the ground software with the aid of dedicated simulation facilities. In addition to software-level checks, the operational procedures and the interfaces of the various ground segment elements are to be exercised in the presence of the real software and hardware constraints well before launch.

Since the integrity of the data products is also affected by the performance of onboard elements, close to real-time performance monitoring of the payload data is being implemented on the Hipparcos-dedicated computer system. This facility will provide statistics on the predicted and actual outputs of the payload detectors for a pseudo-randomly selected set of stars. In this way, useful performance parameters will be available for spacecraft-control purposes. Furthermore, the performance evolution with time can readily be made available for detailed investigations.

Figure 8 provides an overview of the payload-performance monitoring concept. A final level of payload performance evaluation will be performed by the scientists on a weekly basis using 12 h of payload data. This validation will involve the first step of the data-reduction process and will uncover any performance fluctuations down to the milliarcsecond level.

Table 2 — Hipparcos data distribution to the Scientific Consortia

Raw IDT data stream	FAST/NDAC
Star-Mapper data for program stars	FAST/NDAC
Spacecraft subsystems telemetry	FAST/NDAC/TDAC
ESOC-generated auxiliary data	FAST/NDAC/TDAC
Star-Mapper (B and V) data streams	TDAC

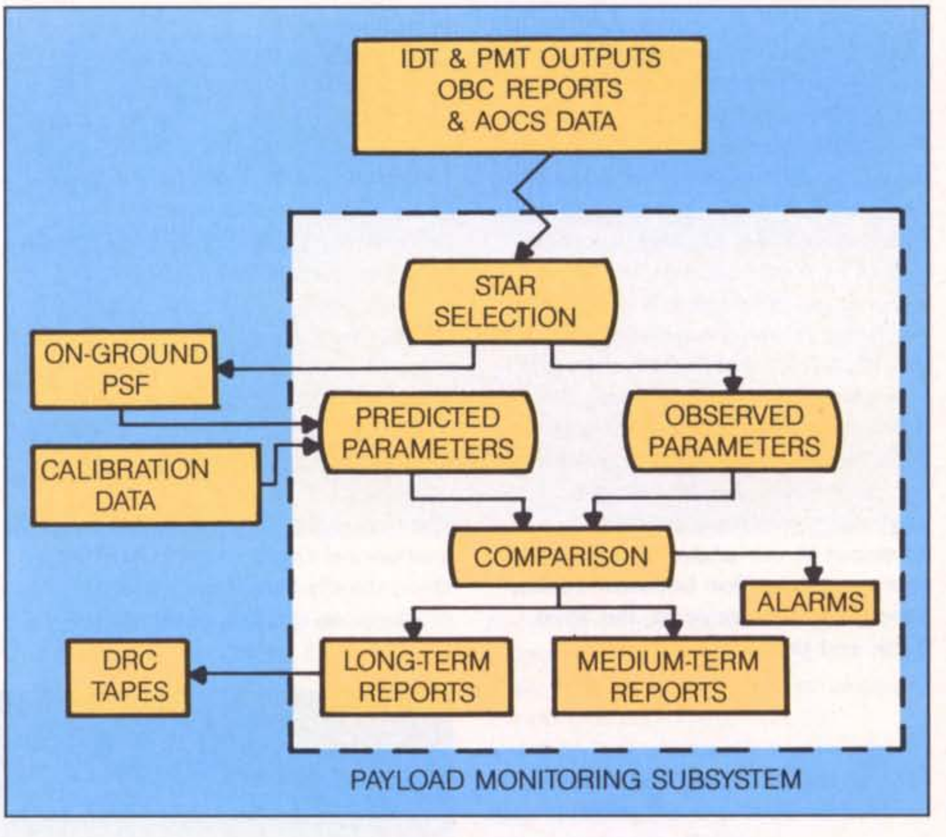


Figure 8 — Overview of the payload performance-monitoring concept

Conclusions
The Hipparcos mission is of fundamental importance to the astronomical sciences. Its success depends critically on good performance from each of a large number of elements in a chain involving the astronomical community, the project group, the spacecraft design and manufacturing teams, as well as the operations support teams.

The vital role of the ground segment in fulfilling the Hipparcos mission objectives may be summarised as follows: on one hand, it must ensure that the inputs prepared by the INCA Consortium are properly communicated to the satellite and, on the other, it must guarantee that the data products delivered to the scientists meet their high expectations.

Acknowledgement
The author wishes to acknowledge the efforts of all ESOC colleagues involved in the Hipparcos ground-support activities, of which this article, by necessity, provides a superficial summary.

The Earth-Observation Preparatory Programme

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The development over the last twenty years of space-based remote-sensing techniques for Earth observation has provided a new perspective of the Earth's environment. Global measurements of the land surface, the oceans, the ice regions and the atmosphere have become a routine means of providing data for weather forecasting, crop monitoring, land-resources management, mapping, etc. Moreover, researchers are also now using such data to study the fundamental problems of climate dynamics and global change. With the aid of satellite data, we are beginning to make significant advances in our understanding of the complex interaction between ocean, atmosphere, ice regions, the solid Earth and the land surface.

Introduction

Europe has made a significant contribution in the field of Earth observation over the last fifteen years, beginning in 1972 in the weather forecasting domain with the development of the Meteosat pre-operational programme. Since the first Meteosat was launched successfully in 1977, these satellites have provided data for both weather forecasting and scientific research. The recent inauguration of the Meteosat Operational Programme (MOP) will provide further Meteosat satellites to ensure continuity of service.

The birth of the newly established International Organisation EUMETSAT stems directly from these earlier programmes and it is expected to cooperate closely with the Agency in conducting both polar- and geostationary-satellite meteorology.

The first satellites dedicated to the Meteosat Operational Programme are expected to be launched in 1988 and 1989, with the launch of a third spacecraft planned in the 1991/1992 time frame. To cover the transition between the existing pre-operational and the operational meteorological satellites, the P2 prototype flight model of the Meteosat pre-operational series is presently being prepared for launch.

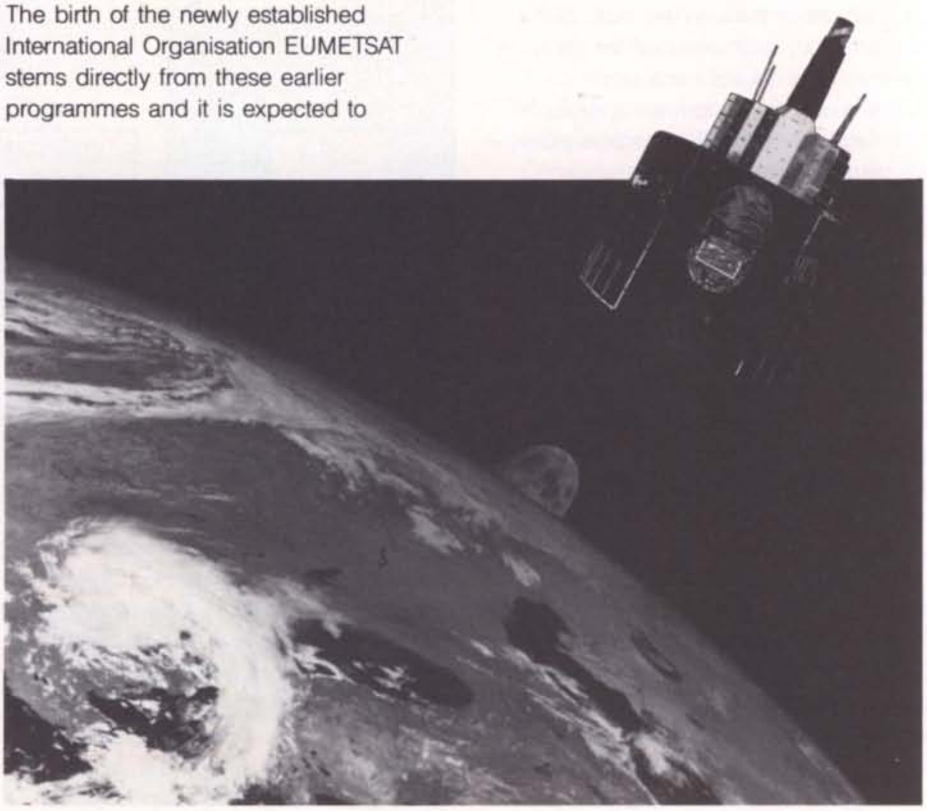


Figure 1 — Meteosat image of the Earth at 11.55 GMT on 17 October 1986, with the Moon in the background. Inset, the Meteosat P2 spacecraft to be launched later this year

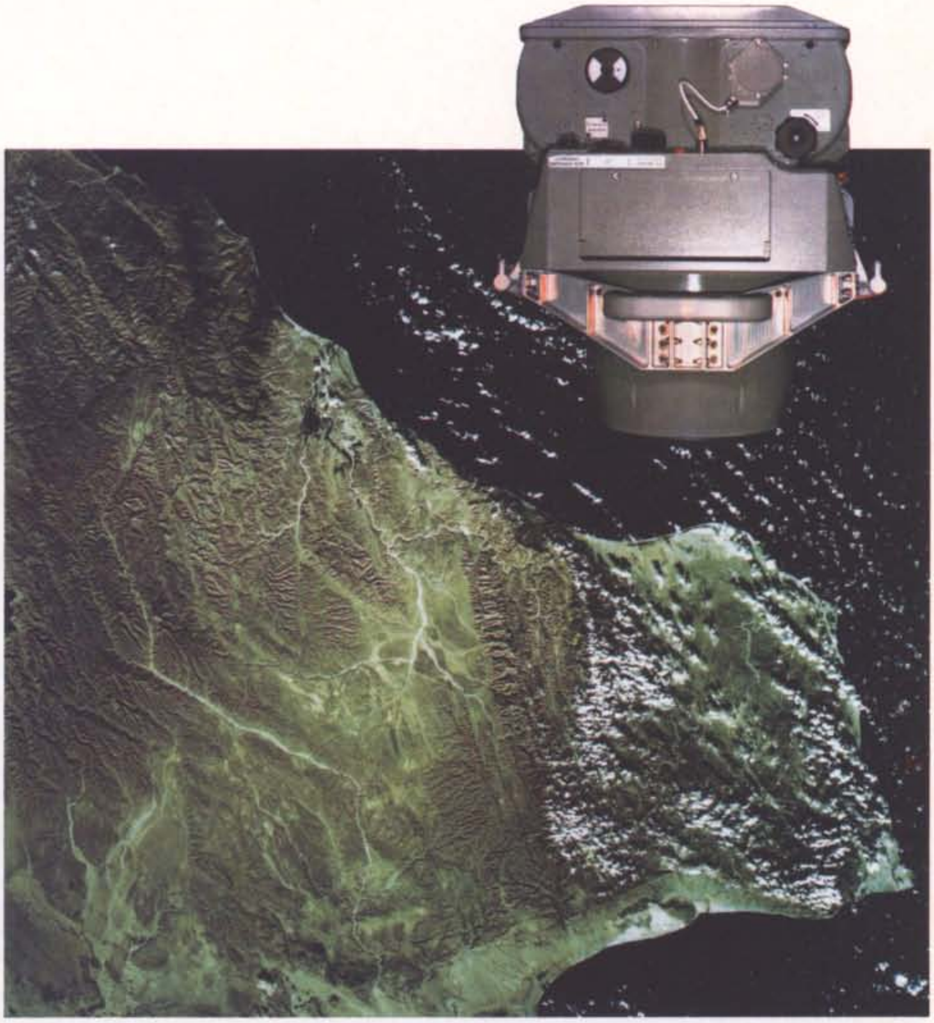


Figure 2 — Metric Camera image of the Horn of Africa, taken on 3 December 1983. Inset, the Metric Camera instrument

ESA has also participated in providing remote-sensing payloads for the Spacelab Programme. Data from a Metric Camera and a Microwave Remote-Sensing Experiment (MRSE) (passive mode) flown on the first Spacelab mission at the end of 1983, were received and made available to both the European and worldwide user communities.

The next major step, which is already well underway, is the development of the first autonomous European Remote-Sensing Satellite (ERS-1). This spacecraft, to be placed into a near-polar Sun-synchronous orbit, will perform primarily an ocean and ice mission, relying mainly on microwave instrumentation. These data will also be used directly for research and development activities associated with meteorology and land applications.

The ERS-1 spacecraft will carry a Radar Altimeter (RA), an Active Microwave Instrument (AMI) — combining a Synthetic Aperture Radar and a Wind Scatterometer — a Laser Retro-Reflector (LRR) and two nationally funded instruments, the Along-Track-Scanning Radiometer (ATSR) and the Precise Range and Range-Rate Equipment (PRARE).

Planned for launch in Spring 1990, ERS-1 is expected to have operational life of approximately two years. The Agency is therefore proposing to the Member States participating in the ERS Programme that a second, identical spacecraft be launched in the 1993 time frame.

Earth-observation long-term planning and objectives of future activities

The overall objectives for Earth observation for the longer term are identified in Europe's Long-Term Space Plan. They include the development of spaceborne methods for acquiring the data and information necessary for a better understanding of the complex global physical processes that govern the state of the Earth's surface and its atmosphere.

As a consequence, future missions will need to provide a continuous supply of high-quality data over long periods (decades) to a large number of interrelated disciplines — ocean, ice, land, solid Earth and atmospheric research and applications. At the same time, these future programmes have to satisfy the prevailing political, technological and operational objectives.

Europe's Earth-observation activities must maintain relative independence to serve the specific needs of the European user, whilst at the same time complementing Earth-observation programmes undertaken by individual countries in Europe (e.g. Spot) and elsewhere (e.g. NASA's Environmental Observation System EOS and Japan's Earth-observation programmes). The necessary international coordination will be arranged through specific forums which have already been created to harmonise such activities and to provide for the mutual exchange of data.

At the same time, ESA's programme must enhance the ground processing capabilities in Europe and provide a number of standard products for the user community, paving the way for a gradual transfer from research to applications.

To date, the Earth-observation activities of the Agency have, in the majority of cases, been non-mandatory (optional) programmes, which require special agreements in terms of the financial contributions from the participating Member States.

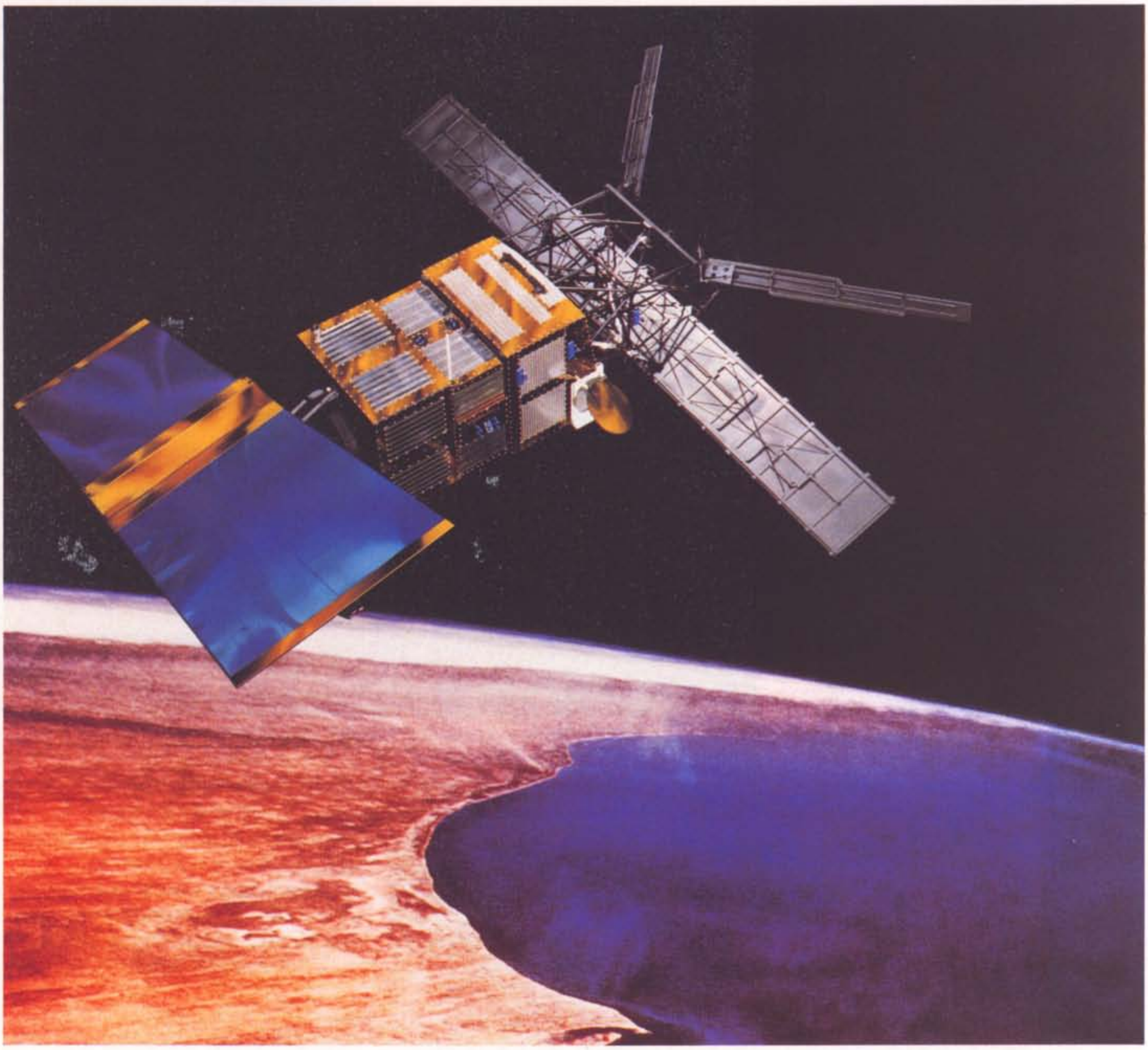


Figure 3 — Artist's impression of the first European Remote-Sensing Satellite, ERS-1, in orbital configuration

The Earth-Observation Preparatory Programme (EOPP)

As previously mentioned, in 1985 the Agency's Member States agreed to a European Long-Term Space Plan (LTP) which identifies, inter alia, the objectives for future ESA Earth-observation activities from space for the next decade. As a consequence, in 1986, the ESA Member States, together with associated and cooperating States, agreed on an Earth-Observation Preparatory Programme that will initially last five years.

The purpose of the EOPP is to develop those programmes that have been identified in the European Long-Term Space Plan to a level of proven overall system feasibility (Phase-A level), in order to provide the necessary information to allow potential participating States to agree on the full implementation of these programmes.

The subsequent phases of the EOPP — Phase-B ('detailed definition'), Phase C/D ('development, qualification, manufacture and launch') and Phase-E ('operation') — will require special approval by the participating States (Enabling Resolution, Declaration, and Implementing Rules).

The programmes to be prepared to system Phase-A level in order to fulfil the overall Earth-observation long-term objectives are:

a. a Solid-Earth Programme to cover missions for precise positioning and geopotential field measurements;
b. a Second-Generation Meteosat Programme to follow the Meteosat Operational Programme with a vastly improved system providing more data of better quality, as well as new types of meteorological data;
c. a Polar-Orbit Earth-Observation Programme which will be multi-disciplinary in nature, and will exploit the Polar-Platform element of the International Space Station venture to which Europe plans to contribute a European Polar Platform that will cross the equator in the morning hours (local time);
d. a Flight-Opportunity Programme, providing flight opportunities for instruments developed nationally, and allowing a broad European and international user community access to the data.

Preparatory studies to be performed within the EOPP include:

— mission-concept studies that address, for example, the best groupings of instruments onboard particular spacecraft for fulfilling the mission objectives in an optimum manner;
— instrument-feasibility studies that identify (parametrically) the technical difficulties and the feasibility of developing specific instruments. This will also provide information on how such instruments could be developed;
— system studies, which address the overall feasibility of an end-to-end system (space segment and ground segment) for the data expected from these future missions;
— airborne measurement campaigns to identify the key parameters and their relative importance in the achievement of specific research and application objectives;
— the investigation and definition of basic technology requirements;
— the pre-development of critical technologies and subassemblies;
— an overall mission-feasibility study at system level (i.e. system-level Phase-A study), including an estimation of programme costs, schedules and risks.

The latter information should be sufficiently detailed for the preparation of a 'Proposal for Programme Implementation' for potential participating States to consider.

Interfaces with the science and applications user community
Frequent and close contacts with the scientific and applications-oriented users are vital to the success of the preparations for future European Earth-observation activities. Consequently,

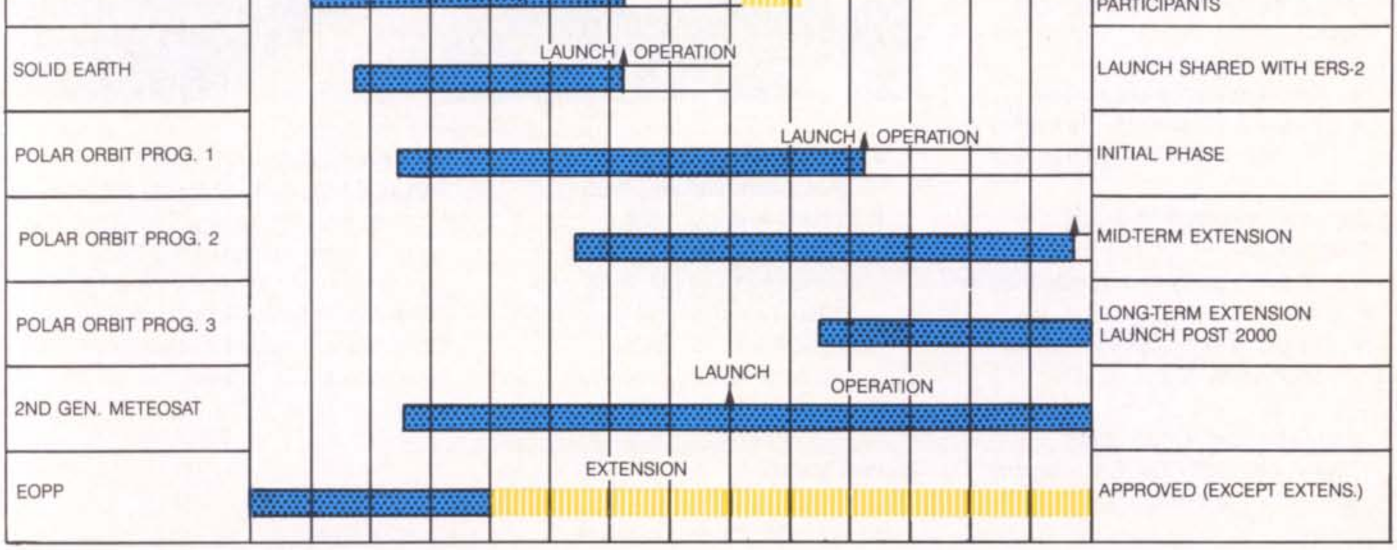


Figure 4 — ESA's long-term planning for Earth-observation missions

Figure 5a — Laboratory model of the 'GRADIO' satellite instrument (with associated electronics) being developed for precise potential-field mapping from space (courtesy of ONERA, France)

Figure 5b — The accelerometer cube of the 'GRADIO' instrument. The cubic cavity containing the proof mass has a side length of approximately 5 cm (courtesy of ONERA, France)

Figure 6 — Artist's impression of the Agency's Polar Platform destined to carry, inter alia, Earth-observation payloads

special endeavours have been and are being made to obtain the necessary feedback from these communities by:
- the holding of special workshops
- the formation of small ad-hoc teams to advise on instrumentation and scientific and technical matters
- the pursuit of interaction with advisory bodies of the Agency
- the formation of expert groups to address technical problems resulting from the implementation of key mission requirements
- the issue of Announcements of Opportunity
- the scheduling of regular overall briefings for the user community.

Organisation and schedule

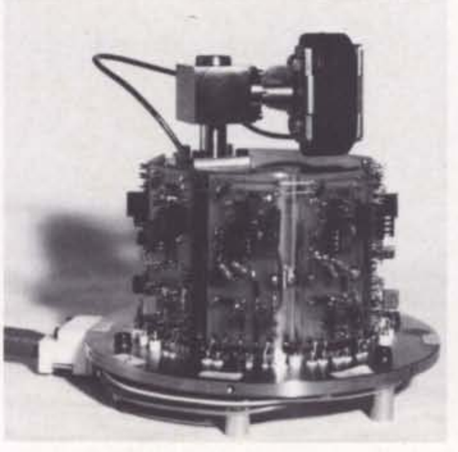
The EOPP started in 1986 and will last for five years. It is managed by a team of fifteen staff located at ESTEC. The cost envelope for the Programme is approximately 52 Million Accounting Units (1985 economic conditions), the major part of which to be spent with European industry and European research institutes.

The States participating in the EOPP are: Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom and Canada.

The following nominal schedules are envisaged:
- *Solid-Earth Programme*
  - Tentative launch date: 1993
  - Phase-A study to be performed at the end of 1987/beginning 1988

- *Second-Generation Meteosat Programme*
  - Phase-A study to be performed in 1988
  - Target launch date for the first spacecraft: 1995

- *Polar-Orbit Earth-Observation Programme using the Polar-Platform Element of the International Space Station*



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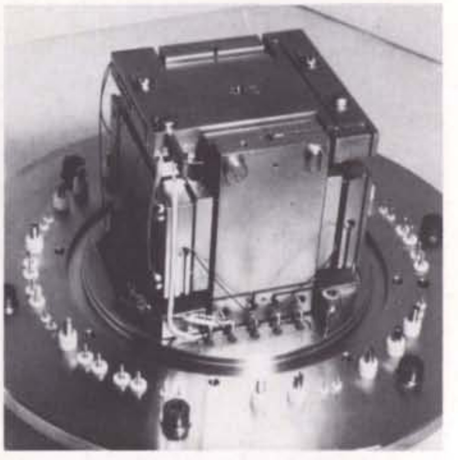

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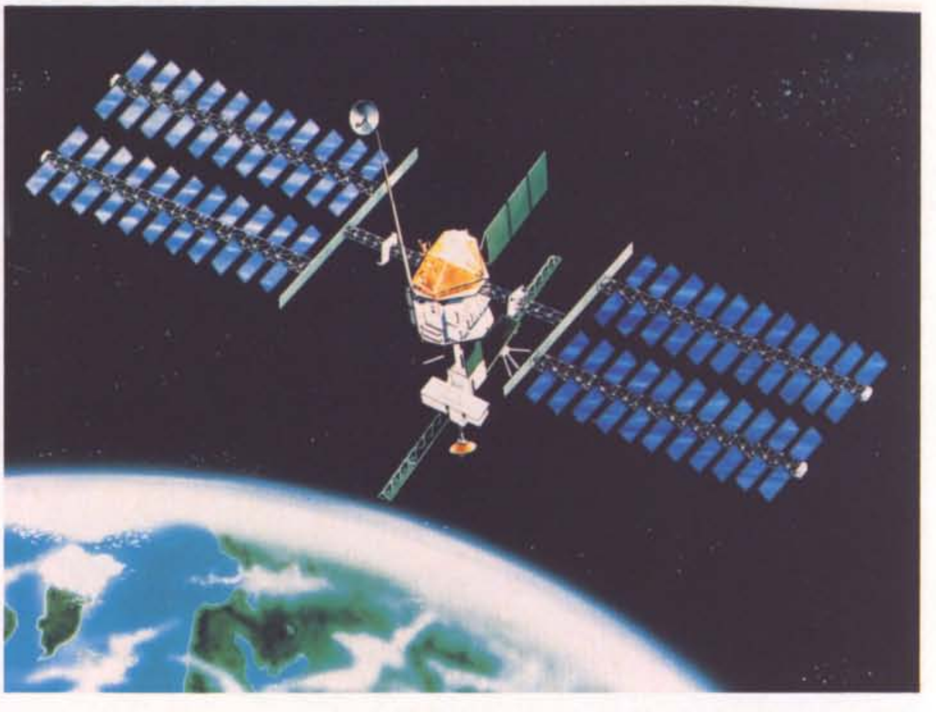


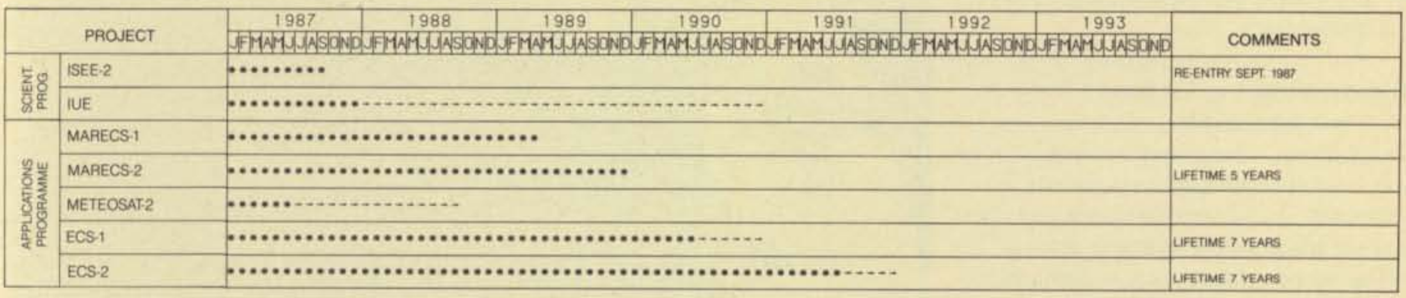
  - Tentative launch date for European platform: 1995
  - Phase-A study: 1989
  - Airborne campaigns to be performed in 1987, 1988, and 1989, aimed at characterisation of optical and microwave instrumentation, primarily for land applications.

Current status

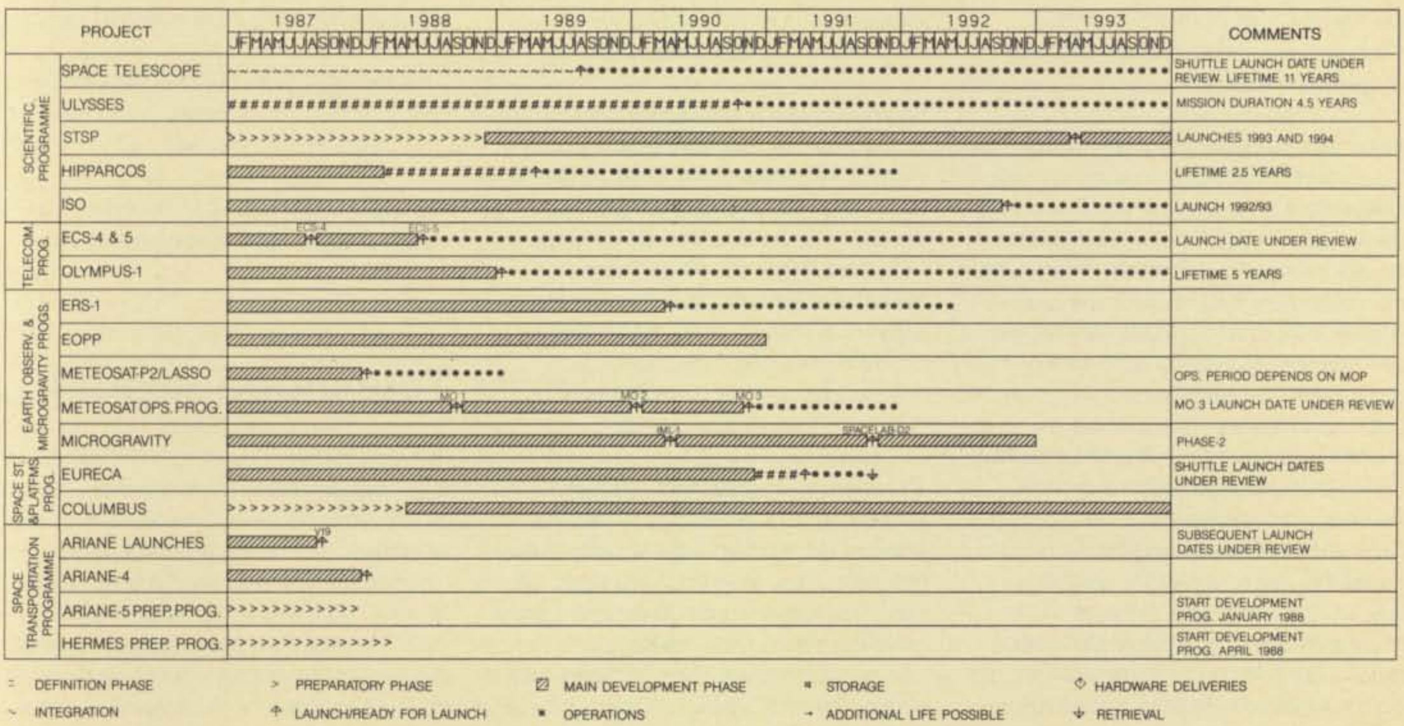
The European Long-Term Space Plan is presently under review, but initial indications are that the objectives in the field of Earth observation are not likely to be changed significantly. The schedule and the means of achieving these objectives might, however, be subject to some modifications, which the Earth-Observation Preparatory Programme will have to take into account.

Programmes under Development and Operations / Programmes en cours de réalisation et d'exploitation

In Orbit / En orbite



Under Development / En cours de réalisation



Météosat

Programme pré-opérationnel
Selon le dernier manifeste des lancements Ariane, début 1988 a été fixé comme date de lancement pour Météosat P2. Il n'est pas exclu que l'ordre de lancement des satellites soit modifié; en attendant, le satellite reste entreposé chez le maître d'oeuvre à Cannes.

Programme Météosat opérationnel (MOP)
Les travaux sur les trois unités de vol du programme se poursuivent de manière satisfaisante à l'Aérospatiale (F) où les satellites seront terminés et, si nécessaire, entreposés dans l'attente d'une occasion de lancement. Entre la fin de l'entreposage des satellites et leur lancement, il sera peut-être nécessaire de procéder à quelques essais supplémentaires.

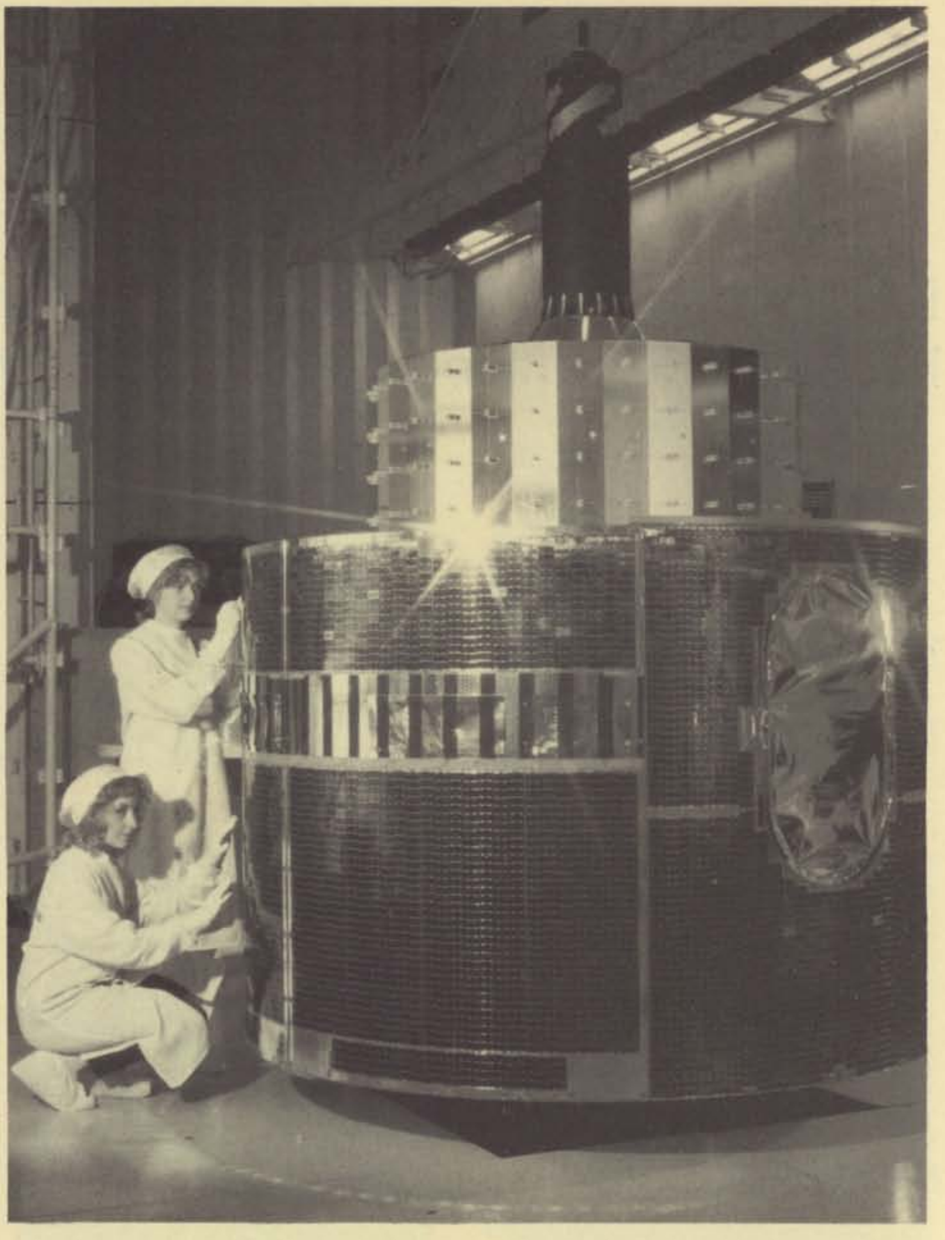
Secteur terrien
Opérations du satellite
Le 24 février, on a procédé à une manoeuvre d'inclinaison du satellite Météosat-F2, qui assure les missions de prise d'images et de diffusion de données, pour lui donner une attitude perpendiculaire au plan orbital. Les batteries ont été remises en condition et la manoeuvre de décontamination du radiomètre s'est faite comme prévu.

La plate-forme de collecte de données (DCP) étant assistée dans sa mission par le satellite GOES-IV, système Météosat pleinement opérationnel a continué d'assurer sa mission bien au-delà des niveaux spécifiés.

Traitement des données météorologiques
La production de vecteurs de mouvement de nuages à 0600 TUC à la demande d'EUMETSAT supposait un fonctionnement opérationnel début mars bien que cette mission se fasse aux dépens du produit 'altitude du sommet des nuages matinaux'. Le nouveau programme d'extraction des vents forts basé sur l'utilisation de fenêtres de radiance est devenu opérationnel le 11 mars. On a procédé début juin aux derniers préparatifs en vue de l'introduction d'un nouveau plan de correction de radiance. De plus, le produit 'humidité dans la haute troposphère' (HHT) a été partiellement redéfini de sorte que les résultats obtenus actuellement se limitent aux secteurs sans le moindre nuage ou ne comportant que des nuages bas.

Réaménagement du secteur terrien
Les travaux de réaménagement des stations sol se déroulent conformément aux plans, lesquels exigent que les stations soient prêtes fin septembre. L'antenne principale de 15 mètres de diamètre a été mise hors fonction de manière à pouvoir effectuer les travaux de réaménagement importants, au nombre desquels le remplacement du système de dégivrage défaillant.

Toutes les opérations Météosat sont actuellement assurées par la seconde antenne de 10 mètres de diamètre située elle aussi dans la forêt d'Odenwald. Mi-juin, il est prévu de procéder aux essais complets du nouveau réseau de communication que l'on vient d'installer, réseau reliant la station d'Odenwald aux installations de l'ESOC, le Centre européen d'opérations spatiales, à Darmstadt.



Intégration de MOP-1 à l'Aérospatiale, Cannes

The integration of MOP-1 at Aerospatiale in Cannes

Télescope spatial

Activités NASA
A la suite du retard prévisible dans la reprise des vols de la Navette, la date de lancement du Télescope spatial a été reportée du 15 novembre 1988 au 31 août 1989, soit un décalage de 9,5 mois. Ce retard est plus important parce que le Télescope spatial a été déplacé de la 5ème position de lancement à la

Meteosat

Preoperational programme
The current Ariane launch manifest indicates the launch of Meteosat-P2 early in 1988. Possibilities of rearranging the launch rankings are being reviewed and in the meantime the spacecraft remains in storage at the Prime Contractor's facility in Cannes.

Meteosat Operational Programme (MOP)
The work on the three MOP flight units is progressing satisfactorily at Aerospatiale (F) where the satellites will be completed and if necessary stored awaiting launch opportunities. Some additional testing may be required after the satellites are taken out of storage prior to launch.

Ground segment
Satellite operations
The attitude of the Meteosat-F2 satellite, which supports the image acquisition and the data dissemination mission, was adjusted to be perpendicular to the orbital plane on 24 February. The batteries have been reconditioned and the radiometer decontamination manoeuvre performed as planned.

With the Data-Collection Platform (DCP) mission further supported by the GOES-IV satellite, a fully operational Meteosat system has continued to perform well above specification.

Meteorological data processing
The production of cloud motion vectors at 0600 UTC assumed operational status at the beginning of March on the request of EUMETSAT, although this was at the expense of the morning cloud-top-height products. The new scheme for extracting high-level winds was introduced operationally on 11 March and involves the use of a radiance windowing technique.

Final preparations were made for the introduction of a new radiance correction scheme at the beginning of June. In addition, the Upper Tropospheric Humidity (UTH) product has been partially redefined such that results are now produced only for segments which are completely free of cloud or contain only low cloud.

Ground-segment refurbishment
Ground-segment refurbishment activities are proceeding according to schedule, which calls for station readiness by the end of September. The main 15 m diameter antenna was taken out of service to permit major refurbishment work, including replacement of the faulty de-icing system.

All Meteosat operations are at present performed through the second 10 m diameter antenna, also located in the Odenwald. Detailed tests on the newly installed communication system, linking the Odenwald station with the ESOC facilities in Darmstadt, are scheduled to take place in mid-June.

Space Telescope

NASA
As a result of the anticipated delay in the resumption of Shuttle flights the Space Telescope launch date has been delayed from 15 November 1988 to 31 August 1989. This 9.5 month shift is longer than the first launch shift because the Space Telescope has moved from fifth to seventh place on the Shuttle manifest as the fifth launch slot now corresponds to a planetary launch window.

Solar array
The solar-array wings were removed from the Space Telescope in early April. The spacecraft side of the interface has been reworked and a fit check is being prepared. Because of the launch delay the wings are expected to be returned to Europe for reworking later in the year.

Faint Object Camera
The Faint Object Camera (FOC) was removed from the Space Telescope in late March to allow the reworking of an equipment shelf in the Telescope's aft shroud. Preparations for the in-air calibration of the FOC are well in hand and the mechanical equipment and light sources have been shipped to USA.

Ulysses

Since the announcement of the NASA decision to delay the launch of Ulysses until late 1990, ESA activity has centred on revising schedules to meet the new launch date, whilst minimising the severe financial and manpower consequences of the latest postponement. The original launch date for Ulysses was February 1983.

On the assumption of an October 1990 launch the build-up of a new team will start in late 1988 and the spacecraft itself will be taken out of storage in early 1989 for reintegration, recertification and a new launch campaign.

A number of technical issues are still being resolved, in particular, it was found that a significant number of micro-processors provided via JPL suffer from a basic defect which could lead to complete failure of the mission. After thorough investigation it has been decided to replace all those parts in critical positions within the spacecraft and experiments. Work on the launcher interfaces is continuing and good progress is being made in most areas.

Hipparcos

The revised satellite launch date of April 1989 is the biggest single factor to affect the Hipparcos programme during this reporting period. The launch delay has introduced new elements into the Hipparcos schedule, namely satellite storage after the Flight Acceptance Review (which remains on schedule for early 1988) and satellite reactivation prior to shipment to the launch site. The requirements for storage and reactivation are being studied in depth by both ESA and industry. It is intended that by the end of the year a contract with industry to perform the required activities will be concluded.

Integration and test activities are now at their height. Following integration of the engineering model payload and spacecraft, the engineering model satellite integrated subsystem testing has been completed. Full satellite integrated system testing is under way and will be completed by the end of June.

In parallel, integration and test of the Proto-Flight Model (PFM) payload continues, and has started for the spacecraft. After completion of telescope assembly testing in Liège, the assembly was returned to Matra, (F), where it was integrated with the focal plane assembly to form the PFM payload. Payload testing, although suffering a setback due to a failure on a remote terminal unit, has continued satisfactorily with straylight and integrated system testing completed. Delivery of the payload to Aeritalia (I) for

7ème, vu que la 5ème position sur le manifeste de lancement de la Navette correspond maintenant à une fenêtre de lancement planétaire.

Générateur solaire
Les ailes du générateur solaire du Télescope ont été démontées début avril. L'interface côté satellite a été retouchée et l'on prépare un essai de compatibilité. En raison du retard pris pour le lancement, on prévoit d'ici à la fin de l'année de renvoyer les panneaux en Europe pour retouche.

Chambre pour objets faibles (FOC)
Fin mars, on a démonté la chambre du Télescope spatial de manière à permettre des travaux sur une case d'équipement située dans le carénage arrière de ce dernier. Les préparatifs pour l'étalonnage de la chambre à la pression atmosphérique se déroulent comme prévu; les installations mécaniques et les sources lumineuses ont été expédiées aux Etats-Unis.

Ulysse

Depuis l'annonce de la décision de report du lancement d'Ulysse à la fin de 1990, les activités de l'ESA se sont concentrées sur la révision des calendriers pour les faire correspondre à ce nouveau créneau de lancement, tout en tâchant de réduire au minimum les graves répercussions de ce retard sur le plan financier et humain. A l'origine, la date de lancement avait été fixée à février 1983.

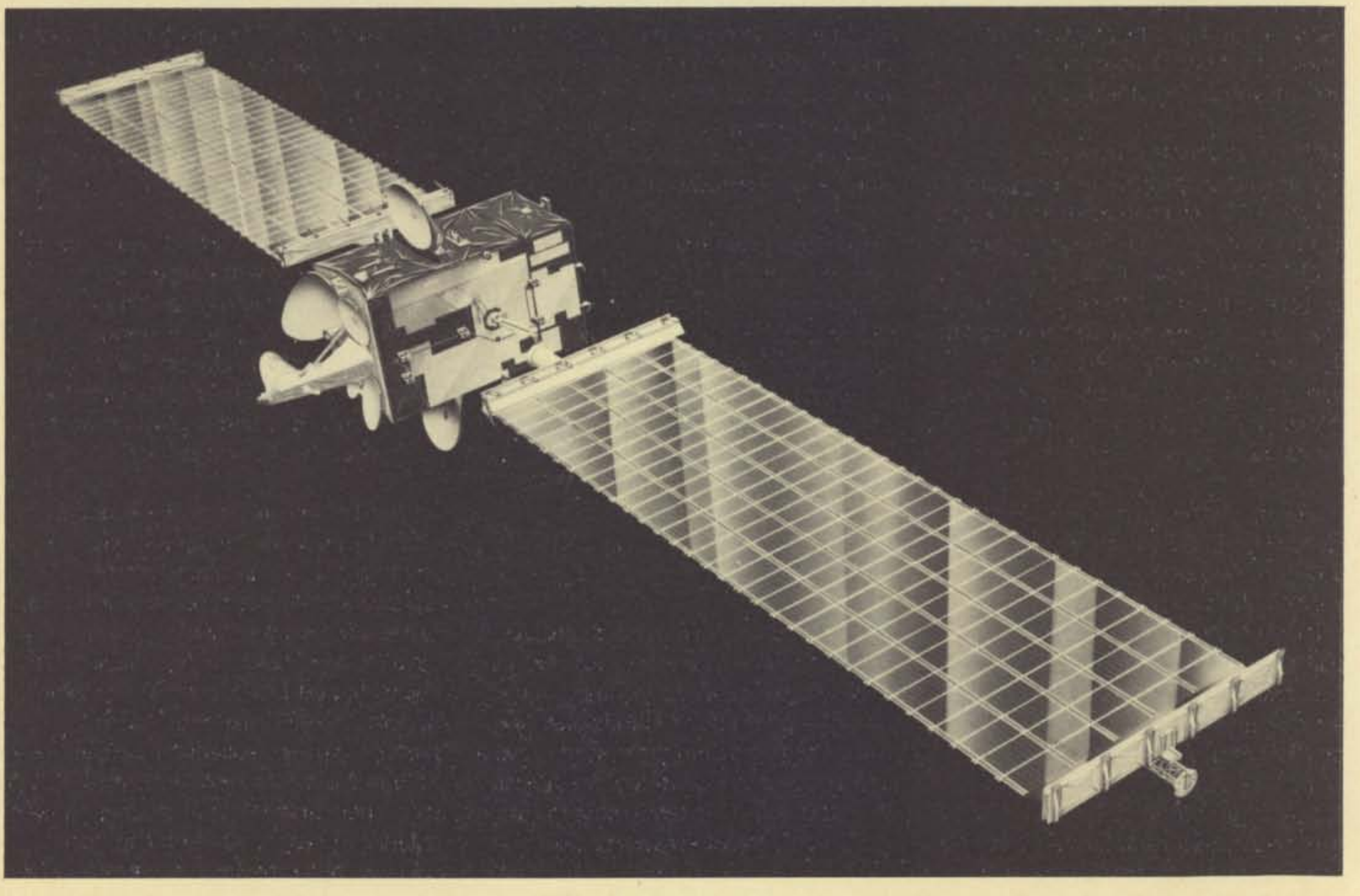
En supposant que le lancement ait lieu en octobre 1990, la mise sur pied d'une nouvelle équipe débutera fin 1988, le satellite lui-même sortant de son entreposage début 1989 pour réintegration, ré-homologation et préparation pour une nouvelle campagne de lancement.

Il reste à résoudre un certain nombre de problèmes techniques; on a constaté en particulier qu'un nombre important des microprocesseurs fournis par le JPL présentent un vice fondamental tel qu'il pourrait ruiner totalement la mission. Après une enquête détaillée, on a décidé de remplacer ces composants partout où ils étaient placés à des endroits stratégiques du satellite et de la charge utile. Les travaux sur les interfaces avec le lanceur se poursuivent et leur avancement est satisfaisant sur bon nombre de points.

Hipparcos

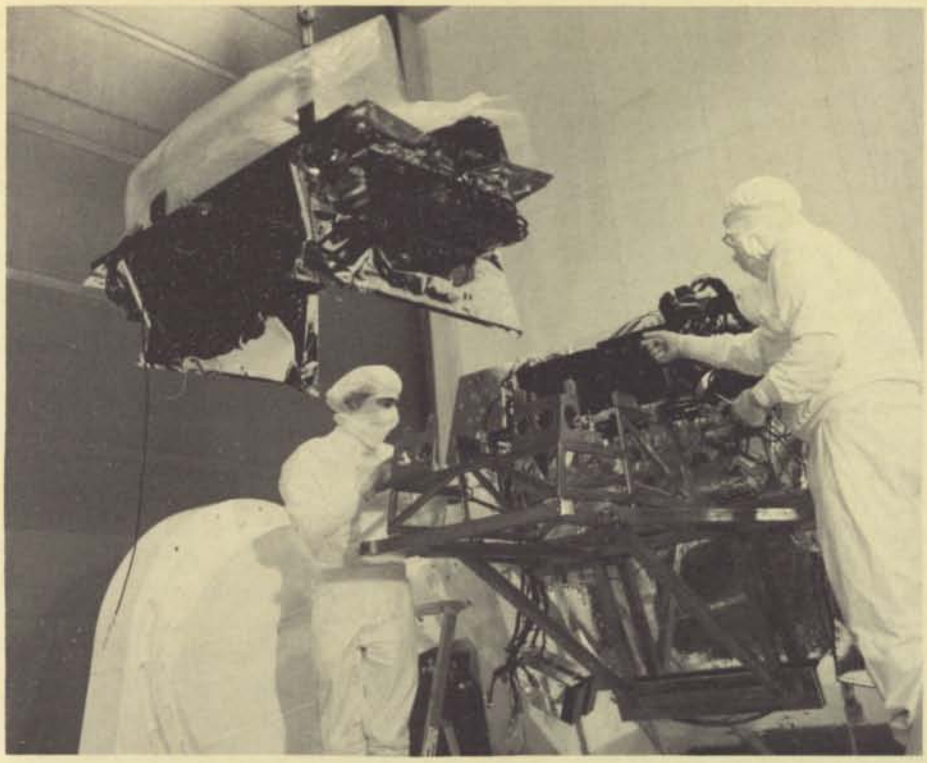
Pour la période couverte par ce bulletin, le report à avril 1989 de la date de lancement du satellite entraîne les conséquences les plus importantes pour le programme Hipparcos. Ce report du lancement introduit de nouveaux éléments dans le programme, à savoir l'entreposage du satellite après la Revue d'Aptitude au Vol (qui reste prévue pour début 1988) et la réactivation du satellite avant son embarquement vers le lieu de lancement. Les exigences liées à l'entreposage et à la réactivation sont étudiées en détail simultanément par l'ESA et l'industrie. D'ici la fin de l'année, il est prévu qu'un contrat aura été conclu avec l'industrie de manière à pouvoir effectuer les opérations nécessaires.

Les activités d'intégration et d'essais battent actuellement leur plein. Après la



Artist's impression of the Olympus spacecraft

Vue imaginaire du véhicule spatial Olympus



Preparation of the Hipparcos Focal Plane Assembly (FPA) for integration with the telescope

Préparation de l'ensemble au plan focal pour intégration au télescope d'Hipparcos

integration with its spacecraft is scheduled for August.

The PFM spacecraft structure together with the integrated harness and reaction control assembly has been delivered to Aeritalia. PFM units for data handling and power subsystems have also been delivered and preparations are in hand for their integration into the spacecraft. Delivery and integration of the other spacecraft subsystems will continue for some months.

The recent failure of a solar panel under qualification thermal vacuum testing at ESTEC is currently under investigation.

Olympus

The System Critical Design Review has been held and the design found to comply with specifications although further work remains to be done in the combined propulsion system area.

Work on the propulsion module incorporating the combined propulsion system has been completed at BPD (I) and the propulsion module delivered to the Prime Contractor BAe. Integration and testing of the four communications payloads has been completed at Selenia Spazio (I) and the north- and south-radiating panels with the payloads mounted on them have also been delivered to BAe.

The three modules of the Flight-1 spacecraft, the communications module, propulsion module and service module, have been mated and the remaining integration and test activities completed. At the end of May the spacecraft was shipped to the Jet Propulsion Laboratory in Pasadena, California for the first of its system-level tests, the solar-simulation test. When this has been completed the spacecraft will be transferred to the David Florida Laboratories in Ottawa for the remainder of its system tests.

An updated version of the Arianespace interface document has been issued and is being reviewed. The latest Ariane launch manifest shows Olympus-1 on V-30, planned for launch in January 1989.

Preparations for satellite operations are well under way. Procurement activities for the ESA earth stations continue according to plan, and many are well advanced. National organisations are now becoming active in earth station procurement. Proposals for use of the Olympus payloads continue to arrive, and a complete overview and preliminary utilisation schedule has been prepared.

Discussions have started on the nature of a possible Olympus Flight-2 mission.

ERS-1

On the structural model assembly, integration and test continues according to schedule and is forecast for completion in the middle of the year, the sole remaining activity being the payload centrifuge test.

On the engineering model, earlier schedule difficulties with the delivery of the Active Microwave Instrument, the Radar Altimeter and the Along-Track Scanning Radiometer, have to some extent been compensated by bringing forward the software compatibility testing. Although there are still delays in the subsystem and instrumentation assembly, integration and verification, the schedule for completion of the engineering model programme remains unchanged.

The flight model programme is progressing satisfactorily although there is still concern regarding the deliveries of hi-rel components and the delays being experienced on the engineering model.

On the ground segment, considerable progress has been made in implementing the work plan established after the System Development Baseline Review. The mission, management and control centre software design for the subsystems common to ERS, Eureca and Hipparcos is progressing satisfactorily.

The evaluation of the responses to the Agency's Announcement of Opportunity for the exploitation of ERS-1 data is in progress and is expected to be completed early in the second half of the year.

Considerable work has been carried out in preparation for the procurement of a second identical flight model, ERS-2. Meetings are in progress with the potential participants in the programme and a formal offer from industry is expected by the middle of the year.

EOPP

Second-Generation Meteosat
The industrial studies for the Infrared Sounder and the Data Circulation Mission are progressing according to

phase d'intégration de la maquette technologique de la charge utile et du véhicule spatial, les essais du sous-ensemble intégré satellite ont été terminés. Les essais de l'ensemble du système satellite intégré sont en cours et se termineront fin juin.

Les activités d'intégration et d'essais du prototype-modèle de vol de la charge utile (PFM) se poursuivent parallèlement et celles relatives au satellite ont débuté. Après les essais de l'ensemble télescope à Liège, ce dernier a été renvoyé chez Matra (F) où il a été intégré avec l'assemblage au plan focal pour constituer la charge utile PFM. En dépit du retard dû à la panne d'une unité de télécommande, les essais de la charge utile se poursuivent de manière satisfaisante tandis que les essais en lumière parasite et les essais du système intégré sont achevés. La livraison de la charge utile à Aeritalia pour intégration au satellite est prévue pour le mois d'août.

La structure du satellite PFM associée au câblage intégré et à l'ensemble de micropropulsion a été livrée à Aeritalia. Les systèmes PFM pour la gestion de données et les sous-ensembles d'alimentation ont aussi été livrés; les préparatifs de leur intégration au satellite sont en cours. La livraison et l'intégration des autres sous-systèmes du satellite suivront dans les prochains mois.

Une enquête est en cours sur les causes de la récente défaillance d'un panneau solaire au cours des essais de qualification en vide-température à l'ESTEC.

Olympus

La Revue critique de la définition du système a eu lieu; il s'est avéré que la conception était conforme bien qu'il reste encore du travail à faire dans le domaine du système de propulsion combinée.

Le travail sur le module de propulsion intégrant le système de propulsion combinée a été achevé chez BPD et le module de propulsion a été livré au maître d'oeuvre. L'intégration et les essais des quatre charges utiles de télécommunications ont été achevés chez Selenia Spazio (I), et les panneaux radiatifs nord et sud ainsi que les charges utiles qui y sont montées ont également été livrés à BAe.

Les trois modules du spécimen de vol No 1, le module de communication, le module de propulsion et le module de servitude ont été accouplés et les activités d'intégration et d'essais restantes ont été menées à bien. Fin mai, le satellite a été transporté au Jet Propulsion Laboratory pour y subir le premier essai au niveau système: l'essai de simulation solaire. Après achèvement de ce dernier, le satellite sera envoyé aux Laboratoires David Florida à Ottawa pour y subir le reste de ces essais-système.

Une version mise à jour du document concernant l'interface d'Arianespace a été distribuée et est en cours de revue. Le manifeste réactualisé des lancements par Ariane mentionne janvier 1989 comme date de lancement d'Olympus-1 sur le vol V-30.

Les préparatifs pour les opérations du satellite avancent bien. Les activités de fourniture pour les stations sol de l'ESA se poursuivent selon les prévisions, un bon nombre d'entre elles ayant atteint un stade avancé. Les organisations nationales se consacrent maintenant aux activités de fourniture des stations sol. Les propositions d'utilisation des charges utiles d'Olympus continuent d'affluer; on a préparé un planning d'ensemble complet et un calendrier d'utilisation préliminaire.

D'autre part, les discussions concernant la nature d'une éventuelle deuxième mission d'Olympus ont démarré.

ERS-1

L'intégration et les essais du modèle mécanique se poursuivent comme prévu et devraient s'achever vers le milieu de l'année, la seule activité restante étant les essais de centrifugation de la charge utile.

En ce qui concerne la maquette technologique, les difficultés de calendrier rencontrées précédemment pour la livraison du détecteur actif à hyperfréquences, l'altimètre radar et le radiomètre à balayage dans le sens de la route satellite ont été partiellement compensées par l'avancement des essais de compatibilité du logiciel, et bien qu'il y ait encore des retards dans l'assemblage, l'intégration et les essais des sous-systèmes et de l'appareillage, les dates prévues pour l'achèvement du programme de la maquette technologique restent inchangées.

Le programme du modèle de vol se poursuit de manière satisfaisante bien que quelques problèmes demeurent sur le plan de la livraison de composants à haute fiabilité et en raison du retard pris pour la maquette technologique.

En ce qui concerne le secteur terrien, des progrès considérables ont été accomplis dans l'exécution du plan de travail établi après la revue des bases de référence du système. La conception du logiciel du Centre de gestion et de commande de la mission pour les sous-systèmes communs à ERS, Eureca et Hipparcos progresse de manière satisfaisante.

L'évaluation des réponses à l'appel d'offres de l'Agence pour l'exploitation des données d'ERS-1 bat son plein et devrait être terminée au début du second semestre de cette année.

Un travail considérable a été accompli sur le plan des préparatifs pour l'acquisition d'un second modèle de vol identique, ERS-2. Des réunions sont en cours avec les participants potentiels à ce programme et l'industrie fera une offre en bonne et due forme vers le milieu de l'année.

EOPP

Météosat de seconde génération

Les études industrielles pour le Sondeur infrarouge et la mission de diffusion de données progressent comme prévu. Deux études parallèles pour le radiomètre de prise d'images ont en outre démarré.

Solide terrestre

Depuis l'Atelier 'Solide terrestre' qui s'est tenu à Matera (I) fin avril, les travaux se sont concentrés sur les préparatifs visant à émettre une proposition pour une étude de faisabilité de la mission Solide terrestre. Cette mission aurait pour but

Olympus-1 being loaded into the Belfast aircraft at Stansted airport, en route to JPL for solar-simulation testing

Chargement d'Olympus-1 dans l'avion cargo Belfast à l'aéroport de Stansted avant son transport au JPL en vue des essais de simulation solaire

schedule and two parallel studies on the Imaging Radiometer have begun.

Solid Earth
Following the Solid Earth Workshop held in Matera (I) at the end of April, work has concentrated on the preparation of the proposal for a feasibility study for a Solid Earth Mission. The objective of the mission is the measurement of the Earth's gravity field from a single low orbit satellite, to be launched in 1993.

Polar Platform
Activities have concentrated on mission-related aspects and preparation of instrument studies. Study work has started on ATLID, which will detect cloud and aerosol particles, and Limbsounder, which will study the chemical composition of the upper atmosphere.

Campaigns
The AGRISCATT campaign started in the second half of May with the main objective of collecting calibrated radar backscatter data over a number of representative European agricultural sites and forests. The data will help to identify gaps in existing knowledge and to improve modelling techniques.

Microgravity

ESA's proposal to extend Phase-2 of the Microgravity Programme — as a consequence of the Shuttle accident in 1986 — was reiterated and refined after discussion with the Microgravity Programme Board. This extension programme proposal includes: sounding rockets and parabolic flights, future programme definition studies and limited payload developments with emphasis on those payloads not requiring the Shuttle as launch vehicle.

The development of the microgravity payloads for the D2 Spacelab Mission (Anthrorack, Critical Point Facility, Advanced Fluid Physics Module) is well under way. Aeritalia was recently selected as Prime Contractor for the development of the Bubble, Drop and Particle Unit. The definition study of the Advanced Gradient Heating Facility is progressing and will be completed in the third quarter of the year.

The Biorack experiment coordination and hardware verification for the IML-1 flight scheduled for early 1990 are continuing well.

Most of the ESA microgravity payloads for Eureca are in an advanced state of development and the engineering models are being prepared for final testing.

A series of ESA-organised parabolic airplane flights was carried out in April. The major experimental theme of these flights was combustion under weightlessness.

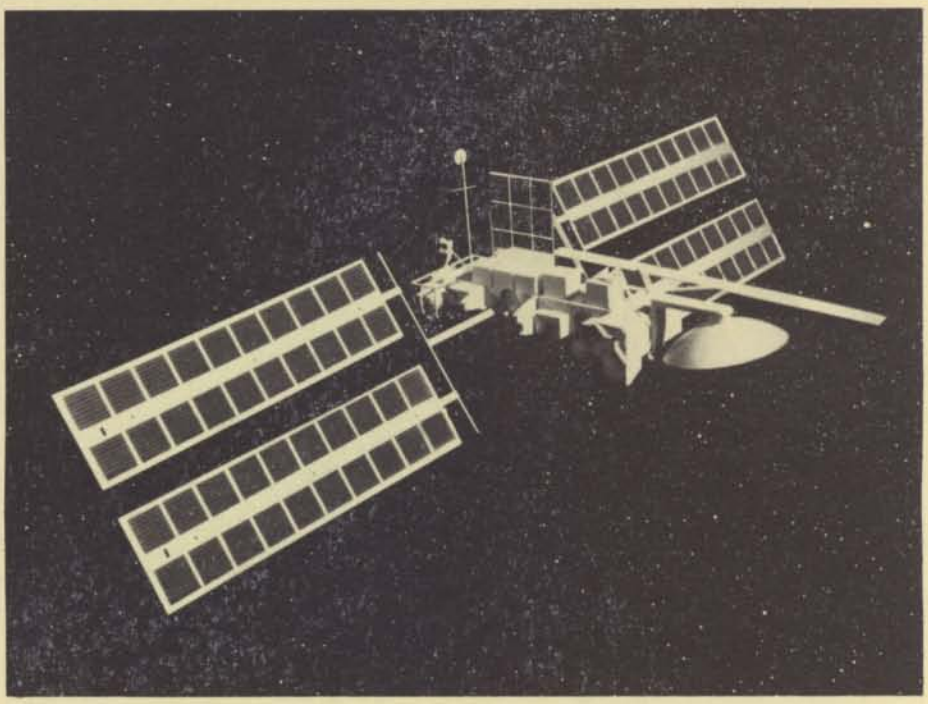
The first Swedish Maser sounding-rocket flight with ESA participation took place in March. In addition to the on-going Texus flights in which ESA already participates, studies are being conducted to evaluate the feasibility of longer duration (15 minute) sounding-rocket flights.

Ariane

Ariane 3/4 3rd-stage HM7-B engine
The campaign of ignition tests carried out since April on the qualification engine was brought to a halt in late May due to a fault in the altitude simulator facility steam generator. Thanks to an emergency solution quickly effected by SEP (the steam was replaced by gaseous nitrogen), it was possible to carry out the in vacuo ignition tests, forming part of the tightened-up Flight 19 engine acceptance procedure, in early July. Final acceptance of the engine is expected after a 60-second test, which must be run at atmospheric pressure.

With regard to improvements in the cooling and lubricating of the turbopump bearings, the first tests on the qualification engine started in June (tests at atmospheric pressure); the endurance programme includes three successive 900-second tests, all of which are due to be run during July.

The Flight 19 launch date will be fixed after final acceptance of the engine; the current status of work indicates a September launch. The launcher campaign at the Guiana Space Centre started on 2 June. The current Ariane launch manifest is shown on page 64.



Vue imaginaire de la plate-forme méridienne

Artist's impression of the Polar Platform

de mesurer le champ de gravité terrestre à partir d'un unique satellite sur orbite basse, satellite qui serait lancé en 1993.

Plate-forme méridienne

Les activités se sont concentrées sur les aspects relatifs à la mission et sur la préparation des études d'instrumentation. Le travail d'études a débuté sur ATLID, qui sera chargé de détecter les nuages et les aérosols, et sur le 'sondeur de limbe' chargé d'étudier la composition chimique de la haute atmosphère.

Campagnes

La campagne AGRISCATT a démarré au cours de la seconde quinzaine de mai; elle a pour objectif principal de rassembler les données d'échos radar calibrés concernant un certain nombre de sites agricoles et forestiers européens types. Les données recueillies serviront à combler les lacunes des connaissances actuelles et à améliorer les techniques de définition des modèles.

Microgravité

La proposition de l'Agence – suite à l'accident de la Navette en 1986 – d'étendre les activités de la phase 2 du programme de microgravité a été réitérée et affinée après discussion avec le Conseil directeur du Programme de microgravité. Cette proposition d'extension du programme comprend: les fusées-sondes, les vols paraboliques, des études de définition des programmes futurs et des travaux de développement limités sur des charges utiles en accordant une attention particulière aux charges utiles dont les caractéristiques n'exigent pas la Navette comme lanceur.

La mise au point des charges utiles de microgravité pour la mission Spacelab D2 (Anthrorack, installation de point critique, module de physique des fluides évolué) progresse de manière satisfaisante. Aeritalia a récemment été choisi comme maître d'oeuvre pour l'élaboration de l'expérience 'Bulles, gouttes et particules'. L'étude de définition du four à gradient se poursuit et se terminera au cours du troisième trimestre de cette année.

La coordination de l'expérience Biorack pour le vol IML-1 qui est prévu début 1990 et les essais du matériel correspondant progressent de manière satisfaisante.

La plupart des charges utiles de microgravité de l'Agence pour Eureca ont atteint un état de développement avancé et les maquettes technologiques sont en cours de préparation en vue des ultimes essais.

Plusieurs vols paraboliques organisés par l'ESA ont été accomplis en avril. Le thème expérimental principal de ces vols était la combustion en apesanteur.

Le premier vol de la fusée-sonde suédoise Maser a eu en mars avec la coopération de l'ESA. En plus des vols Texus actuellement en cours et auxquels participe l'ESA, des études ont été effectuées afin d'évaluer la faisabilité de vols de fusées-sondes de plus longue durée (15 minutes).

Ariane

Moteur HM7-B du 3ème étage Ariane 3/4

La campagne des essais d'allumage effectuée depuis avril sur le moteur de qualification a été interrompue fin mai par suite d'une défectuosité survenue sur le générateur de vapeur d'eau de l'installation de simulation d'altitude. Une solution de secours, rapidement mise en oeuvre par la SEP (utilisation d'azote gazeux à la place de la vapeur d'eau), a permis de réaliser, début juillet, les essais d'allumage sous vide faisant partie de la recette renforcée du moteur V19; la recette finale du moteur est attendue à l'issue d'un prochain essai de 60 secondes devant être effectué à la pression atmosphérique.

En ce qui concerne les améliorations relatives au refroidissement et à la lubrification des roulements de la turbopompe, les premiers essais du moteur de qualification ont débuté en juin (essais à la pression atmosphérique); le programme d'endurance comporte trois essais successifs de 900 secondes chacun prévus courant juillet.

La date du vol 19 sera fixée à l'issue de la recette finale du moteur; l'avancement actuel des travaux permettrait de prévoir un lancement en septembre. La campagne lanceur a débuté le 2 juin au Centre spatial guyanais. Le manifeste des lancements Ariane figure à la page 64.

The European Data Relay System as Part of the In-Orbit Infrastructure

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The Data Relay Preparatory Programme, recently approved, is the first step towards the ESA Data Relay System, which is planned to provide operational service in the later 1990s. This Data Relay System will include two DRS satellites, which together will be able to provide full coverage of a number of user satellites for 85% to 100% of their orbits.

Introduction

Europe's new plans for space projects include new and expanded activities in a wide range of fields, including manned spaceflight, rendezvous and docking, retrieval of satellites, microgravity experiments, Earth-observation operations and remote-controlled robotics ('telescience').

All of these plans require increased communications between space and ground. Almost every parameter describing a communications requirement will need to be augmented: data rates increased, link availability improved, coverage extended, services expanded, access simplified, etc.

Expansion of the existing ground network to provide adequate continuity of communications to Hermes or Columbus would involve the installation of dozens of ground stations around the World, complete with an elaborate data-communications network.

The alternative is to install a Data Relay System (DRS), with satellites in geostationary Earth orbits (GEO) that can each relay data continuously between a user satellite in low Earth orbit (LEO) and an earth terminal, for more than half an orbit of the user satellite.

In-orbit infrastructure

The Long-Term Plan for the Agency includes ambitious expansion of activities in existing fields and exciting exploration in new fields of space research and exploitation. The coining of the term 'in-orbit infrastructure' highlights the transition from individual, independent satellite projects to a coherent programme involving many different types of space vehicle, all cooperating with each other either physically, by means of rendezvous and docking (RVD), or remotely by telecommunications.

The many telecommunications problems that are anticipated can best be illustrated by some examples:

Manned spacecraft, such as Hermes and Columbus, have a vital need for reliable communications. The conventional technique is to use direct radio links between the spacecraft and ground stations located around the World. Communications continuity is disrupted both by gaps in the coverage of the ground stations and by the unreliability of the long-distance links between the control centres and the ground stations, which are often in remote locations. A Data Relay System is able to provide direct links between manned spacecraft and control centres for the majority of their orbit, except for the small exclusion zone round the far side of the globe, where the DRS satellites cannot provide coverage.

Earth-observation satellite users also receive data at present by direct radio links between the satellites and ground stations located around the World. If the satellite is to observe a specific piece of land or sea, one of two techniques can be used. The satellite may relay the data direct to a ground station, which cannot be more than about 1000 km away if it is

Figure 1 — Elements of the Data Relay System

to be visible to the satellite, which means that more than twenty earth stations (many in remote locations on land or in mid-ocean) would be needed to provide full global coverage. Alternatively, the satellite may record the data and play it back later, using a tape recorder, which is a notoriously unreliable piece of equipment with limited data capacity and speed.

The problem is compounded by the complexity of the processing needed to convert the satellite signal into an intelligible image, which requires sophisticated computer equipment that is only available at a limited number of locations.

Hence, even if the user requiring the image can receive the satellite signal, it must first be relayed up to half way round the World to the image-processing centre. All of these problems can be solved by the Data Relay System, which can receive the satellite signal from almost any part of its orbit and relay it direct to the image-processing centre.

Scientific experiments on-board both manned spacecraft, such as the Columbus Pressurised Module, and unmanned spacecraft, such as Eureca, are becoming more complex and cover a wider range of subjects, such as human physiology, fluid science, material science, botanical science and medical diagnosis. On manned spacecraft, astronaut payload specialists will find increasing difficulty in operating efficiently all the experiments in their charge. They will need much better communications with the experimenter, preferably at his own institute on the ground, where all his specialist colleagues and archives are directly available.

On unmanned spacecraft, experimenters are studying major advances beyond conventional remote control by telemetry and telecommand, to include video monitoring and robotic control. Both of these new domains, which are together described as 'telescience', will require high-quality communications with a high degree of flexibility and user-friendliness, which the Data Relay System aims to provide.

The telecommunications programme

The two main elements of the ESA Telecommunications Long-Term Programme are the Data Relay System (DRS) and the Payload and Spacecraft Development and Experiments (PSDE) Programme.

The DRS Programme is planned in three parts. The first part, the Data Relay Preparatory Programme (DRPP), is already approved. The second part, the development of the first generation of DRS satellites (DRS-1), needs to commence at the latest in about 1990 in order to offer an operational service to users by the later 1990s. The third part, the development of a second generation of DRS satellites (DRS-2), is expected to start in the late 1990s in order to ensure proper continuity and improvement of the Data Relay System.

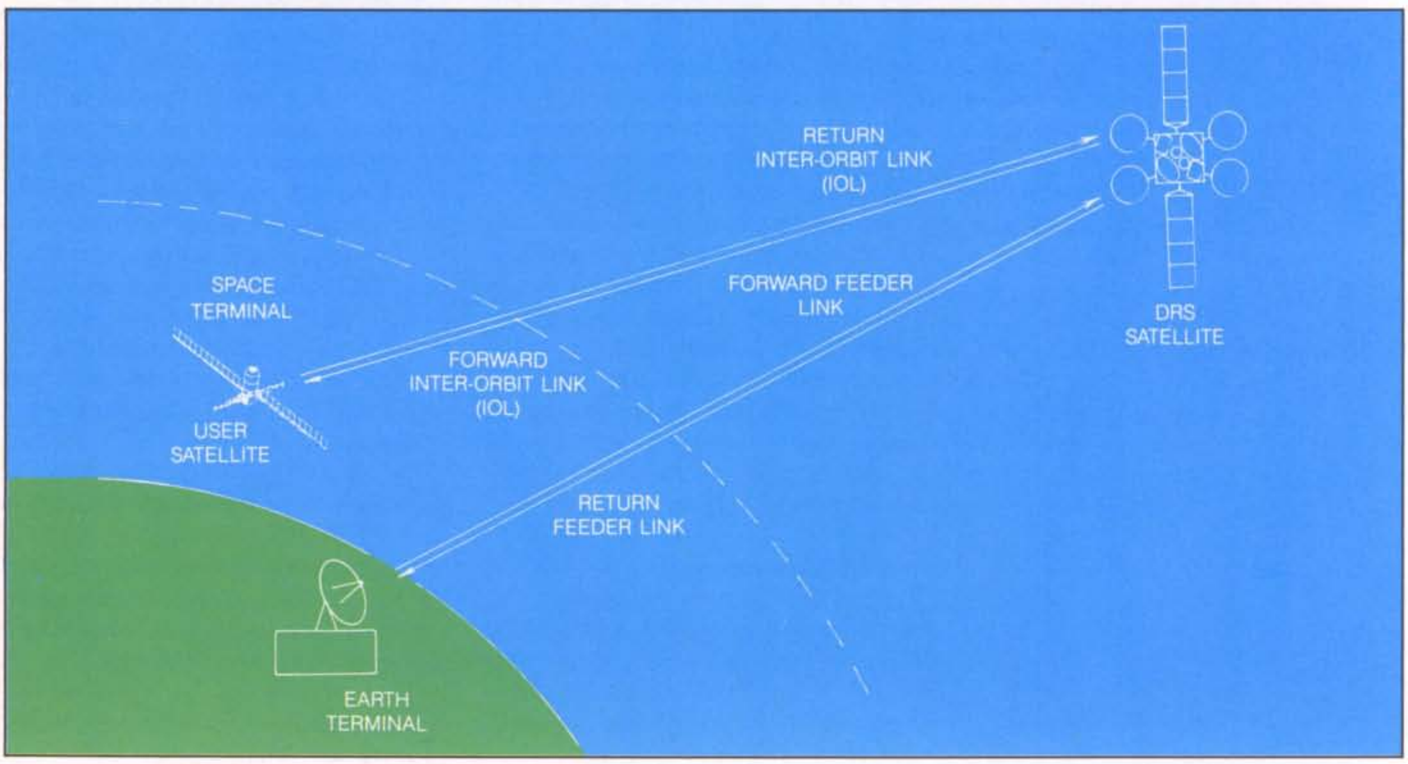


Figure 2 — Coverage geometry of the Data Relay System

The PSDE Programme made up of a wide range of experiments and demonstrations, using existing and new satellites, relevant to fixed, mobile, broadcast and other satellite services (see, for example, the article on ARAMIS in ESA Bulletin No. 50). PSDE is planned to include data-relay elements that are not yet considered sufficiently mature to be incorporated in the operational Data Relay System. These include an S-band (2 GHz) Multiple Access payload, with an array antenna and on-board multiple beam-forming network, and an optical repeater terminal, using semiconductor laser transmitters. The optical equipment developed under PSDE could fly as a pre-operational package on DRS-1 satellites. Other technology developed under PSDE will be considered for service on the DRS-2 satellites.

The fundamental design principle for DRS-1 is the use of existing technology in order offer the best guarantee of an operational service (as described in a previous article:'The ESA Data Relay Satellite Programme', ESA Bulletin No. 47). The main elements of the DRPP are therefore the initial phases of a classical satellite system development programme:
— Phase A1 (1987) : Communication and Operational System Design
— Phase A2 (1988) : System Trade-Offs and Generation of a Preferred Configuration

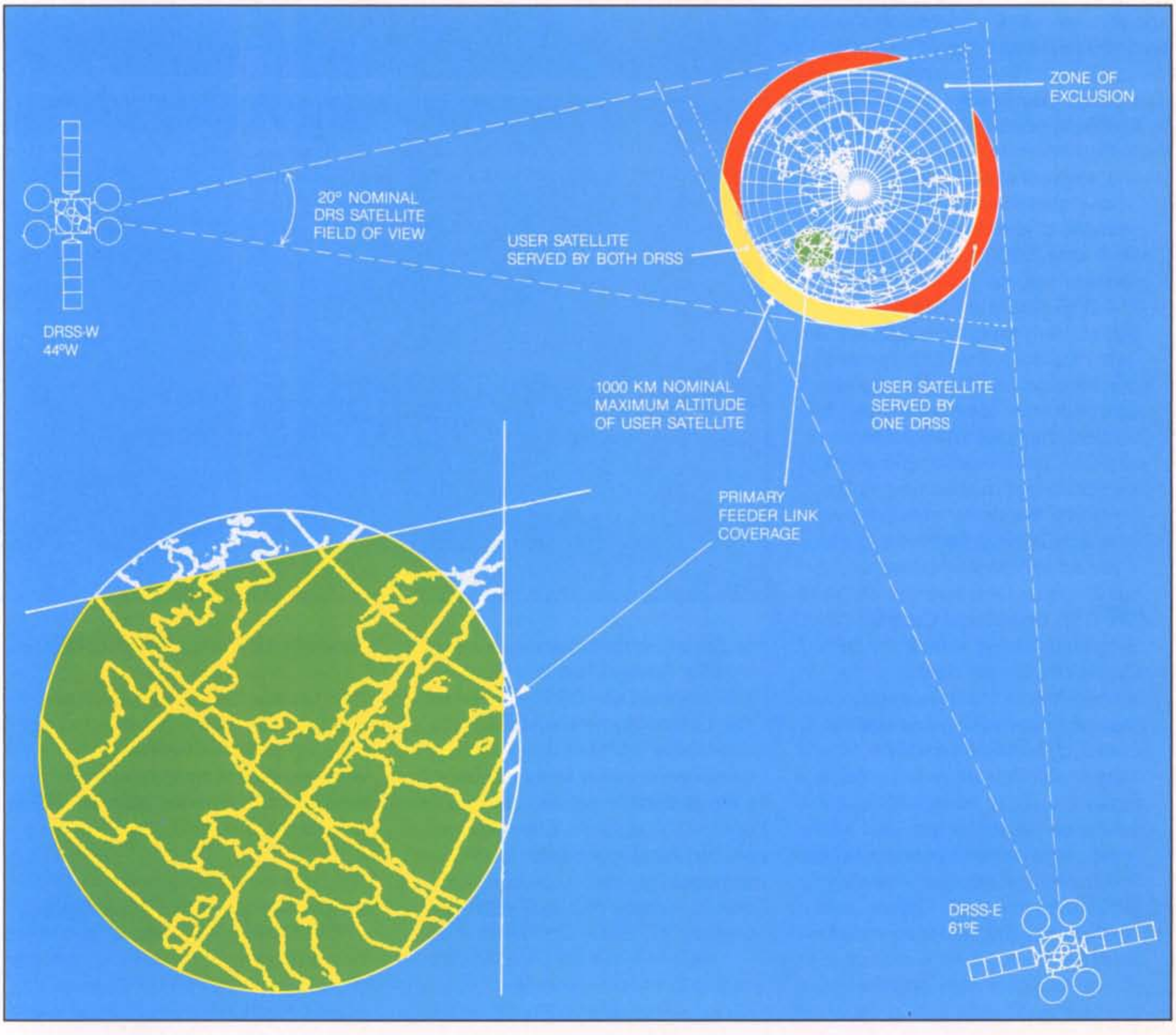
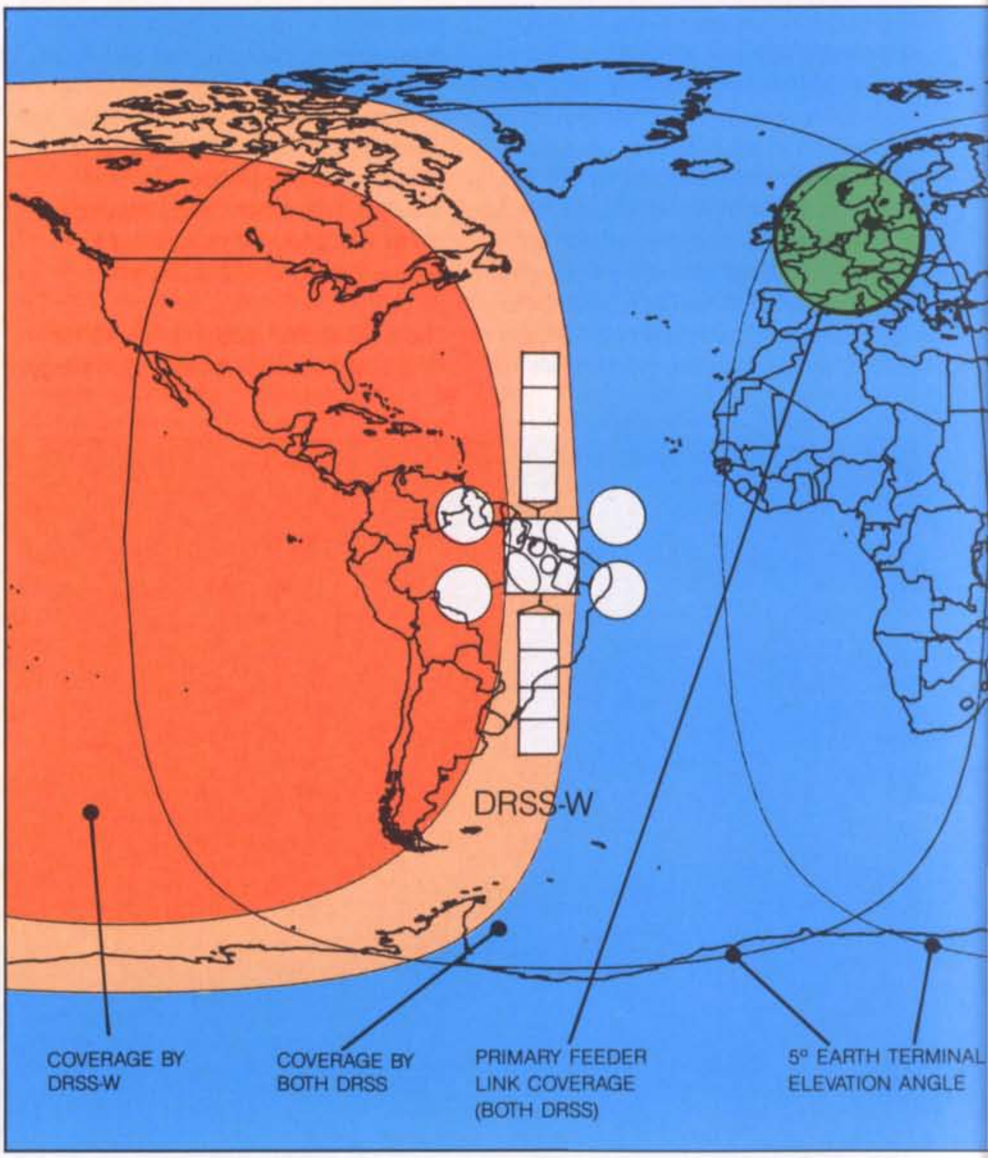


Figure 3 — Geographical coverage of the Data Relay System



— Phase B1 (1989) : System and Subsystem Design of the Preferred System.

The Agency has placed two parallel contracts, both covering these three phases of development.

In addition, it is planned that the DRPP will include studies of specific areas, such as the configuration, operation and interfaces of the ground network, development of critical items, such as high-speed data encoders and decoders, and construction of a transmission simulation test bed.

The Data Relay System

The principal components of the Data Relay System are:

— The **Space Terminals**, comprising the receivers, transmitters and antennas mounted on the **User Satellites** in low Earth orbit (LEO), nominally up to 1000 km altitude.

— The **DRS Satellites (DRSS)**, in geostationary Earth orbit (GEO) at two widely-separated longitudes so as to provide wide coverage for relay of data and other communications between Earth Terminals in Europe and User Satellites over as much of their orbits as possible.

— The **Earth Terminals**, which receive data from **User Satellites** via DRSS and may also transmit data and commands to User Satellites via DRSS.

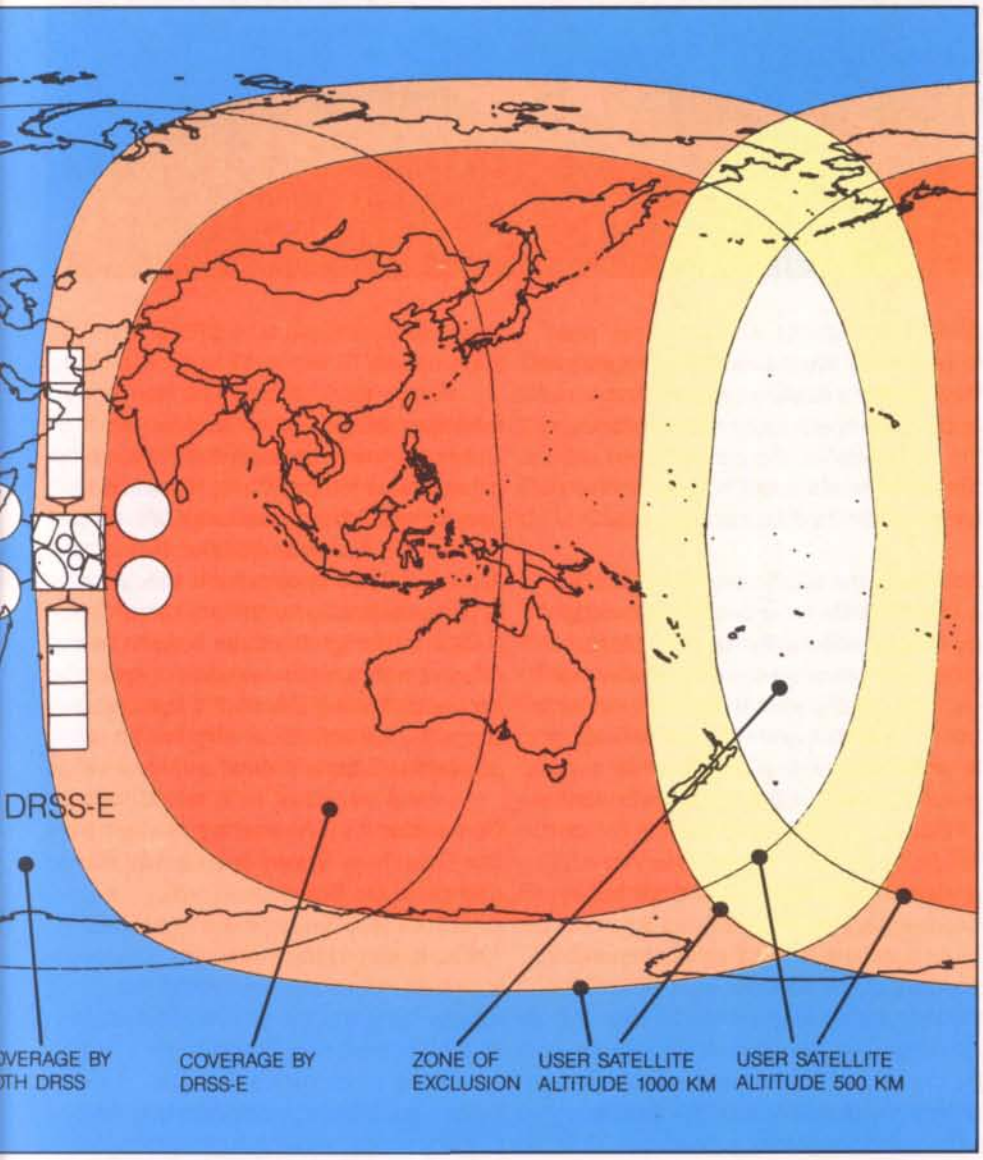
— The **DRS Operational Control System**, which will include the **DRS Operations Control Centre** (responsible for station-keeping, attitude, housekeeping and payload control of the DRSS), the **DRS Mission Control Centre** (responsible for liaison with all users and for setting up the assignment plan for the communications links between Space Terminals and Earth Terminals via DRSSs), and the DRS Traffic Management Centre (responsible for switching, routing and, if required, storing user data and control messages).

The communications links consist of two parts: the **Feeder Links** between the Earth Terminals and DRSS and the **Inter-Orbit Links (IOL)** between DRSS and Space Terminals. We define Forward Links in the direction Earth—DRSS—Space and Return Links in the direction Space—DRSS—Earth. The presently-preferred frequency bands for DRS are as follows:

Forward Feeder Link : 29.5—30.0 GHz
Forward IOL : 2025—2110 MHz
and 23.15—23.55 GHz
Return IOL : 2200—2290 MHz
and 25.25—27.50 GHz
Return Feeder Link : 17.7—20.2 GHz

(This list shows a recently-proposed separation of the SHF forward and return IOLs into different frequency bands, which would give more scope for eventual expansion and ease the design of DRS satellites and Space Terminals).

The GEO longitudes selected for DRSS are provisionally 44°W (DRSS-W) and 61°E (DRSS-E). These appear to offer the best compromise between IOL coverage of the User Satellites in LEO, which is improved with increased DRSS longitude



separation, and Feeder-Link coverage of the Earth Terminals, which is improved with reduced longitude separation.

Additional feeder links are being considered for each DRSS, which would give, for example, coverage of locations in the USA from DRSS-W and in Japan from DRSS-E.

The 30/20 GHz SHF bands have been selected for the feeder links. This will ease the problems of coordination with other communications satellite systems, which mainly use lower frequency bands, and will facilitate the location of Earth Terminals close to the users' control and data-processing centres. On the other hand, the use of such high frequencies combined with geographical constraints, which lead to Earth Terminals operating with relatively low antenna elevation angles, requires the incorporation of considerable power margins and the acceptance of signal loss during periods of heavy rain.

The system performance goal is an overall link quality corresponding to a bit error rate of 10^{-6} for 99% of the time for data rates above 100 Mbit/s and 99.9% of the time for data rates up to 10 Mbit/s when using an earth-terminal antenna with a diameter of 10 m. It is also planned to use 3 m earth terminals for reception of signals up to about 10 Mbit/s data rate.

The data-network structure

The ability to locate Earth Terminals close to users' data-processing centres is particularly important for large, multi-payload satellites, such as the Columbus Polar Platform, which will carry many different experiments, data from most of which will be received by several different users simultaneously. Data from the various experiments is generated at rates ranging from a few kilobits per second up to several hundred megabits per second. Central reception of data was originally proposed, but it has been clearly demonstrated that decentralised reception of data direct by users offers several benefits.

With the higher data rates, commercial communications services are not normally available to allow distribution of data received centrally. With lower data rates, distribution of data has been shown to be more expensive. Moreover, direct reception of data is probably more reliable per se, and has the added possibility of diversity, whereby another receiver can be asked to store and forward data if one link breaks down.

Full decentralisation of forward links is not yet considered, as signals from payload users are invariably channelled via a payload management centre and a satellite control centre before being transmitted to a satellite, whether this transmission is direct or via a data relay system. However, the Agency is considering the possibility of direct transmission from user satellite control centres through DRS, with careful control of signal power, frequency, format and code to ensure that neither DRSS nor any other satellites could be affected. Considering data rates alone, the

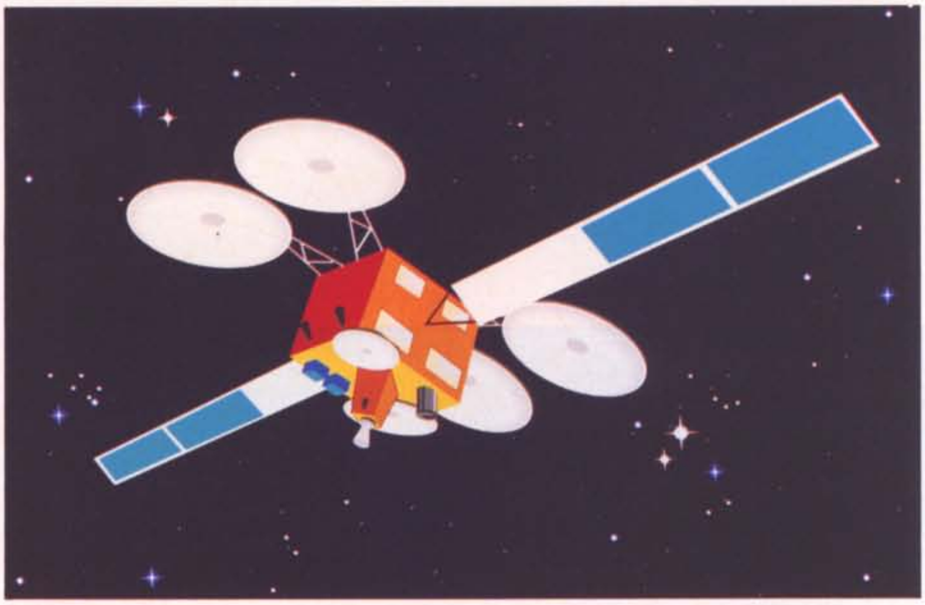


Figure 4 — Artist's impression of a DRS satellite

concept of centralised forward links seems acceptable, as the forward data rates to satellites are mostly low, except for voice and video links to manned spacecraft. Voice and data links can be routed by public telecommunications networks though video links, required for crew training (to explain the operation of experiments to astronaut payload specialists) are likely to be less easy from remote locations in real time. On the other hand, users are requesting very short delays in the communications network for telescience operations, which may lead to a demand for some decentralisation.

Data relay link operation

A User Satellite in equatorial or low-inclination orbit (such as Columbus or the Man-Tended Free Flyer) will spend much of its time in the common coverage zone of both DRSSs, but will have to switch from DRSS-E to DRSS-W and back every half-orbit. During this switch-over, the User Space Terminal antenna will have to swing through an angle of about 250° from one DRSS to the other. This must be done quickly but gently to avoid disturbing the stability of the User Satellite. Then the new DRS link must be set up. All of this could take two or three minutes. Moreover, the User Satellite may also cross the zone of exclusion, which will cause an outage of some seven or eight minutes for an equatorial orbit, or up to thirty minutes for a polar orbit (though not every orbit). Loss of communication during satellite change-over could be avoided by installing a second Space Terminal on board the User Satellite, though this would require the availability of links through both DRSSs simultaneously.

Provision of two Space Terminals would also reduce the visibility requirement for the antennas. To achieve the 250° field of view required to achieve full coverage with a single Space Terminal, the antenna, which will have a reflector approximately 1 m in diameter, must be mounted on a mast above the structure of the User Satellite. This mast may need to be several metres long to allow a clear view past the satellite structure and appendages, especially the solar array, of the User Satellite. Installation of two Space Terminals could allow a much shorter mast, or even no mast at all.

Setting up the IOL between a DRSS and a User Satellite requires prior knowledge by each satellite of the position of the other. The preciseness of this knowledge depends on the frequency band to be used. The beamwidth of the DRSS IOL antennas at 2 GHz (S-band) will be around 3°, so that the antennas on both DRSSs and on the User Satellite (which will probably have smaller antennas with a wider beam width) can be pointed by dead-reckoning in open loop. On the other hand, at 26 GHz the corresponding beamwidth will be around 0.2°, so that closed-loop pointing by radio-frequency tracking will be needed. Moreover, a beacon signal will be needed to initiate acquisition and, because the satellite attitude instability may exceed the antenna beamwidth, a search mode may also be needed.

Precise determination of the location of the User Satellite is generally a basic user requirement, as well as being needed to set up the DRS link. Many users plan autonomous navigation aids, but DRS will offer a localisation service by means of range and range-rate (Doppler) measurements. For the latter, frequency coherence throughout the Data Relay System is necessary, with all frequency converters on DRSSs and on User Satellites and all beacon frequencies transmitted by DRSSs being locked to transmissions to DRSSs from the ground.

Interoperability

The possibility of interoperability between different data relay systems, to allow data relay services to be offered by DRS to users of the American TDRS and Japanese DRTS systems, and vice versa, is being discussed by ESA, NASA and NASDA. Although the three systems have different technical characteristics (e.g. frequency bands), it is hoped that cross-support and back-up services will prove possible at S-band (2 GHz).

Conclusion

The Data Relay System is an essential element of the European in-orbit infrastructure to be deployed in the later 1990s. It will provide the communications links between all the elements of this infrastructure and the ground, and will thus allow maximum benefit to be gained from these programmes. The Data Relay System will offer high-data-rate links for longer periods, allowing more information to be transferred to the ground from satellites. It will extend the coverage of Earth-observation satellites, as well offer flexibility in the location of ground stations. Data and TTC relay and localisation will be provided as operational services of a fully integrated Data Relay System.

Acknowledgement

Thanks are due to André Buelens who created the maps.

Considérations sur la procédure d'engagement des programmes facultatifs

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L'article V.1.b et l'Annexe III de la Convention de l'Agence (voir extraits en Annexe) sont certainement parmi les dispositions de cette dernière les plus connues, peut-être non pas par leur libellé mais leur 'produit', le programme facultatif. Mais il ne se passe guère de réunions de 'Participants potentiels' sans que ne soient posées au Service juridique quelques questions d'interprétation, comme quel est ce délai de trois mois, qui adopte la Déclaration, etc. Après quelque dix ans d'application, on peut tenter d'en tracer un bilan sans avoir la prétention qu'il soit exhaustif.

Des programmes 'à la carte'
Ces dispositions de l'article V.1.b et de l'Annexe III remontent au début des années 70 et ne sont que la reprise de dispositions arrêtées lors de la révision de la Convention du CERS/ESRO.

En 1985, le Conseil a adopté trois Résolutions 'habilitantes', en 1986, quatre Résolutions. Depuis l'entrée en vigueur de facto de la Convention, quelque 57 Déclarations ont été établies. Les programmes facultatifs représentent quelque 70% du total des budgets de l'Agence, c'est dire l'importance de cette notion.

Elle répondait à l'élargissement des activités spatiales au début des années 70 qui avait conduit à la crise du CERS/ESRO (dénonciation conditionnelle de la France et du Danemark) et à la mise en place d'une réflexion, dans le cadre de la Conférence spatiale européenne (CSE), pour l'établissement d'une Organisation spatiale unique en Europe dotée d'un tronc commun et gérant des programmes 'à la carte'. Le CERS/ESRO avait été conçu pour exécuter un programme scientifique unique et obligatoire. Ce schéma se révéla vite trop rigide pour pouvoir suivre l'évolution des activités spatiales (les satellites d'application) ainsi que les différents niveaux d'intérêt des divers Etats membres pour tel ou tel programme.

Un expédient temporaire fut trouvé dans une utilisation imaginative de l'article VIII de la Convention du CERS/ESRO (devenu l'article IX dans la Convention de l'ESA: 'l'aide aux Etats membres'). Cet article servit de support à la mise en route d'un train de programmes facultatifs importants (après la première application qui en fut faite pour le programme TD): Aérosat, Météosat, Ariane, Spacelab, Télécommunications (OTS — Marecs).

Mais sur le plan juridique la mise en oeuvre de cet article VIII restait assez lourde: en effet, il fallait conclure un 'Arrangement' formel entre les Etats membres intéressés d'une part et l'Organisation d'autre part (démontrant la personnalité propre de l'Organisation), traité international faisant l'objet de signature et dans la plupart des cas sous réserve de ratification (ce qui retardait l'entrée en vigueur de l'Accord au moins pour certains signataires). Le procédé pouvait à la rigueur convenir mais seulement si le nombre de programmes demeurait limité.

Simplification et flexibilité
La grande novation apportée par la Convention ESA fut d'incorporer les programmes facultatifs, de les rapatrier et par là de simplifier encore la procédure d'adoption. Plus de signature d'un Accord formel. Plus de procédure de ratification. L' engagement des Etats participants s'exprime désormais dans une forme simplifiée, d'une 'Déclaration', un texte de quelques pages qui définit le contenu technique et calendaire du programme, l'enveloppe financière et le barème de contributions (et qui conserve le caractère d'accord international).

Le concept de programme facultatif peut être utilisé quelle que soit la nature de l'activité visée: recherche scientifique, applications, moyens de transport spatial. Il est nécessaire et suffisant que l'activité soit conforme à la mission de l'Agence et soit décidée et financée par les Etats membres.

Les dispositions de l'Arrangement de type article VIII de la Convention du CERS/ESRO sont à présent réparties à travers trois textes: la Résolution du Conseil (qu'on appelle depuis 1977 'habilitante'), la Déclaration et le Règlement d'exécution. Tout ceci pour exprimer le fait que le programme continue à mettre face à face deux parties: les Etats participants d'une part, l'Agence de l'autre. Autre marque de flexibilité juridique, ce système a été utilisé sans attendre l'entrée en vigueur formelle de la Convention de l'Agence, dès son application 'de facto'.

Qui ne dit mot consent

L' idée de base, sans précédent si l'on compare la Convention de l'Agence à d'autres Conventions, est qu'un Etat membre qui ne dit mot acquiert ipso facto la qualité d'Etat participant. La qualité d'Etat participant se présume. Cette approche a été retenue pour sauvegarder l'idée communautaire: en principe et par principe, tous les Etats membres de l'Agence devraient participer à tous les programmes facultatifs. Mais compte tenu d'une part, de l'incertitude quant à l'ampleur de ces programmes, d'autre part, des capacités contributives des Etats membres, une clause échappatoire leur est offerte. L'Etat membre peut dire non; il peut le dire au cours de la période de trois mois qu'ouvre la Résolution 'habilitante', période incompressible établie par la Convention elle-même. Il peut encore le dire au cours d'une période additionnelle que les Etats participants peuvent insérer ou ne pas insérer dans la Déclaration et dont ils fixent eux-mêmes la durée.

Les textes fondamentaux

Le programme facultatif est régi par trois textes de base: la Résolution, la Déclaration, le règlement d'exécution.

La Résolution

Celle-ci est adoptée par le Conseil à la majorité de tous les Etats membres. Le Conseil est saisi d'une proposition de programme dont l'idée peut venir soit de l'Agence, soit d'un Etat membre (dans ce dernier cas, la proposition d'exécuter un programme comme programme facultatif de l'Agence peut être la suite de l'application de la procédure d'européanisation visée à l'Annexe IV de la Convention).

La Résolution donne le label 'programme de l'Agence' à l'activité en question, reconnaît que ce programme correspond bien aux objectifs de la Convention et qu'il peut être conduit par l'Agence (l'Exécutif). La conduite d'un programme auquel ne participent que quelques Etats membres peut avoir — et a — un effet global sur l'ensemble des Etats membres: utilisation de mêmes ressources (ce qui peut créer des questions de priorité), responsabilité internationale, bénéfice des privilèges et immunités en sont quelques exemples.

La Résolution peut couvrir un programme structuré en tranches ou phases successives, ce qui allège la procédure ultérieure, ou ne s'adresser qu'à un programme préparatoire.

La Résolution 'habilitante'

Celle-ci n'oblige pas le Gouvernement qui l'a voté à participer au programme en question. Par elle-même, elle n'emporte pas d'effet financier. L' effet de la Résolution est d'ouvrir une période de trois mois (parfois la Résolution diffère le point de départ de cette période). A l'issue de cette période, un Etat membre qui n'a pas notifié son non-intérêt est considéré comme Etat participant. Il en est résulté dans la pratique un texte fort simple (trop simple ?) en apparence, un libellé quasi-standard. La question essentielle n'est pas tant le libellé que celle de savoir à quel moment il-faut présenter à l'adoption du Conseil une telle Résolution.

Les rédacteurs de la Convention n'étaient pas naïfs au point de croire que la rédaction et l'adoption d'une Déclaration et d'un Règlement d'exécution pourraient se faire dans les trois mois qui suivent l'adoption de la Résolution habilitante. Quelle que soit la forme que prend l'instrument juridique, quelle que soit la simplification des procédures, il n'en demeure pas moins qu'il faut débattre des objectifs et du contenu du programme, de sa justification, de son calendrier (phases), de l'enveloppe financière, du barème de contributions et du retour industriel. Lorsque plusieurs programmes sont en même temps en cours d'élaboration, peuvent en outre apparaître des considérations de priorité ou d'une autre nature. Aussi, la phase de constitution du dossier est-elle devenue primordiale. Elle se fait au travers de ce qu'il est désormais devenu coutumier d'appeler des 'Réunions de Participants potentiels'. Les organes subsidiaires en place (Conseils directeurs de programme, etc.) conservent un certain rôle (avis par exemple de Conseil(s) directeur(s) de programme sur les aspects de mission, d'adéquation aux besoins d'utilisateurs, examen du règlement d'exécution sur le plan administratif).

La mise en oeuvre de l'Annexe III de la Convention a été étudiée par le Comité administratif et financier qui, en 1981, a rédigé pour faciliter la tâche des délégations, un certain nombre de directives, une procédure-type susceptible d'adaptation (voir Annexe). La situation idéale est celle dans laquelle le Conseil se voit saisi d'un dossier comprenant, outre la proposition de programme, le projet de Résolution mais aussi les projets de Déclaration et de Règlement d'exécution. Ainsi, dans la période de trois mois suivante ne s'agit-il que de vérifier au plan national l'acceptation de ces textes, de compléter les procédures internes; la Déclaration peut alors entrer en vigueur dans les délais les plus courts.

Il n'en est pas toujours ainsi; la Déclaration n'est pas toujours finalisée lorsque le Conseil adopte la Résolution habilitante, en particulier les taux de contributions peuvent ne pas être tous connus, le Règlement d'exécution en est au premier stade d'examen et n'a pas été encore vu par l'AFC ou le Conseil directeur de programme.

La Déclaration L' établissement de la Déclaration comme sa révision ultérieure, est l'oeuvre des Etats participants. Elle est envoyée au Conseil pour information. La Convention a voulu par là laisser toute responsabilité aux Etats participants. L'Annexe III de la Convention se limite à énoncer les points à faire figurer à tout le moins dans un texte de Déclaration, essentiellement l'enveloppe financière (ou sous-enveloppes), le barème de contributions, le calendrier (phases). Il faut ici relever que la disposition selon laquelle un programme peut se dérouler en phases à l'intérieur d'une même Déclaration, le passage d'une phase à une autre se faisant à la double majorité des 2/3 n'a jamais été appliquée jusqu'à présent (le seul exemple est celui de l'Arrangement sur le programme de télécommunications de 1973).

Les Déclarations suivent un schéma standard: un texte principal suivi d'une Annexe technique (A) et d'une Annexe financière (B), ce qui ne signifie pas que leur établissement en est pour autant facilité !

On s'attachera à deux questions: la première intéresse l'entrée en vigueur de la Déclaration, la seconde est spécifique au découpage d'un même programme en séquences juridiquement autonomes.

On a vu plus haut que les Etats participants ont la liberté d'insérer dans la Déclaration un délai venant s'ajouter à la période de trois mois ouverte par la Résolution et qui leur permet de ne pas prendre part au programme. Ce qui signifie, en toute bonne logique, que le texte de la Déclaration doit être 'final' au plus tard à l'issue de cette période de trois mois, sinon comment pouvoir raisonnablement porter un jugement si tel ou tel élément du programme, la position de telle ou telle délégation, restent flous. En particulier, l'enveloppe financière et le barème des contributions doivent être connus.

Ici aussi le principe 'qui ne dit mot consent' s'applique. Toutefois, pour des raisons de sécurité juridique, la coutume s'est installée d'une confirmation positive écrite ou verbale de la Déclaration (confirmation verbale à l'occasion d'une réunion du Conseil, ou par télex...). L'Etat participant confirme sa souscription à la Déclaration. Il faut noter que quelques Gouvernements, malgré le fait que le dispositif figure dans la Convention elle-même qui a fait l'objet d'une procédure de ratification et qui de ce fait a acquis valeur parfois supérieure à la loi, ont encore à rechercher l'approbation parlementaire ou à compléter un processus gouvernemental d'approbation.

Pour refléter les considérations précédentes, la Déclaration contient une disposition selon laquelle l'Etat participant qui, à une date ultime de *x* mois (et ceci varie entre un à trois mois en général), n'a pas confirmé son acceptation du texte (acte positif) cesse d'être considéré comme tel. Ce délai devrait être le plus bref possible: des décisions sont à prendre, avec effet financier, et il convient de savoir qui peut voter, c'est-à-dire s'engager à supporter les dépenses contractées par l'Agence.

Les Déclarations contiennent en outre une disposition selon laquelle l'Agence (l'Exécutif) est autorisée à engager les travaux dans la mesure où les confirmations de souscriptions ont atteint un certain pourcentage de l'enveloppe financière du programme. A l'origine, cette clause dite des '80%' n'avait pas d'autre raison que de tenir compte des problèmes constitutionnels spécifiques de tel ou tel Etat participant (procédure d'approbation gouvernementale ou parlementaire), ni d'autre objectif que de ne pas retarder l'engagement des travaux. Mais l'enveloppe financière du programme était couverte à 100%. Or, cette disposition connaît une certaine déviation; elle est à présent utilisée pour débuter un programme alors qu'on sait qu'il n'est pas couvert financièrement à 100%. D'autres contributeurs ou ressources sont attendus mais il est devenu essentiel de démarrer le programme pour tenir les objectifs calendaires. Dès le départ, est créé un 'déficit structurel' qui amènera à bloquer certains travaux. Quant à ce seuil, il peut varier d'un programme à un autre, aller de 70 à 95%, le seuil retenu étant un certain reflet du barème de contributions.

La Déclaration est certes essentielle mais ne suffit pas; il faut encore qu'un budget soit voté pour que les contributions puissent être appelées et les contrats conclus. Pour des raisons d'urgence, il arrive qu'un budget soit présenté alors que la Déclaration n'est pas encore en vigueur ou parfois n'est pas finalisée; le budget peut être voté (par tous les Etats membres qui n'auraient pas formellement dit non au programme) mais il ne sera opératif que lorsque les conditions prévues par la Déclaration pour sa prise d'effet auront été remplies (effet suspensif). En l'absence d'une délégation de compétence à un Conseil directeur de programme (ce qui se fait en général via le Règlement d'exécution), c'est au Conseil qu'il appartient de voter le budget.

Les Déclarations sur des programmes préparatoires ou en tranches posent des problèmes spécifiques: il faut en effet assurer le déroulement des travaux, leur continuité. Or, le programme ultérieur, de développement par exemple, sera au plan juridique un programme nouveau appelant la trilogie des instruments juridiques. Pour faciliter cette continuité, l'habitude a été prise d'insérer dans ce type de Déclaration la description d'une procédure (ce qui peut aller jusqu'à toucher à des considérations de retour industriel et d'ajustement de contributions).

Un substitut à la Déclaration sur un programme en phases est le système de Déclarations 'gigognes': une première Déclaration suivie par des Déclarations séparées qui n'engagent que ceux des Etats participants qui les souscrivent (ex. programme Ariane-4).

Le Règlement d'exécution
Celui-ci est élaboré par les Participants potentiels, c'est-à-dire qu'il doit recueillir leur agrément, puis être examiné par le Comité administratif et financier et finalement approuvé par le Conseil à la majorité simple. C'est donc un texte qui suit un processus tout à fait distinct de celui de la Déclaration et qui redonne au Conseil un pouvoir de direction et de contrôle. La Convention cherche à maintenir dans toute la mesure du possible, une similarité de gestion des activités obligatoires et des programmes facultatifs et des programmes facultatifs entre eux. Elle dispose que le programme facultatif est exécuté conformément aux règles et procédures en vigueur de l'Agence, tout en permettant aux Etats participants d'établir des règles spécifiques au programme (règlement financier, règlement des contrats, etc.).

Les règles et procédures de l'Agence ne peuvent pas couvrir tous les aspects d'exécution d'un programme facultatif, ni prendre à l'avance en compte toute leur spécificité. Jusqu'où peut aller cette liberté des Etats participants ? Peuvent-ils déroger aux règles de base ? La liberté s'arrête devant les règles générales posées pour tous les programmes et qui manifestement peuvent rendre compte de toutes les situations du programme en cause, s'exprime en l'absence de dispositions ou devant l'incompatibilité d'une disposition générale et d'une spécificité technique du programme. Le Conseil se réserve le droit de vérifier et d'approuver ces règles spécifiques pour maintenir la cohésion maximale de

ANNEXE

Convention

Article V.1:

'Les activités de l'Agence comprennent des activités obligatoires auxquelles tous les Etats membres participent et des activités facultatives auxquelles tous les Etats membres participent, sauf ceux qui déclarent formellement ne pas être intéressés à y participer.

b. au titre des activités facultatives, l'Agence assure, conformément aux dispositions de l'Annexe III, l'exécution de programmes qui peuvent notamment comporter:

........................'

Annexe III:

Article premier

'2. Lorsque le Conseil, conformément à l'article XI.5.c (i) de la Convention, a accepté la réalisation d'un programme facultatif dans le cadre de l'Agence, tout Etat membre qui n'a pas l'intention d'y participer doit, dans un délai de trois mois, se déclarer formellement non intéressé à y participer; les Etats participants établissent une Déclaration qui, sous réserve de l'article III.1, précise leurs engagements en ce qui concrne:

a. les phases du programme;

b. les conditions de sa réalisation, notamment le calendrier, l'enveloppe financière indicative et les sous-enveloppes indicatives relatives aux phases du programme, ainsi que toute autre disposition concernant sa gestion et son exécution;

c. le barème des contributions fixé conformément à l'article XIII.2 de la Convention;

d. la durée et le montant du premier engagement financier ferme.

3. La Déclaration est transmise au Conseil pour information en même temps qu'un projet de règlement d'exécution soumis à son approbation.

4. Si un Etat participant n'est pas en mesure de souscrire aux dispositions énoncées dans la Déclaration et le règlement d'exécution dans le délai que fixe la Déclaration, il cesse d'être Etat participant.'

l'ensemble des programmes, prévenir un émiettement nuisible à la capacité de gestion de l'Agence elle-même. Le Règlement d'exécution est par ailleurs l'occasion soit de créer le cas échéant un organe subsidiaire (le Conseil directeur de programme) et lui déléguer des tâches de la compétence du Conseil, soit de les déléguer à un organe subsidiaire existant. Cette délégation appelle alors un vote à la majorité des 2/3 des Etats membres. Le Règlement d'exécution peut aussi être l'occasion de définir les modalités d'association d'organismes extérieurs à l'exercice des responsabilités de l'Agence. Les raisons de calendrier, de procédure, font qu'il est quasiment impossible de disposer d'un Règlement d'exécution approuvé par le Conseil à l'issue de la période de trois mois ouverte par la Résolution habilitante.

L'expérience montre qu'une période d'une dizaine de mois est le délai minimum entre le début de réunions de Participants potentiels et l'entrée en vigueur d'une Déclaration, le vote du budget et l'attribution des contrats. Aussi est-il sage de partir de la date objectif du début du programme et de bâtir le calendrier à reculons en tenant compte des délais incompressibles.

La Convention avait à naviguer entre deux écueils: une certaine rigidité nécessaire pour assurer l'objectif de cohésion de l'ensemble des programmes et la plus grande similarité de gestion, et une nécessaire souplesse pour assurer l'objectif de responsabilité des Etats participants.

Les difficultés pratiques dont quelques-unes ont été identifiées ci-dessus ne doivent pas cacher le fait que la souplesse d'engagement de programme facultatif permet à l'Agence de coller à l'évolution des activités spatiales et de prendre en compte les contraintes de nature diverse. Aussi, le bilan est-il plus que positif.

PROCEDURE-TYPE RECOMMANDEE PAR L'AFC POUR L'ADOPTION DES PROGRAMMES FACULTATIFS

On distingue trois phases:

— **phase 0: identification du programme.**
Elle se manifeste par la présentation aux délégations du résultat d'études (phase A) sur un programme possible;

— **phase 1: établissement du dossier de programme.**
Elle consiste dans l'examen approfondi par les délégations du programme identifié: adéquation aux besoins, contenu technique, découpage en phases éventuellement, coût à achèvement et barème possible de contributions; elle comporte aussi la rédaction de projets de documents juridiques. L'objectif est de parvenir à un dossier complet et à une identification des Participants potentiels. Cet examen peut prendre place soit dans le cadre d'un organe subsidiaire soit dans celui d'un groupe ad hoc et ces réunions sont ouvertes à l'ensemble des délégations des Etats membres et des membres associés. Les avis et commentaires des divers organes subsidiaires intéressés sont recueillis et le Conseil est régulièrement tenu informé de l'avancement des travaux. La pratique montre que la durée d'une telle phase est au moins de l'ordre de six mois.

— **phase 2: établissement du cadre institutionnel**
(a) Lorsque le Directeur général a l'impression que la proposition de programme a reçu un appui suffisant, il saisit le Conseil du dossier établi au cours de la phase 1 ci-dessus.

(b) Le Conseil est alors invité à se prononcer sur l'exécution de ce programme, comme programme facultatif dans le cadre de l'Agence. Après avoir demandé et reçu, le cas échéant, des informations complémentaires, le Conseil adopte une Résolution par laquelle il accepte l'exécution du programme facultatif en question dans le cadre de l'Agence.

(c) Le Directeur général communique sans délai aux Etats membres la Résolution du Conseil accompagnée du dossier de programme. Les Etats membres qui ne désirent pas prendre part audit programme disposent d'un délai de trois mois à compter de la Résolution pour notifier par écrit au Directeur général leur décision de non-participation.

(d) Au cours de ce même délai de trois mois, les Etats membres intéressés communiquent au Directeur général, le cas échéant, leurs propositions d'amendement aux projets de Déclaration et de règlement d'exécution élaborés au cours de la phase 1. Il est alors procédé à l'établissement définitif du texte de ces deux documents juridiques.

(e) Le plus tôt possible après le vote de la Résolution du Conseil et au plus tard à l'issue de la période de trois mois à compter de cette date, les Etats qui le désirent souscrivent la Déclaration et acceptent le règlement d'exécution qui est transmis au Conseil pour approbation.

(f) A l'issue de la période de trois mois à compter de la Résolution du Conseil ou, le cas échéant, à l'expiration d'un délai supplémentaire fixé dans la Déclaration:

(i) les Etats membres qui n'ont pas fait connaître leur décision de ne pas participer mais qui n'ont pas encore souscrit la Déclaration doivent le faire; sinon leur souscription ultérieure serait équivalente à une adhésion et soumise à des conditions particulières si la Déclaration le prévoit;

(ii) le Conseil approuve le projet de règlement d'exécution.

Office Automation in the Agency

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There is a natural evolution currently taking place in the office environment from word processing to the wider domain of the 'electronic office', both functions being primarily concerned with text and written communication. The professional press concerned with administrative management leaves no doubt as to the strong trend today towards the combination of basic office functions capable of access from a single work-station. Extensive analysis carried out by Booz Allen & Hamilton of the introduction of office automation concludes that it could result in an estimated 25% reduction in office overheads over the next ten years in comparison with historical trends (Fig. 1).

Introduction

'Office automation' can be defined as 'the utilisation of technology to improve the realisation of office functions'. The time when pencil, or pen, and paper were the sole technology of the office environment has long gone. The great strides made in computing in the last two decades have brought improvements in virtually all office functions, for secretarial staff, administrators and engineers alike.

The Agency has so far kept up well with these developments in office automation and is determined to maintain and even improve on its present level.

Historical background

The first serious step towards the introduction of specific office-automation technology in the Agency was taken in 1978, with the decision of the Director of Administration to introduce modern word-processing equipment. This led in 1980 to standardisation on one type of advanced word processor (the P5000-series) for the whole of the Agency.

One of the major selection criteria was the communications potential of the equipment. Exchange of documents using telephone connections was available as a standard facility. A few connections between the various ESA Establishments have been installed since and are still operational. Introduction of the word processors also gave the Agency its first experience with electronic mail.

In 1982, the ESA Computer Department (ECD) was charged with the definition of technical standards for word-processing equipment and the study of a 'satisfactory and well-proven concept for word-processing communication'. Since office-automation technology was already

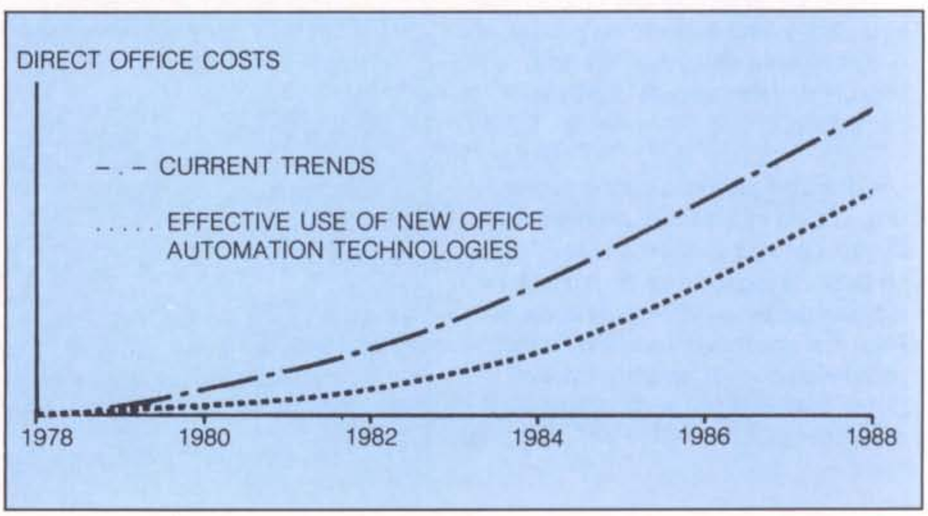


Figure 1 — Projected trends in direct office costs for the remainder of the 1980s

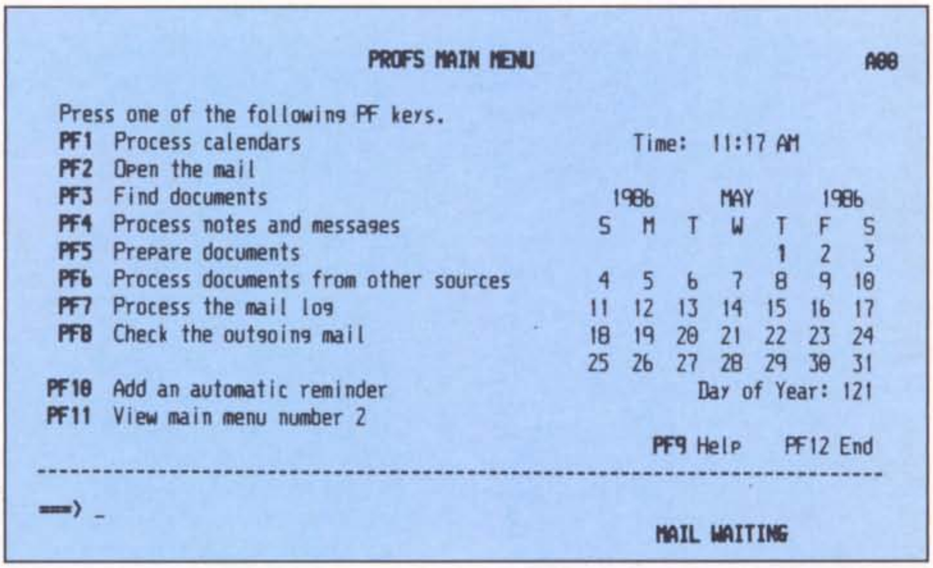


Figure 2 — The PROFS Main Menu

moving towards the integration of data processing, word processing and telecommunications, the problem of communicating word processors was considered in the overall context of developments in office automation.

The second major step occurred in 1983 with the approval of the ESA medium-term Computer Policy, which proposed standardisation of all central computing facilities (the so-called 'mainframes') for the different Establishments. With compatible mainframes in all Establishments and an already existing communication network between them (ESANET), the possibilities of using this infrastructure for office automation also, and in particular for electronic mail, were explored.

Communicating word processors require the simultaneous presence of staff at both ends. Computers could provide a 'store-and-forward' facility whereby mail could be passed to the local mainframe, where necessary transmitted to another mainframe, and then presented to the 'addressee' on a 'mailbox' principle.

A commercially available software product called the 'PRofessional OFfice System (PROFS)', which could be supported by the mainframes, was installed at ESTEC for experimentation in 1983 Fig. 2). PROFS turned out to be a very attractive product. In addition to electronic-mailing facilities, it offered a set of user-friendly personal services like calendar/diary, electronic archiving, text editing and easy interfacing to other software facilities on the mainframe for 'spread-sheets', database access, etc. A wide variety of computer terminals could be used to access the system, and the communication facilities of the word processors allowed for the transfer of text to and from the mainframe.

Following a small-scale 'pilot' project with PROFS, this system was recommended as the backbone for the Agency's future office-automation activities. The system was subsequently made available to all users at ESTEC in Noordwijk (The Netherlands) in 1984, at ESOC in Darmstadt (Germany) in 1985, and at HQ in Paris in 1986. The installation at ESRIN in Frascati (Italy) took place in June 1987. By the end of 1986, around 1000 staff were registered as PROFS users (600 at ESTEC, 300 at ESOC and 100 at HQ/ESRIN).

What is office automation today?

There are presently four distinct application areas in office terms:

1. Text Processing
2. Electronic Mail
3. Personal Services
4. Decision Support.

The trend in office automation today is a rapid move towards full integration of all four areas. This integration is not restricted to improvements in the exchangeability of information between the different applications, or in ease of use. It is aimed at making all office functions available to all individuals to the degree required for their particular work. This calls for a work-station with sufficient flexibility in terms of physical configuration, communications and programming.

The introduction of Personal Computers (PCs), with their inherent flexibility, has constituted a major step in facilitating the 'integrated office'. The Agency's Computer Standardisation Board (CSB) has therefore approved PC-based work-stations for office-automation applications. Assessment of the extent to which a PC can satisfy the Agency's requirements still requires some further analysis of the different applications.

Text processing

Since the PC is constructed as a multi-purpose unit, it is understandable that the user interface, i.e. the keyboard, cannot be optimally designed for text processing, unlike those of dedicated word processors. This makes word processing on a PC less user-friendly. The word-processing packages on a PC can, however, make use of the fact that it provides, in general, more sophisticated filing and communications facilities. National-language support is also an integral part of the PC support software and a wide variety of peripheral equipment can be attached.

Electronic mail

The PC's communications facilities allow for error-free transfer of data to and from the mainframe. With the mainframe taking care of further transmission to the other ESA Establishments, using the PROFS 'mailbox' facility, electronic mailing becomes a practical possibility. Furthermore, a PC can be configured as a VT-100-compatible terminal with file-transfer facilities for asynchronous transmission. In this mode, access to external databases using public-network services can be established.

Personal services

These usually embrace facilities that improve efficiency at a personal level, such as diaries, address lists, action files, electronic archiving or indexing, spreadsheets, message/note facilities, viewgraph production, electronic note pads, calculators, etc. With a PC, use can also be made of facilities residing on mainframes (i.e. PROFS personal services and mainframe software packages) by using the PC in terminal mode, or facilities on the PC itself, or a combination of both (i.e. PROFS PC Support).

Decision support

This covers the possibilities of gaining access to database information in an interactive mode, to retrieve information on the basis of logical combinations of selection criteria. For this type of application, the ESA Board for Software Standardisation and Control (BSSC) has selected the type of database ('relational') and the interrogation language ('SQL') to be used in the Agency. Fourth-generation application languages are required to analyse and present the extracted data. The PC, in either terminal or stand-alone mode, allows unrestricted access to these facilities (Oracle, SQL/DS, Application System AS, Lotus 1-2-3, etc.).

From the above it is clear that, with the facilities offered by PROFS, the introduction of PC-based work-stations, and the ESA communications infrastructure (ESANET), the Agency has already achieved a high level of integration and standardisation in its endeavours towards office automation.

Standardisation

Standardisation of office automation in the Agency must be considered at three different levels:

1. At the Agency-wide level, with standards mainly for:

a. Exchange of text/images/graphics. When interchanging text that needs further editing, or which forms part of a multi-author document, formatting instructions must be embedded in the text. Such text, referred to as 'Revisable-Form Text' (RFT), must be standardised. The Agency has adopted the industry-standard Document Content Architecture (DCA), which is fully supported by the present standard mainframes (Displaywrite/370) and work-stations (Displaywrite). No standards have yet been set for images and graphics, with the exception of business graphics on the mainframe and certain types of work-stations (GDDM).

b. Electronic mail. At present PROFS is used in the Agency as a vehicle for electronic mailing. Support for international document-exchange standards (e.g. x400) will be incorporated as soon as proven and reliable software is available. Telex support is already fully integrated at ESTEC in PROFS.

2. At the organisational-unit level, with standards for document registration and filing, interfaces with organisational data-processing applications and interchange between work-stations. These standards are usually based on requirements from within the organisational unit and implemented as special applications or purchased for use within the unit only. Examples are: special document-registration programs in AS, project-specific database systems and spread sheets, project-control programs, financial systems (EFSY), personnel management (GIP), contract status (ESCA), etc.

3. At the work-station level, for both hardware and software as defined in the CSB instruction : 'Work-Stations for Office Automation'. These standards are set to ensure compatibility with standards at the higher levels. In order to maintain a similar office-automation environment on the mainframes in the different Establishments, an Office-Automation Change Control Board (OACCB) has been set up, with representatives from the different support groups within the ESA Computer Department.

External interfaces

Interfaces with industry and other Agencies have been defined for the transfer of information (at present mainly text) to and from the Agency's office-automation environment (Fig. 3). These interfaces are:

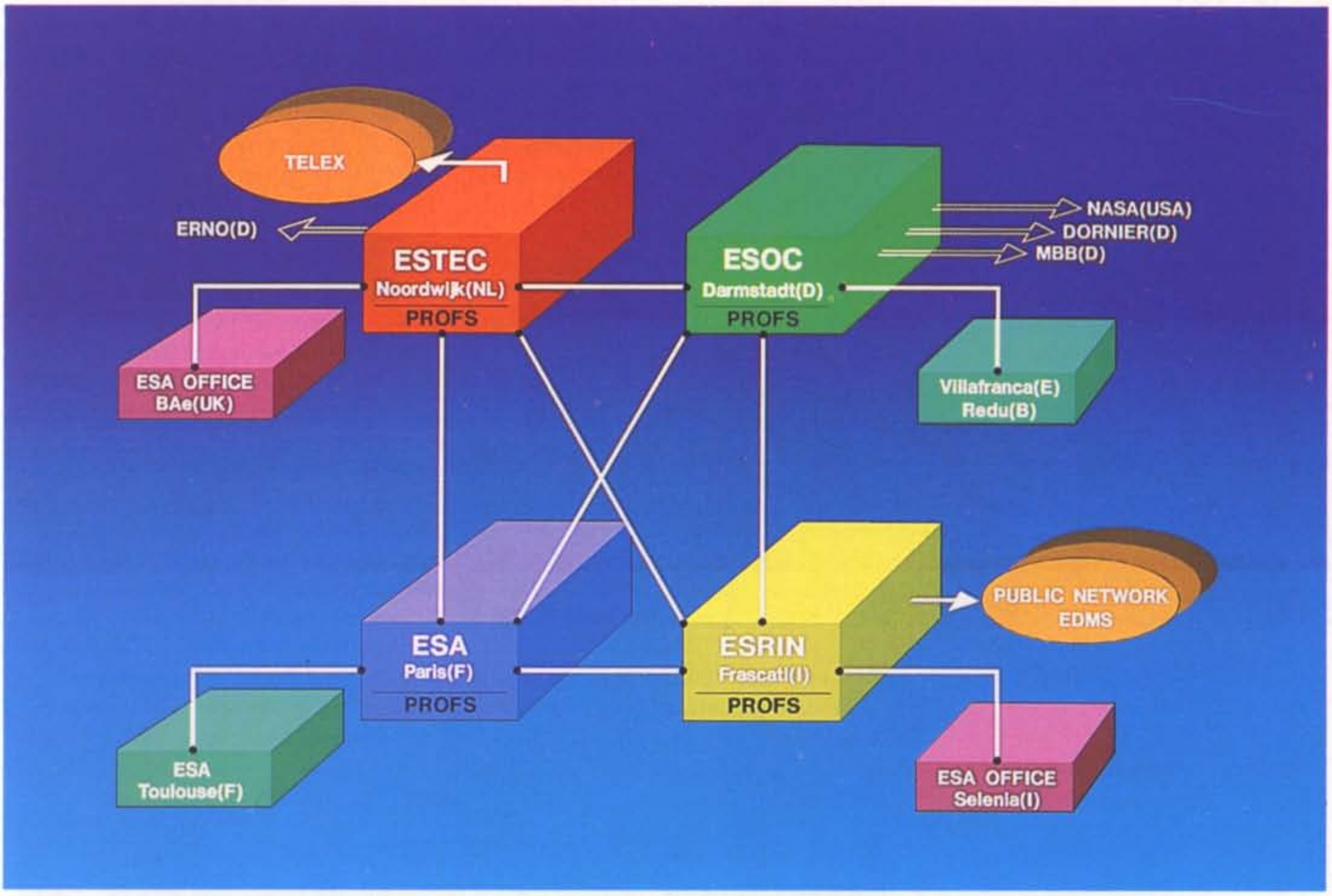
1. PROFS to PROFS connections. Where another agency or a member of the space industry has compatible mainframes, the Agency supports the installation of PROFS and connection via a leased line to one of the ESA mainframes. This type of connection has already been established with Dornier, ERNO, MBB and NASA.

2. PROFS access via public networks. There are two types of users here:

   a. External ESA—PROFS users, usually for the execution of an ESA contract to communicate with the responsible ESA staff. Access is therefore of limited duration.

   b. QUESTMAIL users. For external users wanting to send/receive PROFS notes and documents, ESRIN and ECD have jointly developed an interface to PROFS. This interface is available to everyone who has access to the ESA Documentation Management Services (EDMS). For document exchange, the ESA document standards must be adhered to.

Figure 3 — ESA's Office-Automation Network (per June 1987)



3. ESA Documentation Management Services (EDMS) at ESRIN, which are designed to provide the Agency with tools for the distribution and archiving of documentation. This service, which is complementary to the Agency's office-automation activities, supports:

a. The Electronic Mail Invitation to Tender System (EMITS), used to distribute information on the Agency's tender actions to industry and to Delegations.

b. The Document Distribution System (DODIS), for the distribution of documents to a closed user group (e.g. IPC papers).

c. Archiving and retrieval of Agency documentation.

The EDMS services adhere to the Agency's office-automation standards for documents.

Future developments

The present standards for software are well-defined and unlikely to change drastically in the near future. Continuous improvements will, however, be made to achieve greater functionality. The situation is rather different for the hardware involved, namely the work-stations. The hardware technology is changing rapidly, with a pronounced trend towards:

1. More powerful PCs with improved user interfacing (windowing, graphs and images, voice synthesis, etc.).

2. Constant strengthening of the integration with mainframes.

3. Improved ergonomics geared towards particular applications.

4. New, inexpensive peripheral equipment for input (scanners) and output (plotters, laser printers, optical discs) purposes. These will contribute substantially to early integration of images in the office environment.

The present communications infrastructure (ESANET) will, in the future, support continuous availability of the ESA internal network. More and more international network operators will offer 'bridges' between the various office-automation implementations on the basis of recognised standards. The Agency, however, is well-prepared for these future changes.

In Brief

New Chairman of ESA Council

In the 78th session of the ESA Council the Danish delegate, Mr Henrik Grage, was unanimously elected as Chairman for the next two years. Mr Grage (aged 46) succeeds Mr H. Atkinson (UK) who has chaired the Council for the last three years.

After graduating in law in 1966, Mr Grage worked at the Danish Ministry of Education and Research. He has been involved with European space activities for the last seventeen years and has served as Chairman of the ESA International Relations Advisory Committee and as Vice-Chairman of Council. Until his appointment as Chairman of Council, Mr Grage was Chairman of ESA's Industrial Policy Committee.

Director General's Mandate Extended

The ESA Council in its 78th session on 22 and 23 June elected to extend the mandate of its Director General Prof. R. Lüst by another two years.

Prof. Lüst took up office in September 1984, having been appointed for a initial term of four years. His current term would therefore have expired on 1 September 1988, and is now extended until 31 August 1990.

Prof. R. Lüst, ESA's Director General, in the life-sized model of the Hermes spaceplane at the 37th International Aerospace Exhibition

ESA at Le Bourget

The 37th International Aerospace Exhibition at Le Bourget took place from 12–21 June. This year ESA had two pavilions; the first, with a surface area of 700m², housed life-sized models of ECS-2, Olympus, Hipparcos and Giotto. Also on display were 1:10 models of Ariane-4 and Ariane-5, and half-size models of ERS-1, Eureca and the international Space Station concept. Animated computer graphics of Columbus, Hermes, Ariane-5 and ERS-1 were also projected across the dome of the pavilion.

In the smaller, joint ESA/CNES pavilion, linked to the first, life-sized models of the Hermes spaceplane and the Man-Tended Free-Flyer (MTFF) were on display for the first time, as part of an exhibition entitled 'Man in Space'.

On 10 June, prior to the offical opening of the exhibition, a joint press conference was given by ESA's Director General, Prof. R. Lüst, and the Director General of CNES, Mr F. d'Allest. In-orbit infrastructures and a permanent European presence in Space were the themes of the press conference, which was followed by a visit to the ESA/CNES pavilion.

On the opening day of the exhibition the three ESA astronauts, Ulf Merbold, Wubbo Ockels and Claude Nicollier were on hand at the pavilion to meet the press. A briefing for journalists on existing and planned aerospace databanks available through the Agency's Information Retrieval Service (IRS) was also held.

Throughout the airshow various workshops were held in the two pavilions, including a demonstration of the EMITS system, an electronic mailing system used by ESA to issue Invitations to Tender, and SPIDAB, a catalogue of products and expertise available within European industry, jointly developed by ESA and Eurospace.

The joint ESA/CNES press conference at Le Bourget, given by Prof. R. Lüst (left), ESA's Director General and Mr F. d'Allest, Director General of CNES

Two Successful Prodat Demonstrations

The first live demonstration of Prodat was given at the Le Bourget Airshow in June. Messages were transmitted via satellite to ESA's ground station at Villafranca in Spain and onward to the public telex and data networks.

Prodat is a satellite communications relay system for data transmission between users on land, at sea and in the air. It will provide a reliable method of communicating an aircraft's position and other information (e.g. flight operations and maintenance data) once out of radar and VHF range. It will also offer passenger telex facilities via ground networks during flight. The programme is financed by seven Member States (Belgium, France, Germany, Italy, Norway, Spain and the United Kingdom) and is part of ESA's Prosat project (see ESA Bulletin 48, pp. 13-17).

A further successful demonstration of Prodat was held at the Villafranca ground station on 9 July with messages transmitted to the station from a land mobile Prodat terminal via Marecs-B.

Service trials of Prodat, organised by SITA (Société Internationale de Télécommunications Aéronautiques) in cooperation with ESA and Inmarsat, are due to commence in September. The trials will enable selected SITA member airlines to extend AIRCOM coverage to oceanic and other low traffic density areas. A Transportes Aereos Portugueses (TAP) Tristar will be the first aircraft to be fitted with Prodat, followed by European Falcon Service private Falcon 50s. Other airlines taking part include Air France, Sabena and the Brazilian airline VARIG.

The use of Prodat is not confined to aircraft, and long-distance lorry trials will commence shortly under the auspices of URBA 2000. The first six lorries (Trans-Artos Frigo) will be fitted with terminals in September.

Latest Ariane Launch Manifest

Year	*Month*	*Flight serial no.*	*Launch vehicle*	*Spacecraft*
1987	August*	V19	AR-3	Aussat-K3 & ECS-4
	October	V20	AR-2	TV-Sat-1
	December	V21	AR-3	G-Star-III/Geostar-R01 & Telecom-1C
1988	January**	V22	AR-4	APEX 401: Meteosat-P2, Amsat & Panamsat
	March	V23	AR-2	Intelsat-V F13
	April	V24	AR-2	TDF-1
	May	V25	AR-3	Spacenet-IIIR/Geostar-R02 & SBS-5
	June	V26	AR-3	ECS-5 & Insat-1C
	September	V27	AR-4	Astra-1 & Operational Meteosat-1
	October	V28	AR-2	Intelsat-V F15
	November	V29	AR-4	Tele-X** & Skynet-4B
1989	January	V30	AR-3	Olympus
	February	V31	AR-4	JC-Sat & DFS-1
	March	V32	AR-2	SPOT-2
	April	V33	AR-4	Superbird-A & Hipparcos
	May	V34	AR-4	Intelsat-VI F1
	June	V35	AR-4	Superbird-B & Inmarsat-2 F1
	September	V36	AR-4	TDF-2 & DFS-2 (or Inmarsat-2 F2 or G-Star-IV/Geostar-TR1)
	October	V37	AR-4	Satcom-K3 & Inmarsat-2 F2 (or DFS-2 or G-Star-IV/Geostar-TR1)
	November	V38	AR-4	Intelsat-VI F2
1990	January	V39	AR-4	Eutelsat-IIA & Operational Meteosat-2
	February	V40	AR-4	TV-Sat-2 & G-Star-IV/Geostar-TR1 (or DFS-2 or Inmarsat-2 F2)
	March	V41	AR-4	Eutelsat-II B & Skynet-4C (or ERS-1)
	April	V42	AR-4	Intelsat-VI F3 (or Anik-E1)
	May	V43	AR-4	ERS-1 (or Eutelsat-IIB & Skynet-4C)
	June	V44	AR-4	Anik-E1 (or Intelsat-VI F3)
	September	V45	AR-4	Eutelsat-IIC & Italsat-1
	October	V46	AR-4	Satcom-K4 & Geostar-II
	November	V47	AR-4	Anik-E2

* Now likely to be September

** The decision to launch Ariane-401 between Flights 21 & 23 or between Flights 20 & 21 will be taken later

'Encounter '86' Presentations

A limited edition of leather-bound copies of the book 'Encounter 86', which summarised the main results of the encounters with Comet Halley, was prepared by ESA on behalf of the Inter-Agency Consultative Group for Space Science (IACG). The first two copies of the limited edition were presented in November 1986 to His Holiness Pope John Paul II and the President of the Republic of Italy, Francesco Cossiga. Copies were also given to the Presidents, Heads of Government and Ministers of Science of the ESA Member States and IACG countries and key individuals involved with the space missions to Halley's Comet.

The IACG is a multi-agency forum for the coordination of space science projects. Members of the IACG are: Intercosmos, the Japanese Institute of Space and Astronautical Science (ISAS), NASA and ESA. From 1981 – 1986 the IACG coordinated the six missions to Halley's Comet, and is currently coordinating 13 projects involving 20 spacecraft in solar-terrestrial science (see also pages 8–21 of this issue).

Presentation of 'Encounter '86' to the President of the Republic of France on 5 February 1987. From left to right: President F. Mitterand; Prof. R.M. Bonnet, ESA's Director of Scientific Programmes; Dr H. Atkinson, Chairman of the ESA Council; Prof. R. Lüst, ESA's Director General; Mr D. Sacotte, Director of International Relations and Industrial Policy for CNES; Mr J.B. Levi, Scientific Advisor to the French President

Presentation of 'Encounter '86' to the President of the Federal Republic of Germany on 29 June 1987. From left to right: Prof. R. Lüst, ESA's Director General; Prof. R.M. Bonnet, ESA's Director of Scientific Programmes; Dr R. Reinhard, Giotto Project Scientist; His Excellency Dr Richard von Weizsäcker and Dr H.U. Keller, Principal Investigator for Giotto's Halley Multicolour Camera

Presentation of 'Encounter '86' to Her Majesty the Queen of The Netherlands on 10 March 1987. From left to right: Dr Th. J. Siskens, Dutch delegate to the ESA Council; Prof. R.M. Bonnet, ESA's Director of Scientific Programmes; Her Majesty Queen Beatrix; Dr R. Reinhard, Giotto Project Scientist; Prof. R. Lüst, ESA's Director General; Mr D. Dale, Giotto Project Manager and Mr M. Delahais, Head of ESA's Scientific Programme Department

25th Anniversary of Norway's Andøya Rocket Range

Norway's geographical position has inspired a particular interest in the processes and mechanisms creating the northern lights, and Norway has a long tradition in upper atmosphere and auroral research.

In the 1960s Norway* entered the Space Age with the construction of the Andøya rocket range to further the study of the polar ionosphere. The first instrumented rocket was launched on 18 August 1962 and the first scientific balloon was launched on 11 September of the same year.

Since 1962 scientists and engineers from more than 70 institutes and universities representing 16 nations have been engaged in scientific projects using Andøya. A total of 390 sounding and meteorological rockets and 159 scientific balloons (the largest 50 000 m³) have so far been launched.

Since 1 July 1972 the Andøya range has been given support by a number of ESA Member States who, in return, have been able to use the range on a marginal-cost basis. The range is run on a non-profit basis, with the emphasis on adaptability for a wide range of user requirements, easy access and few restrictions concerning launch operations. It offers a variety of possible trajectories, covering a large sea impact area.

Improved facilities currently being investigated include the possibility of launching a four-stage rocket with an impact range of more than 1600 km and a peak altitude of 1500 km (requiring a rocket guidance system and flight termination control system); a payload recovery service, and facilities for the launch of small satellites (weighing about 500 kg) into low Earth orbit.

In this, Andøya's 25th anniversary year, the largest rocket campaign ever accomplished is taking place. A total of 105 rockets will be launched from the range as part of a series of European campaigns in middle-atmosphere and thermosphere research. The Middle Atmosphere Cooperation/Summer in Northern Europe (MAC/SINE) project has already been successfully carried out, and MAC/Epsilon is scheduled for October/November.

A. Gundersen
Manager, Andøya Rocket Range
& Space Science Coordinator,
Norwegian Space Centre

*Norway became a full Member of ESA on 1 January. On 5 June the previous Space Activity Division of NTNF was established as the Norwegian Space Centre, whose budget and programmme come under the responsibility of the Ministry for Industry.

Andøya rocket range

Publications

The documents listed have been issued since the last publications announcement in the Bulletin. Requests for copies should be made in accordance with the Table and using the Order Form inside the back cover of this issue.

ESA Journal

The following papers have been published in ESA Journal Vol. 11, No. 2:

ADVANCED MATERIALS FOR ESA SPACECRAFT
DUNN B D

EFFECTS OF THE SPACE ENVIRONMENT ON LASER DIODES
ROUX M

THERMAL ANALYSIS AND ITS APPLICATION TO MATERIALS EVALUATION
JUDD M

SIMULATION TOOLS FOR THE DEVELOPMENT OF AN AUTONOMOUS RENDEZVOUS AND DOCKING SYSTEM
ELFVING A & FEHSE W

LOW-THRUST NAVIGATION TO COMETS OR ASTEROIDS
NOTON M & SALEHI S V

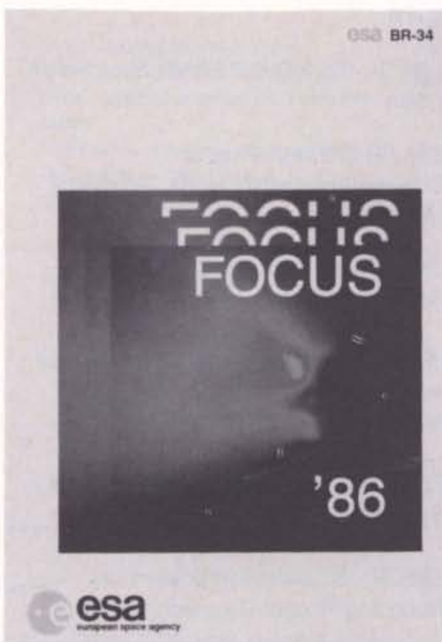
LATITUDE COVERAGE OF SOLAR ABSORPTION SPECTROMETRY OBSERVATIONS IN THE MIDDLE ATMOSPHERE FROM A HELIOSYNCHRONOUS ORBIT
VERCHEVAL J

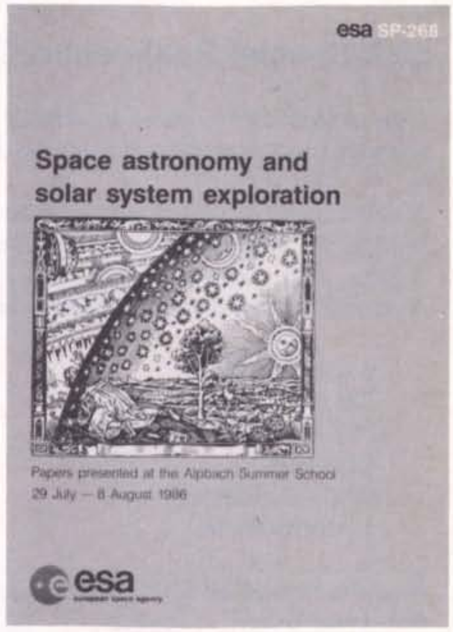
THE ON-BOARD SOFTWARE OF THE VEGA TV SYSTEM
DENES E ET AL

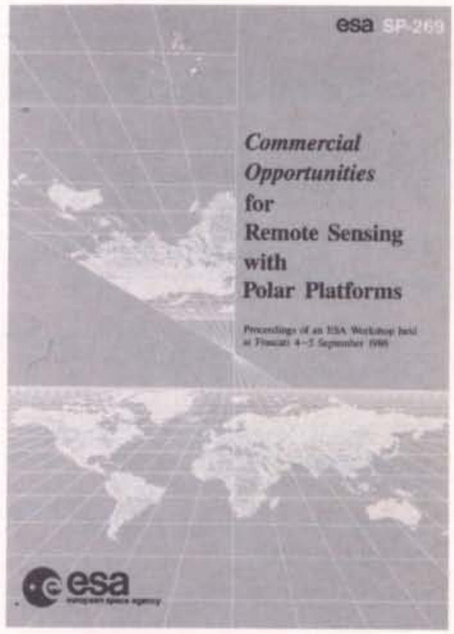
ESA Special Publications

ESA SP-268 // 149 PAGES
SPACE ASTRONOMY AND SOLAR SYSTEM EXPLORATION, PAPERS PRESENTED AT THE ALPBACH SUMMER SCHOOL, 29 JULY – 8 AUGUST 1986 (MAY 1987)
BURKE W R (ED)

ESA SP-269 // 75 PAGES
COMMERCIAL OPPORTUNITIES FOR REMOTE SENSING WITH POLAR PLATFORMS, PROC ESA WORKSHOP, FRASCATI, ITALY, 4–5 SEPTEMBER 1986 (APR 1987)
GUYENNE T D & HUNT J J (EDS)







ESA SP-282 // 696 PAGES
MESOSCALE ANALYSIS & FORECASTING, PROC INTERNATIONAL SYMPOSIUM, VANCOUVER, CANADA, 17–19 AUGUST 1987 (AUGUST 1987)
BATTRICK B & ROLFE E J (EDS)

ESA SP-1090 // 163 PAGES
REPORT ON THE SCIENTIFIC SATELLITES OF THE EUROPEAN SPACE AGENCY (MAY 1987)
TAYLOR B G & BURKE W R (EDS)

ESA Brochures

ESA BR-34 // 85 PAGES
FOCUS '86, A SUMMARY OF THE 1986 ANNUAL REPORT OF THE ACTIVITIES OF THE EUROPEAN SPACE AGENCY
LONGDON N & DAVID V (EDS)

ESA Scientific & Technical Memoranda

ESA STR-220 // 41 PAGES
ISDN STATUS AND OPPORTUNITIES FOR SATELLITE SYSTEMS (MAY 1987)
CASA J M

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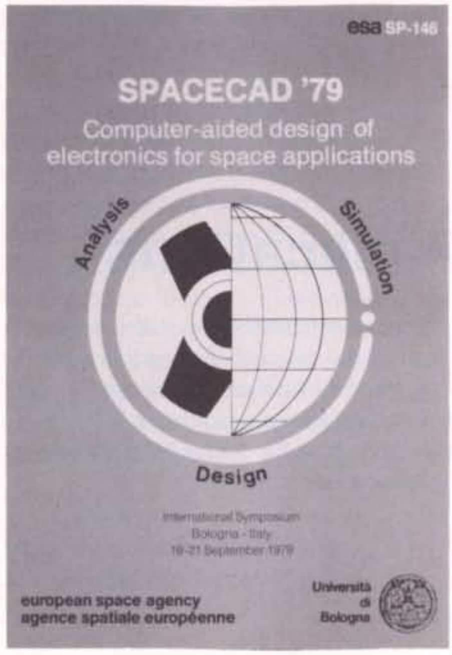


ESA SP-137 SONG 78 Workshop (1978)

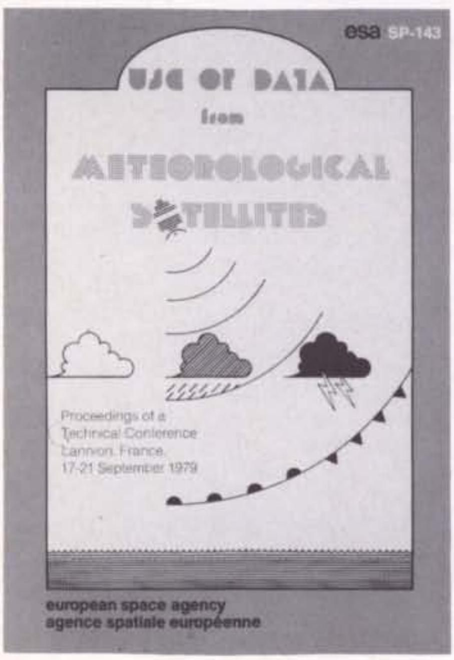
ESA SP-143 Conference sur l'utilisation de données de sat. mét. (1979)

ESA SP-144 Symp. sur la pyrotechnie spatiale (1979)

ESA SP-146 Computer–Aided Analysis of Circuits and Systems (1979)

ESA SP-148 Magnetopheric Boundary Layers (1980)

ESA SP 149 Earthquake Prediction Workshop (1979)



ESA SP-151 Space Activities, Cost Effectiveness (1980)

ESA SP-152 5th Sounding Rocket Symposium (1980)

ESA SP-155 Second Comet Halley Workshop (1981)

ESA SP-156 Second European Workshop on Earthquake Prediction (1980)

ESA SP-157 Second European IUE Conference (1980)

ESA SP-162 ESO/ESA Workshop (1981)

ESA SP-164 Alpbach Summer school. The Solar System and its Exploration (1981)

ESA SP-165 NOWCASTING Symposium (1981)

ESA SP-166 Workshop on Coherent/Incoherent Radar Scattering (1981)

ESA SP-176 Third European IUE Conference (1982)

ESA SP-178 2ème symp. intern. sur les materiaux pour sat. et sondes spat. (1982)

ESA SP-181 Alpbach Summer School on Solar Energy (1982)

ESA SP-183 Sixth Symposium on Sounding Rocket Research (1982)

ESA SP-194 URSI/ESA Symposium on Wave Propagation and Remote Sensing (1983)

ESA SP-195 Active Experiments in Space (1983)

ESA SP-196 European Space Mechanisms Symposium (1983)

ESA SP-197 Workshop on Spacecraft Vibration Testing using Multi-axis Hydraulic Vibration Systems (1983)

ESA SP-199 Symposium on Software Engineering (1983)

Publications Available from ESA Publications Division

Publication	Number of issues per year	Scope/Contents	Availability	Source
Periodicals				
ESA Bulletin	4	ESA's magazine	Free of charge	ESA Publications Division, ESTEC,
ESA Journal	4	ESA's learned journal	,,	2200 AG Noordwijk, The Netherlands
Earth Observation Quarterly (English or French)	4	Remote sensing newspaper	,,	,,
Columbus Logbook	4	Space Station/Columbus newspaper	,,	GTS Ltd., Forge House, 20 Market Place, Brentford Road, Middx. TW8 8EQ, UK
News & Views	6	ESA Information Retrieval Service's newspaper	,,	ESRIN, Via Galileo Galilei, CP64, 00044 Frascati, Italy
Monographs	**Code**			
Conference Proceedings	(SP-xxx)	Volumes on specific Conference subjects	Prices below	ESA Publications Division, ESTEC,
Scientific/Technical Monographs	(SP-xxxx)	Specific/detailed information on graduate-level subjects	,,	2200 AG Noordwijk, The Netherlands
ESA Brochures	(BR-xxx)	Summary of less than 50 pages on a specific subject	,,	,,
ESA Folders	(F-xxx)	'Folders' giving short description of a subject for the space-interested layman	Free of charge	ESA Publications Division, ESTEC, 2200 AG Noordwijk, The Netherlands
Scientific & Technical Reports	(STR-xxx)	Graduate level — reflecting ESA's position on a given subject	Prices below	,,
Scientific & Technical Memoranda	(STM-xxx)	Graduate level — latest but not finalised thinking on a given subject	,,	,,
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