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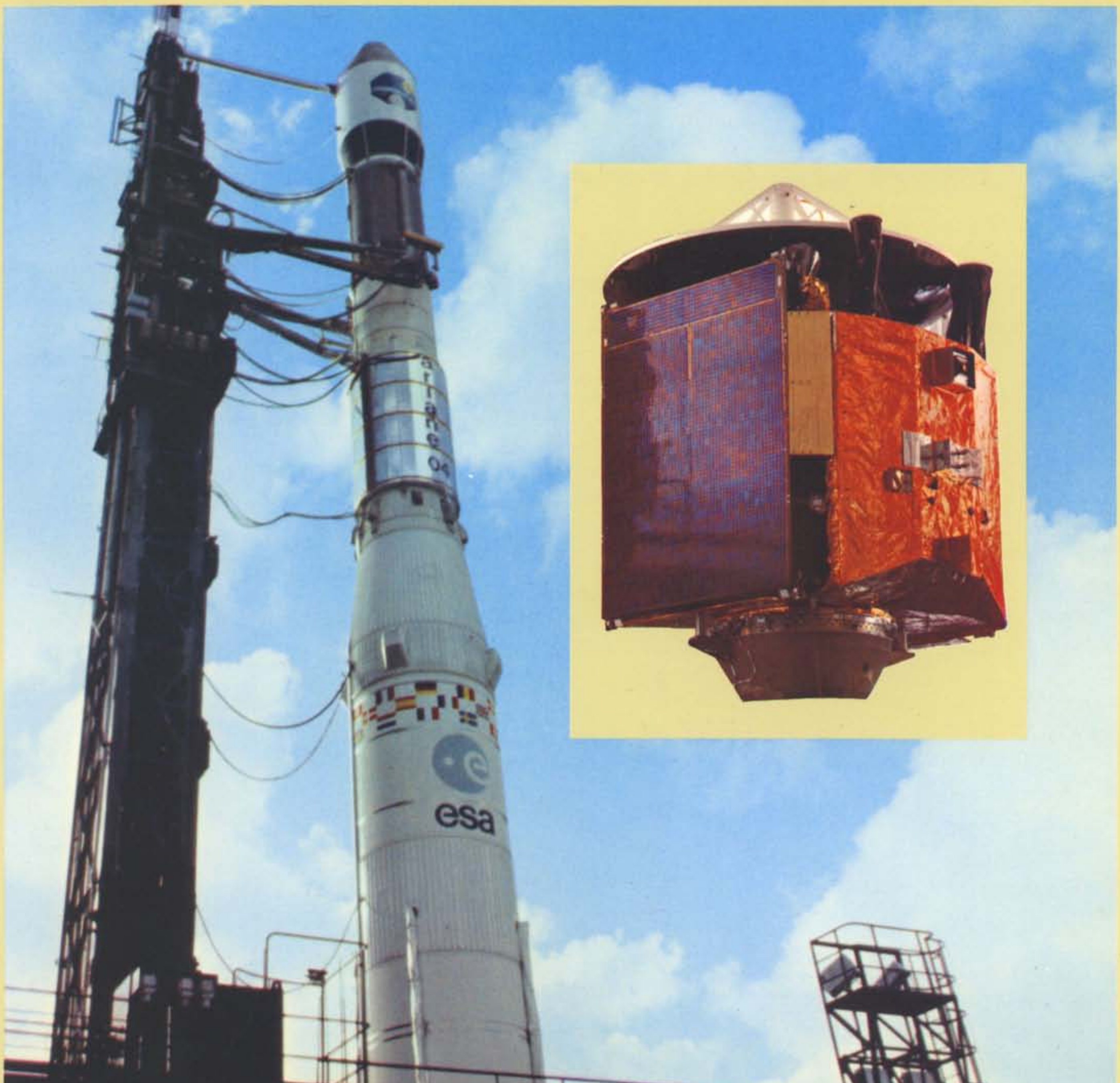

european space agency

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 Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden, Switzerland and the United Kingdom. Austria and Norway are Associate Members of the Agency. Canada has Observer status.

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 Director of Scientific Programmes; the Director of Applications Programmes; the Director of Space Transportation Systems, the Technical Director, the Director of ESOC, 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: Prof. H. Curien (France).

Director General: Mr. E. Quistgaard.

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, la Belgique, le Danemark, l'Espagne, la France, l'Irlande, l'Italie, les Pays-Bas, le Royaume-Uni, la Suède et la Suisse. L'Autriche et la Norvège sont membres associés de l'Agence. Le Canada bénéficie d'un statut d'observateur.

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 satellites 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, du Directeur des Programmes scientifiques, du Directeur des Programmes d'Applications, du Directeur des Systèmes de Transport spatial, du Directeur technique, du Directeur de l'ESOC 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.

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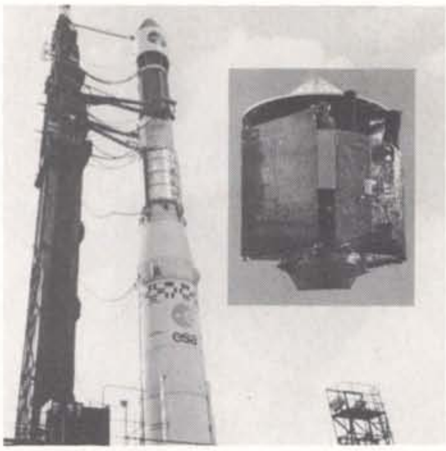

Front cover: Ariane L04 ready for the last launch of the development programme.

Inset and back cover: The Marecs-A spacecraft

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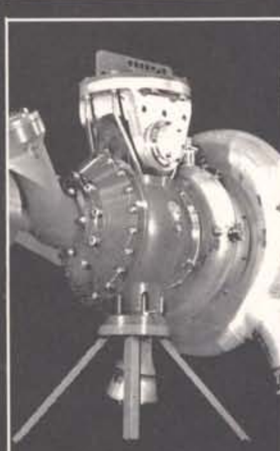
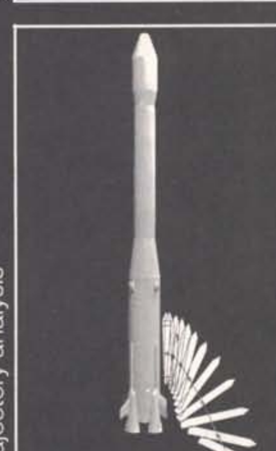
Apogee solid-fuel boost motor


Thrust frame with watertank


Turbopump at the final assembly stage


Gas generator and main regulator unit


European launcher Ariane


Trajectory analysis

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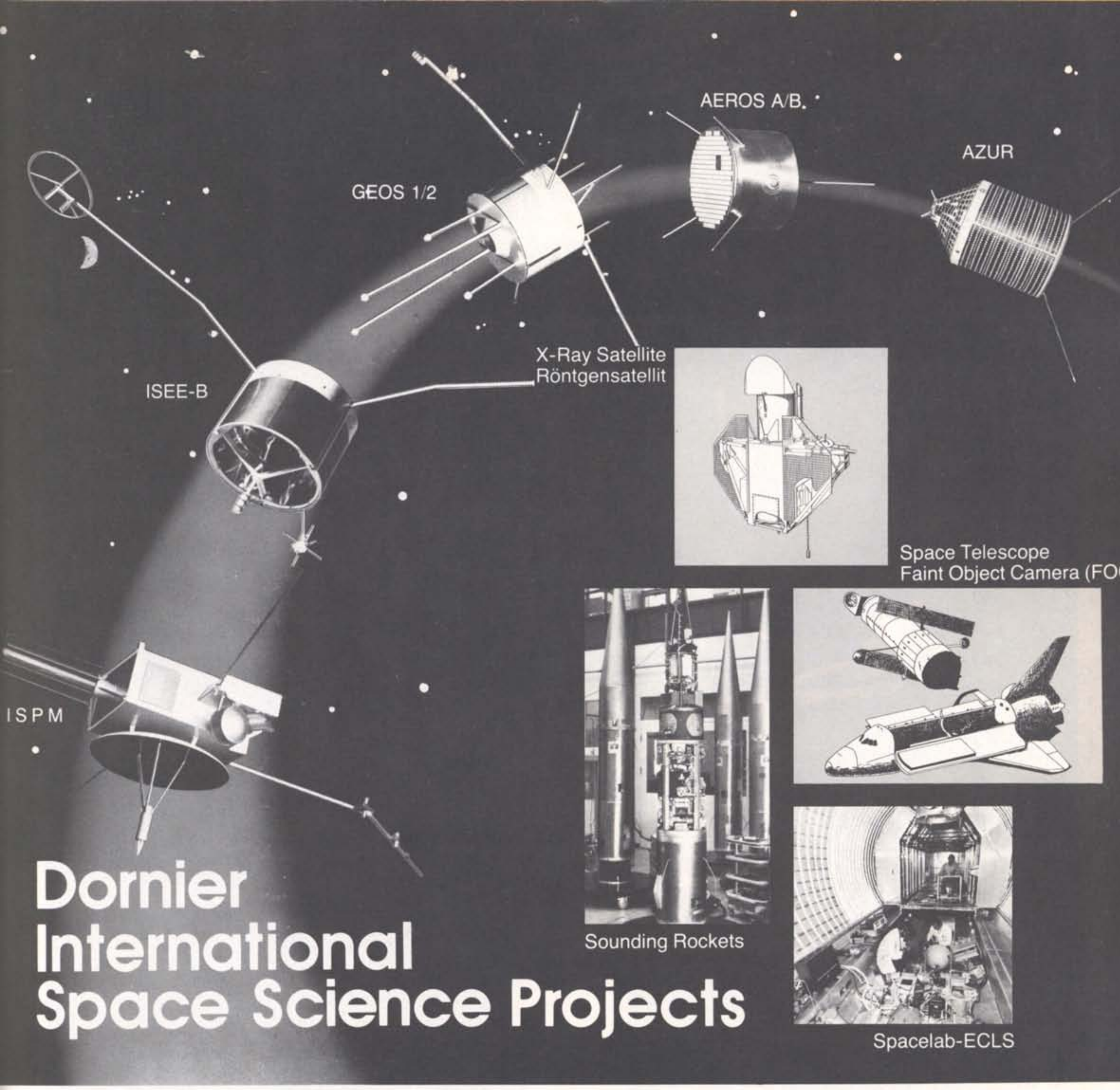
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AZUR
GEOS 1/2
ISEE-B
X-Ray Satellite
Röntgensatellit
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Faint Object Camera (FO
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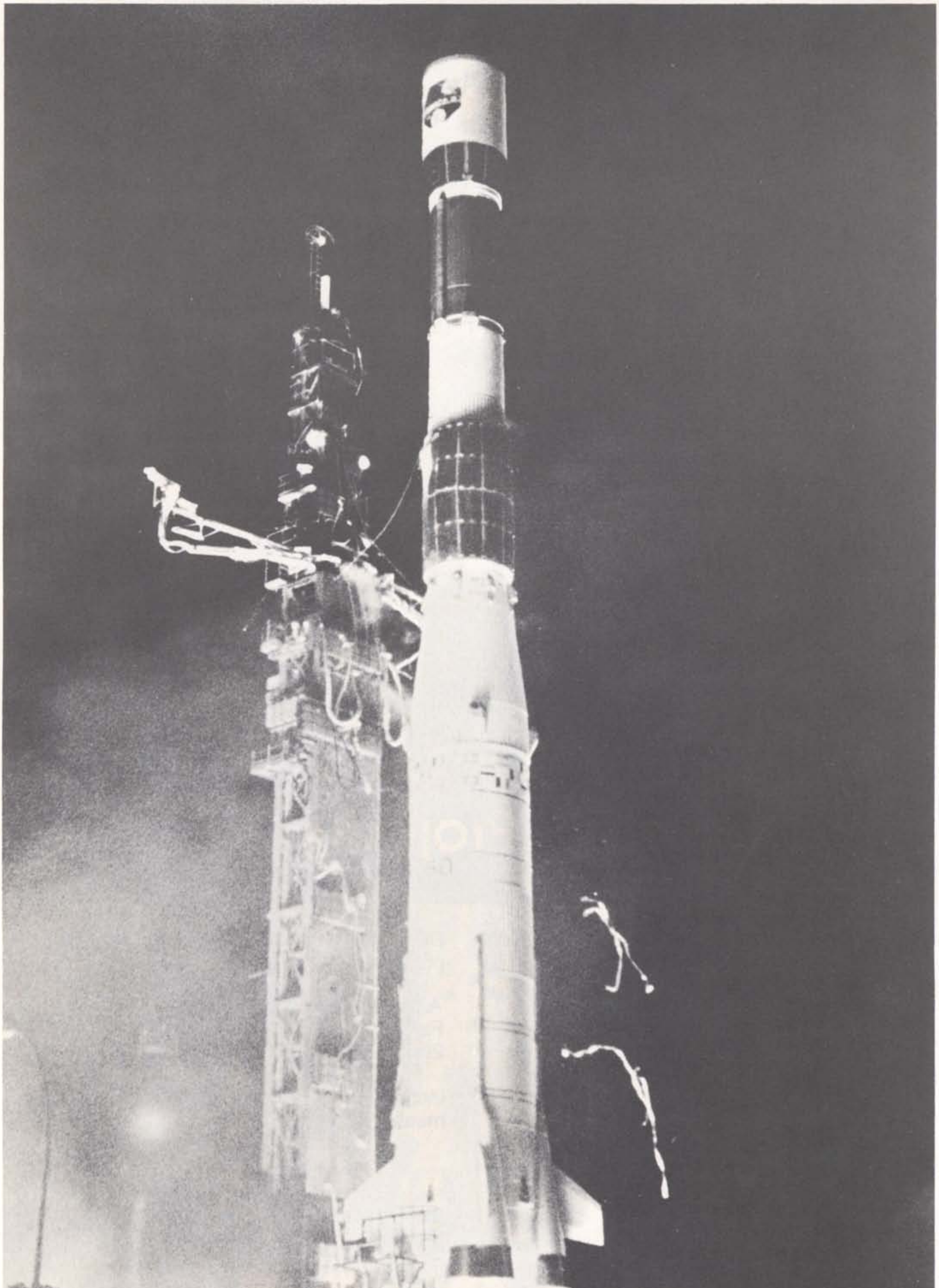
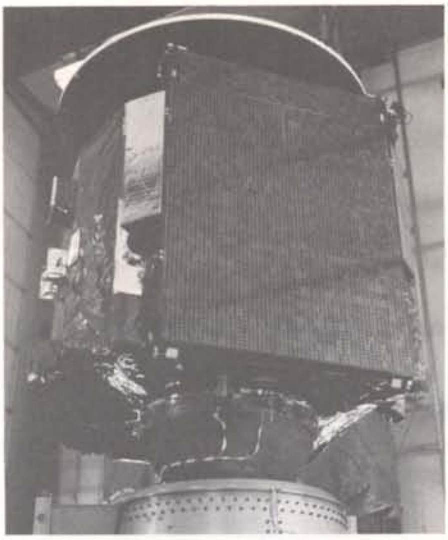
Sounding Rockets
Spacelab-ECLS
Dornier
International
Space Science Projects





Successful Launch for Marecs-A

J.-J. Dumesnil, Maritime Satellites Project Division, Directorate of Application Programmes, ESTEC, Noordwijk, Netherlands

The launch of Marecs-A on 20 December 1981 marked ESA's entry into the international commercial-satellites market, as well as the end of a long period of spacecraft development and testing.

Being the first of the series, the Marecs-A spacecraft had been protoflight qualification tested at Sopemea, Toulouse and IABG, Munich, between May and October, the key elements in this test programme being acoustic noise testing, sine vibration testing, solar simulation and full performance verification under extreme thermal/vacuum conditions.

The Marecs spacecraft was shipped to the Agency's Kourou launch base on 8 November after being declared flightworthy at the Protoflight Model Review, and a six-week launch campaign was instituted to maintain a pre-Christmas launch.

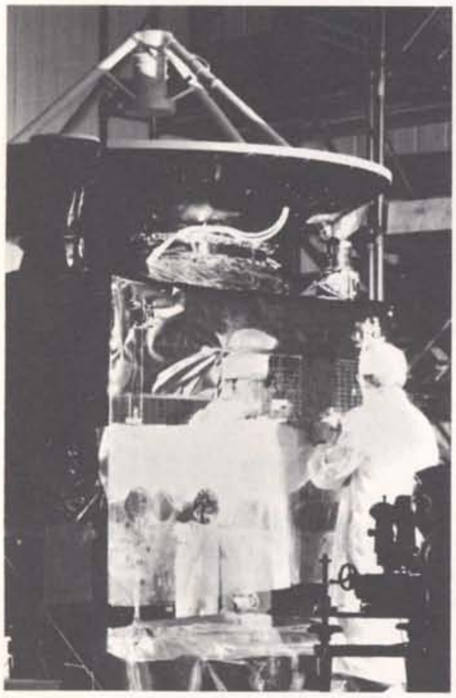
No serious problems hindered progress and on 19 December, at 22.29 h Kourou time (20 December, 01.29 h GMT), after an uninterrupted countdown, Ariane lifted off flawlessly into the night sky. Sixteen minutes later, with spacecraft separation, the Marecs VHF telemetry transponder was automatically switched on and data reception via the Malindi ground station quickly confirmed that everything was nominal on board the satellite. A fine attitude manoeuvre was carried out and the spacecraft's apogee boost motor (ABM) was successfully fired at the fourth transfer-orbit apogee. Soon afterwards, the solar arrays were deployed and the complex sequence of manoeuvres required to achieve three-axis-controlled attitude was carried out.

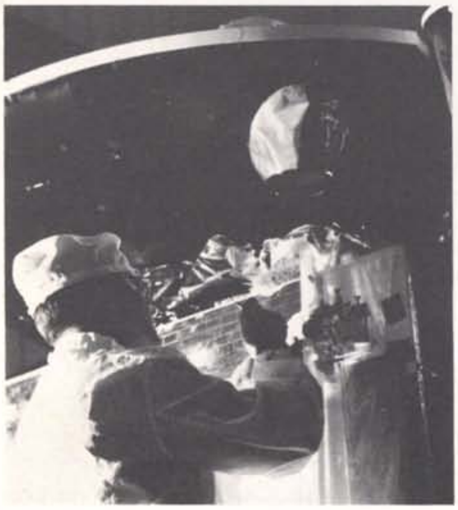
By 22 December Marecs had acquired its nominal operating configuration and was drifting slowly towards its final orbital position at 26°W, which it reached on 2 January. Due to the nominal performance of both the Ariane launcher and the ABM, the spacecraft's hydrazine consumption remained very small during this sequence of manoeuvres.

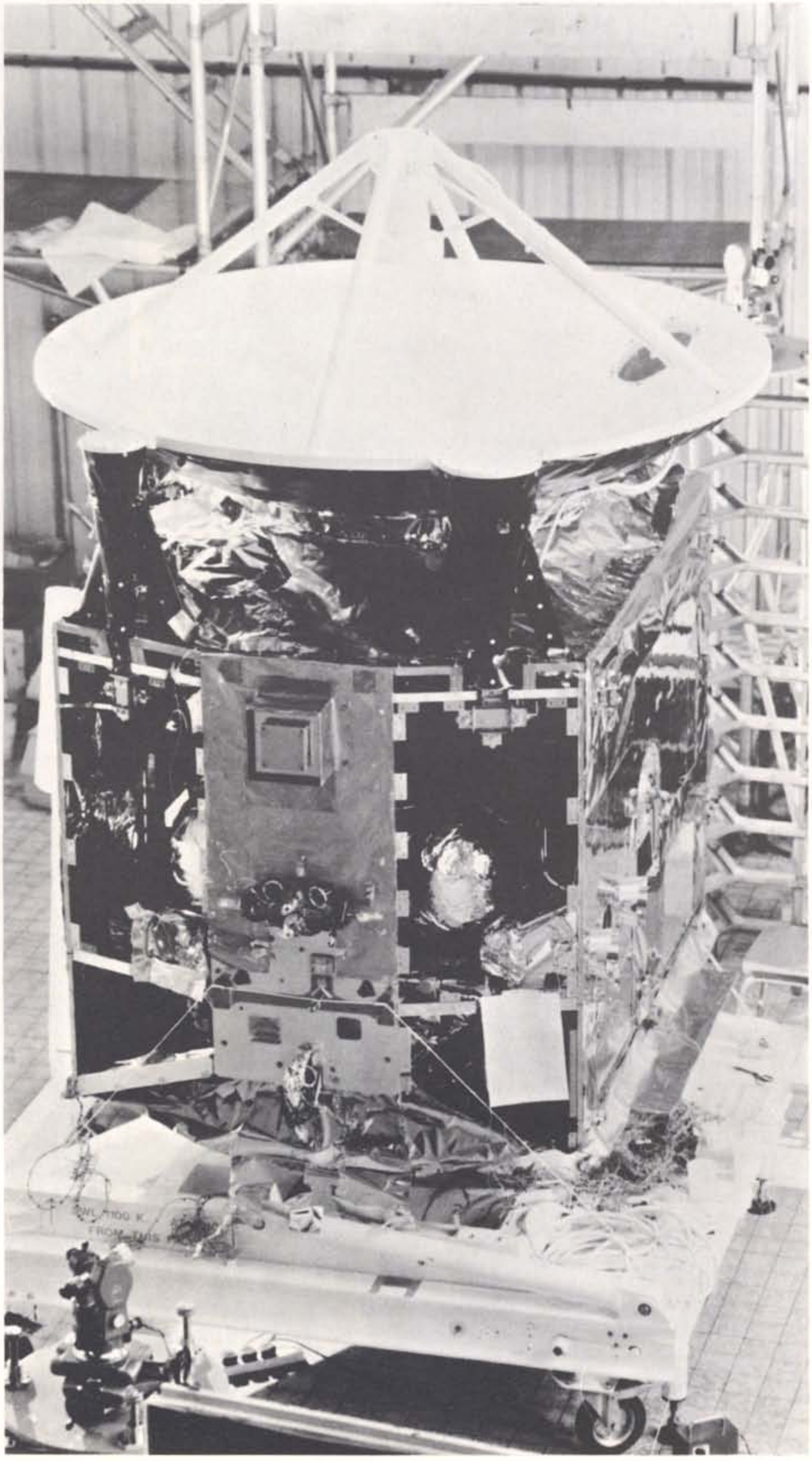
Commissioning tests have now been initiated which are aimed at a detailed survey of the spacecraft's health and performance in all operating modes, and at in-orbit verification of the operational procedures. Although these tests are scheduled to continue until the end of January, it can already be confirmed that all Marec's subsystems are performing as expected.

Transfer from VHF to C-band telemetry, tracking and control (TTC) is gradually taking place with the handover to the Villafranca station near Madrid.

Acceptance testing of Marecs-A will be carried out in February by the International Maritime Satellite Organisation (Inmarsat), which will then lease the Marecs communications capacity throughout the satellite's seven-

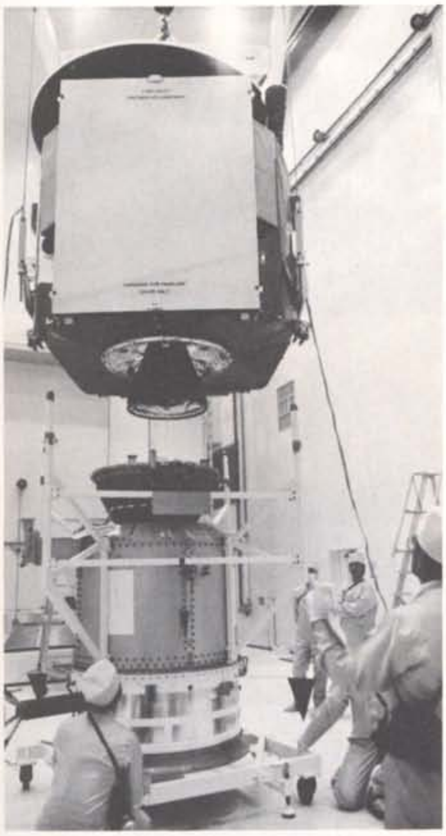


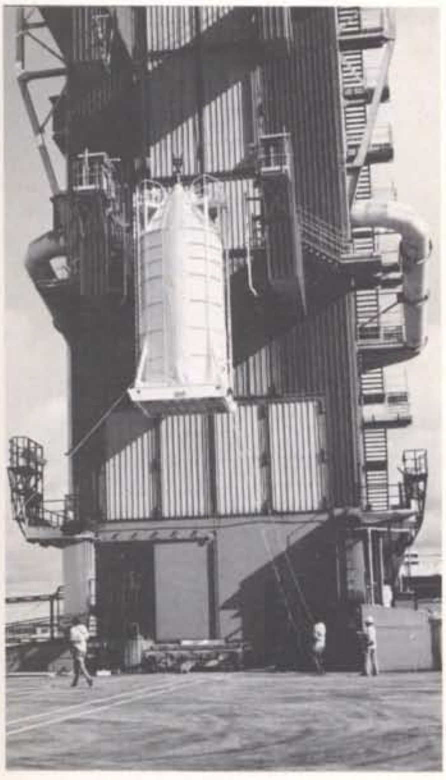


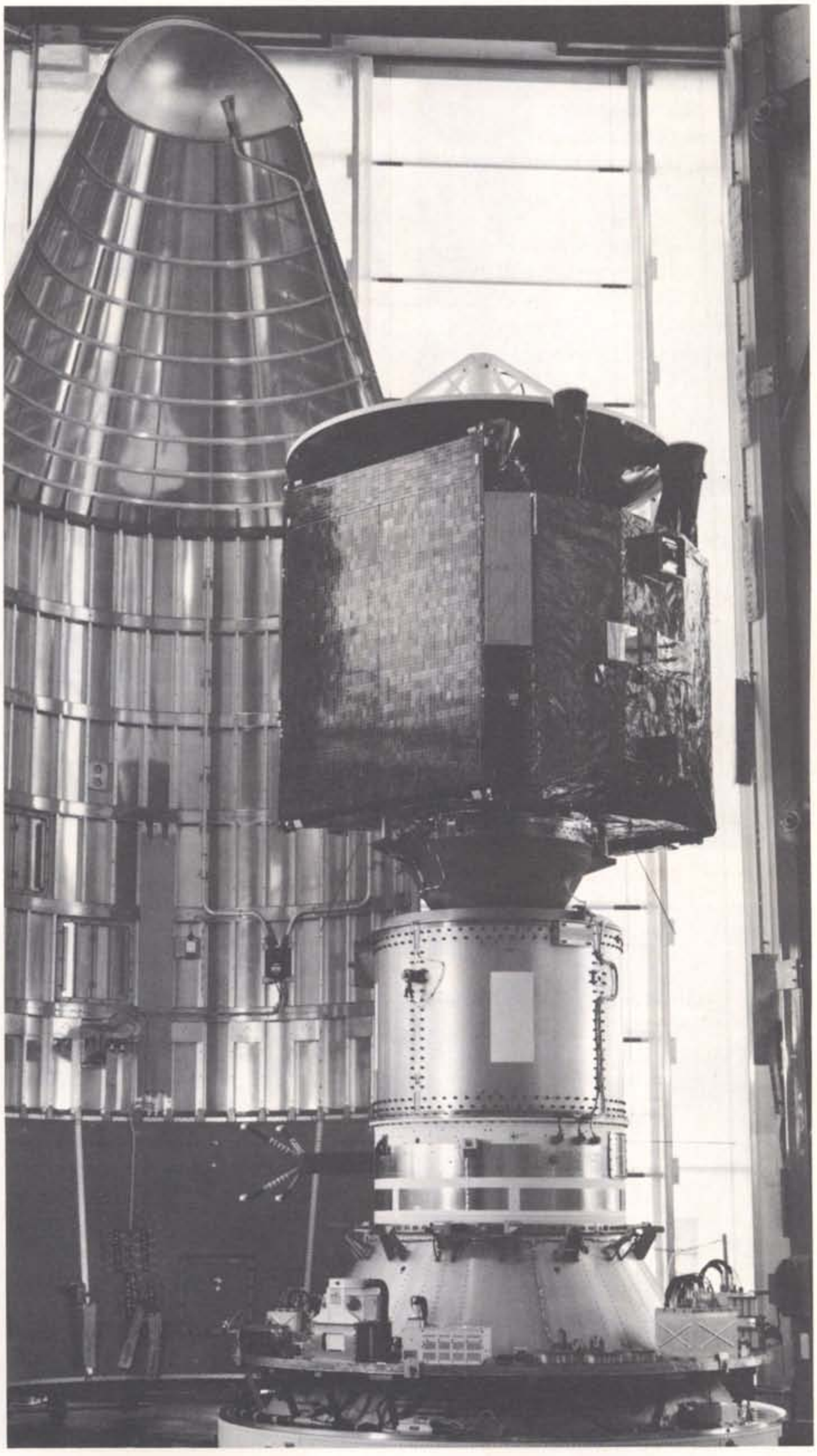


year lifetime. For those acceptance tests, the Villafranca Payload Test Laboratory (PTL) will be used.

In parallel, the second spacecraft Marecs-B is being prepared for launch at the end of April 1982 together with Sirio-2, on Ariane vehicle L5. Marecs-B will be placed over the Pacific Ocean area, in accordance with Inmarsat's requirements, and will be operated through the specially built Ibaraki ground station in Japan.







The Ariane L04 Launch Success

This launch, the fourth and last in the development programme for the Ariane-1 version of the launcher, was of the utmost importance because it was required to:

- confirm the excellent results achieved with the third flight L03, and thus finally vindicate the modifications to the Viking engine's injectors;
- validate the operational configuration of the electrical systems;
- complete the launcher-qualification process, which was commenced after the L03 flight.

The launch campaign lasted from 3 November to 20 December, and there were no incidents of note, save for the premature release of a LOX valve plate on the third stage which led to a 24-hour postponement, to 01.29 h GMT on 20 December.

A preliminary evaluation of the telemetered parameters shows that the launcher functioned nominally and confirms:

- The correctness of the modifications made to the flight programme in order to achieve greater accuracy at injection; the error at apogee was reduced to less than 10 km.
- The small impact on the payload of the launcher's thermal and dynamic environments, and the very slight contamination of the payload by the launcher.
- The smooth operation of the propulsion systems of all three stages.

Furthermore, the launcher demonstrated its ability to place a payload of some 1780 kg into transfer orbit.
The launch also underlined the operational ability of the launch base, which had to meet very stringent timing requirements, the launch window imposed for Marecs being of the order of only 45 minutes.

Ariane: succès du lancement L04

Ce lancement était le quatrième et dernier du programme de développement de la version Ariane-1 du lanceur; l'essai en vol L04 revêtait une importance capitale car il devait:

- confirmer les excellents résultats obtenus sur L03 et par là même accréditer définitivement les modifications apportées sur les injecteurs des moteurs Viking;
- valider la configuration opérationnelle des chaînes électriques;
- mettre un point final à la qualification du lanceur, dont le processus avait été engagé après L03.

La campagne de lancement L04 s'est déroulée du 3 novembre au 20 décembre sans faits marquants autres que l'incident qui a motivé le report de 24 heures du lancement, à savoir le déverrouillage prématuré d'une plaque à clapet LOX sur le 3ème étage. Le lancement a eu lieu le 20 décembre à 1h29' GMT.

Les premiers résultats d'exploitation des paramètres télémesurés démontrent le fonctionnement parfaitement nominal du lanceur, et confirment:

- l'adéquation des modifications apportées au programme de vol afin d'acquérir une meilleure précision à l'injection (erreur sur apogée ramenée à moins de 10 km);
- les faibles sollicitations de la charge utile par l'ambiance thermique et dynamique du lanceur et le très faible niveau de pollution de la charge utile par le lanceur;
- le fonctionnement régulier des systèmes propulsifs des trois étages.

Par ailleurs, la performance démontrée se situe à environ 1780 kg pour la charge utile mise sur orbite de transfert.

Ce lancement a également prouvé le fonctionnement opérationnel de la base de lancement qui a satisfait à des exigences très contraignantes en ce qui concerne 'les fenêtres de tir' puisque celle imposée par Marecs était de l'ordre de 45 mn.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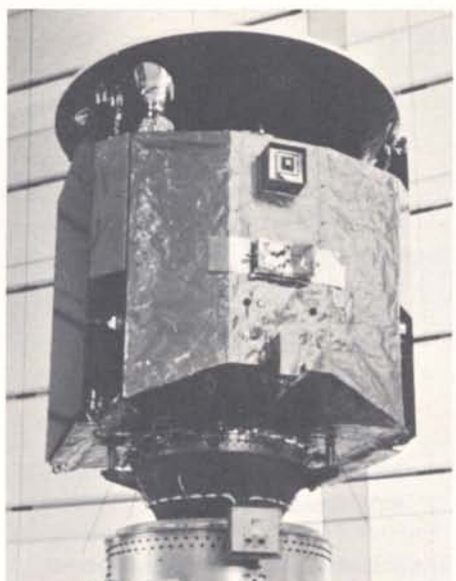


Detection of Natural Disasters via Meteosat

A. Robson & J. Morgan, Meteosat Data Management Dept. European Space Operations Centre (ESOC), Darmstadt, Germany
R.W. Herschy, Water Data Unit, Dept. of the Environment, Reading, England
J. Zschau, Institut für Geophysik, University of Kiel, Germany

The Meteosat geosynchronous satellites, positioned over the intersection of the equator and prime meridian, provide an Earth-imaging capability, a broadcasting service for images, and a data-collection service. The imaging and broadcasting features make it possible for a large number of authorities to monitor weather phenomena that could give rise to natural disasters, while the data-collection service provides a cheap and reliable means of relaying environmental measurements over 40% of the Earth's surface, i.e. within about 80° great circle arc of the subsatellite point. Existing hydrological and storm-surge-prediction applications already serve as indicators of how the Meteosat system could be used on a wider scale for disaster detection.

The Meteosat satellites are designed to fulfil three main missions:

- acquisition of images of the Earth's disc every 30 min in the visible and infrared parts of the spectrum. From these images a variety of meteorological parameters can be determined, e.g. wind vectors, sea-surface temperatures, cloud-top heights, etc.
- dissemination of corrected and annotated images via the satellite to users' ground stations
- collection and distribution of environmental data gathered by terrestrial platforms.

The first of the Meteosat satellites was launched in November 1977. It suffered an onboard failure in November 1979, preventing the first two missions from continuing, but leaving the data-collection mission intact. The second Meteosat was launched in June 1981. During its in-orbit checkout, it was discovered that the transponder system used for data collection was defective, but that the other mission capabilities were intact. Hence together Meteosats 1 and 2 are able to provide the full mission capability.

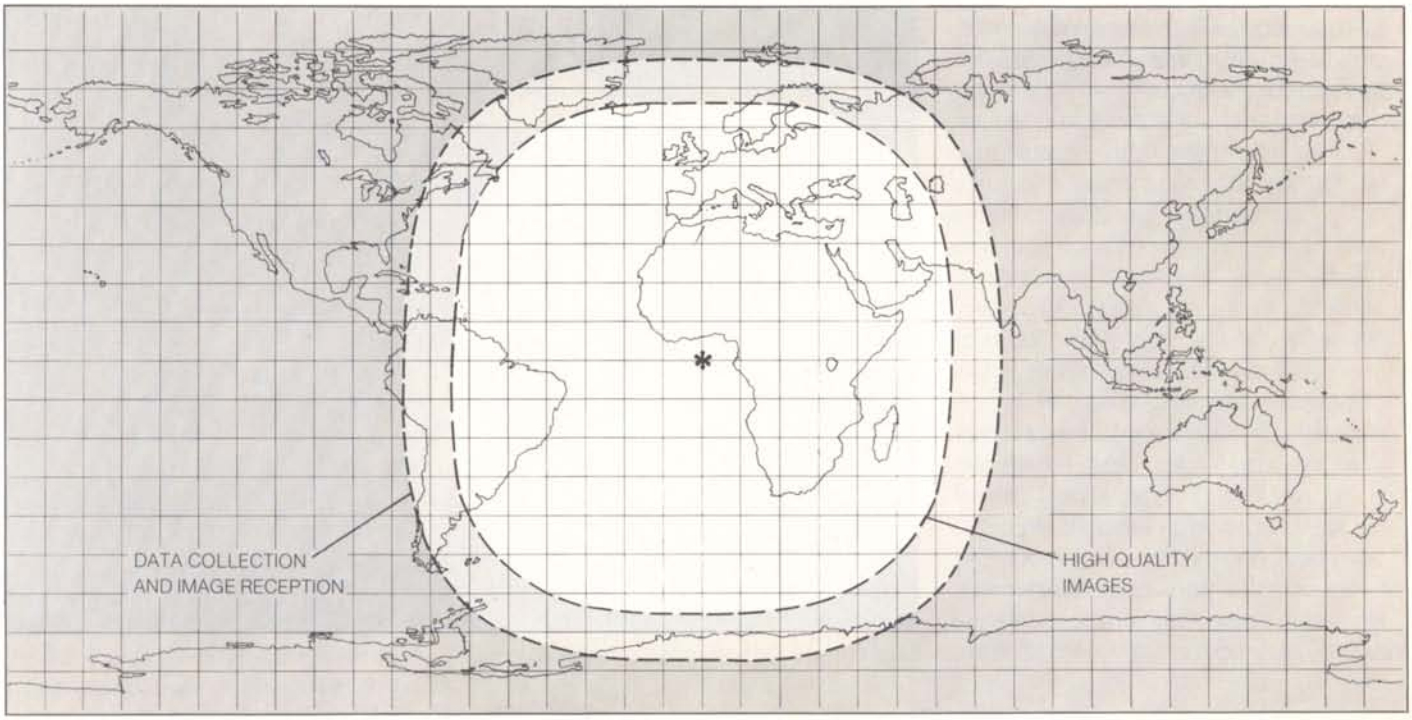
Operation of the two satellites is funded until the end of 1983 but, barring onboard failures and given further funding, they could supply services until 1985/1986. The two satellites are considered part of a pre-operational system for the meteorological agencies of the participating states. The ground work needed to establish an operational programme up to the mid-1990s is presently in preparation.

As far as the use of Meteosat for the detection of natural disasters is concerned, all three missions can contribute in their different ways:
1. The imaging mission, with its 65° great circle arc* coverage from the intersection of the equator and the prime meridian and its imaging frequency of 48 frames per day, permits near-real-time monitoring of exceptional weather phenomena that can have disastrous consequences.
2. The dissemination mission, in which the received images are processed and sectorised and then retransmitted at high power by the satellite, permits reception by authorities and other users of images relevant to their areas. These images can be received by rather simple and therefore inexpensive stations, putting virtually all authorities in the Meteosat coverage zone in a position to set up image stations for the monitoring of weather phenomena.
3. The data-collection mission provides for the relay of conventional environmental measurements via Meteosat to the data user. This service is suitable for relatively small quantities of data for locations within about 80° great circle arc of the subsatellite point. This includes about 40% of the Earth's surface.

The operational application of these three missions can help substantially in the detection of natural disasters, given appropriate organisation throughout the coverage area.

* Although the image covers the full Earth's disc, its potential for the detection of natural disasters is limited to about the 65° arc.

Figure 1 – The Meteosat coverage area



Imaging and image broadcasting

Meteosat's main payload is an imaging radiometer capable of generating images in three spectral bands at half hourly intervals for the full Earth's disc, or more frequently in the case of smaller areas. The three spectral bands include a visible channel, an example from which is shown in Figure 2, and two channels in the infrared part of the spectrum. The first of these has a response centred around 11 microns, and is generally known as the infrared or 'window' channel (Fig. 3), because radiation in this part of the spectrum is absorbed only slightly by the atmosphere. Consequently, it provides a view of the Earth's surface on a 24 hour basis, unlike the visible channel which of course is useful only during daylight hours. The third channel, near 6 microns, is associated with radiation from water vapour in the atmosphere. This is of great interest to meteorologists and other atmospheric physicists, but as this channel does not provide a view of the surface it is of limited usefulness in the context of disaster monitoring.

The first two channels, providing Earth views every 30 min, have the ability to observe events larger than the resolution of the individual picture elements. This pixel size is a square 2.4 km × 2.4 km at the subsatellite point in the case of the visible channel, and about 4.8 km × 4.8 km for the IR window channel. With these resolutions the images cannot be used to detect very localised events, but there are disasters for which information on this scale is of use, particularly when coupled with the satellite's ability to relay this data very quickly to local user stations.

Observable events

The disaster-associated phenomena that can be observed with the Meteosat radiometer are mainly, but not entirely, meteorological in nature. In many cases it is not possible to see the final impact of such phenomena, but only that, for instance, severe weather is to be expected or is in progress. The images can be used to track hurricanes, for example, and to estimate their intensity, but do not directly show the resulting damage, except in the case of widespread flooding. The potential extent of damage can, however, be inferred in many instances.

Hurricanes

These are defined as tropical storms with sustained wind speeds in excess of 64 knots. The wind speeds close to the central core can be far higher than this and their potential for devastating coastal areas is well known.

Tropical storms can be readily observed in Meteosat images and they can be tracked easily from image to image. This allows forecasts to be made of their progress, and their characteristic cloud patterns in Meteosat imagery also allow their violence and destructive potential to be estimated. Three areas within the Meteosat field of view suffer from tropical cyclones of this type – the eastern seaboard of the USA and the Caribbean, the Arabian Sea, and the southwest Indian Ocean.

Figure 2 – Full-disc image from Meteosat-1 in the visible channel. Weather systems are clearly delineated by the cloud patterns. Surface features such as rivers, mountains, lakes and variations in vegetation are also visible, particularly when computer enlargements are made.

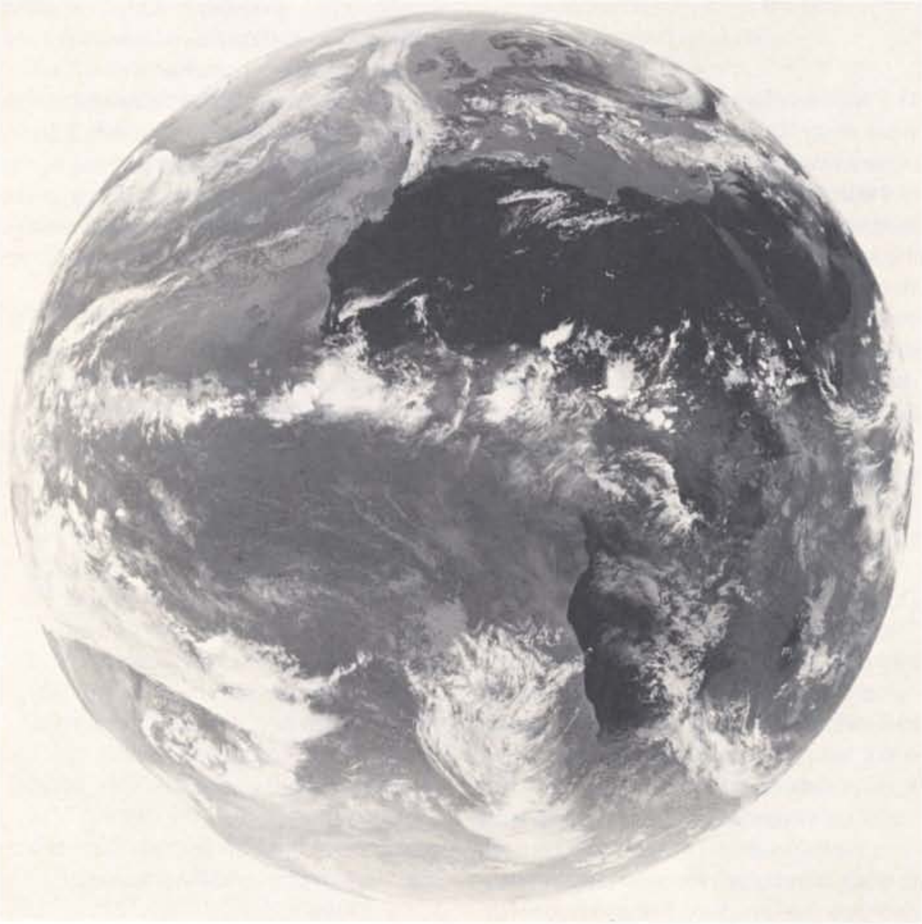


Figure 3 – Full-disc image from Meteosat-1 in the infrared (11 μm) 'window' channel used to monitor surface conditions and weather systems on a 24 h per day basis

Greatest awareness of such cyclones relates to those affecting the densely populated areas of the USA. These have their origin near the west coast of Africa and hence Meteosat can be used to provide the earliest warning of the impending danger (Fig. 4), which can then be monitored by American satellites and aircraft.

Less publicised are the cyclones affecting southern Arabia and Madagascar, where Meteosat images are possibly the only source of information. Figures 5 and 6 show examples of tropical storms detected on Meteosat images in those two areas.

Early availability of images of this type provides the warning needed to ensure that all possible precautions are taken before the storm's arrival. These images can be used by aid centres in areas remote from the storm to estimate potential areas of maximum damage, and in the case of widespread flooding to identify the areas affected after the storm has passed, so helping in the direction of relief aid to areas with shattered communications systems.

Figure 4 – Hurricanes Davis and Federick over the Atlantic on 28 August 1979

Extra-tropical depressions
The belts between 40° and 60° latitude are characterised by mid-latitude depressions, which all too frequently produce poor weather near western seaboards. Most are not associated with natural disasters, but just bring poor weather. The few that are, are typically very vigorous disturbances which grow very rapidly and move quickly. Their rate of growth means that they can easily slip through a conventional observing-station network, especially in their early stages. Alternatively the conventional data hints at their existence, but cannot adequately monitor their growth and speed. The half-hourly images from Meteosat solve this problem and disturbances can be monitored much more easily, thus improving forecasts. Because of the rarity of such events the potential of Meteosat imagery is not quite so obvious as in the case of tropical cyclones, but one can nevertheless quote instances that must be classed as exceptional weather and with the potential for being classified as 'disasters'. Examples include exceptional storms at sea (e.g. the Fastnet storm of August 1979) and storms causing exceptionally heavy rain in northwest Europe, resulting in damage to bridges, and associated wind damage to property.

Droughts
Meteosat images can also be used to infer the onset of drought situations, which on a large scale are classified as disasters. Areas of marginal agricultural activity can be monitored for the presence of rain-bearing clouds and the absence of such clouds over long periods is a clear precursor of possible drought and famine. Furthermore, the appearance of the ground surface on the visible image actually changes in these areas with the vegetation cover. The infrared image also plays a part, since this measures the temperature of the surface, and the diurnal rate of temperature change can be linked to soil moisture content, so helping to delineate drought-stricken regions. On a smaller scale the areas of lakes can be monitored, large changes being a danger signal for irrigation projects, the failure of which can lead to local famines.

Floods
Meteosat imagery can also be used to detect extensive flooding, or even changes from merely marshy conditions to complete water cover, near coasts after cyclones or inland after long periods of rain. The likelihood of flooding after severe local storms in mountainous regions and following thaws in snow-covered areas can also be assessed and monitored.

Image distribution
Image data cannot be exploited, of course, unless made available promptly to those directly concerned, and so Meteosat has a comprehensive and rapid dissemination system. Raw images received at the European Space Operations Centre (ESOC) in Darmstadt are pre-processed in real time and then sent back via the satellite to the user stations. National authorities and aid centres throughout the Meteosat coverage zone can therefore gain rapid yet inexpensive access to these images. The image data are broadcast according to a routine schedule, whereby some 400 image sectors are transmitted daily (schedules can be obtained, presently free of charge, from ESOC). The user can acquire the data in digital or analogue format. The former lends itself to computer processing, for example to monitor the extent of arid conditions automatically or to apply algorithms for rainfall prediction. The analogue formats are better suited to the reproduction of the

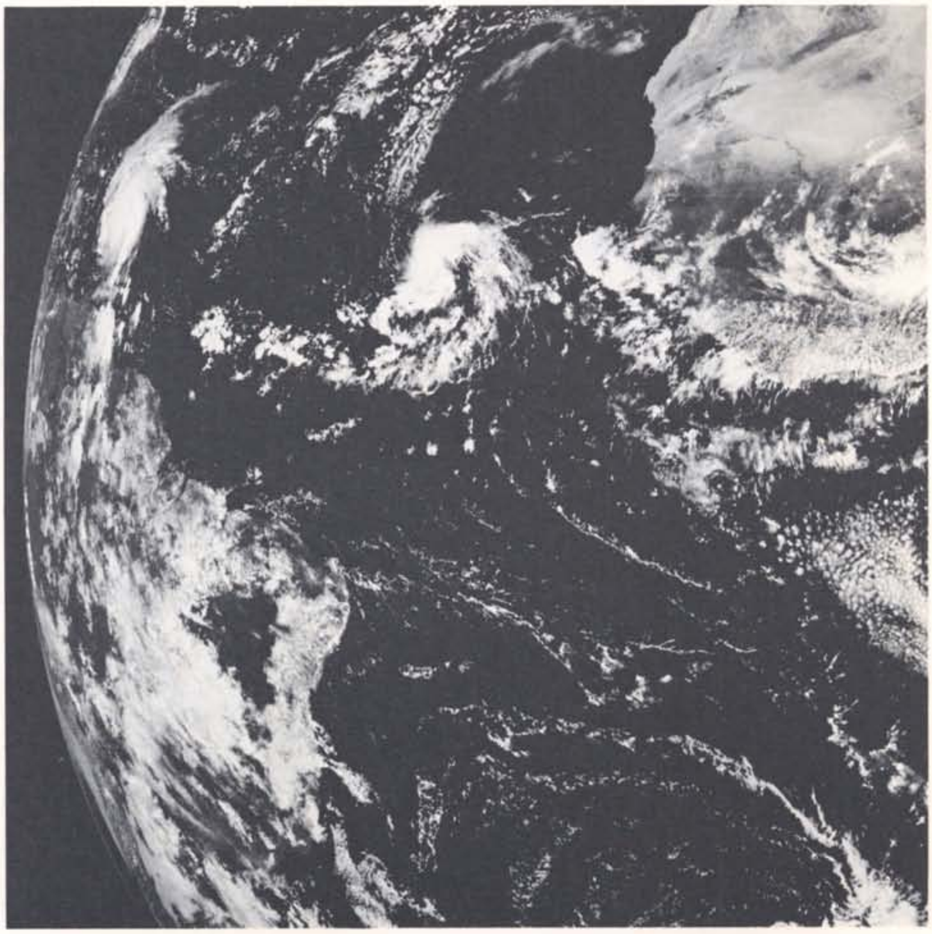


Figure 5 – Tropical cyclone over the Arabian Sea

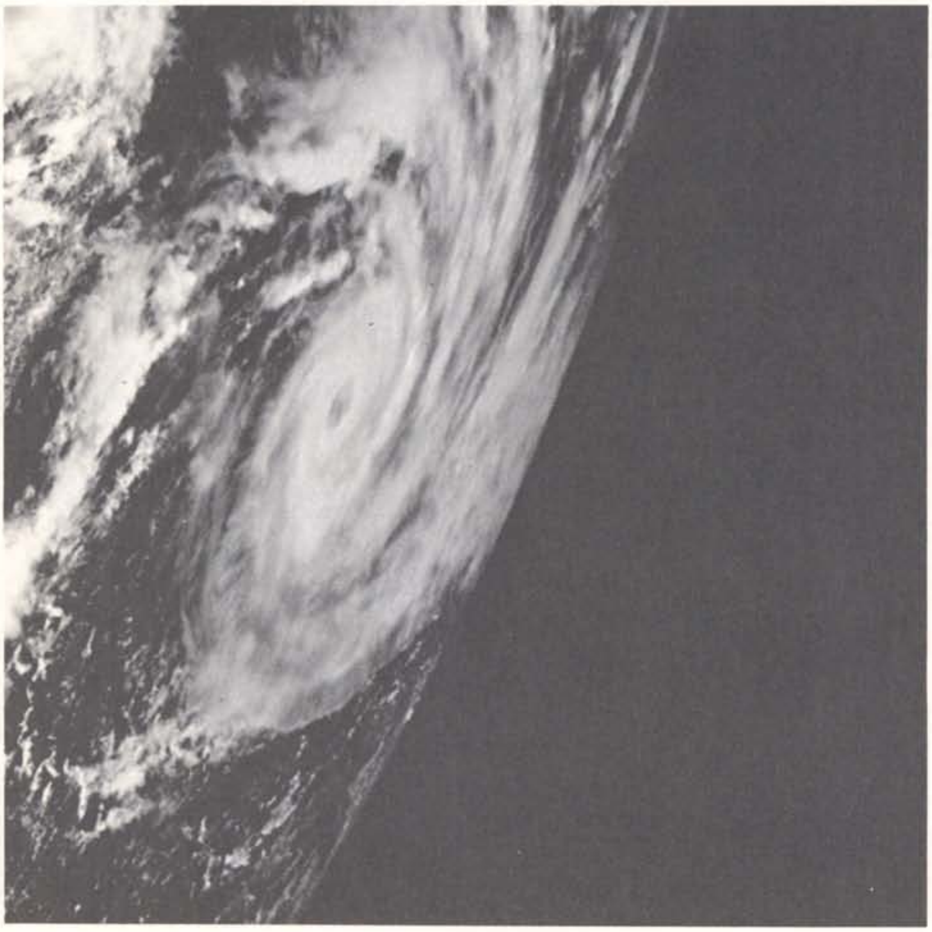


Figure 6 – Tropical cyclone in the southwest Indian Ocean, centred northeast of Mauritius

image data, either as hard copy or on a television screen, for more qualitative applications.

At the time of writing there were about a dozen of the more expensive digital receiving stations in operation, while cheap analogue devices are already in widespread use throughout the Meteosat field of view, at more than 200 locations (Fig. 7).

Data collection

The Data Collection System (Fig. 8)

Because Meteosat is a geostationary spacecraft, it provides a link that is permanently available to all compatible data platforms within its field of view (about 80° great circle from subsatellite point). The link, restricted in its use to data related to the Earth and its natural phenomena by ITU regulations, is fed by small UHF transmitters connected to environmental sensors and known as 'Data-Collection Platforms' (DCPs).

There are three basic types of DCP:

– 'self-timed', which transmit their data at regular intervals based on an internal clock

- 'interrogated', which transmit their data upon reception of a request signal from the satellite
- 'alert', which transmit either a small amount of data or a request for interrogation when a particular parameter has been exceeded.

The DCPs transmit to Meteosat on any one of sixty-six 3 kHz reporting channels in the 402 MHz band. After conversion to the 1675 MHz band, the satellite retransmits the messages to its central ground station, in the Odenwald in Germany. There, the signals received are checked for quality before being transmitted to ESOC for processing and distribution.

At ESOC, messages from self-timed and interrogated DCPs are collected, processed and disseminated every 30 min. Any message received from an 'alert' DCP is processed immediately and made available for transmission to the platform's owners.

To interrogate a DCP, an interrogation message is generated in Darmstadt and sent to the Odenwald ground station. From there it is transmitted in the 2122 MHz band to Meteosat, which then retransmits the message on one of two frequencies in the 468 MHz band. The message includes the unique address of the DCP to be interrogated and only that particular platform will respond by transmitting the data it has collected.

Currently, the platform data received in ESOC are provided to the platform owners and to others who wish to receive the data either via the World Meteorological Organisation's Global Telecommunications System (GTS), by telex, or on magnetic tapes for non-real-time applications. To date, the only way for a user to receive data in real-time has been to build a receiving station capable of acquiring data directly from the satellite. However, the cost of such a station is prohibitive for the majority of users. For this reason, relay of the data via

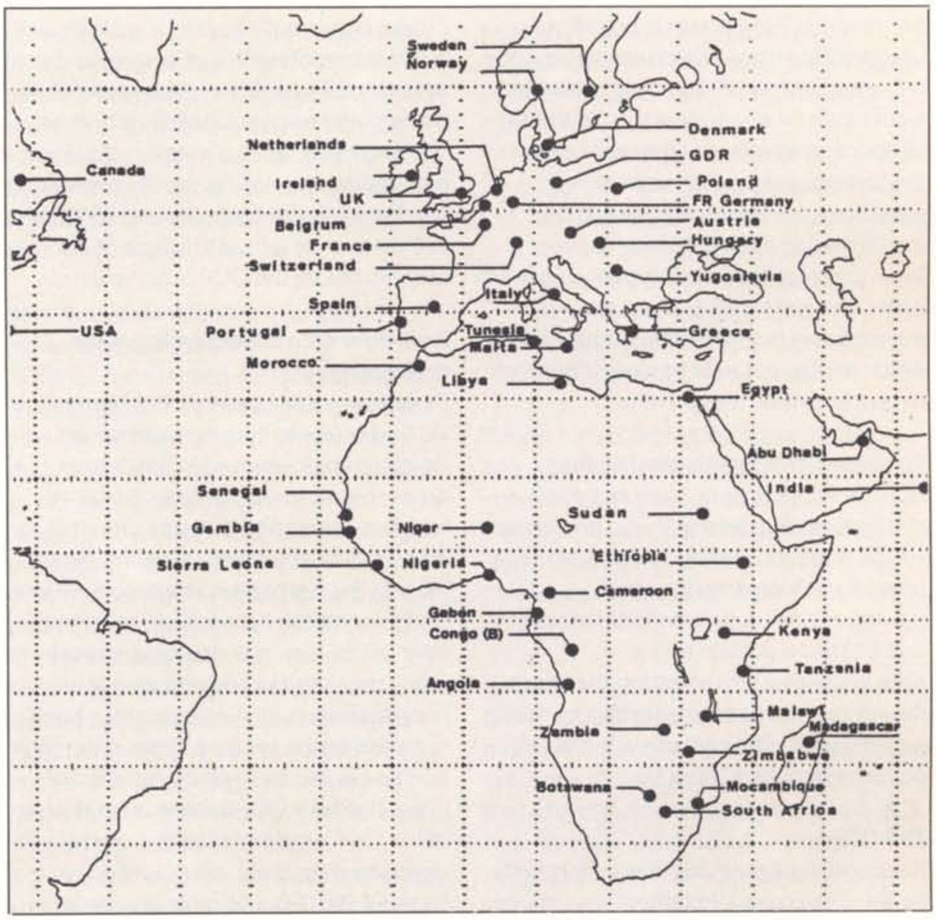


Figure 7 – User stations equipped to receive analogue transmissions

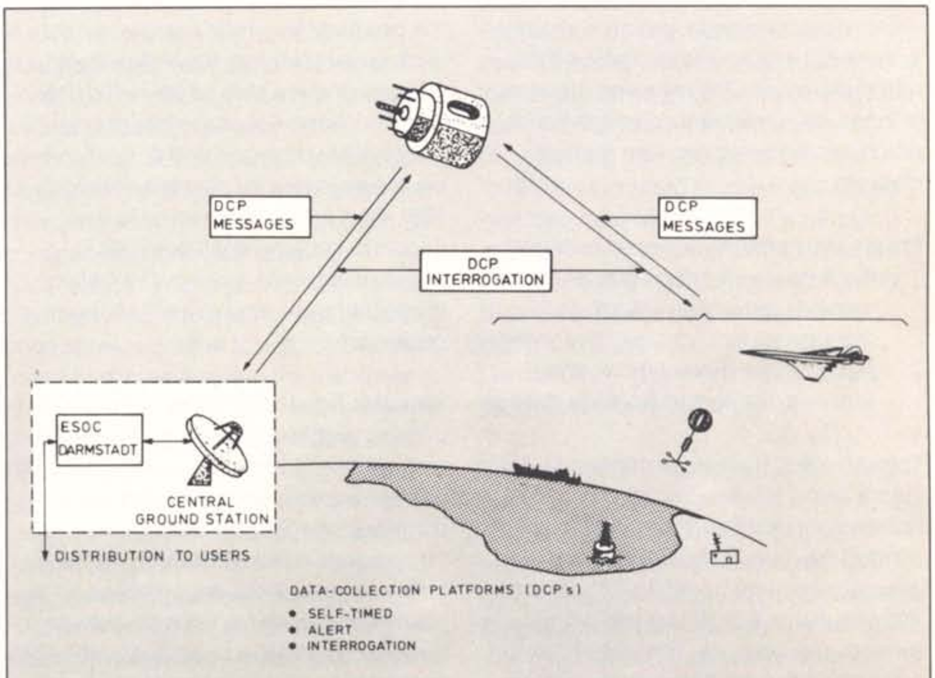


Figure 8 – The Meteosat Data Collection System

the satellite's high-power transmitters used for the image broadcasting service is being considered. The data messages would then be received at the Odenwald station and stored until the next break in the analogue image transmission schedule, whereupon they would be transmitted to the satellite for broadcasting. These breaks occur every 4 min and last for 23 s. The data transmission rate would be about 7 kbit/s, which should allow 20 or more messages to be transmitted every 4 min.

To receive their messages, the users would then have to procure a ground station based upon the cheap analogue image reception station. A 2 m diameter antenna with preamplfier and downconverter, a conventional receiver with FM demodulator and a microprocessor for extracting the user's own data messages for display or printing would suffice. The cost of such a station could be less than $20 000.

The DCPs

Although the system has been designed for the three types of platform – interrogation, self-timed and alert – there has been a reluctance on the part of users to procure interrogation platforms since their complex nature makes them rather expensive. The following therefore refers to 'self-timed' and 'alert' platforms, which can be combined into a single platform.

The DCPs consist of two main elements:

1. sensors: a wide range is available, for many aspects of environmental monitoring
2. radio sets: UHF transmitter and antenna, timing circuits, data storage.

The radio sets have to be certified by ESA before being allowed to use the system, but many manufacturers now offer these certified designs. The radio sets are generally no more than $50 \times 40 \times 20$ cm^3 and weigh less than 20 kg, excluding sensors and antenna. The size of the antenna depends upon the transmitter output power needed from the DCP; with a 5 W transmitter, a 1.5 m long helical antenna suffices. Power requirements are modest and can be satisfied by a variety of energy sources, e.g. rechargeable lead-acid batteries, solar-cell power generators etc. The radio set costs around $5000 and to this must be added the price of the sensors before the DCP is complete.

Real-time data collection for water management

Floods are now causing more damage to life and property than ever before, and as development continues in flood-plain areas this trend will increase. Fatalities regularly occur and damage amounts to many millions of dollars annually. Whilst most of this damage is to agricultural land and to domestic or industrial premises, dam failure due to flooding can cause many thousands of deaths as well as necessitating costly replacement of water or hydroelectric services. Serious damage can be caused by even the smallest of rivers; the April 1981 flood in a small area of the UK for example caused damage to agricultural land alone amounting to some £3 000 000. The most catastrophic floods, affecting both large areas of population and agricultural land, occur in the basins of the world's largest rivers, such as the Yangtze, the Yellow River, the Ganges and the Mississippi. In the July 1981 monsoon floods in India at least 60 people were drowned and some 3 million people were directly affected. Also in July 1981 the Yangtze suffered its highest flood this century, when some 4000 people were killed, some half a million made homeless, and more than 2 million people affected.

A reliable flood-warning system should prevent or at least reduce this loss of life and material damage. A warning received too late is useless, and too frequent warnings when no flooding actually occurs have a reducing value. Flood forecasts must therefore be based on a reliable maximum rainfall or maximum river level prediction or both, and the rapid transmission of these data to the flood forecasting centre is crucial. In small catchment areas the time between the rainstorm and the flood peak is short (1 to 2 h), so that forecasts are not usually practical and an alarm-type warning is necessary. In large catchment areas there is normally sufficient time to collect the rainfall and river level or flow data needed to prepare a forecast and to issue a warning based on this forecast. No matter what method is used in preparing and issuing the forecast, the initial 'alert' or 'emergency' warning is crucial to the system. It is here that satellite transmission offers a reliable and cost-effective alternative to terrestrial telemetry transmissions.

The use of geostationary satellites for hydrological data collection is currently under investigation, particularly in the United States, Canada and the United Kingdom. In the United States and Canada the GOES satellite is being used and in the United Kingdom Meteosat. These investigations are concerned with the possible future implementation of a satellite-based data-collection system to replace existing systems. The latter rely on a semi-automatic computer system and involve considerable labour and transportation costs when used for routine data collection on a monthly basis. Over 300 self-timed hydrological DCPs are presently being operated in the USA and Canada and some 10 DCPs with 'alert' facility are currently being operated in the UK.

All three investigations have shown that the Data Collection Platform is a low-cost, reliable device and that a satellite data collection system offers a reduction in existing operational costs, a reduction in manpower, less travel to sites and improved data capture.

The system is particularly reliable in transmitting alarm or emergency conditions. In the UK study, alarm levels are set at both flood-danger and drought-emergency levels with both rain gauges and river-water-level recorders.

Present methods of flood warning generally in use throughout the world rely on either manual or telemetry warnings (the former is clearly unsatisfactory and will not be discussed here). The two telemetry systems in common use rely on land lines (telephones) or line-of-sight radio communication. Land lines are prone to damage during floods and are thus unreliable just when the data that they are carrying are crucial. Because rivers often flow through valleys, line-of-sight radio links require expensive repeater towers or relay stations. The most important disadvantages of land-line or line-of-sight radio systems, however, are probably the high installation and maintenance costs and hardware redundancy, all of which increase with time. Furthermore such systems are usually designed as independent local systems, having distinct disadvantages for national coverage and leading to additional hardware and maintenance costs.

Satellite systems, once launched and commissioned successfully, do not suffer from any of these disadvantages and because of their large potential international market are expected to become more cost effective with time. Furthermore such systems are virtually interference free. In the UK investigation, the only problem encountered was the vandalising of an antenna at a city-centre station. This problem was easily solved by re-siting the antenna inside the equipment hut.

One of the UK DCPs is sited on a remote mountain hillside in the Scottish Highlands, and this platform has been in trouble free operation since its installation 2 yr ago.

DCPs are themselves able to monitor certain station faults and detect malfunctions. These are then dealt with on a call-out basis rather than requiring routine visits as does the existing data collection system.

Based on the American, Canadian and British studies there is little doubt that governments considering installing flood warning or forecasting systems should seriously consider a satellite system. It offers reliability under extreme climatic conditions and also appears to be the most cost-effective system.

Real-time data collection for Earth-movement applications

DCPs for transmitting surface data to an orbiting satellite for relaying to a central data centre have great potential for studying crustal movements of endogene as well as exogene origin. The first category covers all kinds of movements connected with the dynamics of plate tectonics, and with the distribution of strain and its propagation within lithospheric plates, including both earthquakes and volcanic eruptions. The second category comprises landslides, Earth deformations due to tidal forces, as well as crustal loading and unloading caused by marine tides, by storm surges, by seasonal sea-level changes, by regional and local air-pressure variations, and by seasonal changes in the global air-pressure distribution.

Such phenomena may be studied for purely scientific reasons, or for hazard prediction to reduce losses due to major natural catastrophies such as earthquakes, volcanic eruptions, storm surges and landslides. In both cases the crustal movements are monitored continuously or at least quasi-continuously. This in general implies that the measuring equipment must be visited once or twice a week to replace the chart paper and to ensure that the instruments are performing correctly. This is extremely time consuming, especially if data are to be collected from a dense network of geophysical instruments, as is needed for an operational earthquake prediction system. Data transmission via telephone lines is often impossible because the measurements have to be made far from industrial noise, and sometimes in remote and underdeveloped regions where land lines are practically nonexistent. It is in these cases that data transmission via satellite is of greatest value, providing means for:

1. real-time acquisition of geodynamic data from geophysical networks in isolated regions where no other data-retrieval method is feasible
2. real-time but sophisticated interpretation of such data in a modern geodynamics centre far from the measurement region.

This in turn provides the basis for the immediate decisions needed before an impending disaster, such as an earthquake, a volcanic eruption or a storm surge. The advance warning in these cases may be no more than a few hours.

Satellite relay of Earth-movement data has been little practised so far, mainly because the cost of a satellite system has only recently become competitive with that of ground-based systems. The USGS has, however, operated a prototype volcano-surveillance system for 15 volcanoes in Alaska, Hawaii, the contiguous United States, Central America and Iceland, transmitting information on the number of earth tremors per day as well as ground tilt in the neighbourhood of the volcanoes, via Landsat. Successful transmissions of tiltmeter data from the Lesser Antillian Arc to NASA's Goddard Space Flight Center was also reported, in 1977. Two projects are currently underway at the University of Kiel (Germany) in which ground-motion data will be relayed by satellite: one is a storm-surge prediction study for the German Bay, the other an earthquake-prediction survey in Turkey.

Storm-surge prediction in the German Bay

Northern Germany's North-Sea coast, especially the German Bay at the mouth of the river Elbe, suffers from heavy storm surges which are sometimes catastrophic. The most recent storm surge disaster occurred in January 1976, just five years

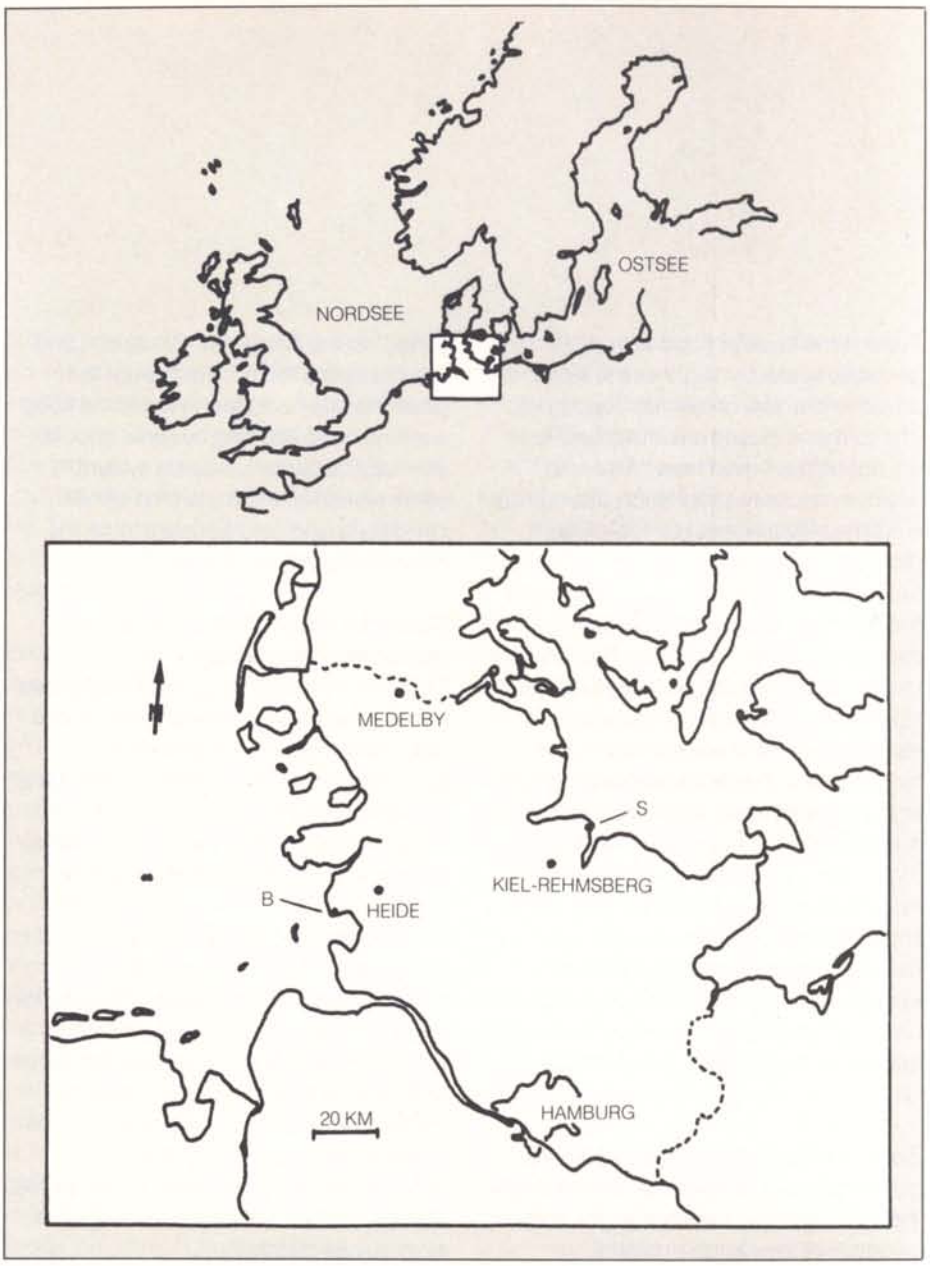
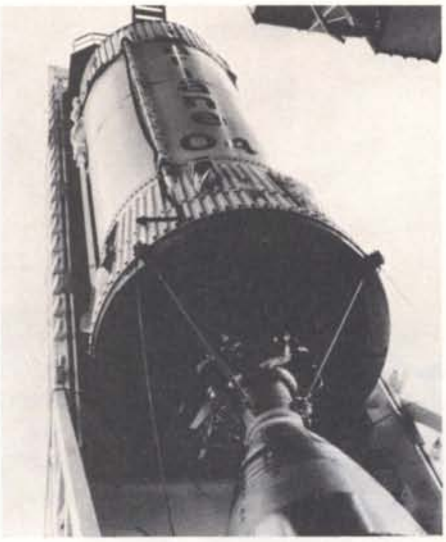


Figure 9 – Tiltmeter sites for storm-surge prediction: Kiel-Rehmsberg, Heide and Medelby (B and S are reference tidal gauges)

ago. The Geophysical Institute at the University of Kiel has therefore started to investigate whether these storm surges can be forecasted from the crustal tilt induced by the change in the water load distribution during and before the surges. It has been found that even 70 km inland from the sea, the Earth's surface tilts by some tens of milliseconds of arc when a heavy North Sea surge approaches the coast. This is several hundred times the accuracy of the borehole-tiltmeters used for these investigations. Furthermore it has been found that the measured crustal tilts precede the water-level changes in the German Bay by up to 12 h, suggesting that the development of storm surges can be predicted from tiltmeter readings. The Kiel Geophysical Institute has therefore installed three such borehole-tiltmeters in this region (Fig. 8); two of these tiltmeters are equipped with a DCP and regularly send data via Meteosat, and the third will be equipped with a DCP very soon. The DCPs collect tiltmeter data every two minutes and relay it in a short time slot once every hour to ESOC in Darmstadt, from where it is transmitted by telex to Kiel, where a minicomputer carries out the necessary real-time analysis. The satellite system has already proved extremely worthwhile for the regular control of the tiltmeter stations, which are more than 50 km apart.

Earthquake prediction in Turkey
The Kiel Geophysical Institute, together with the Geophysical Institute at the University of Frankfurt and the Institute of Theoretical Geodesy at Bonn University, and in collaboration with the University of Istanbul, have prepared a long-term project on earthquake prediction research in the western part of the North Anatolian Fault Zone in Turkey. In a first step, five experiments are planned, including monitoring of seismicity in the area, regular checking of seismic propagation velocity, its anisotropy and absorption along a fixed line crossing the fault zone, crustal tilt measurements on both sides of the fault, high-precision distance and angle measurements, and water-level monitoring in wells. As this geodynamic network will be in a remote area, satellite relay of the acquired data via Meteosat to a centre in Germany is envisaged. The project is planned to begin in spring 1982.

Conclusions
From the foregoing it can be concluded that Meteosat's potential for assisting in the detection of natural disasters over a large part of the globe is extremely high. The basic information can be derived from the Meteosat images themselves and from conventional instrumentation making measurements that can be relayed via Meteosat. Their usefulness for disaster prediction depends very largely upon the information being presented within a time span that allows alleviatory measurements to be implemented, and this is a telecommunications problem. Meteosat has been designed with this function in mind, and particularly to permit such operations with cheap user stations. Within the next year, it should be possible for users to receive DCP data in near-real-time from the satellite, giving them immediate access to information originating in remote areas. This will provide the responsible authorities and agencies with a unique tool with which to ameliorate the effects of natural disasters.



Récupération en mer du premier étage d'Ariane

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La nécessité d'offrir des lancements à des coûts aussi bas que possible, surtout dans le contexte de compétition où les aspects financiers joueront un rôle prépondérant, a poussé les responsables du programme Ariane à envisager la récupération du premier étage du lanceur. Une étude à cet effet est conduite dans le cadre du programme de développement complémentaire Ariane 3 dont les deux objectifs principaux sont l'augmentation de la performance (masse et volume offerts aux utilisateurs) et la réduction des coûts.

L'une des solutions envisageables pour atteindre ce deuxième objectif porte sur la diminution du prix de revient du premier étage qui à lui seul représente environ 40% du coût de fabrication du lanceur. La récupération partielle des matériels de cet étage devrait permettre une économie substantielle.

Une étude de faisabilité est en cours pour déterminer les solutions techniques envisageables et en quantifier l'intérêt économique; une décision quant à l'implantation du système sur les lanceurs de série et sa mise en oeuvre pourrait être prise par la suite. La première phase de cette étude a permis de démarrer le développement des matériels du système et sera suivie par un essai de récupération du premier étage (Fig. 1) à l'occasion d'un lancement opérationnel de la série de promotion d'Ariane 1 (L5 à L10). Cet article porte uniquement sur l'aspect technique du problème.

Pour réussir une récupération permettant la remise en état de l'étage et sa réutilisation ultérieure, deux conditions essentielles doivent être satisfaites:
- freinage de l'étage avant son impact sur l'eau (récupération en vol);
- repérage et repêchage rapides (récupération en mer).

Récupération en vol

Le but de cette première phase est de ralentir suffisamment la chute de l'étage, pour assurer un impact sur l'eau compatible avec la résistance mécanique de la structure.

Le mode de freinage qui consiste, après orientation correcte de l'étage, à allumer un moteur de décélération, conduit bien évidemment à un système compliqué et coûteux, d'une mise en oeuvre délicate et hasardeuse. Par contre, l'utilisation d'une chaîne de parachutes réduisant progressivement la vitesse de descente de l'étage s'est avérée tout à fait envisageable.

Des études préliminaires ont été entreprises pour permettre d'apprécier les difficultés à surmonter en vue des objectifs fixés.

Une étude de la trajectoire du premier étage après sa séparation du reste du lanceur a permis de déterminer les valeurs probables de certains paramètres critiques: efforts généraux auxquels est soumis l'étage lors de sa retombée; flux thermiques subis par les différentes parties de la structure. Elle a par ailleurs amené à conclure que le freinage naturel de l'étage rendait possible sa récupération en vol, au moyen de parachutes s'ouvrant à basse altitude.

Une seconde étude avait pour but de déterminer les pressions appliquées à l'étage lors de son impact sur l'eau. Des essais au moyen d'une maquette au 1/16 ont été réalisés dans différentes hypothèses de vitesse verticale, de vent horizontal et d'inclinaison de l'étage. La similitude employée est celle de Froude-Thoma, basée sur l'invariance des nombres de Froude et de Thoma, où:
- le premier exprime le rapport entre les forces hydrodynamiques et les forces de gravité

$$F = V/\sqrt{gH};$$

- le second exprime le rapport entre les forces de pression au sein du liquide, et les forces hydrodynamiques

$$T = \left(P_a + \rho g H + P_v - \rho\frac{V_2}{2}\right)\Big/\rho\frac{V^2}{2}$$

P_a = pression atmosphérique
P_v = tension de vapeur.

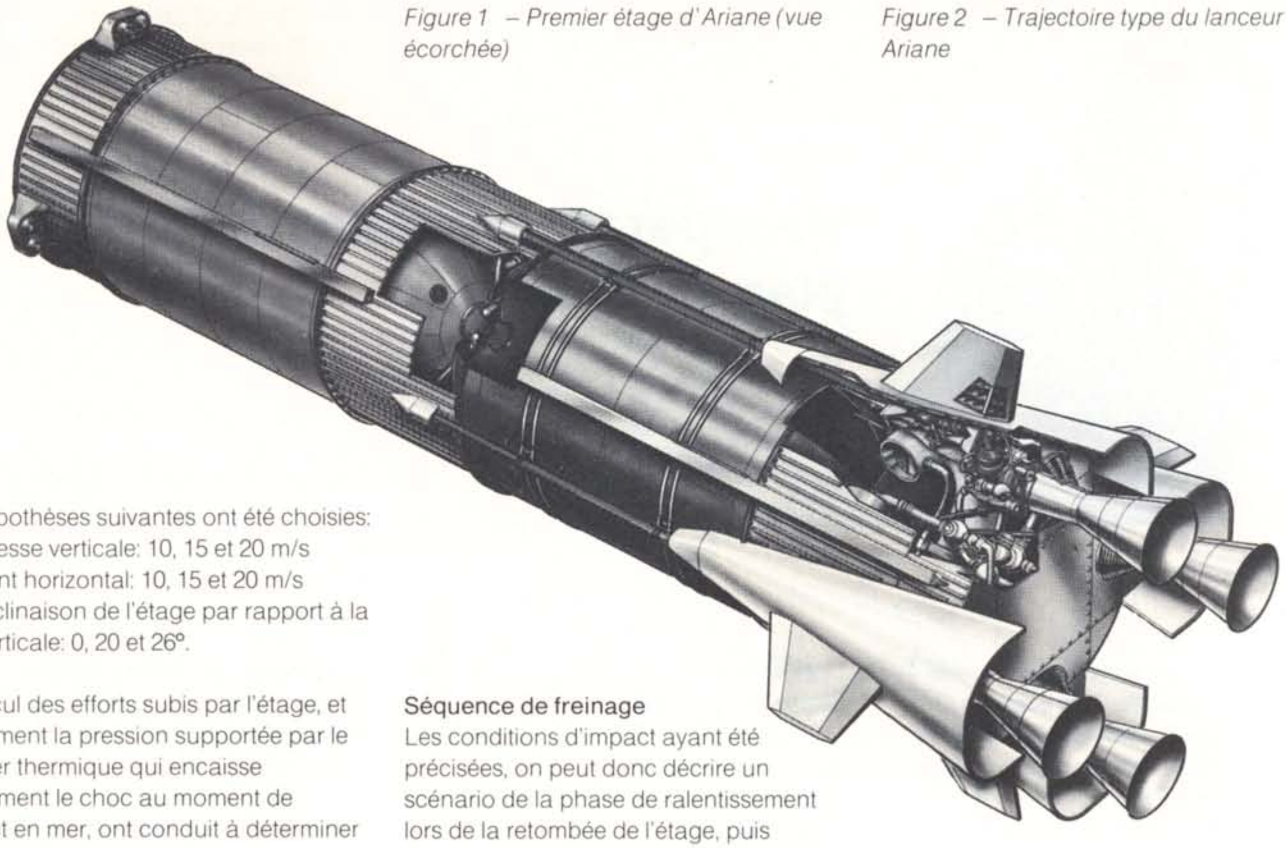


Figure 1 – Premier étage d'Ariane (vue écorchée)

Les hypothèses suivantes ont été choisies:
- vitesse verticale: 10, 15 et 20 m/s
- vent horizontal: 10, 15 et 20 m/s
- inclinaison de l'étage par rapport à la verticale: 0, 20 et 26°.

Le calcul des efforts subis par l'étage, et notamment la pression supportée par le bouclier thermique qui encaisse directement le choc au moment de l'impact en mer, ont conduit à déterminer comme valeurs acceptables:
- vitesse verticale: 12,5 m/s
- inclinaison: 0° (légère inclinaison favorable)
- vent maximal: 20 m/s.

Séquence de freinage

Les conditions d'impact ayant été précisées, on peut donc décrire un scénario de la phase de ralentissement lors de la retombée de l'étage, puis déterminer la configuration des éléments participant au déroulement de la séquence élaborée.

A la fin de sa phase propulsée (altitude: environ 50 km), le premier étage (L140) du lanceur se sépare de la partie haute. Il amorce alors une phase balistique (Fig. 2) au cours de laquelle sa vitesse est freinée

Figure 2 – Trajectoire type du lanceur Ariane

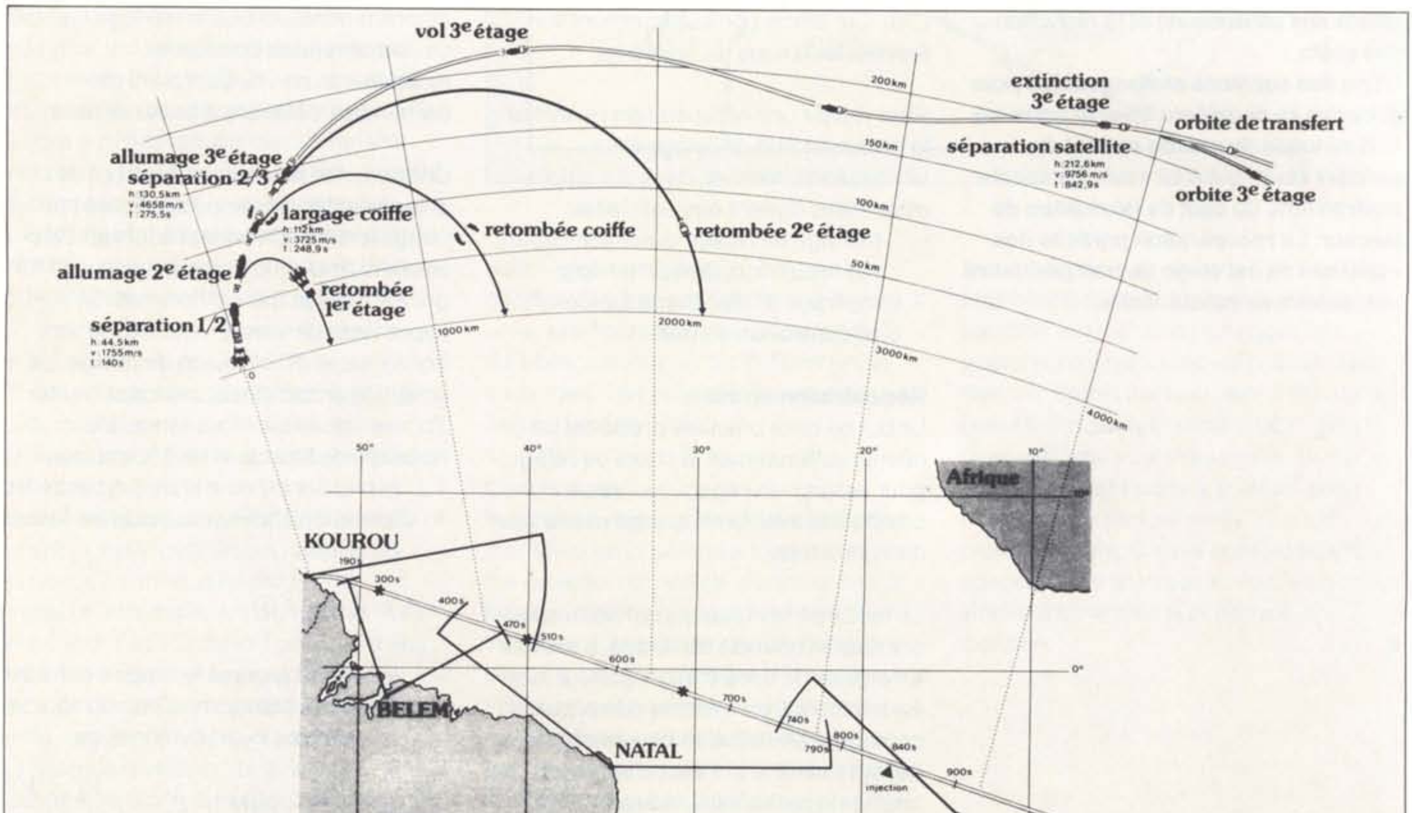


Figure 3 – Séquence de récupération du premier étage

par l'atmosphère environnante, et passe de 1800 m/s à environ 160 m/s vers l'altitude de 5 km. A partir de ce moment, le processus de freinage par parachutes (Fig. 3) se déroule selon le schéma suivant:

Top récupération

- altitude maximale: 5000 m
- vitesse maximale: 160 m/s

↓

Repointage et ralentissement primaire

- facteurs de charges: (longitudinal) 5,2 g et 1,5 g (latéral)
- vitesse terminale: 70 m/s

↓

Ralentissement terminal et hyperstabilisation

- facteurs de charges: idem
- oscillations pendulaires d'amplitude: 5°

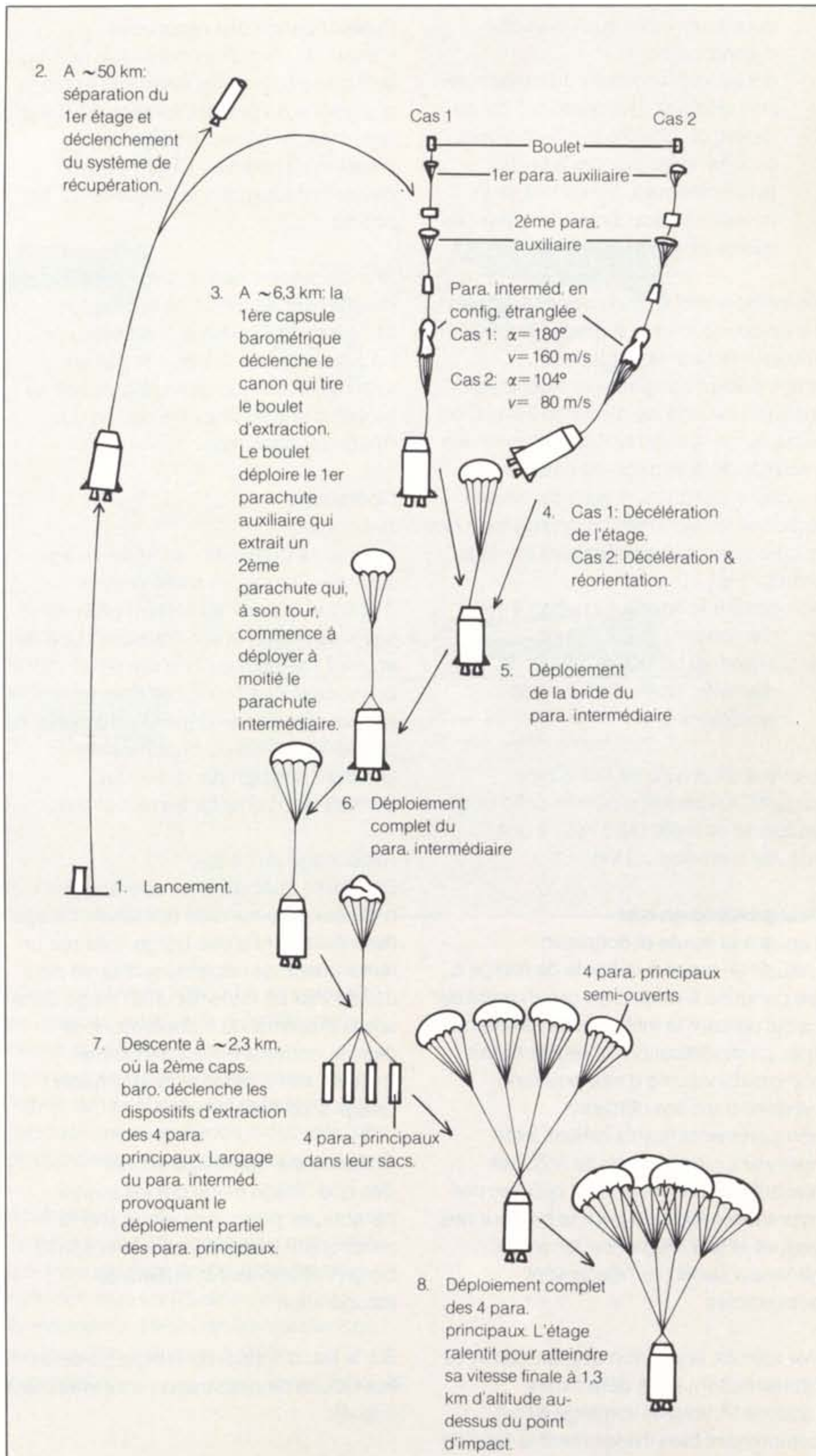
↓

Impact sur mer

- vitesse: 10 à 20 m/s

Top de récupération
L'initialisation de la séquence est obtenue au moyen d'un câble de commande largué après utilisation, relié d'une part au deuxième étage du lanceur, et d'autre part à un actionneur pyrotechnique qui arme un boîtier de commande barométrique (un retard pyrotechnique de 12,5 s évite le fonctionnement prématuré du boîtier barométrique). Ce dernier, à une altitude d'environ 5 km, commande un canon qui éjecte un boulet extracteur d'un premier parachute auxiliaire (diamètre: 0,56 m) qui lui-même aide au déploiement du parachute extracteur principal, (diamètre: environ 1,5 m).

Repontage et ralentissement primaire
Le déploiement complet du parachute auxiliaire principal permet alors l'extraction du parachute intermédiaire, destiné à opérer un début de ralentissement de l'étage, à réduire ses éventuelles oscillations et enfin à assurer son orientation correcte. L'ouverture de ce parachute s'effectue en deux temps:



- ouverture limitée à un diamètre d'environ 2 m;
- déploiement complet du parachute intermédiaire (diamètre: 12,5 m) au moyen de cisailles pyrotechniques commandées par des retards pyrotechniques, armés lors de la première phase d'ouverture par des câbles de commande.

Ralentissement final et hyperstabilisation
Le lanceur continue à descendre, freiné uniquement par le parachute intermédiaire complètement déployé, jusqu'à une altitude d'environ 2 km. C'est alors qu'un second boîtier barométrique commande le largage du parachute auxiliaire. Durant son éjection, celui-ci actionne les systèmes de déploiement des quatre parachutes principaux en deux temps:
- ouverture limitée à environ 4 m de diamètre;
- ouverture complète à 20 m de diamètre, environ 4,3 s après extraction.

La mise en oeuvre de ces quatre parachutes permet d'obtenir enfin une descente verticale (12,5 m/s) à une altitude d'environ 1,3 km.

Récupération en mer

Tenue à la houle et flottaison
L'étude de tenue à la houle de l'étage a été conduite à l'aide d'un programme de calcul utilisant la méthode des éléments finis. La modélisation de l'étage tenait compte du volume d'eau pouvant pénétrer dans ses différents compartiments (partie arrière, inter-réservoirs, jupe inter-étage 1/2). Les résultats obtenus montrent qu'avec des hypothèses réalistes pour la hauteur des vagues et leur fréquence, les efforts généraux subis par l'étage sont acceptables.

Par ailleurs, la position approximative de l'étage flottant a été déterminée (assiette 5°; volume immergé 42 m^3, comprenant bien évidemment la baie de propulsion).

Pressurisation des réservoirs
L'étude de l'évolution thermique des gaz de pressurisation des réservoirs après la séparation du premier étage a montré que, sous certaines conditions, la pression du réservoir UDMH pouvait descendre jusqu'à une valeur de 0,9 bar absolu.

Afin d'écarter le risque d'une détérioration du réservoir par l'effet de la pression atmosphérique externe, il est prévu de pouvoir le repressuriser, soit par un système embarqué dans l'étage, soit au moyen d'une source externe, lorsque l'étage est dans l'eau.

Opérations

Repérage
Lors de sa phase de retombée, l'étage sera suivi au moyen d'instruments d'optique, à partir du bateau prévu pour sa récupération et son transport. Une fois en mer, il se peut qu'il ne soit plus localisé optiquement de façon certaine, aussi est-il prévu d'implanter dans la jupe avant, une série de trois ou quatre balises émettant des signaux radio, qui permettront d'orienter les recherches.

Repêchage de l'étage
Un moyen spécial de récupération en mer a été conçu pour cette opération. Il s'agit essentiellement d'une barge, tirée par un remorqueur, de capacité suffisante pour transporter en toute sécurité l'étage dans son bâti spécial de récupération; ce dernier, communément dénommé 'cuillère', sert à amarrer, puis à hisser l'étage à bord de la barge.

Scénario du repêchage en mer
Dès que l'étage freiné par les quatre parachutes principaux est en vue, le remorqueur tracte dans sa direction la barge transportant la cuillère de récupération.

Sur le lieu d'impact de l'étage, plusieurs opérations de préparation sont effectuées (Fig. 4):

- contrôle des fuites d'ergols
- mise en position angulaire adéquate de l'étage
- enlèvement des parachutes
- réglage de l'assiette de la barge, en concordance avec celle de l'étage (en même temps qu'elle est amenée en position de travail)
- mise en position récupération de la cuillère
- amarrage de l'étage au moyen d'un câble fixé à un treuil sur la barge.

L'ensemble est alors tracté par le remorqueur, à vitesse réduite, afin d'aligner l'étage avec l'axe de la cuillère. Ensuite, l'étage est treuillé lentement pour être placé dans la cuillère, dont l'intérieur est garni de coussins gonflés d'air. L'étage étant solidement amarré à la cuillère, l'opération de hissage à bord de la barge peut alors commencer. Ceci se fait par treuillage de la cuillère qui glisse sur une rampe prévue à cet effet. L'ensemble est ensuite assuré en position fixe, en vue de son transport jusqu'au port.

Remise en état

Dès l'arrivée au port de Cayenne va commencer la deuxième phase de l'étude de faisabilité, celle qui correspond à la récupération des matériels. Elle débutera par un rinçage soigné à l'eau douce de l'ensemble du lanceur, suivi d'opération de neutralisation et de séchage.

Ensuite un démontage systématique de l'ensemble sera immédiatement entrepris afin d'effectuer une expertise des matériels, en vue de leur revalidation. Les résultats des différentes expertises de revalidation en Europe seront les données principales de l'étude de rentabilité économique.

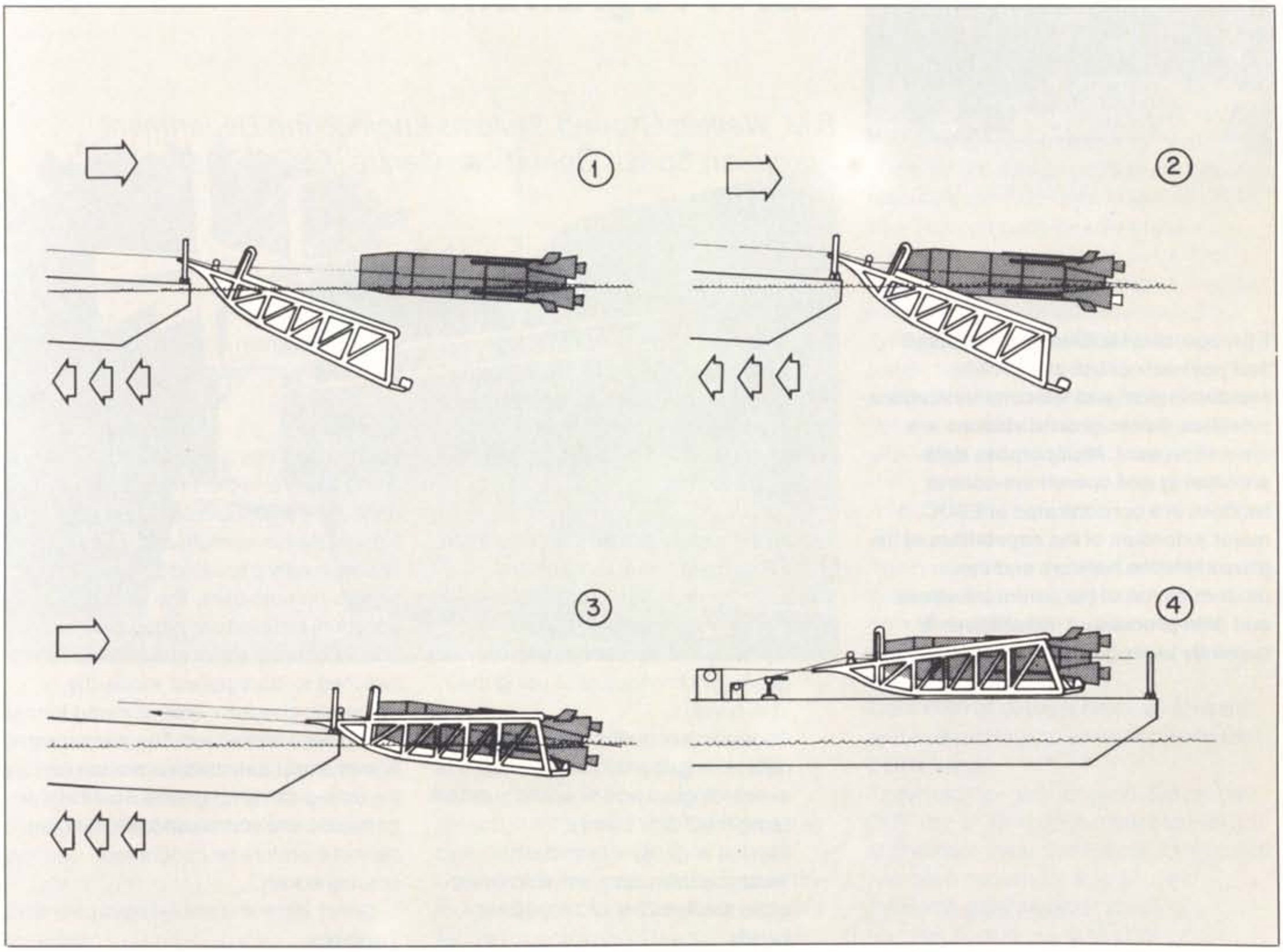
Conclusion

Ce programme de récupération du premier étage se décompose en trois parties:

Etude de faisabilité

La première phase de cette étude s'est terminée au début de l'année 1981 et

Figure 4 – Scénario de repêchage en mer



concluait à la possibilité technique de récupérer le premier étage du lanceur, dans des conditions d'intégrité suffisante pour permettre la réutilisation de bon nombre de ses éléments.

Démonstration pratique

Un planning de développement du système de récupération et de son intégration dans la jupe avant d'un premier étage a été établi. La définition de tous les matériels a été faite, une revue de définition s'est tenue au cours du mois de juin 1981. Actuellement les équipements sont en cours de réalisation et les essais de mise au point et de qualification sont déjà entrepris pour certains d'entre eux. La livraison du matériel est prévue pour le début de l'année 1982, afin de permettre un essai en vol à partir du milieu de la même année. Après cet essai, commencera la deuxième phase de l'étude de faisabilité; une expertise sera conduite sur les matériels récupérés afin de compléter l'étude économique.

Application

Le bilan global de l'opération permettra aux responsables du programme de formuler leurs conclusions et éventuellement leurs recommandations sur les suites à donner à cette expérience.

Operational Support Facilities for ESA Programmes

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ESA operates facilities for spacecraft and payload control of scientific, meteorological and telecommunications satellites. Seven ground stations are used at present. Multipurpose data-processing and operations-control facilities are concentrated at ESOC. A major extension of the capabilities of the ground-station network and the modernisation of the communications and data-processing installations is currently in progress.

The Agency and its predecessor, the European Space Research Organisation (ESRO), have operated an integrated system of ground stations, spacecraft control centres and data-processing facilities since 1968.

Today, the capabilities and configuration of the ESA operational facilities are adequate for the following operational tasks:
- Operation of satellites during transfer to geosynchronous orbit using the VHF band.
- Acquisition of control and experiment data from geosynchronous meteorological and scientific satellites using the 2 GHz band.
- Control of geosynchronous telecommunications satellites using either the 4–6 GHz or 11–14 GHz bands.

The ESA ground stations

ESA presently utilises seven ground stations, which are most conveniently discussed when grouped by purpose.

Operation of geosynchronous satellites during the launch and early orbit phase

Current ESA geosynchronous satellites use the VHF band for telemetry, telecommand and ranging while in the equatorial transfer orbit. ESA ground stations used during this phase of operations are located at Kourou (French Guiana), Malindi (Kenya), Carnarvon (Western Australia) and Redu (Belgium). This network of four stations permits the simultaneous operation of two satellites in transfer orbit, matching the dual-launch capability of the ESA Ariane launch vehicle. The main characteristics of the stations are as follows.

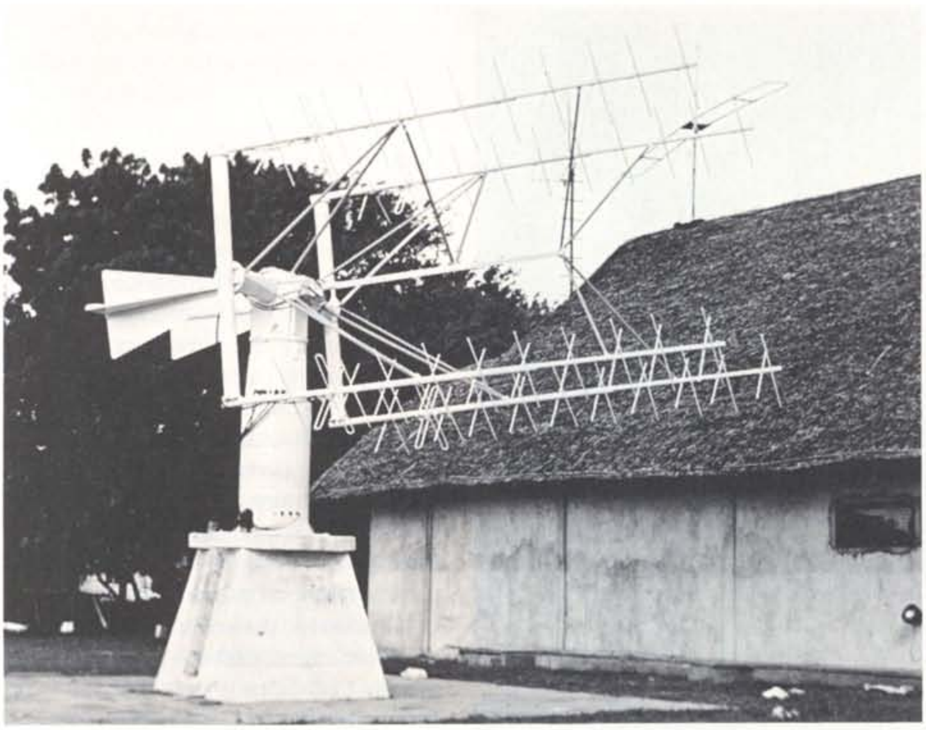
Command
Each station has a command antenna giving 50 dBW in the 148 to 150 MHz band. The antenna mounts provide 5 deg/s slew in azimuth and 2.5 deg/s in elevation with a tracking acceleration of 5 deg/s on both axes. The telecommand encoders installed are compatible with the ESA PCM telecommand standard. When switched to 'transparent' mode, the automatic check for telecommand format correctness is inhibited. The telecommand antenna and transmitter are also used for the up-leg of the range-measurement transaction: telecommand and ranging cannot therefore be conducted simultaneously.

Telemetry
One telemetry antenna is installed at each site with slew and acceleration performances identical to those of the telecommand antenna. The worst-case G/T* is 11 dB/K. Telemetry data are recorded on site or transmitted in real time to the Operations Control Centre at ESOC. The maximum telemetry transmission rate to the Control Centre is 9.6 kbit/s.

Ranging
Stations are equipped with the ESA standard tone ranging system which uses coherent tones, with one major tone at 20 kHz and four minor tones. The system

* G/T = a quality factor (ratio of gain and noise temperature)

Figure 1 – Malindi station antenna



performance is characterised by a ground-station calibration error of less than ±200 ns and an RMS noise and dynamic error of less than 75 m per sample.

Extended capabilities presently being installed

All newly started ESA geosynchronous satellite projects will use the S-band instead of the VHF band for operations in transfer orbit. The installations at Kourou, Malindi and Carnarvon are now being extended to provide telemetry, telecommand and ranging capability in this band by the first quarter of 1983.

The network is designed to support the operation of a single S-band satellite in equatorial transfer orbit. Requirements for telemetry, telecommand and ranging access to the spacecraft, coupled with the need for high availability of these functions during critical operations such as apogee-boost-motor firing, will be met by equipping each site with a single antenna. The geographical location of the stations provides double (two-station) coverage for critical operations at the apogee of the first, fourth and sixth transfer orbits. The apogees of the second, third and fifth orbits are covered by a single station only. Thus apogee boost motors will normally be fired at the fourth apogee of the transfer orbit, with a second opportunity at the sixth apogee.

Network performance

Worst-case spacecraft performance in transfer orbit is defined by a spacecraft downlink EIRP* equal to or better than −13.5 dBW with a spacecraft uplink G/T equal to or better than −41.0 dB/K, both at a slant range of 41 000 km. This gives minimum performance requirements for the station downlink of 22 dB/K with 68 dBW EIRP on the uplink. Ranging ground station calibration has been reduced to ±50 ns.

Communications between the three S-band stations and the Operations Control Centre will be improved by installing a node of the new ESA packet-switching system at each site. This system is fully compatible with the ISO/DP 7498 'Data Processing – Open Systems Interconnection – Basic Reference Model', recently published in the USA as NCS TIB 814. This compatibility offers future savings in line rental costs, since it will become possible to meet excess capacity requirements by overflow to the public system. It is, however, unlikely that the public system will wholly replace the present ESA private-line communications net in the medium term due to the difficulty of ensuring timely availability of line capacity when needed for operations.

Future extensions

Antennas at Kourou and Carnarvon will be duplicated should it become necessary to operate two S-band satellites simultaneously in transfer orbit.

Operation of geosynchronous scientific and meteorological satellites using the 2 GHz band

These facilities are concentrated on the ESA sites at Villafranca (near Madrid) and Michelstadt (near Darmstadt). Michelstadt has been chosen for scientific and meteorological missions needing to transmit data in real time at very high rates to the computers at ESOC. Restrictions in frequency allocations on this site lead to the selection of Villafranca for other scientific missions.

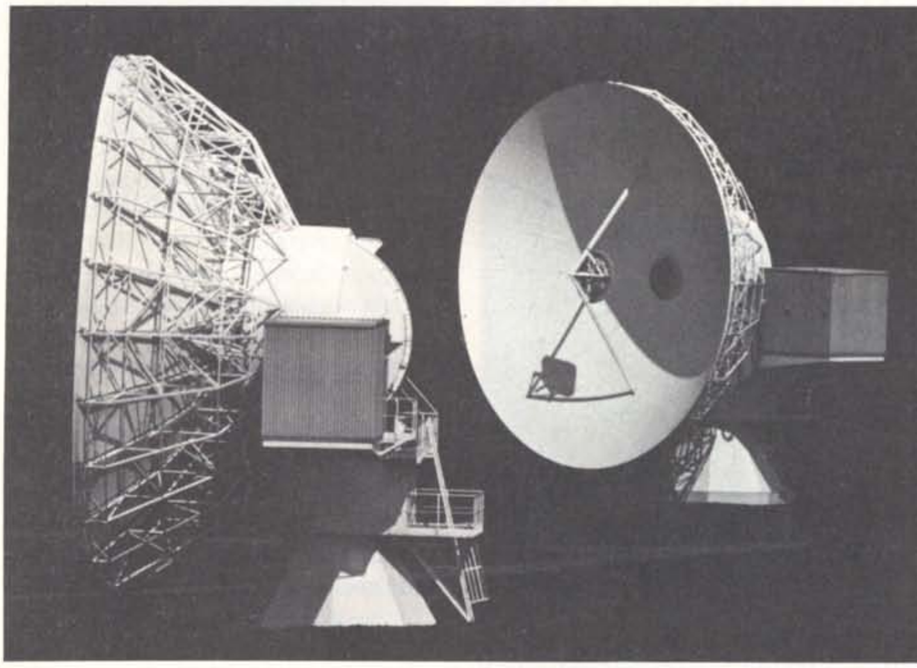
Scientific and meteorological facilities at Michelstadt

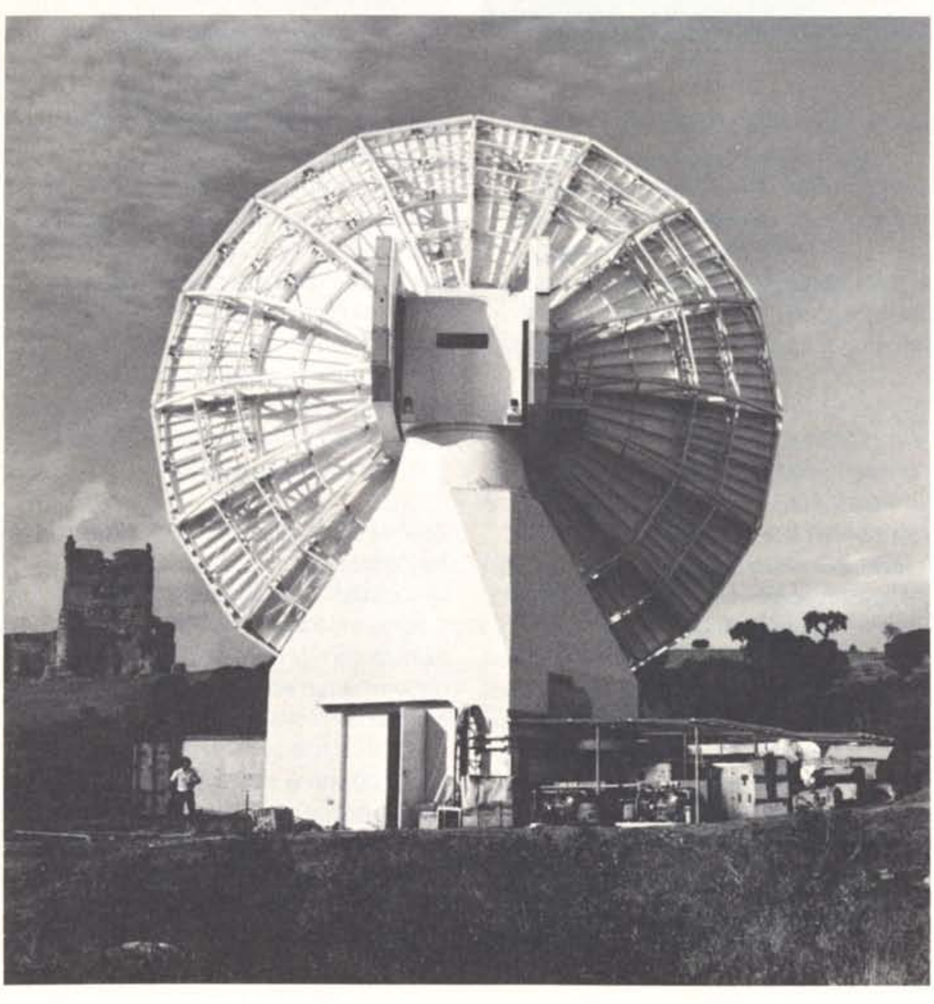
Michelstadt is equipped with two 15 m S-band antennas, one for meteorological satellite control data acquisition and dissemination and one for scientific satellite control and data acquisition. The meteorological system has both an uplink and a downlink capability with simultaneous transmission of three carriers, two at 64 dBW and one at 57 dBW EIRP and a figure of merit of 23 dB/K. The scientific antenna has downlink capability only, with a 27 dB/K figure of merit.

* EIRP = Effective Isotropically Radiated Power

Figure 2 — Meteosat (left) and Geos (right) antennas at the Michelstadt station

Figure 3 — Exosat antenna at the Villafranca station





Both antennas are linked to fully automated signal-processing equipment at the station.

Data is interchanged with the Control Centre computers at ESOC using a full duplex 2 Mbit/s link.

Scientific facilities at Villafranca
Scientific facilities at Villafranca consist of a 15 m diameter S-band antenna identical in design to the two at Michelstadt. This antenna is equipped for reception only and is used in conjunction with a VHF telecommand antenna to operate the International Ultraviolet Explorer (IUE) satellite. These telemetry and command facilities are directly linked to a spacecraft control centre, a data-processing centre and a scientific observatory, installed at Villafranca specifically for the IUE mission.

Other scientific facilities under development

Extensions at Villafranca
A second 15 m antenna and associated signal-processing equipment is currently being installed at Villafranca for the ESA Scientific Programme. This antenna is of a new design, featuring a reflector optimised for reception at both S- and X-bands designed to service future scientific missions using other than geosynchronous orbits. The antenna mount has relatively high slew rates and accelerations (azimuth slew is 15 deg/s with 7.5 deg/s^2 acceleration; elevation slew is 5 deg/s with 2.5 deg/s^2 acceleration).

These figures, coupled with beam defocussing, reduce the 'keyhole' effect inherent in the elevation over azimuth mount for zenith passes to 4 deg in elevation for a satellite at 900 km altitude. The antenna will be delivered with an S-band feed for reception and transmission. A G/T of 27.5 dB/K will be achieved. A compatible feed for both S- and X-bands will be developed.

Uplink, downlink and ranging equipment utilising ESA's current technology and

Figure 4 – *The Carnarvon station antennas*

Figure 5 – *Antennas at the Fucino station*

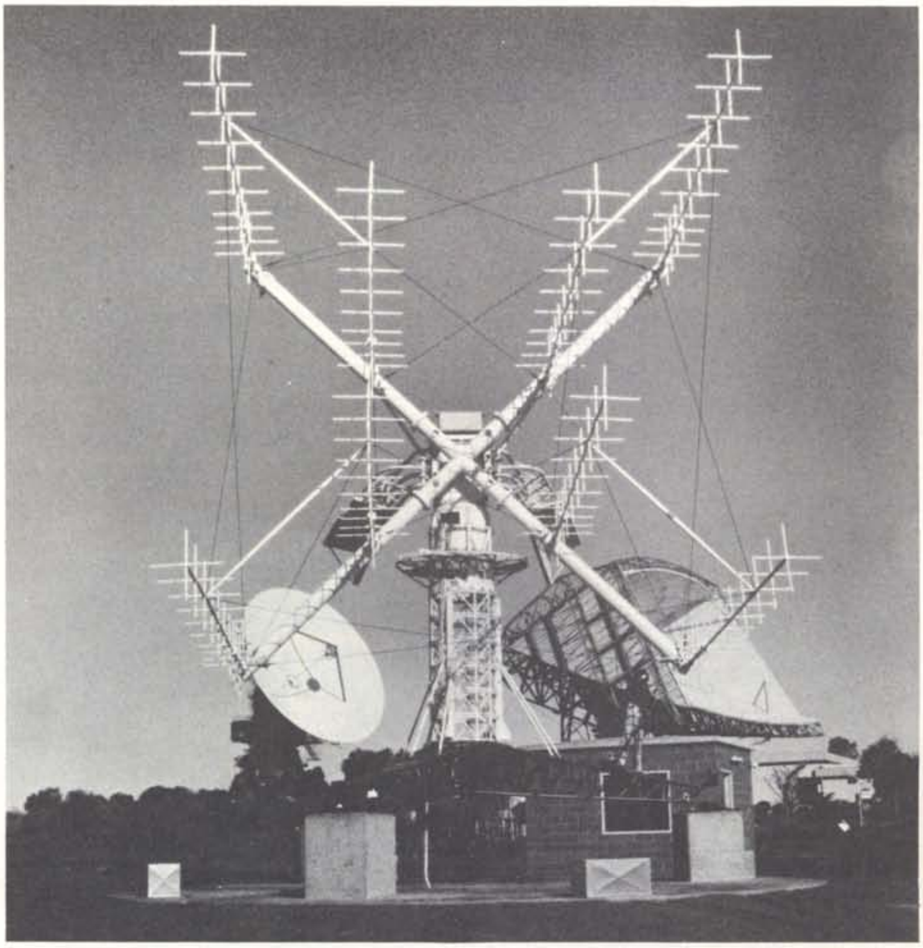
standards is being installed. The facility will be linked to the Operations Control Centre at ESOC by a node of the ESA packet-switching communications system.

New features at Carnarvon
Carnarvon will accommodate key elements of the ground system for ESA's Giotto satellite, which will make a close approach to Halley's comet just after its next perihelion in 1986.

A second 15 m antenna, identical to that presently being installed in Villafranca (described above), has been ordered for delivery in early 1983. The high performance of the antenna mount allows the station to be used to support the operation in S-band of geosynchronous satellites while in transfer orbit. Uplink, downlink and ranging equipment utilising ESA's current technology is being installed. More advanced ranging equipment will be needed to range the Giotto spacecraft out to the cometary encounter. Convolutional and Reed Solomon decoders will also be added for Giotto.

Facilities for the operation of geosynchronous telecommunications satellites operating in the Ku- and C-bands
The Ku-band facilities presently used by the Agency are located at Fucino, Italy. The Ku-band station, designed and installed to the Agency's specifications, was pre-financed by Telespazio and is made available to ESA under a 'lease back' agreement. Villafranca houses the Agency's C-band station set up for the Marecs programme. Both the Ku-band and the C-band capabilities of the Agency are presently undergoing significant expansion.

Installation at Fucino
The Fucino Ku-band station was built for two operational functions, TT&C (telemetry, tracking and command) and the in-orbit testing of communications payload transponders. Those functions



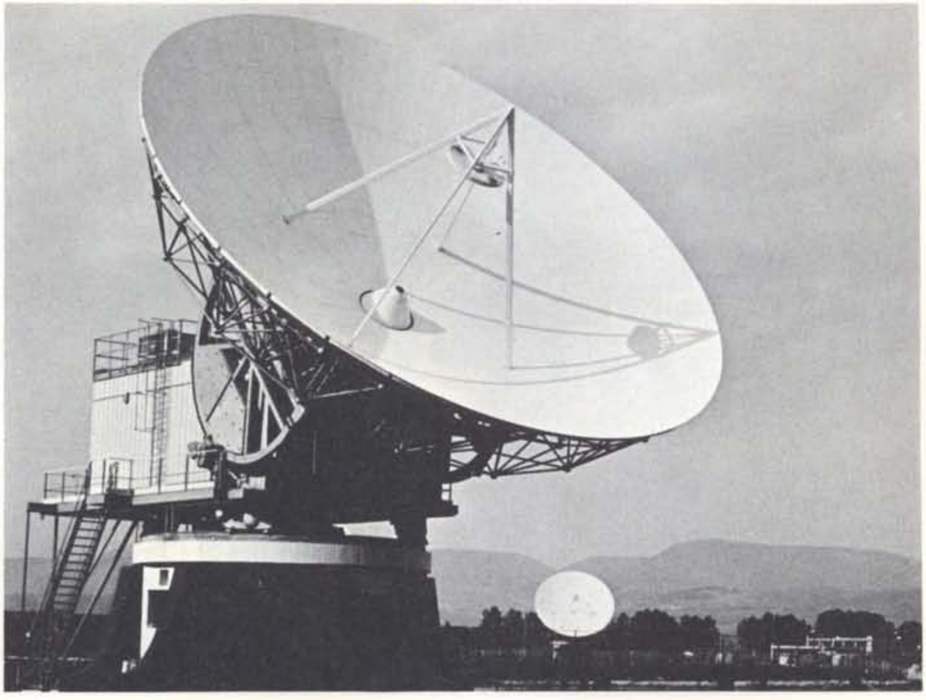


Figure 6 — The Main Control Room at ESOC

were combined in order to avoid duplication of the high-cost parts of the station (e.g. antenna, RF systems). The station can be extended to become a complete telecommunications station for the European Communications Satellite (ECS) presently being procured by ESA. The Agency retains the ownership of the TT&C equipment and the interface equipment used to interchange TT&C data with the Control Centre at ESOC. Reliability of the TT&C equipment is achieved by duplication of all processing chains and a 'hot standby' configuration.

The main antenna, a 17 m diameter Cassegrain, uses a wheel-and-track mount. Reception is in the bands 10.95–11.2 GHz and 11.45–11.7 GHz. Gain is 63.15 dB. Three receiver chains are provided.

Three high-power amplifiers are installed. Transmission frequencies range from 14 to 14.5 GHz, with EIRP ranging from 92.5 dBW (used for 180 Mbit/s digital testing) to 84 dBW for the telecommand carrier. A 3 m auxiliary antenna slaved to the main antenna is provided for transmission test purposes.

Reception of satellite telemetry and measurement of antenna pointing angles are performed continuously and the data transferred to the spacecraft Control Centre at ESOC. Telecommand and ranging transactions are generated by the Control Centre computers and processed automatically on station. Optical and acoustic alarms are provided for a wide variety of equipment malfunctions, allowing the operator to move freely within the station.

Installations at Villafranca

The Agency's C-band station at Villafranca has been constructed to perform the TT&C and payload monitoring of the 'Atlantic' satellite of the Marecs programme. It features a 12 m diameter transmit/receive antenna operating in the 4.188–4.201 GHz receive band and the 6.415–6.427 GHz transmit band. A G/T of 32.5 dB/K and EIRP of 81 dBW are achieved. Two identical and interchangeable downconverters give high reliability in telemetry reception. A third downconverter is provided for payload test signals. Telecommand and ranging transmissions are handled by two identical and interchangeable 1.5 kW High-Power Amplifiers (HPAs). A separate HPA is provided for the transmission of payload test signals.

Telemetry and telecommand processing chains are duplicated for high reliability. A single ranging unit is installed. Telemetry, telecommand and ranging data are interchanged with the Operations Control Centre at ESOC using a fully redundant communications system dedicated to this station.

Payload testing in the L-band is accomplished using a standard gain horn to measure accurately the spacecraft radiated power in the 1.534–1.546 GHz transmit band. An additional L-band transmit receive dish with a G/T of 1.5 dB/K and an EIRP of 53 dBW is provided for other measurements. These L-band facilities are linked to a payload test laboratory where computer-driven test equipment allows both L-band and C-band payload test sequences to be initiated and executed automatically. Payload test measurements can be initiated by the computers in the Control Centre at ESOC. Test measurements are available at Villafranca or may be transmitted to ESOC.

New Ku-band facilities at Redu

Redu has been selected to house the main TT&C and payload-test facilities required to operate the satellites of the ECS series. The equipment, co-located with the existing VHF station, is sufficient to operate two ECS satellites simultaneously. A special feature is the location of the spacecraft data-processing and control centres on the same site as the transmission and reception facilities.

Telemetry data are acquired by two identical 11 GHz reception stations with a G/T of 21.5 dB/K. Telecommand (at VHF) utilises a single system, shared by both satellites with an EIRP of 62 dBW. A second telecommand antenna, normally used for launch support, is available to back-up the prime system. Loss of the Ku-band telemetry due to a malfunction would be overcome by switching to VHF and using one of the existing VHF facilities at Redu for reception.

Ranging is normally performed in the 11 to 14 GHz bands using a third terminal having a G/T of 21.5 dB/K and a maximum EIRP of 61 dBW.

Three telemetry processing chains are provided with two telecommand processing chains and one ranging system.

Payload test and performance monitoring is carried out using a specilised Ku-band terminal with a G/T of 36.7 dB/K and a maximum EIRP of 93 dBW. This terminal is equipped with two receive and two transmit chains. Data is routed to and from equipment housed in a payload test laboratory adjacent to the spacecraft control room. Payload tests and the processing and recording of results are under the control of a specialised computer system.

All facilities are configured for a minimum operational team. Spacecraft control operations in VHF mode can be directed from either Redu or ESOC in order to smooth the transfer of control from the launch and geosynchronous-orbit-injection phase to the 'on-station' phase.

Additional Marecs facilities

The second satellite of the Marecs series will be located over the Pacific. TT&C and payload monitoring will be performed from Ibaraki in Japan. The station operators, Kokusai Denshin Denwa, are currently procuring (under contract to ESA) the C-band, L-band and VHF terminals required (VHF is used to back-up the C-band TT&C links). ESA is currently procuring the telemetry, command, ranging and payload test equipment. The station will be linked by ESA's new communications equipment to the Marecs Operations Control Centre at ESOC.

Two identical 13 m diameter C-band antennas will be provided. One is included primarily for TT&C, whereas the other is primarily for communications traffic at C- and L-band. A simple VHF receive/transmit antenna will be installed.

Three telemetry chains, two telecommand chains and one ranging system are provided by ESA. A payload test laboratory identical to that installed at Villafranca is also provided by ESA.

photo kokusai denshin denwa

Figure 7 – The installations at Ibaraki to be used for Marecs-B

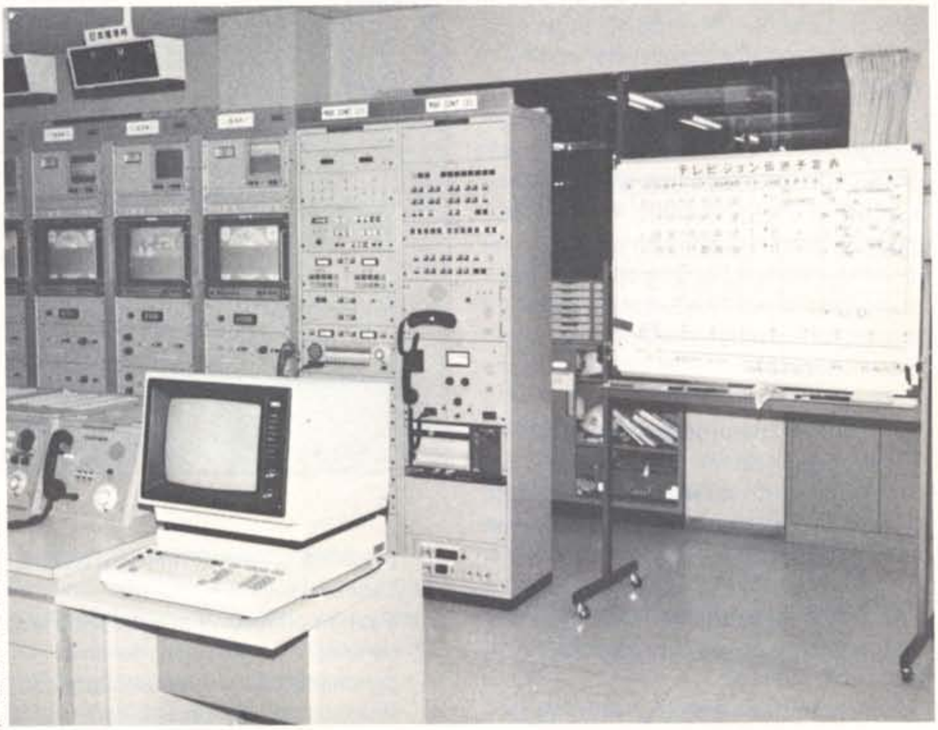
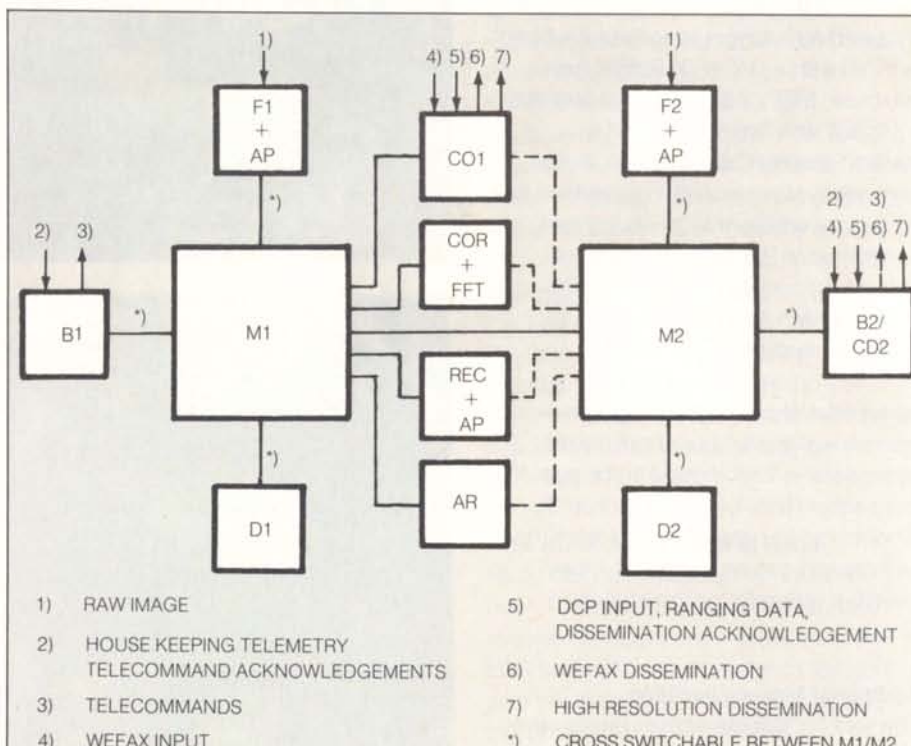


photo kokusai denshin denwa

Figure 8 – The Control Room at Ibaraki

Figure 9 – Configuration of the Meteosat Ground Computer System (MGCS)



ESA operational data-processing facilities

The satellite operational tasks of ESA are supported by a variety of computer systems which are divided into three categories according to their usage:

1. Small special-to-purpose computers (mini- and microcomputers) used at the ground station for process control and data communications to and from the Operations Control Centre at ESOC.
2. Real-time computer systems used in the control centres. These systems are linked to ground stations by the communications systems referred to above.
3. General-purpose computers used for mission analysis, feasibility studies and off-line payload data processing.

Computers of Category 1 are dedicated to specific tasks and fully integrated with ground-station subsystems.

Category-3 computers are standard general-purpose computers as supplied by the established computer industry. Machines are located at different ESA sites and are interconnected in order to facilitate exchange of data and load sharing.

Category-2 computers are associated with spacecraft and mission control centres to support satellite operations. They are multicomputer systems with an architecture particularly adapted to their operational tasks. The functions and architecture of these systems are presented below.

Operational data-processing functions

There are operational functions common to the ground-based elements of the data systems of most current and planned ESA missions.

Spacecraft control data processing

Performed throughout the satellite's lifetime in order to:

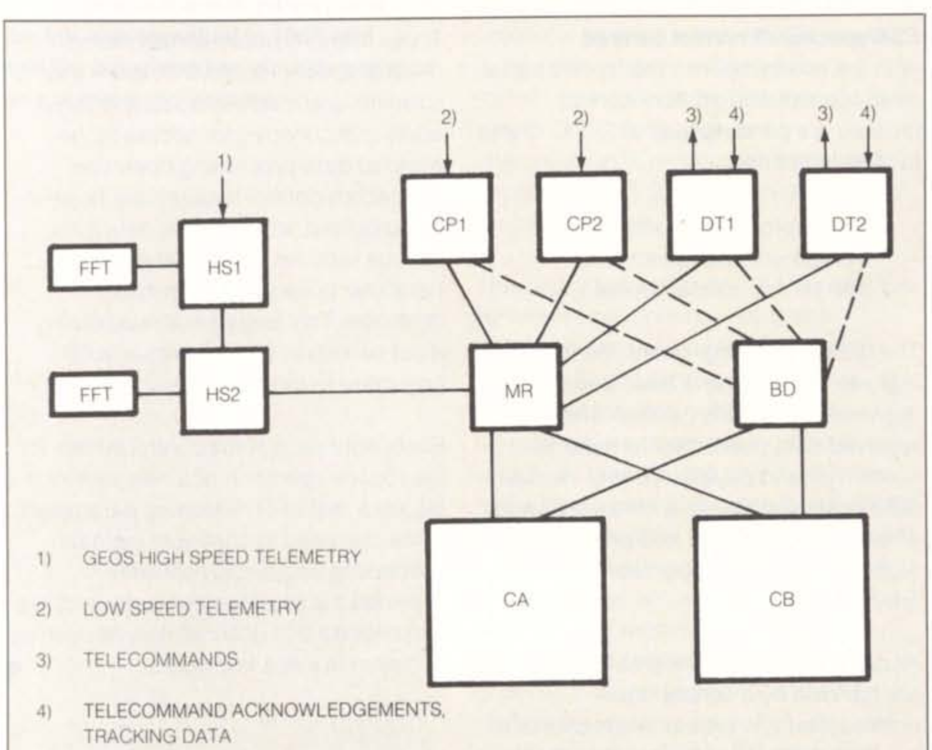
– Monitor housekeeping telemetry, to present real-time or retrieved data to controllers.
– Support command activities (manual commands, automatic real-time commands, scheduled commands).
– Produce status reports.

Flight-dynamics data processing

Performed throughout the satellite's lifetime in order to:

– Determine and predict the satellite's position and attitude.

Figure 10 – Configuration of the Multi-Satellite Support System (MSSS)



- Plan and execute orbit and attitude changes.
- Update mission analyses (e.g. in-orbit lifetime predictions, utilisation of consumables, system degradation trends).

Payload-control data processing
Requirements vary from the full support of a scientific observatory, through partial processing of instrument data for 'quick look' and manual or automatic telecommand purposes, to minimal support for communications payloads.

Payload data processing
This includes generation of the data products required by the user community, ranging from raw telemetry data and related auxiliary data (orbit, attitude, time) on magnetic tape, to system-corrected images or even precision-processed images and data products requiring feature extraction.

System concept
ESA currently uses four different computer systems for the support of satellite operations. Three are dedicated to specific satellites, whereas the fourth is designed to support several missions simultaneously. These systems are:
- the Cos-B Support System, installed at ESOC
- the IUE Ground Computer System (IGCS), installed at Villafranca
- the Meteosat Ground Computer System (MGCS), installed at ESOC
- the Multi-Satellite Support System (MSSS), installed at ESOC, and at present supporting OTS, Geos-2 and the 'launch and early orbit phases' of all ESA satellites.

A fifth system, presently being installed, will be located at the Redu ground station for ECS spacecraft control.

Conceptual and architectural design
The IGCS is a single computer system performing all four operational functions defined above. All other ESA on-line systems are multicomputer systems comprised of classical minicomputers as used in process-control applications and general-purpose computers having some real-time capabilities.

The classical minicomputers are mainly used for spacecraft control and flight-dynamics data processing, whereas the general-purpose computers are used for payload control and payload data processing.

This concept has been abandoned for

the ECS computer system at Redu, which is comprised of two mini-machines, one prime and one back-up. The prime machine executes all operational tasks except flight-dynamics data processing, which is almost entirely performed by the MSSS at ESOC, and payload data processing, which is not required for a telecommunications mission.

Configuratons

The Cos-B Support System comprises two machines, one IBM 1800 front-end computer linked by a parallel data channel to an IBM 370/148.

The IGCS is a Sigma-9 computer, compatible with the machines used by NASA to support the IUE mission. This enables ESA to use the IUE mission-support software developed by NASA.

The original MGCS configuration (Fig. 9) consisted of seven Siemens-330 and three Nova-830 minicomputers (D1, D2, AR) and two ICL-2980 mainframes (M1, M2). The system is presently being modernised and reconfigured.

The MSSS (Fig. 10) consists of six Siemens-330 front-end computers, two of which (HS1 and HS2) are dedicated to the support of the Geos mission, two CII-10070 (a French licence of the SDS Sigma-7) back-end-computers and two Siemens-330 machines (MR and BD) with central system functions such as message routing and configuration control.

The ECS Computer System consists of two Siemens R30 minicomputers, which are modernised versions of the Siemens-330.

System development until 1990

The Cos-B and the IUE systems will be dismantled at the end of the useful lifetimes of these spacecraft.

The Meteosat system is at currently being modernised. Some Siemens-330 computers will be replaced by R30 computers, and the ICL-2980 mainframe computers will be replaced by more modern machines. The present system concept, as well as the system functions, will be unchanged by this. The modernisation process is planned for completion in 1982.

The MSSS configuration is being modernised by replacing the obsolete back-end computers by two SEL 32/77 machines which will become operational in the Spring of 1982. The present front-end computers are being slightly upgraded and reconfigured, but they are expected to become obsolete by 1985. At that time their functions will be transferred to the new SEL 32/77 computers. Although the system architecture will then be changed, the multi-mission support concept will be retained.

ESA spacecraft control centres

With the two exceptions mentioned earlier, all spacecraft and network control facilities are concentrated at ESOC. These facilities comprise:

- a data-processing centre
- a communications centre
- operational control rooms.

The data-processing centre, the main features of which have been described, is organised to provide the real-time or retrieved data needed for all aspects of spacecraft and payload control. Auxiliary data-processing tasks such as orbit and attitude determination and prediction are also executed in the operational environment.

All data to and from the ground stations are handled by a central data communications system which connects the communications channels to the appropriate computer port as required for the operation in progress. Data routing and data-processing task initialisation and termination are controlled from the network control position. Facilities also exist for voice and telex communication with the ground stations.

Critical operations – typically the launch and early-orbit phase during which the satellite is launched, activated, checked and placed in its final operational orbit and operational configuration – are controlled from the main control room. This room has facilities for operations management, network control, spacecraft control and attitude and orbit control. Extensive alphanumeric, strip-chart and wall-display facilities are available. Practically all equipment and software is multi-function, which allows several data streams to be processed and displayed simultaneously. Command safety features (physical and procedural) are extensively used.

Routine operations are conducted from dedicated control rooms configured to reduce manning levels to a minimum. These rooms typically contain some mission-specific displays or, in the case of scientific and meteorological missions, additional consoles for access to the payload data-processing operation. Spacecraft-control features are, however, standardised, which allows data from various satellites to be routed to a particular console by the network controller. This feature is utilised during quiet periods to allow one spacecraft controlled to monitor several satellites.

Reconfiguration of the control system for the routine operation of a new satellite is largely a matter of redefining parameters in the files used to configure the data processing and display software. Provided the satellite's characteristics are well defined and documented, this can be achieved in just a few weeks.

Launch Service Contracts

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In the times of Columbus, it was an adventure to cross the Atlantic. Now, many generations later such journies are a matter of routine, the greatest challenge being that of obtaining the cheapest ticket. Similar progress will occur in space transportation, but it will not take as many generations to happen. We have witnessed extraordinarily rapid progress in space technology since Sputnik was launched in 1957, and satellite launching has already grown to be a commercial venture.

The recent history of space transportation can be considered to have had three phases. During the first, only the USSR and the USA had launchers available. In this period NASA provided a launch service to other western countries whose space technology was less developed, either by furnishing no-cost flights within the framework of bilateral programmes or by providing reimbursable flights for unilateral projects with no NASA interest. In this initial phase NASA showed a certain generosity to its customers in the way in which such aspects as interpretation of reimbursable cost and acceptance of liabilities were reflected in the launch contracts.

The second phase began in the seventies, by which time more countries and industries were capable of developing spacecraft, and the requirements for spacecraft for both public and commercial purposes were growing rapidly. At that time the only launchers available commercially were those offered by NASA, the USSR abstaining, except for a few special arrangements, from offering any kind of launch service. It was during this period of monopoly that NASA reinforced its contractual policy as a supplier of launch services, and cost reimbursement was applied much more widely than ever before. Margins were built into the price to cover unforeseen events, and NASA limited its own liabilities to a minimum. Third-party liabilities had to be accepted by the customer, leading to the development of a new insurance market.

We are now entering the third phase in the history of space transportation with three launch systems in direct competition:

- the Space Transportation System (STS/Space Shuttle)
- conventional, nonrecoverable NASA launchers
- Europe's Ariane.

Other available launchers, particularly those of the USSR, have yet to really enter into commercial competition.

The newly competitive environment has caused considerable change in the terms and conditions offered for launch-service contracts. Table 1 shows the contractual arrangements into which the Agency has entered in the past for the provision of launch services. In legal terms these contracts are service contracts, not purchase contracts; they are designed to provide all necessary services to put a spacecraft into orbit as specified in the contract, including any special supporting services. It can be seen from Table 1 that for a number of bilateral projects between ESA and NASA, launch services have been supplied by NASA free of charge. Specific agreements governed the rendering of launch services in these cases and contracts as such were therefore not required.

Other ESA scientific projects are covered by the 'Memorandum of Understanding between ESRO and NASA' (MOU) of 30 December 1966, which established the mechanism for obtaining launch services from NASA. After an exchange of letters between the NASA Administrator and ESA Director General, to be considered as a

Figure 1 – ESRO-IB/Boreas satellite ready for launch at Western Test Range aboard a Scout rocket in October 1969

political clearance procedure, specific contracts for each spacecraft launch would be agreed.

The MOU confirms the principle of reimbursement to NASA of costs incurred and defines the liabilities of both parties. NASA is liable for certain third-party claims and for damage or loss of Government property, within certain limitations.

It has been questioned in the past whether experimental (pre-operational) satellites could be considered as falling under this MOU. Although a definitive interpretation has never been agreed, NASA and ESA have always reached agreement in the past on the provision of launch services. A much discussed case was OTS, where there was a question of conflict with the Intelsat agreement. NASA did, however, agree to provide a launch, with OTS being considered an experimental and regional telecommunications satellite.

A further problem is whether the MOU could also be applicable for Shuttle flights. NASA has always followed the principle of equal treatment of external customers. Some of the terms and conditions of the MOU are in conflict with the Shuttle-user contract conditions. The MOU could at the most be applied mutatis mutandis.

With the availability of Ariane, the Agency has nominated this European launcher as the preferred carrier for its missions. The first two series of launchings* are under ESA management and no user contracts are required when the Agency uses these launches for its own purposes.

In the meantime Arianespace has been created as a private company which will take over the commercialisation of Ariane. All Ariane launches beyond the promotional series will be furnished by Arianespace.

The basic rules covering the provision of Ariane launch services to ESA are established in the 'Convention between the European Space Agency and the Arianespace', which applies to Ariane-1. For Ariane-2 and -3 launches, an addendum is presently being negotiated between ESA and Arianespace. Individual launches are covered by specific contracts between Arianespace and ESA, the first one, negotiated for ECS-2, being signed in August 1981.

The entry of Ariane has produced a competitiveness in the market and this is now being reflected in the terms and conditions being offered by NASA and by Arianespace.

* Ariane launches 1 to 4 lead to qualification, while launches 5 to 11 form the promotional series.

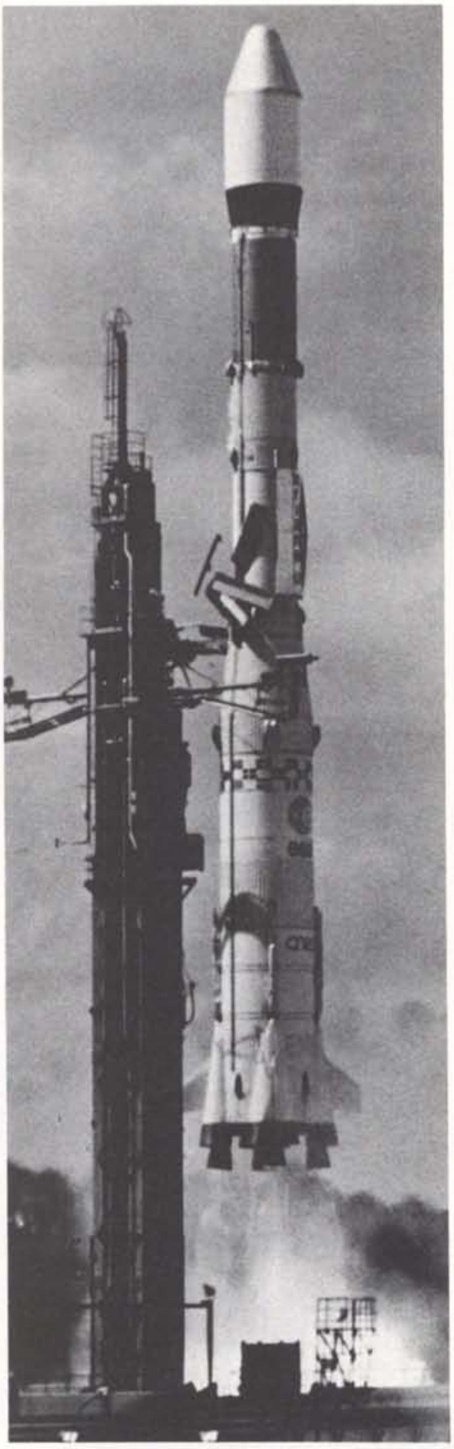
Figure 2 – Cos-B's Delta-2913 launch from Western Test Range in August 1975

Pricing policy

In the past NASA's pricing policy on nonrecoverable launchers (Thor-Delta, Atlas-Centaur) was based on the cost-reimbursement principle. The total cost of a launch contained fixed price elements, such as the purchase of launchers from industry, and cost-reimbursement elements, such as the cost of industrial and governmental support teams as well as overheads. The cost estimates also contained forecast figures for cost-of-living increases and a margin for unforeseen changes. Although the contracts provided for sufficient retroactive visibility and NASA complied with this in every respect, there were some considerable deficiencies. There was an arbitrary element in the estimates as some important cost elements were not

Figure 3 – Ariane's first and completely successful test flight from the Guiana Space Centre in December 1979

accounted directly against one specific contract, but against batches of contracts. It could happen that, despite an individual launch failure, additional money for incentives had to be paid



because a batch of launches showed above nominal performance. There were cost elements completely beyond the customer's control.

This method also had the consequence that final invoices normally only arrived several years after the launch, depending upon whether a user happened to be early or late in a batch of launches. In fact NASA is only now submitting the final invoices for ESA's OTS, Meteosat and Geos launches.

The Arianespace pricing policy is based on a fixed-price philosophy. The only open element is an inflation factor that is the subject of a contractual price escalation formula based on official indices.

To make its launch services more attractive, NASA is now offering fixed prices also. For Shuttle users, NASA offers fixed prices that are valid until 1985, but are subject to revision thereafter. More recently, it has also adopted a fixed-price policy for conventional launchers, margins being included for estimated price escalations.

Launch failures

Conventional launch services are provided on a best-effort basis, so that failures are the risk of the customer, regardless of whether the failure is due to the spacecraft or the launcher. The customer seeking a launch is therefore well advised to assess the implications carefully. He should first establish whether and at what time a back-up spacecraft would be available. NASA contracts on conventional launchers normally foresaw replacement launches being made as and when a slot was next available, with no guarantee of a specific date. If a back-up spacecraft is available, the customer should therefore consider booking a back-up launch. He risks losing money if the back-up is not required, but the likelihood of recovering his investment through an alternative customer being found is extremely high.

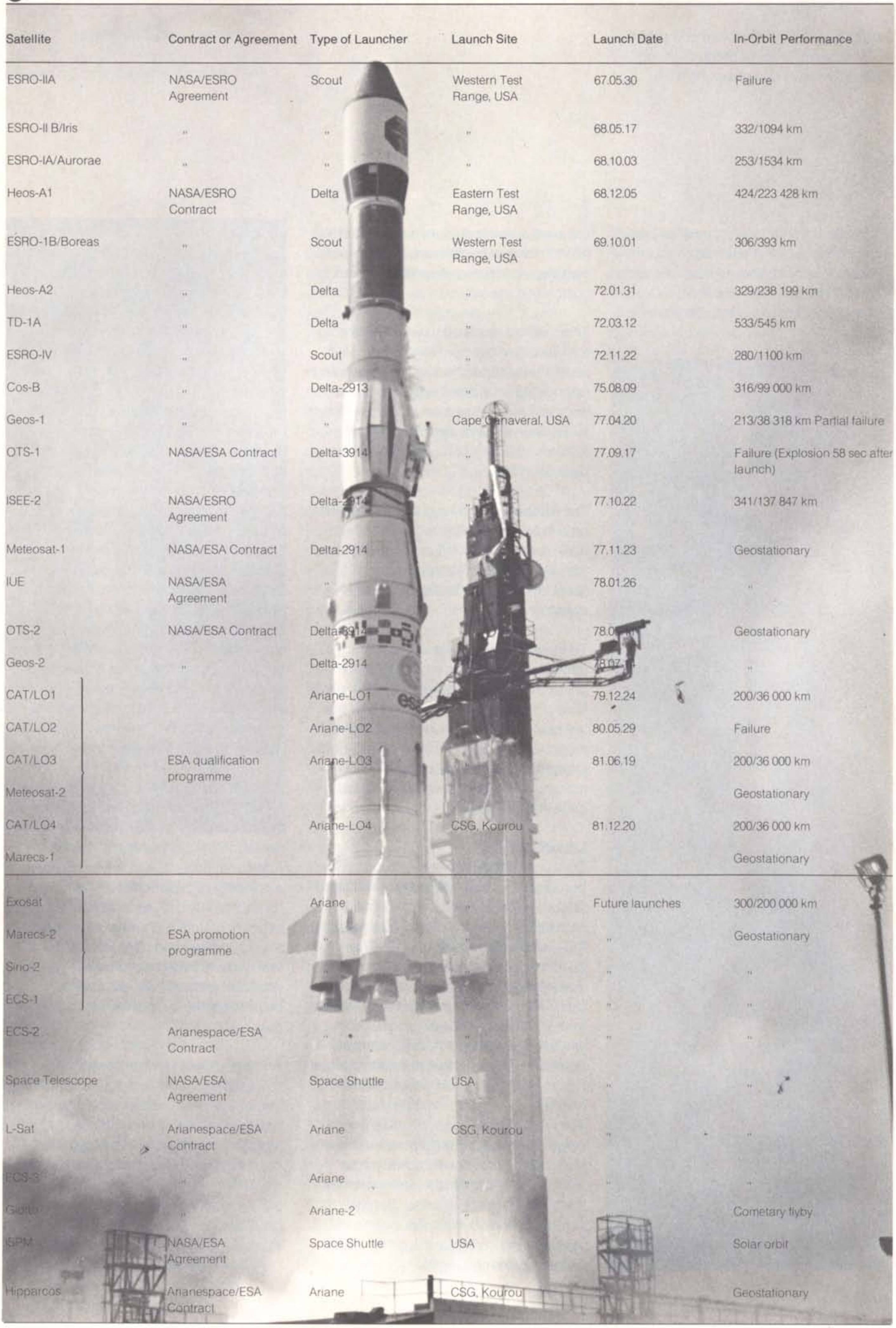
For the Shuttle, NASA has adopted a different policy in that it guarantees one re-flight at no additional charge if, through no fault of the user, the prescribed orbit is not achieved. This is another notable deviation from their former 'no loss, no profit' policy.

The procedure in the event of an Ariane launch failure is presently covered by the Arianespace – ESA convention for ESA launches. Because Ariane has been financed by the ESA Member States ESA has been able to obtain special conditions for back-up launches. Somewhat similar to the Shuttle-user conditions, a distinction is made between launch failures due to the launcher and those due to the spacecraft. In case of an Ariane failure, ESA would have the opportunity of obtaining the first launch slot compatible with the availability of the back-up spacecraft. In the case of a spacecraft failure, Arianespace would do its best to assign in the first slot, and in any event a slot not later than 10 months after receipt of a written request.

Arianespace generally quotes fixed prices for back-up launches. The Agency takes the view that for its launches the prices agreed in the Convention shall apply. Additional costs due to the accelerated availability of a launch shall be reimbursed by ESA as incurred. There might of course be customers who would already prefer fixed charges, but it is felt that it would be premature to try to establish realistic fixed prices now, because of the lack of relevant statistical data.

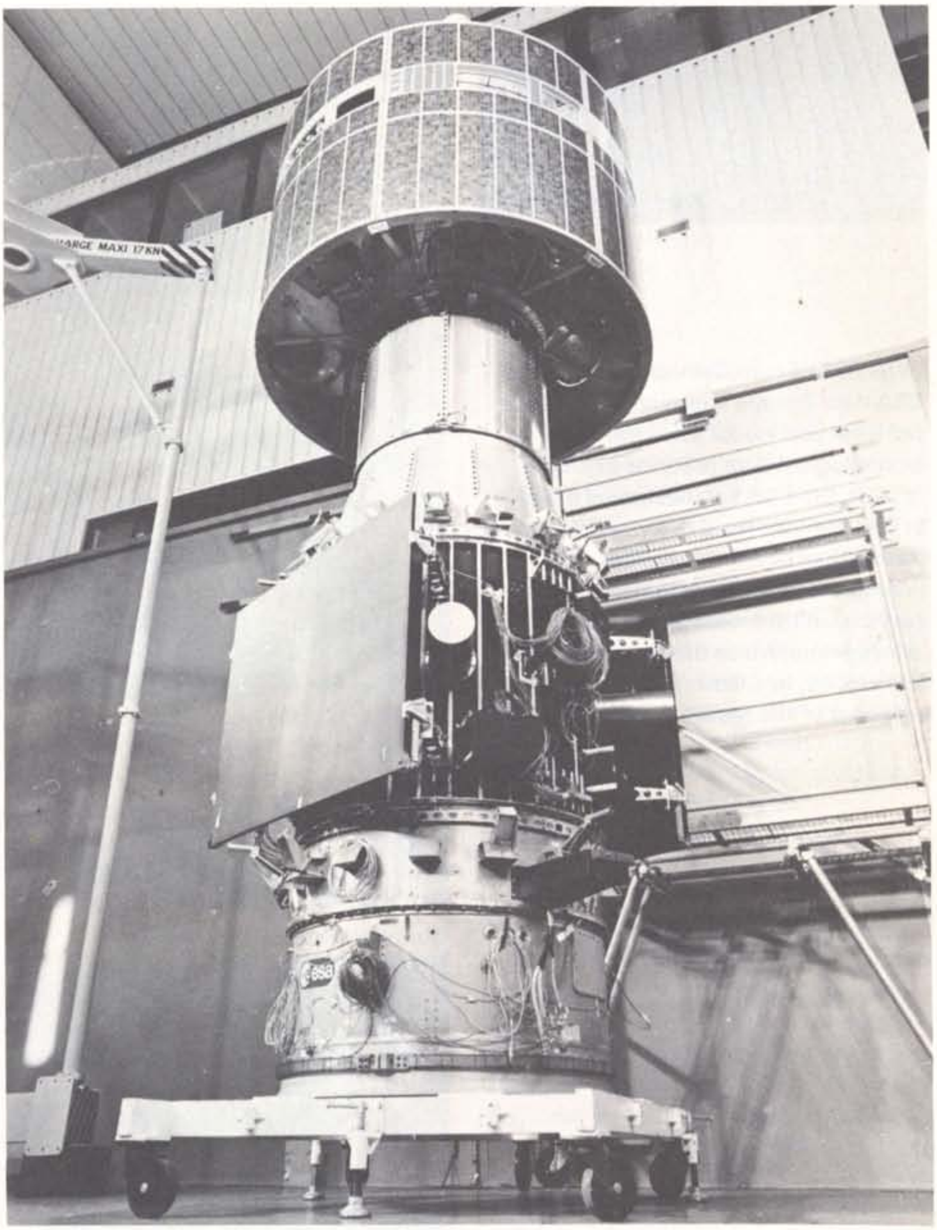
Another aspect is the coverage of financial loss (cost of back-up launching, loss of income) by insurance. The Agency has taken out such insurances for specific projects, and this aspect has been covered in some detail in Bulletin No. 16.*

* See 'Insurance of Satellites', in ESA Bulletin No. 16, November 1978.



Satellite	Contract or Agreement	Type of Launcher	Launch Site	Launch Date	In-Orbit Performance
ESRO-IIA	NASA/ESRO Agreement	Scout	Western Test Range, USA	67.05.30	Failure
ESRO-II B/Iris	"	"	"	68.05.17	332/1094 km
ESRO-IA/Aurorae	"	"	"	68.10.03	253/1534 km
Heos-A1	NASA/ESRO Contract	Delta	Eastern Test Range, USA	68.12.05	424/223 428 km
ESRO-1B/Boreas	"	Scout	Western Test Range, USA	69.10.01	306/393 km
Heos-A2	"	Delta	"	72.01.31	329/238 199 km
TD-1A	"	Delta	"	72.03.12	533/545 km
ESRO-IV	"	Scout	"	72.11.22	280/1100 km
Cos-B	"	Delta-2913	"	75.08.09	316/99 000 km
Geos-1	"	"	Cape Canaveral, USA	77.04.20	213/38 318 km Partial failure
OTS-1	NASA/ESA Contract	Delta-3914	"	77.09.17	Failure (Explosion 58 sec after launch)
ISEE-2	NASA/ESRO Agreement	Delta-2914	"	77.10.22	341/137 847 km
Meteosat-1	NASA/ESA Contract	Delta-2914	"	77.11.23	Geostationary
IUE	NASA/ESA Agreement	"	"	78.01.26	"
OTS-2	NASA/ESA Contract	Delta-3914	"	78.0[illegible]	Geostationary
Geos-2	"	Delta-2914	"	78.07.[illegible]	"
CAT/LO1	ESA qualification programme	Ariane-LO1		79.12.24	200/36 000 km
CAT/LO2		Ariane-LO2		80.05.29	Failure
CAT/LO3		Ariane-LO3		81.06.19	200/36 000 km
Meteosat-2					Geostationary
CAT/LO4		Ariane-LO4	CSG, Kourou	81.12.20	200/36 000 km
Marecs-1					Geostationary
Exosat	ESA promotion programme	Ariane	"	Future launches	300/200 000 km
Marecs-2		"	"	"	Geostationary
Sirio-2		"	"	"	"
ECS-1		"	"	"	"
ECS-2	Arianespace/ESA Contract	"	"	"	"
Space Telescope	NASA/ESA Agreement	Space Shuttle	USA	"	"
L-Sat	Arianespace/ESA Contract	Ariane	CSG, Kourou	"	"
ECS-3	"	Ariane	"	"	"
Giotto	"	Ariane-2	"	"	Cometary flyby
ISPM	NASA/ESA Agreement	Space Shuttle	USA	"	Solar orbit
Hipparcos	Arianespace/ESA Contract	Ariane	CSG, Kourou	"	Geostationary

Figure 4 – The Meteosat-2 and Apple satellites being readied for launch, together with the Technology Capsule (CAT), aboard the third Ariane test flight (LO3) in June 1981



Changes in launch date

Launch services are presently rendered, as we have said, on a best-effort basis, which means that specific dates are not guaranteed by the launcher authorities – neither by NASA nor by Arianespace. Launching a spacecraft is still a technically risky business, but no claims are accepted for a delayed launch. This can be very hazardous for missions with a narrow launch window. For the ESA mission to Halley's comet (Giotto), for example, the launch window is at most two months. A delay in the launch would put the mission back 76 years, and the high storage costs incurred would be for the customer's account!

The user on the other hand is expected to deliver his spacecraft for launch on time, and there are complicated contractual provisions to cover any postponement that he may request. In the past NASA was fairly flexible for conventional launches, the user having to bear the supplementary cost caused by the delay in certain situations. The risk of additional cost was relatively low because of the high number of launches taking place, which gave NASA sufficient flexibility for finding replacements. The situation is quite different for the Shuttle, the flight of which cannot be delayed if a specific payload is late and NASA will in most cases not be able to find a replacement. Fixed-price penalties are therefore applied.

Arianespace is trying to apply the same philosophy to its customers, although the same reasoning cannot be applied to a conventional launcher. The fixed-penalty charges proposed by Arianespace cannot yet be justified by statistical data based on experience. In its first launch-service contract with Arianespace, for ECS-2, ESA has therefore insisted on the cost-reimbursement principle for schedule slippages caused by the payload. This policy might be changed when there are sufficient statistical data available.

Conclusion

Contractual agreements for launch services are as unconventional as the space activities themselves. They cannot work successfully without involving some risk and being receptive to innovation. A number of questions are still under discussion to which solutions have not yet been finally found. There is, for instance, the question of liabilities between users on multipayload launchings. Would one user be liable to the other in case of delay or damage? Should this be covered in the contract with the launching authority, and in which way? Should such liability risk be insured? Many other problems have also to be solved, but in the present competitive situation the chances of equitable solutions emerging which do not completely disregard the interests of the customer must be considerably higher than they would have been a decade ago, when there was a virtual monopoly in the launch-service market.

Application of Videotex Techniques to a Major Information Retrieval System

W.A. Martin, Information Retrieval Service, ESRIN, Frascati, Italy

At its ESRIN establishment near Rome, ESA runs Europe's largest information retrieval service for scientific and technological data (see, for example, 'ESRIN, the ESA Establishment in Italy', in ESA Bulletin No. 27). In recent months, a study has been made of the interconnection of this major retrieval service with videotex devices; this article summarises the basic videotex techniques, and then reviews the outcome of this recent work.

In recent years, much effort has been expended in a number of countries on the development of viewdata (often called 'videotex') services. These enable anyone with a colour television receiver and a telephone to use the receiver to display pages of information from a large central store, with the addition only of a simple and inexpensive adaptor. Few developed countries are not at least considering such services. In Europe, service names such as Bildschirmtext, Datavision, Prestel, Teletel, Telset, etc., are now becoming known. In the United Kingdom the British Post Office, now British Telecom, has been running a market trial of a proposed 'Prestel International' service, aimed at the international business community, whilst the Commission of the European Communities has sponsored studies of the international application of videotex services, particularly by Télésystèmes, France, including the possibility of a Euronet Videotex Gateway, which could permit international access to a number of national videotex services via the Euronet data-communications network.

Current videotex systems

A videotex service enables anyone with a colour television and a telephone to use the receiver to display pages of information chosen from a large central store. A telephone call (often a local call), is made to the nearest videotex number and the television set is connected via the adaptor. The latter identifies the customer (for invoicing purposes) and the screen announces that the service is available (the so-called 'Welcome Page'). From this point on, any information offered by the videotex service may be displayed quickly and easily by means of a very simple 'menu' search procedure (Figs. 1 & 2).

As an alternative to the use of an adaptor with a standard domestic television set, many purpose-built videotex receivers are available with integral adaptors (Fig. 3).

Information stored in the main videotex computer is organised by means of hierarchic relationships – popularly called a 'tree structure'. Each page displayed offers the user a choice of up to ten pages at the next level. The user presses any one of the keys 0 to 9 or # in order to display the next page.

If the requisite page number is already known (printed directories are often available), it is possible to go directly to the required information without prior routing through indexes. The procedure may be compared with looking through a mail-order catalogue, travel agent's catalogue, or airline or railway timetable. The important differences, however, are that access is available from one point (the television set) to a very wide range of sources of information not normally to hand, and that these sources can be up-to-date to the extent that information displayed on the screen may have been added to the videotex computer only minutes earlier.

As with any radically new service unlike anything previously available, videotex will need time to find its place among all the other conventional sources of information. People are used to consulting printed information sources or

Figure 1 – Typical Prestel set, showing index on the screen and the keypad used for searching in a business environment

Figure 2 – Prestel screen with a typical search menu

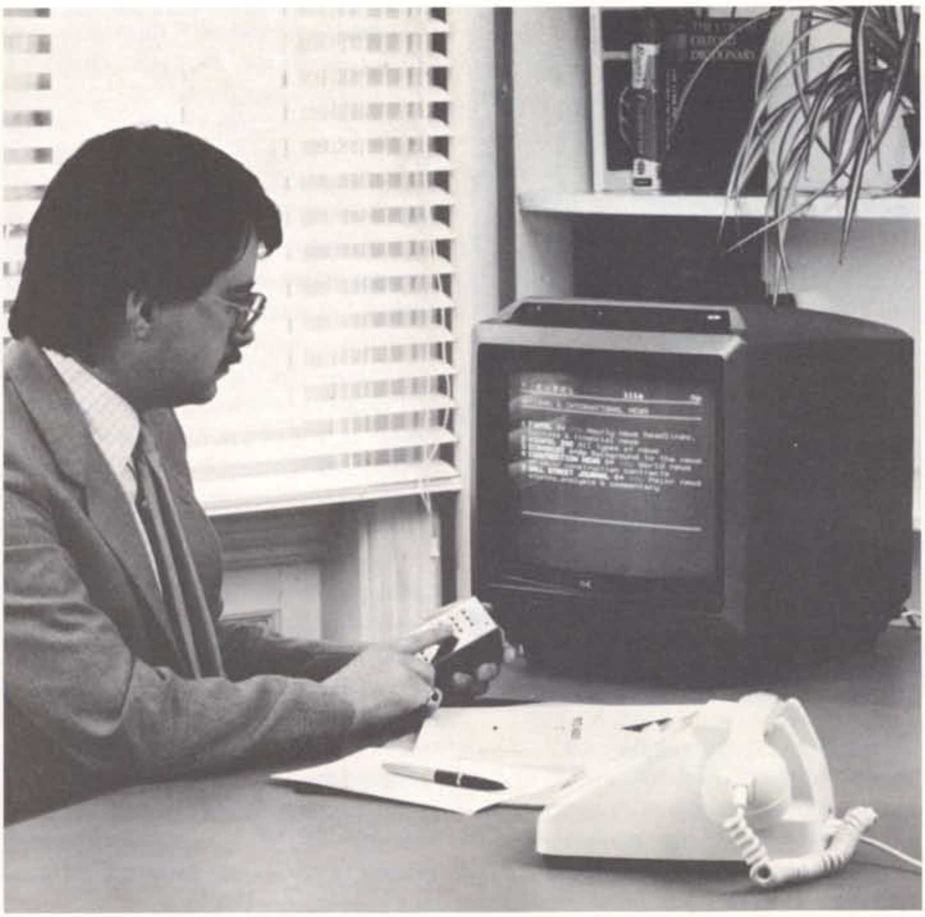
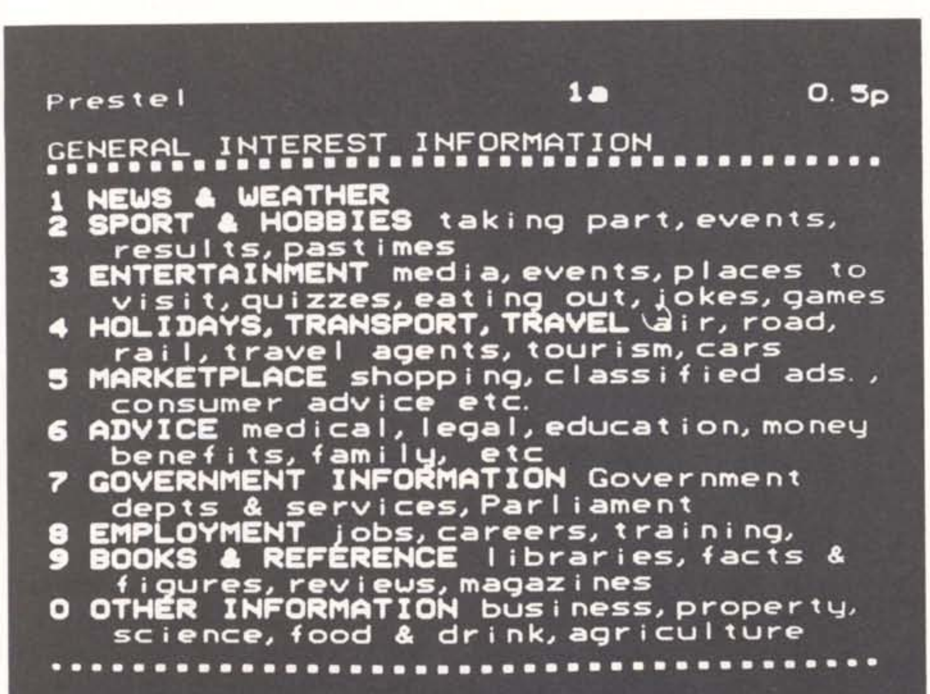


photo british telecom



telephoning to make an (voice) enquiry; the idea of using telephone and television in this manner is novel.

As might be expected, widely divergent views may be found concerning the future market for videotex services. Originally conceived (as Prestel) as a service aimed at the residential viewer via the domestic television set (Fig. 4), much more attention is now being paid to the potential of the business and professional market.

The attractions of the residential market as a means of improving the off-peak loading of the telephone network are obvious. However, there are indications that it may be in the business section that the initial market will be found. A knowledge of the partitioning of the market is a necessary precursor to the provision of the information sources. The domestic user may be interested in sports news; local events; encyclopaedias; consumer advice; social services advice; advertisements similar to newspaper 'classified ads'; or perhaps television games.

The business user may require air and railway timetables; financial and economic data (e.g. stocks and shares quotations; currency conversion rates; etc.); legal and legislature information; company news (new contracts; takeovers, etc.); referral data (whom to contact for the most authoritative information on topic 'X'); etc.

Videotex may also be used with advantage by what are termed closed user groups. The national service provides the carrier system for data that may only be accessed by authorised videotex sets. An early application of the closed user groups has been in the travel business. Large travel agencies maintain, and constantly revise with up to the minute data, details of all available holidays, with vacancies, booking levels, price changes, etc. Each local agency has access to this data, whilst a further feature of videotex, the possibility of using the

Figure 3 – Plessey Vutel terminal

photo plessey

keypad to enter the data as well as retrieve, is employed to inform the centre each time a holiday is booked. This interactive feature makes possible a whole host of applications, such as the making of reservations (restaurants, hotels, travel, etc.); the placing of orders in response to advertisements; the instruction of banks, brokers, etc.

A closed user group may, as an alternative to this special use of a public videotex service, choose to introduce a private service based on its own computer. A consideration in this case would be telecommunications with the central computer. Private videotex services may provide a most convenient means of access to large quantities of administrative data, since the time of busy staff is not taken up with training and refresher courses in how to use the system – it is so simple that anyone can search easily using the 'menu' feature.

Any videotex service provides a simple and convenient means for the client to consult a large store of information; in this sense it is a distribution network for the stored information. The latter is not usually supplied or created by the operator of the service, but by organisations often termed 'information providers'. Many are publishing organisations that issue regular printed lists which must be continually updated. Videotex facilities available to the information providers enable such data to be updated as often as is needed, daily if required, something which would tend to be uneconomic in printed paper terms.

Application to major information retrieval services

ESA's Information Retrieval Service (IRS) based in Frascati operates a very advanced scientific and technical information retrieval service which was introduced in 1969 and is now the largest such service in Europe. More than 30 major databases, of worldwide coverage and interest, provide indexes to the literature of science and technology published over the last ten to fifteen years. Each database is updated at least monthly with the latest information published. Several contain over a million items; two databases, Chemical Abstracts CA-SEARCH, and the French multidisciplinary database PASCAL produced by CNRS, each have more than 4 million items. Because of the powerful computer and highly developed software, the system's response to any command is near-instantaneous, even for the largest databases.

IRS numbers its clients, mainly in the ESA Member States, in thousands; most are attached to library services of government departments, universities and institutes, and major industrial companies. Videotex, on the other hand, looks for a huge market of tens of thousands to hundreds of thousands. Would then the information stored in the IRS computer be of interest to a significant number of videotex users? This question is very difficult to answer at this stage, the more so because searching the IRS databases calls for more skill (which implies training) than a currently conventional videotex service. Nevertheless, the potential cannot be overlooked and IRS has been carefully watching the development of videotex in Europe, both as a way of expanding IRS's availability as well as making its service available to a broader cross section of 'less sophisticated' users.

Already it is being recognised in many informed circles that the very simple 'menu' search procedure is not always satisfactory, even for relatively modest databases (the ease with which any item can be found is heavily dependent on the quality of the indexing that has been applied) and that this approach will be inadequate for large stores of information. Some search procedure more powerful than present videotex facilities (including those with simple 'keyword' access) yet simpler than the typical present-day scientific and technical systems seems to be needed. It is possible that each type of system will move towards common ground until virtual overlap is achieved.

Late in 1980 IRS was approached by Aregon International Limited, a UK company (previously known as Insac Viewdata) which has been intimately involved in several major videotex projects

Figure 4 – Use of Prestel in a domestic environment

photo british telecom

for European PTTs, notably the supply of network software for the Deutsche Bundespost Bildschirmtext service. Aregon has established an international reputation for expertise in this new technology and was interested in the possibility of using an absolutely standard Prestel terminal to access the IRS databases in Frascati, using Euronet as the telecommunications route. Euronet is a data-communications network for scientific and technical data, created by a consortium of European PTTs for the Commission of the European Communities, and Aregon's Prestel terminal had already been demonstrated to interface satisfactorily with Euronet. The problem was to build support for the Prestel terminal into the IRS computer, i.e. to enable the IRS computer to understand all messages received from the Prestel terminal, and to transmit to it, over Euronet, data correctly formatted for display on the Prestel terminal. The difficulty here was that, although the data transmission speed of the Prestel terminal is identical to that of the terminals used with Euronet, the screen format of 24 rows (or lines) each of 40 characters, is unusual. Also Prestel pages use colour, the key for which must be transmitted by the main computer. Colour is not utilised in present-generation retrieval services for scientific and technological information.

Following detailed technical discussions between Aregon and IRS, the software modifications that would be required in the IRS computer were defined and specified. Fortunately the IRS applications software, ESA-QUEST, had been developed with flexibility in mind (necessary due to the dynamic nature of modern computer-based information services which are continually being enhanced) and the magnitude of the programming task appeared to be feasible within the timescale foreseen. The CEC was approached and was enthusiastic, agreeing to sponsor a major part of the development that would be necessary.

Work on the Prestel support modifications began in January 1981; by August 1981 it was possible for Aregon to carry out tests from London via Euronet, showing that the target had largely been achieved.

All videotex procedures are designed to simplify the user interface as much as possible and to reduce to an absolute minimum the operations that must be performed at the terminal. In the spirit of this philosophy IRS built into the user's password the terminal's 'personality', i.e. the information that the caller is from a videotex terminal, defining the type of videotex system (French, British, etc.), the line size (which may be from 40 to 132 character positions), and the number of lines per page (which may be from 10 to 37). Also, although colour is not normally used by IRS, colour signals are incorporated for the videotex terminals thus rendering the data displayed easier and quicker to scan (Fig. 5).

The completed project was demonstrated to CEC officials and members of the Committee for Scientific & Technical Documentation & Information (CIDST) in Luxembourg at the beginning of October.

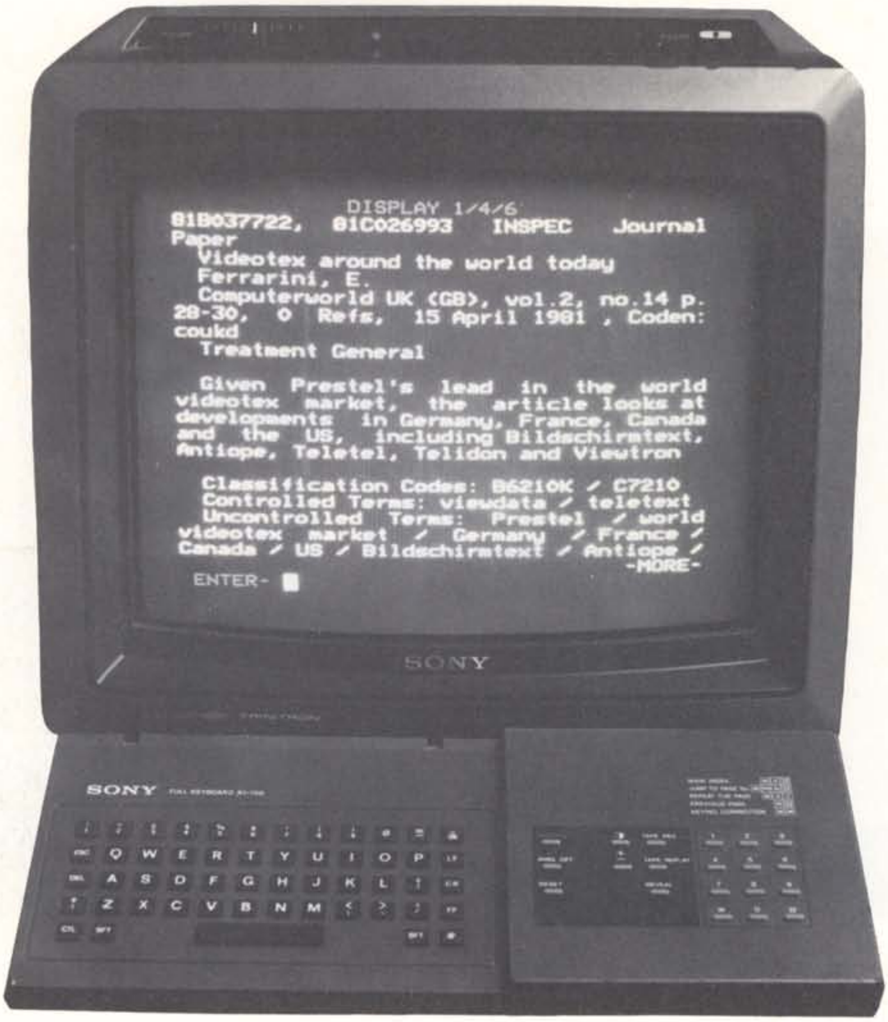
As a result of this experimental project, a videotex terminal in any European country providing Euronet facilities (i.e. the CEC member countries plus Switzerland, and soon Spain and Sweden) can now be used to search Europe's largest store of online scientific and technical information.

Future possibilities

One obvious difference between the type of terminal normally used to search IRS and a videotex set is that the latter is not equipped with a printer. This would enable the user to print out whatever is displayed on the screen. However, this requirement has already been foreseen by equipment manufacturers. The price of monochrome hard-copy printers is falling rapidly and full-colour printers are already available.

How much more convenient it would be, however, if instead of having to use an unfamiliar network access procedure, the videotex user could switch to IRS whilst connected to the national videotex service! This is now becoming possible as a result of the development of Videotex Gateways. First developed for the

Figure 5 – Prestel screen carrying typical ESA-QUEST data



Bildschirmtext service in Germany, British Telecom has recently announced the introduction of the Prestel Gateway, to be available in 1982. This will enable a third-party computer (such as IRS) to be linked directly to the computer of the national videotex service, thereby permitting the client to switch to IRS simply by selecting a page from the menu displayed on the screen.

In addition, videotex offers a possible third level of sophistication for the future. The first level is the selection and display of data on the user's television set. The second level is the 'interactive' mode of videotex in which the user may, say, instruct a transfer of funds from a bank account by means of a message keyed on his videotex set. A third level would be the possibility of activating stored programs to carry out certain processing of data selected from the videotex store. IRS is already actively developing such stored program facilities in cooperation with the Italian firm of Slamark International. This project, known as the Raw Materials Price Index (RAMPI), is being developed as an interactive multilingual information system for the world base prices and indices of raw materials and commodities. These will include strategic materials (copper, lead, zinc, etc.); agricultural raw materials (cotton, wool, jute, etc.); foodstuffs (cereals, coffee, sugar, etc.); and energy raw materials (crude oil, etc.). The system will be international in coverage and will incorporate the major published indices and data obtained directly from at least eight commodity markets around the world and the ten major currency exchanges. It will enable a user to select from the database the appropriate time series data for the commodity of interest and then to submit the data to one or more stored econometric models for processing to output, say, absolute and relative maxima and minima for the time interval chosen; variations in trends with time; a series of averages (daily, weekly, prices, etc.); and so on. An extensive set of options will be provided by the series of econometric models. This facility will be offered via IRS's normal online service, but could also be made available via videotex and, indeed, may well form an ideal vehicle for the investigation of the growing business and professional videotex market in Europe.

Recently, the twenty-six member countries of the European Conference on Posts and Telecommunications (CEPT) have announced agreement on a unified approach to videotex (viewdata) standards. The text of a statement issued jointly by British Telecom, Direction Général des Télécommunications, and the Deutsche Bundespost, which represented British, French and German interests at the meeting, was as follows:

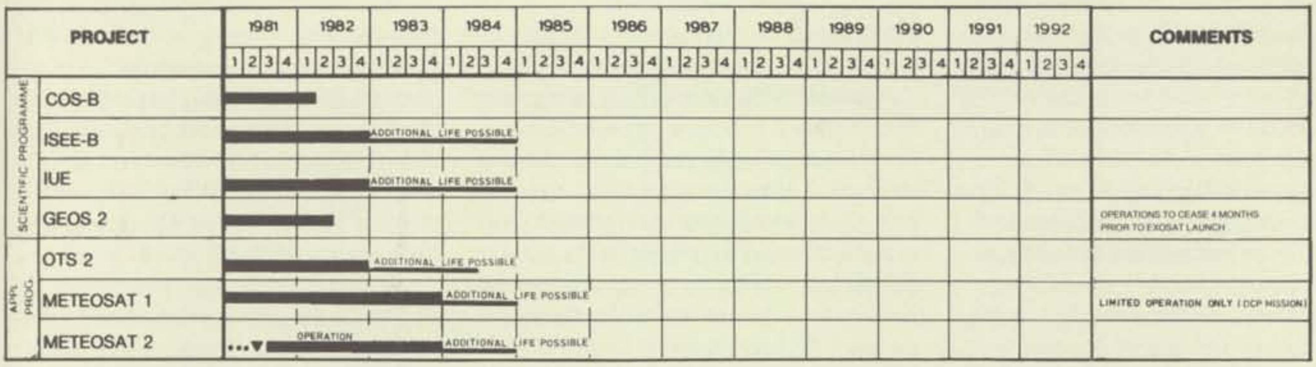
> 'The Telecommunications Commission of the CEPT meeting in Innsbruck have agreed a recommendation describing a unified standard for basic alphamosaic videotex. The existing European systems, namely the British Prestel system, the French Télétel system, and the German Bildschirmtext system have been merged into a single standard which incorporates the advantages of each of them. The new system has a high degree of compatibility with these existing systems and incorporates features which enhance the behaviour of these systems. This result, which is the culmination of technical discussions over a period of three years especially in CEPT, is a major achievement for European co-operation.'

Terminals designed to the new standards will be able to receive both Prestel and Teletel services in addition to having a number of more advanced features not available with current terminals.

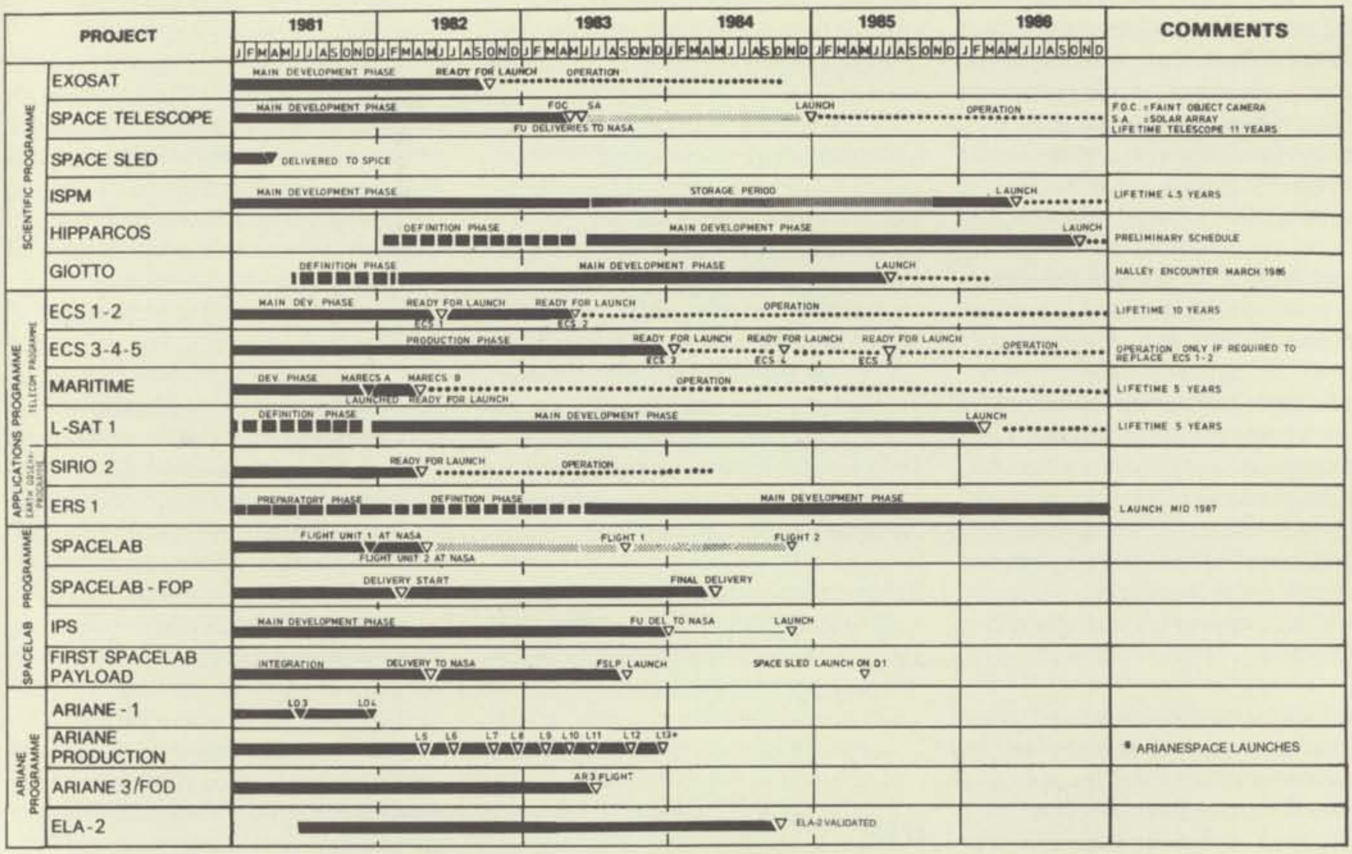
Programmes under Development and Operations*

Programmes en cours de réalisation et d'exploitation

In Orbit / *En orbite*



Under Development / *En cours de réalisation*



* Reporting status per 1 December 1981/Bar chart valid per 1 January 1982

Situation des projets décrits 1er décembre 1981/Planning 1er janvier 1982

Cos-B

En août 1981, la mission Cos-B achevait avec succès sa sixième année d'exploitation en orbite. Tous les sous-systèmes du véhicule spatial et des expériences continuent de fonctionner conformément aux prévisions. En particulier, l'instrument rayons gamma fournit toujours des données de haute qualité.

En 1981, les manoeuvres d'orientation ont été peu nombreuses, conformément à la politique consistant à augmenter les temps d'observation afin de pouvoir procéder à des recherches sur les sources variables dans le temps. Il reste donc suffisamment de gaz dans le système d'orientation pour poursuivre l'exploitation de Cos-B assez loin en 1982. On a procédé en septembre au dernier remplissage (partiel) de la chambre à étincelles, ce qui s'est traduit par un remplacement de 50% du gaz utilisé depuis près de neuf mois. La qualité des données de la chambre à étincelles fera l'objet d'une surveillance étroite, car c'est elle qui déterminera à quel moment la mission scientifique aura terminé sa vie utile.

Les résultats les plus récents de Cos-B ont été présentés dans une série de rapports à la Conférence internationale sur le rayonnement cosmique de juillet. Le large éventail des titres témoigne de l'étendue des résultats de Cos-B dans les domaines de l'astrophysique et de la physique du rayonnement cosmique.

Pour les sources ponctuelles, des signes de variabilité dans le temps ont été détectés dans la courbe lumineuse du rayonnement gamma en provenance du Crabe et confirmés par les résultats de recherches menées sur la variabilité dans le temps d'autres sources. Les témoignages de variabilité dans le temps de sources de rayonnement gamma semblent franchir le seuil de la crédibilité, et de nouvelles observations contribueront grandement à renforcer cette étude.

En ce qui concerne les émissions galactiques, on a présenté un tableau du ciel dans le rayonnement gamma établi en relation avec les propriétés connues du milieu interstellaire en ce qui concerne aussi bien les émissions lointaines que les émissions proches. Les données de Cos-B font apparaître des relations manifestes entre les matières interstellaires proches et l'émissivité des rayons gamma, en particulier dans la nébuleuse d'Orion où la carte du rayonnement gamma reproduit fidèlement la répartition des nuages moléculaires géants.

Des observations récentes ont porté sur la région d'émission gamma intense de la galaxie de Norma (=330°) et une période du côté opposé, moins intense, de la galaxie (=30°), à proximité de l'intéressante source de rayonnement X SS433.

ISEE-2

Le satellite ISEE-2 continue de fonctionner correctement. Une série de manoeuvres ont été exécutées et continueront de l'être dans un proche avenir afin de parvenir aux distances de séparation entre ISEE-1 et 2 décidées par le groupe de travail scientifique. Avec les ergols qui restent, le satellite pourra continuer à fonctionner pendant plusieurs années. Le mode de fonctionnement de la charge utile s'est modifié par rapport au dernier rapport, la vitesse de comptage de l'expérience vents solaires d'ISEE-2 ayant quelque peu diminué en raison d'effets de fatigue des multiplicateurs d'électrons à microcanaux.

La communauté scientifique d'ISEE poursuit une activité intense dans de nombreuses directions et le groupe de travail scientifique s'est scindé en sous-groupes ayant pour objet d'étudier des domaines et des phénomènes spécialement choisis. De nombreuses collaborations ISEE-Geos ont vu le jour. Plusieurs ateliers se sont réunis et sont encore prévus au sujet de la physique des vents solaires et de la magnétosphère. ISEE a déjà donné lieu à plus de 300 publications.

La récupération des données continue d'être très élevée, de l'ordre de 80%, les recoupements entre ISEE-1 et 2 s'établissant à plus de 70%.

IUE

IUE est toujours un outil de premier ordre pour les études astrophysiques. Son état de fonctionnement a été examiné au cours des récentes réunions biannuelles ESA/NASA/SERC qui ont eu lieu à Vilspa du 20 au 22 octobre: aucune défaillance majeure n'ayant été annoncée, on s'attend que le satellite demeure opérationnel jusqu'en 1985 compris. On a également évalué et approuvé un nouveau logiciel de traitement des images, permettant la réduction des spectres à haute dispersion, qui exploite complètement la résolution de l'instrument. Ce logiciel sera prochainement mis en oeuvre aux stations sol de Vilspa et du centre Goddard.

Des articles scientifiques basés sur les données d'IUE continuent de paraître à raison d'environ 70 par an. Sur ce nombre, 45% ont utilisé des données provenant seulement des observations de Vilspa. De surcroît, quelques articles ont utilisé des spectres ressaisis dans les archives des données d'IUE, activité dont l'importance devrait croître à l'avenir.

Il continue à y avoir une très forte demande de temps d'observation d'IUE en Europe: le Comité de sélection IUE de l'ESA a reçu 187 propositions (22 de plus que l'an passé) pour la période d'observation 1982–83. Les demandes dépassent d'environ 4 fois le temps d'observation disponible.

Un groupe d'astronomes européens et américains, réunis récemment à Vilspa, a étudié les possibilités d'établir au moyen des données UV d'IUE une grille des étoiles de référence. Ce travail, qui sera d'un grand intérêt à l'avenir, sera essentiellement fondé sur les archives d'IUE.

Un effort particulier a été accompli les mois derniers pour suivre les variations du vent solaire de l'étoile gamma de Cassiopée: le temps d'observation alloué a été divisé en tranches d'une et deux heures, et des spectres ont été obtenus tous les trois ou quatre jours.

Une fois de plus, IUE a fait la preuve de ses possibilités de réaction rapide en observant l'étoile variable V458 du Sagittaire à un moment de luminosité maximale: à cette occasion, l'observatoire avait été alerté par un astronome amateur et l'on a pu coordonner rapidement des observations dans le domaine optique et dans les ultraviolets.

Cos-B

The Cos-B mission completed six successful years of orbital operations in August 1981. At the present time all spacecraft and experiment subsystems are performing nominally. In particular, the gamma-ray instrument is still delivering high quality data.

Attitude manoeuvres in 1981 have been few, consistent with the policy of increased observation times to enable searches for time variable sources to be undertaken. Consequently, there still remains sufficient attitude gas to take Cos-B well into 1982. In September the last (partial) filling of the spark chamber was carried out. This replenished by 50% the gas which had been in use for almost nine months. A careful watch will be kept on the quality of the spark-chamber data since it is this that will dictate when the scientific mission has reached the end of its useful life.

The most recent results of Cos-B were presented in a series of papers at the International Cosmic-Ray Conference in July. The wide-ranging titles reflected the wide ranging impact of the Cos-B results in the fields of astrophysics and cosmic-ray physics.

On point sources, evidence for time variability in the Crab gamma-ray light curve was presented, together with results from searches for time variability in other sources. The evidence for time variability of gamma-ray sources seems to be crossing the threshold of credibility and further observations will greatly assist this investigation.

On galactic emission, the picture of the gamma-ray sky in relation to known interstellar medium properties was presented for both distant and local emission. The Cos-B data show clear correlations between local interstellar matter and gamma-ray emissivity, especially in the Orion Nebula where the gamma-ray map closely resembles the distribution of the giant molecular clouds.

Recent observations have included the intense region of gamma emission in the galaxy in Norma ($l^{II} = 330°$) and a period on the opposite, less intense, side of the galaxy ($l^{II} = 30°$) near the interesting X-ray source SS433.

ISEE-2

The ISEE-2 spacecraft continues to operate well. A series of manoeuvres have been performed and will be continued in the near future in order to achieve the separation distances between ISEE-1 and -2 decided upon by the Science Working Team (SWT). The propellent left will still allow spacecraft operations for several years. The status of the payload has changed with respect to the last report, the counting rate of the solar-wind experiment on ISEE-2 having degraded somewhat due to fatigue effects in the channel electron multipliers.

The activity of the ISEE scientific community remains intense in many directions and the Science Working Team has split into subgroups aiming to study specially selected topics and phenomena. Many ISEE–Geos collaborations are being developed. Several workshops have been held and are being planned on the physics of the solar wind and of the magnetosphere. Already, ISEE has led to more than 300 publications.

Tracking and data recovery is still very high, ranging around 80%, with the overlap between ISEE-1/2 more than 70%.

IUE

IUE has continued to be a prime tool for astrophysical investigations. Its status has been assessed during the recent bi-annual ESA/NASA/SERC meetings which took place at Vilspa on 20–22 October: no major faults have been reported and the spacecraft is expected to have an operational lifetime through 1985. New image-processing software for the reduction of high-dispersion spectra, which fully exploits the resolution of the instrument, has been evaluated and approved. It will shortly be implemented at the Vilspa and Goddard ground stations.

The flow of scientific papers based on IUE data continues at a high rate (about 70 per year). About 45% of them rely on data solely from Vilspa observations. In addition, a few papers have been based on spectra retrieved from the IUE data archive, an activity that is expected to be of increasing importance in the future.

The demand for IUE observing time remains very high in Europe: the ESA IUE Selection Committee has received 187 proposals (22 more than last year) for the coming 1982/83 observing period. The available viewing time is about four times oversubscribed.

A group of European and American astronomers met recently at Vilspa to discuss possible actions for the construction of a grid of reference standard stars based on IUE UV data. This work, which will become of great interest in the future, will be mainly based on the IUE archive.

A special effort has been made in the last month to allow a monitoring of the stellar wind variability of the star Gamma Cassiopae: the allocated observing time was divided into 1–2 hour slots and spectra were obtained every 3–4 days.

Once again, IUE has demonstrated its ability to react quickly, by observing the variable star V458 Sagittarii while at maximum light: this time the observatory was alerted by an amateur astronomer and coordinated UV and optical observations were quickly arranged.

Geos-2

Owing to workload limitations at ESOC in conjunction with Exosat preparations, Geos operation was limited during the reporting period to only twelve hours in twenty-four, with coverage mainly at night. All experiments except the magnetometer are still producing good data. Special computer routines have been developed to determine the magnetic-field vector by using measured particle pitch-angle distributions and the gyrofrequency measured by the active wave experiment.

During the Summer of 1981, Geos-2 was moved to the intersection point of geographic and geomagnetic equator in order to explore further a particular electron and proton population which had been discovered during an earlier visit of Geos-2 to this location. The aim was now to study in more detail the role played by this population in magnetospheric wave-particle interactions. In late September, Geos-2 was rushed back to the magnetic longitude of Northern Scandinavia after news had been received from EISCAT that this facility was operational. A joint operational scheme for EISCAT and Geos-2 for the next few months has been agreed at a recent meeting between Geos

Geos-2

En raison des limitations imposées au plan de travail de l'ESOC par les préparatifs d'Exosat, l'exploitation de Geos s'est limitée au cours de la période à l'examen à 12 heures sur 24, la couverture étant principalement assurée la nuit. Toutes les expériences, à l'exception du magnétomètre, continuent de fournir des données intéressantes. Des méthodes de calcul spéciales ont été mises au point pour déterminer le vecteur du champ magnétique en utilisant les distributions mesurées de l'angle d'incidence des particules et la gyrofréquence mesurée par l'expérience de stimulation du plasma environnant. Au cours de l'été 1981, Geos-2 a été porté au point d'intersection des équateurs géographique et géomagnétique afin d'explorer plus précisément une population particulière d'électrons et de protons qui avait été découverte au cours d'un précédent passage de Geos-2 à ce point. Il s'agissait cette fois-ci d'étudier de façon plus détaillée le rôle joué par cette population dans les interactions ondes magnétosphériques-particules. Fin septembre, Geos-2 a été renvoyé rapidement à la longitude magnétique du nord de la Scandinavie lorsque l'on a su que l'installation EISCAT était opérationnelle. Une activité opérationnelle commune à EISCAT et Geos-2, intéressant les prochains mois, a fait l'objet d'un accord lors d'une récente réunion entre des expérimentateurs de Geos et le responsable scientifique du projet EISCAT.

Les données de Geos-2 continuent à jouer un rôle clé dans la phase d'analyse des données consécutive à la campagne IMS. Pour l'analyse des données, les efforts ont porté récemment sur les périodes pour lesquelles il existe des observations au sol de bonne qualité dans le nord de la Scandinavie, alors que Geos travaillait dans une position en conjugaison magnétique avec le nord de la Scandinavie et que les satellites ISEE-1 et 2 étaient positionnés à plus longue distance dans la magnétoqueue. Des mesures simultanées de ce type ont contribué à une meilleure connaissance des processus dynamiques de la magnétosphère. Des mesures combinées de particules, de champs d'ondes et de plasma, prises par un seul satellite, ne cessent d'améliorer la connaissance des processus physiques fondamentaux qui créent des instabilités et qui provoquent leur augmentation ou leur diminution en fonction des conditions réelles du plasma.

La durée totale de fonctionnement des deux satellites Geos approche maintenant cinq années et couvre une partie significative d'un cycle solaire, ce qui constitue une nouvelle dimension intéressante de l'analyse des données.

Météosat

Secteur spatial

Le fonctionnement de Météosat-2 reste conforme aux prévisions à l'exception de la mission de collecte des données qui ne pourra vraisemblablement pas être reprise si l'on se base sur les résultats des recherches et simulations effectuées au sol.

Depuis le lancement, deux phénomènes de charge statique du véhicule spatial ont été observés, c'est-à-dire nettement moins que ceux qui s'étaient produits sur Météosat-1 pendant une période comparable; cela prouve l'efficacité des modifications apportées à Météosat-2.

Le comportement thermique du satellite pendant l'équinoxe et la période d'éclipse est, de façon générale, supérieur à celui du modèle F1. Aucun problème ne s'est posé pendant la première saison d'éclipse.

Le satellite F2 n'étant pas en mesure d'assurer le soutien de la mission de collecte des données, c'est le satellite F1, mis à poste à 10° Est, qui en est chargé. Pour régler le problème des cycles de gel-dégel dans la partie haute du réseau d'hydrazine au cours des éclipses, une stratégie de manoeuvre a été mise au point et appliquée avec succès au cours des trois premières semaines de septembre.

Secteur sol

Les travaux relatifs au remplacement du système de calculateur se poursuivent. Une unité centrale a été installée et acceptée, et on l'utilise désormais pour les essais du logiciel, tandis que la 'mini-configuration' est toujours utilisée pour l'exploitation de F2.

La conversion du logiciel se poursuit conformément au calendrier. Les données d'images reçues de F1 ont permis la production de quatre des six produits météorologiques. Les résultats sont identiques à ceux obtenus en utilisant l'ancien logiciel sur l'ancien matériel.

L'exploitation de F1 se poursuit par l'intermédiaire du système provisoire qui a été mis sur pied utilisant l'antenne de PDUS et un processeur principal. Toutefois, pour améliorer la mission de collecte des données, l'approvisionnement d'une plus grande antenne et du matériel connexe est en cours.

Opérations

L'exploitation de routine du satellite F2 est tout à fait conforme aux spécifications en ce qui concerne le calendrier des transmissions, à la fois pour les transmissions numériques aux PDUS et pour les transmissions analogiques aux SDUS. L'intérêt pour cette mission continue de croître et l'on a dénombré des utilisateurs dans 49 pays.

Programme opérationnel

Les différents documents juridiques et techniques ont été examinés par les groupes de travail. La prochaine session de la Conférence intergouvernementale est pour l'instant reportée jusqu'à ce que l'on obtienne l'engagement ferme de l'un des principaux participants.

OTS

Le fonctionnement d'OTS est resté satisfaisant ces deux derniers mois. Outre les essais et démonstrations de routine, on a procédé, en novembre, à des mesures de performances en relation avec les primes d'intéressement. Une analyse préliminaire a fait apparaître des résultats positifs.

La commande d'orientation d'un satellite tel qu'OTS peut s'effectuer sans utiliser les propulseurs de pilotage, en recourant à la technique des voiles solaires. Cette technique consiste à faire tourner les panneaux solaires pour faire varier la pression du vent solaire sur le satellite. Cette technique est utilisée avec succès depuis deux mois sur OTS.

Le satellite a été utilisé ces dernières semaines pour de nouvelles applications. L'une des plus intéressantes a été l'expérience de téléimpression d'un journal réalisée entre les bâtiments du Financial Times *à Londres et Francfort.*

experimenters and the EISCAT Project Scientist.

Geos-2 data have continued to play a key role in the Post-IMS data analysis phase. Efforts in data analysis have recently concentrated on periods for which good-quality ground observations in Northern Scandinavia exist, when Geos was operating at the magnetically conjugate position to Northern Scandinavia and when the ISEE-1 and -2 spacecraft were positioned in the more distant geomagnetic tail. Simultaneous measurements of this kind have contributed to a better phenomenological description of dynamic processes in the magnetosphere. Combined particle, wave-field and plasma measurements from a single spacecraft are leading more and more to a better understanding of the basic physical processes that create instabilities and cause them to either grow or decay, depending on actual plasma conditions.

The total operation time of the two Geos spacecraft is now approaching five years and covers a significant part of a solar cycle. This adds a further interesting dimension to data analysis.

Meteosat

Space segment

The performance of Meteosat-2 continues to be nominal, with the exception of the Data Collection Mission, which is now unlikely to be recovered, based on the investigations and simulations that have been conducted on the ground.

Two spacecraft-charging events have been observed since launch. This is considerably fewer than observed on Meteosat-1 during a comparable period, and demonstrates the effectiveness of the modifications introduced on Meteosat-2.

The thermal behaviour of the satellite during equinox and the eclipse period is generally superior to that of Meteosat-1. The first eclipse season presented no problems.

With Meteosat-2 unable to support the DCP mission, this function is maintained by Meteosat-1, stationed at 10°E. To overcome the problem of freeze-thaw cycles in the upper hydrazine system during eclipses, a manoeuvre strategy was developed and successfully applied during the first three weeks of September.

Ground segment

Work is continuing on the replacement of the computer system. One mainframe has been installed and accepted and is now being used for software testing, while the mini-system configuration is still used for Meteosat-2 operations.

Conversion of the software continues on schedule. Using Meteosat-1 image data, four of the six meteorological products have been generated. The results were identical to those using the old software on the old machine.

The operation of Meteosat-1 is being maintained via the interim set-up using the PDUS antenna and one back-end computer. However, a large antenna and associated hardware are now being procured to provide an improved DCP service.

Operations

Routine operations with Meteosat-2 are fully nominal as regards transmission schedule for both digital transmission to PDUSs and analogue transmissions to SDUSs. Interest in the mission continues to grow, with known users in 49 countries.

Operational programme

The various legal and technical documents have been reviewed by the Working Groups. Meanwhile, the next session of the Intergovernmental Conference has been postponed until such time as a firm commitment from one of the major participants has been obtained.

OTS

OTS has continued to operate satisfactorily during the last two months. Apart from routine tests and demonstrations, incentive measurements were performed in November. A preliminary analysis of the results showed them to be positive.

Attitude control of a spacecraft such as OTS can be performed without the use of thrusters by applying the so-called 'solar-sailing' technique. This technique is based on the deliberate rotation of solar arrays to vary the solar pressure on the spacecraft. For the last two months this technique has been satisfactorily implemented on OTS.

OTS has been used for some new applications in the course of recent weeks. Of particular interest is an experiment in newspaper remote-printing, from the Financial Times building in London to Frankfurt.

For the first time also, OTS was used in November to restore telephone traffic interrupted by an accident affecting the French terrestrial network. A fire in a major telephone exchange in Lyon cut all long-distance connections transiting through this city. The French PTT restored the traffic by setting up a satellite link between a transportable station in Lyon and the main OTS station in Bercenay-en-Othe.

The continuation of the OTS operations during 1982 has recently been approved by the Joint Board on Communications Satellite Programmes.

Exosat

Good progress has been achieved over the past months with the integration of subsystems and payload units into the flight-model satellite. To facilitate fully automatic performance verification during later test phases, checkout software updating and commissioning has been a major portion of the activities. The satellite configuration is almost complete with the exception of the experiments, where only one of two imaging telescopes and two of six medium-energy detectors are available. Owing to the known problems with the late supply of medium-energy detectors, and in view of the remedial actions initiated to overcome a lifetime problem in one of the focal-plane detectors (PSD) of the telescope, these units can only be integrated in June next year.

Progress in the immediate future is dependent on removing uncertainty caused by a component problem in the AOCS electronics. All possible remedial steps are being taken to allow functional testing of the AOCE box to continue at satellite level and to complete qualification at unit level.

The tightness of the programme schedule and the need for adequate retesting after reconfiguration of the satellite next year has necessitated a further shift in the launch date from the end of the summer window, closing in early September, to the

En novembre, OTS a en outre inscrit une 'première' à son actif en rétablissant le trafic téléphonique interrompu par un accident survenu sur le réseau terrestre français. Un incendie, qui s'était déclaré dans un important central téléphonique de Lyon, avait interrompu toutes les communications à longue distance transitant par cette ville. Les services français des P.T.T. ont rétabli le trafic en mettant en place une liaison par satellite entre une station mobile à Lyon et la station OTS principale de Bercenay-en-Othe.

Lors d'une réunion récente, le Conseil directeur commun des Programmes de satellites de communications a approuvé la poursuite de l'exploitation d'OTS en 1982.

Exosat

Des progrès sensibles ont été enregistrés au cours des derniers mois, qui ont vu l'intégration des sous-systèmes et des éléments de la charge utile dans le modèle de vol du satellite. Pour rendre la vérification des performances pleinement automatique au cours des dernières phases d'essai, une partie importante des activités a porté sur la mise à jour du logiciel de vérification et sa mise en oeuvre. Le satellite est maintenant presque complet, à l'exception des instruments d'expériences, car on ne dispose actuellement que de l'un des deux télescopes imageurs et de deux des six détecteurs 'moyenne énergie'. En raison des difficultés connues que pose la fourniture tardive des détecteurs au modèle de vol, ainsi que des mesures correctrices qui ont été prises pour résoudre le problème de la durée de vie de l'un des détecteurs au plan focal (PSD) du télescope, ces derniers éléments ne pourront être intégrés qu'en juin 1982.

Les progrès dans l'avenir immédiat dépendent de l'élimination des incertitudes introduites par un problème de composants dans l'électronique du système de correction d'attitude et d'orbite (AOCS). Toutes les mesures correctrices possibles sont prises afin de poursuivre les essais fonctionnels du boîtier AOCS, au niveau satellite, et d'achever la qualification au niveau des éléments.

L'étroitesse des délais du programme et la nécessité de refaire correctement les essais après la reconfiguration du satellite en 1982, ont entraîné un nouveau report du lancement, de la fin du créneau d'été, qui se ferme au début de septembre, à l'ouverture du créneau d'hiver le 18 octobre. La disponibilité du lanceur est actuellement fixée au début de décembre mais elle sera précisée en temps utile, à la lumière des progrès accomplis par les autres missions candidates.

Un premier essai a eu lieu pour vérifier la validité du logiciel d'exploitation préparé jusqu'ici par l'ESOC. On a utilisé pour cet essai le modèle d'identification, installé dans les locaux du contractant et au Centre de Contrôle de l'ESOC (MSSS, etc.), tous deux étant reliés par des lignes louées de téléphonie et de données. Les essais effectués ont été très utiles, ils seront repris ultérieurement lorsque l'on disposera de tout le logiciel, en particulier de la partie qui concerne la dynamique du vol.

Télescope spatial

Réseau solaire

Le modèle de qualification du mécanisme de déploiement secondaire a passé avec succès les essais thermiques sous vide et les essais d'endurance. On procède actuellement au remontage des nappes de photopiles sur ce mécanisme de dépliement pour préparer l'intégration finale des ailes du réseau solaire.

Le mécanisme de déploiement principal a été expédié à BAe et a été intégré avec le mécanisme d'entraînement du réseau solaire. Cet ensemble intégré a été monté dans l'installation HBF-3 et a subi avec succès le programme d'essais thermiques.

Les recherches au moyen de cycles thermiques effectuées sur des échantillons de nappes de photopiles ont suffisamment progressé pour que ces échantillons soient soumis à la qualification officielle.

Les examens critiques de conception au niveau des sous-systèmes et au niveau système ont eu lieu sans faire apparaître de problèmes majeurs.

Chambre pour astres faibles

L'intégration du modèle de vol a continué de se dérouler en suivant de près le calendrier. Certains réaménagements ont dû être faits pour tenir compte de la livraison tardive d'éléments fournis par la NASA (unités d'interface périphériques et verrous). Les essais supplémentaires effectués sur les résistances chauffantes se sont achevés et l'on a compris la cause de l'exfoliation constatée au cours de l'étuvage de la structure porteuse. Une solution a été trouvée et mise en oeuvre.

Les essais d'interface de la mémoire des données scientifiques et du formateur des données scientifiques se sont achevés avec succès au Centre des Vols spatiaux Goddard.

Détecteur de photons

Le modèle thermique mis à jour de la structure, destiné aux essais thermiques du module 'chambre', a été livré en temps voulu à Dornier.

Le modèle d'identification complet a maintenant été intégré et les premières images obtenues. Les essais au niveau système progressent de façon satisfaisante.

La fabrication du matériel de vol se poursuit.

Il est apparu que les aimants de l'intensificateur se dégradaient avec le temps, à la suite des modifications introduites par le fournisseur dans la composition des matériaux. De nouveaux matériaux ont été approvisionnés et l'on va fabriquer de nouveaux aimants. Il semble que l'on ait résolu les problèmes apparus au cours de la fabrication du tube de l'intensificateur, un étage intensificateur ayant subi avec succès le premier cycle thermique de qualification.

Un pré-amplificateur satisfaisant a été fourni à BAe. L'optimisation du dispositif de traitement vidéo est en cours, à l'aide du modèle d'identification. Une défaillance s'est produite au cours des essais thermiques sous vide de l'alimentation haute tension de l'intensificateur. Le problème sera réglé en modifiant l'équipement de mesure.

Les problèmes techniques ci-dessus se sont traduits par des retards dans la livraison des détecteurs aux normes du modèle de vol. Cette livraison est maintenant prévue pour la fin d'octobre 1982.

opening of the winter window on 18 October. Launcher readiness is presently defined for the beginning of December, but will be redefined in due course in the light of the progress achieved by other intervening satellite missions.

A first test has been performed to check the validity of the operational software prepared so far by ESOC. This test employed the engineering model, located at the Contractor's premises, and the ESOC Control Centre (MSSS etc.), the two being linked via rented voice and data lines. The tests proved very successful and will be repeated at a later stage in the programme when all the software, and notably the flight dynamics element, is available.

Space Telescope

Solar array

The development-model secondary deployment mechanism has successfully completed its thermal vacuum and life tests. Solar-array blankets are being refitted to this deployment mechanism in readiness for the final solar-array wing integration.

The primary deployment mechanism has been delivered to BAe and integrated with the solar-array drive mechanism. This integrated assembly has since been installed in the HBF-3 facility at ESTEC and has now successfully completed its thermal test programme.

The thermal-cycling investigations on the solar-array blanket samples have been completed sufficiently for samples to be submitted to formal qualification.

Critical Design Reviews have been held at subsystem and system levels and no major problems have been identified.

Faint Object Camera

Integration of the flight model has continued close to schedule. Some rearrangements have had to be made to cater for delayed NASA-provided items (remote interface units and latches). The additional tests on the heater mats have been completed and the cause of the heater delamination during bake-out of the load-carrying structure has been found and remedial action taken.

Scientific-data-store and scientific-data-formatter interface tests have been successfully completed at Goddard Space Flight Center.

Photon Detector Assembly

The updated structural thermal model for use in the camera-module thermal test was delivered to Dornier on time.

The full engineering-model system has been completely integrated and the first system pictures have been obtained. System testing is proceeding satisfactorily.

Flight hardware manufacture continues.

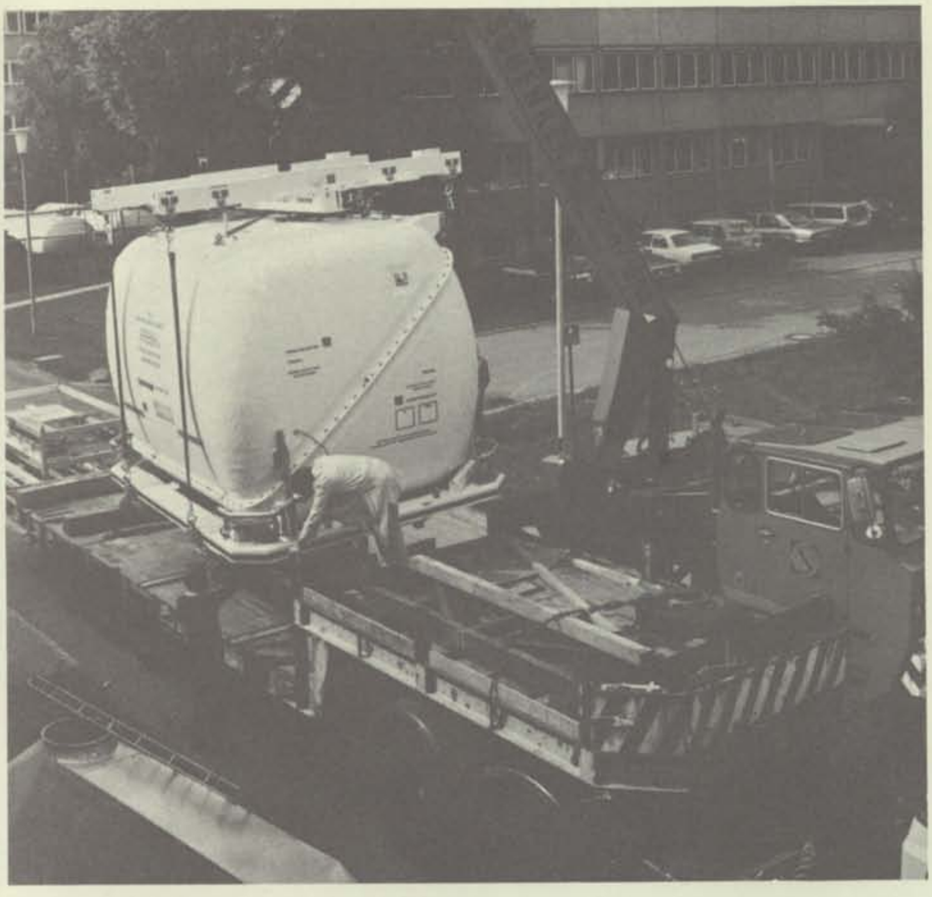
The intensifier magnets were found to have degraded with time due to modifications in the material composition introduced by the original supplier. New material has been procured and new magnets will be manufactured. Problems during intensifier tube production appear to have been overcome and an intensifier section has successfully passed the first thermal qualification cycle.

A satisfactory pre-amplifier has been delivered to BAe. Optimisation of the video processing unit is taking place using the engineering-model system. During thermal vacuum testing of the intensifier high-voltage unit a failure did occur, but a modification to the test equipment will correct this problem.

The above technical problems have resulted in delays in delivery of the flight-model detectors, which is now foreseen for the end of October 1982.

ISPM

Following a prolonged period of uncertainty, ISPM once again appears to be well established as a joint ESA-NASA project, although unfortunately with only one spacecraft now going out of the ecliptic plane and over the poles of the Sun. Clearly, this modified division of responsibilities will lead to some changes in technical interfacing between the ESA and NASA project teams, and these are currently being evaluated.



Modèle de structure du satellite ISPM dans son conteneur de transport, chargé pour expedition depuis Dornier à l'IABG en vue des essais d'ambiance.

The ISPM structural model spacecraft, in its transport container, being loaded at Dornier System for shipment to IABG for environmental testing.

ISPM

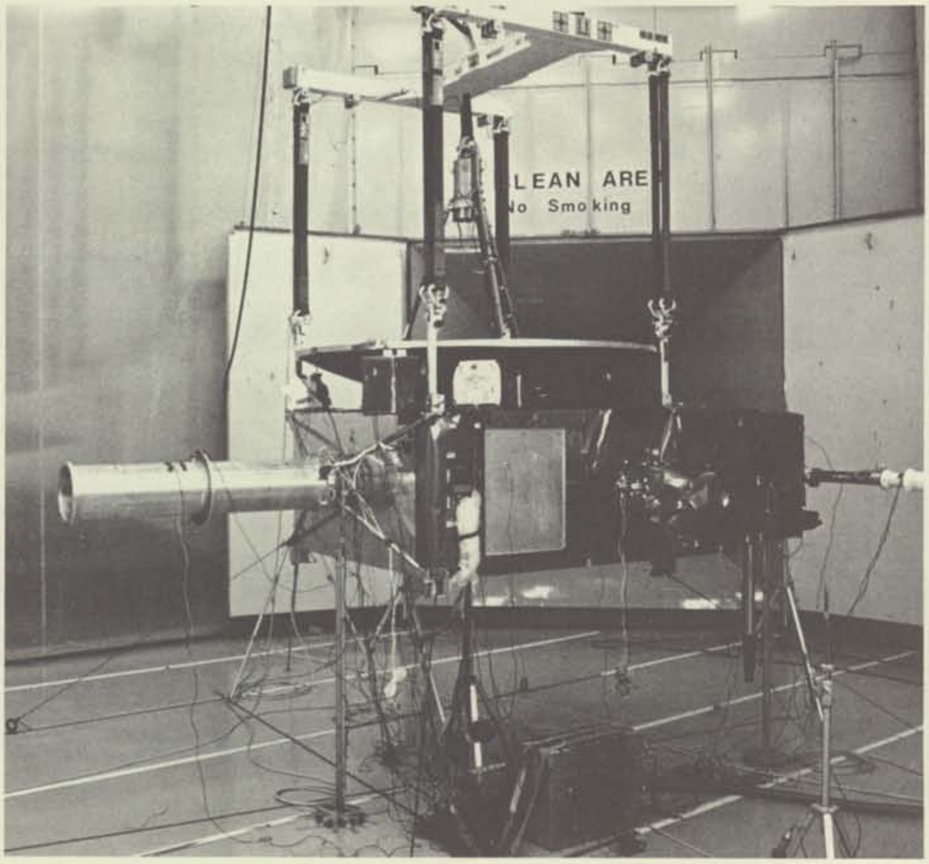
Après une période d'incertitude prolongée, le projet ISPM apparaît à nouveau fermement établi en tant que projet conjoint de l'ESA et de la NASA. Malheureusement, il ne comportera qu'un satellite qui quittera le plan de l'écliptique pour évoluer au-dessus des pôles du Soleil. Manifestement, ce nouveau partage des responsabilités conduira à introduire des modifications dans l'interface technique entre les équipes de projet de l'ESA et de la NASA et ces modifications sont actuellement en cours d'évaluation.

Bien que la date de lancement officielle soit maintenant fixée pour mai 1986, les deux Agences examinent activement la possibilité d'avancer cette date jusqu'au mois d'avril 1985.

Les travaux à l'échelon système et sous-système se sont poursuivis sans interruption au cours de cette période d'incertitude et certaines étapes majeures ont été franchies. Le modèle de structure du satellite, qui sert à éprouver la sécurité mécanique du système et juger de sa validité en ce qui concerne les vibrations, vient de subir les essais statiques et dynamiques ainsi que l'essai acoustique.

Tous ces essais ont été réussis mais une résonance élevée, apparue dans une partie de la plate-forme des expériences, suscite quelque inquiétude quant à l'ambiance dans laquelle risque de se trouver un détecteur d'une expérience. En conséquence, on envisage une modification et la réédition de quelques essais.

Le modèle de qualification du satellite, qui permet de démontrer la compatibilité fonctionnelle, au niveau système, de tous les sous-sytèmes et instruments d'expériences, parvient à son stade final d'élaboration. Tous les sous-systèmes, à une exception près, sont intégrés et les travaux d'installation et d'essai de la charge utile expérimentale sont bien avancés. La seule exception concerne le sous-système des télécommunications, pour lequel le sous-traitant responsable a eu un certain nombre de problèmes de conception, de fabrication et d'essai. De ce fait, ce sous-système a pris plusieurs mois de retard sur le calendrier et il sera intégré à l'achèvement de la phase d'intégration des instruments d'expérience, en février 1982.



ISPM structural-model spacecraft undergoing acoustic noise testing at IABG, Munich.

Modèle de structure d'ISPM au cours des essais acoustiques à l'IABG à Munich.

L'examen de conception du matériel est prévu pour décembre 1981. Les essais effectués à ce jour seront examinés et l'autorisation officielle sera donnée pour la fabrication des exemplaires de vol de tous les sous-systèmes.

Au début de 1982, une série de réunions portant sur les interfaces avec le lanceur, les aspects de sécurité, la conception de la mission, etc. auront lieu avec la NASA. En outre, une équipe chargée des travaux scientifiques rencontrera les chercheurs principaux.

Après cela, on espère trouver un chemin sans embûche jusqu'à l'achèvement de l'intégration et de la fabrication de l'exemplaire de vol du satellite vers la mi-1983. Viendra ensuite une période de stockage jusqu'au moment voulu pour procéder à la recertification du satellite avant le lancement.

Giotto

Satellite
L'essentiel de l'activité concernant le projet a porté sur l'étude industrielle de la phase B. Les deux premières parties de la phase B (B0 et B1) se sont achevées avec succès. Elles comprenaient: la conception du satellite au niveau système, la spécification des sous-systèmes et le choix des contractants pour ces derniers. La dernière partie de la phase B, à savoir B2, a commencé le 1er novembre et s'achèvera vers la fin de février 1982. Le calendrier du programme exige que la phase C/D de réalisation du matériel commence en mars pour que le satellite soit livré en janvier 1985.

Dans la conception du satellite, élaborée au cours de la phase B, on a observé une certaine prudence afin de réduire les risques pour le calendrier. C'est ainsi que les sous-sytèmes principaux de traitement des données, de télémesure et de télécommande sont directement dérivés de ceux qui ont été utilisés pour l'ISPM et que l'on a limité le plus possible la réalisation de dispositifs nouveaux.

Charge utile
La charge utile scientifique comprend quelque 10 expériences multidisciplinaires dont l'objet est résumé dans le tableau ci-

Although the official launch date is now May 1986, ESA and NASA are actively examining the possibility of advancing it to April 1985.

Work at subsystem and system level has continued without interruption during this time and some major milestones have been passed. The structural-model spacecraft, upon which the safety and vibrational validity of the system is proven, has completed static and dynamic testing, plus the acoustic test.

It has successfully passed all tests, but a high resonance apparent in one area of the experiment platform is giving concern about the environment likely to be experienced by one experiment sensor. Consequently, consideration of a modification and some retesting is now taking place.

The qualification-model spacecraft, which proves the functional compatibility at system level of all subsystems and experiments, is in the process of final build-up. All subsystems but one have been integrated, and work is well advanced on installing and testing the experimental payload. The one exception is the telecommunications subsystem, with which the subcontractor responsible has had a number of design, manufacture and test problems. As a result, this subsystem is several months behind schedule and will now be integrated at the conclusion of experiment integration, in February 1982.

The Hardware Design Review that takes place in December 1981 will consider the testing to date and should formally release for manufacture the flight units of all subsystems. Early in 1982 a series of meetings with NASA will take place concerning launcher interfaces, safety, mission design etc. A Science Working Team meeting with the principal investigators will also be held.

Once these are accomplished, we look forward to a smooth run to the completion of integration and building of the flight spacecraft by mid-1983, followed by a period of storage until the appropriate time for recertification prior to launch.

Giotto

Spacecraft

Major project activities are now centred on the industrial Phase-B study. The first two parts of Phase-B, (Board B1) have been successfully completed. These included spacecraft system design/subsystem specification, together with subsystem contractor selection activities. The final part of Phase-B (Phase-B2) was initiated on 1 November and will be completed by the end of February 1982. The programme schedule requires that the hardware phase (Phase C/D) then be initiated in March for a spacecraft delivery in January 1985.

The spacecraft design approach developed in Phase-B has attempted to be conservative in the interests of minimising schedule risk. The major data-handling and telemetry and telecommand subsystems are close derivates of those for ISPM, and new unit development has been kept to a minimum.

Payload

The scientific payload consists of ten multidisciplinary experiments, which are summarised in the accompanying table. The overall resource allocation to the payload is about 55 kg/62 W, with a science data rate during Halley encounter of 40 kbit/s. During the course of 1981, Principal Investigators have been concentrating on the design and definition of their instrument and, together with the project, establishing the detailed interfaces with the spacecraft. This essentially study-oriented activity will be terminated by the end of 1981, with a formal Conceptual Design Review for each experiment. This will allow formal agreements on individual resource allocations and interfaces to be signed-off early in 1982.

Experiment		Acronym	Principal Investigator	
Camera		HMC	H.U. Keller	1
Neutral Mass Spectrometer	M-Analyser E-Analyser	NMS	D. Krankowsky	
Ion Mass Spectrometer	High-Energy Range Spectrometer High-Intensity Spectrometer	IMS	H. Balsiger	2
Dust Mass Spectrometer		PIA	J. Kissel	
Dust Impact Detector System	Meteoroid Shield Momentum Sensor Impact Plasma and Momentum Sensor	DID	J.A.M. McDonnell	3
Plasma Analysis 1	Fast Ion Sensor Implanted Ion Sensor	JPA	A. Johnstone	
Plasma Analysis 2	Electron Electrostatic Analyser Positive Ion Cluster Comp. Anal.	RPA	H. Rème	4
Energetic Particles		EPA	S. McKenna-Lawlor	
Magnetometer		MAG	F.M. Neubauer	
Optical Probe Experiment		OPE	A.C. Levasseur-Regourd	5

1. To determine the size, albedo, rotation, and surface structure of the comet nucleus; to observe the active sublimation process; to determine the spacecraft trajectory relative to the nucleus.
2. To determine the chemical and isotopic composition of the cometary neutrals, ions and dust particles; to investigate the various chemical and physical processes that occur in the cometary ionosphere, and to identify the 'parent molecules'.
3. To determine the mass/size spectrum of cometary dust particles and to deduce the dust/gas ratio by mass.
4. To analyse the various plasma physical processes resulting from the interaction between the solar wind and the cometary plasma.
5. To determine the large-scale dust density and intensity of gaseous emissions.

contre. La dotation globale de ressources pour la charge utile est d'environ 55 kg et 62 W, avec un débit de données scientifiques, au moment de la rencontre avec la Comète de Halley, de 40 kbit/s. Au cours de l'année 1981, les chercheurs principaux ont concentré leurs efforts sur la conception et la définition de leur instrument et, en accord avec les responsables du projet, sur l'établissement des interfaces détaillées avec le satellite. Cette activité, qui a essentiellement le caractère d'une étude, s'achèvera vers la fin de 1981 par un examen officiel de la conception de principe de chaque instrument d'expérience. Ceci permettra de conclure un accord officiel, qui devra être signé au début de 1982, sur les attributions individuelles de ressources et sur les interfaces.

Instruments d'expérience		Sigle	Chercheur principal	
Chambre photographique		HMC	H.U. Keller	1
Spectromètre de masse pour constituants neutres	Analyseur M Analyseur E	NMS	D. Krankowsky	2
Spectromètres de masse pour les ions	Spectromètre dans la gamme des hautes énergies Spectromètre pour les hautes intensités	IMS	H. Balsiger	2
Spectromètre de masse pour les poussières		PIA	J. Kissel	2
Système de détecteurs d'impact des poussières	Capteur d'énergie cinétique, bouclier contre les météoroïdes Capteur de plasma d'impact et d'énergie cinétique	DID	J.A.M. McDonnell	3
Analyse du plasma (1)	Capteur d'ions rapides Capteur d'ions implantés	JPA	A. Johnstone	4
Analyse du plasma (2)	Analyseur électrostatique d'électrons Analyseur de composition des amas d'ions positifs	RPA	H. Rème	4
Particules énergétiques		EPA	S. McKenna-Lawlor	4
Magnétomètre		MAG	F.M. Neubauer	4
Sonde optique		OPE	A.C. Levasseur-Regourd	5

1. Déterminer la dimension, l'albedo, la rotation et la structure superficielle du noyau de la comète; observer le processus de sublimation en action; déterminer la trajectoire du satellite par rapport au noyau.

2. Déterminer la composition chimique et isotopique des constituants neutres, des ions et des particules de poussière qui forment la comète; étudier les différents processus physiques et chimiques qui se déroulent dans l'ionosphère de la comète et identifier les 'molécules mères'.

3. Déterminer le spectre de masse, les dimensions des particules de poussière de la comète et en déduire le rapport massique poussière/gaz.

4. Analyser les différents processus physiques qui résultent de l'interaction entre le vent solaire et le plasma de la comète.

5. Déterminer la densité des poussières à grande échelle et l'intensité des émissions gazeuses.

Hipparcos

Le projet Hipparcos doit se dérouler en trois phases:

- *la phase B1, qui est une phase d'études concurrentielles et doit durer 13 mois;*
- *la phase B2, de définition détaillée et de conception, qui sera non concurrentielle et devrait durer environ 5 mois;*
- *la phase C/D, qui est la phase de réalisation, fabrication et vérification.*

Un appel d'offres a été lancé le 1er juillet 1981 et un exposé industriel a été fait aux contractants potentiels le 9 juillet.

La date de clôture de l'appel d'offres pour la phase B1 avait été fixée au 20 octobre. Des offres ont été faites par deux consortiums, COSMOS et MESH: elles sont actuellement en cours d'évaluation à l'ESA. La phase B1 devrait commencer au début de 1982.

L-Sat

Le programme de réalisation de la phase C/D de L-Sat doit démarrer à la mi-décembre 1981, en vue d'un lancement du satellite en mars 1986. Ces derniers mois, les activités de la phase-relais ont été principalement axées sur la soumission de la proposition pour la phase C/D, proposition qui a été reçue en novembre et qui devait être soumise à l'IPC pour approbation à sa réunion de décembre. La déclaration relative à ce programme est ouverte à la signature depuis fin octobre. Il est probable que le Royaume-Uni, l'Italie et le Canada, qui y ont déjà souscrit, seront rejoints par d'autres pays avant la fin de l'année. Une étude portant sur un dérivé de L-Sat destiné à des applications 'télécommunications des services mobiles' au Canada a déjà été engagée par l'industrie britannique et canadienne.

ECS

Le programme d'assemblage, d'intégration et d'essais d'ECS-1 se déroule sans problèmes majeurs, en fonction d'un lancement fin juin 1982. ECS-1 sera lancé avec Oscar-9b grâce à l'adaptateur Sylda qui permettra de loger ce dernier en position de passager inférieur. Le moteur d'apogée factice chargé (Mage-II) a été livré et accepté pour intégration sur ECS-1. Des

Hipparcos

The Hipparcos project is planned to be carried out in the following phases:
- Phase B1: definition study, competitive, duration 13 months
- Phase B2: detail definition and design non-competitive, duration about five months
- Phase C/D: development, manufacture and verification.

Invitations to Tender were released on 1 July 1981 and an Industrial Briefing was held with candidate contractors on 9 July.

The closing date for responses to the Phase B1 Invitation to Tender was 20 October and submissions from two consortia, COSMOS and MESH, are currently being evaluated by ESA.

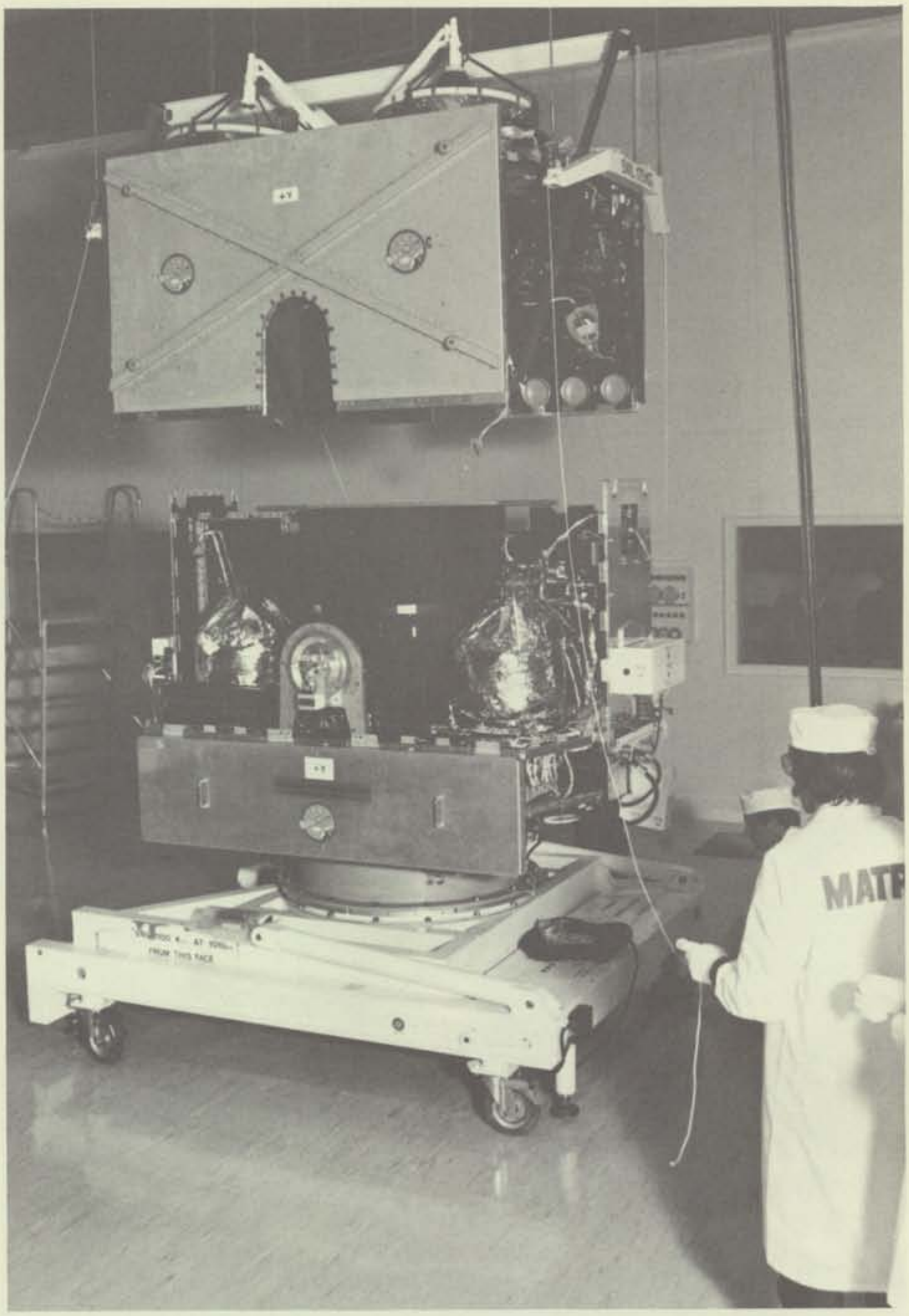
It is anticipated that Phase B1 will commence at the beginning of 1982.

L-Sat

The L-Sat Phase-C/D development programme is planned to start in mid-December 1981, leading to launch of L-Sat-1 in March 1986. Activities under the bridging-phase contract over the last few months have centred around the submission of the Phase-C/D proposal, which was received in November and will be submitted for approval to the December IPC. The programme declaration has been open for subscription since the end of October. The present subscriptions by the United Kingdom, Italy and Canada are expected to be followed by other participants before the end of the year. A study of an L-Sat derivative for mobile communications applications in Canada has already been undertaken by British and Canadian industry.

ECS

The assembly, integration and test programme of ECS-1 is proceeding without major difficulties towards a launch at the end of June 1982. ECS-1 will be launched with Oscar-9B using the Sylda adaptor to accommodate Oscar as the lower passenger. The loaded dummy apogee boost motor (Mage-II) has been delivered and accepted for integration into ECS-1. Flight-motor procurement is also being arranged. The changes to the satellite necessary to incorporate the Mage-II ABM have been agreed with industry and approved by the IPC. The construction of ECS-2 is proceeding as planned.

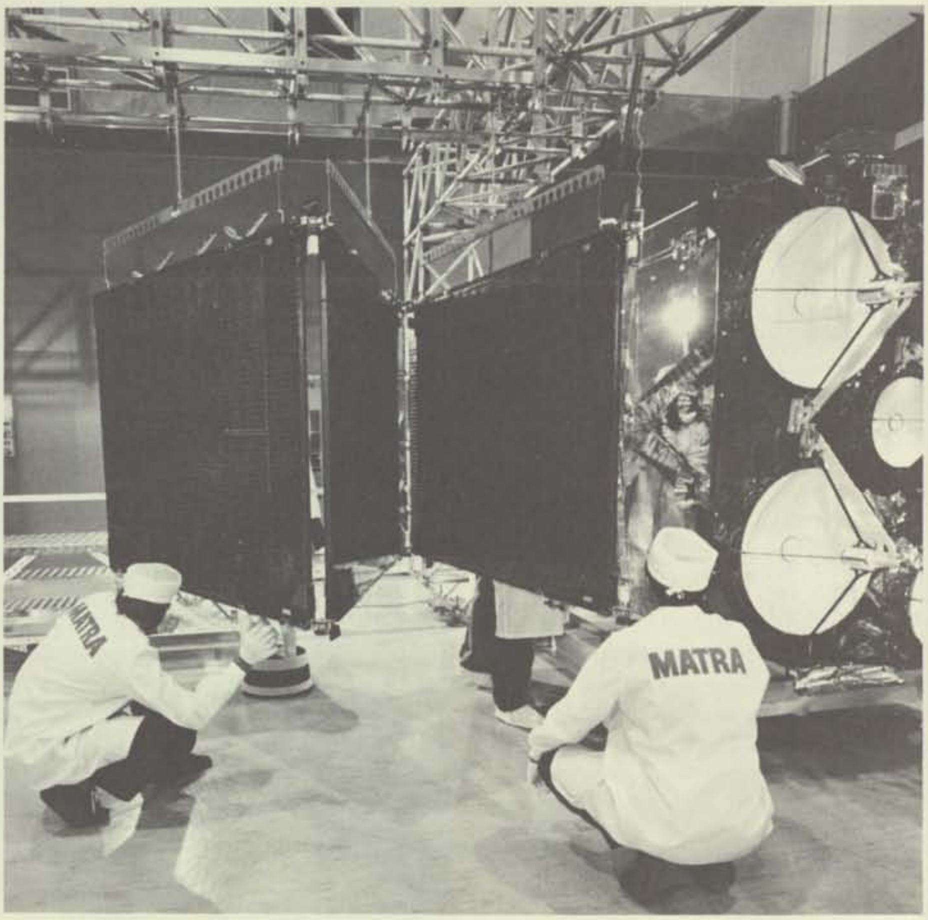


Assemblage de l'antenne, du module de la charge utile et du module de service d'ECS chez Matra à Toulouse.

Mating of the ECS antenna assembly, payload module and service module at Matra, Toulouse.

Sirio-2

The readiness of the Sirio-2 system – including the satellite, the ground facilities at ESOC and Fucino and the resources being deployed for the MDD and Lasso field experiments – was scrutinised during the Flight Readiness Review held in Toulouse on 24–26 November 1981. Apart from some areas requiring minor verification analyses and tests, the system was declared ready for flight. A dual-launch readiness meeting will be held in early 1982 to confirm the readiness of the



ECS solar-array deployment mechanism under test at Matra, Toulouse.

Mécanisme de déploiement du réseau solaire d'ECS en cours d'essais chez Matra à Toulouse.

dispositions sont actuellement prises pour l'approvisionnement du moteur de vol. Les modifications à apporter au satellite pour permettre l'intégration de l'ABM Mage-II ont été arrêtées avec l'industrie et approuvées par l'IPC. La construction d'ECS-2 se poursuit comme prévu.

Sirio-2

L'état de préparation du système Sirio-2 – notamment le satellite, les moyens sol à l'ESOC et à Fucino et les ressources déployées pour l'expérimentation de MDD et de Lasso – a été vérifié au cours de l'examen d'aptitude au vol qui s'est tenu à Toulouse du 24 au 26 novembre 1981. A l'exception de certains secteurs qui appellent des analyses, vérifications et essais mineurs, le système a été déclaré apte au vol. Une réunion d'aptitude au lancement double aura lieu début 1982 pour confirmer que les installations de l'ESOC sont prêtes à assurer le soutien des satellites Marecs-B et Sirio-2 pendant leur phase initiale en orbite.

La Grèce et l'URSS ont fait part de leur intérêt à l'égard de la mission Lasso de Sirio-2, ce qui porte à 12 le nombre des pays susceptibles de participer à ce programme. En outre, l'Allemagne finance une expérience dont l'objectif est d'utiliser MDD pour la synchronisation des horloges atomiques, ce qui permettra à la communauté 'temps et fréquences' de comparer les techniques laser et radioélectriques dans des conditions limites identiques.

Télédétection

Une proposition de programme ERS-1 révisé (satellite de télédétection de l'ESA) a été présentée avec succès au Conseil directeur du Programme de Télédétection le 17 septembre à la suite d'un excercice de réduction des coûts qui a abouti à la suppression d'un élément de la charge utile du satellite (l'instrument de mesure de la couleur des océans) et au transfert aux organismes nationaux de certaines activités de traitement des données au sol.

La résolution habilitante a été votée par le Conseil le 28 octobre ce qui a permis à l'Agence de mettre au point définitivement la documentation de l'appel d'offres pour la phase B au cours de la première semaine de novembre.

La modification de la charge utile du satellite a entraîné une réorientation des éléments définitifs au programme préparatoire de télédétection.

Les deux expériences de télédétection de la FSLP ont été livrées pour intégration (chambre photogrammétrique et expérience de télédétection hyperfréquences), et le succès du bloc d'expériences 'observation de la Terre' (OSTA-1), embarqué sur le deuxième vol de la Navette spatiale (STS-2), a donné un nouvel élan aux activités consacrées aux campagnes expérimentales.

Spacelab

La plus importante étape dans le programme de développement du Spacelab vient d'être franchie: il s'agit de l'examen de recette définitif de FU1 qui a eu lieu au cours des mois d'octobre et de novembre. 84 agents de la NASA et la plupart des membres de l'équipe Spacelab de l'ESA ont participé à cette activité qui a abouti à la recette de FU1 le 30 novembre et à son expédition d'Europe pour les Etats-Unis. A la cérémonie officielle de 'sortie', qui a eu lieu le 4 décembre, assistaient l'Administrateur adjoint de la NASA, le Directeur général de l'ESA, les membres du Conseil directeur du Programme Spacelab, et de nombreuses autres personnes ayant participé aux travaux sur le Spacelab.

FU1, qui avec sa documentation et ses rechanges pèse environ 100 tonnes, va rejoindre le Centre spatial Kennedy (KSC) en trois vols: un vol sur Boeing 707 en novembre, un vol sur C5A de l'Armée de l'Air américaine le 11 décembre et un vol sur Boeing 747 le 21 décembre.

combined Marecs-B/Sirio-2 early-orbit support facilities at ESOC.

Greece and the USSR have announced interest in the Sirio-2 Lasso mission, raising the number of countries likely to participate to 12. In addition, Germany is funding an experiment aimed at using MDD for atomic-clock synchronisation, thus offering the time and frequency community an opportunity to compare laser and RF techniques under identical boundary conditions.

Remote Sensing

A revised ERS-1 (ESA Remote Sensing Satellite) programme proposal was successfully presented to the Remote Sensing Programme Board on 17 September, following a cost-reduction exercise which resulted in a descoping of part of the satellite payload (the Ocean Colour Monitor) and a transfer of some ground data-processing activities to national organisations.

The enabling resolution was voted by Council on 28 October, which permitted the Agency to finalise the Invitation to Tender documentation for Phase-B by the first week of November.

The descoping of the satellite payload has resulted in some re-orientation of the final elements of the Remote Sensing Preparatory Programme.

The two remote-sensing experiments for the First Spacelab Payload (FSLP) have been delivered for integration (the Metric Camera and the Microwave Remote Sensing Experiment), and activities towards the experimental campaigns have found renewed impetus following the success of the earth observation package (OSTA-1) on the second Space Shuttle mission (STS-2).

Spacelab

The most important milestone in the entire Spacelab development programme has now been reached. This milestone was marked by the Flight Acceptance Review for Flight Unit 1 (FU 1), which was held during October and November. 84 NASA personnel and most of ESA's Spacelab team were involved in this activity, which finally resulted in the acceptance of FU 1 on 30 November for shipment from Europe to the USA. The formal 'roll out' ceremony took place on 4 December and was attended by NASA's Deputy Administrator, ESA's Director General, the Spacelab Programme Board, and many others who have been involved with Spacelab.

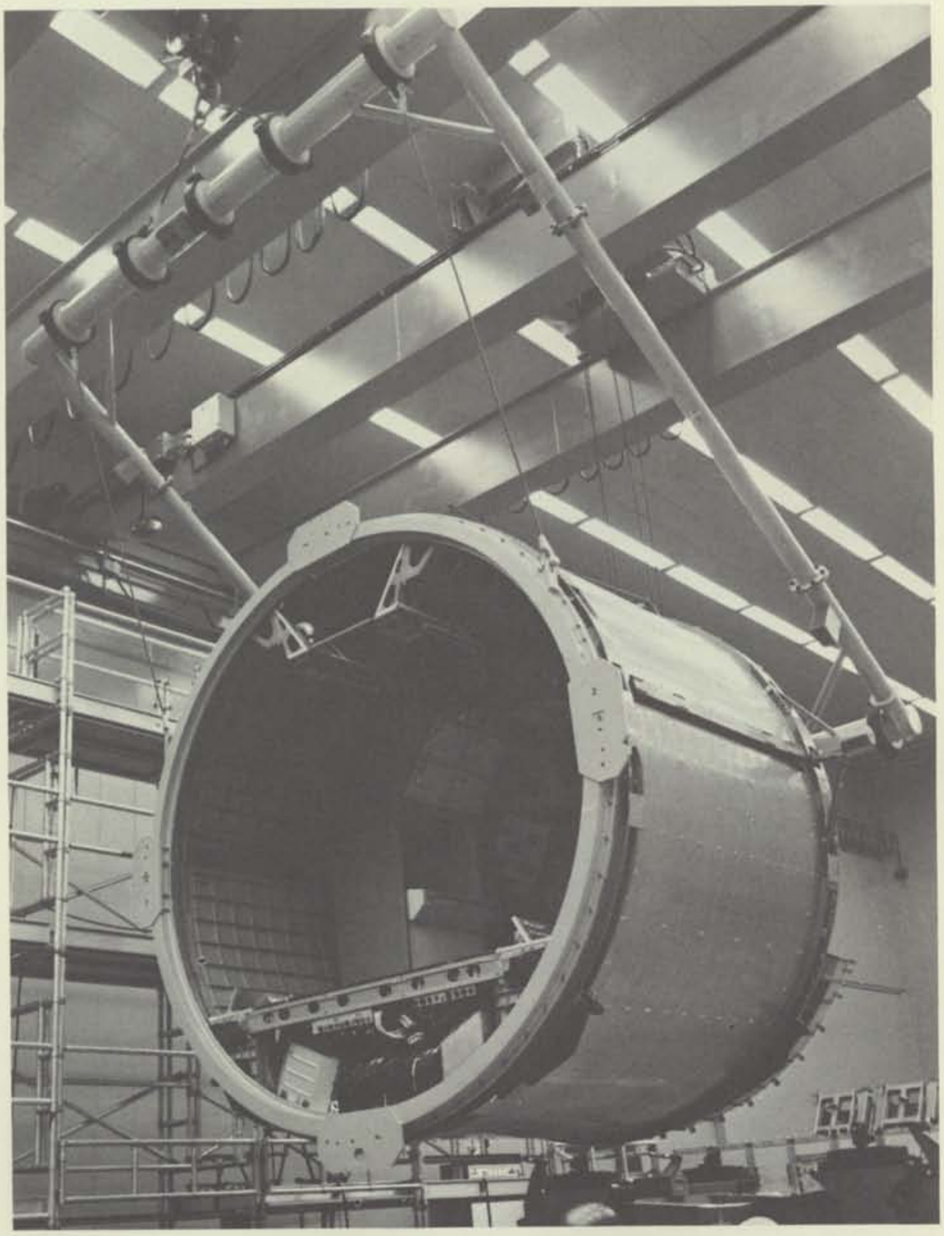
FU 1, which with associated documentation and spares weighs about 100 t, is being flown to Kennedy Space Center on three flights: a Boeing-707, which left in November, a US Air Force C5A on 11 December, and a Boeing-747 on 21 December.

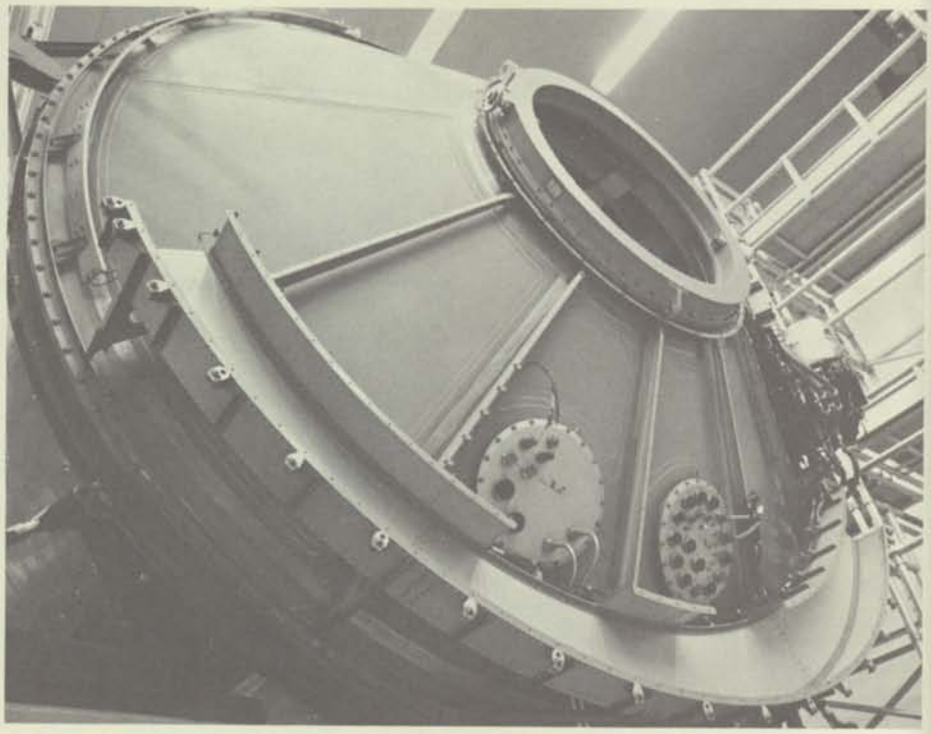
The Spacelab Engineering Model, which was delivered to Kennedy Space Center in December 1980, is now integrated and in service. Numerous small problems are being resolved, providing development experience and knowledge that will be useful for the Spacelab Flight Unit (FU) integration.

The second flight of the Orbiter on 12 November 1981 carried an OSTA-1 payload, comprising five experiments integrated with a Spacelab Pallet. This Pallet was the first Spacelab equipment to fly and the Administrator of NASA has sent ESA his congratulations on the

Préparation du segment central de module du Spacelab avant expédition au Centre spatial Kennedy.

Preparation for transport to Kennedy Space Center of the core segment of the Spacelab module.





Forward end cone of the Spacelab module showing the interface for the Space Shuttle tunnel.

Cône avant du module du Spacelab et son interface avec le 'tunnel' de la Navette.

Le modèle d'identification du Spacelab, qui a été livré au KSC en décembre 1980, est maintenant intégré et en service. De nombreux petits problèmes en cours de résolution vont apporter des connaissances et une expérience de la réalisation qui sera utile pour l'intégration de l'exemplaire de vol (FU) du Spacelab.

Au cours du deuxième vol de l'Orbiteur, le 12 novembre 1981, celui-ci a emporté une charge utile OSTA-1 composée de cinq instruments d'expériences intégrés avec un porte-instruments du Spacelab. Ce porte-instruments est le premier équipement du Spacelab qui ait volé et l'Administrateur de la NASA a envoyé à l'ESA ses félicitations pour 'les excellentes performances du porte-instruments du Spacelab aux normes du modèle d'identification' ainsi que ses remerciements pour la contribution de l'ESA. Le porte-instruments et ses instruments d'expériences ont été présentés en décembre au Smithsonian Museum de Washington, où ils seront exposés en permanence.

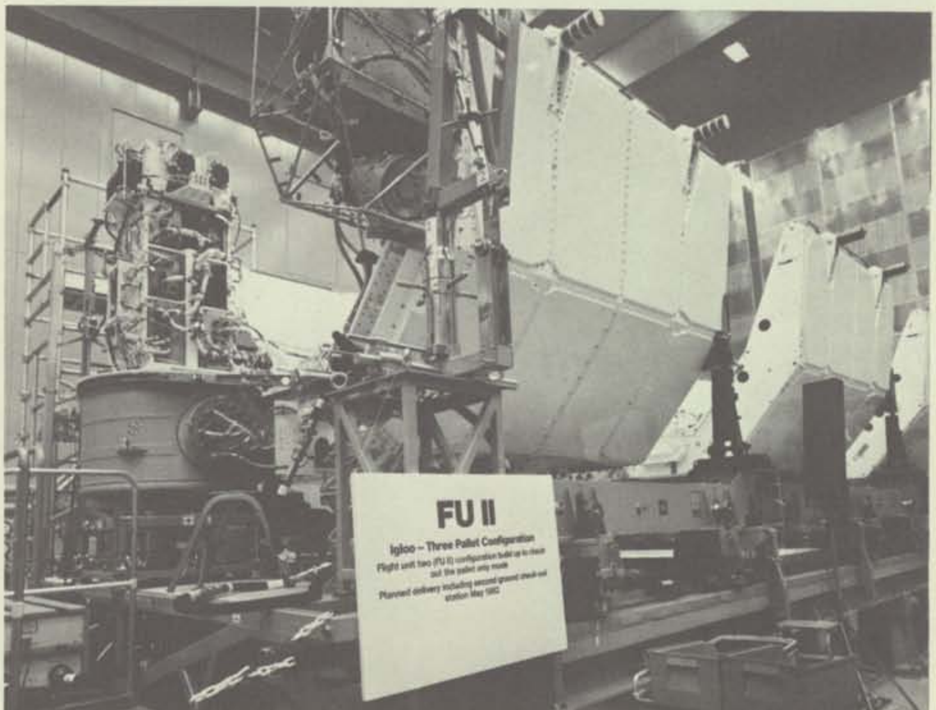
Les modifications majeures du Spacelab, rendues nécessaires par le fait que les contraintes appliquées par l'Orbiteur sont supérieures à ce qui était prévu, ont été incorporées dans le premier exemplaire de vol du Spacelab (FU1).

L'exemplaire de vol no. 2 (FU2), actuellement au stade de l'intégration, doit être livré à la mi-mai 1982. Les vols de la Navette où FU1 et FU2 seront transportés pour leur première mission sont prévus pour septembre 1983 (FU1) et novembre 1984 (FU2). Tous les efforts de l'équipe du Spacelab portent de plus en plus sur les tâches de soutien nécessaires pour que ces vols soient un succès. Une équipe mixte d'ERNO et de l'ESA réside actuellement au KSC; elle est prête à travailler directement avec la NASA sur les problèmes qui se présenteront sans doute lorsque le Spacelab sera intégré avec l'Orbiteur.

La révision des charges appliquées par l'Orbiteur a également conduit à la nécessité de revoir le système de pointage d'instruments. Ce travail a été accompli et toutes les modifications contractuelles nécessaires ont été approuvées.

Le programme de production ultérieure (FOP), aux termes duquel un équipement Spacelab équivalant à un Spacelab doit être fourni aux frais de la NASA, est maintenant bien avancé et les progrès sont très satisfaisants.

Le programme de développement ultérieur (FOD), qui comprend une série d'activités logiques pour faire suite au



Igloo/three-pallet configuration for the Second Spacelab Flight Unit.

Configuration igloo/3 porte-instruments prévue pour la 2ème unité de vol du Spacelab.

'excellent performance of the Spacelab Engineering Model Pallet' and his appreciation for ESA's contribution. The Pallet and its experiments will be presented in December to the Smithsonian Museum in Washington for permanent exhibition.

Major Spacelab modifications, made necessary by the higher than expected Orbiter loads, have been incorporated into the first Spacelab Flight Unit (FU 1).

Flight Unit 2 (FU 2) is now in integration and is scheduled for delivery in mid-May 1982. The Shuttle flights, which will transport FU 1 and FU 2 on their first missions, are scheduled for September 1983 (FU 1) and November 1984 (FU 2) and the efforts of the Spacelab team are more and more directed to the supporting tasks necessary to make these flights a success. A combined staff from ERNO and ESA is now resident at KSC, ready to work directly with NASA on the problems that will undoubtedly arise as Spacelab is integrated with the Orbiter.

The revised Orbiter loads have also led to a need to redesign the Instrument Pointing System. This has now been accomplished and all of the necessary contractual changes have been agreed.

The Follow-on Programme (FOP), in which Spacelab equipment equivalent to one Spacelab is to be provided at NASA's expense, is now well under way and progress is completely satisfactory.

The Follow-on Development (FOD) programme, which consists of a logical sequence of activities to follow Spacelab, is now in the decision phase with the Spacelab Programme Board. The main element of the FOD programme is a 'retrievable carrier' system that will allow experiments to be carried into orbit by the Shuttle, supported in orbit for an extended period, and then retrieved by the Shuttle and returned to Earth.

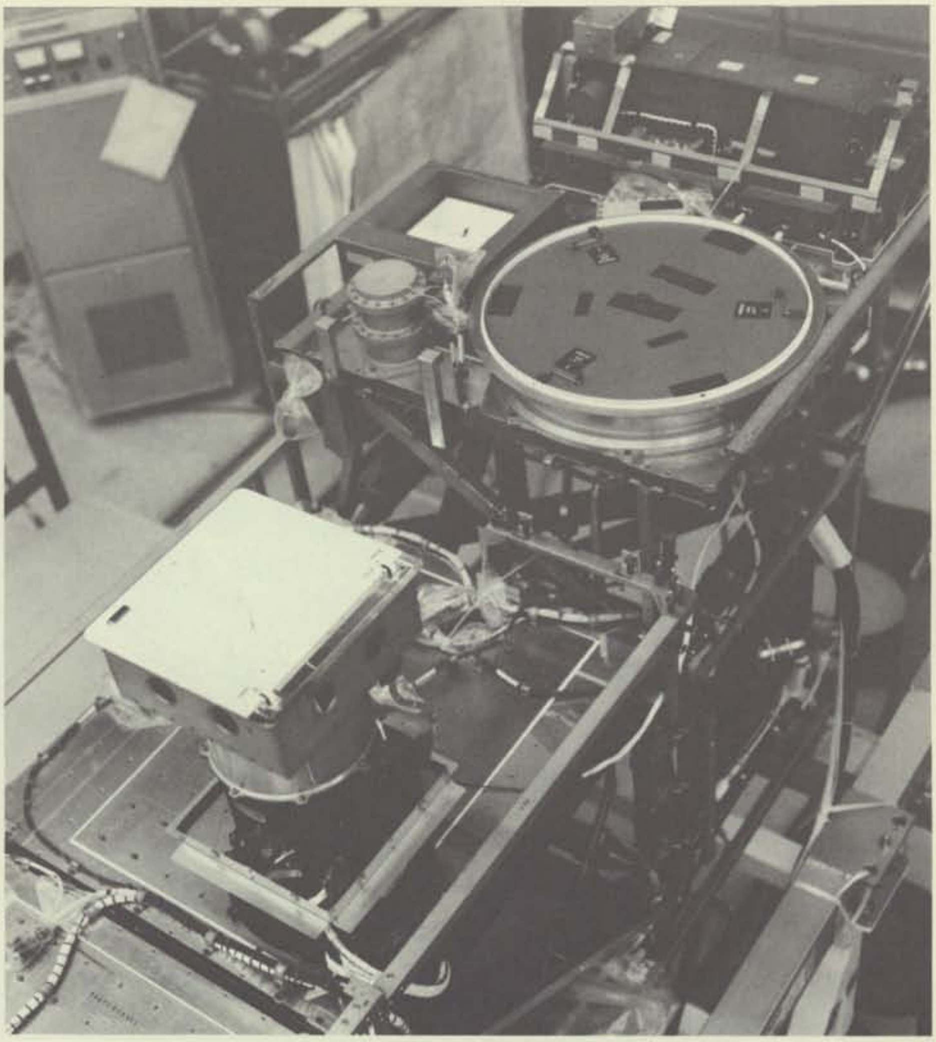
FSLP

The Material Science Double Rack was delivered to ERNO on 9 September 1981, and interface testing was successfully completed by the end of that month. The Rack was subsequently prepared for refurbishment activities, which included rack strengthening and replacement of prototype elements.

Interface tests were also performed on experiments 1 ES 014 (Waves in the OH Emissive Layer), re-test, 1ES016 (Solar Spectrum), 1 ES 019 A (Low-Energy Electron Flux), re-test, and 1 ES 031 (Effect of Weightlessness on Lymphocyte Proliferation). The installation of the Microwave Remote-Sensing Experiment, 1 ES 034, has proceeded, but is requiring more time and effort than planned.

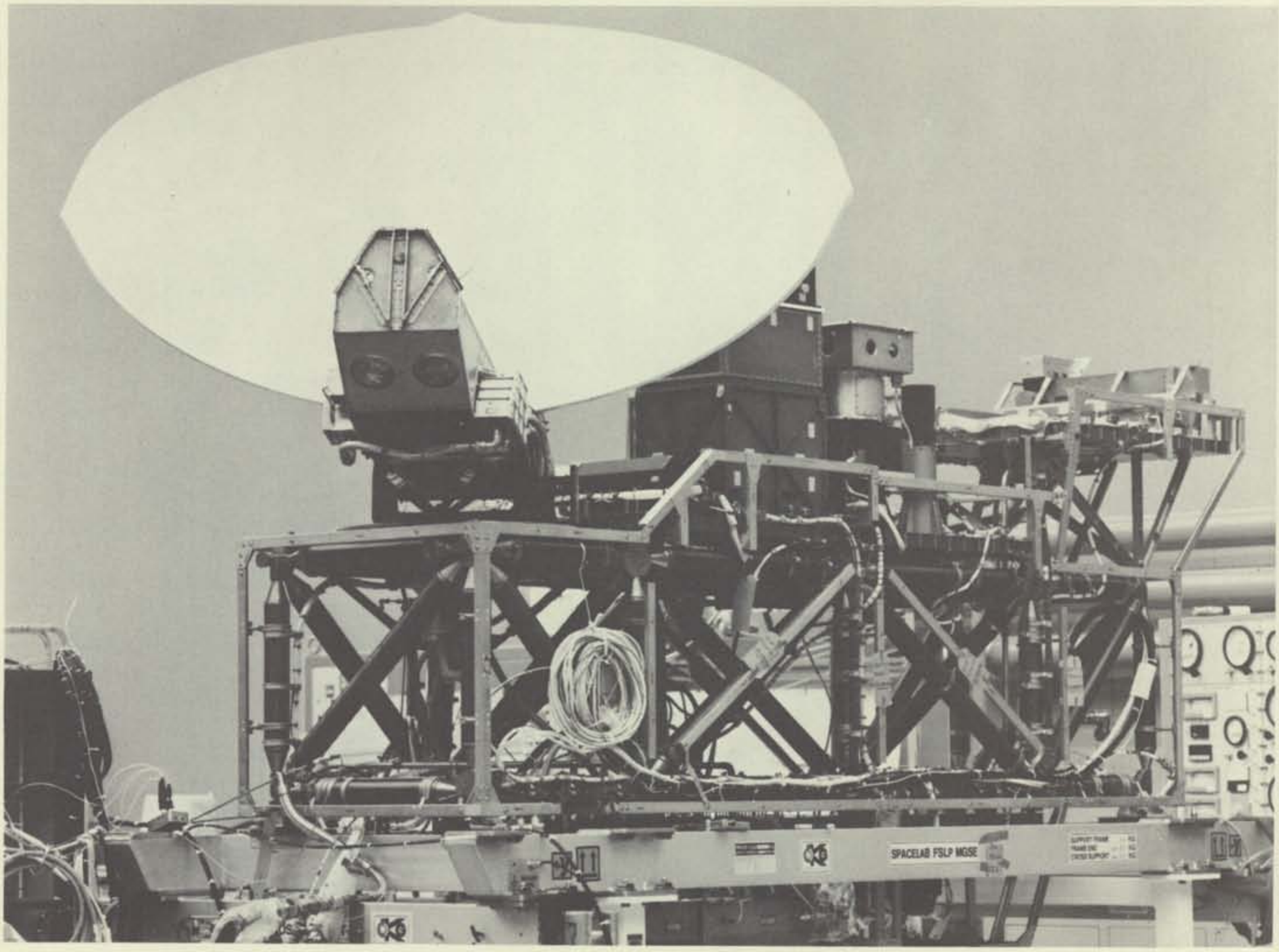
At the end of November two further experiments were delivered, i.e. 1 ES 013 (Grille Spectrometer), and 1 ES 022 (Very Wide Field Camera). The last experiment to be delivered for integration, 1 ES 017 (Lyman α Emissions Measurement), will be available by early December.

The Completion of payload testing at ERNO is scheduled for the end of January 1982. The payload is required by NASA at Kennedy Space Center in May. The time between January and May will be used for calibration, physical measurements and maintenance.



Structure du pont du porte-instruments au cours de son intégration chez ERNO à Brême, avec les expériences 1 ES 017, 023, 024, 027 et 029.

Spacelab pallet bridge structure during integration at ERNO, Bremen, showing experiments 1 ES 017, 023, 024, 027 and 029.



Structure du porte-instruments du Spacelab au cours de son intégration chez ERNO: on distingue, au premier plan, l'antenne de l'expérience européenne de télédétection hyperfréquence (MRSE).

Spacelab bridge structure during integration at ERNO, Bremen, with the Microwave Remote Sensing Experiment (MRSE) antenna in the foreground.

Spacelab, est maintenant parvenu au stade de la décision par le Conseil directeur du Programme. L'élément principal du programme FOD est un 'porte-instruments récupérable' qui permettra à la Navette de transporter des instruments d'expériences jusqu'à leur orbite, d'assurer leur soutien en orbite pendant une période plus longue et de les ramener ensuite sur Terre.

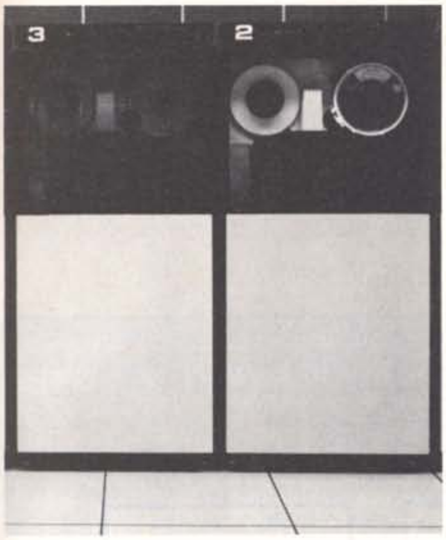
FSLP

Le bâti double 'Sciences des matériaux' a été livré à ERNO le 9 septembre 1981, et les essais d'interfaces se sont achevés avec succès à la fin du même mois. Le bâti a ensuite été préparé en vue de sa remise en état.

Des essais d'interfaces ont été également effectués sur les expériences 1 ES 014 (ondes dans la couche d'émission OH), 1 ES 016 (spectre solaire), 1 ES 019 A (flux d'électrons de basse énergie) et 1 ES 031 (effet Weigert sur la prolifération des lymphocytes). L'installation de l'expérience de télédétection en hyperfréquences (1 ES 034) s'est poursuivie mais requiert plus de temps et d'efforts que prévu.

Fin novembre deux nouvelles expériences ont été livrées, le spectromètre à grille (1 ES 013) et la chambre à très grand champ (1 ES 022). La dernière expérience dont la livraison est attendue pour intégration – mesure des émissions Lyman α (1 ES 017) – devait être disponible début décembre.

Selon les plans, les essais de la charge utile doivent se terminer chez ERNO fin janvier 1982 et la NASA demande qu'elle soit livrée au Centre spatial Kennedy en mai. On procèdera entre janvier et mai à des étalonnages, à des mesures physiques et à des activités de maintenance.



Les systèmes d'information administrative de l'Agence sur le chemin de la rénovation

R. Soisson, Direction de l'Administration, ESA, Paris

Les systèmes d'information administrative sont influencés par trois facteurs principaux: l'organisation administrative, la règlementation et les procédures, les moyens matériels et logiciels disponibles. L'évolution de chacun de ces facteurs obéit à des impératifs qui se conjuguent rarement en faveur du progrès des systèmes d'information. Aussi deviennent-ils progressivement complexes, mal adaptés et coûteux. Toutefois, lorsque ces phénomènes atteignent un niveau par trop préoccupant, les conditions nécessaires à une rénovation substantielle se mettent en place. Cette opportunité est aujourd'hui présente.

Le traitement de l'information est une tâche fondamentale de l'Administration. Traiter l'information administrative signifie la saisir, la contrôler, la valider, l'agréger, la consolider, la diffuser, l'expliquer et l'interpréter. Un nombre considérable d'opérations se trouve par conséquent associé à ce traitement qui s'effectue en des lieux différents, à des échelons hiérarchiques successifs, à l'aide de procédures et d'instruments variés et au profit d'une clientèle diversifiée, qui s'étend du membre du personnel au Conseil de l'Agence en passant par toutes les Directions.

Les systèmes d'information administrative sont l'image de l'organisation de ces opérations pour l'exercice d'une fonction administrative au profit de ses différentes parties prenantes. Cette définition empirique va permettre:

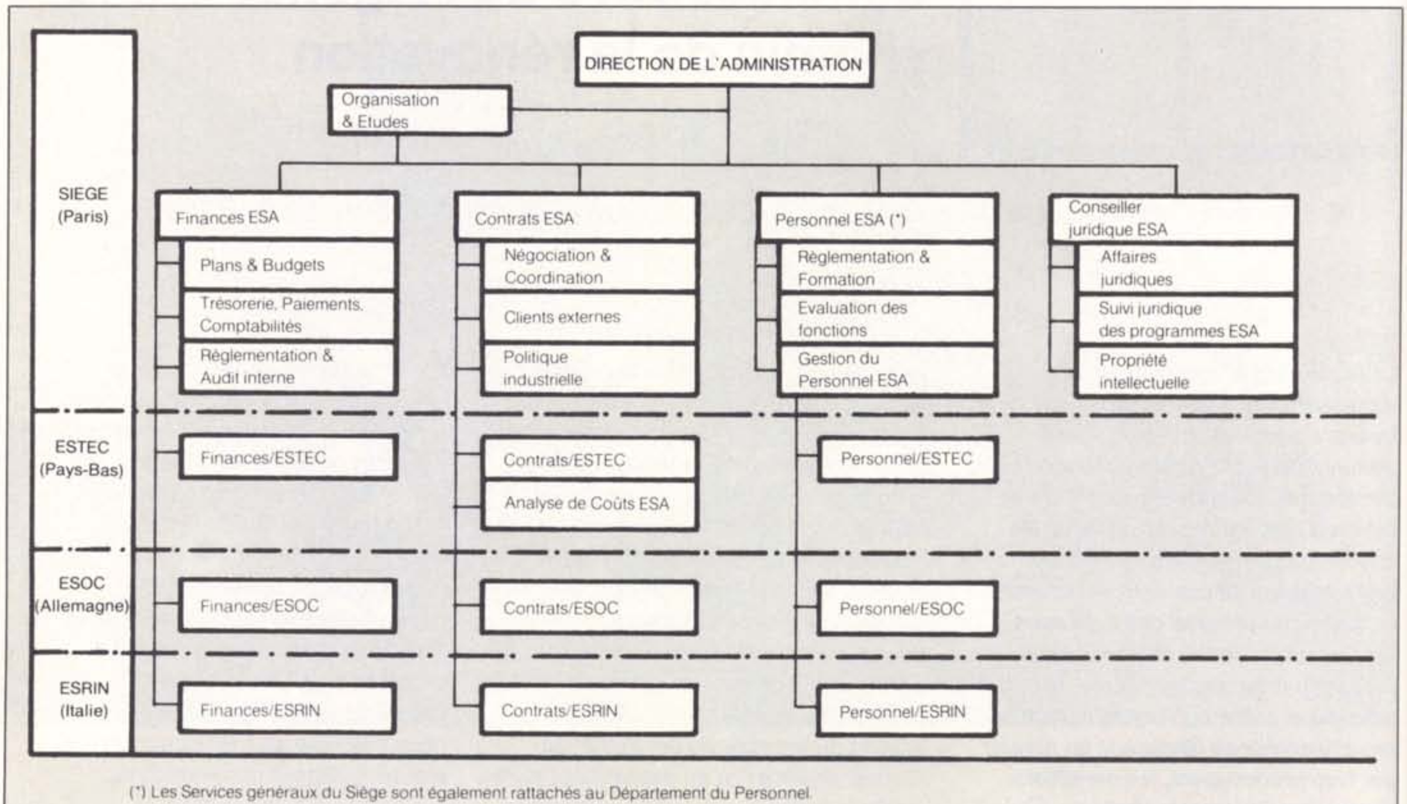
- en premier lieu de faire une esquisse des systèmes d'information administrative de l'Agence par l'observation simultanée des trois facteurs essentiels qui en régissent l'existence et le fonctionnement:
  - l'organisation administrative qui structure la hiérarchie des opérations et les flux d'information,
  - la règlementation et les procédures qui déterminent l'étendue et la complexité des opérations à réaliser, et
  - les moyens matériels et logiciels qui conditionnent l'organisation des traitements et les modalités d'obtention des résultats;
- ensuite de s'interroger sur les besoins d'amélioration des systèmes d'information administrative de l'Agence et d'en déduire les éléments d'un projet de rénovation;
- et enfin de préciser les lignes directrices de ce projet.

L'organisation administrative
La représentation la plus significative de l'organisation administrative est la structure de la Direction de l'Administration (Fig. 1). Dans le cadre qui nous intéresse ici, il est opportun d'y ajouter quelques commentaires:

Dans chaque *Etablissement*, les unités administratives traitent l'information administrative qui prend sa source au niveau même de l'Etablissement: cette information peut être générée d'une façon interne ou provenir de l'extérieur (industriels, organes financiers, etc.). De ce point de vue, le Siège constitue lui-même un Etablissement.

Le *Siège* est également centre de décision et organe de consolidation de l'information administrative. Il est centre de décision par la structure même des processus de décision de l'Agence qui concentrent à Paris l'essentiel des réunions de Direction ainsi que des sessions des instances délibérantes des Etats membres; il est organe de consolidation par le simple fait que la Direction de l'Administration doit être apte à favoriser à tout moment l'activité du centre de décision, notamment par la présentation, l'explication et si nécessaire l'interprétation des résultats synthétisés de la gestion administrative de l'Agence dans son ensemble.

Figure 1 – Structure de la Direction de l'Administration de l'ESA



(*) Les Services généraux du Siège sont également rattachés au Département du Personnel.

La règlementation et les procédures
L'Agence est l'instrument communautaire de onze Etats membres. Le fonctionnement organisé de cet instrument suppose qu'il obéisse à des règlementations qui font la synthèse des intérêts de chacun de ses membres. Le propos de cet article n'est pas de démontrer la difficulté qui existe à établir et à faire vivre une règlementation applicable à une organisation internationale à partir des doctrines et des démarches de gestion propres à chacun des Etats membres. Posons comme postulat que la symbiose est délicate et observons que dans la réalité la bonne volonté de chacun et l'art du compromis permettent de la réaliser. Il n'en demeure pas moins que ces règlementations sont complexes et que leurs modifications requièrent de longs et formels processus d'examen.

Les procédures ont un caractère plus interne: elles sont le reflet de la façon dont les responsables exécutifs estiment que les règlementations doivent être appliquées dans la pratique des opérations quotidiennes et de manière à être adaptées à l'organisation administrative. Cela signifie qu'à ce niveau il existe certains degrés de liberté qui peuvent être mis à profit pour une recherche de simplification notamment des opérations et des tâches administratives associées au traitement de l'information. Nous reviendrons sur ce point un peu plus loin.

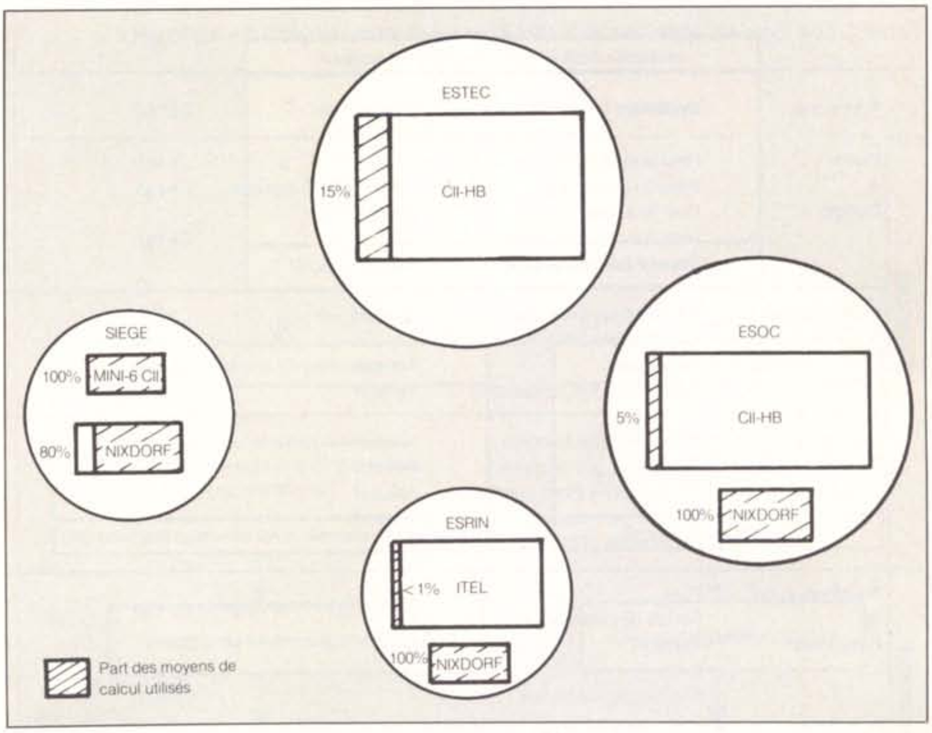
Les moyens existants
Le traitement des données et des textes fait appel à une panoplie de *moyens matériels* qui va de la machine à écrire aux gros ordinateurs, en passant par les machines à calculer, les matériels de traitement de textes et les micro-ordinateurs programmables par tout utilisateur doué d'un minimum de logique et de curiosité.

Les systèmes d'information administrative bénéficient naturellement à l'Agence des possibilités d'utilisation des puissants ordinateurs CII-Honeywell-Bull affectés au traitement en temps différé et situés à l'ESTEC et à l'ESOC. Des mini-ordinateurs Nixdorf dédiés aux traitements administratifs locaux complètent le parc des matériels disponibles, au Siège, à l'ESOC et à l'ESRIN.

La Figure 2 représente approximativement la part d'utilisation de ces moyens informatiques pour les systèmes d'information administrative.

Les *logiciels administratifs* ont pour rôle de transcrire les procédures et les opérations administratives dans un langage compréhensible par un ordinateur. Les procédures administratives ont leurs exigences et les ordinateurs ont les leurs. Les logiciels se trouvent remis en cause dès que l'on modifie soit l'organisation administrative,

Figure 2 – Utilisation des moyens informatiques pour les systèmes d'information administrative



soit les procédures, soit les ordinateurs. Cette observation s'avèrera utile un peu plus loin.

Le Tableau 1 dresse, par fonction administrative, la liste des logiciels existants avec indication de leurs moyens de traitement. Le terme 'manuel' signifie qu'en l'absence d'instrument informatique, les tâches sont réalisées manuellement.

Les besoins d'amélioration
Pris dans leur ensemble, on peut considérer que les systèmes d'information administrative existants permettent de maîtriser la gestion administrative de l'Agence avec une grande rigueur. On citera comme unique mais significatif exemple le cas d'une étude qui a été conduite sur deux années et dont l'objet était de comparer les coûts des satellites de l'Agence avec ceux des satellites nationaux européens, américains et canadiens. Il est apparu qu'à de rares exceptions ponctuelles près, seule l'Agence disposait de systèmes d'information administrative qui pouvaient rendre compte de ces coûts d'une façon détaillée, exhaustive et sur les longues périodes considérées.

Etudiés dans leurs détails, ces systèmes apparaissent toutefois comme souvent complexes et fort consommateurs aussi bien de ressources humaines que de moyens de calcul. Or la Direction de l'Administration se trouve, au même titre que les autres Directions, confrontée à des nécessités impératives de réduction de ses effectifs et de ses coûts. Elle est donc conduite à observer d'un oeil critique:

- le degré de complexité des opérations qu'elle réalise;
- la qualité des moyens logiciels qu'elle utilise;
- l'adéquation à ses besoins des moyens matériels qu'elle emploie,
- le coût du traitement de l'information administrative.

Opérations administratives
L'Administration de l'Agence traite en moyenne 500 000 transactions administratives par an qui mettent à jour un ensemble de fichiers représentant environ 100 millions de caractères. La transaction administrative est le reflet d'un événement qui survient dans la vie de l'Agence et les fichiers constituent la mémoire administrative de ces événements. Il n'existe par conséquent pas de possibilité de réduction notable du volume de ces informations. Cependant il peut être envisagé de diminuer les efforts associés au traitement de ces informations par la recherche d'une simplification des procédures visant par exemple une certaine globalisation des éléments prévisionnels, un allegement du contrôle détaillé des pièces justificatives, un accroissement de la périodicité de production de certains rapports.

Moyens logiciels
Les logiciels d'application administratifs représentent environ 250 000 lignes d'instructions et 500 programmes groupés en une vingtaine de systèmes. Certains de ces logiciels sont de conception ancienne et ont fait l'objet, depuis leur origine, de conversions successives et de multiples modifications. Ainsi, par exemple:

- le système de gestion budgétaire a plus de dix ans d'âge: il a été conçu sur IBM en 1971, converti sur ICL en 1975, puis sur CII-HB en 1980; il a été modifié notamment par des changements de structure budgétaires en 1974, en 1977, et devra l'être à nouveau dès 1982 pour 1983;
- le système de paie et d'information sur le personnel présente des caractéristiques similaires.

Une refonte substantielle de ces logiciels serait donc nécessaire afin d'apporter à leurs utilisateurs une plus grande souplesse d'emploi et une meilleure aptitude aux modifications. D'autre part, des développements complémentaires devraient être entrepris afin de doter certaines fonctions administratives d'un meilleur soutien dans le domaine du traitement automatique de l'information assorti d'une diminution du volume des tâches manuelles.

Table 1. Les logiciels administratifs de l'Agence et leurs moyens de traitement

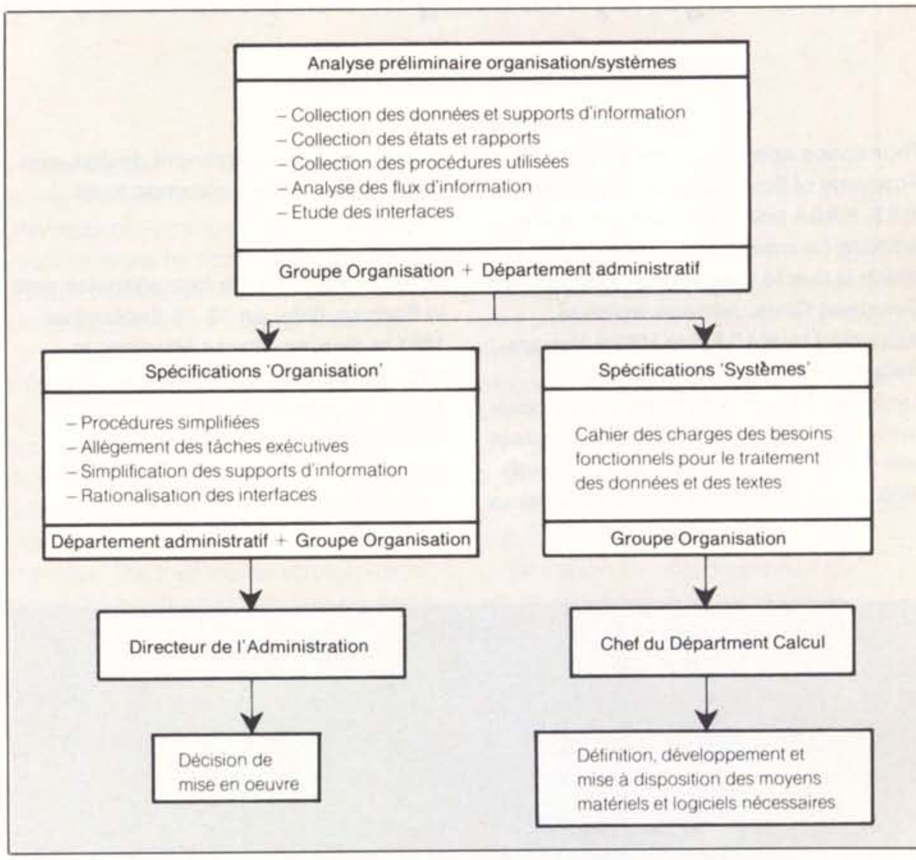
	Fonctions	Systèmes	Siège	ESTEC	ESOC	ESRIN
Finances	Plans & Budget	Prévisions à moyen terme	–	CII-HB	CII-HB	–
		Gestion des budgets	CII/ESTEC + terminal	CII-HB	CII-HB	Nixdorf
		Plan financier	Nixdorf	–	–	–
		Mise à jour des budgets	Nixdorf	CII-HB	CII-HB	–
		Consolidation budgétaire	Nixdorf	–	–	–
	Comptabilités	Comptabilité générale	Nixdorf	CII-HB	Nixdorf	Nixdorf
		Comptabilité analytique	–	CII-HB	CII-HB	–
		Inventaires	Nixdorf	CII-HB	CII-HB	Nixdorf
		Consolidations comptables	Nixdorf	–	–	–
	Paiements & Trésorerie	Traitement des factures	Nixdorf	CII-HB	CII-HB	Nixdorf
		Traitement des missions	Nixdorf	CII-HB	Nixdorf	Nixdorf
		Contributions Etats membres	Nixdorf	–	–	–
		Gestion de trésorerie	Nixdorf	–	–	–
		Recettes de l'IRS/ESRIN	–	–	–	Nixdorf + ITEL
Personnel	Administration du Personnel	Paie } Fonds de prévoyance }	CII/ESTEC + Terminal	CII-HB	CII/ESTEC + Terminal	CII-ESTEC + Terminal
		Pension	Nixdorf	–	–	–
		Prêts	manuel	CII-HB	manuel	manuel
		Prestations médicales	–	CII-HB	manuel	manuel
	Gestion du Personnel	Fichiers du Personnel	CII/ESTEC + Terminal	CII-HB	CII/ESTEC + Terminal	CII/ESTEC + Terminal
		Structure & fonctions	manuel	manuel	manuel	manuel
		Qualifications du Personnel	manuel	manuel	manuel	manuel
		Vacances de poste	manuel	manuel	manuel	manuel
Contrats	Gestion & administration des contrats	Planification et suivi des actions contractuelles	manuel	CII-HB	manuel	manuel
	Politique industrielle	Statistiques sur les contrats passés	ICL/ESOC + Terminal	–	–	–
	Analyse des coûts	Banque de données Coûts	–	ITEL/ESRIN + Terminal	–	–
Juridique	Propriété intellectuelle	Base de données Brevets	ITEL/ESRIN + Terminal			
	Affaires juridiques	Textes officiels & juridiques	manuel			

Moyens matériels

Les logiciels administratifs sont traités en partie sur des miniordinateurs et en partie sur les ordinateurs centraux, notamment celui de l'ESTEC. D'une manière générale les ordinateurs centraux sont utilisés pour les systèmes importants et les consolidations, les miniordinateurs étant réservés aux opérations locales et aux logiciels de faible volume. Cette configuration mixte serait convenablement adaptée au traitement de l'information administrative si elle était stable. Malheureusement l'influence des systèmes administratifs dans les spécifications, le choix et le rythme de changement des ordinateurs centraux est marginale: c'est naturel puisque ces applications n'interviennent que pour environ 10% dans le plan de charge global de ces moyens de calcul; mais ces changements génèrent inévitablement d'une part des conversions de systèmes improductives, d'autre part des incompatibilités avec les éléments de configuration inchangés et par conséquent une certain déstabilisation des systèmes d'information administrative qui utilisent ces moyens à usage général.

La mise en oeuvre, en parallèle avec la refonte des principaux logiciels, d'une configuration de traitement qui favorise une meilleure stabilité des systèmes administratifs serait donc également nécessaire.

Figure 3 – De l'analyse des données à la mise en oeuvre des moyens matériels et logiciels



Coût du traitement de l'information administrative
Le traitement automatisé de l'information administrative coûte en moyenne 1, 6 millions d'unités de compte par an qui se partagent de manière équitable entre, d'une part l'usage des moyens de calcul, et d'autre part le développement ou la conversion des logiciels ainsi que leur maintenance. A cela il faudrait ajouter le coût des traitements manuels liés à la préparation et la validation des données ainsi qu'à l'exploitation des résultats. La simplification des procédures et des opérations, associée à la modernisation des logiciels, devraient conduire à une réduction sensible de ces coûts.

Lignes directrices du projet de rénovation
L'analyse qui vient d'être développée a conduit la Direction de l'Administration à élaborer, en étroite collaboration avec le Départment Calcul, un projet de rénovation substantielle des systèmes d'information administrative de l'Agence pour les années 1982 et 1983.

Objectifs fonctionnels
Les objectifs fonctionnels assignés par le Directeur de l'Administration à ce projet s'énoncent ainsi:
- réduction du plan de charge de la Direction de l'Administration dans le domaine des tâches exécutives par une simplification des procédures administratives visant à un allègement des efforts liés en particulier au traitement manuel de l'information;
- adaptation des systèmes à des procédures administratives simplifiées, modernisation des logiciels anciens et complexes, harmonisation de la configuration de traitement, visant à la fois à l'amélioration de la qualité des systèmes d'information administrative et à la réduction des tâches associées à leur exploitation.

Démarche de l'Administration
La Direction de l'Administration procède à l'examen des fonctions administratives qu'elle exerce en assignant une priorité particulière à la rénovation des systèmes d'information financière et au développement de moyens adaptés pour la gestion du personnel. Les autres Directions de l'Agence qui constituent les principaux clients de ces systèmes d'information sont associés à cet exercice par les Départements administratifs eux-mêmes, le groupe 'Organisation et Etudes' étant chargé de la coordination de l'ensemble. La Figure 3 donne le schéma général selon lequel cette démarche est conduite:

Soutien du Département Calcul
Le Département Calcul de l'Agence a entrepris des études approfondies pour favoriser l'aboutissement de ce projet, sous deux aspects essentiels et qui sont sa responsabilité:
- la mise en oeuvre d'une configuration de traitement assurant aux systèmes d'information administrative une plus grande stabilité que par le passé;
- l'allocation à ce projet de ressources de développement de logiciels de haute technicité et bénéficiant du soutien du maximum de compétences du Département dans son ensemble.

Conclusion
Le Directeur général a demandé au Directeur de l'Administration de lui présenter le plan de réalisation du projet, couvrant les domaines de simplification administrative et les secteurs d'amélioration des moyens matériels et logiciels envisageables ainsi que les économies réalisables. L'intérêt ainsi manifesté au plus haut niveau permet d'escompter que les opportunités présentes produiront de substantielles améliorations pour la gestion administrative de l'Agence.

'Space Missions to Halley's Comet and Related Activitie

The inter-agency meeting in Padova, 13–15 September 1981

Four space agencies – the USSR Academy of Sciences, the Japanese ISAS, NASA and ESA – are presently working on missions to Halley's comet which is due to reappear in 1985/86. The European Giotto mission which is supported by NASA, the USSR Venera-Halley 1 and 2 mission, and the Japanese Planet-A mission are all post-perihelion flybys, and all the encounters with the comet will take place in March 1986. Many aspects of mission planning, spacecraft and experiment design, and data evaluation are common to all missions.

Delegations from the four agencies met in Padova, Italy, on 13–15 September 1981 to discuss 'Space Missions to Halley's Comet and Related Activities'. The three articles that follow are a 'Welcoming Address' by Prof. G. Colombo of the University of Padova, who hosted the meeting, an explanation of 'The Need for Inter-Agency Collaboration on Missions to Halley's Comet' by Dr. E.A. Trendelenburg, Director of ESA Scientific Programmes, who convened the meeting, and, finally, an article by Dr. R. Reinhard, Giotto Project Scientist, which summarises the mission descriptions and topical presentations made, and the agreements reached at the Padova meeting.

'Adoration of the Magi', one scene in a fresco cycle, painted by the Florentine master Giotto di Bondone. The cycle decorates the interior of the Scrovegni chapel in Padova and was probably begun in 1303. Halley's comet appeared in 1301 and served as a model for Giotto's 'star of Bethlehem'.

Welcoming address

G. Colombo,
University of Padova, Italy

On behalf of the President and of the Academic Community of the University, I wish to welcome you to Padova. I also wish to express our feeling of gratitude to ESA for having convened this historic meeting here.

The city of Padova is a very old pre-Roman settlement on rich soil, between the rivers flowing from the Dolomites to the Adriatic. During the Roman period the city flourished as a major agricultural and commercial centre. Invasions and natural calamities destroyed the city several times during the middle ages. After the Longobards had razed Padova to the ground, the population of the city and its surroundings took shelter on the many islands of the nearby lagoon, and Venice was born. Almost a century later Padova started to grow again, reaching its greatest splendour as an independent and free community in the thirteenth century with the Carrara family. In the year 1300 a rich family of usurers, the Scrovegni family, bought the land on which the Roman arena stood and its surroundings and there built the family chapel. Giotto di Bondone was asked to paint the fresco, the monumental masterpiece you have admired today. In 1301 Halley's comet revisited the inner solar system, and one or two years later Giotto began his work.

The University of Padova, established in 1222, only one year after the University of Bologna, developed steadily in the following century, reaching its zenith when Venice took over political control of the city. Venice, in recognition of the strong link with its mother city, made the University of Padova an island of freedom, a shelter from the inquisition, a unique 'studium' whose motto was 'Universa Universis Patavina Libertas'.

The Venetian Republic established several basic rules. One was that the Studium Patavinum, the only 'studium' of the Republic, was to be independent of any political or religious control. It was therefore established in Padova and not in Venice. The theological school which formed part of the studium was separate from the University. The Jesuits, who were controlling most, if not all, of the Universities in Europe at that time, did not control Padova. Degrees were conferred in the name of the Venetian Republic and not in the name of the Pope, and a profession of faith was not required to study here.

From the University of Padova the European medical school developed. For more than a century, only in this school did the professors teach in the aisles of the hospital and only here did they teach anatomy by sectioning human bodies in the Anatomic Theatre, which you will have the opportunity to visit tomorrow.

Galileo came to Padova 500 years ago at the end of the sixteenth century and was here for 20 years. From here he observed the four major satellites of Jupiter and showed beyond doubt that the centre of the Universe was not the Earth but the Sun.

Silently and smoothly, just as the gondolas glide through Venice, the modern scientific revolution flourished in Padova, the revolution that brought society from the medieval to the modern age.

The significance of the meeting that will take place over the next two days may go far beyond the scientific and technological interest of the matter with which you will be dealing. The discussions on the scientific experiments and technological problems of the various missions to Halley's comet, as well as the setting up of an efficient worldwide organisation for coordination of the efforts, will play an essential role in maximising the chances of success for such a difficult endeavour. If you can succeed in reaching agreement on optimum integration of the various space probes and the ground and space observations beyond national interests and within the bounds of a fruitful cooperation, you can show the World how men of good will have an intrinsic ability to work together to establish the truth, to increase knowledge among men, and to foster a peaceful and better society.

For the very reason that space has no boundaries, man in his space ventures will be confronted sooner or later with the choice between war, which would probably lead to the final destruction of our civilisation, and cooperation. In the popular tradition, the apparition of a comet has often been considered a precursory sign of calamity, famine, natural disaster or war. Let us try to disprove this belief. Let us try to profit from the unique occasion of the first perihelion passage of Halley's comet in the space age to promote worldwide peaceful cooperation in space.

The Need for Inter-Agency Collaboration on Missions to Halley's Comet

E.A. Trendelenburg, Director of Scientific Programmes, ESA, Paris

With four space agencies planning missions to Halley's comet during its next apparition in 1985/86 there is a need for inter-agency communication and, if possible, cooperation. The various missions to Halley's comet complement each other in instrumentation and flyby distances, they extend the total time of in-situ observations in the cometary environment, and they may even provide simultaneous observations from two spacecraft for some time periods. Only through inter-agency communication will we be aware of these and other possibilities, which will increase the scientific return beyond the simple sum of all the missions.

Missions to Halley's comet pose several problems that have never previously been encountered on space flights, problems that require new scientific and technological approaches and solutions. These problems stem from the fact that the cometary environment is largely unknown and that Halley is in a retrograde orbit, which leads to very high flyby velocities. Inter-agency communication and cooperation could lead to optimum solutions in these areas, a view that can be illustrated with four examples:

1. A mission to a comet can only be planned if the comet's orbit is well known. The position of the comet along its orbit, the comet ephemeris, must be known with an accuracy linked to the desired flyby distance, which for the various missions is a few hundred to a few thousand kilometres. In 1984/85, when the spacecraft are launched, the nucleus position will only be known to within 30 000 km. Through worldwide ground-based observations in combination with modelling of the so-called 'nongravitational forces', it is expected that the nucleus position will be known to within 500 – 1000 km a few days before the encounters take place, when the last spacecraft orbit-correction manoeuvres will have to be made. Each agency flying a mission to Halley must have this continuously updated knowledge on the nucleus position available and it is in the interests of each agency to contribute to its optimisation.

2. The knowledge of the nucleus position in the comet coma could be further improved by making use of the unique situation that several spacecraft will fly to the comet at about the same time: the first spacecraft could be used as a 'pathfinder' to locate the nucleus, allowing subsequent spacecraft to be targetted precisely even without the possibility of onboard optical navigation. Without the 'pathfinder concept' it is probably impossible to get within a few hundred kilometres of the nucleus where most of the parent molecules are found and certain plasma physical phenomena may be observed.

3. The particular dust and gas environment in the cometary atmosphere through which all spacecraft will fly with a velocity of ~70 km/s has never been encountered previously and poses new technological problems. Any spacecraft intended to fly within a few thousand kilometres of the nucleus must be equipped with a special hyper-velocity impact shield in order to have any chance of survival. Laboratory testing of the shield is only possible up to ~10 km/s, results for higher velocities being obtained by computer simulation. The sharing of an optimum shield design between the various agencies would improve the chances of survival of all spacecraft and thereby increase the overall scientific return.

   In a coordinated approach the world's leading comet scientists should also work together to understand, model and quantify the cometary environment. Their results would enable the engineers to quantify the probability of spacecraft survival, which has an impact on mission planning, and would also allow the various investigators to optimise their experiment designs.

4. The hyper-velocity impacts of dust particles and gas molecules on the leading surface of the spacecraft will create secondary ions and electrons which will form a plasma around the spacecraft. This plasma will consist of spacecraft material which might be confused with the ions of cometary origin to be measured by the various plasma experiments onboard the spacecraft. An understanding of the processes involved is therefore needed to minimise the degree of

contamination by clever spacecraft and experiment design and, at a later stage, to analyse the data correctly.

ESA recognised the existence of the above problems at an early stage and has already addressed some of them by holding special workshops, starting in 1979. The Proceedings of these workshops, published in the ESA SP series (SP-153, SP-155 and SP-174), have been distributed to the other agencies. ESA has also initiated a joint NASA/ESA Halley Environment Working Group, which meets regularly, has had discussions with NASA on the problems of the cometary ephemeris, and has had a meeting with the USSR Academy of Sciences in June 1981 at which the potential scope for cooperation was explored.

Inter-agency communication and cooperation as now envisaged goes beyond that. It involves all agencies planning a mission to Halley's comet. It foresees making maximum use of existing resources to find the best possible solutions to the problems that have been outlined. It would allow the agencies to refine their missions collectively, in particular the encounter strategy, and it would provide a forum for discussions between the scientists involved in experiment design and in data evaluation. Inter-agency communication and cooperation would benefit all the agencies and is absolutely necessary if we are to study Halley's comet as efficiently as possible during its next apparition. It was with these goals in mind that I took the initiative, with the agreement of the other agencies, of organising the meeting on 'Space Missions to Halley's Comet and Related Activities' in Padova.

Presently, only three of the missions to Halley's comet are approved projects. The NASA Halley Earth Return Mission is not yet approved, and in fact the chances of it becoming an approved project are minute in view of the high technological risk in combination with the compressed schedule. Nevertheless, the other agencies welcomed NASA's participation in view of its extensive expertise in planning and carrying out planetary missions. Also, NASA will be contributing significantly to the success of the space missions to Halley's comet by funding several ground-based observational networks on an international level, which will provide the necessary link between Earth-based and in-situ observations and the comet ephemeris. NASA is organising these networks within the International Halley Watch (IHW), an activity strongly supported by the other three agencies. The more international the scientific community represented at all levels of the IHW, the more successful it will be.

The inter-agency dialogue that has been initiated with the meeting in Padova should be continued on an annual basis until after the Halley encounters, the organisation of the meetings and their venues being rotated within the four agencies. It has already been agreed that the next meeting will be convened in Hungary in September 1982 by the USSR Academy of Sciences, and that the final meeting in the series, after the comet encounters in 1986, should again take place in Padova, where it all started.

Comet Halley photographed on 6 June 1910 by Lick Observatory, University of California, Santa Cruz.

photo lick observatory

Space Missions to Halley's Comet and Related Activities

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Introduction

Comets are among the most spectacular and least explored objects in our solar system. Although the comet nucleus itself is a body only a few kilometres in diameter, it is able to produce a coma ('cometary atmosphere') extending for several hundred thousand kilometres when the comet is less than 1 AU from the Sun. It is this activity that differentiates comets from all other members of the solar system.

It is generally believed that a comet consists of a mixture of ices and snows of condensed gases, mostly water ice, and dust particles ranging in size from about 0.1 microns to several centimetres; the mixture can best be described as a dirty snowball. On approaching the Sun the nucleus surface layers on the sunward side are heated up and gas is released by sublimation. This produces the neutral gaseous coma, which in turn is ionised by sunlight and solar-wind collisions. The cometary ions so formed are entrained by the solar wind, eventually producing the plasma tail, which is straight and narrow and always directed away from the Sun.

As the neutral gas is released from the nucleus it carries with it dust particles. Although their outflow velocity is initially directed predominantly towards the Sun, the solar radiation pressure gradually forces the dust particles in the anti-solar direction, forming the dust tail. The dust tail is broad, reflecting the size spectrum of the dust grains, and curved because the dust velocity is comparable to the comet's orbital velocity. What is visible and known as 'the comet' is in fact the sunlight scattered by the dust particles and line emission from neutral particles and ions excited by sunlight (fluorescence).

It has been estimated that $\sim 10^{11}$ comets orbit the Sun at a distance of $\sim$50 000 AU. This population is very old; comets were probably formed at the time of the formation of the solar system, $\sim$4.6 billion years ago. Since they have spent all of their lives in a 'deep freeze', they may have preserved the records (chemical composition and isotopic ratios) of the early history of the solar system. The absence of external heating and heating by self-gravitation due to the small mass of a comet may have led to a composition which is qualitatively different from that of all other bodies in the solar system. Occasionally, the orbit of a comet is changed due to chance gravitational perturbations from the nearest stars and the comet may be deflected into the inner solar system where it becomes observable.

Near-Earth observations (ground-based or from space) of comets are limited in that they can only provide line-of-sight integrations. Only molecules with strong emission lines in suitable wavelength ranges can be observed by remote sensing. Nevertheless, cometary research has made significant progress during the last 20 years through application of modern observational techniques and improved theoretical modelling. Still, such fundamental questions as 'is there actually a nucleus' or 'which are the parent molecules' (those molecules released from the comet nucleus and that form the beginning of a chain of chemical reactions) are still open and can only be answered by in-situ measurements from spacecraft. Comet scientists have tried for more than a decade to convince committees that a comet mission is needed and might provide totally unexpected results that could drastically change our present ideas. All past attempts to get a mission approved were unsuccessful, but now a truly outstanding comet which appears only once every 76 years is approaching the inner solar system and it is due to reappear in 1985/86: Halley's comet. Halley's next apparition has attracted the attention of scientists everywhere, working in a multitude of fields, with the result that not only one space mission has been approved, but four from three different agencies.

Figure 1 – Head of Halley's comet as seen on 8 May 1910 (Mt. Wilson Observatory)

Up to now, approximately 1000 different comets have been recorded, so why, apart from its fame, has Halley been selected as a target for a first cometary mission?

The most important selection criterion is that the comet must have a predictable orbit if a mission is to be planned, which means that it must have returned at least a few times to the inner solar system. This immediately rules out the bright and most active 'new' comets – comets that have never previously approached the Sun – and leaves only the short-periodic and a few intermediate-periodic comets as candidates. Halley, with its 76-year period, is a member of the intermediate-periodic category.

Unfortunately, all short-periodic comets are considerably less bright than new comets, and they produce two orders of magnitude less gas and dust. The intermediate-periodic comets on the other hand are either not very bright, or have not returned, or will only return in the 21st century, with one exception: Halley's comet. Halley is not only the brightest of all intermediate-periodic comets, it also has made by far the highest number of returns (29 previous apparitions). Its dust and gas production is comparable to that of the long-periodic or new comets. Moreover, a mission to Halley requires one of the lowest launch energies of all cometary missions, allowing a high payload mass to be flown. Also, Halley will be visible from Earth during the encounter, allowing simultaneous ground-based and near-Earth observations. Finally, the comet encounter will take place near the Sun, when the comet displays its full activity. There is only one disadvantage to a Halley mission: Halley's orbit is retrograde (orbit inclination 162°), i.e. its orbit sense is opposite to that of the Earth and therefore of the spacecraft, which has the consequence of a very high flyby velocity, a disadvantage that can only be partly compensated for by a high data rate.

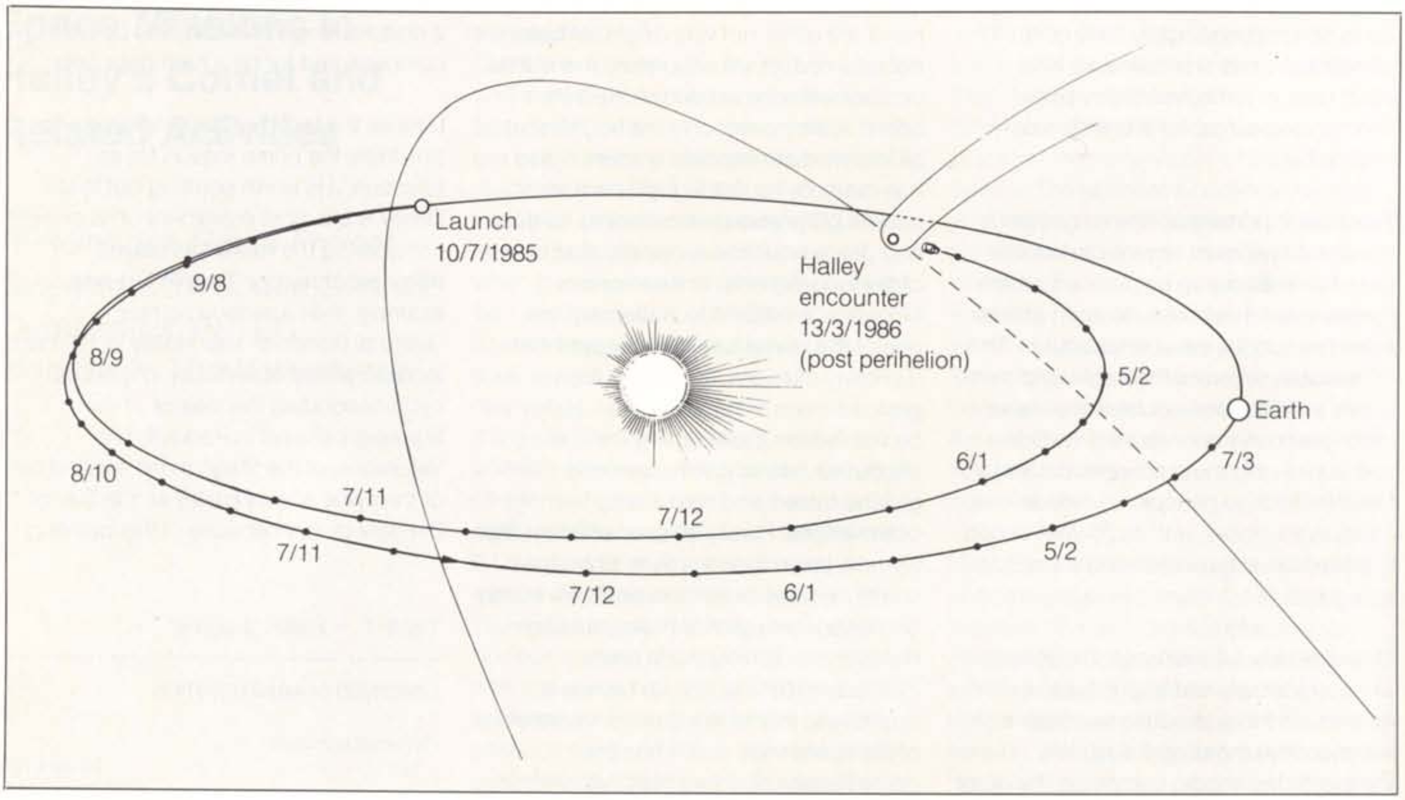
Despite the fact that Halley's fame was not, then, the prime reason for its selection, it is worth pointing out that Halley is the most prominent of all comets, considering the role it has played throughout history. To give just one example, the Florentine painter Giotto di Bondone saw Halley in 1301 and incorporated it realistically in a fresco cycle decorating the interior of the Scrovegni chapel in Padova. The 'Adoration of the Magi', in the second tier of the cycle, shows Halley as the Star of Bethlehem. It is because of this painting,

Table 1 – Halley's comet

OBSERVED CHARACTERISTICS	
Perihelion passages	
last	20 April 1910
next	9 February 1986
Earliest recorded apparition	240 BC
Number of recorded apparitions	28
Distance to Sun	
at perihelion	0.59 AU
at aphelion	35 AU
now (Feb. '82)	12.4 AU
Orbital inclination w.r.t. ecliptic	162°
Absolute total magnitude	5
ESTIMATED PARAMETERS	
Nucleus	
Diameter	6 km
Density	1 g/cm^3
Composition	mostly water ice
Albedo	0.2
Surface temperature	185 K
Rotation period	10 h
At 0.9 AU	
Gas production	1.46×10^7 g/s
Dust production	7.3×10^6 g/s
Extent of coma	4×10^5 km
Bow shock expected at	10^5 km
Contact surface expected at	10^3 km

Figure 2 – Reference trajectory for Giotto from launch on 10 July 1985 to post-perihelion encounter on 13 March 1986. The trajectory lies completely in the ecliptic and has a closest approach to the Sun of 0.7 AU. The Halley orbit is inclined at 162°; it crosses the ecliptic twice, the first time (from south to north) on 9 November 1985, the second time on 11 March 1986.

Below: Spacecraft trajectory through Halley's coma. The spacecraft is targetted at a point 500 km sunward of the comet. The targetting uncertainty is of about the same order



which is considered to be the first scientific description of Halley recorded in history, that ESA has given the name 'Giotto' to its Halley cometary mission.

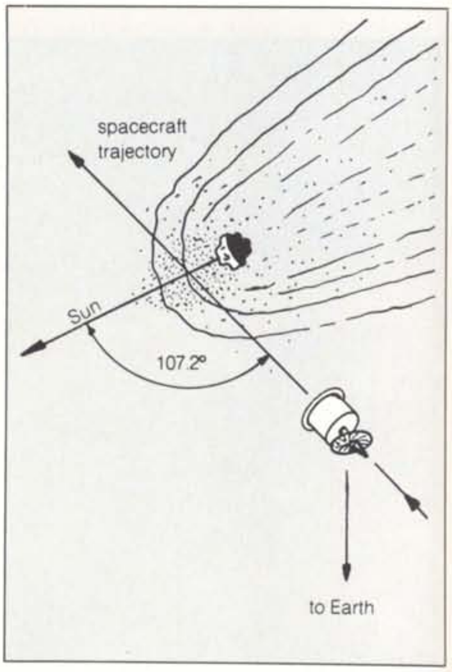
The European Giotto mission

Mission description

The Giotto mission is a fast flyby of comet Halley near the comet's post-perihelion crossing of the ecliptic plane around 13 March 1986, about 1 month after its perihelion passage. The baseline approach is a launch by Ariane in tandem with another spacecraft. During a ten-day nominal launch window in mid-July 1985, Ariane will launch the two spacecraft from Kourou, French Guiana into a geostationary transfer orbit (GTO), where spacecraft separation will take place. After some revolutions in this orbit, Giotto's onboard solid-propellant motor will be fired close to perigee to inject the spacecraft into its heliocentric transfer trajectory to Halley (Fig. 2) which lies completely in the ecliptic plane and has a closest approach to the Sun of 0.7 AU. After a cruise phase of eight months Giotto will encounter Halley's comet on 13 March 1986. At that time Halley will be 0.89 AU away from the Sun and 1 AU away from the Earth. The phase angle to the Sun will be 107.2° (see right), the flyby velocity will be 68 km/s. Giotto will be targetted at a point 500 km sunward from the nucleus, with a targetting accuracy that is of about the same order.

The flight operations can be divided into five principal phases:

- launch and GTO (from launch until leaving of the GTO)
- near-Earth (from leaving the GTO until execution of the first mid-course manoeuvre)
- cruise
- pre-encounter (from 5 d until 4 h before closest approach)
- encounter (from 4 h before closest approach until the end of the mission).



Under discussion is operation of the scientific experiments onboard the spacecraft at a reduced data rate (about 7 kbit/s) during part of the cruise and

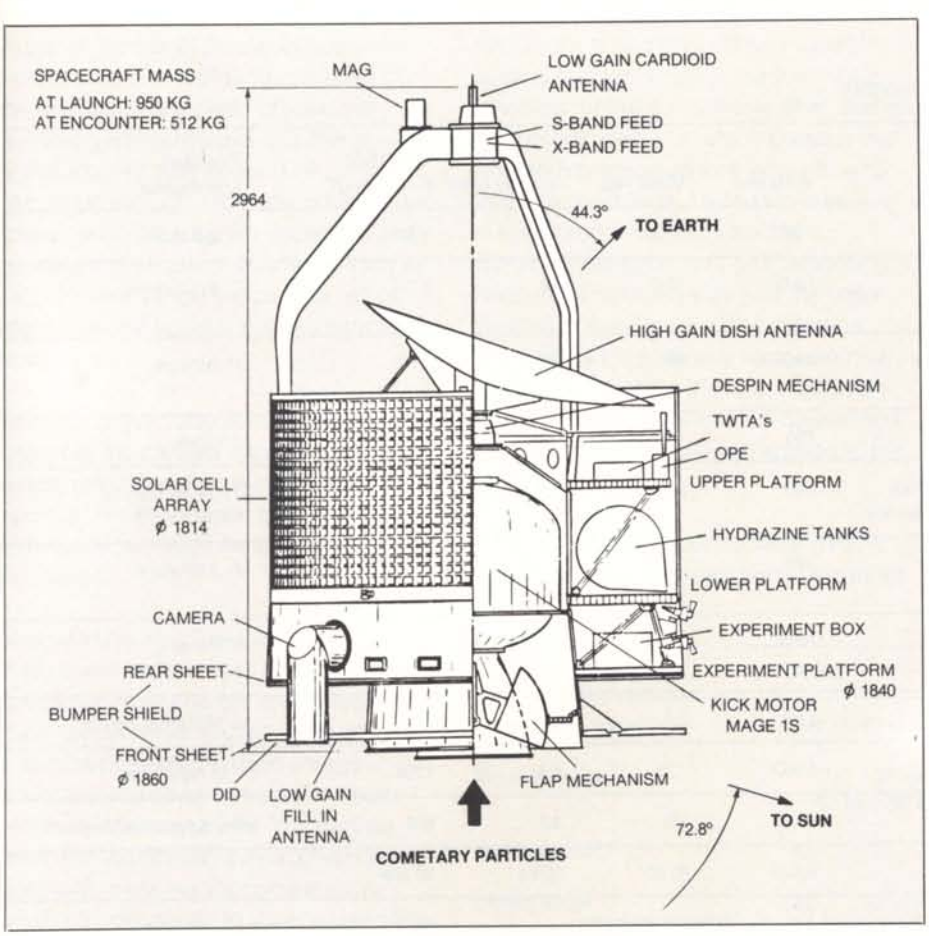


Figure 3 – Cross-section of the Giotto spacecraft, which is basically cylindrical in shape with an overall height of almost 3 m and a diameter of 1.86 m

throughout the pre-encounter phase. At encounter, the spacecraft will provide a full (40 kbit/s) science data take period of at least 4 h, starting at about $t_0 - 4$ h (t_0 = time of closest approach). In view of the potential hazard posed to the spacecraft by impacting cometary dust particles, the data will be transmitted to Earth in real time (no spacecraft memory is provided). The mission will probably end close to t_0 because spacecraft survival is unlikely beyond this point. The duration of the science-data-take period is also limited by the battery capacity and the availability of ground receiving stations.

Spacecraft system

Figure 3 shows a cross-section of the Giotto spacecraft, which is spin-stabilised, nominally at 15 rpm. During the comet encounter the spin axis will be aligned with the relative velocity vector ('relative' meaning in the comet frame of reference), i.e. cometary particle streaming is from below in Figure 3.

At launch the spacecraft will weigh 950 kg, reducing to 512 kg when the solid-propellant kick motor has burnt out and the hydrazine has been used up for the various mid-course attitude and orbit-correction manoeuvres.

The spacecraft will be protected from hypervelocity-dust-particle impacts by a dual-sheet bumper shield, composed of a thin front sheet (1 mm aluminium) and a thick rear sheet (12 mm kevlar) separated by 25 cm. Two quadrispherical shell sectors close over the kick motor nozzle after firing to complete the front sheet of the bumper shield.

The spacecraft has three equipment platforms: from top to bottom in Figure 3, the 'upper' and the 'lower' platforms carrying spacecraft equipment boxes, and the 'experiment' platform mounted on top of the rear bumper shield (with a small separation). The sensors of the Dust Impact Detector System (DID) are mounted on the front bumper shield, the Magnetometer Sensor (MAG) is mounted on the hollow carbon-fibre tripod as far away from the spacecraft and other experiment magnetic fields as possible, and the Optical Probe Experiment (OPE) is mounted on the upper platform inside the spacecraft looking rearward. All other experiment sensors and electronics boxes are mounted on the experiment platform (camera shown as example). The experiment sensors can protrude from the spacecraft side wall up to 17 cm, to allow measurements in the undisturbed flow of cometary particles.

A solar-cell array will provide 190 W of power during the encounter, which is not quite sufficient when one of the two redundant X-band travelling-wave-tube amplifiers (TWTAs) (78 W), all other spacecraft subsystems (70 W), and all experiments (51 W + 11 W margin) are switched on. Four batteries (silver cadmium; 16 Ah, 14 cells each) are required in addition, not only to bridge this gap in power, but also to provide full power during the last part of the encounter should the solar cells' power output deteriorate as a result of dust-particle impacts.

The spacecraft main antenna is a high-gain dish antenna (HGA) with an effective reflector diameter of 1.47 m. The HGA can be operated in either S-band (2.1 GHz uplink, 2.3 GHz downlink) or X-band (8.4 GHz downlink). The HGA beam is inclined at 44.3° with respect to the spacecraft spin axis and despun so that it points permanently at the Earth during the encounter. The pointing requirements in the X-band are rather stringent: if during the encounter the spacecraft spin axis is not well aligned with the spacecraft relative-velocity vector, or if the spacecraft attitude changes as a result of the impact of a large dust particle, the telemetry link to the ground receiving station may be lost (antenna gain decreases by 3 dB for 0.8° misalignment in X-band and 3° in S-band). For operations in the GTO and near Earth, two low-gain antennas operating in S-band are used. These are located at either end of the spacecraft: a cardioid antenna at the upper end of the carbon-fibre tripod, a fill-in antenna (microstrip patch) flush-mounted on the front bumper shield.

The X-band link budget shows that 40 kbit/s can be achieved during the encounter even if a 5 dB weather margin (rain at the receiving station) is included. During its cruise phase the spacecraft will be controlled from the European Space Operations Centre (ESOC) in Darmstadt, Germany, using the 30 m antenna at Weilheim. For the Halley encounter, the Australian CSIRO Institute has offered the use of its 64 m antenna at Parkes, which is normally used for radio astronomy. This antenna will be linked via a communications satellite to ESOC, where quick-look data, including the first images of the nucleus, will be available during the encounter.

Scientific payload

The scientific objectives of the Giotto mission are:

- *to provide the elemental and isotopic composition of the volatile components in the cometary coma, in particular to identify the parent molecules*
- *to characterise the physical processes and chemical reactions that occur in the cometary atmosphere and ionosphere*
- *to determine the elemental and isotopic composition of the cometary dust particles*
- *to measure the total gas production rate and the dust flux and size/mass distribution and to derive the dust-to-gas ratio*
- *to investigate the macroscopic system of plasma flows resulting from the interaction between the cometary and the solar-wind plasma*
- *to provide numerous images of the comet nucleus with a resolution down to 50 m. From these the nucleus size and rotation may be deduced and its mass may be estimated.*

An intense Earth-based observation programme is a natural and necessary complement to the Giotto mission.

To accomplish these objectives the Giotto spacecraft will carry 10 scientific experiments, which are listed in Table 2 together with their mass/energy/data-rate allocations as of September 1981. A brief description of the experiment principles, together with some key performance data, is given below.

Table 2 – Summary of Giotto scientific experiments

Experiment		Acronym	Mass (kg)	Energy (Wh)*	Data Rate F_1/F_2 (bps)**	Principal Investigator
Camera		HMC	10.2	42	19971	H.U. Keller
Neutral Mass Spectrometer	M-Analyser E-Analyser	NMS	10.0	36	4121	D. Krankowsky
Ion Mass Spectrometer	High-Energy-Range Spectrometer High-Intensity Spectrometer	IMS	8.2	36	3170	H. Balsiger
Dust Mass Spectrometer		PIA	10.0	45.6	2853/5706	J. Kissel
Dust Impact Detector System	Meteoroid Shield Momentum Sensor Impact Plasma and Momentum Sensor	DID	2.0	7.2	317/951	J.A.M. McDonnell
Plasma Analysis 1	Fast Ion Sensor Implanted Ion Sensor	JPA	3.6	14.4	4121/1268	A. Johnstone
Plasma Analysis 2	Electron Electrostatic Analyser Positive Ion Cluster Comp. Anal.	RPA	2.6	12	2536/1902	H. Rème
Energetic Particles		EPA	0.4	2.0	317	S. McKenna-Lawlor
Magnetometer		MAG	1.25	4.8	1268	F.M. Neubauer
Optical Probe Experiment		OPE	1.0	4.4	634	A.C. Levasseur-Regourd
		Totals	49.25	204.4	39 308	

* Based on a 4 h encounter ** Format 1: from switch-on until – 1 h Format 2: thereafter

Halley Multicolour Camera
The camera telescope, a modified Ritchey-Chrétien design with correcting *field lens, has a focal length of 1 m (f/6)* and a field of view of 2.3°. The camera is mounted inside the spacecraft and therefore protected from direct dust-particle impacts. Only a 45° deflecting mirror, which is used to look at the comet, and a 450 mm long baffle, assuring adequate reduction of diffuse sunlight and spacecraft-reflected light, are exposed to the dust. The telescope images onto a focal-plane arrangement of one linear detector (Reticon with 2 × 936 pixels, pixel size 30 micron × 370 microns) and two area CCDs (each having two segments of 328 × 292 pixels, pixel size 22 microns × 22 microns).

The long linear CCD is used to detect the nucleus and later to clock the two area CCDs. The latter are used in a mode in which only one active line scans the image of the comet during its apparent motion across the rotating (because of the spacecraft spin) field of view; the remaining lines are used as a low-power, highly efficient data buffer. The camera can rotate through 180°, which allows it to follow the nucleus during approach and to image it even after the flyby. Already at 1400 km slant range the camera will be able to resolve nucleus surface structures down to 30 m.

By imaging the nucleus from different distances the camera will also provide the spacecraft trajectory relative to the nucleus, this information being needed by all other experiments for later data evaluation.

Neutral Mass Spectrometer
In the lower mass range (1–36 amu) a double-focussing (angle and energy) mass spectrometer is used, consisting of a parallel-plate electrostatic energy analyser followed by a magnetic-sector-field momentum analyser. The particle beam is imaged onto a microchannel plate with linear readout where each position corresponds to a particular mass.

The energy information which is lost in the 'M-analyser' is provided by the 'E-analyser', which is simply a parallel-plate *electrostatic analyser with single* focussing (angle) properties covering the energy range 20–2110 eV. This corresponds to a mass range of 1–86 amu for cold neutrals. Again, the particle beam is imaged onto a microchannel plate with linear readout, where each position corresponds to a particular energy. For analysis the beam of cometary neutrals first has to be transformed into a beam of ions, which is achieved by bombardment with an electron beam. The M-analyser has a mass resolution of 0.25 amu, the integration time is 1.4 s; a density range from 10 to 10^7 cm^{-3} is covered.

Ion Mass Spectrometer
The High Energy Range Spectrometer (HERS) consists of an electrostatic mirror to deflect the cometary ions into the instrument, a pair of grids with variable applied voltage, a sector magnet which serves as momentum/charge filter, and an electrostatic deflector which spreads the momentum-analysed ions according to their energy/charge. The beam is then imaged onto a two-dimensional microchannel plate, with one dimension a measure of mass/charge and the other dimension a measure of the elevation angle of the ion's velocity vector. Azimuth angle is scanned by the spacecraft spin and the energy distribution is determined by variation of the voltages applied to the pair of grids.

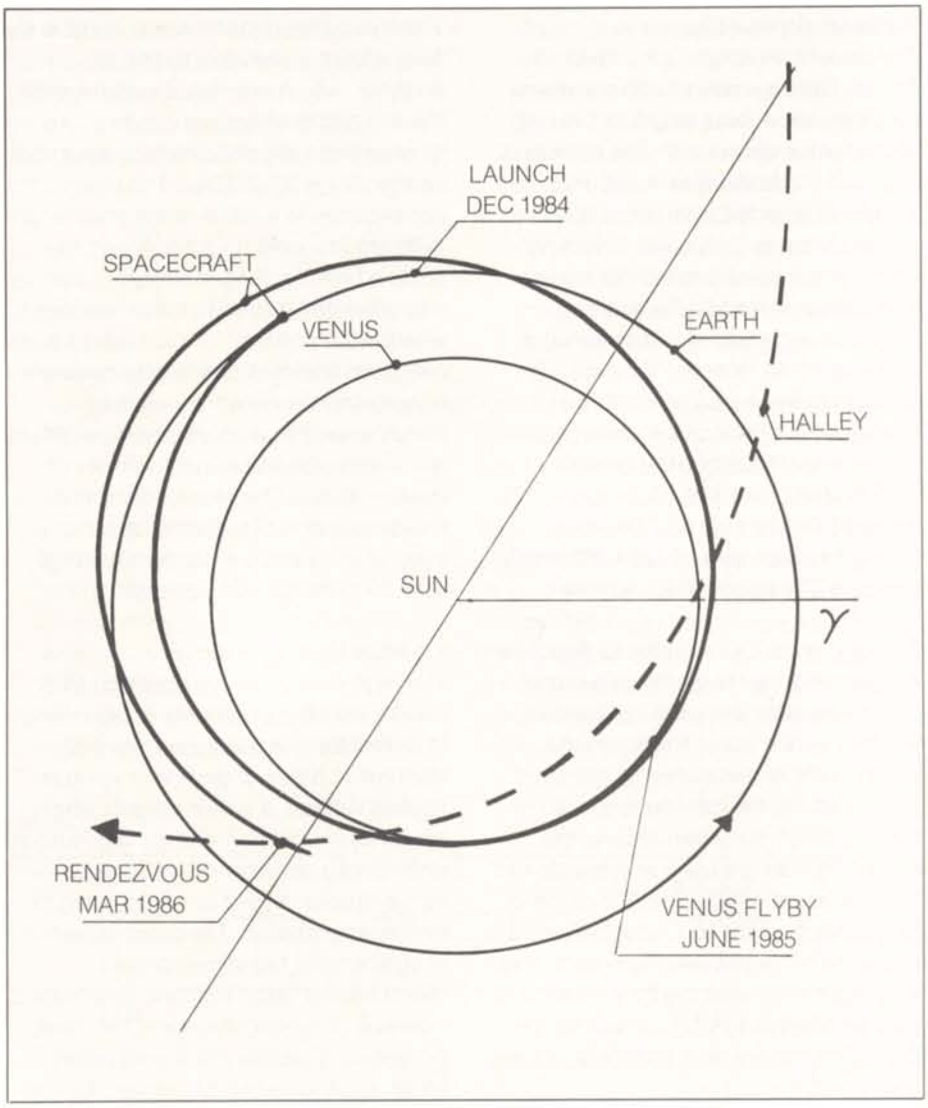
The High Intensity Spectrometer (HIS) is mainly intended for operation in the inner coma region where high fluxes of relatively cold cometary ions are expected. The sensor consists of two *quadrispherical analysers with a magnet* in between to disperse the ions according to their momentum/charge.

Dust Mass Spectrometer
This instrument measures the chemical and isotopic compositions of individual dust particles. Upon impact of a dust particle on the instrument's target area (area variable from 5 cm² down to 1 mm²), a plasma is generated from which ions are extracted and accelerated via a 1.5 kV acceleration grid. The accelerated ions fly through a time-of-flight tube ~1 m long where they are separated in time according to their mass. The spectrum of elements of which the dust particle is composed is recorded by an electron multiplier at the end of the drift path. The time-of-flight tube actually consists of two tubes at an angle of 10°, with an ion reflector between, used for energy focussing. The achievable mass resolution over the complete mass range from 1 to 110 amu is sufficient to resolve two peaks at m and m + 1 if their relative intensities are as large as 1:50. The instrument will predominantly analyse the most common dust particles, which are expected to be in the mass range $10^{-14} - 10^{-10}$g.

Dust Impact Detector System
Impacts of large dust particles on the bumper shield (area 2 m²) are detected by three microphones mounted 120° apart at the outer edge of the front sheet and a fourth microphone which is mounted on the rear sheet and detects dust particles

Sensor characteristics	HERS	HIS
Mass/charge range	1–4, 12–65 amu/q	12–65 amu/q
Elevation range	− 1° to + 25° (mirror on) + 45° to + 75° (mirror off)	− 13.5° to + 13.5°
Time resolution	12 s	4 s
Density range	$10^{-3} - 10^{2}$ cm^{-3}	$10^{-2} - 10^{4}$ cm^{-3}

Figure 4 — Flight trajectories for the two Venera-Halley spacecraft. They intercept Halley's comet after one and a half revolutions around the Sun



that have penetrated the front sheet (penetration limit 3×10^{-7}g).

Very small dust particles down to 10^{-17}g will be detected by an impact plasma detector, which has high counting rate capability and is also located on the front sheet of the bumper shield. An estimate on the dust particle's bulk density is obtained by covering half of the detector array with a metallised mylar penetration film several microns thick.

Plasma Experiments
The interaction of the solar wind with the cometary ionosphere is to be investigated by a variety of plasma experiments:

1. A 'Fast Ion Sensor' measures the three-dimensional velocity distribution of positive ions coming predominantly from the solar-wind direction in the energy range 10 eV – 20 keV.
2. An 'Implanted Ion Sensor' measures cometary ions with energies of up to 70 keV and masses of up to 44 amu implanted in the solar wind. Some cometary neutrals can travel large distances from the nucleus before they are ionised by charge exchange or photo-ionisation.
3. An 'Electron Electrostatic Analyser' measures the pitch-angle distributions for suprathermal electrons in the energy range 0.01–30 keV.
4. A 'Positive Ion Cluster Composition Analyser' measures positive ions and positive clathrate hydrates $R^+ \cdot (H_2O)_m$ up to masses >200 amu in the innermost part of the coma.

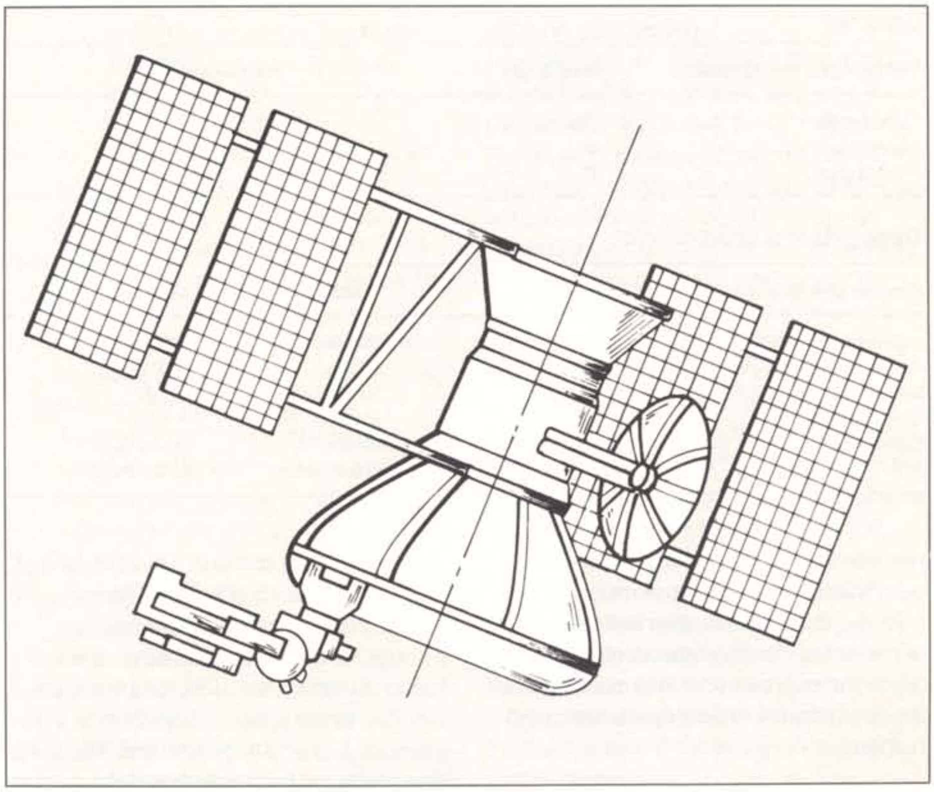
These instruments all use electrostatic analysers with different geometries (hemispherical or quadrispherical) and channeltrons or microchannel plates as detecting devices.

The group of plasma experiments is completed by:

5. A triaxial ring-core fluxgate 'Magnetometer', which is mounted on the antenna tripod and can measure the ambient magnetic field (30 vectors/s) over a wide range (0.004–65536 nT).
6. An 'Energetic Particles Experiment', which consists of a stack of three circular solid-state detectors, measuring higher energy particles (electrons ≥30 keV, protons ≥100 keV and particles with $Z \geq 2$ and ≥2.1 MeV).

Optical Probe Experiment
For a photopolarimeter aimed tangentially to the spacecraft orbit, inversion of the brightness integral is rigorous and, without any assumptions, provides in-situ observations of the local spatial density of dust and gas and of the scattering properties of dust grains. The photopolarimeter uses a small refracting photometer with an objective lens 18 mm in diameter, eight interference filters, two spectrally matching polaroid foils and a microchannel plate for spectral analysis. The rotation of the polaroid analysers needed to determine the polarisation is provided by the spin of the spacecraft. The dust will be observed in four spectral bands which are free or almost free of gaseous emissions. Simultaneously, the discrete gaseous emissions of OH, CN, C_2 and CO^+ will be observed.

Figure 5 – The Venera-Halley spacecraft. The automatic pointing platform carrying nucleus pointing experiments is shown on the bottom left



[The Giotto scientific experiments are described in more detail in ESA Special Publication SP-169, available from ESA Scientific & Technical Publications Branch (see page 104 for address)].

The Russian Venera-Halley mission
The following description of the Soviet mission to Halley's comet is mainly based on a paper by Sagdeev et al*.

Mission description
The Soviet mission to Halley's comet is a combined Venus-swingby/Halley-flyby mission. Two identical spacecraft will be launched during the period 22–28 December 1984. After carrying Venus entry probes to the vicinity of Venus (arrival and deployment of probes 14–22 June 1985), the two spacecraft will be retargetted using a Venus gravity field assistance to intercept Halley in March 1986. The first spacecraft will encounter Halley's comet on 8 March 1986, and the second about a week later. The heliocentric trajectory is shown in Figure 4.

The flyby velocity will be 77.7 km/s. Although the spacecraft can be targetted with a precision of ~100 km, the position of the spacecraft relative to the comet nucleus might possibly only be known to within a few thousand kilometres. This, together with the problem of dust protection, could lead to flyby distances of around 10 000 km for the first and 3000 km for the second spacecraft.

Spacecraft system
The spacecraft (Fig. 5) is three-axis stabilised. Its main features are large solar panels, a high-gain antenna dish, and an automatic pointing platform carrying those experiments that require pointing at the comet nucleus.

The automatic platform can rotate through ±110° and ±40° in two perpendicular directions with a pointing accuracy of ±5' and a stability of $\pm 1' s^{-1}$. It will carry the narrow- and the wide-angle camera, the three-channel spectrometer and the infrared sounder. All other experiments are body mounted, with the exception of two magnetometer sensors and various plasma probes and plasma wave analysers which are mounted on a 5 m boom.

The total scientific payload will weigh 125 kg and a data rate of 65 kbit/s is envisaged (see Table 3). The comet-encounter science data take is from 2.5 h before until 0.5 h after closest approach, with several periods of data take before and thereafter, each lasting about 2 h. Continuous coverage for plasma instruments is provided by an onboard memory (5–10 Mbit tape recorder). The spacecraft is shielded from hypervelocity dust impacts by a shield consisting of a 100 micron multilayer sheet, 20–30 cm from the spacecraft, and a 1 mm Al sheet, 5–10 cm from the spacecraft.

Scientific payload
Wide- and Narrow-Angle Cameras
The wide-angle camera is used for large-scale coma imaging and as a guide for the narrow-angle camera.

Both cameras use CCDs with about 500 × 500 pixels each as detecting devices in the focal plane. The combined data rate for the two cameras is 48 kbit/s, which is not sufficient to transmit the full contents of the CCDs. Only a 'window' one tenth of the area of the CCD, around the centre of brightness, will be transmitted. The exposure time must be kept short to keep image blur to a minimum; on the other hand it cannot be less than 0.01 s if good sensitivity is to be achieved. The narrow-angle camera can resolve nucleus surface structures down to 200 m from a distance of 10 000 km. It is planned to use a set of six replaceable filters with a relatively wide (~80 nm) passband in the

* R.Z. Sagdeev, G.A. Skuridin, A.A. Galeev, V.I. Moroz, V.I. Shevchenko, V.D. Shapiro, B.S. Novikov, G.A. Avanesov, T.A. Chugarinova, P.E. El'yasberg, A.A. Suhanov and S.N. Rodionov. On encounter with comet Halley in 1986 (Strategy of Studying). Preprint IAF-81-200. IAF, Rome, Italy, September 6–12, 1981.

Cameras

Performance characteristics	Wide angle	Narrow angle
Focal length	100 mm	1200 mm
f-number	f/2	f/6
Field of view	4°	0.5°

Three-Channel Spectrometer

Channel characteristics	UV	Visible	Infrared
Wavelength (nm)	120–350	350–900	900–2000
Spectral resolution (Å)	5	10	100–120
Sensitivity (Rayleigh)	3	10	3×10^4
Spatial resolution	3′×6′	3′×6′	6′×60′
Detecting device	micro-channeltron	micro-channeltron	germanium photodiode

narrow-angle camera. In addition to the pure scientific objectives of imaging the nucleus, the cameras also have the task of providing the information needed to guide the platform and information about the spacecraft's trajectory relative to the nucleus.

Three-Channel Spectrometer
This experiment is intended for:
- spectral and polarisation studies of the dust
- spectral mapping of the coma
- determination of the outflow rates of various gases and their content.

The instrument has a Cassegrain-type telescope with a focal length of 500 mm and an objective diameter of 140 mm. The light flux passes through three 1° slits located in the focal plane to three independent spectroscopic channels.

Infrared Sounder
The instrument's scientific objectives are to determine:

- the size, radiation capacity and temperature of the nucleus
- the nature, density, distribution and temperature of the dust
- the nature, relative content and temperature of the parent molecules.

The instrument has a Cassegrain-type telescope with a focal length of 500 mm, a diameter of 140 mm and a field of view of 1°. The radiation flux is separated into three beams, each of which passes through its own filter located on a wheel (up to 20 rpm). Two of the channels are devoted to the spectroscopic mode in the intervals 4–8 and 8–16 microns. The third channel is devoted to nucleus imaging at 7–14 microns. Three HgCdTe photoconductors cooled by liquid nitrogen to 80 K are envisaged as detecting devices.

Dust Mass Spectrometer
This instrument is mounted parallel to the relative velocity vector and analyses the chemical and isotopic composition of individual dust particles. Impact of a dust particle on the instrument's target area causes a plasma to be formed consisting of dust and target material, from which ions are extracted by a 1.5 kV electric field. The ions travel through a time-of-flight tube (actually two tubes with an electrostatic reflector between, total length ~1 m) where they are separated according to their mass before being recorded by an electron multiplier. The mass range is 1–110 amu, with resolution $m/\Delta m = 200$. The instrument will observe the spectra of the most common dust particles, which are expected to be in the size range 0.1–10 microns.

Dust Counter
Three detectors (piezo-elements) mounted on a special metallic plate

Table 3 — The Venera-Halley mission scientific payload (as of July 1981) after Crifo (1981)

Instruments	Weight, kg	Power, W	Telemetry allocation, kbit/s
Pointed			
Visible-light camera (narrow angle & wide angle)	25	50	33
Three-channel spectrometer	12	25	16
Infrared sounder	15	14	2
Pointing platform	25	65	0.5
Subtotal	77	154	51.5
Body mounted			
Dust composition analyser	12.5	22	7
Dust-impact counter	4	4	1
Plasma analyser	7.5	19	3
Magnetometer	4	4	0.5
Low-frequency wave analyser	2.5	4.5	1.5
High-frequency wave analyser	2.5	2.5	0.5
Subtotal	32.5	56	13.5
Command and data-management system	16	16	–
Total	125.5	226	65

measure the amplitude of the wave generated by dust particles $>10^{-10}$g impacting on that plate. The amplitude is proportional to the mass of the dust particle. From the arrival time of the pulse at the three detectors, the coordinates of the impact point can be determined. This method can be improved if instead of one plate the multilayer system used for spacecraft protection is used with three detectors in each layer to increase the range of measurable mass distribution. The dead time of the instrument depends on the acoustic decay of the signal in piezo-elements and can turn out to be significant.

Plasma Experiments

1. A 'Neutral Mass Spectrometer' will measure the elemental and isotopic compositions of the neutral gases in the coma.
2. Ions and electrons will be measured by an 'Ion Mass Spectrometer and Electron Analyser' consisting of three sensors:
   - An ion spectrometer oriented *parallel to the relative-velocity vector* covers the energy range 15–25 000 eV with a resolution $E/\Delta E \sim 25$ and an angular aperture of 40°. Provided the thermal velocities of the cometary ions are considerably lower than the encounter velocity, a mass spectrum in the range 1–100 amu can be obtained. The ion density threshold is 10^{-3}cm^{-3} and the dynamic range 10^6.
   - An ion spectrometer oriented *towards the Sun* covers the energy range 50–25 000 eV with a resolution $E/\Delta E \sim 25$ and an angular aperture of 40°. This sensor is intended for measuring basic parameters of the solar-wind ion flows and the transition layer plasma. The flow threshold value is 10^5 (cm^2 s sr)$^{-1}$ and the dynamic range 10^5.
   - A single-channel electron analyser will measure electrons in the energy range 3–5000 eV. The sensor has an angular aperture of ±5°.
3. An 'Energetic Particles' experiment will measure accelerated cometary ions in the energy range 20 keV – 20 MeV. The field of view is 30°, and the detector is oriented in the ecliptic plane.
4. A 'Magnetometer' will measure the constant component of the magnetic field and its low-frequency fluctuations in the cometary and solar-wind interaction zone and in interplanetary space. The instrument consists of two sensor units mounted 1.5 m apart on a 5 m boom.
5. Two 'Wave Analysers' will monitor waves excited in the cometary environment, in particular the low hybrid ($\sim$10 Hz), ion cyclotron ($\sim$1 Hz), and plasma waves ($\sim$100 KHz), to study
   - the mechanism of anomalously high ionisation of cometary gas
   - the shock-front structure
   - the phenomena in the contact-surface region (ionopause).

   One experiment has a frequency range 0.1–1000 Hz. A twin-probe technique is used to measure the potential difference between two probes placed on the 5 m boom isolated from the spacecraft. The plasma flow fluctuations are measured with a Faraday cup at the boom's tip.
   The other wave experiment has a frequency range 0–300 kHz and a dynamic range of 70 dB. In addition, a Langmuir probe will measure cometary plasma density (10–10^5 cm^{-3}) and temperature (0.1–10 eV).

The Japanese Planet-A mission

The following summary has been extracted from an ISAS Planet-A status report*.

* Planet-A, Japanese First Interplanetary Flight (Status report), Institute of Space and Aeronautical Science (ISAS), Tokyo, November 1980.

Mission description

The Institute of Space and Astronautical Science (ISAS) in Tokyo is planning to send a scientific probe, tentatively called Planet-A, to Halley's comet in 1986. A test spacecraft, tentatively designated MS-T5, will be launched six months earlier to prove the capability of the launch vehicle, new techniques such as velocity and attitude controls, and deep-space communications capabilities.

The Planet-A encounter with Halley will take place on 8 March 1986. At that time MS-T5 will be about 0.1 AU away from the comet, which will also be about its closest distance to Halley. Figure 6 shows the trajectories of both spacecraft. In view of its flyby distance and instrumentation, MS-T5 has more the character of an 'interplanetary' mission; only Planet-A has the character of a 'cometary' mission. The major emphasis here will therefore be on the description of the Planet-A mission and spacecraft.

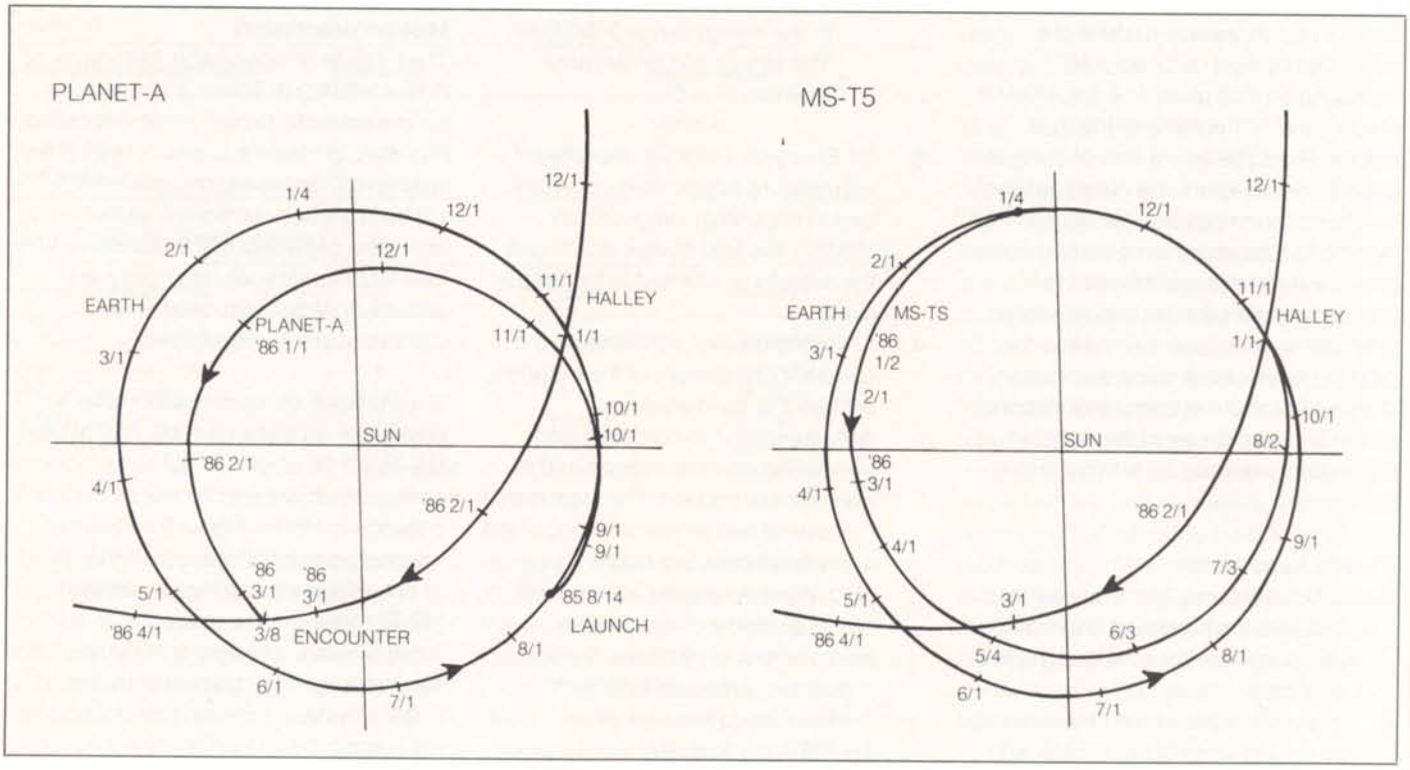
Planet-A will be launched from the Kagoshima Space Centre, in southern Japan, on 14 August 1985 by a three-stage Mu-3U rocket. To inject the Planet-A spacecraft, a fourth-stage kick motor with about 400 kg of propellant will be added. Direct injection without parking is to be employed, the spin-stabilised third stage and the kick stage being fired serially near the apogee of the second-stage trajectory. As the injection error will be unknown until after the launch and the orbit-control capabilities of the on-board attitude and velocity control system are limited by the amount of hydrazine carried, the Planet-A spacecraft cannot be precisely targetted at the comet nucleus. It is estimated that the spacecraft flyby distance will be between 10 000 and 100 000 km.

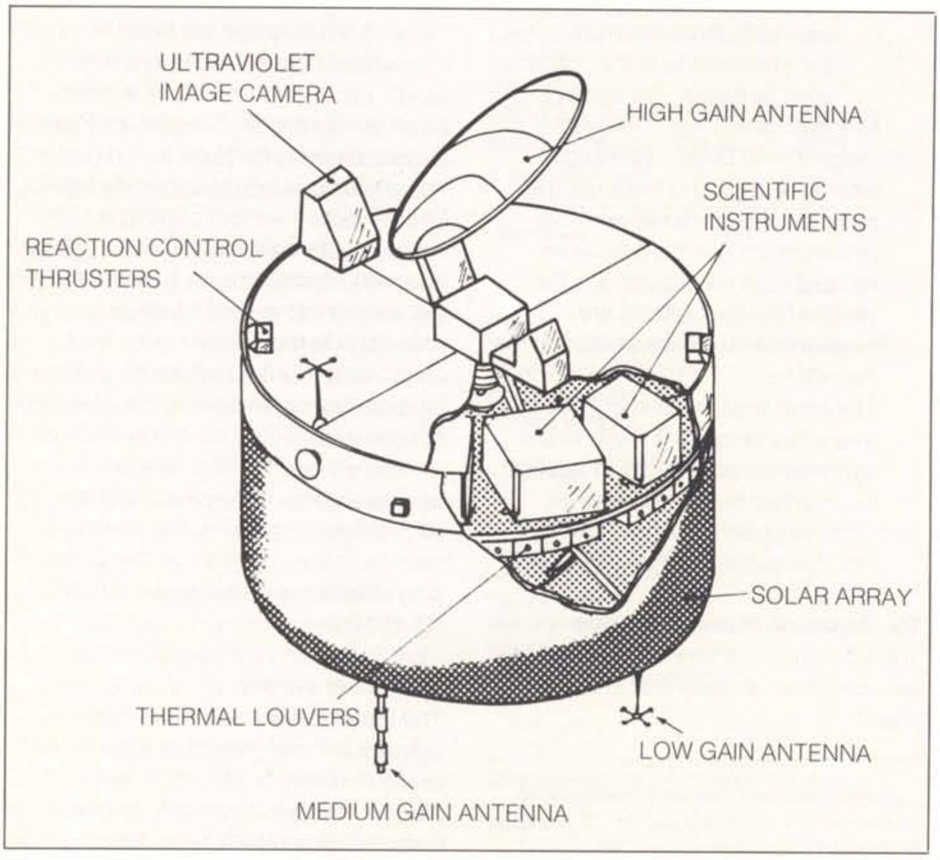
Spacecraft system

The Planet-A spacecraft (Fig. 7) is cylindrical in shape, with a height of 70 cm and a diameter of 140 cm. At launch it weighs 135 kg, including 10 kg of scientific instruments and 5 kg for hydrazine for the

Figure 6 – The Planet-A (left) and MS-T5 spacecraft heliocentric trajectories. The Planet-A encounter with Halley will take place on 8 March 1986. MS-T5 will be launched on 31 December 1984; only the last part of its orbit is shown, from 2 January 1986 onwards

Figure 7 – The Planet-A spacecraft. It is cylindrical in shape, with a height of 0.70 m and a diameter of 1.4 m; it weighs 135 kg





attitude and velocity control system. Planet-A is spin-stabilised, nominally at 5 rpm, and has a despun, high-gain dish antenna which points permanently at the Earth. Before taking photographs with the UV (Lyman-α) camera, the spin is reduced to ~0.2 rpm by running up a bias momentum wheel to stabilise spacecraft attitude. During this phase, only uplink communication is possible and imaging data are stored in a magnetic bubble memory. They are transmitted to Earth after the spacecraft is spun up again to 5 rpm. During both phases, the spin axis is controlled to be perpendicular to the ecliptic plane.

The attitude and velocity control system consists of two fully redundant Sun sensors, only one of which is active at a time, a star scanner with two light-sensitive slits, a momentum wheel with an angular momentum of 20 Nm s at 3300 rpm, and a gas-jet subsystem consisting of six body-fixed thrusters. Two thrusters are mounted axially, four are canted on the top side of the spacecraft. They apply spacecraft torques as couples, and have redundant operational modes. Nitrogen is used as pressurant gas, and hydrazine as fuel.

A solar-cell array provides 82 W at a heliocentric distance of 0.83 AU (where the encounter takes place) for 90° solar aspect angle. A battery consisting of 15 nickel-cadmium cells is needed in addition during periods of peak power. Each cell has a nominal capacity of 2 Ah.

Planet-A has four antennas: a high gain, a medium gain, and a pair of low gain antennas located at both ends of the spacecraft. All antennas are operated in the frequency range 2050–2350 MHz (S-band). The despun high-gain antenna is an offset-parabolic reflector with 80 cm diameter used for telemetry transmission, command reception and ranging over large distances. The medium-gain antenna is a broadside array with three co-linear elements with a pancake beam pattern used as a backup for the high-gain antenna. The low-gain antennas, having an omnidirectional pattern, are used when the spacecraft is near the Earth. Data are transmitted to the ground at two data rates: 1024 bit/s without coding and 64 bit/s with coding.

The data will be received by a 64 m ground station to be constructed in Japan.

Scientific payload

The scientific objectives of the Planet-A mission are:

- *to observe the growing and decaying processes of the hydrogen corona around Halley's comet by taking a series of Lyman-α pictures on several tens of days before and after perihelion*
- *to observe the velocity of the expanding hydrogen atoms from which the formation mechanism(s) of the atoms can be deduced*
- *to measure the solar-wind flux intensity, energy spectrum and the angular distribution in the vicinity of the comet, since the solar wind, in particular a shock front, can cause a turbulent structure in the cometary coma or in the plasma tail.*

The scientific objectives are addressed by two experiments which are briefly discussed below.

UV (Lyman-α) Camera

The camera is composed of the image-forming element (vacuum ultraviolet telescopic mirror lens), image detector (CCD with 125 × 150 pixels), and controlling electronics including a microprocessor. The camera has a 2.5° square field of view and a resolution of 1′ (corresponding to 30 km from 100 000 km). Since the expected signal of the resonant fluorescent Lyman-α emission above the background interplanetary hydrogen glow is very low and a sufficient signal-to-noise ratio is difficult to achieve on a spinning spacecraft, the spacecraft spin is reduced from 5 rpm to 0.2 rpm when taking photographs. To prevent the image blur associated with spacecraft spin, the electronic charge on the CCD is shifted in synchronism with the apparent motion of the image on the CCD caused by the spinning spacecraft. It is possible to integrate the electronic charge in the CCD up to about 1 s, by this spinning synchronised charge shift. The image data read out from the CCD are converted to digital form and stored temporarily in the buffer memory. The microprocessor reads out the image data from the buffer memory and stores them in compressed form in the main memory before they are transmitted to the ground at 50 bit/s.

Solar-Wind Analyser

The aim of the experiment is to measure the three-dimensional distribution of the solar-wind plasma within ±30° of the ecliptic plane. The experiment consists of two 270° spherical electrostatic analysers for electrons and ions, respectively, covering the energy range 30 eV – 16 keV in 96 steps. A microchannel plate is used as the detecting device; it is split into five parts to provide a 12° angular resolution in the polar direction. The azimuthal resolution is 5.6° within ±22.5° of the solar-wind direction and 22.5° in other directions. The experiment is operated only at the high spin rate (5 rpm). At high bit rate (1024 bit/s), observations of the three-dimensional distributions of electrons and ions are carried out continuously. It takes 288 s to complete the whole sequence of 96 energy steps. At low bit rate (64 bit/s), observation of two-dimensional distributions is carried out intermittently, every 512 s.

Problems and interests common to all missions

Optimisation of encounters and experiments

In March 1986 four spacecraft, the European Giotto spacecraft, two Soviet Venera-Halley spacecraft, and a Japanese spacecraft, will fly through Halley's coma. The coma trajectories of the four probes can be characterised by a set of five parameters, which are summarised in Table 4.

The spacecraft complement each other in that the two Venera-Halley spacecraft are three-axis stabilised, while Giotto and Planet-A are spin-stabilised. Three-axis stabilisation is more advantageous for imaging since longer integration times can be achieved, while spin-stabilisation is more advantageous for plasma experiments since an azimuthal range of 360° is provided by the spacecraft spin and full 4 π viewing is possible. The scientific experiments on the various spacecraft are summarised in Table 5, which shows that all experiments together provide the full complement of experiments that can be flown in a flyby mission (last columm). Table 5 also shows that there is a large amount of overlap between experiments on different spacecraft, providing a stimulating basis for comparing data after the encounters.

As is evident from Tables 4 and 5, there is ample scope for optimisation of the

Table 4 — Spacecraft encounters with Halley in March 1986

Spacecraft parameter	Venera-Halley 1	Planet-A	Giotto	Venera-Halley 2
Flyby date	8 March	8 March	13 March	~16 March
Heliocentric distance, AU	0.83	0.83	0.89	~0.93
Flyby velocity, km/s	77.7	~70	68.7	~77
Phase angle to Sun at which coma traversed	110°	105–110°	107.2°	~110°
Minimum distance in the orbital plane from cometary nucleus, km (+ sunward, − antisunward side)	$\sim 10^4$	10^4–10^5	+500	TBD (perhaps 3×10^3 km)
Distance above/below comet orbit plane at closest approach, km	$\sim 10^4$	10^4–10^5	TBD	TBD (perhaps 3×10^3 km)

overall encounter scenario and for useful collaborations among the experimenters before and after the launches. The missions complement each other in instrumentation and flyby distances, they extend the total time of in-situ observations in the cometary environment, and may even provide simultaneous observations from two spacecraft for some time periods.

Halley ephemeris and spacecraft navigation

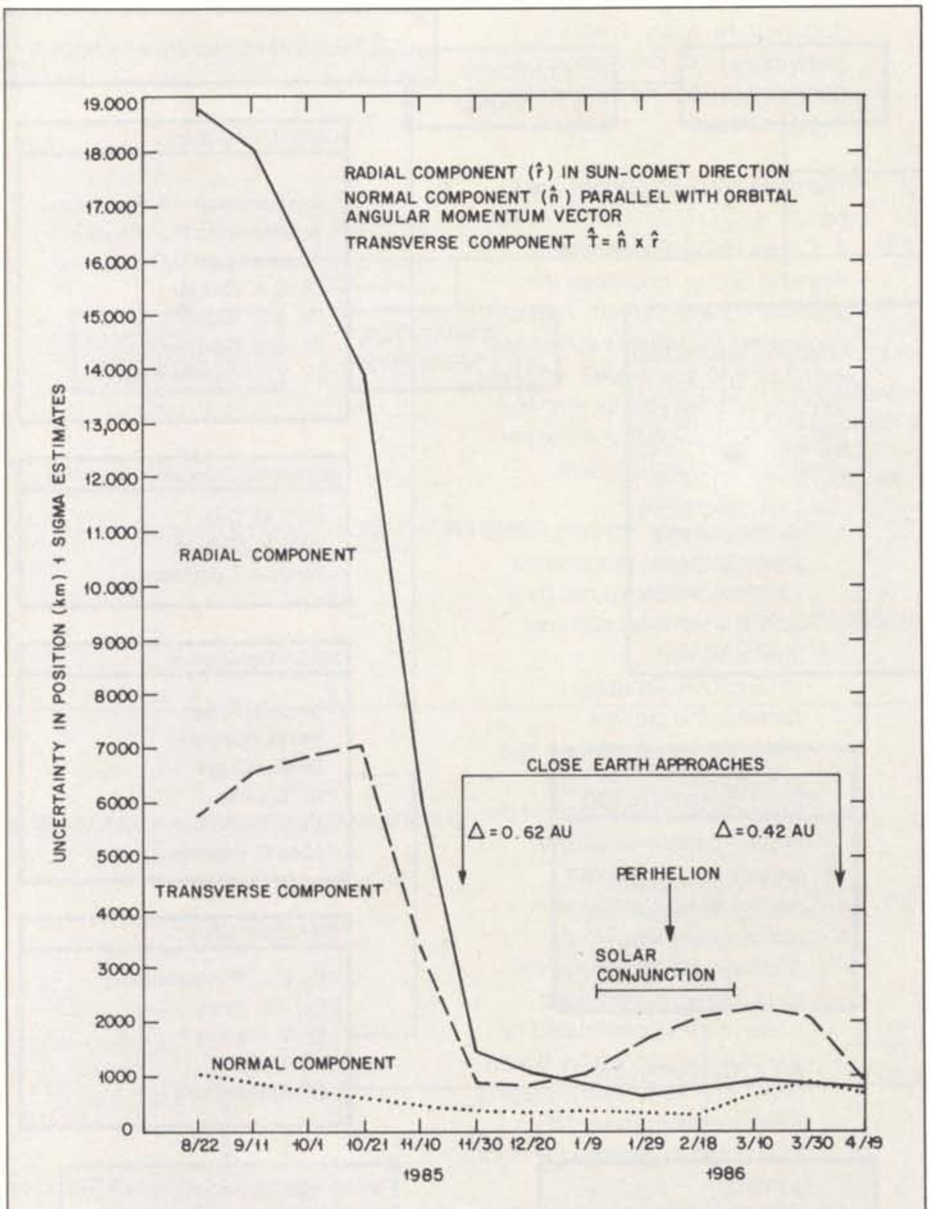
Targetting the various spacecraft to Halley's comet is considerably more difficult than targetting a spacecraft to a 'normal' object in the solar system such as a planet or asteroid, simply because the comet nucleus is too small to be seen from Earth, and when it comes close to the Sun the nucleus position is obscured by the gas and dust cloud forming the coma. Although Halley's orbit is one of the most accurately modelled including the effects of the nongravitational forces*, the estimated uncertainty in the nucleus position is at present ~100 000 km, reducing to ~30 000 km by end-1984/mid-1985 when the various spacecraft will be launched to intercept Halley's comet. Figure 8 shows how the 1 σ knowledge of the various components of the nucleus knowledge can be improved in 1985/86 through extensive observations from Earth. Without improvement of the nongravitational force model, however, the nucleus position in the coma will be known only to within 1500 km. It is hoped that through the combined efforts of a

Table 5 – Full complement of experiments

			Venera-Halley (three-axis stabilised)	Giotto (spin-stabilised)	Planet-A (spin-stabilised)	Combined complement
Remote Sensing	Camera	Wide Angle	X			X
		Narrow Angle	X	X		X
	UV Camera				X	X
	IR Sounder		X			X
	Photopolarimeter			X		X
	Three-Channel Spectrometer		X			X
In-Situ Measurements	Neutral Mass Spectrometer		X	X		X
	Ion Mass Spectrometer		X	X		X
	Dust Mass Spectrometer		X	X		X
	Dust Impact Detector		X	X		X
Plasma	Solar-Wind Ions		X	X	X	X
	Electrons		X	X	X	X
	Plasma Waves		X			X
	Energetic Particles		X	X		X
	Magnetometer		X	X		X

* D.K. Yeomans, Comet Halley – The orbital motion, *Astron. J.*, **82,** 435, 1977.

Figure 8 – Expected improvements in the 1 σ estimates of the Halley nucleus position through observations in 1985/86 (courtesy of D.K. Yeomans)



special astrometry network and further improvements in the nongravitational force model, this uncertainty can be reduced.

A significant improvement (factor 10) in the knowledge of the nucleus position could only come from the 'pathfinder concept': The first spacecraft that encounters the Halley coma would find and locate the nucleus, allowing subsequent spacecraft to be precisely targetted even without the possibility of on-board optical navigation. It is important to reach the near-nucleus environment in order to observe the 'parent molecules' and to observe certain plasma physical phenomena, such as the contact surface that separates cometary from solar-wind ions. Precise targetting is also needed for the cameras in order to achieve favourable nucleus aspect angles and optimum flyby distances.

The Halley environment

Once the spacecraft enter the coma, dust and gas particles will impact at a velocity of ~70 km/s on their leading surfaces. This leads to two problems that have never before been encountered on space flights:

- dust particles impacting at these high velocities can easily penetrate the spacecraft walls and an expanding cloud of debris inside the spacecraft would destroy it unless it is properly shielded
- impacting dust and gas particles cause the emission of secondary ions and electrons, which in turn cause a space-charge cloud, lead to a spacecraft potential, and cause a high background for the plasma analysers.

These adverse effects due to hypervelocity impacts of dust and gas have been studied to some extent in two Workshops (the Proceedings are reported in ESA publications SP-153 and SP-155). Considerably more work, however, is required to optimise the spacecraft shield design and the experiment protection and to understand the effects of the impact-generated plasma. To highlight just one problem, the shield cannot be tested against hypervelocity dust impacts on Earth in the required velocity/mass regime. The other agencies have also looked into these problems and may have found similar or quite different solutions. The overall science return would be enhanced if the best solutions could be applied in all spacecraft designs.

The basis for all calculations is a model for the Halley environment, which represents another area of common interest. In mid-1980 a joint NASA/ESA Working Group was formed to provide a 'nominal model' for the Halley environment using the best available sources of information on comets in general and Halley in particular. Considerable progress was made in 1981 and these efforts were finally 'distilled' in nine papers contained in ESA Special

Publication SP-174. Two of these papers discuss the problem of visibility of the nucleus in a dusty cometary coma and arrive at the conclusion that it is not at all certain that we will actually see the nucleus.

As has already been pointed out by Dr. E.A. Trendelenburg (see page 66), there are a considerable number of problems and interests common to all missions, which makes collaboration between the agencies concerned very useful. This inter-agency collaboration started with the first meeting in Padova in September 1981.

The Padova Inter-Agency Meeting
This first meeting was attended by 21 delegation members from the USSR Academy of Sciences, Japan's Institute of Space and Astronautical Science, NASA and ESA. Presentations were given on the missions described above and also on the NASA Halley Sample Return Mission, which was in the planning stage at that time, but later could not be funded. Topical presentations were given by specially invited experts on the problem areas outlined above and also on the International Halley Watch, an international effort to coordinate observations worldwide of Halley's comet during its next apparition.

In the subsequent general discussion all four agencies expressed their interest in inter-agency communication and agreed to cooperate in an 'Inter-Agency Consultative Group' and three Working Groups, which were defined as follows:

1. *The 'Inter-Agency Consultative Group' will informally coordinate all matters related to the space missions to Halley's comet. Members of this Consultative Group will be nominated by the four Agencies: NASA, ESA, the USSR Intercosmos and Japan's ISAS. The Consultative Group will, as a rule, meet annually. It was provisionally agreed to hold the next meeting in Budapest, Hungary, in early September 1982, preferably immediately after the IAU meeting in Patras, Greece.*

2. *The three Working Groups are to be:*

2.1 *A 'Comet Halley Environment Working Group' to provide the scientific community with a set of parameters for Halley's comet and with dust and gas models. The next meeting is scheduled for end-May 1982, to coincide with the Cospar meeting in Ottawa, Canada.*

2.2 *A 'Plasma Science Working Group'*
- *to study the various plasma physical processes resulting from the solar-wind/comet interaction*
- *to stimulate discussion between the plasma experimenters on the various spacecraft*
- *to investigate the effects of the impact-generated plasma around the spacecraft.*

2.3 *A 'Spacecraft Navigation and Mission Optimisation Group'*
- *to obtain Halley ephemeris data from ground-based observations coordinated by the International Halley Watch (IHW) and from Halley imaging experiments on-board the spacecraft to improve the flight strategy*
- *to optimise the mission profiles during the respective pre-encounters and encounters and to investigate the possibilities of simultaneous observations from two or more spacecraft and from Earth.*

Chairmen were appointed for these working groups who will nominate members in agreement with the Agencies, set meeting dates, and organise the work. A report on the activities of the working groups will be given by the Chairmen to the Inter-Agency Consultative Group at its next meeting. The Consultative Group appointed a secretary who will coordinate the activities of the working groups and provide liaison between the Agency delegations comprising the Consultative Group.

The activities of the Inter-Agency Consultative Group will be limited to coordination of all matters related to the space missions to Halley's comet. All ground-based and near-Earth Halley observations will be coordinated by the IHW.

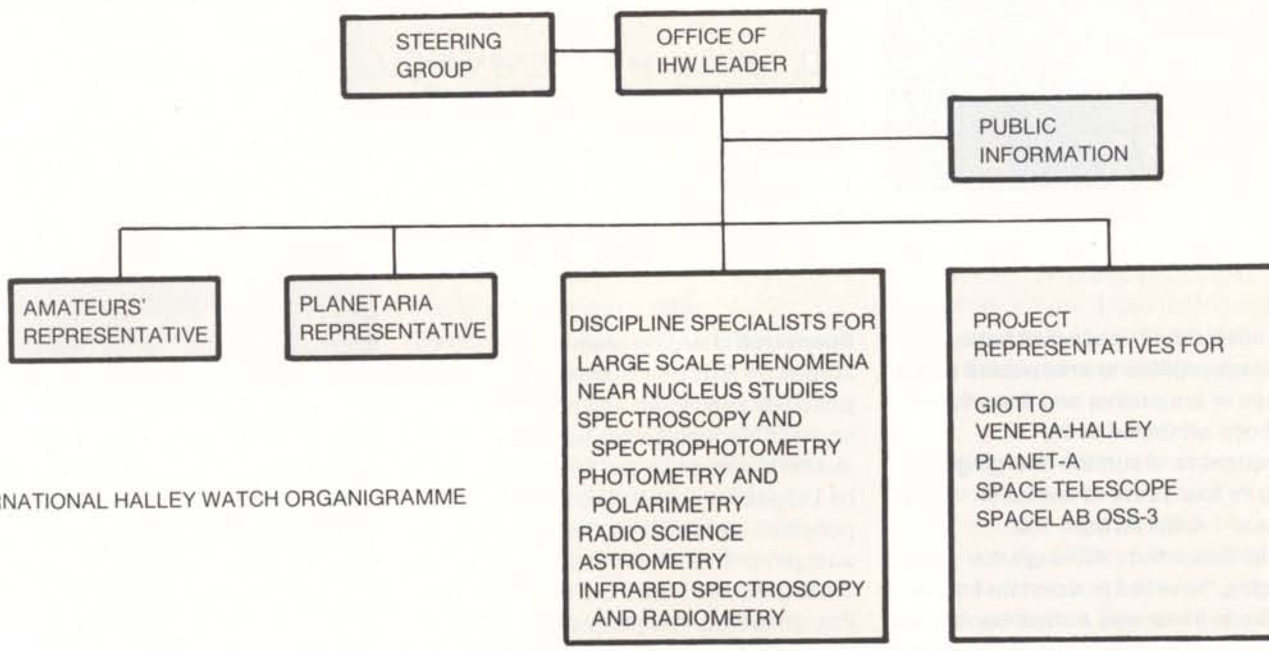
DELEGATION MEMBERS AT PADOVA

USSR Delegation:
Academician V.A. Kotelnikov
Academician R.Z. Sagdeev
Academician G.O. Gazenko
Dr. G.A. Skuridin
Dr. A.A. Galeev
Dr. G.S. Balayan
Dr. V.S. Vereshchetin

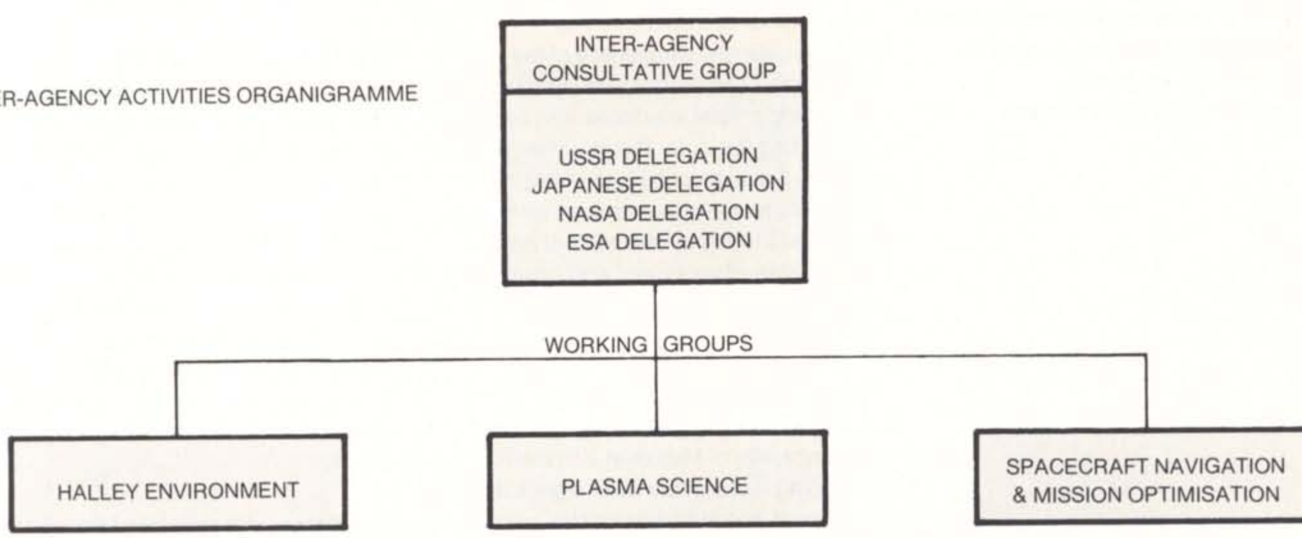
Japanese Delegation:
Prof. M. Oda
Prof. H. Matsuo
Mr. K.-I. Takahashi

NASA Delegation:
Mr. A.J. Stofan
Mr. D. Herman
Dr. G. Briggs
Dr. E. Levy
Dr. J. Beckman
Miss D. Rausch

ESA Delegation:
Dr. E.A. Trendelenburg
Dr. D.E. Page
Dr. V. Manno
Mr. D. Dale
Dr. R. Reinhard



INTERNATIONAL HALLEY WATCH ORGANIGRAMME



INTER-AGENCY ACTIVITIES ORGANIGRAMME

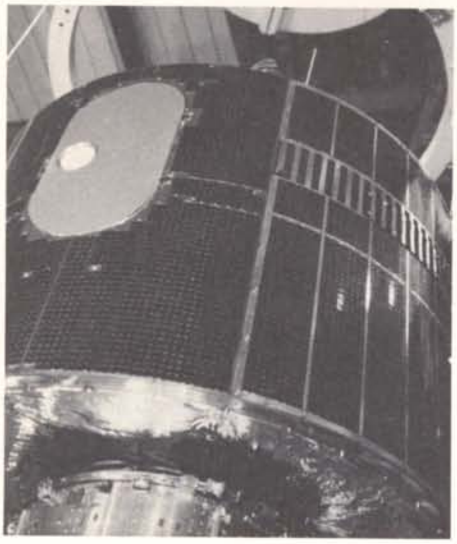
Related Publications

ESA SP-153, The Comet Halley Micrometeoroid Hazard, Proceedings of a Workshop held at ESTEC, Noordwijk, The Netherlands, 18 – 19 April 1979.

ESA SP-155, The Comet Halley Probe Plasma Environment, Proceedings of a Series of Workshops held in 1979/80.

ESA SP-169, Scientific and Experimental Aspects of the Giotto Mission, Proceedings of an International Meeting on 27/28 April 1981, Noordwijkerhout, The Netherlands.

ESA SP-174, The Comet Halley Dust and Gas Environment, Proceedings of a Joint NASA/ESA Working Group Meeting on 26/27 August 1981, Heidelberg.



First Results from Meteosat-2 Discharge Experiments

A.D. Johnstone & G.L. Wrenn, Mullard Space Science Laboratory, University College London
A. Huber, Emmanuel College, Boston, USA
D. Hoge, Meteosat Satellite Manager, ESA, Toulouse, France

Many operational spacecraft have proved susceptible to unexpected status changes or anomalies and these have often been attributed to the consequences of surface charging. During its four years of operation Meteosat-1 suffered from 150 irregularities which, although not damaging, have led to a certain loss of data. Since there was a clear correlation between occurrence of anomalies and periods of geomagnetic activity, two new instruments were included on Meteosat-2 to see if anomalies are caused by discharges resulting from magnetospheric electron fluxes.

Spacecraft charging phenomena
Irradiation tests on the Meteosat prototype spacecraft and numerous spare components after Meteosat-1's launch showed that the anomalies could be triggered by arcing from high potentials generated by the impact of charged-particle fluxes, but these investigations posed more questions than they answered. The Meteosat-2 flight model had already been built by this time, but two actions were undertaken with a view to finding a solution. The electromagnetic cleanliness of the Meteosat-2 spacecraft was improved by changing critical interfaces and by grounding the outer thermal shields to reduce the susceptibility to charging. In addition, two new instruments were included in the payload so that data on the plasma environment and internal-discharge transients would be available if the anomalies were not eliminated.

After four months in orbit and only two such status changes, it does appear that the immunity of Meteosat-2 to the charging hazard has been significantly improved, but the problem has not been completely suppressed. The question now is, do the special on-board monitors give a plausible explanation of what is happening?

The Meteosat-1 anomalies
Meteosat-1, launched in November 1977, was fully operational for its first two years in orbit. Since then, a reduced mission has been performed as a result of a malfunction in the satellite's overload protection system. Soon after Meteosat-1 operations began, it became evident that anomalous status changes were occurring occasionally within a few sensitive command interfaces, and there was evidence of a correlation with geomagnetic index. Ground simulations gave somewhat contradictory results, and could not provide a model for the mechanism that was leading to the anomalies. Most anomalies were observed during the period of full operations, but status changes have been observed even in the reduced mode.

The Meteosat-2 anomalies
Meteosat-2, launched on 19 June 1981, has shown only a small number of anomalies compared with Meteosat-1 and only two might be attributed to spacecraft charging – on days 251 and 271 (8 and 28 September). A major peak in the Fredericksburg geomagnetic index (Fig. 2) occurred on day 206 (113), and a second one on day 235 (48), but September was in fact a quiet month. Significantly, no anomaly occurred near either of these increases in geomagnetic activity.

The Meteosat-2 charging instruments
In addition to its normal payload, Meteosat-2 is carrying three special 'experiments'. One, suggested and incorporated by ESTEC Power Systems & Electronics Section, and involving a Hexfet power transistor, was conceived as a technology demonstration. So far no changes in its parameters have been detected. The other two experiments are designed to seek a correlation between the environment of the spacecraft and the electromagnetic interference within it. Energetic electrons in the neighbourhood

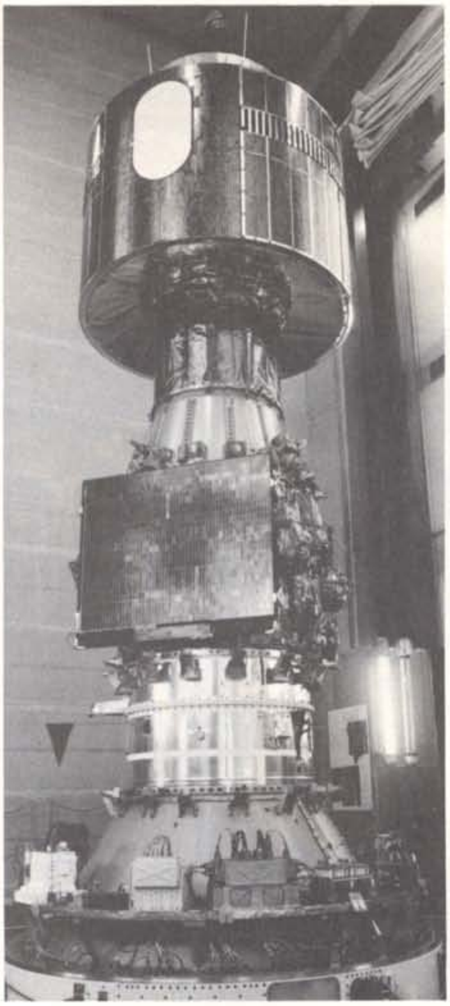


Figure 1 – Meteosat-2 being readied for launch on 19 June 1981, together with the Indian experimental communications satellite 'Apple' and the Ariane technological capsule (CAT)

Figure 2 – Record of the Fredericksburg geomagnetic index (A-index) on days 170 to 300 of 1981

of the spacecraft are being monitored by an electron spectrometer (SSJ/3, Fig. 3a) built by Emmanuel College, Boston. The electrical environment inside the spacecraft is being studied with an electrostatic event monitor (the EEM, Fig. 4), again developed and built by ESTEC Power Systems & Electronics Section.

The Electron Spectrometer (SSJ/3)
This instrument has been designed to count precipitating electrons in the energy range 50 eV–20 keV. The energy analysis is performed by a pair of electrostatic analysers employing a time-sequenced deflecting electrostatic field. Electrons entering the input aperture must have a certain energy to pass the deflecting electrostatic field of the curved plates and reach the exit aperture; this energy is proportional to the plate voltage. At the exit aperture, channeltron electron multipliers are used as detectors to provide the counting signals for the registers. The instrument provides a total of 16 energy-level counts, between 50 eV and 20 keV, by stepping the plate voltages of a low- and a high-energy channel sequentially twice per format. The output data are provided in a set of three, 16-bit data words containing four counts. Reduction of these data into 16-point energy spectra and production of suitable displays required a special processing arrangement.

Although the SSJ/3 instrument is fairly small and has a very low power consumption, it was quite difficult to incorporate on Meteosat-2 because the satellite was already in a very advanced state of integration. Two particular problems were:

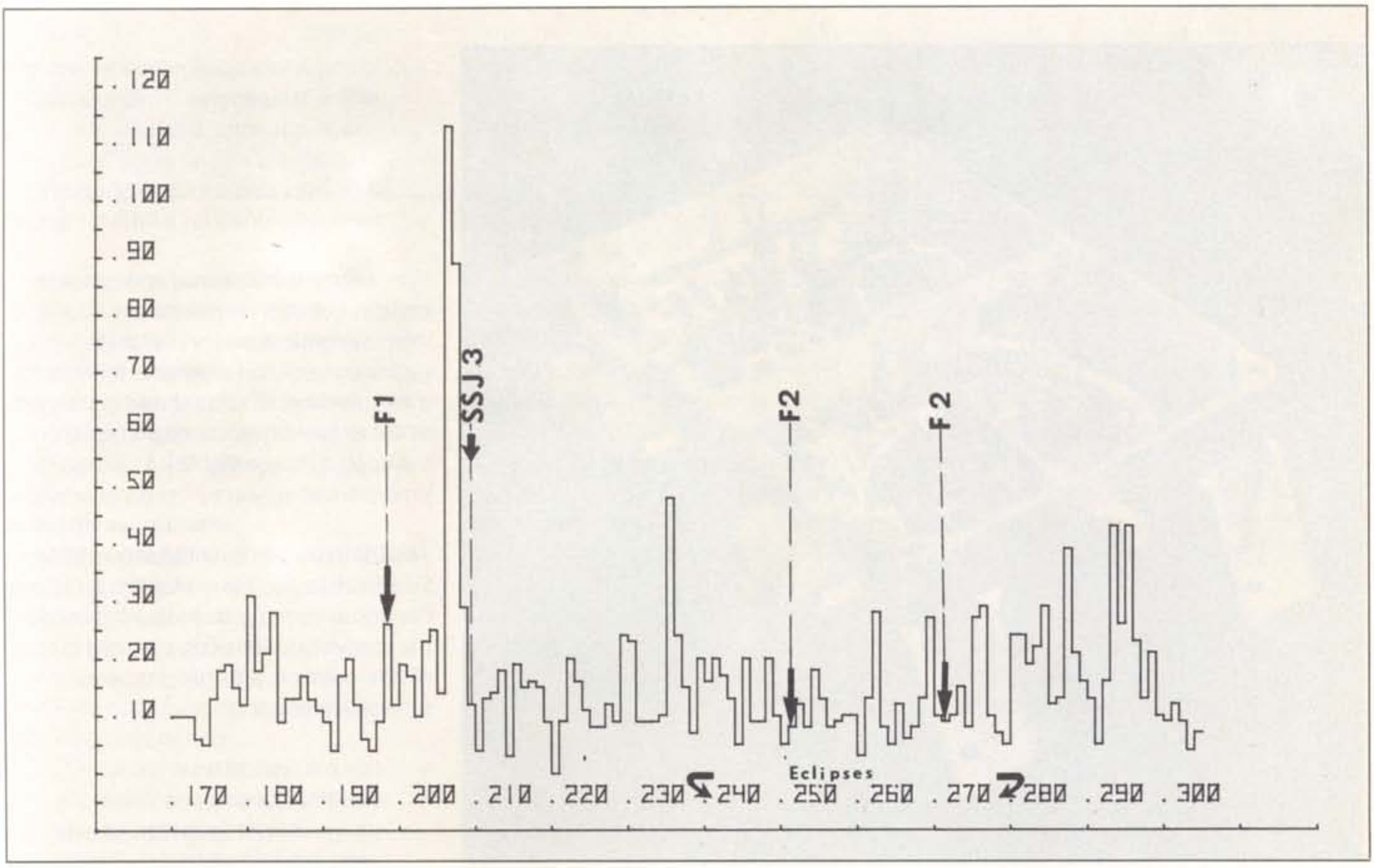
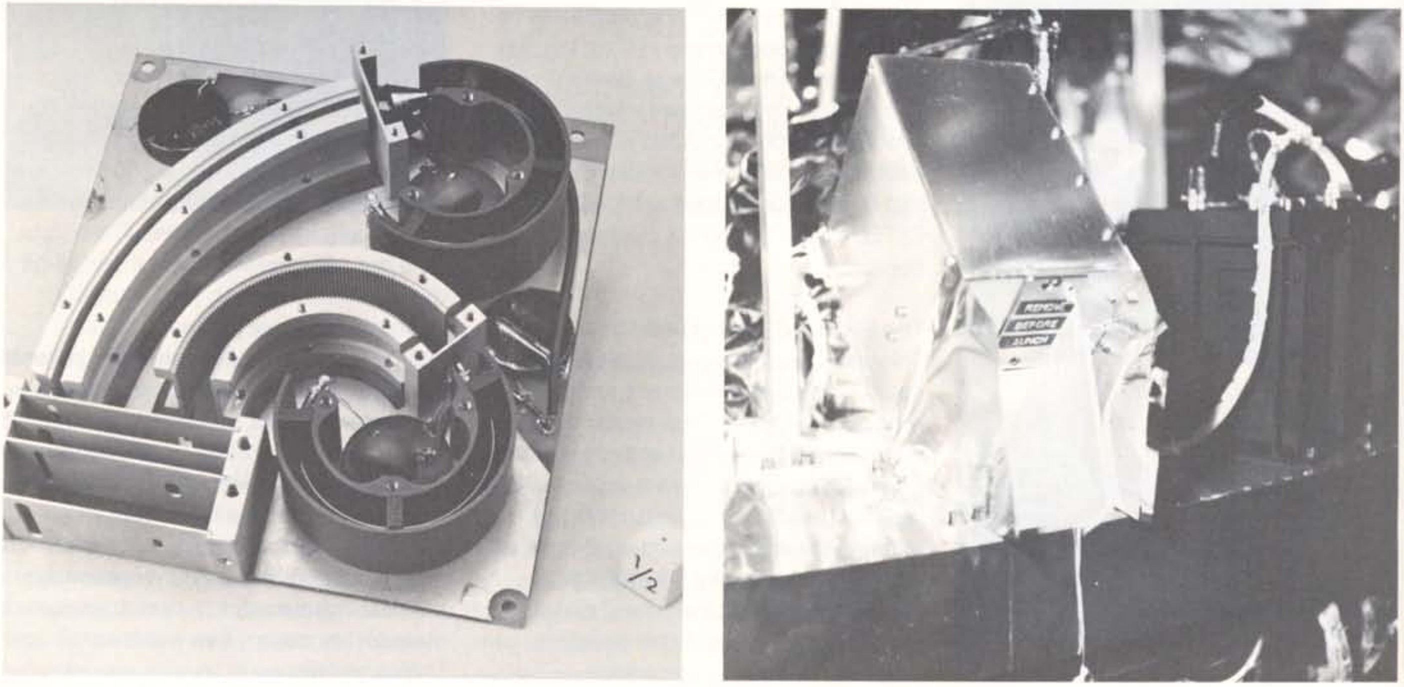


Figure 3 – The Electron Spectrometer (SSJ/3) for Meteosat-2 provided by Emmanuel College, Boston

Figure 4 – The Electrostatic Event Monitor (EEM) for Meteosat-2 provided by ESTEC Power Systems & Electronics Section



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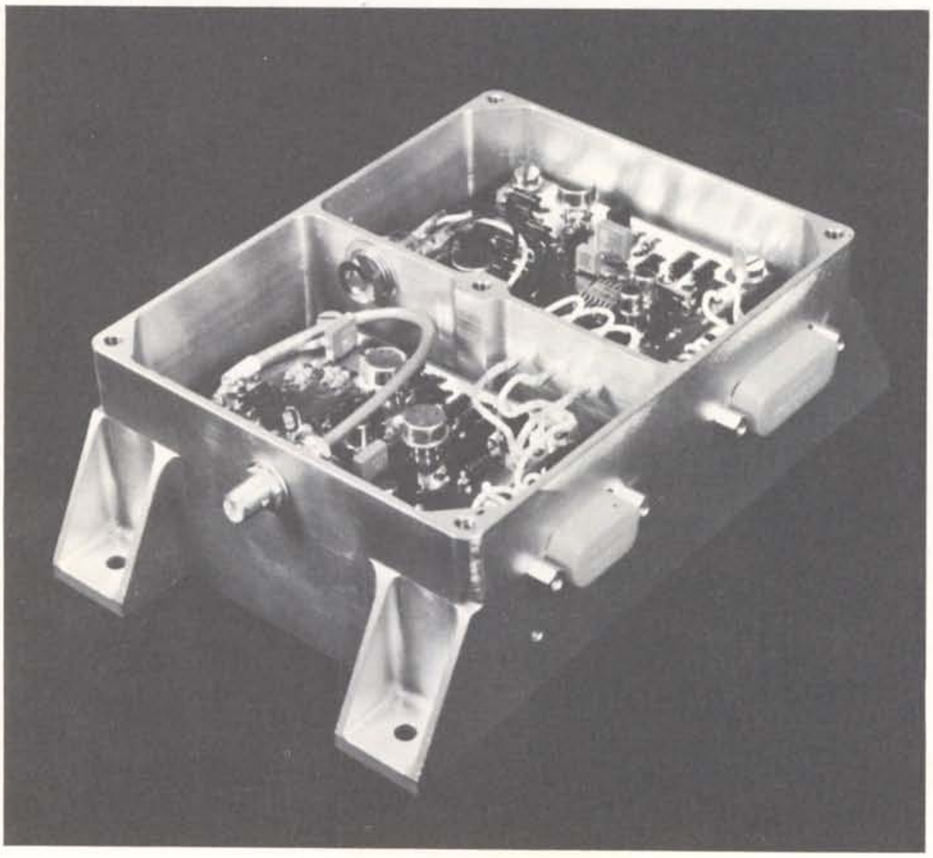


- to find a location for the instrument where its apertures could look into space, but not at the Sun
- to adapt the instrument's data to the 8-bit standard, as it had originally been developed for a 9-bit format.

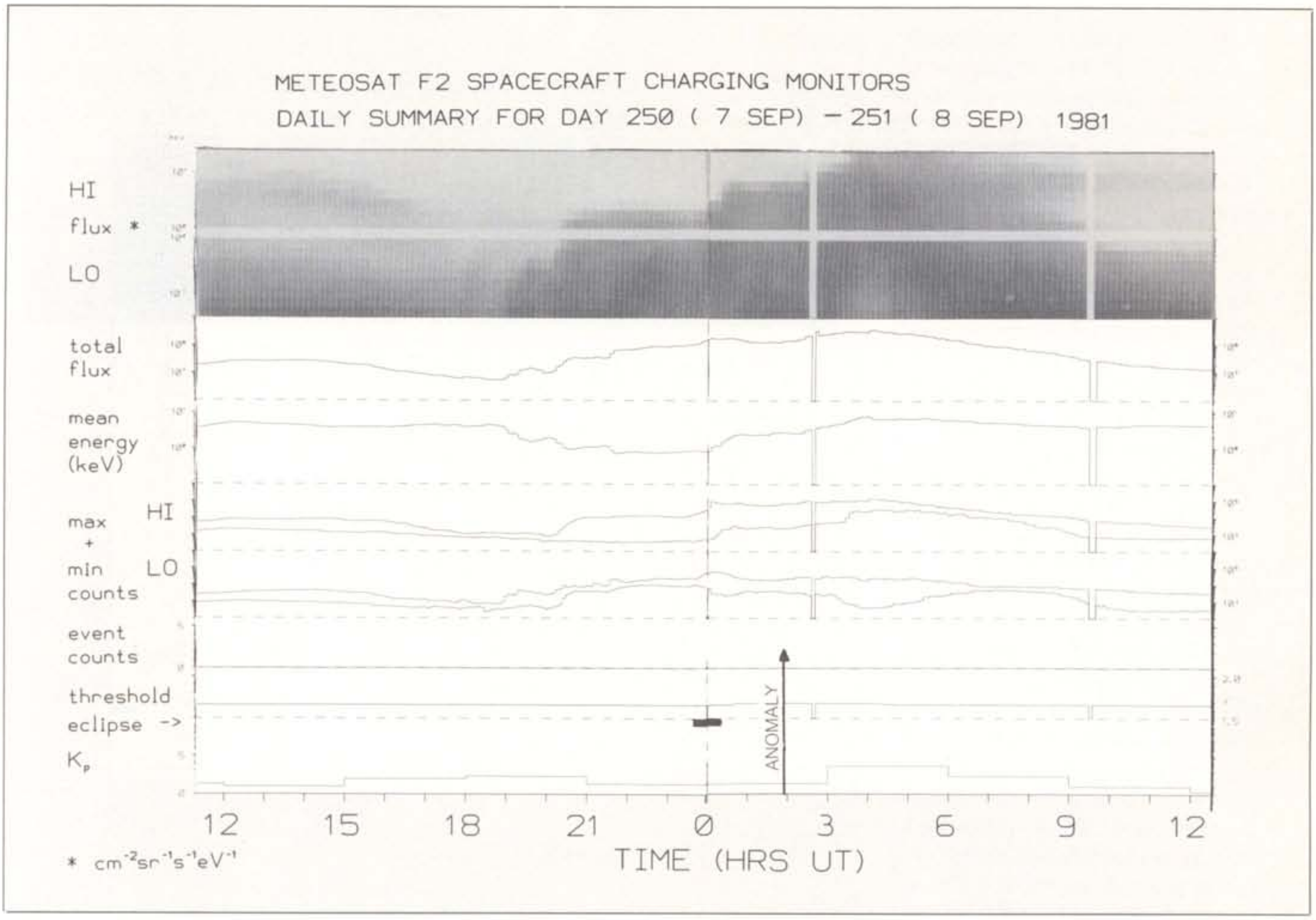
Fortunately, the Meteosat solar panels contain cut-outs to make them interchangeable and one of these openings could be used as a window for the experiment. The latter had to be tilted at 45° to avoid direct sunlight falling on the apertures (see Fig. 3b). The second problem was solved by the experimenter.

The Electrostatic Event Monitor (EEM)

The Electrostatic Event Monitor measures the signal from a probe mounted inside the spacecraft. For each telemetry format of 25 s duration, a signal processor provides a record of:

- noise threshold level
- events exceeding this threshold (number; total time; highest peak amplitude).

Figure 5 – Daily summary of SSJ/3 and EEM instrument data for 7/8 September 1981 (day 251) showing the first Meteosat-2 charging anomaly at 01.56 UT



The instrument itself, which uses analogue circuitry for simplicity of design, is small, light, and employs a flexible antenna. Its installation on the spacecraft therefore caused no major problems. Its data are processed together with the data from the SSJ/3 instrument.

Initial measurements

The data from the charging experiments are being processed at Mullard Space Science Laboratory to give daily summary plots in the form of Figure 5. Five-minute integrations are carried out for the SSJ/3 and EEM outputs to compose the following data panels:

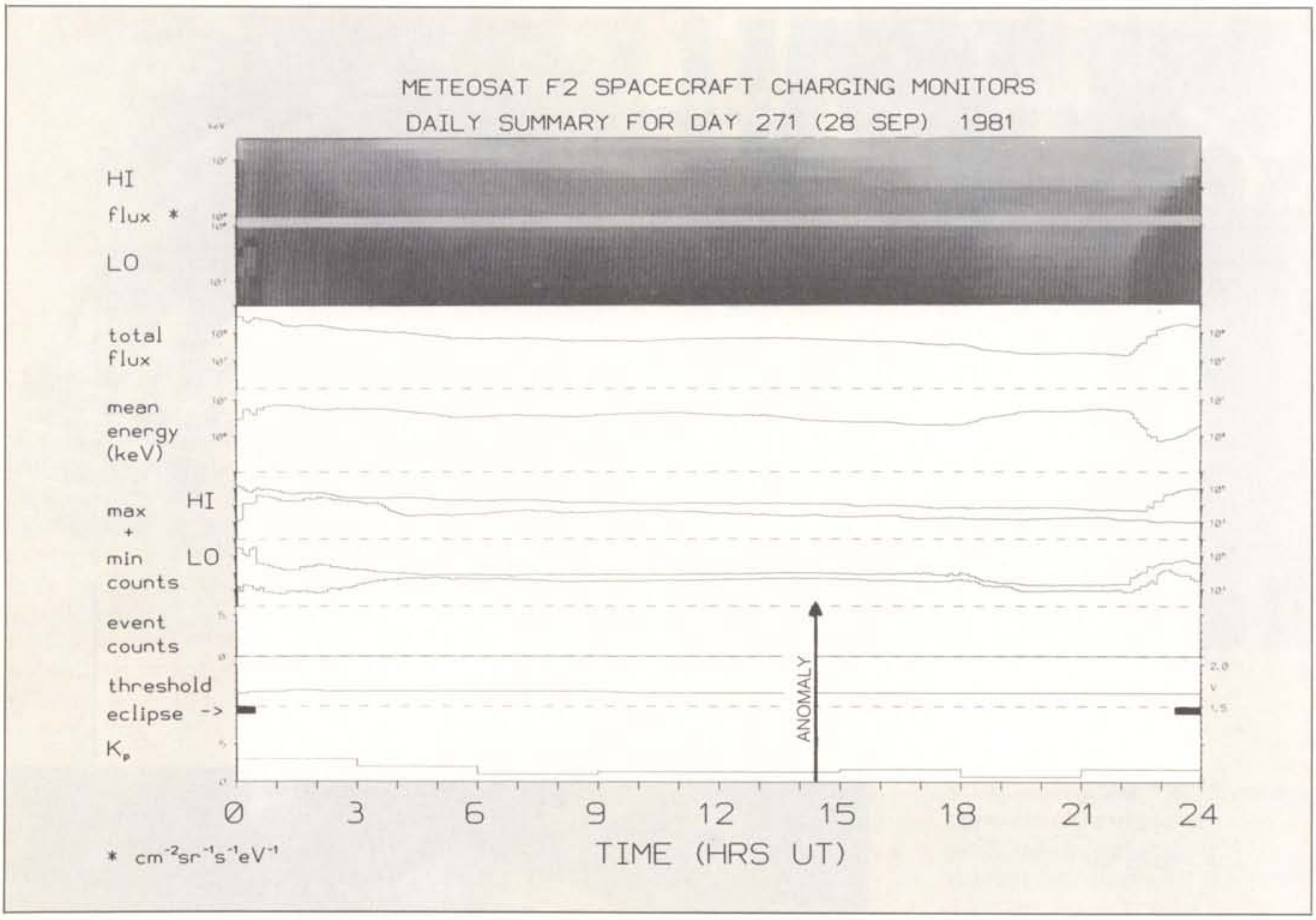
1. Differential number flux ($cm^{-2} sr^{-1} s^{-1} eV^{-1}$) of electrons for the 16 energy bins, grey-scaled logarithmically as the inset key.
2. Total number flux ($cm^{-2} sr^{-1} s^{-1}$) of the electrons. This is proportional to the electric current carried by the electrons to the spacecraft.
3. Mean energy (keV) of the detected electrons. This is a measure of the potential to which the electron flux could charge the spacecraft.
4. Maximum and minimum counts per 12.5 s sampling period, registered by the HIgh-energy detector.
5. Maximum and minimum counts registered by the LOw-energy detector.
6. Accumulated number of EEM events detected.
7. Threshold voltage for the event detection.
8. A bar indicates periods of satellite eclipse.
9. Three-hour Kp index appended to monitor geomagnetic activity.

Kp is derived from the variations in the magnetic field measured at eleven stations around the world; it has a value from 0 to 9. In contrast, the Fredericksburg A index, referred to earlier, is a 24 h integration of variations recorded at a single subauroral station.

Figure 5 is composed of two daily summaries of SSJ/3 and EEM data, centred at midnight, covering the first charging anomaly at 01.56 UT on 8 September, whilst Figure 6 shows data for 28 September, covering the time of the second anomaly at 14.23 UT.

These data permit a number of immediate

Figure 6 – Daily summary of SSJ/3 and EEM instrument data for 28 September 1981 (day 271) showing the second Meteosat-2 charging anomaly at 14.23 UT



observations:

i. There is a complete absence of discharge events.

ii. The electron flux variations are completely consistent with previous measurements from geosynchronous orbit (ATS-5, ATS-6, Geos-1, Geos-2), showing daily plasma-sheet encounters with entry occurring at 23–24 UT on 10 August, 19–20.30 UT on 7 September and 22–24 UT on 28 September.

iii. There are no special or unusual features in the electron flux near the anomaly times.

iv. There are flux enhancements at low energy before 01 UT on 28 September when the satellite was in eclipse. Spacecraft charging to negative potentials is common during eclipses because the current of photoelectrons leaving the spacecraft is cut off.

A review of four months of data establishes that no discharge events have been detected although the EEM experiment is functioning correctly. A small change in threshold voltage appears to be associated with battery charging following each eclipse. The electron spectrum frequently changes during eclipse and might indicate charging of the spacecraft to a few hundred volts. No such charging events are seen at other times. The electron data clearly show how the plasma-sheet boundary moves in response to changes in the solar wind, which are also monitored by the geomagnetic-activity index Kp. The inner edge of the plasma sheet is typically characterised by lower temperatures, and this gives rise to the energy dispersion observed at the boundary. Increased dispersion often results from particle-injection events near local midnight.

Geos-2 data

Geos-2, also in a geostationary orbit, but displaced in longitude from Meteosat-2 by between 25° and 37°, has a payload ideally suited to measuring the particle environment. Numerous attempts to use the data to understand the Meteosat-1 anomalies have met with little success, but the difference in local time (1.7–2.5 h) could be sufficient to prevent detection of the charging fluxes. Geos-2 now operates

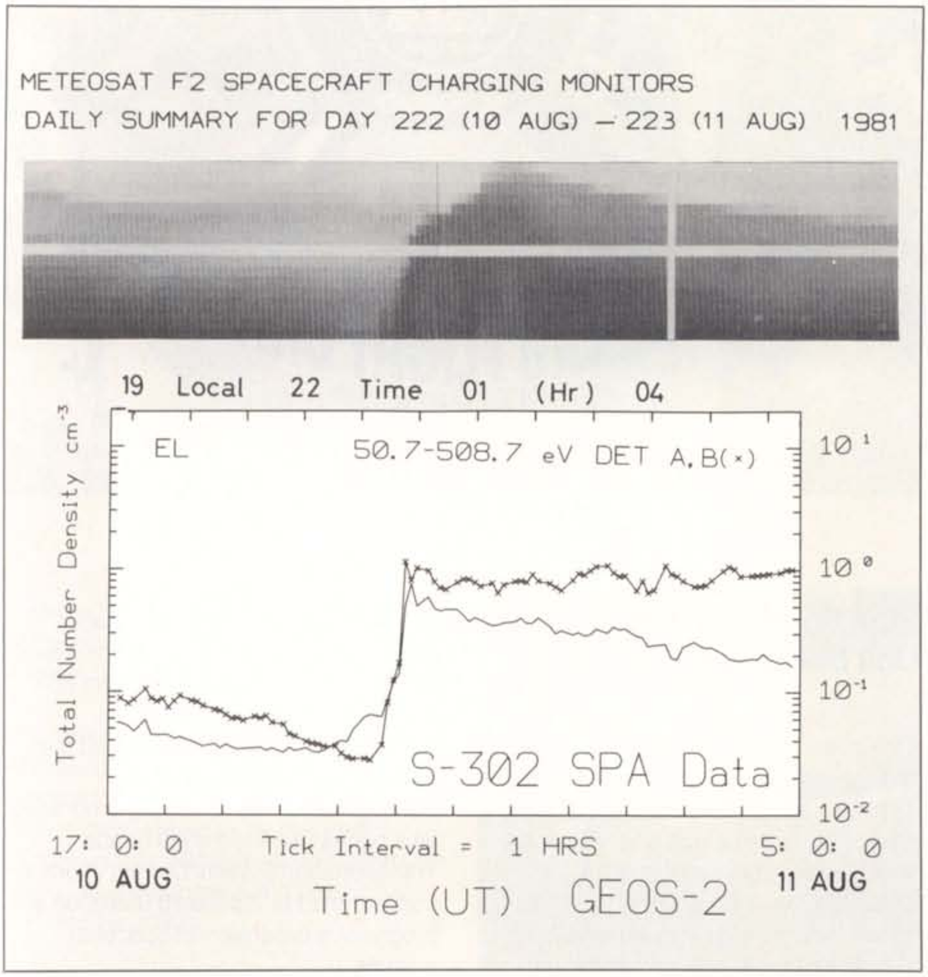


Figure 7 – Comparison of Meteosat-2 and Geos-2 charging data for 10/11 August 1981

for only 12 h per day (17–05 UT), and not during eclipses.

Figure 7 presents densities of electrons with energies in the 50–500 eV range as measured by the MSSL experiment (S302) on Geos-2. These plots for 10/11 August can be compared with the SSJ/3 low-energy data for that day. The plasma-sheet entry at 22 UT is at a local time of 23.30, which is virtually the same as the Meteosat-2 crossing. In quiet times the boundary remains stationary, but comparison of the two data sets for disturbed days gives a better measurement of the boundary motion than was previously available.

Higher densities are recorded at disturbed times; on 25 July 1981, for example, a strong compression drove Kp to 8 for 15 h and 50–500 eV electron densities exceeded 20 cm^{-3} at 6.6 Earth radii as the plasma sheet and the magnetopause approached the Earth.

Geos-2 data for 8 September confirm the lack of charging fluxes near the anomaly time. The only significant particle injection occurred just before 04.00 UT, well after the anomaly, at very high energies (30–37 keV electrons, recorded by Geos-2 experiment S321).

Conclusions

After four months of Meteosat-2 data compilation, it appears that anomalies are few and far between. The improved electromagnetic cleanliness of this second spacecraft could account for this, although the decreasing activity on the Sun will also be a factor. The two radiometer position jumps observed cannot be explained simply by the data from the new experiments. There is no evidence for discharge events, but in both cases there was an unexplained telemetry break and it is possible that vital measurements were lost. Further investigation is needed to find out why these synchronisation failures occurred.

It is also possible that the EEM instrument has been set up with insufficient sensitivity, but this will only be proved if forthcoming status changes have full telemetry coverage.

The SSJ/3 instrument is providing reliable monitoring of the electron fluxes believed to produce surface charging, but for the two anomalies it is clear that significant enhancements did not occur at the critical times. This suggests either that the charging takes place very much earlier and the consequent discharge is triggered by some internal spacecraft event, or that the offending particles are of a different type. It has been proposed that very energetic penetrating radiation might be responsible for many spacecraft problems. The delayed-discharge theory must be carefully investigated and a lot more anomalies would certainly help, though satellite operators and users would obviously not agree!

The comparison of the Meteosat-2 and Geos-2 data has demonstrated once again the advantage of having two spacecraft available in orbit to discriminate between temporal and spatial changes. The SSJ/3 data promises to be most valuable for pursuing a number of studies in magnetospheric physics and copies of the daily summaries are to be made available for that purpose.

In Brief

First Spacelab Flight Unit Delivered to NASA

One of the most important milestones in the European space programme was achieved on 4 December when the Flight Unit of the first manned and reusable space system, Europe's space laboratory Spacelab, was handed over to NASA. When placed inside the cargo bay of the Shuttle orbiter, Spacelab components will convert the Shuttle into a versatile, Earth-orbiting scientific research centre for both astronauts and scientists.

The delivery ceremony in Bremen marked a primary milestone in eight years of development, manufacture, assembly, and qualification in this historic programme of European-American cooperation, which began in 1973.

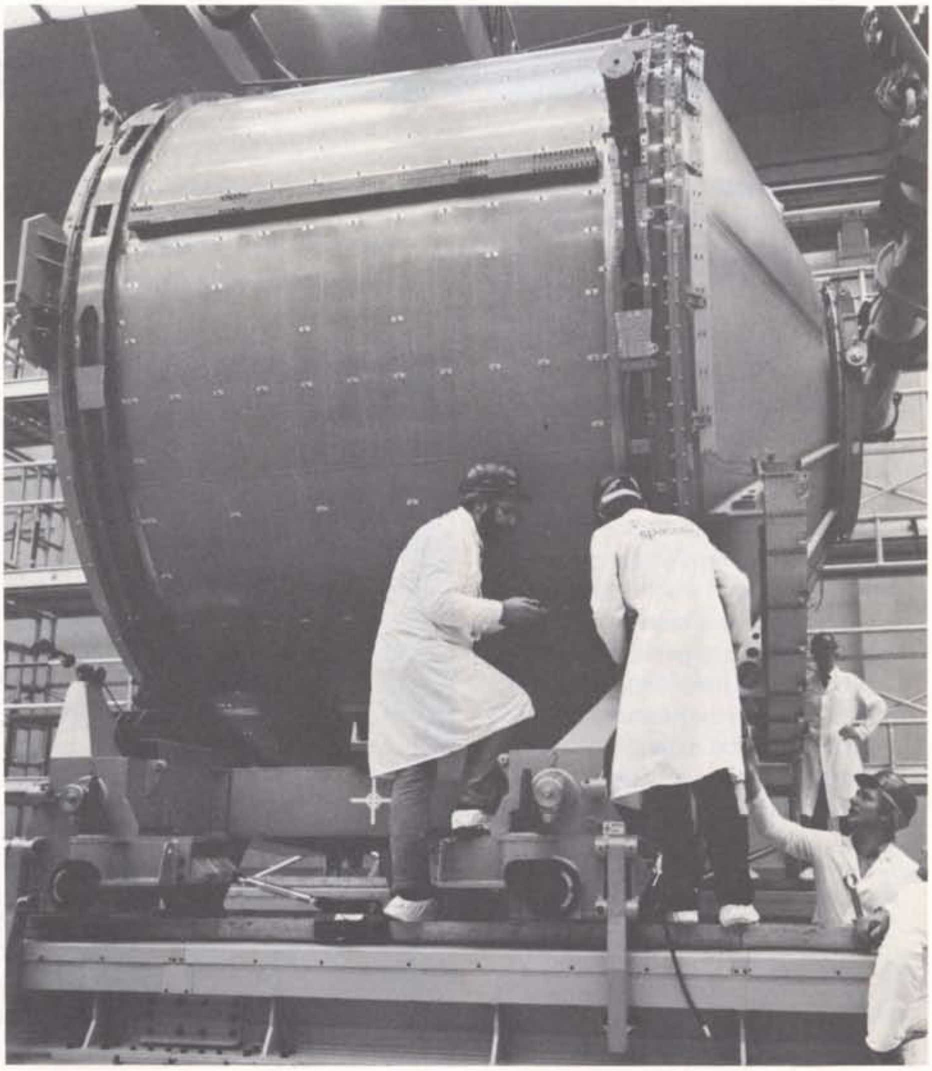
The next major event will take place in May 1982, when the second Flight Unit is to be delivered. In the meantime the European payloads for the first joint flight of the new reusable space transportation system, currently foreseen for September 1983, have already been developed and are currently being integrated in Bremen for operation. The First Spacelab Payload (FSLP) will be handed over to NASA in May 1982.

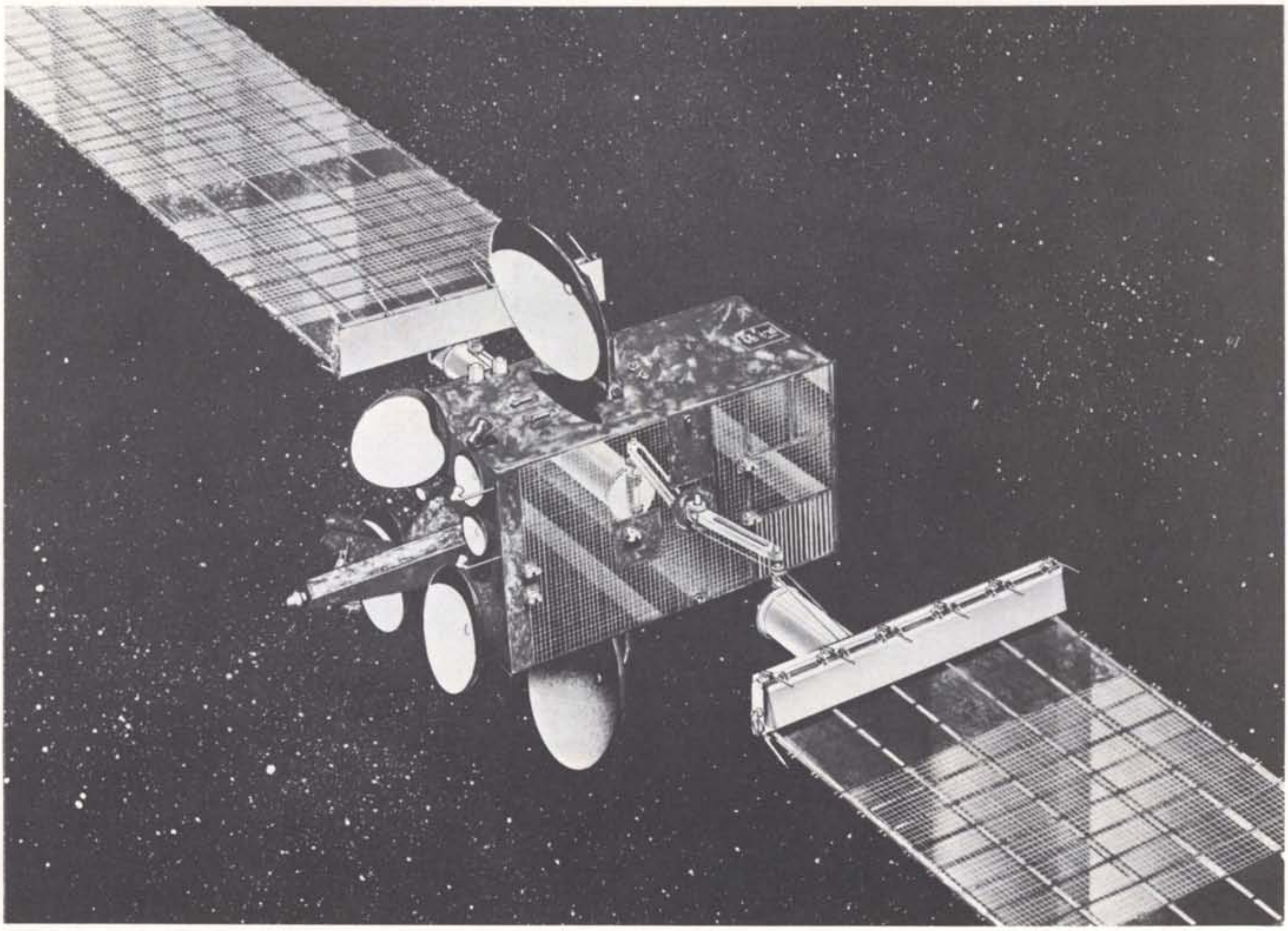
The European community of space experts, represented on the political level by international committees within ESA and, at the industrial level, by the Spacelab consortium, has created the basis for future activities by the development of the first space laboratory as a contribution to the US Space Transportation System. Current efforts are concentrated on Spacelab utilisation and progressive expansion of Spacelab systems.

ESA has already laid down the initial guidelines for Spacelab Follow-on Development (FOD). These cover three aspects of the programme, the first of which relates to improvements to the system already developed. The mission duration, for instance, is to be extended from seven days to twenty days or so, calling for changes related primarily to improved cooling. Provision is also being made for stepping up the electrical power supply available to experimenters, which necessitates changes in the electrical power distribution system. The second part of the FOD programme involves the definition, development and carrying-out of a mission with a free-flying, retrievable carrier. Thirdly, there are medium-term studies on further development of the carrier elements. One of the aspects to be investigated is in how far it is going to be

possible to integrate the basic segments of Spacelab (the module and pallets) with a NASA Space Operations Centre.

The delivery of the first flight unit on 4 December must therefore be seen as the culmination of the first development programme, with work on manned European spaceflight proceeding through follow-on development and production well into the 1990's.





New European Telecommunications Satellite Programme Approved

The main development phase of Europe's Large Telecommunications Satellite (L-Sat) programme was given final approval in December. In financial terms, it is one of the biggest satellite programmes yet undertaken by the Agency, the prime objectives being:

- the development, launch and in-orbit operation of a large multipurpose platform designed for a range of future telecommunications applications on a basis that will maximise future European competitivity in the world market;
- the development of a number of telecommunications payloads and the in-orbit operation of them to stimulate users, and to promote new market applications through a comprehensive programme of tests, demonstrations and utilisation.

L-Sat will carry four payloads:

- a direct-broadcast payload
- a specialised/business service payload
- a propagation beacon payload
- a millimetre-wave communications payload.

The definition phase of the L-Sat programme, agreed in the summer of 1979, was completed in August 1981. A short bridging phase was created to maintain continuity from that point until the start of the main development phase, foreseen for the end of the year.

The industrial structure for the main development phase of the programme has evolved in the course of the definition phase and has now been finalised. Some 40 industries from 12 countries will have responsibilities at subsystem or equipment level within this structure. Three development test models of L-Sat will be built prior to the fabrication of the flight and flight-spare models. British Aerospace was selected as the prime contractor in November 1979.

It is planned to launch L-Sat on an Ariane flight in early 1986; the satellite will also be fully compatible with the US Space Shuttle. Plans are already being made for utilisation of the satellite by the user community for experiments, technical tests, demonstrations of new applications, and for revenue-earning services. The budgeted cost of the development phase including the industrial contract, launch, establishment of the ground segment, in-orbit operations for at least five years, and programme management, is 388 MAU at 1980 price levels ($520 million).

With the entry into force of the legal arrangements for the programme on 21 December, the development activities were initiated with the release of the main contract, valued at approximately 257 MAU ($345 million) at 1980 price levels, to British Aerospace.

The eight ESA Member States participating in the L-Sat programme are: Austria, Belgium, Canada, Denmark, Italy, the Netherlands, Spain and the United Kingdom.

ESA and Japanese Meet to Review Future Space Programmes

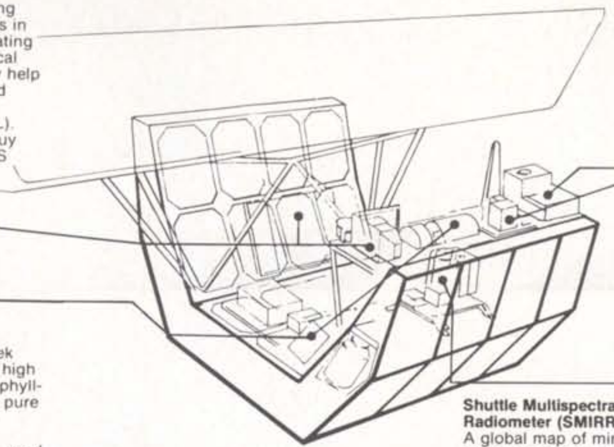
The seventh meeting to be held within the framework of an existing cooperative agreement between Japan and ESA took place in Paris between 2 and 4 November. Both space programmes currently under development and those being considered for the future in Europe and in Japan were reviewed. Several Working Groups met to discuss in detail possible areas of coordination or cooperation.

ESA and the Japanese will be sending spacecraft to study Halley's comet when it reappears in 1985, and to ensure that maximum advantage is taken of this unique opportunity, the two parties plan to coordinate their missions as closely as possible. Working relationships have also been established with the USSR and the USA within the framework of the Inter-Agency Consultative Group on Space Missions to Comet Halley (see page 64 of this issue).

In about a year's time both Japan and ESA will have X-ray astronomy observatories in orbit, and Japanese and European astronomers will be encouraged to ensure that the two observing programmes complement and support one another to maximise the scientific return.

Significant progress was made at this seventh meeting in the coordination of the European (Meteosat, Sirio-2, ERS-1) and Japanese (GMS, MOS-1, MOS-2) earth-observation programmes, particularly in the area of ocean monitoring in which only Japan and ESA are now engaged.

Japan plans to launch its first Marine Observation Satellite (MOS-1) in 1986 and the first ESA Remote Sensing Satellite is scheduled for launch in 1987. It was agreed that, in view of the similarity in mission objectives and time scales of the two programmes, bilateral coordination should be intensified, including arrangements for data acquisition.



The OSTA-1 pallet-mounted experiments.

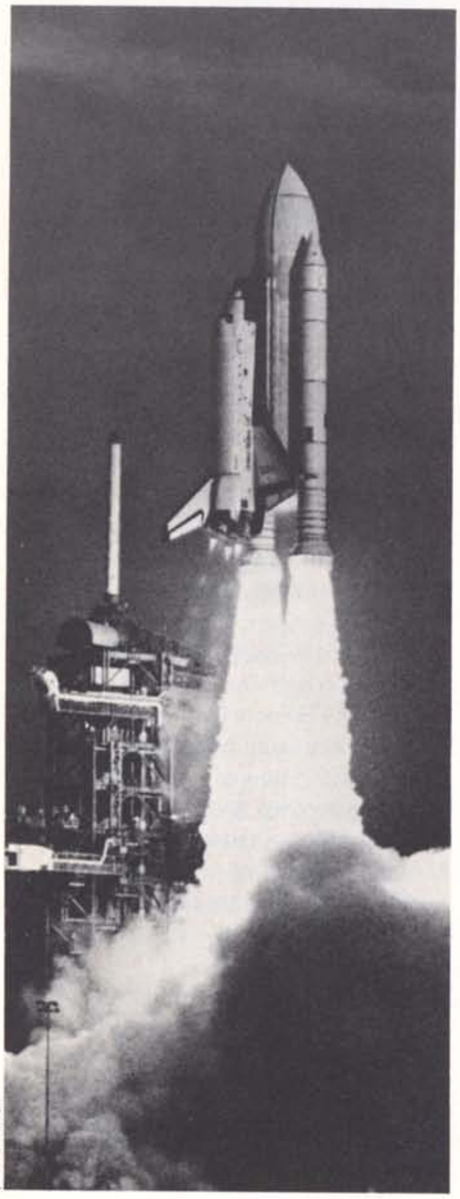


photo nasa

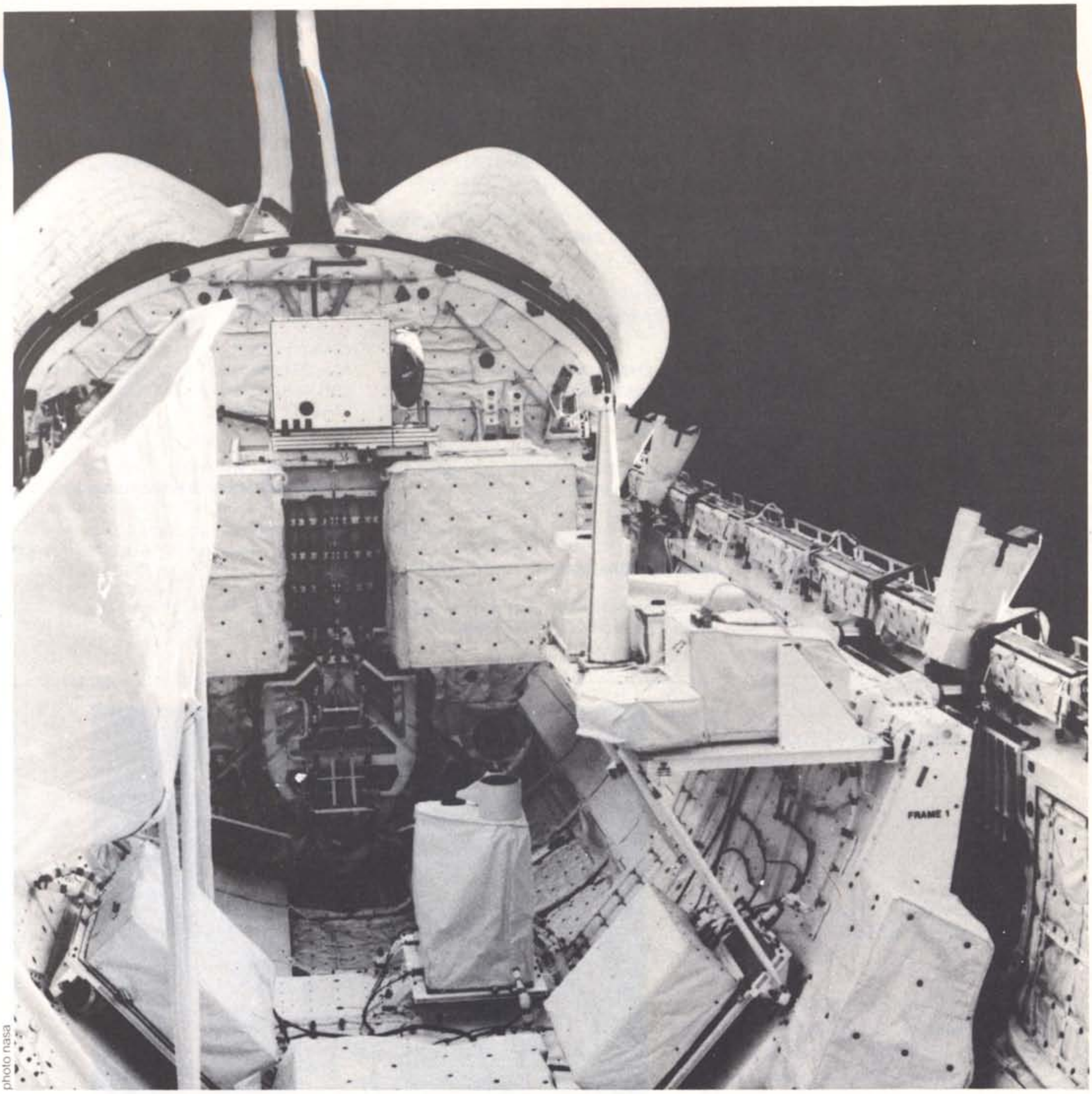
European Hardware on the Second Shuttle Flight

The second test flight of the Space Shuttle Columbia was an event of some importance for Europe in that the Orbiter carried a Spacelab pallet built in Europe in its cargo bay.

The engineering-model pallet was designed and built under ESA contract by the British Aerospace Dynamics Group, a co-contractor in the European Spacelab industrial team, headed by ERNO (Germany).

On this second Shuttle flight the pallet carried five OSTA-1 (Office of Space and Terrestrial Applications) scientific experiments:

- the Shuttle imaging Radar-A, similar to the system flown on Seasat, but applied in this case to land resources (oil and other mineral deposits).
- the Shuttle Multi-Spectral Infrared Radiometer (SMIRR), to determine the spectral bands to be included in a future high-resolution system for mapping rocks associated with mineral deposits.
- The Feature Identification and Location Experiment (FILE), a data management package intended to help sensors such as the SIR-A and SMIRR, find the scenes from which data are to be taken by selecting specified quantities of data representing water, vegetation, bare ground, snow or clouds.
- The Measurement of Air Pollution from Satellites (MAPS), to measure the distribution of carbon monoxide in the troposphere and also to study the feasibility of using orbiting spacecraft to measure environmental quality.
- The Ocean Colour Experiment (OCE), to validate a technique for gathering ocean-colour information that could be used to map the distribution of algae, and thus help to locate fish schools or ecological disturbances caused by pollutants.



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OTS to the Rescue

On 11 November, the main terrestrial PTT switching centre at Lyon in France was destroyed by fire. As a result, all national telephone and telex connections to and from Lyon were lost, together with international through-connections to Italy. The local telephone service in the Lyon area was also knocked out.

Within hours of the emergency, a transportable 3 metre antenna diameter earth station had been deployed at Lyon by the French Administration and 30 telephone channels for priority traffic were established between Lyon and Bercenay (near Paris) through ESA's OTS satellite.

By providing the vital communications needed between Lyon and the outside world, this satellite service has provided a striking example of the value and flexibility of satellite communications in such emergencies.

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 on page 104 and using the Order Form on page 105.

ESA Journal

The following papers have been published in ESA Journal Vol. 5, No. 4:

THE GIOTTO PROJECT – A FAST FLYBY OF HALLEY'S COMET
R. REINHARD

NAVIGATION AND DEFORMATION MODELLING FOR METEOSAT IMAGERY
M. JONES

ADJUSTMENT OF METEOSAT-1 RADIOMETER RESPONSE BY GROUND PROCESSING
M. JONES & J. MORGAN

A NEW SOFTWARE PACKAGE FOR COMMUNICATIONS SYSTEMS ANALYSIS AND DESIGN: THE TOPSIM COMPUTER PROGRAM
G. CANOVAI

SYNCHRONISATION METHODS FOR SATELLITE-SWITCHED TDMA NETWORKS
G.K. SMITH

Special Publications

ESA SP-160 SPACECRAFT FLIGHT DYNAMICS – PROCEEDINGS OF AN INTERNATIONAL SYMPOSIUM HELD AT DARMSTADT, GERMANY IN MAY 1981 (AUGUST 1981)
GUYENNE, T.D. & LEVY, G. (EDS)
ESA PRICE CODE C4

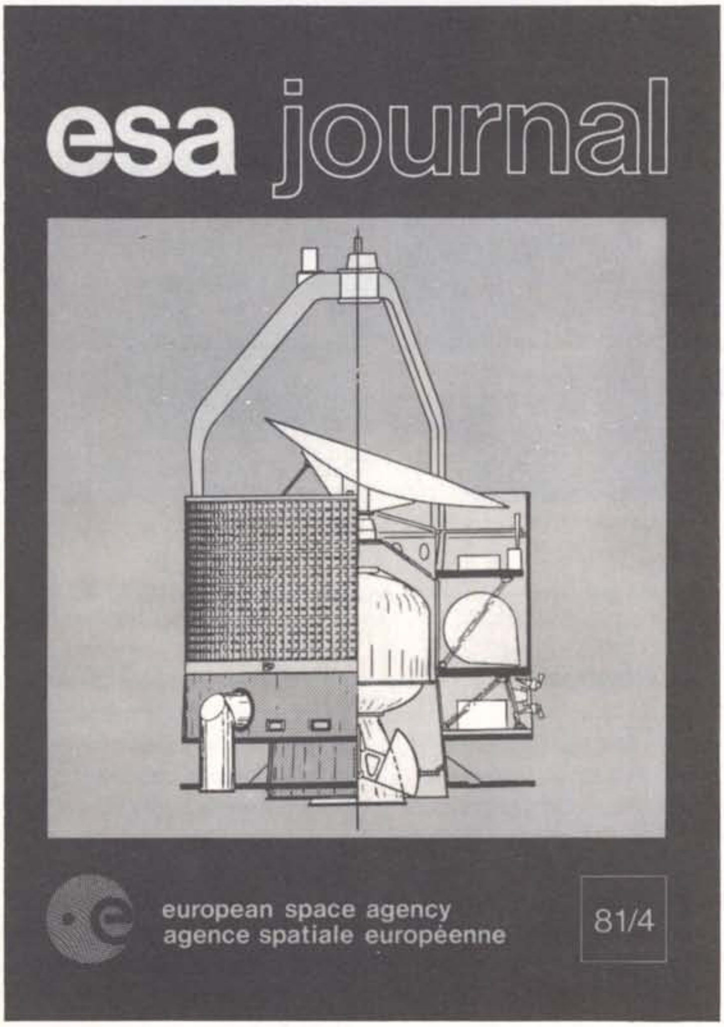
ESA SP-172 SAR IMAGE QUALITY PROCEEDINGS OF THE 3RD SEASAT-SAR WORKSHOP ORGANISED BY EARTHNET AND EARSEL
LONGDON, N. (ED)
ESA PRICE CODE C1

ESA SP-174 THE COMET HALLEY DUST & GAS ENVIRONMENT
BATTRICK, B. & SWALLOW, E. (EDS).
ESA PRICE CODE C1

ESA/SP-1035 SATELLITE REMOTE SENSING APPLICATIONS TO RURAL DISASTERS (1981)
LONGDON, N. (ED)
ESA PRICE CODE C2

Scientific & Technical Memoranda

ESA STM-220 VIDEO TELECONFERENCE BY SATELLITE – COMPARISON OF MEETING STRUCTURE AND SATELLITE SYSTEM DESIGN. (JUNE 1981)
DINWIDDY, S.E.
ESA PRICE CODE E1



Procedures, Standards & Specifications

ESA PSS-01-736 ISSUE 1 MATERIAL SELECTION FOR CONTROLLING STRESS-CORROSION CRACKING OF ESA SPACECRAFT AND ASSOCIATED EQUIPMENT. (MAY 1981)
PRODUCT ASSURANCE DIVISION, ESTEC
ESA PRICE CODE E1

Contractor Reports

ESA CR(P)-1416 INVESTIGATION OF TOLERANCE ANALYSIS OF REFLECTOR ANTENNAS. (OCT 1980)
CANADIAN ASTRONAUTICS LTD, CANADA
ESA PRICE CODE C2

ESA CR(P)-1417 INVENTORY FOR ERS-1 END USERS – FINAL REPORT. (FEB 1981)
EUROSAT, SWITZERLAND
ESA PRICE CODE C2

ESA CR(P)-1418 EVALUATION AND ASSESSMENT OF LOW-NOISE PREAMPLIFIERS FOR INFRARED DETECTORS – FINAL REPORT. (OCT 1980)
SELENIA, ITALY
ESA PRICE CODE C2

ESA CR(P)-1420 FLUID PHYSICS MODULE – OPTIMISATION AND IMPROVEMENT STUDY – FINAL REPORT. (SEP 1980)
CENTRO RICERCHE FIAT, ITALY
ESA PRICE CODE C3

ESA CR(P)-1421 STUDY OF THE INFLUENCE OF THE ATMOSPHERE ON THE PERFORMANCE OF AN IMAGING MICROWAVE RADIOMETER. (JUL 1980)
UNIV. CATH. DE LOUVAIN, BELGIUM
ESA PRICE CODE C3

ESA CR(P)-1422 TELEMETRY, TRACKING AND COMMAND SYSTEM SIMULATOR; VOLUME 1 – SIMULATION MODEL; VOLUME 2 – USER'S MANUAL. (SEP 1980)
MARCONI RESEARCH LABORATORIES, UK
MICROFICHE ONLY (VOL 1 36 PAGES; VOL 2 156 PAGES)

ESA CR(P)-1423 THE TORQUE BEHAVIOUR OF GREASE-LUBRICATED ANGULAR CONTACT BEARINGS OPERATING AT LOW SPEEDS.
ESTL/UKAEA, UK
MICROFICHE ONLY (23 PAGES)

ESA CR(P)-1429 PERFORMANCE ANALYSIS OF UPLINKS FOR REGENERATIVE SATELLITE REPEATERS – FINAL REPORT. (JAN 1981)
RICERCHE E PROGETTI, ITALY
ESA PRICE CODE C3

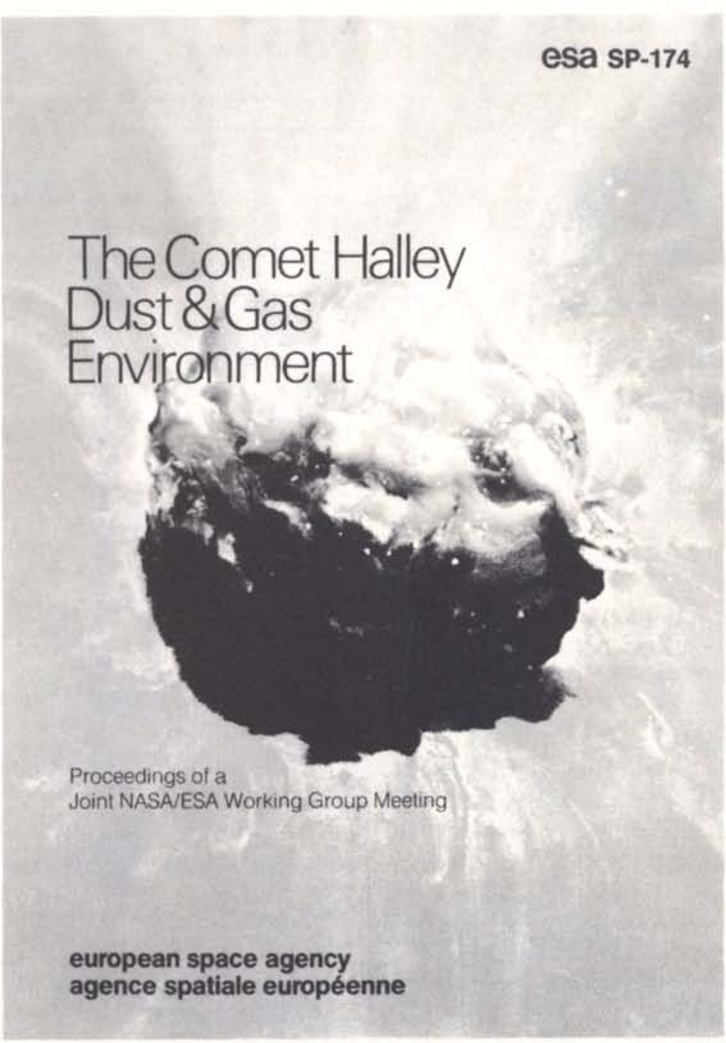
ESA CR(P)-1430 STUDY OF AN ATTITUDE ACQUISITION MEASUREMENT TECHNIQUE USING THE ESA STAR MAPPER. PART II – FINAL REPORT. (NOV 1979)
NLR, THE NETHERLANDS
MICROFICHE ONLY (89 PAGES)

ESA CR(P)-1431 ASSESSMENT OF THRUSTER PERFORMANCE – VOLUME 1: TECHNICAL REPORT – VOLUME 2: USER'S MANUAL. (MAY 1980)
MATRA, FRANCE
VOL 1: ESA PRICE CODE C2
VOL 2: ESA PRICE CODE C1

ESA CR(P)-1432 STUDY OF SCAN GEOMETRY IMAGE CORRECTION FOR THE COASTAL OCEAN MONITORING SATELLITE SYSTEM (COMSS). (SEP 1980)
LOGICA LTD, UK
ESA PRICE CODE C2

ESA CR(P)-1433 COMSS SYSTEM EVALUATION STUDY (CSES) – FINAL REPORT. (JAN 1981)
BADG, UK
ESA PRICE CODE C2

ESA CR(P)-1435 STUDY OF NOISE FILTERING AND CONTROL OF POINTING SYSTEMS – FINAL REPORT. (DEC 1980)
BADG, UK
MICROFICHE ONLY (451 PAGES)



ESA SP-174
THE COMET HALLEY DUST & GAS ENVIRONMENT

Compiled by R. Reinhard and B. Battrick and published by ESA Scientific & Technical Publications Branch.

These Proceedings contain nine papers that summarise the major results achieved to date through the work of the joint NASA/ESA Comet Halley Environment Working Group. This Working Group was conceived in mid 1980 to improve:

(i) 'knowledge' of the Halley nucleus parameters
(ii) models for cometary neutrals and dust
(iii) estimates of the nucleus' visibility.

Copies are available from the Distribution Office, ESA Scientific & Technical Publications Branch, c/o ESTEC, Postbus 299, 2200 AG Noordwijk, Netherlands.

Price 60 FF or equivalent.

ESA CR(P)-1436 FINE ATTITUDE MEASUREMENT STUDY – FINAL REPORT: VOLUME I. EXECUTIVE SUMMARY; VOLUME II. TECHNICAL REPORT; VOLUME III. APPENDICES. (OCT 1980)
BADG, UK
VOL I: ESA PRICE CODE C1
VOL II: ESA PRICE CODE C2
VOL III: ESA PRICE CODE C1

ESA CR(P)-1437 STUDY ON SATELLITE RADAR ALTIMETRY IN CLIMATOLOGICAL AND OCEANOGRAPHIC RESEARCH – FINAL REPORT. VOLUME 1: EXECUTIVE SUMMARY. VOLUME 2: MAIN REPORT. (DEC 1980)
RUTHERFORD AND APPLETON LABORATORIES, UK
VOL 1: ESA PRICE CODE C1
VOL 2: ESA PRICE CODE C3

ESA CR(P)-1438 FUTURE EARTHNET DISSEMINATION SYSTEM (FEDS) STUDY – FINAL REPORT. (DEC 1980)
LOGICA, UK
ESA PRICE CODE C1

ESA CR(P)-1439 MICROWAVE DEVICES WITH ASYMMETRIC FREQUENCY CHARACTERISTICS AND CASCADE DECOMPOSITION STUDY
FILTRONIC COMPONENTS LTD, UK
ESA PRICE CODE C1

ESA CR(P)-1441 FUTURE SPACE TRANSPORTATION SYSTEMS FOR EUROPE
MBB, FRG
ESA PRICE CODE C1

ESA CR(P)-1443 STUDY ON CALIBRATION METHODS FOR EARTH OBSERVATION OPTICAL IMAGING INSTRUMENTS – FINAL REPORT. (NOV 1980)
UNIV. COLL. DUBLIN, IRELAND
ESA PRICE CODE C3

ESA CR(P)-1444 RAPPORT FINAL RELATIF A L'ETUDE DE LA MISE EN PLACE D'UN PROGRAMME D'ASSURANCE DE QUALITE DES LOGICIELS – PHASE 1. (NOV 1980)
ECA AUTOMATION, FRANCE
ESA PRICE CODE C2

ESA CR(P)-1445 DATA RATE REDUCTION PHASE II – SAAB FINAL REPORT. (DEC 1980)
MATRA, FRANCE
MICROFICHE ONLY (70 PAGES)

ESA CR(P)-1449 SIMULATION OF A TELECOMMUNICATION DISTRESS SYSTEM – FINAL REPORT. (JUL 1980)
POLITECNICO DI TORINO, ITALY
MICROFICHE ONLY (154 PAGES)

ESA CR(P)-1450 INTERPRETATION OF REMOTELY SENSED IMAGE DATA AND IMPACT OF CLUSTER COMPRESSION. (FEB 1981)
MATRA, FRANCE. LOGICA (SUBCONTRACTOR), UK
ESA PRICE CODE C2

ESA CR(P)-1453 EXTRACTED-POLE FILTER MULTIPLEXION AND ASYMMETRIC DOUBLE ARRAY NETWORK SYNTHESIS. (UNDATED)
FILTRONIC COMPONENTS LTD., UK
ESA PRICE CODE C1

ESA CR(P)-1454 VALIDATION, MODELISATION ET LOGICIEL DE CONCEPTION ASSISTEE DES CONVERTISSEURS DE PUISSANCE – RAPPORT FINAL. (JUN 1981)
ONERA/CERT, FRANCE
MICROFICHE ONLY (82 PAGES)

ESA CR(P)-1456 SYSTEM SOFTWARE FOR THE ESTEC MULTIPROCESSOR RECONFIGURABLE SIMULATOR FINAL REPORT. (FEB 1981)
SCICON, UK
ESA PRICE CODE C1

ESA CR(P)-1457 OVERALL ECONOMIC IMPACT OF AN OPERATIONAL METEOSAT SYSTEM – FINAL REPORT. (JAN 1981)
EUROSAT, SWITZERLAND
ESA PRICE CODE C1

ESA CR(P)-1458 STUDY ON A REFINED IMAGE PROCESSING SYSTEM FOR SPACE ASTRONOMY. (MAR 1981)
SRC (RUTHERFORD & APPLETON LABS.), UK
MICROFICHE ONLY (257 PAGES)

ESA CR(P)-1459 DEVELOPMENT OF AN IMPROVED HIGH PERFORMANCE ARTERY HEAT PIPE – FINAL REPORT. (MAY 1981)
IKE, FRG
ESA PRICE CODE C1

ESA CR(P)-1460 POSITION AND HOLD MOUNT – DEMONSTRATION MODEL – FINAL REPORT. (MAY 1981)
DORNIER SYSTEM, FRG
ESA PRICE CODE C1

ESA CR(P)-1461 BALL BEARING EVALUATION FOR A HIGH PRECISION RADIOMETER MIRROR DRIVE (MAY 1981)
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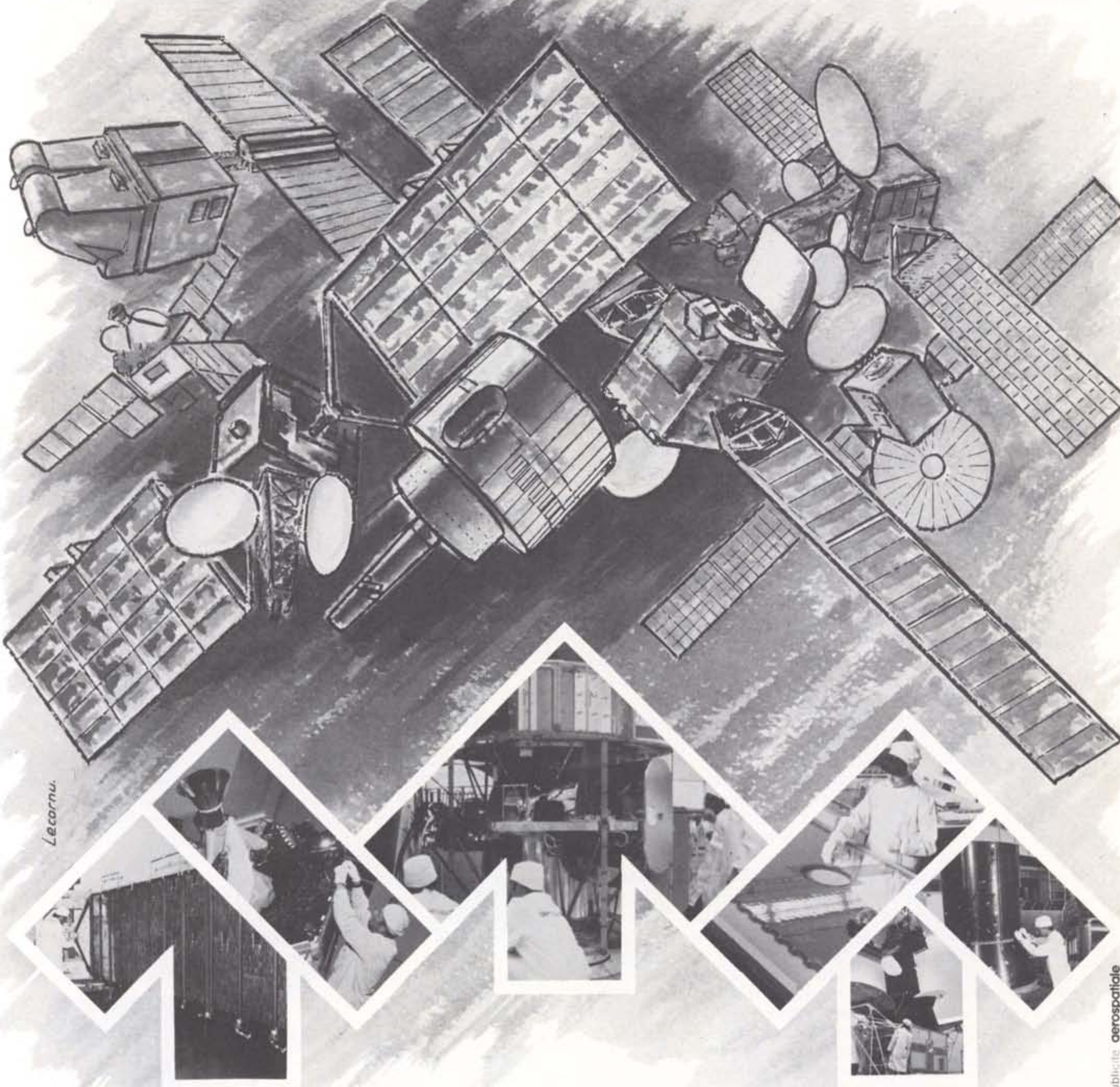

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The Next 30 Years - Symposium
October 4-6, 1982
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Abstract Deadline:
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For those of us scientists and engineers working in space astronomy observatories, the next 30 years offer both a promise and a challenge; a promise of significant discovery and a challenge to look ahead and prepare. If we are to do many of the exciting and useful programs being planned both here and in Europe for this period and beyond, we must be prepared better than ever before—prepared with our technology and with ideas to limit and control programs costs. Science needs and requirements, technology and cost management are the subjects of this Symposium; it provides an opportunity for us to integrate our ideas and to take the initiative to keep a vigorous space astronomy program.

The first session will explore and analyze the plans, goals and implications of future space astronomy/astrophysics programs. We plan invited papers from scientists who will lead this work and solicit others that will contribute to our understanding and perspective of this coming period.

For the following five technology sessions, we solicit papers from the engineering and design community: these papers should address the current state-of-the-art and projected technology developments necessary to achieve the planned programs.

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- **Optics** - covering the full spectrum - assessment of optical system design and analysis, materials, configuration, assembly, alignment and testing in space.
- **Detectors and Data Processing** - assessment of sensitivity requirements, configurations, developments, storage, data processing, cryogenic cooling systems.
- **Pointing Controls** - accuracy and stability requirements, sensor concepts, attitude controls systems, acquisition, discrimination.
- **Structural/Thermal** - requirements, design concepts, materials, thermal controls.

The seventh session will address what many consider the most challenging problem of the space programs, that of program cost control and will focus on changes needed to insure a healthy space science program. We plan this session as an invited panel - with participants who are experienced, know the problem first hand and who will put forth candid assessments of how this problem can be managed.

Other highlights include a tour of the Space Telescope OTA assembly at Perkin-Elmer, and a nationally prominent speaker at the Symposium dinner.

All papers accepted for presentation will appear in the proceedings. Prospective authors are invited to submit three (3) copies of an abstract of 500-1000 words by March 1, 1982 to the *Conference Administrative Chairman:*

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and the Technical Program Committee, comprised of members of the AIAA Space Science and Astronomy Technical Committee and Session Chairpersons.

Authors will be notified of acceptance by May 5, 1982. Authors of accepted papers should submit a short 100 word abstract or less by May 26, 1982. The final manuscript of the paper will be due by August 11, 1982. The language for the conference, papers, and manuscript will be English. International participants are welcome to write the General Chairman for further information. General inquiries concerning the conference should be directed to:

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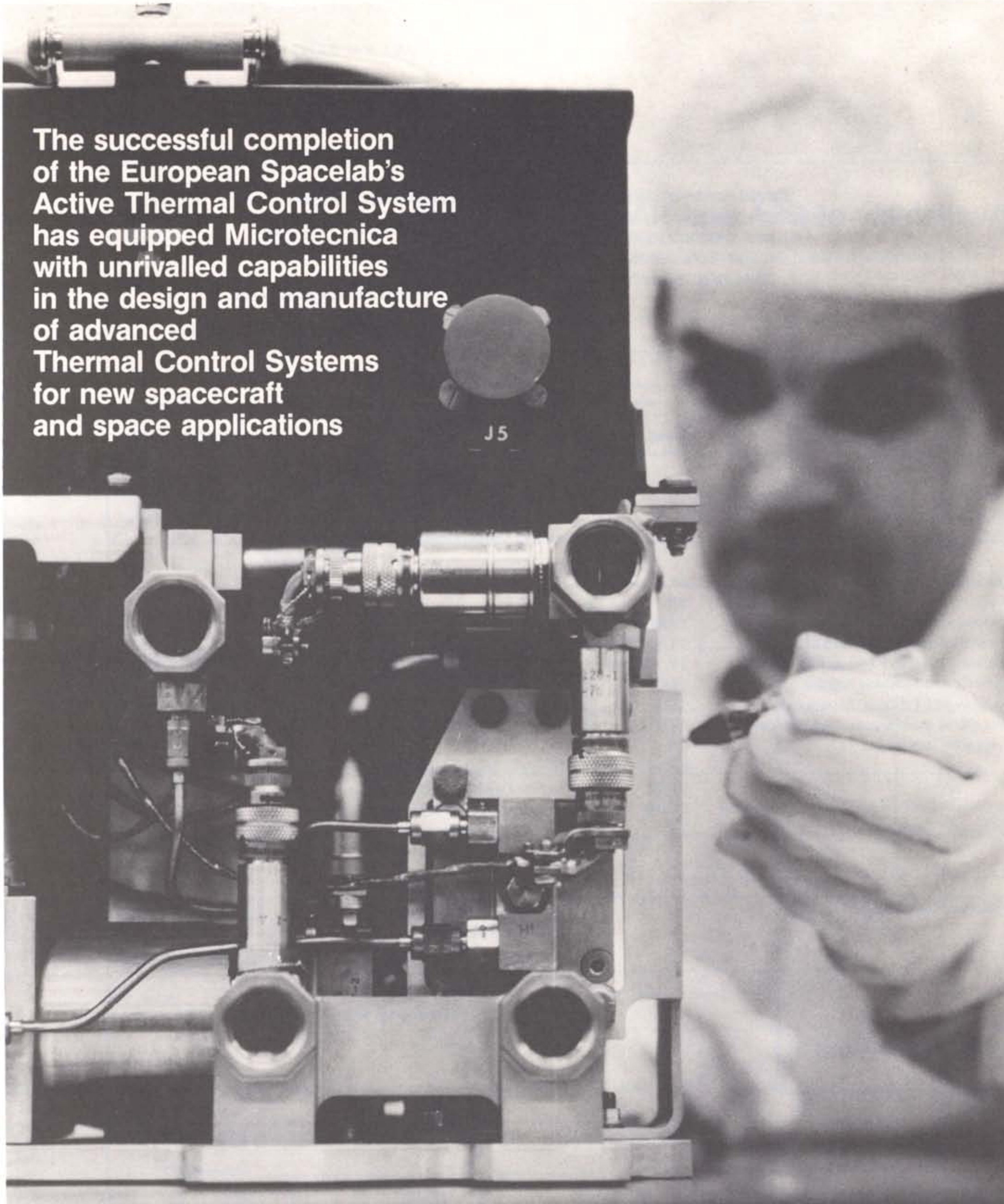
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