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(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;
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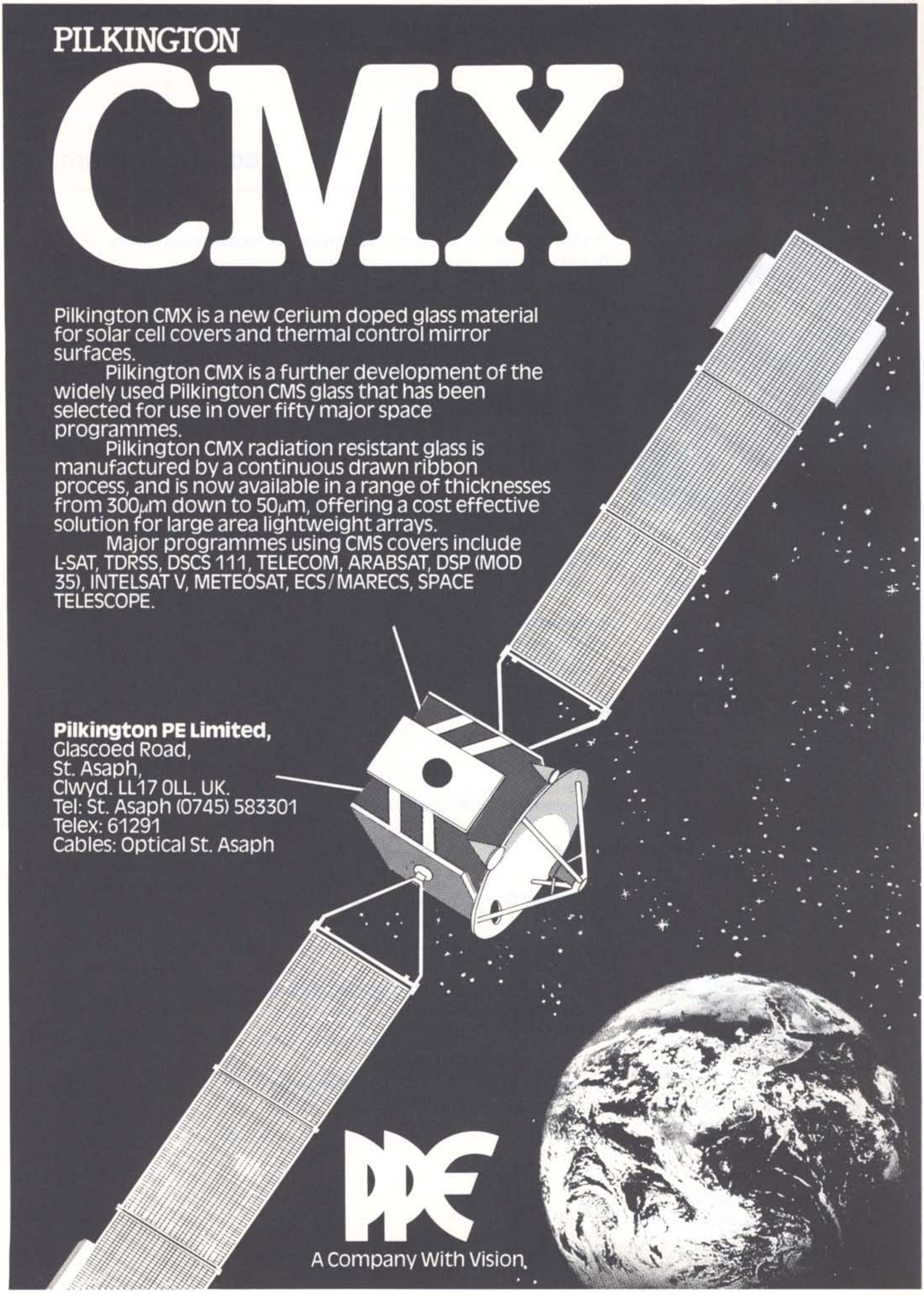
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The MAGE Family of European Solid-Propellent Apogee Boost Motors

W. Asad, Société Européene de Propulsion (SEP), Bordeaux, France

The MAGE family consists of three motors of different sizes which, by appropriate choice of their propellent load, can put satellites weighing 655 to 1210 kg in transfer orbit into geosynchronous orbit. All three motors – MAGE 1, 1S and 2 – were qualified in 1981-1982 in a test programme that demonstrated reproducible, reliable, state of the art performance.

Background

Although extensive work has been carried out in Europe in the solid-propulsion field during the last 15 years, the first conclusive demonstration of European apogee-boost-motor capabilities was provided on 25 April 1977 by the successful firing of the motor carried aboard ESA's Geos spacecraft to inject it into near-geosynchronous orbit.

The MAGE (Moteur d'Apogée Géostationnaire Européen) project was started in 1974 with the dual objectives of improving the performance characteristics of the basic motor design and providing apogee motors for European applications satellites. The motors are developed by Société Européenne de Propulsion, France (SEP), Bombrini Parodi Delfino – Difesa Espazio, Italy (BPD), and Maschinenfabrik Augsburg Nürnburg, Germany (MAN), under contract to ESA.

Performance specifications for the MAGE motors were initially centred on the needs of Delta-2914-launched geostationary satellites. Europe's development of the Ariane launcher and the evolution in ESA's programmes in the applications satellite field subsequently led to the definition of the 'family' of MAGE motors.

The first space application of the MAGE-1 motor was on the successful Meteosat-2 mission on 20 June 1981. The next will be the use of a MAGE-2 motor with the ECS-1 satellite in 1983. A total of some 20 flight motors are either already ordered or being proposed for the Telecom-1, ECS, Meteosat, Giotto and Hipparcos missions.

The role of the apogee boost motor

The apogee boost motor (sometimes called the apogee kick motor) is used to inject satellites into geostationary orbit once the spacecraft and apogee motor have been put into the appropriate transfer orbit by the launch vehicle, whether that be Ariane or the Space Shuttle (the latter in conjunction with a propulsion assist module).

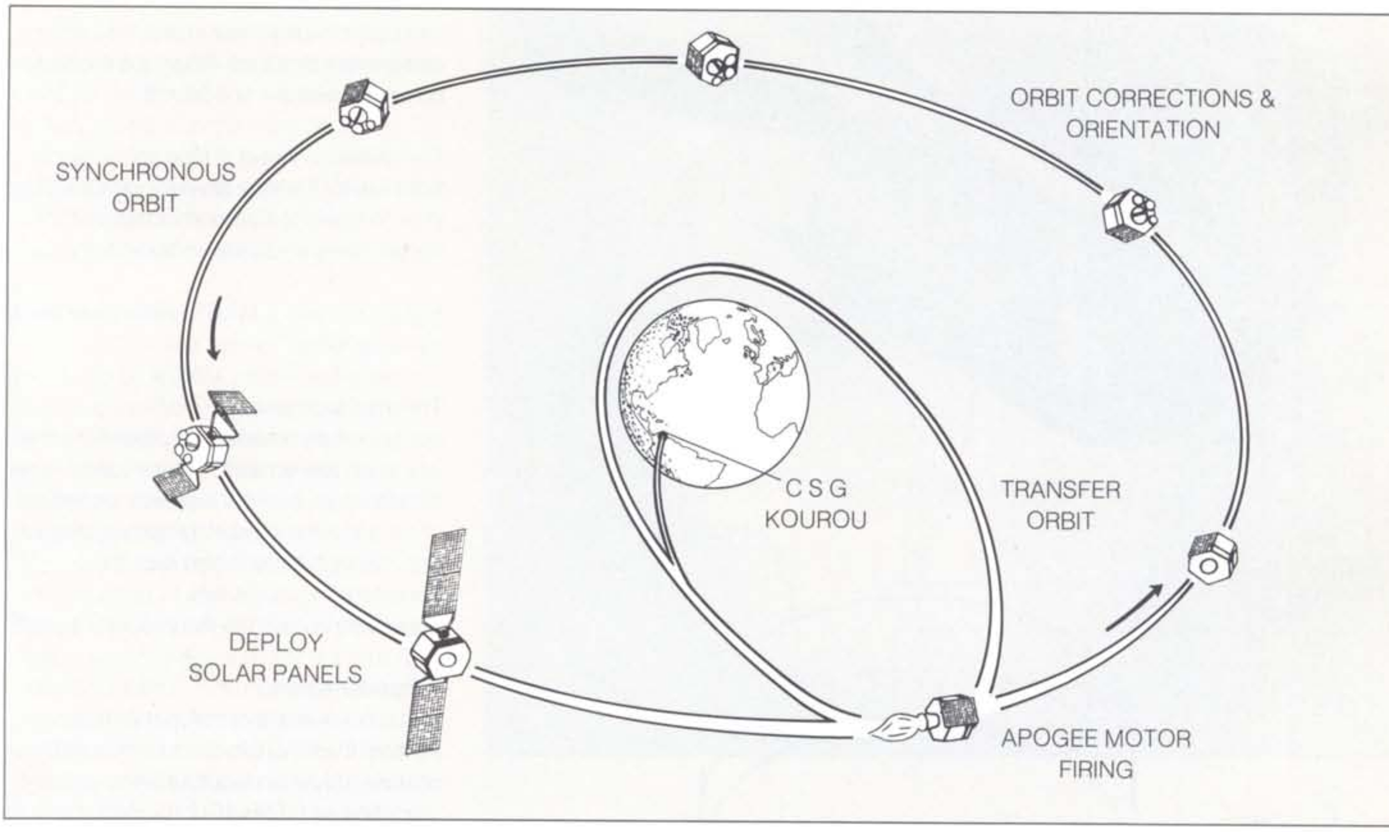
It takes about 10 minutes from the moment of the Ariane launcher's lift-off from the Guyana Space Centre (CSG) in Kourou for the transfer orbit to be achieved. The nominal injection sequence, illustrated in Figure 1, calls for precise orbit/attitude verifications, requiring two to five days, before the apogee boost motor is ignited at the highest point (apogee) of the elliptical transfer orbit. The pre-determined boost or kick brings the satellite into near-geostationary orbit approximately 36 000 km above the Earth.

Apogee boost motors have been developed primarily for geostationary-orbit applications, but they can also be used for other orbit changes requiring large changes in momentum. One such example is the need for a MAGE-1S motor to propel the Agency's Giotto spacecraft from its transfer orbit towards its flyby of Halley's comet in 1986.

Performances of MAGE motors and their applications

Apogee motors must be designed to impart the velocity increment necessary for a given spacecraft to reach geostationary orbit. Their size therefore

Figure 1 — Typical launch-event sequence for a geostationary spacecraft



depends on the mass of the particular spacecraft, which itself depends upon the nature of the mission (meteorological, communications, scientific, etc.). The present MAGE family of motors is suitable for spacecraft ranging in initial mass from about 655 to 1210 kg. Table 1 shows some application criteria for the MAGE-1, 1S and 2 motors in more detail.

Features of a typical apogee motor

Solid-propellent apogee motors (Fig. 2a,b) have the following principal components:

- motor case
- thermal protection and propellent grain
- nozzle
- ignition system.

Motor case

With solid-propellent motors, the motor case serves as both the propellent tank and the combustion chamber. To achieve good performance characteristics, the MAGE case is constructed from an advanced composite material. It consists

Table 1 — Performance capabilities of the MAGE family of motors (for Ariane launches from Kourou)

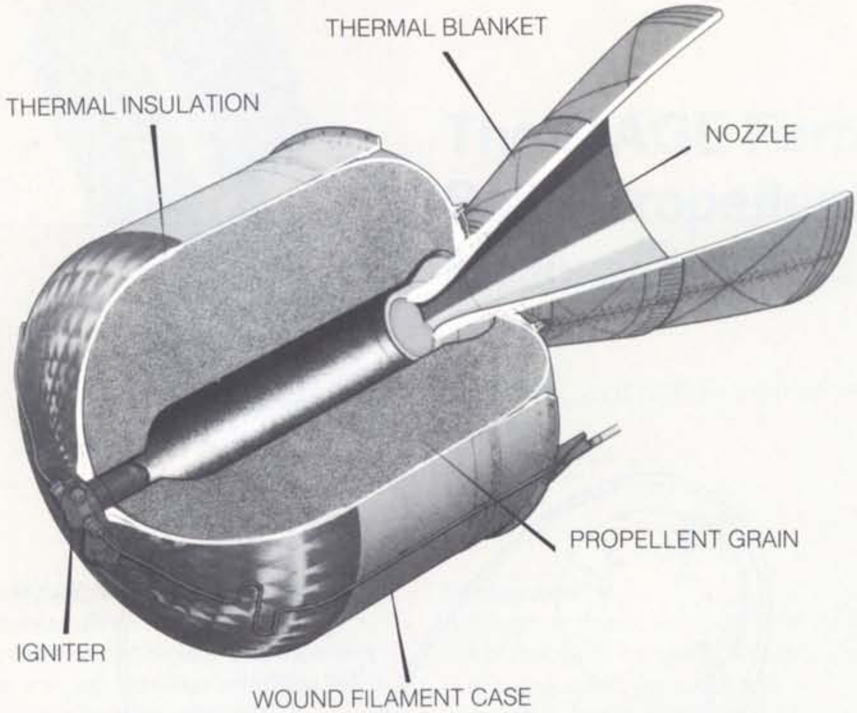
Motor type	MAGE-1	MAGE-1S	MAGE-2
Total satellite mass in transfer orbit (kg)	655 - 820	810 - 1001	992 - 1210
Satellite useful mass excl. apogee motor (kg)	345 - 451	445 - 553	552 - 674
Apogee-motor mass before firing (kg)	301 - 368	365 - 447	440 - 540
Apogee motor max. total impulse (Ns)	9.45×10^5	11.67×10^5	14.07×10^5

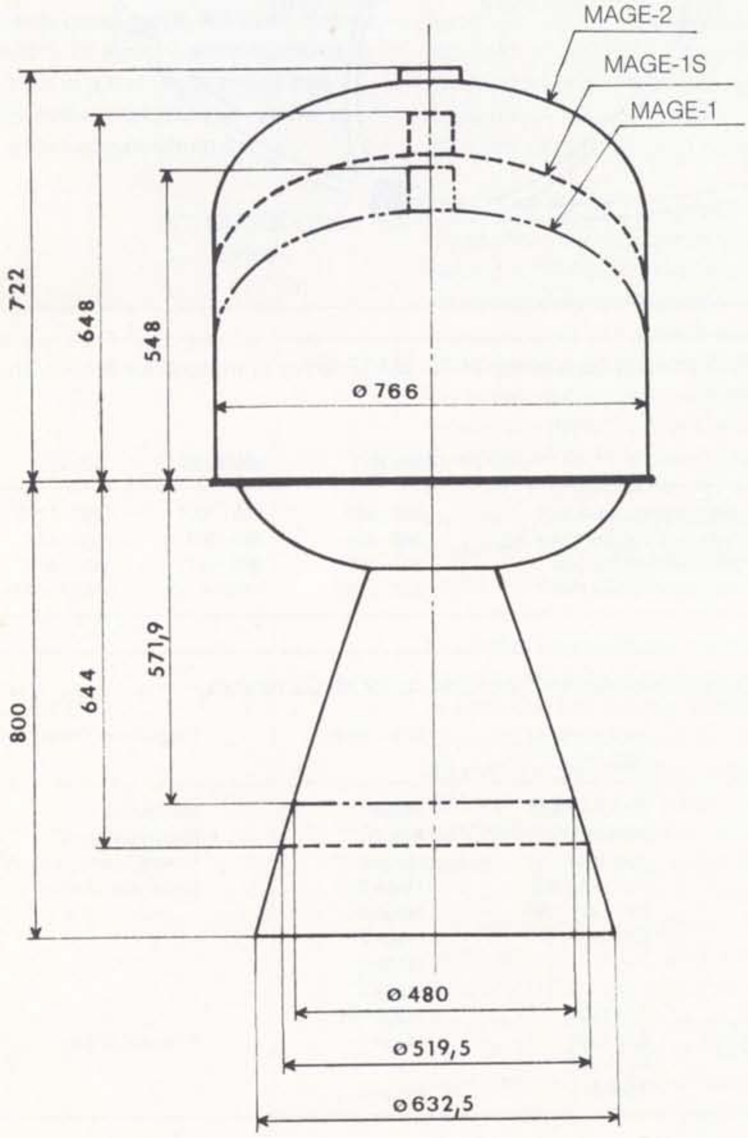
Table 2 — Current and planned applications for MAGE motors

Spacecraft	Launch date (approx)	Motor type	Programme status
Meteosat	20 June 1981	Mage-1	Successful
ECS-1	April 1983	Mage-2	Motors delivered*
TC-1A	July 1983	Mage-2	Motors nearing delivery*
ECS-2	October 1983	Mage-2	Under manufacture
TC-1B	February 1984	Mage-2	"
ECS-3	Not yet fixed	Mage-2	"
ECS-4	"	Mage-2	"
ECS-5	"	Mage-2	"
Giotto	July 1985	Mage-1S	"
Operational Metsats 1, 2, 3, 4	End 1985 Mid 1992	Mage-1	Proposal phase
Hipparcos	1986-87	Mage-2	"

* Flight unit plus flight spare

Figure 2a – Cutaway view of the MAGE-2 motor
Figure 2b – Size comparison for the MAGE-1, 1S and 2 motors





basically of a pressure vessel and an attachment skirt that allows the motor to be mated with the spacecraft.

The pressure vessel is filament-wound from Kevlar fibres in an epoxy matrix. The skirt consists of a wound composite of Kevlar fibres and carbon-fibre cloth.

Figure 3 shows a MAGE motor case being manufactured.

Thermal insulation

The thermal protection or propellent liner, which performs the dual function of flame inhibitor and thermal insulation, consists of an asbestos-filled ethylene/propylene/terpolymer rubber. It also has an important structural task in providing the necessary support to the propellent grain.

Propellent grain

The solid-propellent composite that powers the MAGE motors consists of a mixture of fuel and oxidiser, and is identified as CTPB-1612 (Carboxyl Terminated Poly-Butadiene 1612). It contains 72% ammonium perchlorate, 12% CTPB binder and 16% aluminium powder.

The propellent composition is cast into the insulated motor case after proper mixing. Final grain geometry is obtained after curing and machining operations.

Nozzle

The nozzle enables optimum thrust to be achieved through the expansion and acceleration of the gas produced by propellent combustion. It has two main elements:

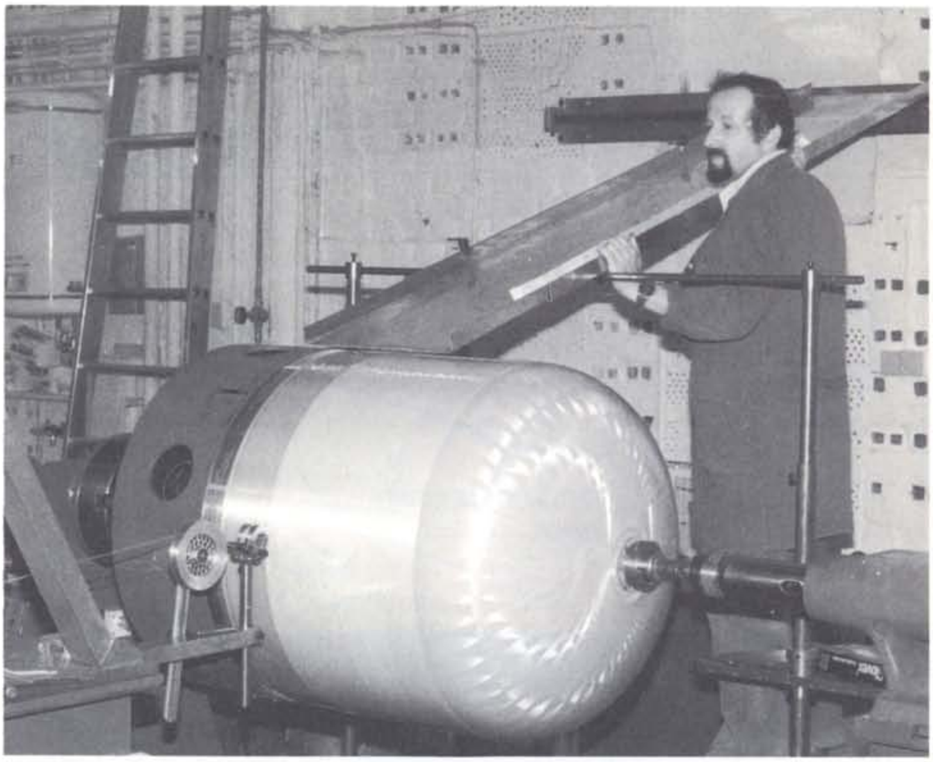
- a subsonic section (throat subassembly)
- a supersonic section, namely the exit cone.

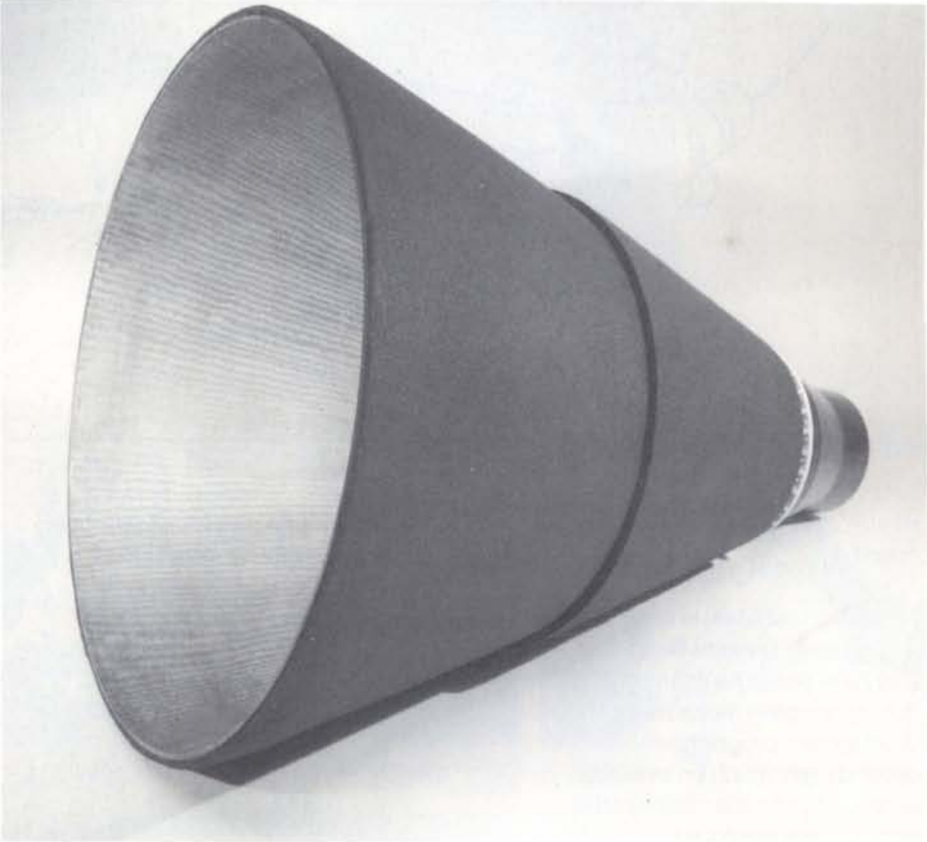
All MAGE motors have a throat section made from a high-density erosion-resistant, carbon/carbon composite (Sepcarb 4 D). The MAGE-2 nozzle (Fig. 4) is based on an ITE (Integral Throat Entrance, self supported) concept,

Figure 3 – Manufacture of a MAGE motor case in progress

Figure 4 – The nozzle of the MAGE-2 motor

whereas MAGE-1 and 1S have a titanium support housing. The supersonic exit cone for the MAGE-2 is made from a low-density carbon/carbon composite (Sepcarb 2 D), allowing a thickness of about 2 mm. The exit cones for the MAGE-1 and 1S motors are made of thicker carbon phenolic material.





Ignition system

Motor ignition is achieved by hot gas produced by a small propellent grain in a steel or glass-fibre housing inside the motor's combustion chamber. This igniter is initiated by redundant pyrotechnic cartridges, which in turn are ignited by an electrical current pulse from the spacecraft's power supply.

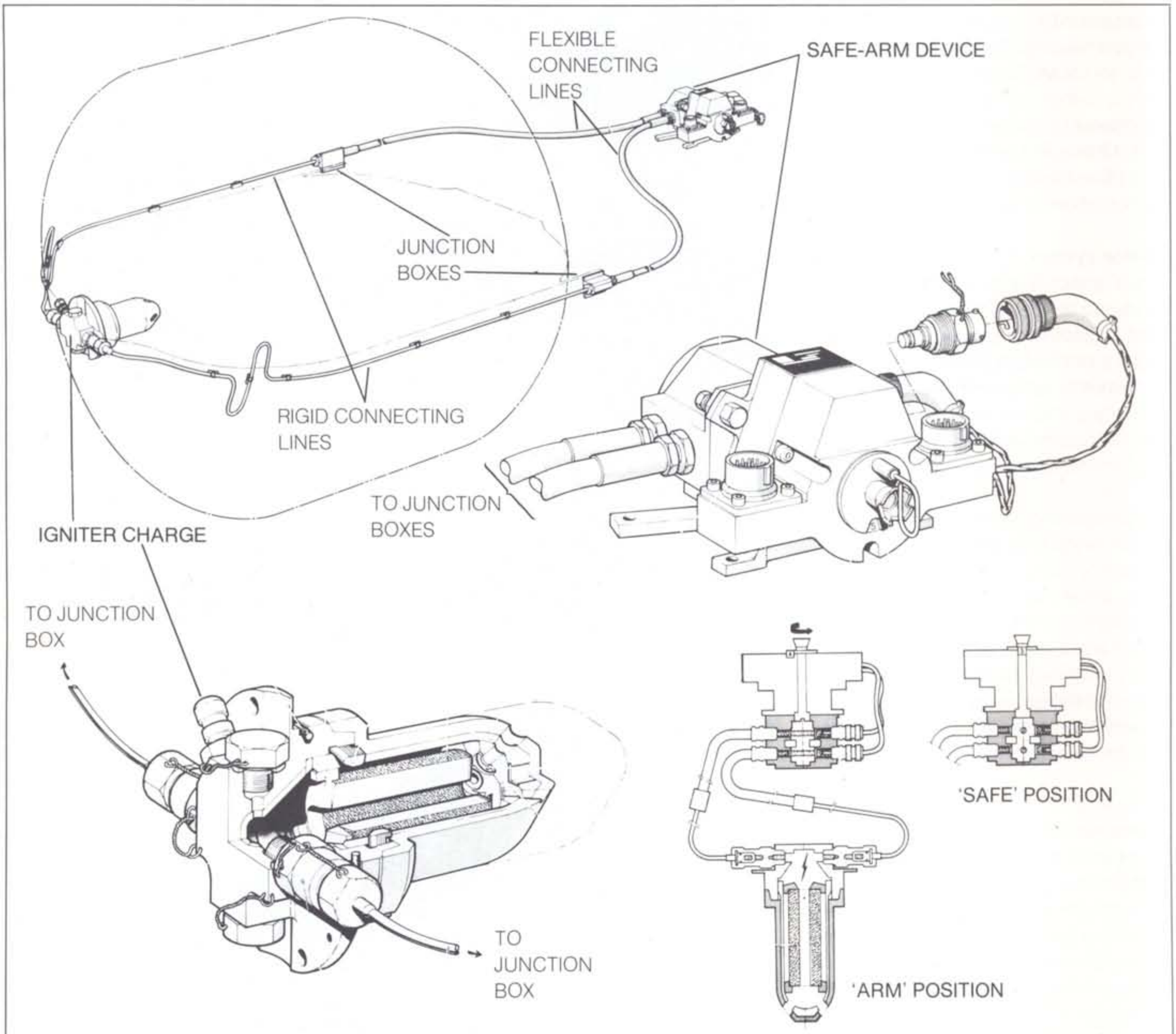
The ignition system also has a safe-arm device, which is required for reasons of personnel safety. This device is interposed between the pyrotechnic initiator cartridges and the main igniter. When the device is in the safe condition, it prevents motor ignition in the case of accidental firing of the ignition cartridges. The device is 'armed' by an electric motor, a few minutes before launch.

In the MAGE-1 and 1S motors, all of the above described elements are mounted at the head-end of the motor. The MAGE-2 motor has a design improvement in that the safe-arm device and ignition cartridges can be located remotely at any convenient point on the spacecraft (Fig. 5); in this case, the igniter is connected to the ignition cartridges by explosive transfer lines. The MAGE-1 and 1S motors can be equipped with a similar remote safe-arm device.

Development/qualification testing

Following trade-off studies, optimisation analyses and detailed design work, motor development work typically leads to component-level tests. The motor case is subjected to hydraulic burst tests to verify the design approach and to determine the safety margins experimentally. Igniter tests are performed to verify safe and

Figure 5 — The MAGE-2 ignition system with remote safe-arm device



reliable ignition under adverse mission conditions.

The design engineer is confronted with difficulties as some of the critical items (nozzle in particular) can only be tested during complete motor firing. The development programme therefore depends very much on available experience and the nature of the technologies employed.

The first test of a new motor design is almost invariably performed at atmospheric pressure. Exposure to environmental conditions such as vibration and temperature cycling allows design deficiencies to be detected. Firing temperatures are chosen to explore the operational limits and to assess motor performance under extreme conditions.

Motor performance is characterised in terms of total impulse or delivered specific impulse, which can only be measured under vacuum. Simulated-altitude facilities are used to perform at least the qualification, if not all test firings.

The development/qualification programme for a new motor design can involve four to eight firings. The qualification tests performed for the MAGE family are summarised in Table 3.

Figure 6 — MAGE-2 motor undergoing a fit-check with the Agency's ECS-1 telecommunications spacecraft

Table 3 — MAGE qualification-test characteristics

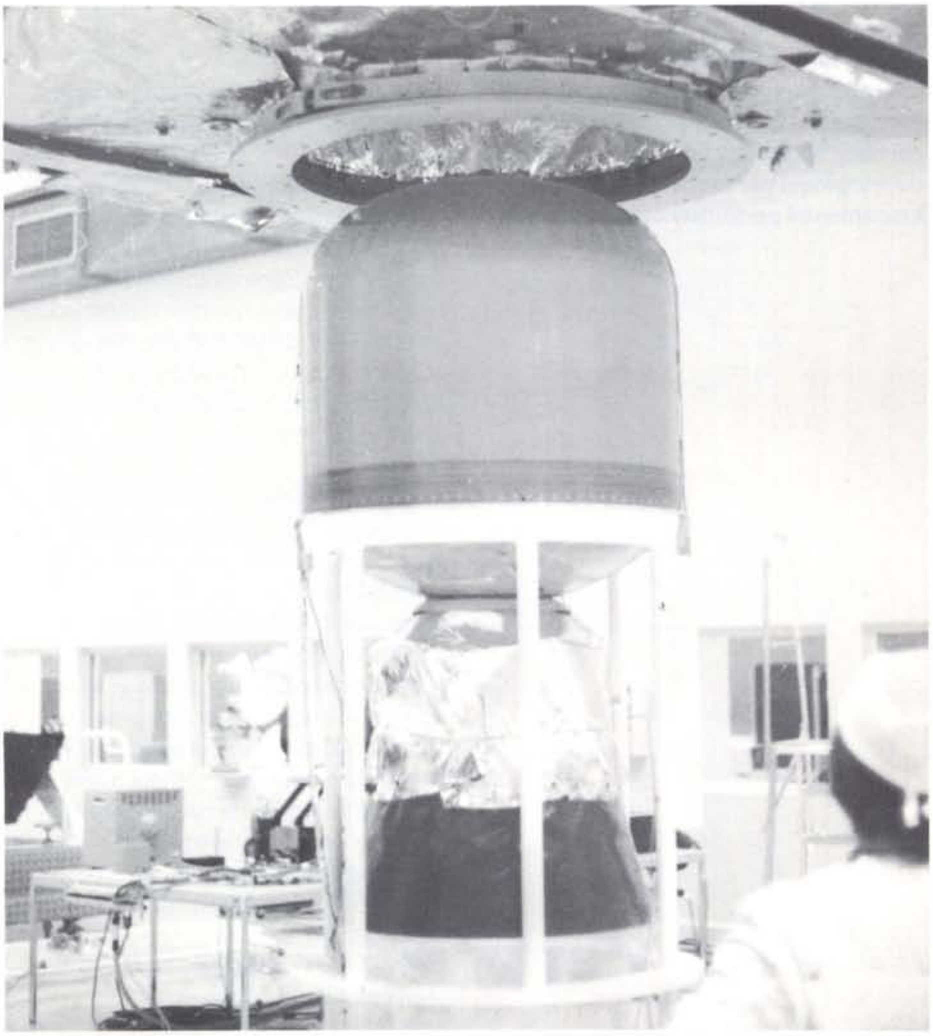
Motor tests	Propellent (kg)	Environmental tests			Test-firing conditions		
		Vibration	Acceleration	Thermal cycling	Spin rate	Vacuum	Temperature (°C)
MAGE-1							
Q1	272	x	x	x	0	x	−10
Q2	272	x	x	x	110	x	+40
MAGE-1S							
Q1S	410	x	x	x	0	x	−10
Q2S	410	x	x	x	75	x	+20
Q23	410	x	x	x	75	x	+40
MAGE-2							
Q1	490	x	x	x	90	x	−10
Q2	400	x	x	x	67	x	+40*
Q3	490	x	x	x	90	x	+40

* Exit cone cooled to −125°C before ignition

Conclusions and future outlook

Apogee motors of the MAGE family are already being used for European satellite programmes (ECS, Telecom and Meteosat) and will continue to be used for the next five to six years for payloads of half Ariane-3 size. With the MAGE-2 motor, European industry has achieved a level of performance equivalent to today's state of the art in apogee motors in the United States (comparison based on delivered specific impulse and motor mass fraction).

Through the use of improved materials and new technologies that are now becoming available from research and development programmes, it is possible to improve, and to add new members to, the MAGE family of motors. The next appropriate size (600-650 kg propellent) would cover the initial requirements of one-third Ariane-4 capacity payloads.



ISA-2: A Facility for Vacuum Firing Tests on Solid-Propellent Motors

L.M. Palenzona, ESA Technical Directorate, ESTEC, Noordwijk, The Netherlands
V. Mantini, BPD-Difesa e Spazio, Colleferro, Italy

When geostationary satellite missions, which require an Apogee Boost Motor (ABM) to circularise their final orbits, became a substantial part of the ESRO/ESA programme in the early seventies, European industry was encouraged to develop and qualify its own solid-propellent motors and related technologies. The environmental requirements for the functional testing of such motors under simulated operational (vacuum) conditions call for very special test facilities, in order to conduct 'static' test firings of development motors and to derive fundamental performance parameters.

A typical static-firing-test facility consists of three basic elements:
- an instrumented test chamber in which the motor is installed
- a gas-extraction system, to maintain specified environmental conditions in the test chamber before, during and after firing
- a facility-control and data-acquisition system.

The first ESRO satellite programme to make use of a test installation of this kind was Geos in 1975. This facility, called ISA-1 (Impianto Simulazione di Altitudine-1), was installed at a test range belonging to BPD-Difesa e Spazio, the Italian company charged with Geos motor development. Development work on new motors such as MAGE-I and MAGE-IS and the testing of further models of existing ABMs, such as that for Sirio-2, benefitted from the existence of this facility.

The ISA-1 facility was, however, only suitable for motors with up to approximately 400 kg of propellent. By the mid seventies, the trend in the development of European geostationary satellites, particularly those for communications purposes, was already such as to suggest a steady growth in satellite masses, and consequently in the size and performance of the apogee motors that would be needed. Ariane's development also played a role in the assessment of Europe's future requirements for space propulsion.

In 1977 BPD-Difesa e Spazio made a proposal for the acquisition and installation of an ISA-2 facility at Colleferro on the same range as ISA-1, but with performance capabilities compatible with motors carrying more than 1100 kg of propellent. An agreement was subsequently reached between ESA and BPD under which ESA would provide financial support in exchange for access to the facility on a preferential basis. The final decision to proceed with the new facility was taken in 1978, after a design trade-off had been made between two different operating concepts for the installation.

The trade-off

There are ostensibly only two systems available for ABM testing under vacuum conditions:

1. A gas diffuser system, which ensures suitable gas-pressure conditions by using motor-gas energy to 'pump' the combustion gases out of the facility. Diffuser systems are relatively simple and inexpensive. They are optimised only as 'single operating point' devices, and are thus particularly suited for steady-state operations for one type of motor. They are not readily adaptable to motors of different sizes and are not particularly suitable for transient testing. Furthermore, vacuum conditions can only be attained during the actual firing, and the motor plume cannot be observed because it remains hidden in the diffuser.
2. An ejector system, using auxiliary fluids to sustain a venturi-type effect, and capable of maintaining the desired pressure levels downstream of the motor-nozzle exit cone. In general, a multistage device is used

Figure 1 – Functional scheme for the ISA-2 facility

to achieve the requisite low-pressure conditions. The major implication of such a system is the need for a fairly high secondary-fluid flow rate, the choice of 'fluid' virtually being limited to steam.

Mechanical pumping systems cannot provide the capacity needed to accommodate motor-gas flow rates at the desired pressure. In addition, the rotating parts need sophisticated systems to protect them from high-temperature corrosion effects caused by the combustion gases. Vacuum pumps are, however, a valid complementary facility for evacuating the test chamber prior to motor firing.

The trade-off analysis made by BPD led in fact to the choice of a hybrid solution and selection of a continuous steam generator (also called a chemical steam generator), operating a two-stage steam-ejector system. The resulting facility combines the advantages of the two systems, meets the environmental test requirements, and produces vacuum conditions prior to motor ignition. It also allows lower pressure levels to be achieved and maintained whilst firing motors of different sizes, enables transient conditions to be tested, and allows thermal soak conditions to be monitored after motor firing.

The maximum performance and size of the ISA-2 facility has been determined by the sizes of the motors to be tested and, more specifically, by the maximum gas flow rates of the motors during the combustion period. When designing the gas extraction system, the total flow rate to be 'pumped' is approximately three times the hot-gas flow rate generated by the motor, since it must include the cooling water. This overall flow rate is the main dimensioning parameter.
The design for the facility's monitoring, control and data-acquisition systems has been largely influenced by safety and reliability considerations and, as far as motor data are concerned, by current and future programme requirements.

ISA-2 design
The main elements of the ISA-2 facility (Figs. 1 & 2) are:
- The instrumented chamber (TC in Fig. 1), which can be maintained under simulated altitude conditions during and after the firing of the motor. The motor is installed on a special test bench which allows thrust measurements to be made even with the motor spinning and provides the necessary instrumentation for pressure and temperature measurements.
- The mechanical pumping system (VP in Fig. 1) connected to the test chamber.
- The diffuser (D in Fig. 1) located

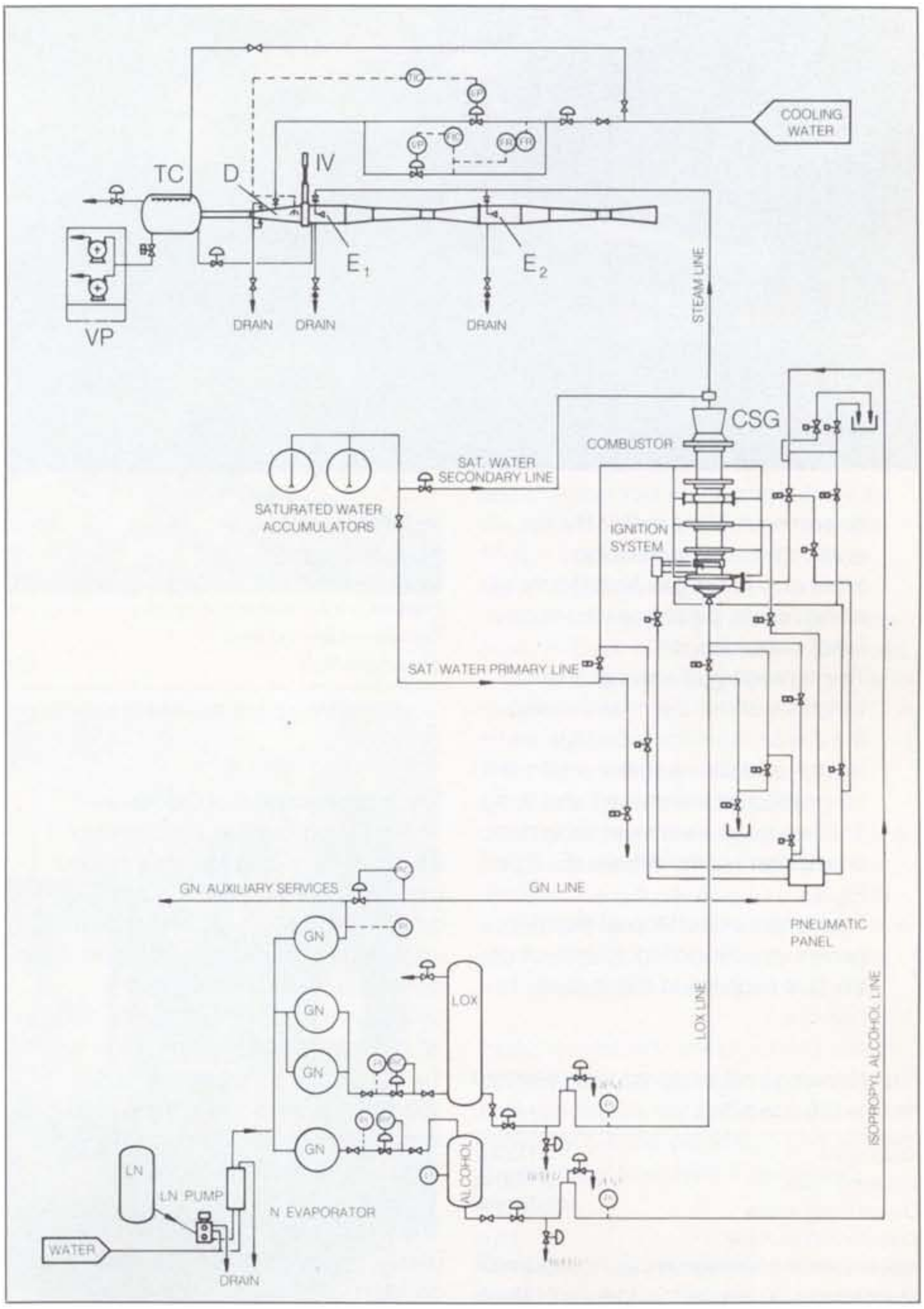
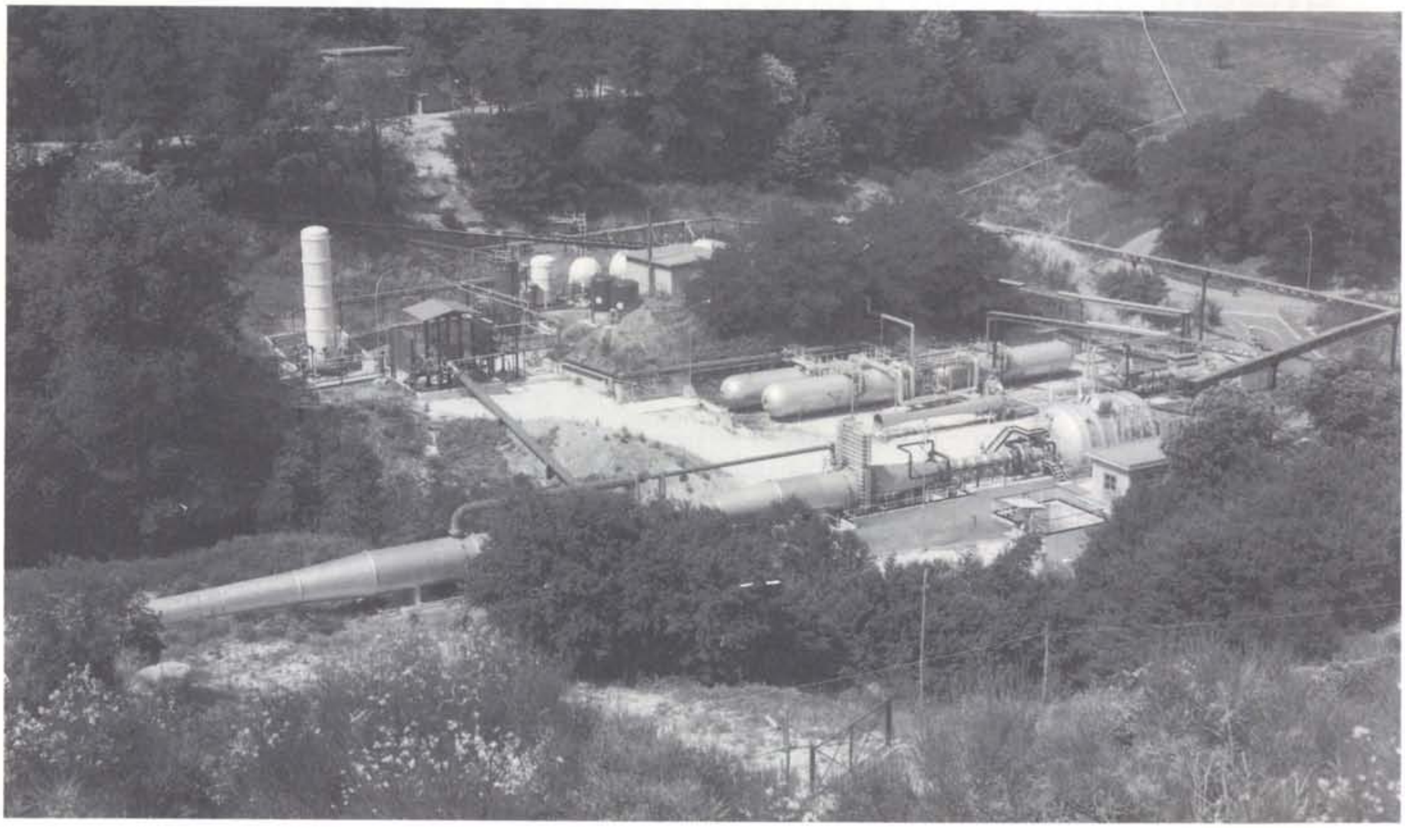


Figure 2 — The ISA-2 facility. In the foreground the long ejector stages, separated from the diffuser by the isolation valve, are recognisable. The test chamber is on the right. In the background from left to right, are the LOX tank, the CSG, the isopropyl alcohol tank, the cylindrical LN_2 tank and two of the spherical GN_2 tanks. The tanks in the centre of the photograph are the saturated-water accumulators



downstream of the motor. By enabling correct supersonic expansion of the gas from the throat of the nozzle, it also constitutes an initial ejector stage.

- The isolation/gate valve (IV Fig. 1) which separates the chamber and the diffuser from the two-stage steam ejector, and allows soak conditions to be established before and after firing.
- The two-stage steam-ejector system downstream of the diffuser (E_1, E_2 in Fig. 1).
- The continuous chemical steam generator (CSG in Fig. 1), including the fluid supply and distribution network.

The following design-drivers were selected for the ISA-2 facility:

Motor mass	⩾1100kg
Propellent mass	⩾1000 kg
Overall motor length	2 m
Overall motor diameter	1.5 m
Motor combustion temperature	3450 K
Motor exhaust gas flow rate	30 kg/s
Nozzle throat diameter	90 mm
Nozzle expansion ratio	65
Combustion time	70 s
Pressure in the chamber during firing	1–2 kPa*
Turnaround time between consecutive tests	72 h

* 1 kPa = 1000 N/m^2 = approx. 0.01 atm.

The instrumented test chamber

The test chamber (Fig. 3) consists of a 9.5 m long, 6 m diameter steel cylinder terminating in two domes. A 3 m × 3 m door at ground level permits speedy insertion of the motors to be tested. A test bench (Fig. 4) installed inside the chamber holds the motor during tests and allows measurements to be made with it fixed or spinning. Rotation at up to 150 rpm is provided via a three-phase AC motor connected to an external inverter for speed control.

The thrust measurements are made by means of redundant transducers, operating in tension, to guarantee optimum thrust alignment. Two TV cameras and two movie cameras monitor the motor and the bench continuously from positions outside the chamber during a test. Optical and infrared instruments can be directed at a visible portion of the plume to study its characteristics.

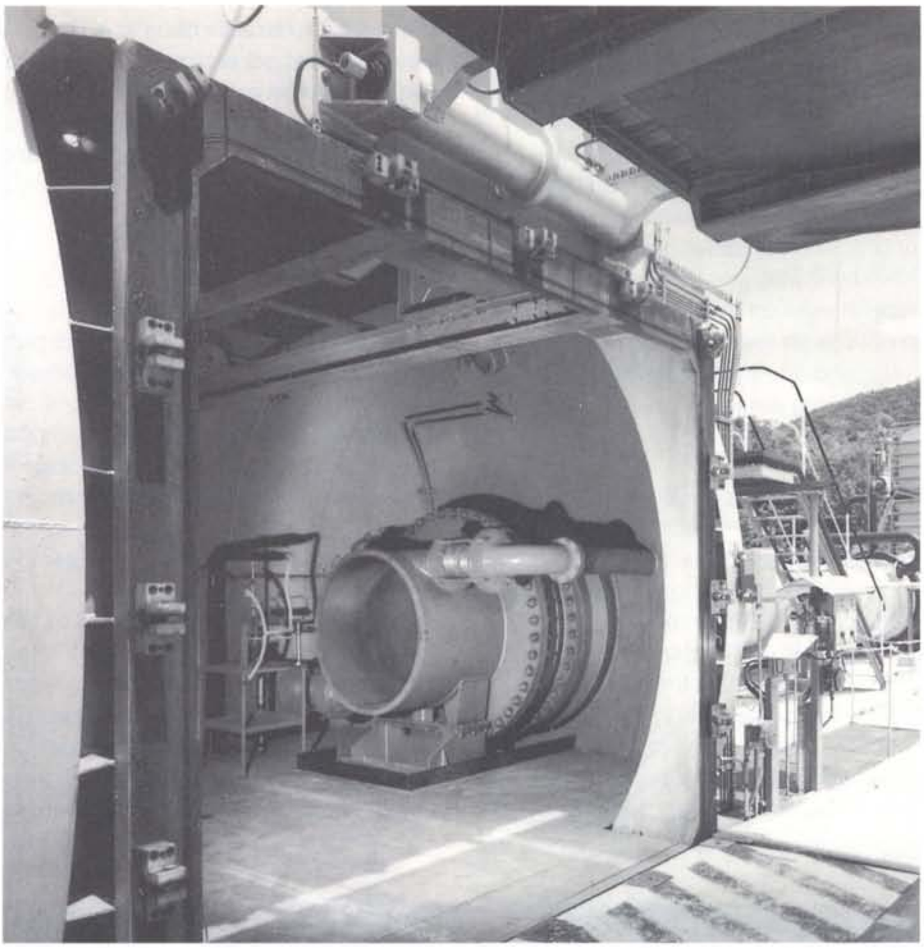
The gas-extraction system

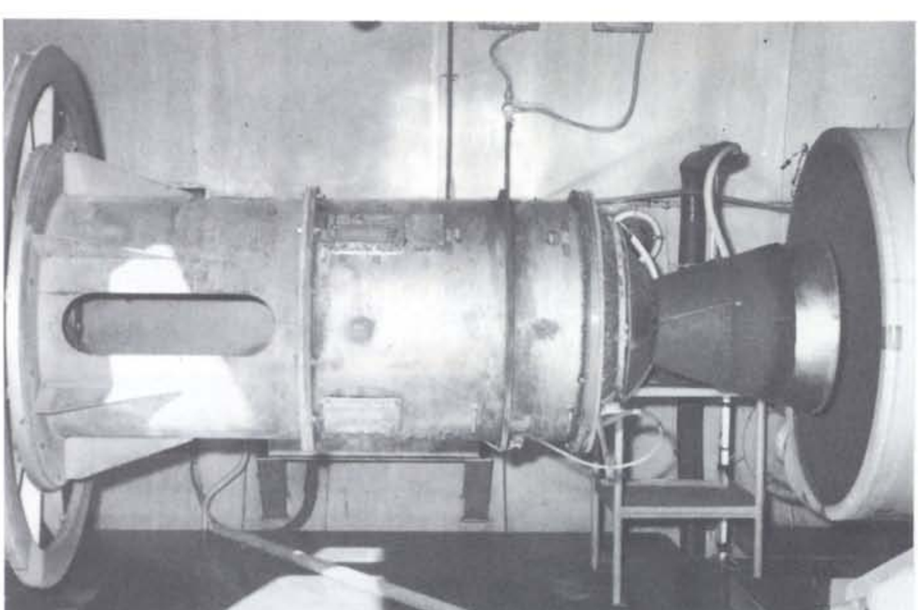
The mechanical vacuum-pump station (VP in Fig. 1) is the first 'on-line' operating device of the gas-extraction system whenever a static firing test is being conducted. The chamber containing the test motor is evacuated by mechanical pumps to avoid pressure gradients during steam-ejector start-up. A pressure of 16 kPa can be achieved in about 60 min.

The hydraulically-operated gate valve (IV) between the diffuser exit and the inlet of the first ejector (E_1) limits the section of the facility to be evacuated prior to motor firing and to be kept at low pressure after motor burnout.

Figure 3 — The inside of the test chamber, showing the leading edge of the diffuser with the connection to the cooling-water supply in its double wall. The unit on the left-hand side of the diffuser entrance is used to cool the tip of the motor's exit cone during firing at 120°C

Figure 4 — The test bench, on which the motor under test is mounted in a cantilevered position. The carbon-felt blanket on the nozzle of the motor is used to protect the surroundings from the intense heat radiated by the exit cone





A gate valve was chosen to obtain good sealing properties, which are essential during the post-firing soak phase, and because the particular composition of the gas mixture contains alumina droplets, which can form deposits to which other valve types could be more sensitive (the pressure level in the test chamber under post-fire soak conditions has been measured to be better than 25 kPa 100 min after ejector cut-off). This valve also prevents shock waves from entering the test chamber and reaching the motor after firing, when the ejectors blow down and there is a repressurisation shock wave inside the facility. The gate valve can be opened or closed in 15 s and in an emergency can be operated consecutively three times. A bypass line is used to equalise the pressures prior to opening the main valve.

The second on-line operating device is the two-stage noncondensing steam-jet ejector system, activated when the gate valve is still closed and the pressure in the test chamber has reached a sufficiently low level. Nominal steam flow rates are 50 kg/s and 200 kg/s for the first and second ejectors respectively, to which steam is conveyed by a 60 cm diameter pipeline. Each of the ejectors is 25 m long and has a diameter of 2.75 m at its inlet section.

The third component of the gas-extraction system, which actually constitutes the first on-line gas pumping stage, is a second throat-type supersonic diffuser. The diffuser structure is double-walled, allowing a cooling-water flow rate of 110 l/s (at 500 kPa) to keep the inner-wall temperature at acceptable levels.

Expansion joints in the outer wall absorb differential expansions. An expansion joint between the diffuser and the test chamber allows for thermal expansion and isolates the chamber from ejector-generated vibrations.

Combustion gas is cooled to minimise the need to protect individual components.

This cooling is provided via a set of uniformly distributed water nozzles in a section of the diffuser.

Sufficient distance is allowed between the point of injection and the gate valve for the gas and water to mix, thereby ensuring a uniform temperature at the valve, which is the first and most critical uncooled component subjected to the hot gas.

The steam generator

The chemical steam generator (a Rockwell-type engine) consists of a combustion chamber, similar to a liquid-propellent rocket-motor chamber, into which saturated water is injected and instantaneously vaporised to produce a continuous supply of steam for the ejectors. Isopropyl alcohol is used as the fuel and liquid oxygen as the oxidiser.

The water is forced into the unit by its own vapour pressure, which results in small time-dependent pressure and temperature variations. These variations in flow conditions in turn cause variations in the flow of liquid oxygen and alcohol, finally resulting in small time-dependent changes in steam flow, temperature, and pressure. The unit is controlled by pneumatically actuated, high-pressure valves in each of the primary fluid feedlines.

Liquid oxygen and alcohol are forced into the combustor by a GN_2 pressurisation system. The GN_2 is also used for pre- and post-test purging. The steam generator also uses water as a coolant. Three combustor 'spools' inject a water film near the chamber inner wall. This is only a small portion of the total water flow. The rest is injected via two other lines, one to the chamber for main water flow, and one downstream of the combustor for secondary water flow (Fig. 1). The water from these lines is then converted into steam.

The control and data-acquisition system

Test operations are controlled by a General Automation 440 computer (Fig. 5). The control language used consists of 25 different commands which can produce a test sequence which checks for proper positioning and functioning of facility valves, actuates these valves in any desired time sequence and/or when predetermined conditions have been met, performs 'redline' limit-valve checks on recorded-data channels, produces on-line printouts of selected data, and displays 24 channels of on-line engineering data on television-type screens.

The system has up to 96 digital input channels for microswitch signals, power signals etc. such that all operations can be monitored throughout the sequence. In addition, up to 128 analogue data and up to 96 digital output signals are available throughout the sequence for controlling or monitoring purposes. The 128 data channels are controlled by a programmable amplifier system with one differential amplifier per channel.

This system is capable of up to 40 000 measurements per second. The input and output channels are recorded on disk, and a printout can be produced after each test sequence. This allows quick and accurate verifications of event sequence and timing to be carried out.

A second GA 440 computer is used for test-data acquisition. The binary data from analogue channels can be reduced on-site immediately after a test, or stored on magnetic tape for processing elsewhere with more sophisticated programs. This second data recording system can handle up to 64 channels.

The decision to employ two computer systems in parallel was made for redundancy and reliability reasons.

Test results to date

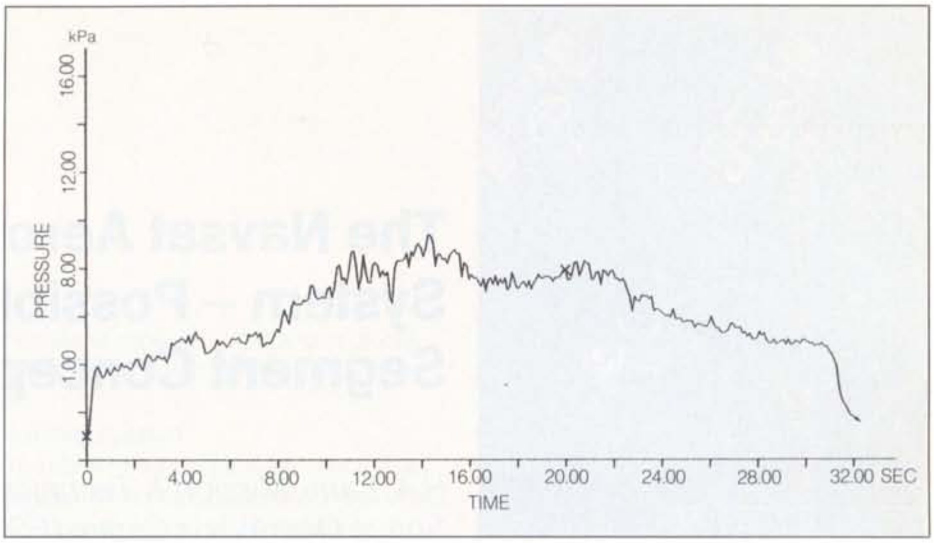
Several ABM units have already been test fired in the ISA-2 facility. During the test-firing of one of the MAGE series of motors, the minimum pressure in the test chamber

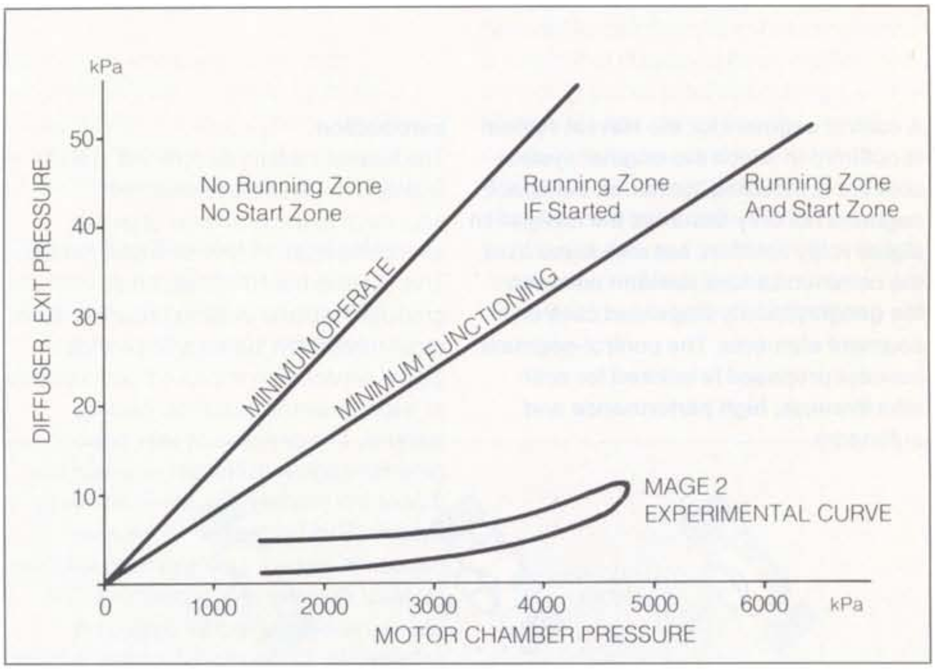
Figure 5 — The Control Centre. Behind the glass partition are the facility control console (left), the two computer tape units and disk units (right), and the two printers (background). In the foreground are the display units for the facility operators

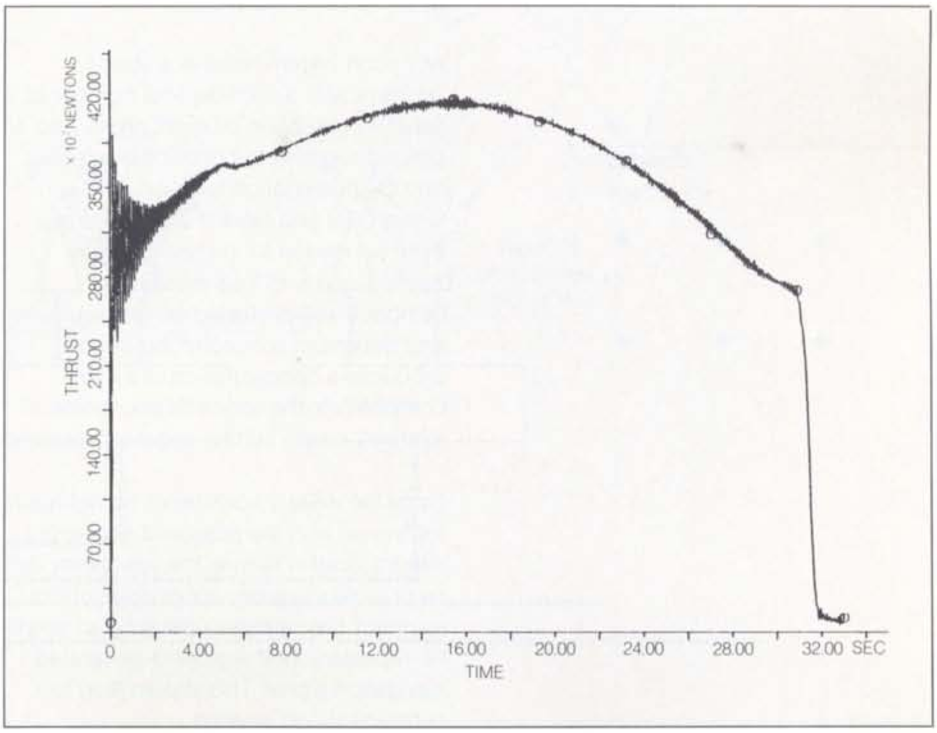
Figure 6 — Pressure evolution, during combustion, at the diffuser exit during the testing of a MAGE motor

Figure 7 — Diffuser theoretical performance diagram. Note how the experimental points recorded during the firing of a MAGE-2 motor lie entirely within the diffuser 'run' and 'start' zone

Figure 8 — Thrust of the MAGE-2 motor measured during firing by means of transducers operating in tension. The plot reflects normal running of the motor, following the initial transient during start-up





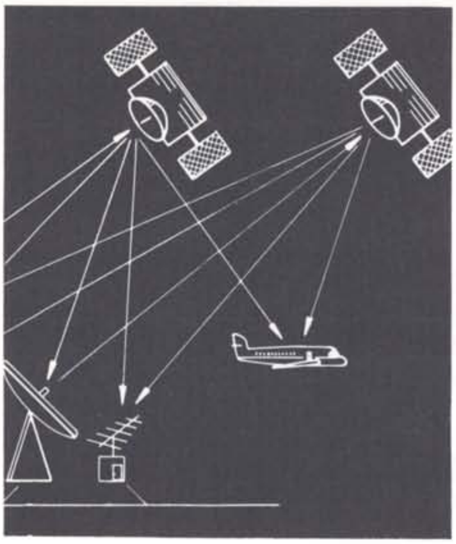


was found to be around 0.6 kPa, and the average value about 0.8 kPa, corresponding to an altitude of approximately 33 km. Figure 6 is a gas repressurisation diagram for the diffuser exit, showing that an average repressurisation ratio of about 8 is obtained.

Figure 7 shows the theoretical diffuser performance for a MAGE-2 motor under test. It gives the limit zone for a running condition. The minimum functioning line is the upper limit for correct diffuser operation. Above the zone between this minimum and the minimum operating line the diffuser no longer works correctly.

Finally, in Figure 8 the thrust produced by one of the MAGE family of motors is shown as a function of time.

This motor was loaded with 490 kg of composite propellent type CTPB 1612 and produced a maximum thrust of 41.2 kN at a combustion-chamber pressure of 4464 kPa. The burn time was approximately 32 s and the maximum gas flow rate 15 kg/s. The motor was spun at 90 rpm during the test firing.



The Navsat Aeronavigation System – Possible Control-Segment Concepts

H.A. Laue, Mission & Technical Coordination Office, European Space Operations Centre (ESOC), Darmstadt, Germany

A control segment for the Navsat system is outlined in which the original system concept is modified insofar as the space segment not only assumes the navigation signal relay function, but also takes over the communications function between the geographically dispersed control-segment elements. The control-segment concept proposed is tailored for cost-effectiveness, high performance and autonomy.

Introduction

The Navsat system, as outlined in ESA Bulletin No. 30, represents a new approach to the problems of global aircraft navigation and air-traffic control. This satellite-based system could gradually replace existing ground-based radio navigation systems, to provide a global service with improved performance at a lower overall cost than existing systems. The principle of user position determination with Navsat is similar to that of the (military) Global Positioning System (GPS) in that an RF receiver measures (pseudo) ranges from satellites (at least 4) operating as beacons. The user's three-dimensional position is provided by trilateration, together with an estimate of his clock offset.

Any such system requires a space segment with a considerable number of satellites (18–24) in different orbits, and a ground segment to control the satellites and their navigation function. This is where GPS and Navsat differ. GPS has been conceived for primarily military applications and thus requires a compact, well-protected control segment and maximum spacecraft autonomy. This produces a concentration of system complexity in the space segment, with relatively simple control-segment elements.

Since the military constraints do not apply for Navsat and the proposed system is international in nature, the complexity can be put into the easily accessible control segment, the satellites operating as simple RF repeaters for the ground-generated navigation signal. This should lead to substantial cost savings.

Control-segment requirements

With the Navsat system, all complex system tasks are performed by the control segment; they can conveniently be broken down into navigation-mission, navigation-support and satellite-support functions.

Navigation mission

The navigation system functions involve the generation, distribution and uplinking of the navigation signals. The signals from the 24 satellites are modulated by the same PN* code, but they differ in the phasing of ground transmission times and in the content of the data message modulated onto the PN code (700 bit/s). As the navigation signal is generated at ground stations and only relayed to users via the satellite transponders, each satellite must always be in view of at least one ground uplink station. The navigation signals generated at the various stations around the globe must be correlated within the TDMA** scheme, so that a central facility for control and coordination of this function is required.

Navigation support

The user's navigation accuracy is directly linked to that of the satellite position information contained in the navigation signal, and to the timing accuracy at the uplink stations. Navigation support therefore includes control-segment functions related to satellite ephemeris calculation and time synchronisation, the

* PN = Pseudo-random Noise Sequence.

** TDMA = Time-Division Multiple Access

Figure 1 — Navsat system concept

requirements for which are currently set as:
- 1.5 m satellite ephemeris accuracy
- 3 ns clock-offset between any two uplink stations.

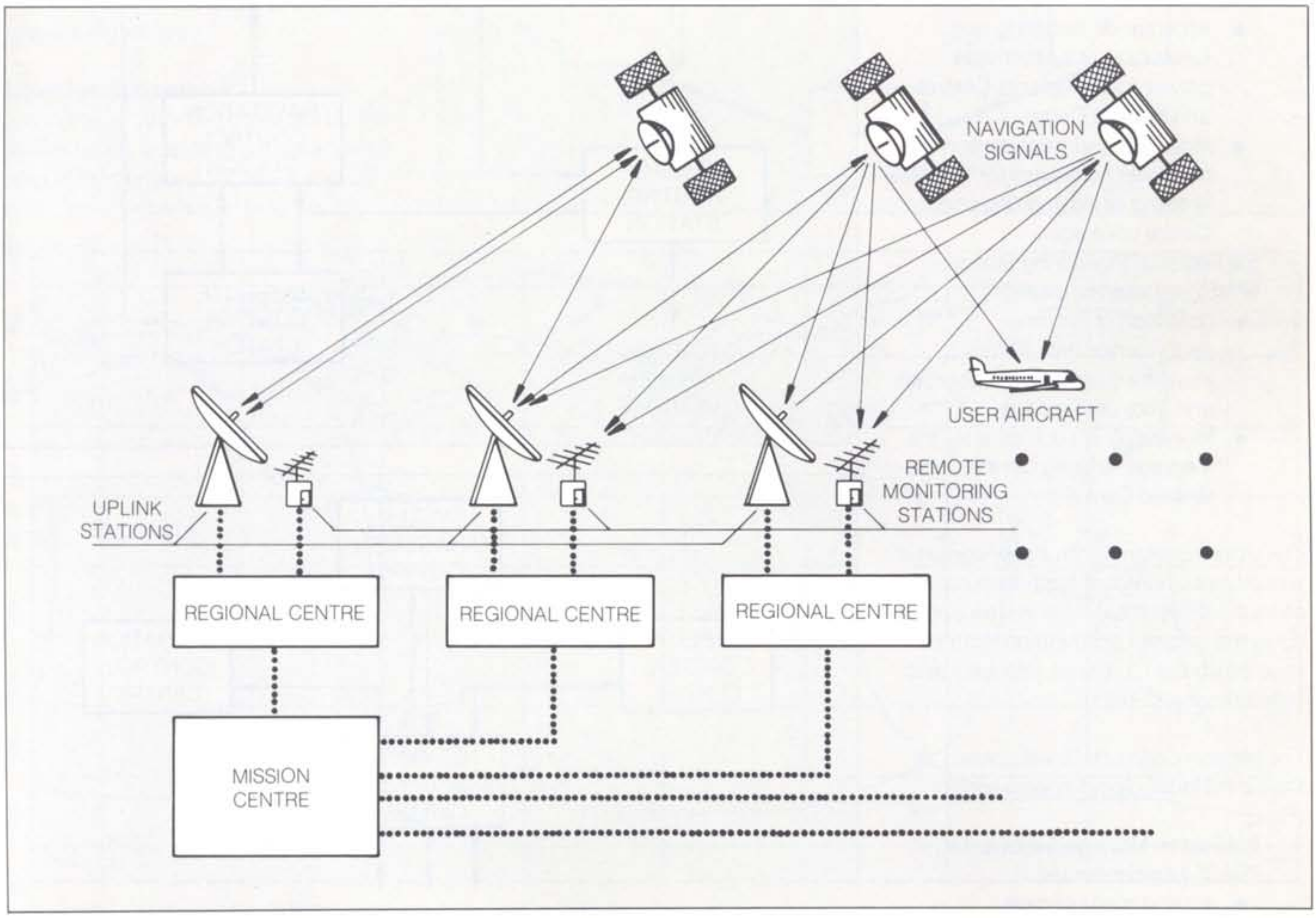
Another important navigation-support task is continuous monitoring of system availability and performance. In its simplest form, this requires a set of standard navigation receivers co-located with the uplink stations. For a more accurate evaluation, a denser network of monitoring receivers is required, also involving airborne sets. The latter network should ideally be connected to airport navigation installations used for differential approach navigation. An associated data-collection system is needed to allow fast central or regional evaluation of system performance.

Satellite support
The satellite support function comprises spacecraft control, payload control, orbit configuration control, and system-resource management.

Spacecraft and payload control requirements will be similar to those of conventional communications satellites, aided by the intentionally low complexity of the Navsat satellite design.

Orbit configuration control and system-resource management (allocation of redundant subsystem modules or of in-orbit spare satellites etc.) are complex tasks because of the large number of satellites involved. They call for special attention in terms of ensuring mission performance and minimising system life-cycle cost.

Control-segment concept
Based on the above requirements, the Navsat Control Segment should consist of a number of dispersed Regional Centres, providing global satellite coverage, and a Mission Centre, controlling the overall conduct of the mission and coordinating the Regional Centres. Regional Centres must be connected with the Mission Centre in a communications network that allows rapid exchange of navigation system data and control information (Fig. 1).



Control-segment elements

The main elements of a Regional Centre are (Fig. 2):

- the Navigation Control Station (NCS), responsible for
  - short-term ephemeris calculation
  - navigation signal generation
  - time synchronisation
- the Satellite Control Station (SCS), responsible for
  - spacecraft control
  - orbit maintenance
  - tracking data preprocessing
- the Uplink Station (ULS), responsible for
  - navigation signal uplinking
  - telemetry/telecommand communication
  - satellite tracking
  - (data relay via satellite)
- the Message Routing Station (MRS), responsible for
  - acceptance, buffering and forwarding of system data between the Regional Centres and Mission Centre
  - reception and transmission of handover messages for satellites entering or leaving Regional Centre coverage
- the Regional Monitoring Station (RMS), responsible for
  - collection of systems-performance data from monitoring of standard user sets and from user reports
  - forwarding of such data via the Message Routing Centre to the Mission Centre.

The Uplink Station will probably consist of a number of individual earth terminals to serve the different satellites in view and to cover the different ground/spacecraft links: navigation (L-band), telemetry and telecommand (S-band).

The Mission Centre (MC) will contain all the elements for global system control (Fig. 3):

- the System Management Centre (SMC), responsible for
  - mission management
  - management of system resources (space and ground)
- the Navigation Control Centre (NCC), responsible for
  - central emphemeris determination
  - navigation-message synchronisation
  - system-performance monitoring
- the Satellite Control Centre (SCC), responsible for
  - long-term satellite monitoring
  - satellite operations planning
  - orbit configuration control
- the Network Management Centre (NMC), responsible for

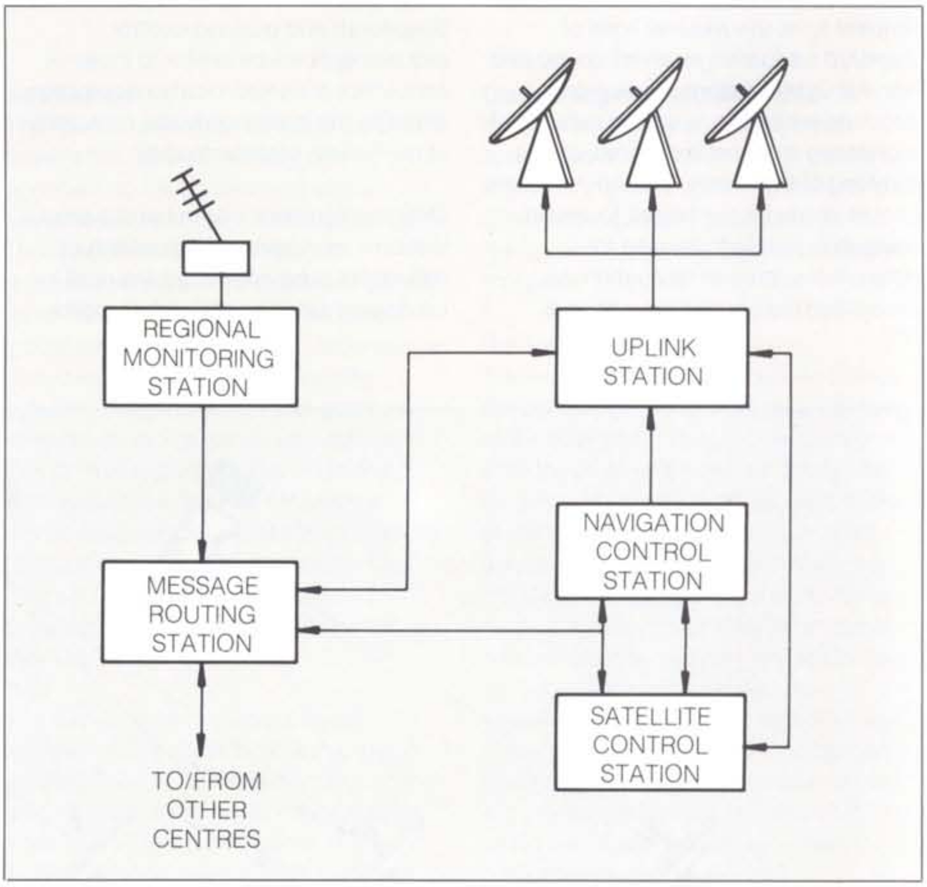


Figure 2 – Regional Centre functional block diagram

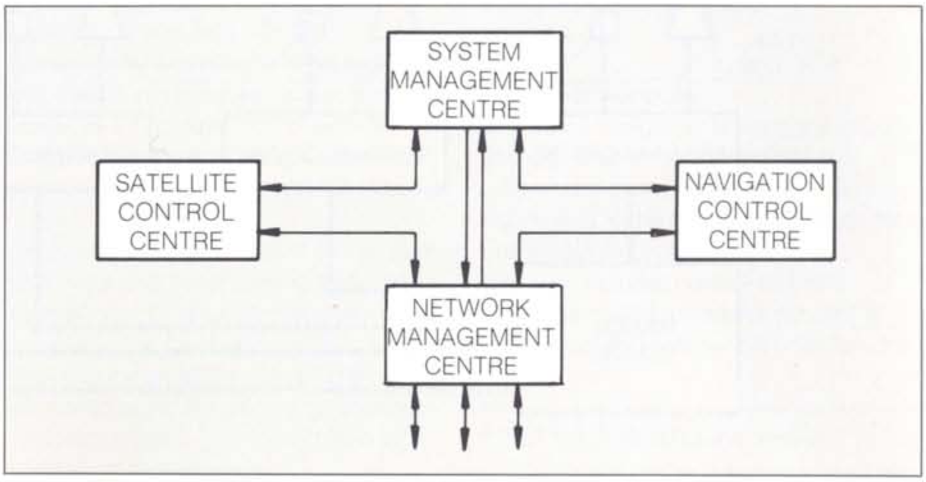


Figure 3 – Mission Centre functional block diagram

- data transmission to and from the central facility
- control of network nodes.

Control-segment communications
The communications network, which links the geographically dispersed Regional Centres and the Mission Centre, can best be implemented as a ring network (Fig. 4). To reduce the volume of data transmitted over the individual links, it is proposed to separate those functions performed at Regional Centres in real time from the coordination functions of the Mission Centre which, it turns out, can mostly be done in deferred time. The Navsat satellites themselves could be used as data relays between adjoining Regional Centres. While not imposing an undue burden on satellite design, this solution would make the overall system completely autonomous and independent of external data-link resources.

Ground-station network
Due to the 55° inclination chosen for the satellite orbits, satellite ground tracks will never extend beyond 55° North and 55° South, which means that polar-sector ground coverage is not required. With a satellite altitude of 20 183 km (for a 12 h orbit), and assuming a minimum elevation above the horizon of 10° for safe satellite contact, full coverage can just be achieved with four equatorial stations, spaced by 90° in longitude (Fig. 5).

In practice, however, no suitable combination of four land bases exists at the equator due to the Pacific-Ocean gap. A network of at least six Regional Centres is therefore considered more realistic, and the following additional criteria should be considered in planning its layout:

- The dual coverage areas between adjacent stations should be such that a minimum handover time (during

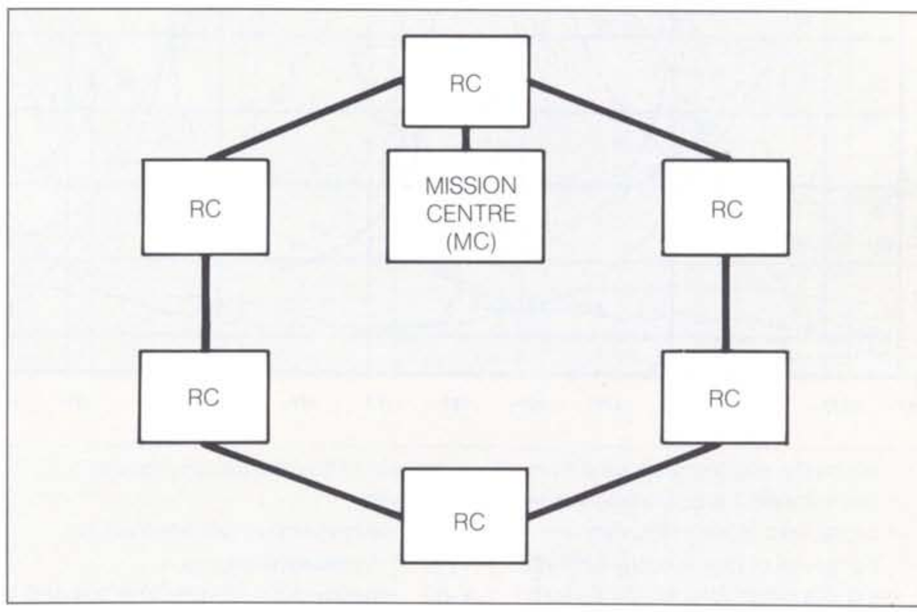


Figure 4 – Network configuration

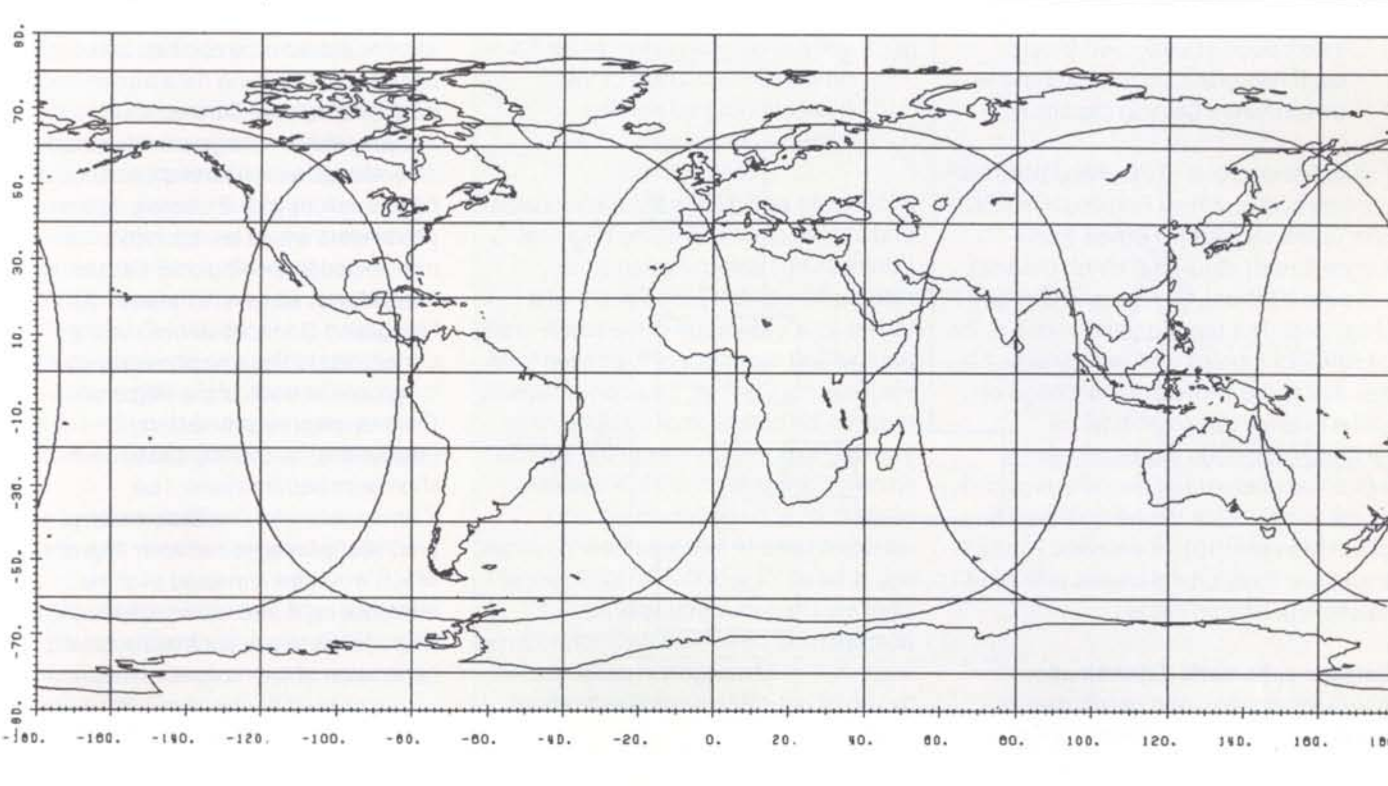
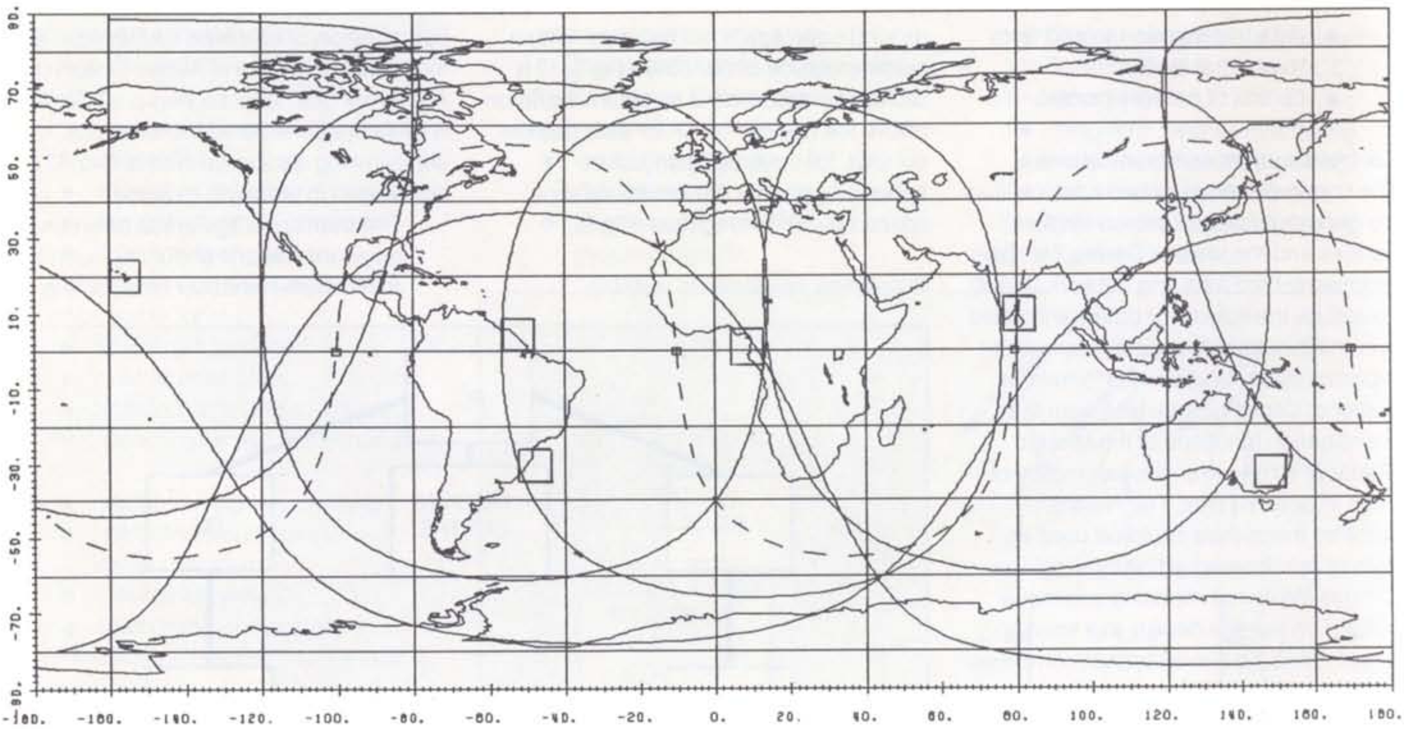


Figure 5 – Coverage by four equatorial stations

Figure 6 — Coverage by six Regional Centres



which the spacecraft is seen from both stations) is guaranteed, even for crossovers at high latitudes.

- For areas of high-density air traffic, e.g. the North Atlantic, dual-station coverage would be desirable from a safety point of view, even though each Regional Centre must have its own inherent backup capability.

Figure 6 shows one of the many possible configurations with six Regional Centres, with uplink stations in Hawaii, Porto Alegre (Brazil), Kourou (French Guiana), Libreville (Gabon), Ceylon, and Orroral (Australia). The ground track of one of the 24 satellites repeats itself exactly after 1 day due to the chosen orbital period of half a sidereal day (= 11 h 58 min), ignoring orbit-node regression. An indication of coverage period is provided by the length of the dashes in Figure 6, which represent 10 min intervals. Figure 7 shows the three orbital planes with all 24 satellites at a given instant.

Satellite ephemeris determination

The determination and distribution of satellite ephemerides, which is a key element of the navigation process, involves:

(i) acquisition of satellite-tracking measurements

(ii) computation of satellite orbits and their extrapolation into the future

(iii) suitable representation of the future orbit and modulation of the navigation signal with the ephemeris message.

Activities (i) and (iii) are local in character and can be dealt with at the Regional Centres. Orbit determination (ii) is essentially a global problem in that it relates to a knowledge of the whole orbit and not just segments of it, as seen from the Regional Centres. This conventionally requires the collection of tracking data from all Regional Centres at the Mission Centre, computation of all 24 satellite orbits from accumulated data, and retransmission of future satellite positions, again for all 24 satellites, to all Regional Centres. The turnround time for this process must be sufficiently short to avoid degradation of navigation performance by use of out-of-date satellite-position predictions.

To overcome the problems of data flow between Regional Centres and Mission Centre, division of the orbit-determination process into two steps is proposed (Fig. 8). As a first step, a reference orbit is computed at the Mission Centre for each satellite, based on smoothed and compressed tracking data transmitted from the Regional Centres and accumulated over a one-week period. The reference-orbit predictions should have a validity of 1–2 weeks and their parameters would be regularly transmitted to the Regional Centres. In a second step, as part of the task of the Navigation Control Stations, on-line corrections to this reference orbit can be computed at each of the Regional Centres using recent tracking measurements, thereby taking care of short term perturbations. The Kalman estimator could compute predictions for approximately 12 h ahead, which would be improved over the reference orbit and transmitted to the next Regional Centre to control the satellite, for generation of the navigation message.

The advantages of such a scheme lie in

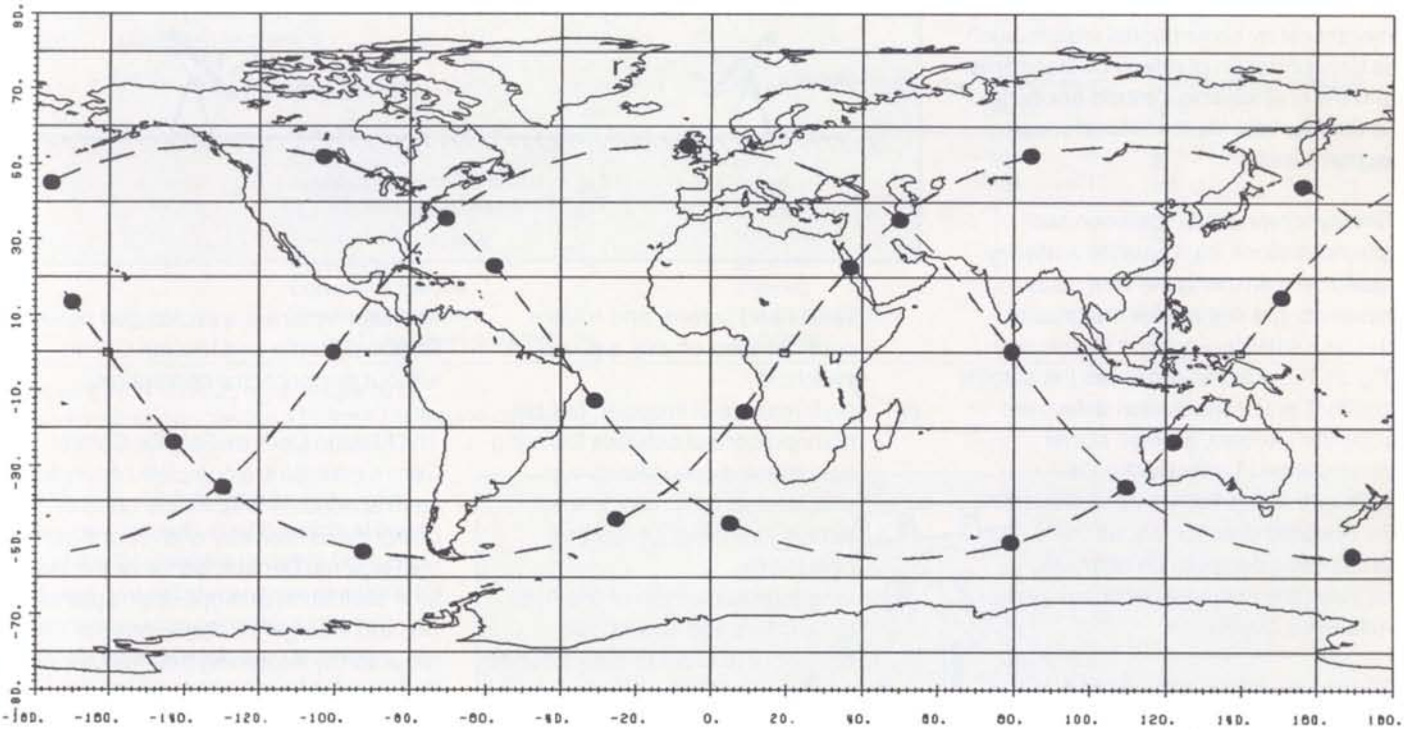


Figure 7 – Snapshot view of Navsat orbital configuration

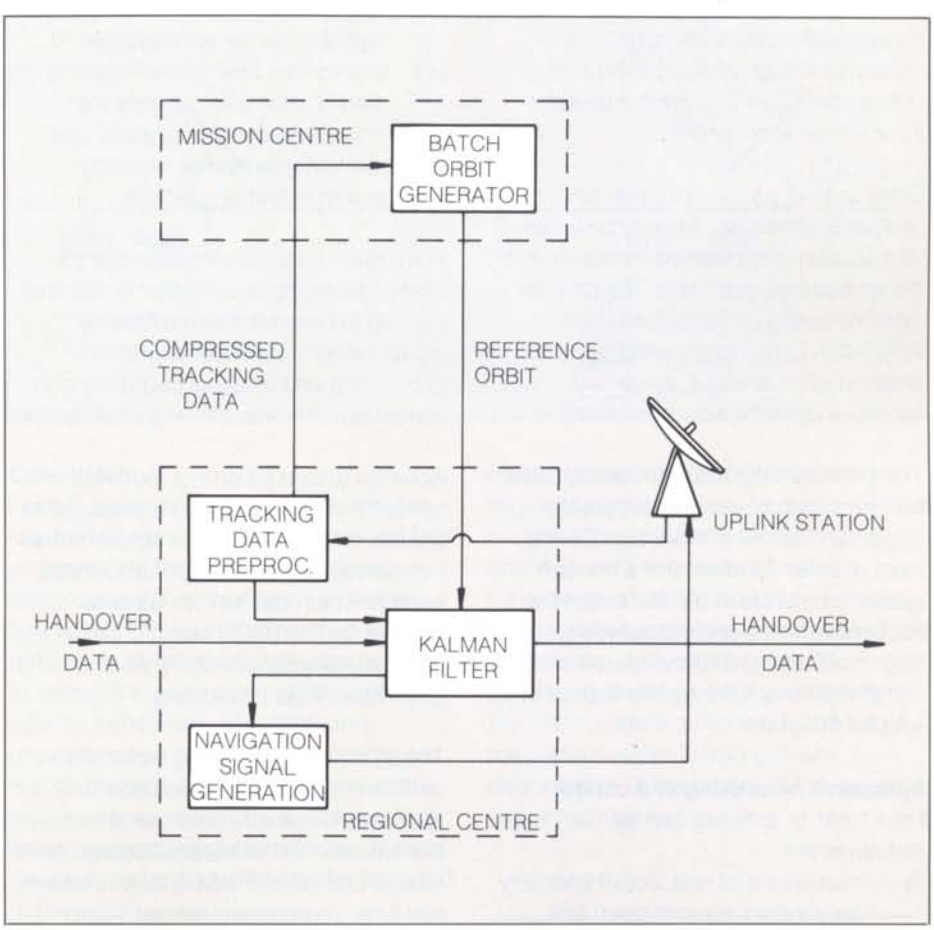


Figure 8 – Two-step ephemeris-determination procedure

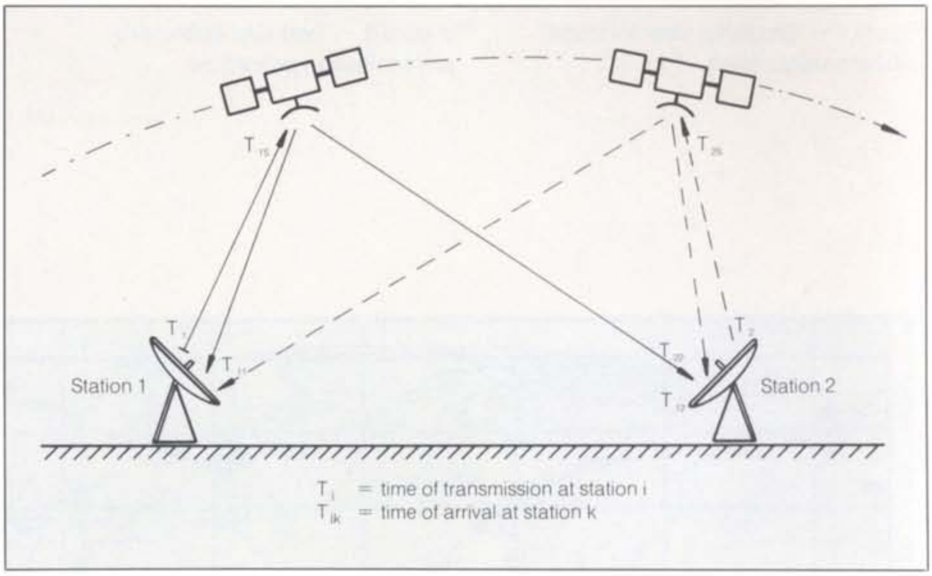
further-reduced data-transmission needs between Mission Centre and Regional Centres, but this has to be traded-off against increased data processing and the danger of discontinuity between segmented orbit-estimation data computed at different installations.

Details of possible orbit-determination schemes, such as algorithms selection, tracking-data types and measurement frequencies, schedules, orbit representation, etc., will be the subject of further studies. Since the navigation signal alone permits two-way ranging at the Regional Centres (not only pseudo-range measurements) and bi-lateration from adjacent Regional Centres during overlap periods, the situation should be more favourable than for the GPS system.

Time synchronisation

The navigation error budget requires ground stations to be mutually synchronised to within 3 ns. If an atomic reference standard stability of 10^{-14}, which appears technologically feasible, is assumed, the clocks would have to be updated every few days. This is clearly

Figure 9 — Time synchronisation via satellite



impractical by conventional means, such as transportation of reference standards, and the only feasible method appears to be time transfer via the Navsat space segment itself.

Time synchronisation between two ground stations via a satellite is always based on measuring the time delay in transmitting a signal over the ground station – satellite – ground station path (Fig. 9). Provided all distances (i.e. satellite position) and transmission delays are accurately known, a single signal transmission in one direction is sufficient. An additional transmission in the opposite direction allows the ionospheric delays to be estimated, provided the measurements are made sufficiently quickly.

Signal echo measurements at the transmitting stations (T_{11}, T_{22}) can give additional information on equipment delays, and finally on-board measurement of satellite arrival time differences ($T_{2s} - T_{1s}$) can be used to eliminate position errors.

Other factors such as Doppler errors, relativistic effects etc. have to be taken into account in a detailed assessment of the accuracies attainable. The optimal synchronisation scheme has to be selected in conjunction with the orbit-determination analysis, since both functions are intimately connected.

The process proposed provides for time synchronisation between adjacent Regional Centres. The Mission Centre must maintain and control a Navsat system time scale to be distributed by successive time transfers between Regional Centres and monitored after completion of a full synchronisation cycle around the globe.

Spacecraft monitoring and control
Four types of activities can be distinguished:

(i) monitoring of spacecraft telemetry parameters against given limit values and criteria, and routine control based on this, e.g. unit switching
(ii) performance of irregular, but pre-planned control activities following documented procedures, e.g. attitude and orbit manoeuvres, battery maintenance, eclipse operations
(iii) long-term evaluation of telemetry parameters and spacecraft behaviour in order to detect trends related to subsystem performance, ageing, consumables supplies, etc. combined with the planning of the operations mentioned under (ii)
(iv) emergency operations following on-board anomalies, usually with ad-hoc developed procedures and using considerable telemetry analysis and simulations.

For a given spacecraft successively in view of several ground stations, activities (iii) and (iv) require a central facility equipped with the necessary data processing and analysis capability and some form of link to the Regional Centres.

Activities (i) and (ii) do not require a 'global' (in the time sense) knowledge of spacecraft status and can be performed independently at the Regional Centres, each of which has its own Satellite Control Station (SCS) with telemetry/telecommand link and associated data processing.

The SCS data-processing facility also performs data compression on the spacecraft telemetry for onward transmission to the Mission Centre. While routine control at the SCS takes place in real time, compressed telemetry and operations plans are exchanged between Regional Centre and Mission Centre without stringent time constraints.

The Mission Centre's Satellite Control Centre maintains a complete history for each spacecraft and, on the basis of the compressed telemetry and reports from the Regional Centres, performs the long-term evaluation and operations planning (iii), and emergency operations as required (iv). Assuming that the Mission Centre would be co-located with one of the Regional Centres, direct contact with each spacecraft would be ensured once per day for uncompressed telemetry analysis and real-time commanding. This would also facilitate operations in emergency situations.

Data links
Accurate data-rate estimates are difficult to make at this point, but an attempt at a rough quantification is shown in Table 1. There are three classes of data flow:

- from Regional Centres to Mission Centre (A)
- from Mission Centre to Regional Centres (B)
- between Regional Centres (C).

Eight different data categories can be identified, with each category further subdivided into a number of 'channels' relating to the individual satellites or stations producing or requiring the data. With six Regional Centres, one arrives at a total of 120 individual data channels.

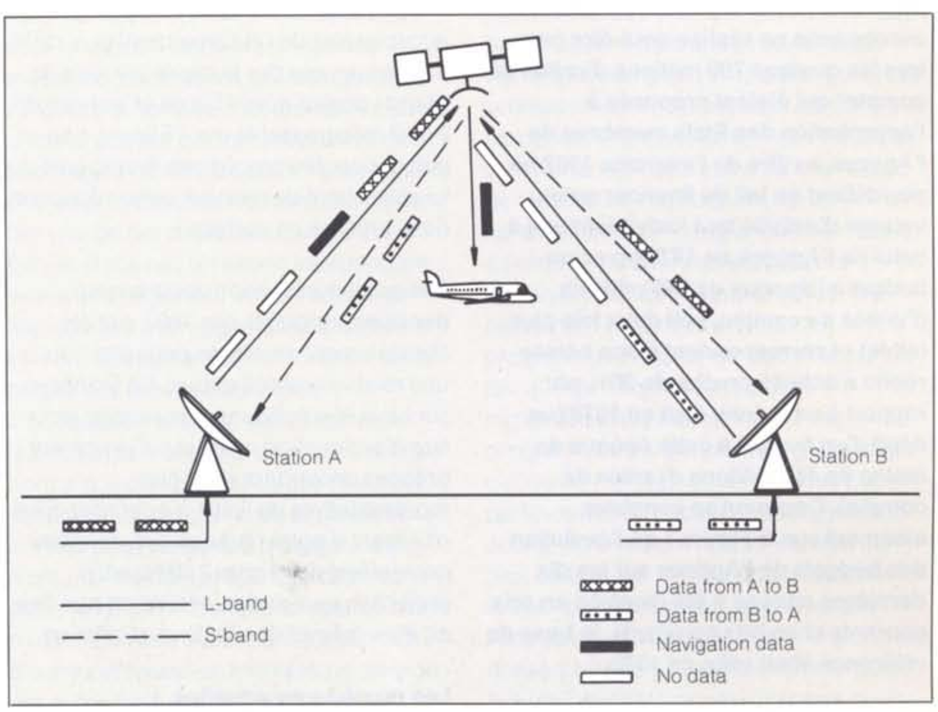
The communications capability inherent in the Navsat space segment can provide an autonomous means of data transmission between the nodes of the control segment. Since the Navsat

Figure 10 – Data-transfer schematic

Table 1 – Data flow estimates

Class	Number	Data category	Number of channels	Raw-data rate per channel	Compression factor	Overall average data rate bit/s
A	1	Tracking data	24	64 bit/10 s	10	16
A	2	Telemetry	24	512 bit/s	100	120
A	3	Navigation monitoring data	6	256 bit/5 min	1	5
A	4	Station monitoring data	6	10 kbyte/d	1	6
B	1	Orbit estimate	24	64 bit/min	1	26
B	2	Operation schedules	6	2 kbyte/d	1	1
C	1	Satellite handover data	6	1 kbyte/handover	1	26
C	2	Updated** ephemeris prediction	24	64 bit/min	1	26

* Assuming 6 × 24 individual handovers per day
** If on-line ephemeris correction is performed at Regional Centres



satellites do not fly in geosynchronous orbits, only periods during which at least one of the 24 satellites is visible from two adjacent ground stations are available for data transmission between those two stations. Such periods are generally available for any two pairs of adjacent stations in a six-station configuration.

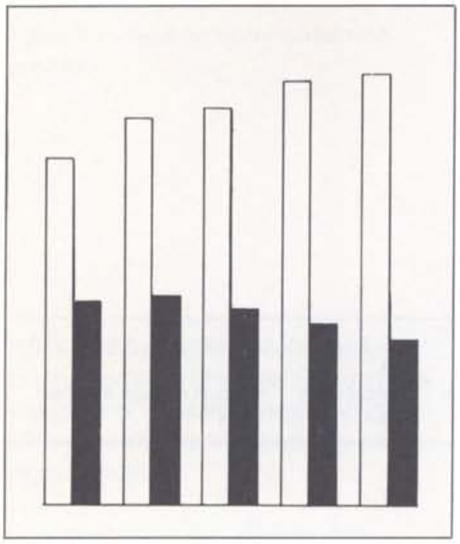
Data transmission over the ring network that was shown in Figure 4 can occur in stages between Regional Centres whenever coverage by one or more satellites exists between those centres. The data can be transmitted in 'packets' with an address code indicating its ultimate destination, the Message Routing Stations at each Regional Centre then being responsible for packet buffering and routing. With the data from Table 1, this yields a bandwidth requirement of far less than 1000 bit/s.

To minimise satellite complexity and cost, reuse of existing RF links is proposed. The data uplink can be combined with the navigation uplink, using the TDMA time slots not already assigned for navigation purposes (a simple on-board command logic would have to disable the L-band navigation transmitter during these slots). For the data downlink, the existing telemetry link can be used by increasing its capacity from 512 bit/s (see Table 1, item A2) to, say, 2.5 kbit/s.

The principle of this data transfer is shown schematically in Figure 10.

Conclusion
Further trade-off and design studies are required where the proposed concept has an impact on the original spacecraft design and signal structure, i.e. for the functions of time synchronisation and data relay. Detailed analyses are needed to assess the accuracies obtainable for satellite-ephemeris estimation and ground-station time synchronisation, as well as the algorithms, procedures and equipment required for this. The result of these analyses will determine the ultimate navigation accuracy that can be provided to the user.

Finally, the sizing of the different control-segment elements at the Regional Centres and the Mission Centre merits further attention, with special emphasis on schemes for sharing ground antennas and radiofrequency equipment. Hardware-redundancy concepts have to be developed to ensure 100% availability of the vital navigation mission functions of the control segment and graceful degradation of the system in the case of a major malfunction.



Les procédures de l'Agence spatiale européenne face à l'inflation

J. Vuagnat, Département des Finances, ESA, Paris

Chacun sait, par expérience quotidienne, qu'il vit depuis des années dans un monde en inflation. Cependant le personnel de l'Agence spatiale européenne ne réalise peut-être pas que les quelque 700 millions d'unités de compte* qui étaient proposés à l'approbation des Etats membres de l'Agence au titre de l'exercice 1982 ne permettent en fait de financer qu'un volume d'activité tout juste identique à celui de l'Agence en 1975 (avec un budget à l'époque de 350 millions d'unités de compte, soit deux fois plus faible) et correspondent à une baisse réelle d'activité proche de 20% par rapport à ce qu'elle était en 1976 (en dépit d'un budget à cette époque de moins de 470 millions d'unités de compte). Ceci peut se constater aisément sur la Figure 1 où l'évolution des budgets de l'Agence sur les dix dernières années a été montrée en prix courants et en prix constants, la base de référence étant celle de 1972.

* L'unité de compte utilisée par l'Agence est équivalente à l'unité monétaire des Communautés européennes. Sa contre-valeur en dollars des Etats-Unis est en général voisine de 1.

Introduction

Dans un environnement économique où l'inflation est largement supérieure aux marges d'incertitude que l'on peut accepter lors de l'établissement puis de la mise en oeuvre des budgets annuels de grands projets scientifiques et techniques, il était indispensable que l'ESA ait à sa disposition des procédures financières qui lui permettent de mesurer cette inflation et de la prendre en compte.

Ces procédures – dont les premiers principes, introduits dès 1967, ont été constamment améliorés pour atteindre une relative stabilité depuis 4 à 5 années – sont à la fois suffisamment simples pour être d'exploitation aisée et suffisamment précises cependant pour être représentatives de l'effet à quantifier. Elles n'utilisent d'autre part que des données constatées, donc mesurables, sans projection sur l'avenir, afin de ne pas être en elles-mêmes des facteurs d'inflation.

Les procédures actuelles

En vertu du principe ci-dessus de '*non-anticipation de l'inflation*', l'Agence fige ses prévisions de dépenses pour l'année à venir (exercice N) sur le niveau des prix du milieu de l'année en cours (exercice N–1) car c'est ce niveau qui est connu au moment où elle établit le projet de budget pour l'exercice N. Une telle procédure, bien entendu, ne permet pas de prendre en compte les hausses de prix qui se produiront vraisemblablement entre ce milieu de l'année N−1 et la fin d'exécution de l'année N en cause. Nous verrons plus loin qu'elle a cependant pour l'instant toujours permis à l'Agence d'honorer ses engagements, une procédure particulière ayant été introduite pour les salaires du personnel de l'Agence et lorsqu'il s'agit de la dernière année d'un programme.

D'autre part, afin de pouvoir comparer – hors inflation – les prévisions de dépenses pour l'année N à venir avec celles de l'année N−1 en cours, puis mesurer et ensuite prendre en compte l'effet sur ces dépenses des hausses de prix intervenues entre le milieu de l'année N−2 et celui de l'année N−1, les prévisions de dépenses pour l'année N sont tout d'abord établies au niveau des prix du milieu de l'exercice N−2, ce niveau étant celui utilisé pour le budget de l'exercice N−1 en cours.

On porte alors les prévisions de dépenses de chaque programme, réparties par pays et par nature, au niveau des prix du milieu de l'année N−1 par application à celles-ci des coefficients de variations des prix constatées dans chaque pays entre le milieu de l'année N−2 et celui de l'année N−1 pour chaque nature de dépense. Les calculs correspondants sont désignés sous le nom d'*actualisation* ('updating').

Pour chaque programme, la variation pondérée des prix qui a résulté des calculs d'actualisation ci-dessus est également appliquée aux prévisions de dépenses pour les années ultérieures N+1, N+2, etc. portant ainsi ces dépenses au même niveau des prix (milieu de l'année N–1) que celles de l'exercice N à venir. Lors de cette opération, il serait idéal de pouvoir également porter à ce niveau de prix du milieu de l'année N−1 les dépenses de l'exercice N−1 en cours qui, par construction, ne sont qu'au niveau des prix du milieu de l'année N−2; mais un tel rattrapage aurait l'inconvénient d'augmenter en cours d'exercice les budgets votés, avec toutes les difficultés qu'une telle opération entraînerait auprès des Etats membres; aussi ce rattrapage n'est-il pris en compte, dans le meilleur des cas, que l'année suivante, et le plus souvent deux ans plus tard, afin de permettre en principe aux Etats membres de financer plus aisément les hausses dues à l'inflation.

Les coefficients de variation des prix utilisés

A l'exception des dépenses de personnel et de fonctionnement de l'Agence (15% environ du budget annuel), le gros des dépenses consiste en dépenses industrielles qui font ou feront l'objet de contrats soit en heures contrôlées, soit en prix fermes actualisables. Les dépenses de l'Agence vont donc évoluer, pour leur plus grande part, en fonction des formules de révision de prix introduites dans les contrats. Au stade prévisionnel de l'établissement des budgets cependant, il n'a pas été jugé utile de retenir ces formules pour actualiser du niveau des prix du milieu de l'année N−2 à celui du milieu de l'année N−1 les prévisions de dépenses au titre de l'exercice N à venir; ces formules, en effet, du fait de leur complexité et de leur variété, feraient intervenir un nombre excessif d'indices élémentaires de variation des prix (dont certains ne seraient appliqués que sur des sommes marginales) pour un résultat dont la précision ne serait qu'apparente puisque les calculs en question se font sur des prévisions de dépenses et non pas sur des comptes. Il faut aussi noter qu'une fraction de ces dépenses prévues correspond à de l'argent frais auquel on ne sait pas encore quels types de contrats seront associés.

L'important a par conséquent été de sélectionner, pour chaque pays, un nombre d'*indices élémentaires de variation des prix* qui soient représentatifs de l'évolution des prix de nos dépenses tout en étant en nombre aussi limité que possible: depuis plusieurs années, ce nombre oscille entre 15 et 20 pour chaque pays où l'Agence effectue ses dépenses les plus importantes, et autour d'une dizaine pour les autres pays.

Parmi ces indices, ceux du coût de la main d'oeuvre dans le secteur aérospatial ont bien sûr une place prépondérante. Il faut noter en passant qu'à l'exception du Royaume-Uni, il n'existe pas d'indices officiels de l'évolution des salaires et des prix des produits dans l'industrie aérospatiale proprement dite, alors que ceux-ci existent dans le secteur des industries mécaniques et électriques. L'Agence a donc eu recours aux indices officiels, publiés par les divers services statistiques nationaux, qui lui paraissaient être les plus proches de l'évolution réelle des prix de ses dépenses. Le choix a en fait été établi par un expert indépendant extérieur à l'Agence (Office Fédéral de Statistique d'Allemagne à Wiesbaden) et il est revu chaque année en fonction de la nature des dépenses prévues. L'adéquation actuelle entre les indices retenus et la réalité des dépenses semble bonne puisque des sondages effectués sur plusieurs programmes et plusieurs années de la vie de ces programmes n'ont montré aucun écart sensible dans la détermination de l'inflation mesurée d'une part à l'aide des indices en question et d'autre part avec les formules de révision des prix introduites dans les contrats industriels de ces programmes (moins de 0,3% d'écart sur quatre années dans le cas du programme Spacelab).

Avantages des procédures actuelles

Les procédures brièvement décrites ci-dessus ont incontestablement le mérite d'une relative simplicité dans la détermination de l'incidence annuelle de l'inflation sur les dépenses de l'Agence.

Elles procèdent en effet de calculs systématiques, à l'aide de jeux standard d'indices de variation des prix appliqués à des prévisions de dépenses établies à chaque fois au niveau des prix du milieu d'un exercice et structurées de telle façon qu'il y ait correspondance bi-univoque entre un indice et une ligne budgétaire. Ceci permet une mécanisation des calculs, avec les avantages qui en découlent de rapidité et de fiabilité dans l'obtention des résultats.

Mais le mérite essentiel réside surtout dans le fait qu'il s'agit, avec de telles procédures, d'*inflation mesurée* et non pas d'inflation estimée. Ceci permet d'une part à l'Agence de pouvoir justifier auprès de ses Etats membres la croissance de ses besoins d'une année sur l'autre du fait de l'inflation – tous autres paramètres inchangés par ailleurs – puisqu'il s'agit de la détermination de l'inflation constatée et non pas d'une anticipation de l'inflation à venir. Cela permet d'autre part, en cours de réalisation, de situer le coût à achèvement d'un programme par rapport à l'enveloppe financière adoptée à un niveau de prix donné par les Etats participant à la réalisation dudit programme. Ceci est un point majeur du fait que les accords juridiques réglementant la réalisation de nos programmes contiennent en général une clause de retrait possible pour les Etats participants, en cas de dépassement du coût à achèvement du programme de plus de 20% de l'enveloppe financière initiale 'pour des motifs autres qu'une variation du niveau des prix'. Il importe par conséquent de pouvoir mesurer le poids des variations de prix au cours de la vie d'un programme afin d'être à même de l'extraire des dépenses effectives et pouvoir ainsi effectuer chaque année une comparaison correcte entre le coût probable du programme jusqu'à son achèvement et l'enveloppe financière qui engage les Etats participants. Cette comparaison s'effectue en ramenant les dépenses constatées au niveau de prix fixé pour l'enveloppe du programme, ceci par application inverse à ces dépenses des coefficients de variation des prix qui avaient été utilisés lors de la phase de prise en compte de l'inflation (actualisation) dans les dépenses prévues. L'opération, appelée

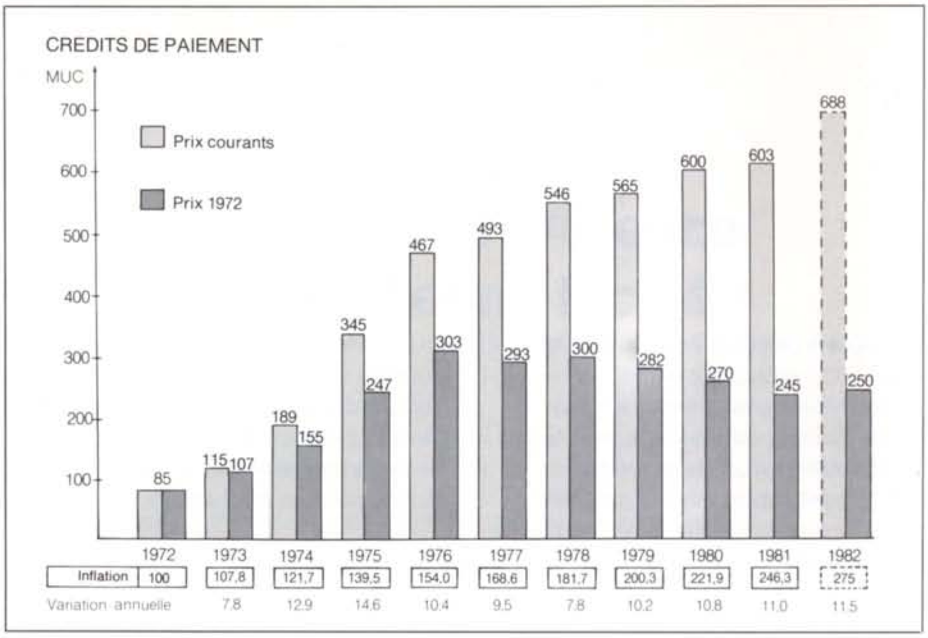


Figure 1 — Evolution des budgets de l'Agence de 1972 à 1982 (1 MUC = 1 million d'unités de compte)

rétroactualisation ('backdating'), permet alors une addition correcte des dépenses annuelles et une comparaison significative de leur total avec l'enveloppe du programme, puisque tous les montants en cause sont alors au même niveau de prix.

Inconvénients

La prise en compte de l'inflation jusqu'au milieu de l'année N−1 au cours de laquelle les budgets de l'année N sont établis, a certes l'avantage de se limiter aux effets passés, donc mesurables de façon incontestable, et de ne pas être un facteur inflationniste en soi. Cette procédure présente par contre l'inconvénient évident d'ignorer, dans les budgets de l'année N, les hausses de prix qui se produiront vraisemblablement au cours des 18 mois allant du milieu de l'exercice N−1 à la fin de l'exercice N.

Ce phénomène n'est pas vraiment gênant pour les programmes dont la durée de réalisation s'étend sur plusieurs années et pour autant qu'il y ait, d'une part, un décalage suffisant dans le temps entre la réalisation des travaux et la facturation des montants résultant des formules contractuelles de révision des prix et que, d'autre part, l'inflation intervenue entre le milieu de l'année N−1 et celui de l'année N soit rattrapée dans les années suivantes.

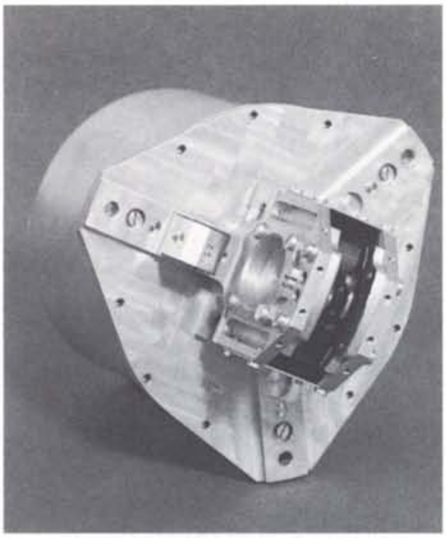
Mais la procédure n'est plus viable dès que l'on atteint la dernière année d'un programme, puisqu'il n'y a en principe pas de rattrapage possible l'année suivante dans ce cas. Elle ne convient pas non plus pour les dépenses de salaires du personnel de l'Agence, dont les hausses doivent être honorées en cours d'exercice dès l'approbation d'un nouveau barème, ce qui ne permet pas de figer pendant 18 mois ce type particulier de dépenses.

Pour remédier au problème posé, l'Agence n'a pas été autorisée à incorporer dans ses prévisions budgétaires son estimation des hausses de prix dans les deux cas (qui devront cependant être payées au cours de l'exercice à venir), les Etats membres ayant argué qu'ils auraient risqué d'avancer des contributions supérieures aux besoins réels avec une telle procédure. L'Agence a par contre été autorisée depuis plusieurs années à introduire dans ses budgets pour l'année N, dans une partie distincte, des réserves bloquées destinées à couvrir les variations de prix prévues entre le milieu de l'année N−1 et celui de l'année N tant pour les rémunérations du personnel que pour les dépenses des programmes qui se terminent au cours de l'exercice N. Ces réserves pour variations de prix demeurent bloquées en dépenses et recettes jusqu'à ce que – à la demande du Directeur général – le Comité administratif et financier de l'Agence décide de leur déblocage (chaque demande doit être justifiée par des preuves statistiques appropriées et être limitée aux besoins réels après prise en compte des économies qui auraient été identifiées par ailleurs). Une telle procédure ménage les intérêts et de l'Agence et des Etats membres, puisque la première est assurée de disposer à terme des ressources dont elle aura besoin (sous réserve d'apporter la preuve de ce besoin, ce qui est tout à fait normal) et les seconds ont la garantie de n'avoir à financer, une fois de plus, que les effets constatés de l'inflation.

Conclusion

Les procédures – exposées de façon schématique dans les paragraphes qui précèdent – de prise en compte des hausses de prix dans les budgets de l'Agence et de détermination de ces hausses dans les coûts à achèvement de ses grands programmes semblent avoir correctement atteint leur but. A l'exception de l'année 1975 où les effets d'une croissance brutale des activités de l'Agence, conjuguée avec une inflation d'un niveau jusqu'alors inconnu en Europe, ont nécessité de faire appel en cours d'exercice à un budget supplémentaire, l'Agence a su chaque année prévoir, justifier et obtenir de ses Etats membres le financement des hausses de prix qui affectent ses programmes et activités, et ce en dépit d'une inflation de 11% par an en moyenne dans son secteur d'activité depuis les dix dernières années.

Un tel succès réside vraisemblablement dans le caractère raisonnable des procédures qui sont celles de l'Agence en la matière, où il n'a en particulier jamais été fait appel à une anticipation de l'inflation; ce succès réside aussi sans doute dans la relative simplicité d'application de ces procédures, permettant à des tiers d'en contrôler s'ils le souhaitent la validité des résultats, simplicité liée cependant à une grande précision, voire dans certains cas à une certaine sophistication, afin de toujours rester aussi proche que possible de la réalité économique. Il est dû enfin à l'expérience unique de l'Agence en la matière, puisque les règles actuelles dans ce domaine sont, rappelons-le, le fruit de quinze années de pratique sur des procédures dont les premiers principes ont été introduits dès 1967 pour être ensuite constamment améliorés et adaptés au fil des années.



Spacecraft Attitude Sensing Based on the Earth's Radiation

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Spacecraft payloads usually have to be oriented towards specific targets and in many cases very accurate attitude parameters must be calculated. The Earth itself constitutes an obvious inertial reference, and one means of determining the absolute orientation of the spacecraft's axes is to observe the Earth's radiation by means of optical sensors working at visible or, more frequently, infrared wavelengths. These sensors work successfully up to altitudes of 300 000 km, and are considerably less complex than the alternative star sensors.

Introduction

Observations of the Earth's disc by optical sensors onboard a satellite yield one parameter for the spacecraft's attitude in orbit. A second parameter needs to be measured to compute the spacecraft's exact attitude in three-dimensional space. Usually the Sun is taken as this second attitude reference. If the attitude of the satellite is largely to be controlled by means of ground commands, the burden of attitude computation usually rests with the ground control centre. Other missions can involve more onboard attitude processing, especially if a continuous closed-loop control is necessary to achieve special pointing requirements. The choice is very mission-dependent.

In either case, particular spacecraft orientations are sought to allow the payloads to point to their respective targets. For some instruments, it is sufficient, or even an advantage, if they sweep periodically through the direction of interest, as in the case of a device measuring particles coming from the Sun. The antenna beam of a telecommunications satellite, on the other hand, must be continuously pointed towards a particular area of the globe. These differing requirements are satisfied by two different classes of attitude stabilisation: spin stabilisation and three-axis stabilisation.

Spin stabilisation

The laws of dynamics specify that the orientation of a rotation axis is stable if the masses around that axis are distributed as in a flat cylinder, called an 'oblate' body. The advantage of the spin stabilisation of oblate satellites is that the control is passive, i.e. the laws of nature rather than man-made energy-consuming devices keep the spin-axis orientation and spin rate constant. The actual orientation or attitude of the spin axis plays no role in this stability. Only torques, such as those generated by thrusters, can change the spin rate and spin-axis orientation.

If the satellite body is dynamically equivalent to an elongated cylinder, i.e. has more the shape of a cigar, it is termed 'prolate'. In this case the spin axis and spin rate change, and they are unstable. Stability can be introduced by incorporating a major nonspinning part in the rotating satellite, i.e. a mechanically despun platform. Satellites with this feature are called 'dual-spin' satellites. Two early examples are the civil telecommunications satellite Intelsat-IV, and the US military communications satellite Tacsat. The telecommunications satellites SBS-3 and Anik-C launched during the Space Shuttle's fifth flight last November are among the most recent examples of prolate, dual-spin satellites.

Three-axis stabilisation

When a spacecraft is actively controlled to have two axes in prescribed directions at a given time, its third axis is automatically fixed in space and the satellite is said to be three-axis stabilised. One axis of ESA's telecommunications satellites OTS and Marecs always points to the centre of Earth, and another always points north. These geosynchronous satellites revolve with the Earth once per day and must continuously face the globe, i.e. like the

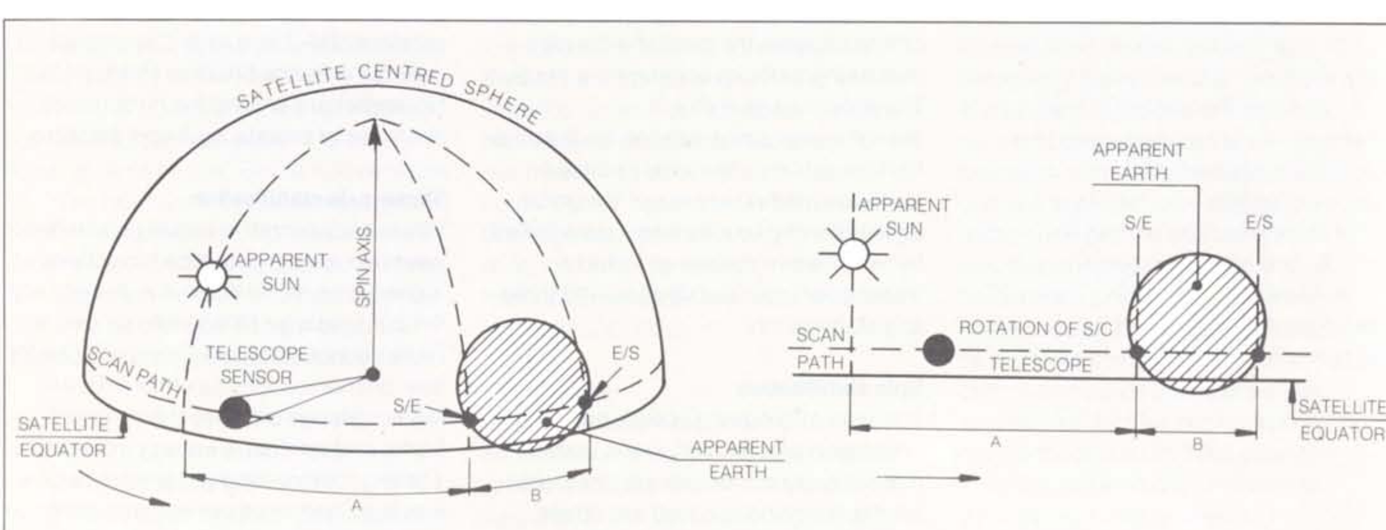


Figure 1 – Operating principle of a telescope sensor

Moon they perform one spin cycle around geographic north per orbit. The measurements of the Earth's direction are used directly onboard the satellite by attitude-control loops for this particular kind of attitude stabilisation.

For three-axis control, the attitude observations are most useful if they give a measure of the deviation from ideal pointing. As the satellite attitude is expected to remain close to the nominal target direction, the attitude optical sensors usually need to operate in only a small range of orientations. The performance of the sensors is then also optimised for that limited operational range.

Earth sensing on spinning spacecraft
On a spinning satellite it is preferable to utilise the sweeping of a sensor across the Earth rather than to make an instantaneous measurement. With the latter, given that the sensor has not 'missed' the Earth when making the measurement, some further analysis is still needed and this is much more complicated than exploiting the rotation of the sensor about the spacecraft's spin axis.

Somewhere during a spin cycle, the sensor optics start collecting radiation from the Earth and the electrical output of the detector increases. When the sensor field of view leaves the Earth, the electrical output decreases. By suitable electronic analysis, the instants of Space/Earth (S/E) and Earth/Space (E/S) crossing can be identified and labelled with a satellite internal time.

The Earth sensors on spinning satellites are of either the telescope or fan-beam type:
- A *telescope sensor* has a very limited field of view and scans on an arc around the spin axis (Fig. 1). The Sun to S/E or Sun to E/S times correspond to angles that carry useful information for attitude determination.
- A *fan-beam sensor* (Fig. 2) observes the radiation in a very narrow, long rectangle (~ 1° wide and 45°-120° long), which is geometrically equivalent to a great-circle arc on a sphere centred on the satellite (hence the dimensions in degrees). The points sensed as S/E and E/S crossings are then the points of tangency of the great-circle arc representing the beam, with the radiating Earth limb.

The advantage of fan-beam sensors over telescope sensors is that they can sense the Earth for much longer time intervals. A definite disadvantage is that they yield a markedly less sensitive measurement, which can lead to less accurate attitude reconstitution.

Earth sensing on three-axis stabilised satellites
As already mentioned, Earth sensors for terrestrial pointing with three-axis stabilisation should provide a direct measure of depointing, i.e. the pointing error. Two basic principles are commonly employed:
- *Static sensing* of the Earth limb, in which the shift between the observed and 'preprogrammed' reference Earth positions is computed (Fig. 3a). The static-sensing principle is only practicable if the 'apparent' Earth radius, i.e. as observed by the satellite, is well-known before, and remains constant during, the mission. Satellites in geosynchronous orbits satisfy this constraint because for them the apparent-Earth radius remains 8.7°.
- *Dynamic sensing* by means of a rotating mirror in front of the Earth radiation detector. Such a sensor, commonly called a 'horizon scanner', searches for the entrance and exit crossings of the Earth's disc in a conical scan. These events are then

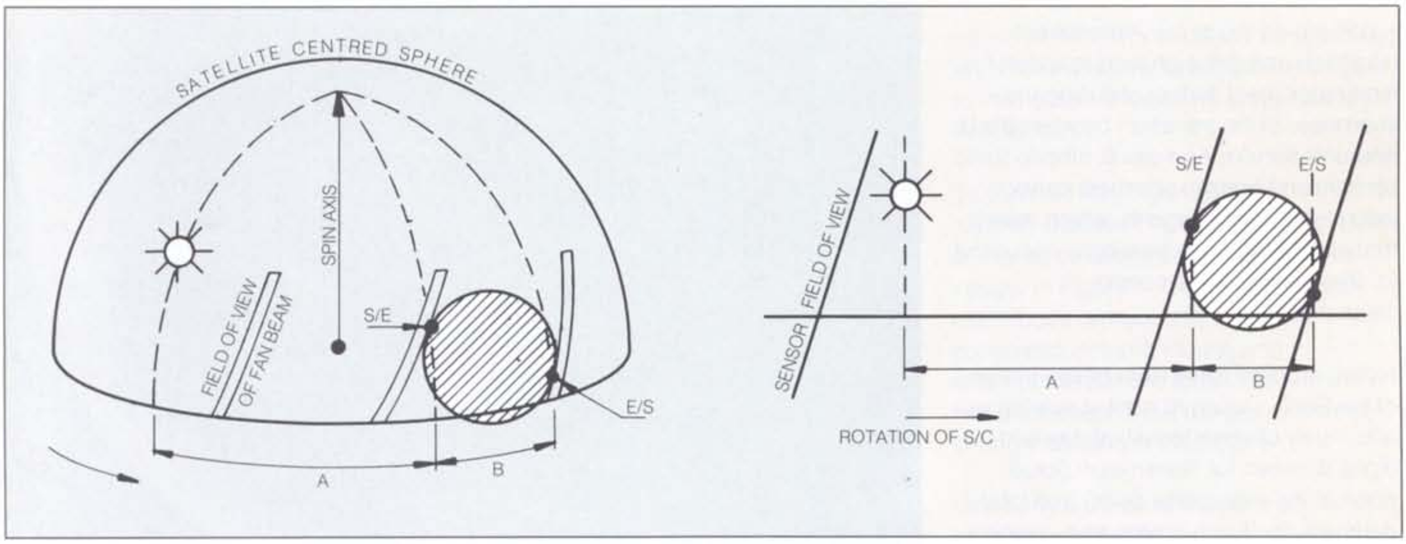


Figure 2 – Operating principle of a fan-beam sensor

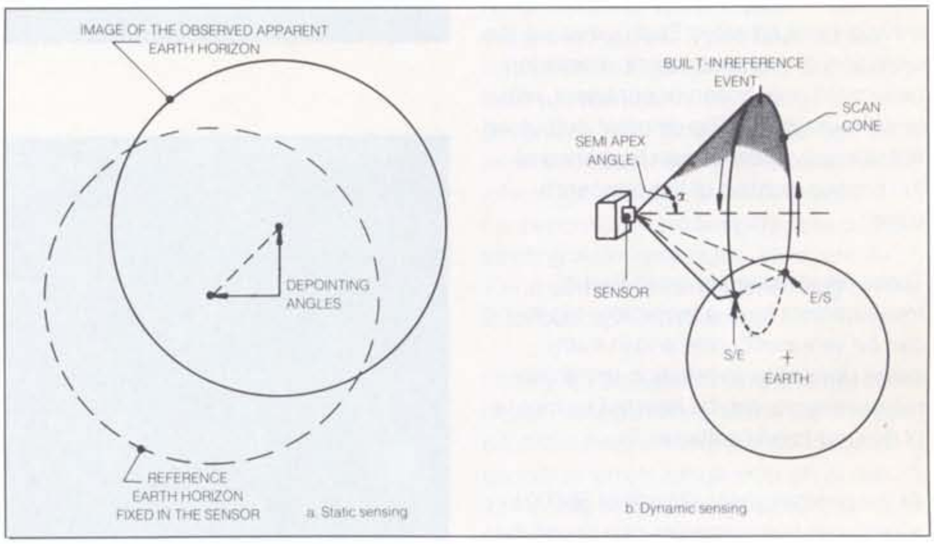


Figure 3 – Earth-sensing principle for three-axis-stabilised satellites

related to an instrument-fixed reference event on the cone, which is directly linked to the position of a satellite-body axis (Fig. 3b). The deviation between the mid-point of the Earth scan and the reference event, established via an on-board control loop, provides a measure of the depointing.

The horizon-scanning sensor is most powerful for low Earth orbits and is therefore appropriate for Earth-observation satellites. The Space Shuttle will carry two horizon scanners when ferrying Europe's Spacelab and its multidisciplinary payloads into orbit in September 1983.

Composition of the radiation

The Earth emits two types of radiation into space: one is the scattered sunlight or 'albedo'; the other the emitted radiation produced because our planet is a 'warm' body. Within these two radiation types, one has to differentiate between a large range of wavelengths. Neither the albedo nor the emitted radiation shows a smooth intensity spectrum. The question posed is therefore 'Which particular type of radiation is best-suited for attitude sensing?'

Albedo radiation

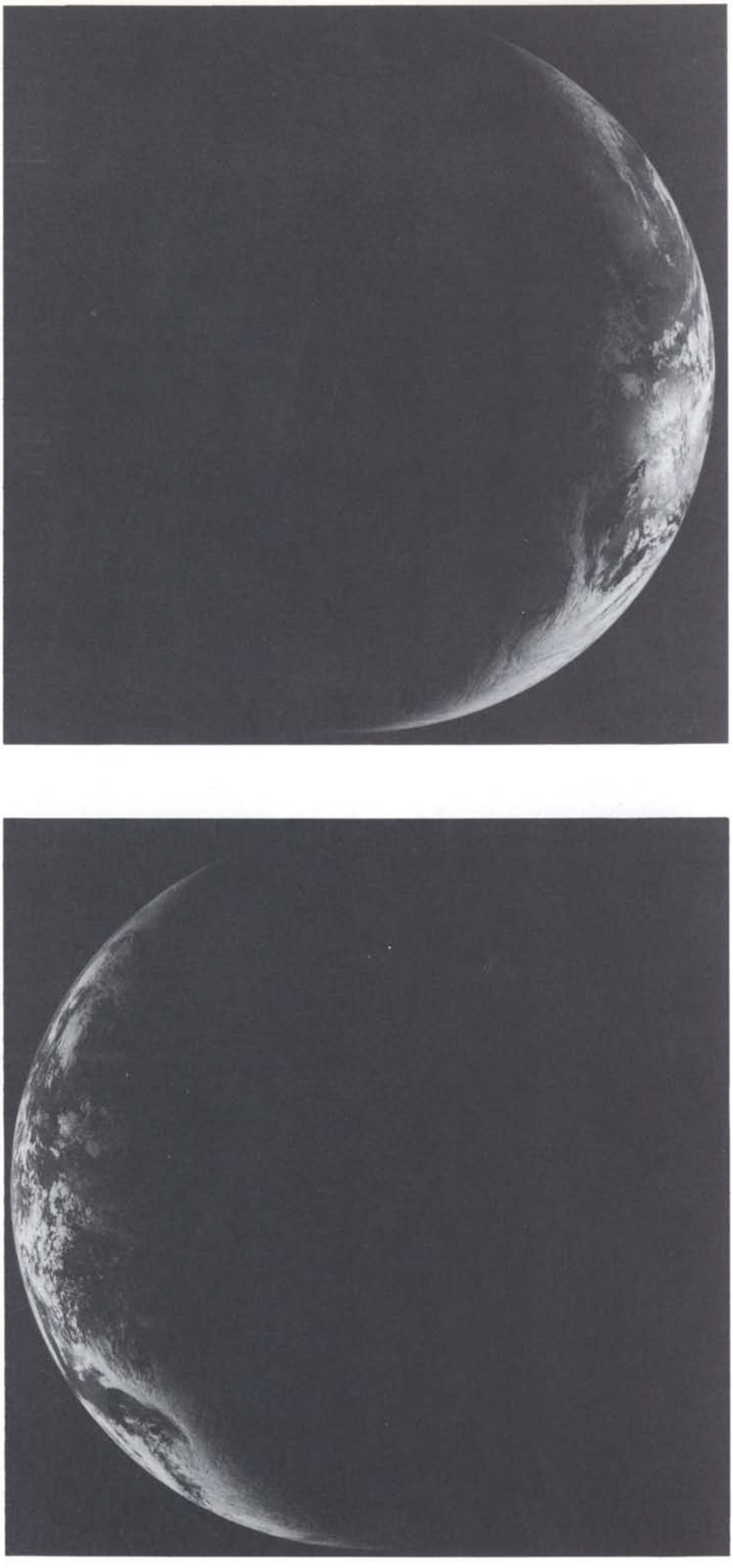
Meteosat images (visible light) show how the human eye sees the Earth from some 36 000 km altitude, via backscattered sunlight from the oceans, clouds and continents (Fig. 4). The clouds are very white, scattering more light, the oceans are dark, and the albedo of the continents lies somewhere in between. Earth albedo accounts for ~30% of the incident solar radiation and, because of its light intensity, is easily measurable.

Albedo sensors are attractive because the photodiode detectors used rely on well-known silicon-cell technology. Moreover, the sensor optics (lenses) handle visible light, which simplifies manufacture and testing. There are, however, problems in interpreting their measurements.

One disadvantage is that albedo is very variable over the sunlit part of the Earth. This inhomogeneity precludes the use of telescope sensors and the large field of view of fan-beam sensors is needed to average out the albedo intensity variations.

A second drawback is related to the terminator curve which separates the illuminated and dark halves of the Earth. The finite dimensions of the Sun's disc mean that the terminator is a band

Figure 4 – Meteosat visible images of the morning and evening crescents



~0.5° arc on the globe. Atmospheric refraction and diffusion tend to widen the terminator band, further reducing the sharpness of the transition between the lit and unlit sectors. As a result, albedo static sensors and horizon scanners cannot yield stable measurements, which means that albedo radiation sensing is not useful for three-axis attitude-control measurements.

A third problem is the illumination phase of the Earth. During its orbit, a satellite will alternately observe terrestrial day and night. Between full illumination (local noon at the subsatellite point) and total darkness, the Earth is seen as a crescent (Fig. 4). The sensor's response will be adversely affected when entering or leaving the illuminated Earth's disc via the tip region of such a crescent, which can be located over ocean or continent, with or without clouds. The detector output will not normally allow correct triggering at the precise location of the crescent's edge.

These disadvantages mean that a measurement from a terminator triggering can be very inaccurate and in many cases unreliable. In practice, terminator measurements can be rejected by means of ground-based software.

At the geostationary altitude of 36 000 km, albedo fan-beam sensors can locate the Earth horizon to an accuracy of approximately 1°. This improves gradually for higher altitudes because the Earth's radius as seen from the spacecraft decreases from 3.7° at 100 000 km to 1.8° at 200 000 km, and the limb location error then reduces to a few tenths of a degree.

Non-visible radiation

Hot bodies like the Sun radiate in the shorter wavelengths: ultraviolet, visible and near infrared (IR). The Earth is a rather cool body (some 293 K) and therefore radiates essentially in the IR at wavelengths between 2 μm and 35 μm. Unfortunately, the globe does not radiate uniformly in the infrared either, each

Figure 5 – Meteosat infrared images in the morning and evening for the 11 μm 'window'. Cold is white and warm is grey to black. Note the difference in grey tone over the Sahara between early morning and early evening.

region of the Earth's surface, atmosphere, and cloud cover radiating differently due to their different radiating properties and temperatures.

To illustrate this, Figure 5 shows infrared images (11 μm) of the Earth taken at exactly the same times as the visible images in Figure 4. They show a typical black-body radiance, to which the continents, oceans, clouds and atmosphere all contribute. The terminator has disappeared, but the global weather strongly influences the picture.

One can also look at the infrared radiation emitted by a substance available everywhere above the Earth's surface, namely water vapour. In the images in Figure 6, again taken at the same time as Figures 4 and 5, but now in the 6 μm waveband, the surface geography is no longer visible, there is no terminator, but there is still a considerable inhomogeneity due to the different concentrations and temperatures of the emitting water molecules, which are 4–10 km above the Earth, depending on the local atmospheric pressure.

Clearly, for attitude sensing one needs better homogeneity, and this can only be expected from a molecular species the density of which is high enough above 12 km and which strongly absorbs and re-emits radiation in a limited wavelength region (the absorption is necessary to suppress radiation from lower, weather-dependent layers).

Carbon dioxide (CO_2) has a very strong absorption and emission band at 14–16.3 μm. Investigations in the United States between 1965 and 1972 have shown that the IR horizon for this wavelength band is season dependent and is between 30 and 40 km above the Earth. A rotating telescope in space sweeping through the Earth's disc 'sees' the full radiation intensity from the IR horizon onwards. Above the horizon there is still carbon dioxide, but 60–70 km above the Earth the radiation intensity drops to zero.

The 14-16.3 μm band
Two aspects of this emitted radiation merit particular attention: the horizon height and the radiance intensity. Both are season-dependent. Only at the equinoxes are the IR-horizon and solid-Earth spheres concentric, with equal IR radiances at all Earth latitudes.

The seasonal variation in the radiance intensity has been investigated in Europe using an IR telescope sensor flown on the ESRO-IV satellite from November 1972 to April 1974. The radiance model derived represents a refinement of the older US model. It demonstrates some asymmetry between the northern and southern summers and winters, which is due to the eccentricity of the Earth's orbit around the Sun. At perihelion (i.e. Earth's closest point to the Sun) on 2 January, the Earth receives 7% more solar radiation than six months later.

These departures from a centred, homogeneously radiating disc have consequences for attitude measurement accuracy. As can be inferred from Figure 1a, the horizon height asymmetry at summer and winter solstice will directly affect the static Earth sensing and will give rise to a systematic pointing error for three-axis-stabilised, Earth-pointing satellites employing such a sensor. Here any improvement by compensation techniques must be at the sensor-hardware level, because pointing is controlled by closed loop on board the spacecraft. Appropriate efforts have been undertaken by the European manufacturers of static Earth sensors, and today's sensors provide a pointing/measurement accuracy of better than 0.05° over the whole year.

Aside from the problem of horizon sensitivity, infrared sensors on spinning satellites are also affected by the radiance variation within the apparent Earth's disc, because the electronics have to handle a variable signal over the whole S/E to E/S interval. While the static sensor always observes the same latitudes, and the detector motion through the horizon is limited and known before flight, the IR sensors on spinning satellites can cross the Earth's disc in many different directions, at various latitudes. The errors in the IR measurements for spinning satellites are therefore not only season-, but also attitude- and orbit-dependent. Obviously any attempt to reduce resulting errors requires a case-by-case treatment.

For spinning satellites in geostationary transfer orbit (GTO), IR telescope sensors are the conventional choice.

To achieve the highest accuracy, a particular procedure has been implemented in the ground-based attitude-reconstitution process at ESOC. Consequently, the S/E and E/S triggering accuracies obtained for ESA satellites are in the order of 0.15°.

The horizon scanners also make errors depending on the IR-horizon variations, but in single sensors they are left uncorrected. These errors and other inaccuracies can be reduced by employing two horizon sensors looking in diametrically opposite directions. A European sensor has been developed that makes such dual observations from a single unit with only one detector and a single rotating mirror. This sensor will be flown on the French Earth-observation satellite Spot, and is proposed for ESA's first Earth-resources satellite ERS-1.

Attitude sensing on ESRO/ESA spacecraft

The accuracy of attitude reconstitution for a given spacecraft is not equal to the accuracy of its sensor outputs. Any error is magnified due to the combination of imperfections in all the measurements and depends on the mathematical algorithm applied. The pointing accuracy of three-axis-controlled satellites is determined by the limit cycle of the control loops and these limit cycles must be a multiple of the sensor accuracy. This is decided before the flight, but biases on the sensors and resulting biases in the pointing can only be fully assessed during the mission. ESOC has accumulated 14 years of spacecraft-attitude-sensor data-processing experience and the synoptic compilation of data in Table 1 highlights some key sensor parameters for ESRO/ESA spacecraft during this period.

The very high pointing accuracy of 0.1° obtained for Meteosat in stationary orbit contrasts with the 1.5° accuracy for Geos.

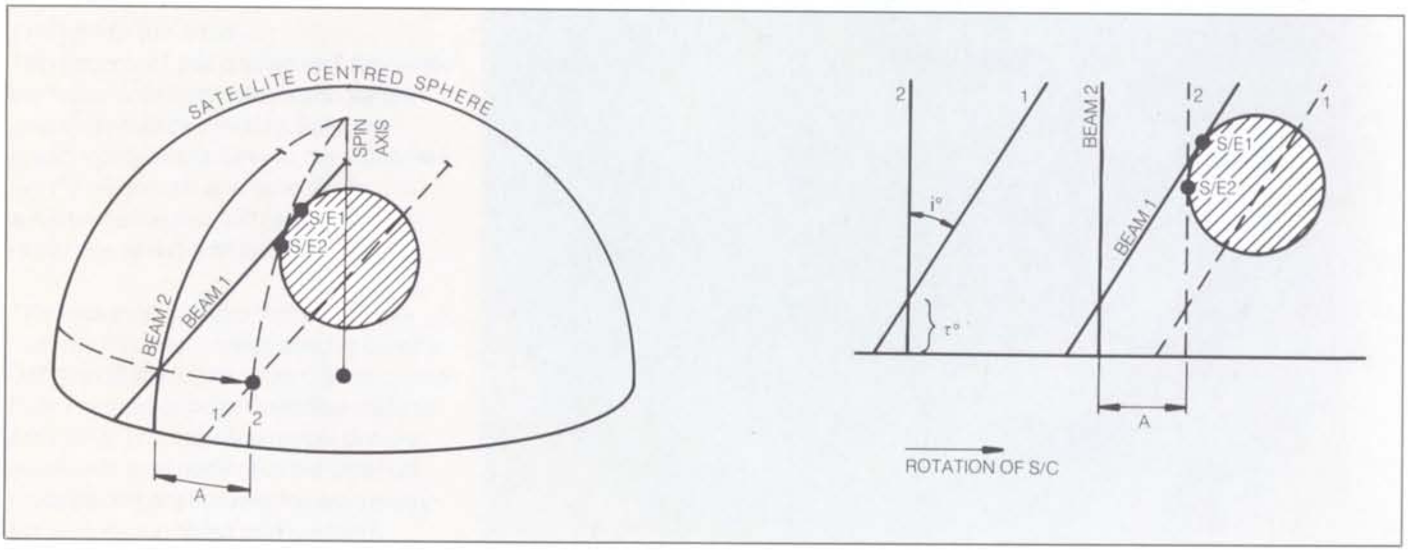
Figure 6 – Meteosat water-vapour images (6 μm infrared radiation) in the morning and evening. White areas represent low temperatures, which can be attributed to areas of high humidity. The darker shades indicate a lower level of humidity in the upper atmosphere

Table 1 – Earth-sensor synoptic table for ESA missions

Satellite	Apogee altitude (km)	Lifetime (launch date/ decay)	Attitude stabilisation	Earth sensors	Field of view	Mounting geometry	Attitude or pointing accuracy
HEOS-1	215 000	1968-75	spin: 10 rpm	2 IR telescopes 2 V-beam albedo	1.3° × 1.3° 120°	±30° τ=0, i=30°	2°
HEOS-2	235 000	1972-75	spin: 10 rpm	2 V-beam albedo	120°	τ=0, i=30°	2°
TD-1A	700	1972-80	3 axes	IR horizon scanner	45° cone	–	0.15°
ESRO-IV	1200	1972-74	spin: 65 to 38 rpm	1 IR telescope	3° × 3°	0°	1.5°
COS-B	86 000	1975-82	spin: 10 rpm	2 V-beam albedo	120°	τ=±15°, i=30°	1°
ISEE-B	130 000	1977-	spin: 10 rpm	2 V-beam albedo	120°	τ=±15°, i=30°	1°
Geos-1/2 GTO* + SO**	36 000	1977/1978-	spin: 90 & 10 rpm	4 IR telescope	1.5° × 1.5°	2× ±6°	GTO 1° SO 1.5°
Meteosat 1/2 GTO* + SO**	36 000	1977-/1978-1982	spin: 100 rpm	4 IR telescope	1.3° × 1.3°	−50°, +23° and 4°	GTO 1° SO 0.1°
Telecom*** GTO*	36 000	1978-; 1981-	spin: 65 rpm	2 IR telescope	1.5° × 1.5°	launch date dependent	1°
Telecom SO**		1983-	3 axes	2 static IR	–	–	0.05°
Sirio-2	36 000	1982 (launch failure)	spin: 90 rpm	4 IR telescope 2 IR fan beam	1.5° × 1.5° 45°	2× ±6° τ=0°	1°
Giotto GTO*	36 000	1985-	spin: 90 rpm	4 IR telescope	1.5° × 1.5°	±10°, ±30°	0.5°(?)
Hipparcos GTO*	36 000	1987-	spin: 60 rpm	2 IR telescope	1.5 × 1.5°	±6°(?)	1°(?)
L-Sat	36 000	1986-	3 axes	2 static IR	–	–	0.05°

*GTO = Geostationary Transfer Orbit SO** = Stationary Orbit ***Includes OTS, Marecs & ECS

Figure 7 — Earth-sensing principle of a V-fan-beam type albedo sensor



The former is achieved by making use of the fact that the spacecraft attitude is always within 1° of the orbit normal, which allows the application of a very specific attitude reconstitution algorithm. This does not apply for Geos, where deviations of 2.5° from the orbit normal are tolerated and where spacecraft balance is affected by six rigid booms and two 20 m cable booms. The requirements for Geos were therefore more relaxed, and no special effort was made to achieve the 1° accuracy that could have been obtained if necessary.

Albedo sensors

All albedo sensors flown on ESRO/ESA satellites have been silicon photodiode detectors of the V-fan-beam type, with one sensor parallel to the spin axis and one inclined sensor (Fig. 7). The inclination angle of the slit (i) and tilt angle (τ) at which the sensor is mounted with respect to the equatorial plane of the spinning satellite must be carefully chosen. From Cos-B onwards, the albedo sensors have been used as Sun sensors, i.e. the electronics looks for a strong signal and upon detection identifies Sun 'in' and 'out' crossing pulses. When a weaker radiation input change is detected, it is recognised as the S/E or E/S crossing, where 'S' may represent the dark Earth instead of space.

IR sensors

There are three IR detectors in use in the Agency's IR sensors: the thermistor bolometer used in the majority of sensors, the thermopiles in static Earth sensors, and the pyroelectric detectors in a fan-beam sensor. All have a much wider sensitivity range than the small CO_2 radiation band used for Earth sensing and the incoming radiation is filtered optically to isolate the 14–16.3 μm wavelengths.

The bolometer is a heat-dependent resistor, usually in the form of a small square of germanium. It is the detector for all IR telescope sensors, and also for the IR fan-beam sensor on Sirio-2.

The static sensors can be made in one of two ways. One type contains four IR telescopes with fixed detectors and mirrors in front of them that oscillate over ±5° five to ten times per second. Another realisation consists of four rigid thermopiles, each consisting of two or more different metals in contact, producing a temperature-dependent potential. Both types of sensor give an analogue output, i.e. depointing yields a continuous range of responses. A digital thermopile static Earth sensor is also currently under development.

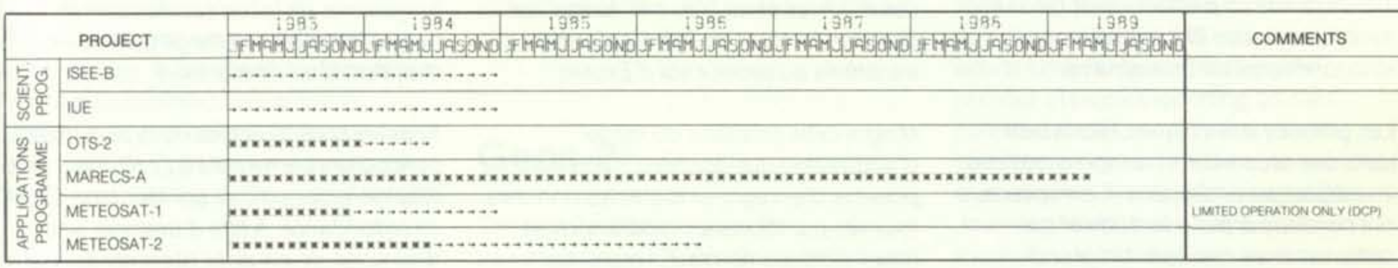
A pyroelectric detector relies on a crystal with a natural dipole yielding a temperature-dependent electrical surface charge. This detector can also be used as a Sun sensor, working in the same way as albedo-sensor silicon photodiodes.

Conclusion

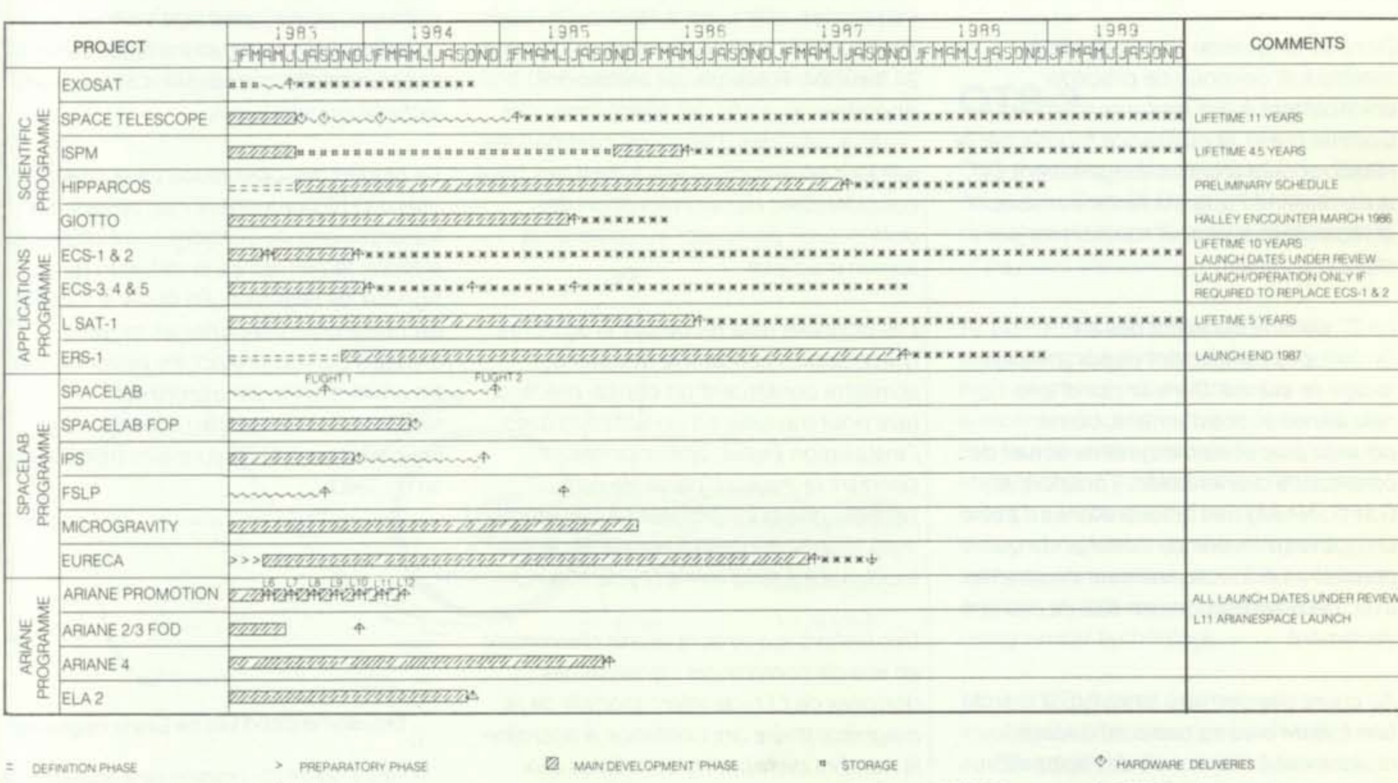
Table 1 combines the elements that have influenced the choices of Earth sensors for past and present ESRO/ESA spacecraft. It is, perhaps, fair to say that in many practical applications albedo sensors have barely achieved the accuracies expected of them. The target accuracies for the IR sensors have always been met and, apart from a few exceptions, the error margins have been comfortable.

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

In Orbit / En orbite



Under Development / En cours de réalisation



ISEE-2

Les satellites ISEE ont continué de travailler sur leurs orbites normales jusqu'en juin, époque à laquelle des manoeuvres d'orbite ont été effectuées sur ISEE-3 afin d'envoyer ce satellite successivement vers la magnétoqueue et vers la comète Giacobini-Zinner. La première traversée de la magnétoqueue aura lieu à la fin d'octobre. Les manoeuvres destinées à envoyer ISEE-3 vers la comète débuteront en mars 1983 et conduiront à son survol en septembre 1985.

Les satellites ISEE-1 et ISEE-2, qui avaient traversé la magnétoqueue de la Terre en février-avril 1982 dans le cadre de leur mission initiale, ont permis de procéder à un certain nombre d'observations intéressantes en parallèle avec Geos et avec l'installation Eiscat (radar ionosphérique) en Scandinavie.

Les groupes scientifiques, réunissant dans des proportions harmonieuses des investigateurs américains et européens, ont continué d'être très actifs et de présenter leurs résultats. Un grand nombre de documents intéressants sur ISEE ont été présentés à la réunion du Cospar à Ottawa en mai.

IUE

Dans sa cinquième année de vie, le satellite IUE continue de procéder efficacement à des mesures scientifiques. Comme prévu, la puissance fournie par le réseau solaire a diminué légèrement, ce qui a resserré l'angle à l'intérieur duquel le véhicule spatial peut fonctionner par rapport au soleil.

Le 27 juillet, le troisième des six gyroscopes initialement disponibles est tombé en panne. Dans le cas d'une défaillance supplémentaire, on ne pourrait plus utiliser le système actuel de commande d'orientation. Toutefois, le GSFC (NASA) met actuellement au point un nouveau moyen de commande qui permettrait le fonctionnement du satellite avec deux gyroscopes en état de marche seulement.

Au cours des derniers mois, IUE a montré une fois de plus sa capacité à réagir rapidement à l'annonce de l'apparition d'un nouvel objectif. Nova Aquilae et Nova Sagittarii, ainsi que la nouvelle comète Austin, ont été observées à Vilspa peu de temps après leur découverte. Les données UV sur la Nova Aquilae sont particulièrement intéressantes du fait du comportement particulier de cet objet. Les premiers résultats, notamment des observations coordonnées dans le visible et l'infrarouge, seront présentés par l'équipe des novae à la prochaine réunion du Comité de sélection IUE.

Geos-2

La transmission des données à haute résolution de l'expérience de mesure des ondes, embarquée sur Geos-2, a pris fin le 30 juin. Les deux calculateurs au sol Siemens 330, affectés à l'acquisition de ces données et au calcul en temps réel des transformées de Fourier, ont été transférés au secteur sol d'Exosat.

Malgré cette limitation du mode d'acquisition des données, il demeure possible d'enregistrer toutes les données fournies par toutes les expériences de mesure des particules. En outre, les données sur les champs électriques DC et ULF ainsi que les données magnétiques ULF sont recueillies sans aucune dégradation. Les données des ondes VLF sont obtenues seulement sous forme de puissance quadratique moyenne à la sortie d'un banc de filtres couvrant les fréquences inférieures à 10 kHz. Ce mode d'acquisition limité est assuré en principe 24 h sur 24. Toutefois, les restrictions apportées au trafic des télécommandes – deux périodes d'envoi de commandes par jour seulement – entraînent des trous considérables dans la réception des données, en particulier au cours de la saison d'éclipse.

Les données déjà recueillies et en cours d'acquisition pendant le deuxième semestre constituent un capital précieux tant pour travailler en conjonction avec l'installation Eiscat, opérationnelle pendant la majeure partie de cette période, que pour procéder à des études magnétosphériques axées sur les incidences à long terme (cycle solaire).

Des ateliers qui se sont réunis récemment en vue de coordonner l'analyse des données de l'Etude internationale de la magnétosphère ont contribué à accroître le nombre de rapports consacrés aux données recueillies simultanément par plusieurs satellites et à l'occasion d'observations au sol dans la zone des aurores boréales. A titre d'exemple, le numéro d'août du 'Journal of Geophysical Research' contient dix articles qui présentent les données de Geos en tableaux synoptiques des phénomènes magnétosphériques à l'échelle du globe. Du 27 au 30 septembre s'est tenu à l'ESOC le premier atelier européen, assisté par calculateur, avec accès transatlantique à une banque de données installée au 'World Data Center' du Goddard Space Flight Center.

OTS-2

OTS-2, qui a maintenant passé plus de quatre ans et demi en orbite, continue à fonctionner de façon satisfaisante et l'exploitation de sa charge utile se maintient à un niveau élevé.

Tous les sous-systèmes de la plate-forme concourent pleinement à l'exécution de la mission, aidés en cela par leur haut degré de redondance. A titre d'exemple, une diminution de poussée observée sur les propulseurs de pilotage en lacet utilisés jusqu'ici n'a aucune incidence sur la mission grâce au recours à la branche redondante.

Cette observation est du plus haut intérêt pour la conception des satellites ultérieurs, et elle paraît également confirmer les constatations faites sur certains satellites américains utilisant une technologie analogue.

La plupart des opérations de la charge utile d'OTS comportent maintenant des transmissions de données entre de petites stations terriennes ou la diffusion de signaux de télévision. En outre, le satellite est utilisé pour étalonner les moyens d'essais qui mesureront les performances en orbite d'OTS. Un accord est récemment intervenu au sujet de l'exploitation d'OTS au moins jusqu'à la fin de 1983.

Excursion of ISEE-3 into the Earth's magnetotail

ISEE-3 lors de son incursion dans la queue de la magnétosphère

ISEE-2

The ISEE satellites continued to operate in their nominal orbits until June 1982, when orbit manoeuvres were initiated to send ISEE-3 first to the Earth's magnetotail and later to comet Giacobini Zinner. The first crossing of the magnetotail took place at the end of October 1982. The manoeuvres to send ISEE-3 towards the comet will be initiated in March 1983, leading to a cometary passage in September 1985.

The ISEE-1 and ISEE-2 satellites, which passed through the Earth's magnetotail in February-April 1982 as part of the original mission, provided some interesting observations in parallel with Geos and the Eiscat (ionospheric radar) facility in Scandinavia.

The scientific groups, consisting of a good mixture of European and American investigators, remain very active in presenting their results. A large number of significant ISEE papers were presented at the Cospar meeting in Ottawa in May 1982.

IUE

During its fifth year of life, the IUE spacecraft is continuing to perform scientific measurements effectively. As expected, the power output from the solar array has decreased slightly, limiting the range of angles with respect to the Sun through which the spacecraft can operate. On 27 July, a third gyroscope of the six originally available failed. One further failure would mean that the present attitude-control strategy could no longer be used. However, GSFC (NASA) is already designing a new control capability which could make operation possible with only two functioning gyros.

During recent months, IUE has again shown its ability to react quickly to the announcement of a target of opportunity. Nova Aquilae and Nova Sagittarii, and the new comet Austin, were observed at the Agency's Vilspa (Madrid) facility, shortly after their discovery. The UV data on Nova Aquilae are particularly interesting because of the peculiar behaviour of this object. Preliminary results, including optical and infrared coordinated observations, will be presented by the Nova Team at the next meeting of the IUE Allocation Committee.

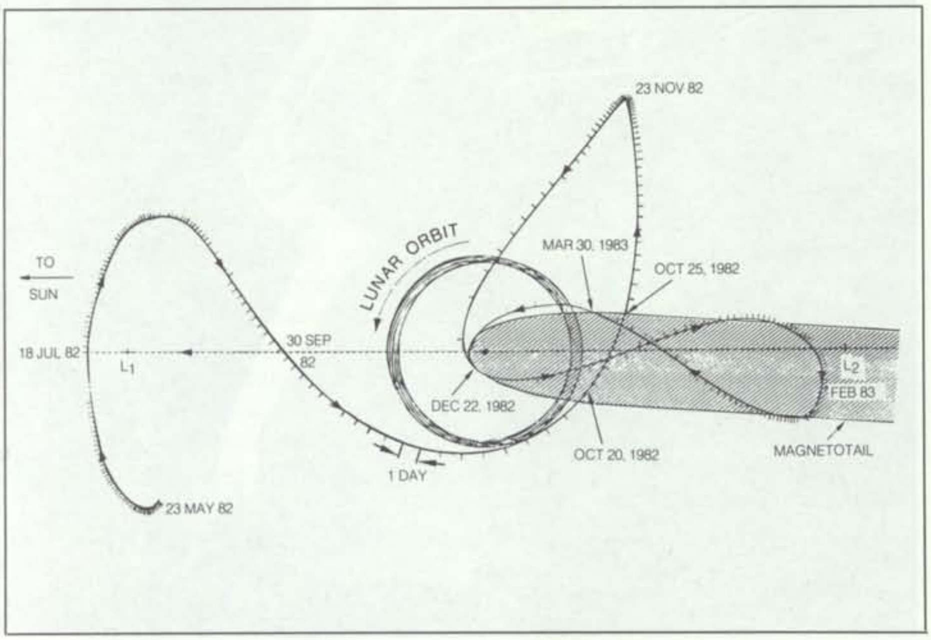
Geos-2

The high-resolution wave data transmission from Geos-2 was terminated on 30 June 1982. The two ground-based Siemens-330 computers dedicated to wave data acquisition and real-time fast Fourier transformation were transferred to the Exosat ground segment.

The reduced mode of data acquisition still makes it possible to record all data from all particle experiments. In addition, DC and ULF electric wave data, as well as ULF magnetic data, are obtained with no degradation. VLF wave data are only obtained in terms of RMS power at the output of a filterbank covering frequencies up to 10 kHz. The reduced mode of acquisition is in principle maintained for 24 hours per day. However, the limited telecommand traffic – only two command periods per day – is causing considerable data gaps, particularly during the eclipse season.

The data already acquired and still being collected during the second half of 1982 represent a valuable asset both for work in conjunction with the Eiscat facility, which has been operational during most of the interval, and for magnetospheric studies looking at long-term (solar-cycle) effects.

Recent workshops conducted with the aim of coordinating IMS data-analysis efforts have helped to increase the number of papers reporting on data collected simultaneously from several satellites and ground observations in the auroral zone. The August issue of the Journal of Geophysical Research, for example, contains ten papers presenting Geos data in synoptic displays of global magnetospheric phenomena. The first computer-aided workshop in Europe with transatlantic access to a data bank, at the World Data Center of the Goddard Space Flight Center, was held at ESOC from 27 to 30 September 1982.



OTS-2

OTS-2 has now accumulated more than 4.5 years of orbital life and continues to operate satisfactorily, with a high degree of payload utilisation.

All platform subsystems are still fully supporting the mission, helped by the high degree of redundancy. For example, a recent reduction in thrust observed on the yaw thrusters used so far will have no impact on the mission as the redundant branch can be used. The experience is extremely valuable for the design of subsequent satellites, and seems to be in line with that on some US spacecraft using similar technology.

Most OTS payload operations now involve data transmissions between small earth stations, or the distribution of television signals. The satellite is also

Météosat

Secteur spatial

Les deux satellites continuent d'assurer correctement la mission: Météosat-2 transmet toutes les demi-heures des images de la Terre dans les bandes visible, infrarouge thermique et vapeur d'eau, et assure la diffusion de données image et météorologiques, tandis que Météosat-1 assure la mission collecte de données.

Secteur sol

La nouvelle antenne destinée au système de collecte de données est en service et assure en outre toutes les liaisons de servitude avec Météosat-2. Vingt-deux nouvelles plate-formes ont été admises dans le système qui en comprend maintenant près de 70 sans compter celles sur avion (ASDAR). Pour faire face à cette augmentation, de nouveaux récepteurs ont été installés dans la station de l'Odenwald.

Un important travail de restructuration du logiciel a été accompli pour concentrer sur un seul ordinateur principal l'ensemble du traitement des données. L'ordinateur ainsi libéré assure la redondance du premier, ce qui améliore notablement la disponibilité du centre de calcul.

Le nouveau programme de diffusion inclut les cartes météorologiques (format M) élaborées par les Services météorologiques allemands.

Programme opérationnel

A la demande des Services météorologiques européens, l'ESA procède à l'actualisation de la proposition qui lui a été antérieurement soumise afin de l'adapter à la nouvelle conception de référence et au nouveau calendrier acceptés par les utilisateurs. Des demandes de prix pour cette nouvelle conception de référence ont été envoyées, et les propositions reçues du consortium Cosmos pour le véhicule spatial et d'Arianespace pour le lanceur sont en cours d'évaluation. Le but est de réunir la documentation nécessaire pour la seconde session de la Conférence intergouvernementale sur un système opérationnel de satellites météorologiques qui doit se tenir du 21 au 23 mars 1983 au siège de l'ESA.

Exosat

Satellite/charge utile

Au cours des mois de juin et juillet, des compléments ont été apportés à la configuration du modèle de vol du satellite pour qu'il réponde aux impératifs définitifs de la norme de vol, et des essais fonctionnels ont été exécutés pour vérifier certains sous-systèmes et éléments d'expériences qui avaient été échangés.

Afin de démontrer une fois de plus l'intégrité fonctionnelle du satellite dans les conditions d'ambiance, une séquence raccourcie d'essais de recette a été exécutée au mois d'août, avec notamment des essais thermiques sous vide et de compatibilité électromagnétique. En prévision de la Revue d'aptitude au vol (FRR) programmée initialement pour la fin septembre, les non-conformités décelées au cours de la phase d'essai en reconfiguration et en recette ont fait l'objet des mesures appropriées et, pour certaines, corrigées.

Le programme a dû être adapté à la suite de l'échec du lancement Ariane et la FRR ajournée au 19 octobre.

Dans l'intervalle, la commission de FRR a examiné le travail de quatre groupes d'experts sur cinq et publié une liste de recommandations.

Il reste à revoir les travaux du groupe chargé des aspects lanceur, interfaces lanceur-satellite et opérations de lancement.

Les travaux sur le satellite ont été interrompus au début d'octobre dans l'attente d'une décision sur le nouveau calendrier de lancements Ariane.

Le lancement d'Ariane étant maitenant prévu pour juin 1983, une modification de programme a été discutée et arrêtée avec le contractant du satellite, portant sur les impératifs d'achèvement des travaux en novembre 82, le stockage entre novembre 82 et avril 83, et le contrôle de l'état du satellite au cours de la

The main Exosat antenna, at ESA's Villafranca (Madrid) ground station

L'antenne principale d'Exosat, à la station terrienne de Villafranca being employed in the calibration of the test facilities that will measure ECS's performance in orbit. An agreement has recently been reached by which OTS will be operated at least until the end of 1983.

Meteosat

Space segment

Both satellites are still performing properly. Meteosat-2 is transmitting images of the Earth every half an hour in the visible, thermal-infrared and water-vapour bands and disseminating image and meteorological data, while Meteosat-1 is carrying out the data-collection mission.

Ground segment

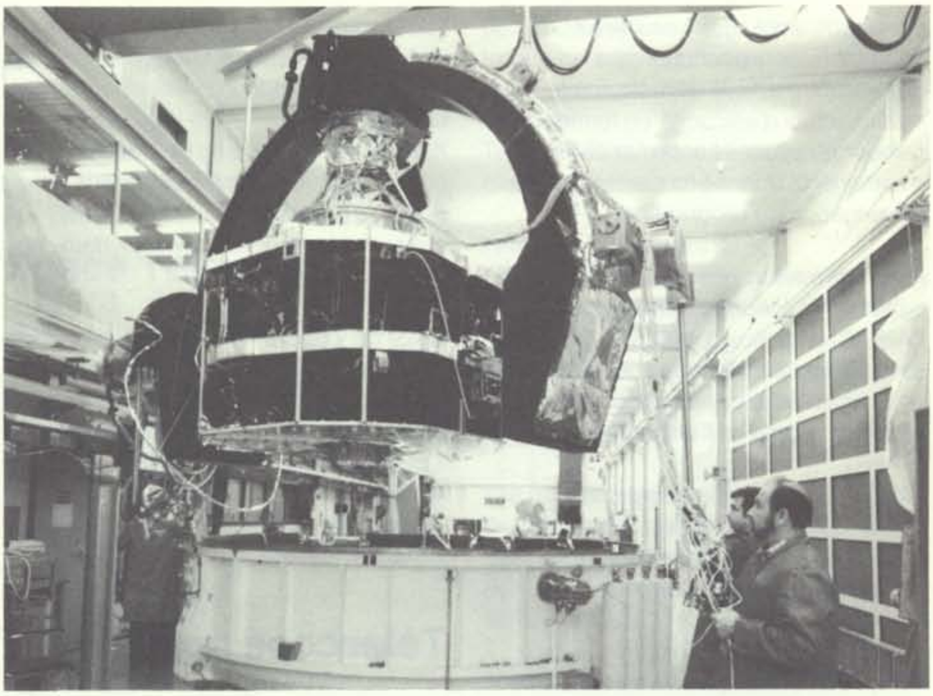
The new antenna for the data-collection system is in service and is being used, inter alia, for all the Meteosat-2 housekeeping links. Twenty-two new platforms have been admitted to the system, which now involves nearly 70 platforms, not counting those mounted on aircraft (ASDAR). To cater for this increase, new receivers have been installed at the Odenwald station.

The software has been largely restructured in order to concentrate all dataprocessing operations on a single main computer. The computer that this has released now provides redundancy for the one in use, thus appreciably improving the availability of the computer centre.

The new dissemination programme includes the meteorological charts (format M) produced by the German Meteorological Service.

Operational programme

At the request of the European meteorological services, ESA is in the process of updating the previously-submitted proposal to be compatible with the new baseline and schedule agreed by the users. Requests for quotation to the new baseline were sent out and proposals from the COSMOS consortium for the spacecraft and from Arianespace for the launcher are currently under evaluation. This is aimed at providing the material for the Second Session of the Intergovernmental Conference on an Operational Meteorological Satellite System, which is now scheduled to be held on 21-23 March 1983 at ESA Headquarters.



Véhicule spatial Exosat au cours des essais thermiques sans vide à l'ESTEC avant la revue d'aptitude au vol

The Exosat spacecraft undergoing thermal vacuum testing at ESTEC prior to last-year's flight-readiness review

Exosat

Spacecraft/payload

During the months of June and July, the flight-model (FM) satellite configuration was supplemented to meet final flight-standard requirements, and functional performance tests were carried out to verify the exchange of some subsystem and experiment units.

To demonstrate once more the functional integrity of the satellite under its expected environmental conditions, an abbreviated acceptance-test sequence was carried out in August, including EMC and thermal-vacuum testing. In anticipation of the Flight-Readiness Review (FRR), initially scheduled for end-September, nonconformances detected during the reconfiguration and acceptance-test phase were properly addressed, and some closed out.

The Ariane launch failure has necessitated some programme adaptation and the FRR had to be postponed to 19 October.

Meanwhile, the FRR board has reviewed the work of four of the five expert panels and has issued a list of recommendations. The outstanding issue concerns the panel dealing with aspects of the launcher, launcher-to-satellite interfaces and launch operations.

Work on the satellite was discontinued early in October awaiting a decision on the future Ariane launch schedule. It is now foreseen that Exosat will be launched in June 1983, and a programme change has been discussed and agreed with the satellite contractor covering the requirements for completion of work in November, the storage between November and April this year, and work related to monitoring of the satellite's status during the storage period.

Work to be performed in November includes exchange of the AOCE unit, the prime flight hardware having been delivered by the subcontractor at the end of October, after successful completion of flight-unit acceptance tests.

All outstanding testing and calibration of flight and spare units of the scientific payload has been completed.

In view of the delay in the launch, some work originally planned to take place at the launch range has been advanced and completed at ESTEC.

Ground segment

Preparatory work at ESOC for support of the launch and subsequent orbital operations is almost complete.

période de stockage. A ce sujet, il convient de souligner qu'il sera extrêmement difficile de maintenir le niveau actuel d'efficacité, en termes de personnel spécialisé et de fiabilité des équipements d'essai, tout au long de la prolongation du programme.

Parmi les travaux de novembre figure également l'échange d'un élément de l'AOCS, rendu possible depuis que le sous-traitant a livré le matériel de vol fin octobre après avoir mené à bonne fin les essais de recette de l'unité de vol.

En ce qui concerne la charge utile scientifique, les opérations d'essai et d'étalonnage qui restaient à faire sur les unités de vol et les rechanges sont terminées.

Compte tenu de l'ajournement du lancement, certains travaux prévus initialement pour la base de lancement ont été réalisés en avance sur le calendrier à l'ESTEC.

Secteur sol
Les travaux préparatoires menés à l'ESOC pour le soutien du lancement et des opérations en orbite lui faisant suite sont pratiquement terminés.

Après achèvement des essais de compatibilité RF au GSFC (NASA), on peut considérer comme acquise la compatibilité des interfaces des stations de routine et de renfort.

Certains jeux de documents nécessaires pour le soutien de la phase opérationnelle sont en cours de révision; c'est notamment le cas du plan des opérations de vol (FOP).

Les préparatifs des opérations d'observation se sont poursuivis de façon satisfaisante. La fiabilité de la liaison données entre Villafranca et Madrid occasionne des préoccupations particulièrement sérieuses du fait qu'elle pourrait avoir des incidences sur la vitesse de transmission des données recueillies en orbite.

La qualité de la ligne de transfert des données entre Villafranca et l'ESOC a été récemment améliorée à la suite de négociations avec l'administration des PTT espagnoles.

On procède actuellement à des essais supplémentaires destinés à réévaluer la fiabilité globale de la transmission des données d'Exosat à 8 kbit/s.

Lanceur
A la suite de la décision de lancer le couple ECS/Amsat avec L6 dans la seconde quinzaine d'avril 1983, il est prévu de lancer Exosat avec L7 deux mois plus tard, vers la fin de juin.

En ce qui concerne l'examen des aspects lanceur, interfaces lanceur-satellite et opérations de lancement, dans le cadre de la revue d'aptitude au vol d'Exosat, on suppose que le groupe responsable aura terminé ses travaux d'ici la fin de novembre.

Télescope spatial

Réseau solaire
Les cassettes 'bi-stem' destinées au modèle de vol des mécanismes de déploiement secondaires ont été livrées au contractant principal après avoir subi le programme d'essais de recette. L'unité de rechange a connu, au cours des essais thermiques sous vide pour la recette, une défaillance à basses températures qui est actuellement à l'étude.

Le premier modèle de vol du mécanisme de déploiement secondaire a été assemblé et les essais ont démarré. L'assemblage du second modèle de vol (pour la seconde aile) est en cours.

Des essais dynamiques très importants ont été faits au niveau système sur les modifications en montage sur table de l'électronique d'entraînement du réseau solaire. Leurs résultats laissent présager de bonnes perspectives de respecter l'ensemble des impératifs rigoureux de couple interactif et de temps d'amortissement pour les manoeuvres d'orientation du réseau solaire.

Les essais ont également débuté sur les modèles de vol des boîtiers de diodes de blocage.

Chambre pour astres faibles (FOC)
Les essais d'interfaces électriques et logiciels entre le système de commande et de traitement des données des instruments scientifiques de la NASA et le modèle de rechange de la case électronique de la FOC ont été menés à bien chez le contractant de la NASA.

Les essais d'interface entre la FOC et le modèle électrique du détecteur de photons ont débuté à la suite de la livraison de ce modèle chez Dornier, début novembre. La cause de certaines défaillances des mécanismes de remise au point automatique lors des essais de recette en vibration a été diagnostiquée et des correctifs sont apportés au matériel.

Détecteur de photons (PDA)
Un point final a été mis aux travaux de développement sur la tête de détection contenant le tube analyseur non enrobé. Par la suite, ce modèle a été intégré avec le modèle d'identification amélioré dans le modèle électrique du PDA et livré à Dornier pour intégration dans la FOC.

Le premier ensemble de tube analyseur a été intégré, les nouveaux tubes Westinghouse étant utilisés, et a subi avec succès les essais thermiques sous vide. Le second ensemble en est au stade de l'intégration. La partie intensificateur aux normes de vol a été livrée ainsi que toutes les unités électroniques destinées à la première chaîne de détection du PDA. Le programme respecte le calendrier qui prévoit la livraison de la FOC à la NASA en septembre 1983.

ISPM

Lanceur et date du lancement
A la suite de la décision de la NASA et du Congrès des Etats-Unis de changer encore une fois d'orientation et de revenir à l'étage Centaur pour le véhicule d'injection interplanétaire, une activité considérable s'est fait jour aux Etats-Unis et en Europe afin de rattraper le temps perdu. C'est en particulier le cas des interfaces électriques, mécaniques et opérationnels qui sont définis en commun avec le Lewis Research Center, établissement de la NASA chargé de l'intégration du couple véhicule spatial-Centaur dans le STS. Les travaux progressent normalement, mais il reste beaucoup à faire avant achèvement des activités sur le véhicule spatial en Europe.

Le changement d'étage supérieur entraîne, entre autres conséquences fâcheuses, la nécessité de reporter de 1985 à 1986 le lancement du satellite Galileo de la NASA. La possibilité d'un lancement en direction de Jupiter en 1986 sera donc partagée entre ISPM et Galileo, qui ont le même créneau optimal. Des

Following completion of the radio-frequency (RF) compatibility tests at NASA/GSFC, interface compatibility of the prime and back-up stations can be assumed.

Some documentation needed to support the operational phase is under review, as is the Flight Operations Plan (FOP).

Preparations for observatory operations have proceeded satisfactorily. One major concern relates to the reliability of the data link from Villafranca to Madrid, which could have an impact on the choice of in-orbit data-transmission rate.

The quality of the data-line between Villafranca and ESOC has recently been improved following discussions with the Spanish PTT. Further tests are currently in progress to reassess the overall reliability for Exosat data transmissions at 8 kbit/s.

Launcher

Following the decision to launch ECS/Amsat on Ariane L6 in the second half of April 1983, as noted above it is now foreseen to launch Exosat on Ariane L7 some two months later, towards the end of June.

It is assumed that the panel reviewing launcher aspects and interfaces to satellite hardware and operations within the framework of the Exosat Flight-Readiness Review can complete its work by the end of December.

Space Telescope

Solar array

The bi-stem cassettes for the flight secondary-deployment mechanisms have passed the acceptance-test programme and have been delivered to the prime contractor. A malfunction that occurred at low temperatures during thermal-vacuum acceptance testing of the spare unit is under investigation.

The first flight model of the secondary-deployment mechanism has been assembled and testing has started. Assembly of the second flight model (for the second wing) is in progress.

Considerable system dynamic testing has taken place, with breadboarded modifications to the solar-array-drive electronics. The results show good prospects for meeting the various demanding requirements on interactive torque and settling time for solar-array slewing manoeuvres.

Testing has also started on the flight blocking diode boxes.

Faint Object Camera

The electrical and software interface tests between the NASA scientific instrument command and data-handling system and the FOC spare electronics-bay assembly have been conducted satisfactorily at the NASA contractor's site.

The interface tests between the FOC and the electrical model of the Photon Detector Assembly have started following delivery of this model to Dornier in early November 1982.

The cause of some refocus mechanisms failing to pass acceptance vibration testing has been identified and hardware corrections are being introduced.

Photon Detector Assembly

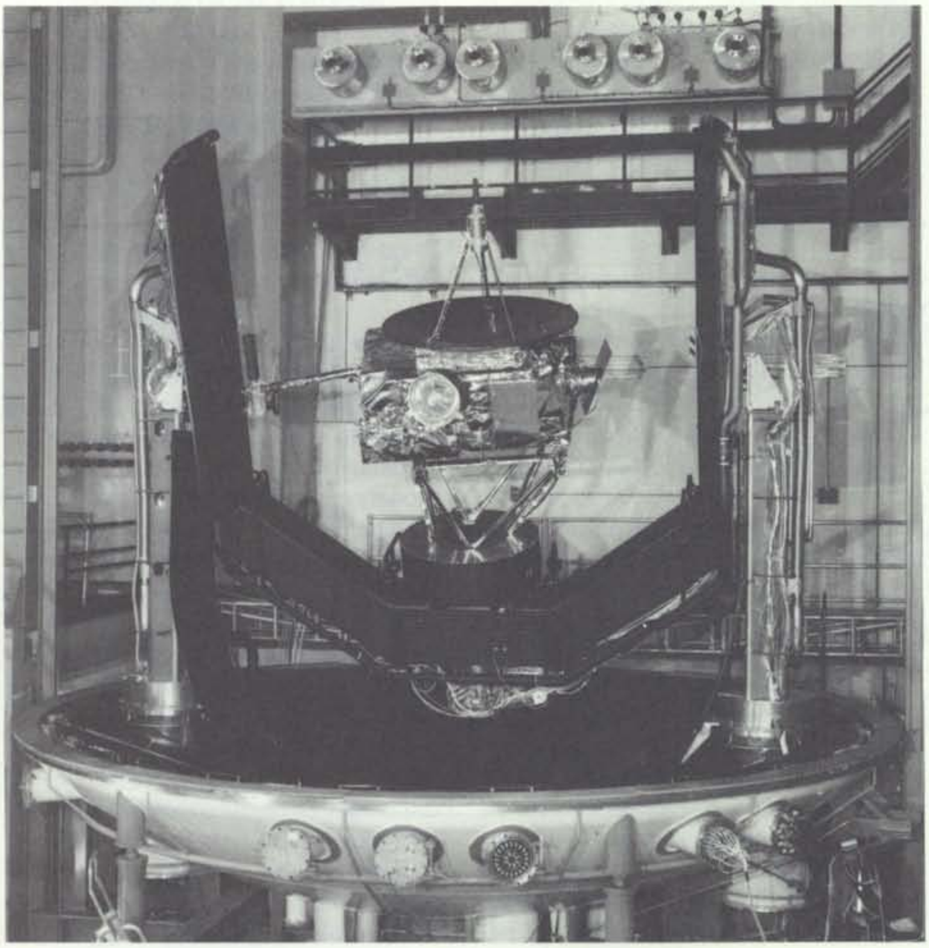
The development work on the detector head unit containing the non-potted camera-tube assembly has been finalised. This unit has since been integrated with the upgraded engineering model into the electrical model of the PDA and delivered to Dornier for integration with the FOC.

The first flight-camera-tube assembly has been integrated using the new Westinghouse camera tubes, and successfully tested in thermal vacuum. The second assembly is in the integration stage. The flight intensifier sections have been delivered as well as all electronic units for the first PDA detector chain. The programme is on schedule for delivery of the Faint Object Camera to NASA in September 1983.

ISPM

Launcher and launch date

Following the decision by NASA and the US Congress to make yet another change of direction and to revert to the Centaur



Modèle de qualification d'ISPM au cours des essais thermiques sous vide dans l'enceinte SIMLES du CNES à Toulouse

ISPM qualification model ready for thermal-vacuum testing in the SIMLES facility at CNES, Toulouse

Artist's impression of the ISPM spacecraft and Centaur injection stage after deployment from the Space Shuttle

Vue conceptuelle du véhicule spatial ISPM avec l'étage d'injection Centaur après séparation de la Navette spatiale

consultations sont en cours en vue d'explorer les possibilités de trouver une solution raisonnable pour les deux projets.

Véhicule spatial

Les travaux sur le véhicule spatial ISPM se sont poursuivis et, malgré de nombreuses difficultés provoquées par le retard de la livraison de certains sous-systèmes et expériences, les essais du modèle de qualification se sont achevés a peu près dans les délais. L'examen final de la conception s'est tenu en octobre et la Commission, qui réunit des responsables techniques de l'ESA et du JPL à un niveau élevé, a décidé que les essais avaient été réussis et a donné la permission de mettre en route l'intégration du modèle de vol du véhicule spatial, tout en notant que l'équipe avait été obligée de travailler sous pression. Pour le moment, les travaux d'intégration des expériences se poursuivent comme prévu en dépit des craintes de retards que pourrait occasionner l'un des sous-systèmes en 1983.

Tandis que les activités sur le matériel atteignent leur maximum en Europe, le planning du lancement et des activités après lancement prend forme. Dans ce domaine, l'une des décisions importantes à noter est l'accord conclu entre l'ESOC et le JPL sur le type de système de télémesure en temps réel à installer pendant la phase opérationnelle de la mission, de 1986 à 1990. Cette décision devait être prise à ce stade afin de permettre en temps utile le développement et la mise en oeuvre du logiciel opérationnel.

Charge utile scientifique

Sous l'angle scientifique, l'événement le plus important de la fin 1982 a été la décision de compter le Dr Bertotti, de l'Université de Pavie, au nombre des investigateurs principaux; il apporte une expérience radioscientifique destinée à détecter des ondes gravitationnelles.

L'équipe de travail scientifique s'est réunie à l'ESTEC à la suite de l'examen final de conception d'octobre et, parmi les sujets abordés, a étudié le partage du créneau de lancement de 1986 avec Galileo. Cette équipe a adopté des résolutions réaffirmant la nécessité de trouver une date de lancement assurant un maximum d'exposition du véhicule spatial aux latitudes solaires élevées, compte tenu en particulier de la suppression du véhicule spatial de la NASA.

Hipparcos

Les travaux de définition du projet se sont poursuivis, l'accent étant particulièrement mis sur les sous-systèmes en prévision de l'examen de définition des sous-systèmes prévu pour la mi-décembre. Ce sera l'occasion de confirmer si la définition du système et des sous-systèmes constitue une base fiable pour les activités de planification et de chiffrage précédant la phase de mise en oeuvre (C/D) et de vérifier si les impératifs de l'Agence au niveau système sont respectés. La proposition en bonne et due forme de l'industrie pour la phase C/D est attendue à la mi-février, la signature du contrat prévue pour la mi-juillet 1983.

Un grand nombre de propositions ont été reçues au sujet des étoiles et autres objets célestes dont l'inscription est demandée dans le 'Catalogue des étoiles à observer' d'Hipparcos. Plus de 20 pays ont soumis 200 propositions couvrant au total plus de 450 000 objets célestes. La proposition Hipparcos a provoqué dans les milieux scientifiques un écho dont l'importance ressort clairement de l'étendue et de la nature de ces propositions, couvrant de nombreux domaines tels que la physique stellaire, la dynamique du système solaire et des galaxies, les cadres de référence de la rotation de la Terre, l'échelle des distances extra-galactiques et la structure du milieu interstellaire. La sélection des propositions à inclure dans le catalogue des étoiles à observer devait se faire en décembre 1982.

L-Sat

Les activités industrielles de la phase principale de réalisation (phase C/D) se sont poursuivies à la suite de l'examen de la conception de référence qui a eu lieu au début de l'année. La plupart des problèmes potentiels décelés au cours de l'examen sont aujourd'hui réglés et l'on met la dernière main aux mesures qui restaient à prendre.

Au niveau du système de satellite, des problèmes ont retenu l'attention, particulièrement en ce qui concerne la croissance de la masse du satellite qui a abouti à une diminution de la marge disponible. En ce qui concerne les sous-systèmes de la plate-forme, les problèmes sont actuellement maîtrisés mais les efforts se poursuivent pour réduire la masse de la charge utile.

rocket as the Interplanetary Injection Vehicle, there has been considerable activity in USA and Europe in trying to recover the lost time. In particular the electrical, mechanical and operational interfaces are being defined jointly with Lewis Research Center, the NASA establishment designated to be responsible for the integration of the Centaur-spacecraft combination to the Space Shuttle. Good progress is being made, although much remains to be done prior to the completion of spacecraft activity in Europe.

One unfortunate effect of the change of Upper Stage is the necessity for NASA to postpone the launch of its Galileo spacecraft from 1985 to 1986. Consequently, the 1986 opportunity to launch towards Jupiter is now shared by ISPM and Galileo, and both have the same optimum launch window. Consultations are in progress to explore the possibilities for both projects to achieve a reasonable solution.

Spacecraft
The activity on the ISPM spacecraft has continued and, despite many difficulties caused by the delayed delivery of some subsystems and experiments, the testing of the qualification-model spacecraft was concluded approximately on schedule. A Final Design Review was held in October and the Review Board, comprised of senior technical managers from ESA and JPL, whilst noting the pressure under which the team had been forced to work, decided that the testing had been successful and gave permission for the integration of the flight spacecraft to be started. At present, work on experiment integration is continuing as planned, although there are fears that delays affecting one subsystem may give rise to difficulties in 1983.

As the hardware activity in Europe peaks, so the planning of the launch and post-launch activity is gaining momentum. One of the important decisions in this area is the agreement between ESOC and JPL on the type of real-time telemetry system to be installed during the mission operational phase from 1986 to 1990. This decision is necessary at this stage to permit timely development and implementation of the operational software.

Scientific payload
From the scientific viewpoint, the most significant decision of late 1982 has been the inclusion of Dr. Bertotti of the University of Pavia among the Principal Investigators, with a radio-science experiment aimed at the detection of gravitational waves.

A Science Working Team meeting was held at ESTEC to follow the Final Design Review in October and among the subjects discussed was the sharing of the 1986 launch opportunity with Galileo. The SWT passed resolutions reasserting the need for a launch to be found which gave maximum exposure of the spacecraft to high solar latitudes, particularly in view of the cancellation of the NASA spacecraft.

Hipparcos

Work has continued on project definition, with increased emphasis at subsystem level leading to the Subsystem Definition Review planned for mid-December. This Review will confirm the system and subsystem definition as adequate for reliable planning and costing activities for the main development phase (C/D), and will ascertain that the Agency's system requirements are not violated. The formal industrial proposal for the C/D phase is expected in mid-February, with contract signature planned for mid-July 1983.

A large number of proposals have been received for stars and other celestial objects to be considered for inclusion in the so-called 'Input Catalogue of Objects to be Observed by Hipparcos'. More than 20 countries have made 200 proposals covering in excess of 450 000 objects. The wide scientific appeal of the Hipparcos project is evident from the extent and nature of these proposals, which embrace many scientific domains, such as stellar physics, solar system and galaxy dynamics, Earth-rotation reference frames, extragalactic distance scale, and the structure of the interstellar medium. Selection of proposals for inclusion in the Hipparcos Input Catalogue takes place during December 1982.

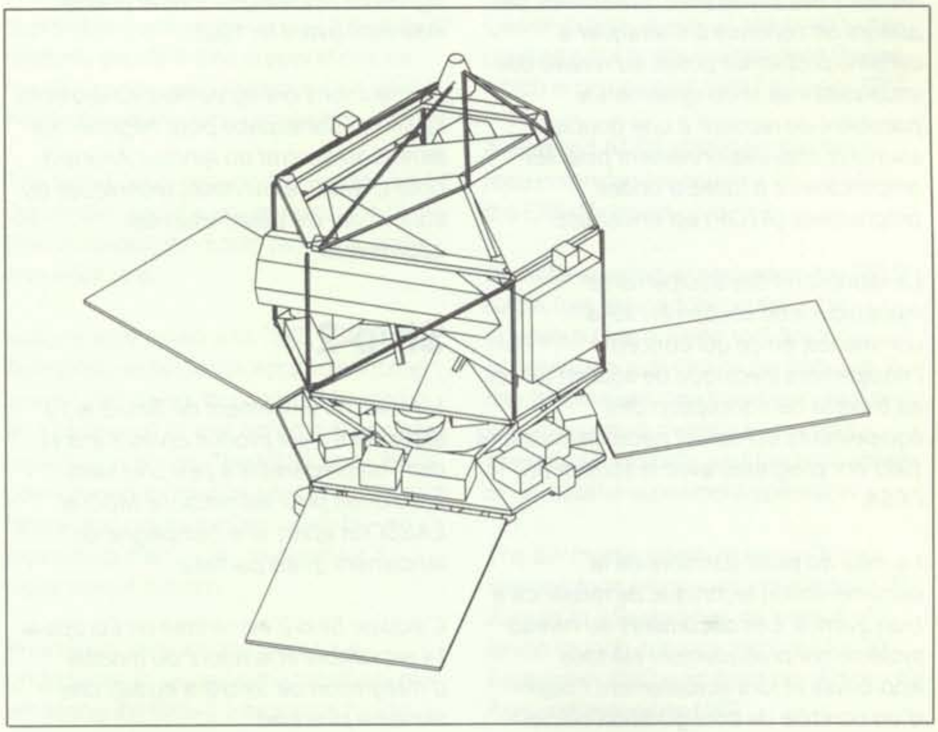
L-Sat

Industrial activities of the main development phase (Phase C/D) have continued following the Baseline Design Review (BDR) earlier in the year. The majority of the potential problems identified in the review have now been resolved and close out of the remaining actions is continuing.

Special attention has been given to system-level problems, particularly in a general growth of the satellite mass which

Visualisation informatisée d'Hipparcos

Computer-aided-design (CAD) visualisation of Hipparcos



Artist's impression of the L-Sat spacecraft

Vue conceptuelle du véhicule spatial L-Sat

British Aerospace (BAe), le contractant principal, a décidé de passer d'un système d'alimentation en courant alternatif à un système en courant continu en raison des problèmes permanents que posent la technologie et la mise en oeuvre du système en courant alternatif.

On envisage d'améliorer la couverture de l'antenne de télémesure, poursuite et télécommande (TTC) dans le cadre des travaux portant sur le mode de renfort du système de commande d'orientation et de correction d'orbite (AOCS).

Les examens préliminaires de la conception sont en cours pour chacun des équipements de la plate-forme; ils seront suivis de travaux de conception détaillée aboutissant aux examens de développement du concept de référence et à la mise en route de la fabrication du modèle d'identification.

Dans le domaine de la charge utile, les travaux de montage sur table au niveau des équipements sont bien avancés et les résultats des essais sont disponibles; par ailleurs on continue à s'attaquer à certains problèmes posés au niveau des sous-systèmes et du système. La possibilité de recourir à une double source d'approvisionnement pour les amplificateurs à tubes à ondes progressives (ATOP) est envisagée.

La fabrication des équipements mécaniques de soutien au sol a commencé; en ce qui concerne l'équipement électrique de soutien au sol, les travaux de conception des équipements qui seront nécessaires début 1983 ont progressé avec le soutien de l'ESA.

La mise au point définitive de la documentation technique de référence a bien avancé. Les documents au niveau système ont pratiquement été tous approuvés et font actuellement l'objet d'un contrôle de configuration officiel.

Les négociations sur les aspects commerciaux et contractuels du programme se sont poursuivies entre l'ESA et BAe. Les détails du contrat de phase C/D en sont actuellement au stade des négociations finales pour que la signature officielle du contrat puisse intervenir avant fin 1982.

Des réunions ont également eu lieu entre l'ESA et Arianespace pour négocier les termes du contrat du lanceur Ariane-3 pour L-Sat 1, les annexes techniques du contrat ont été pour l'essentiel approuvées.

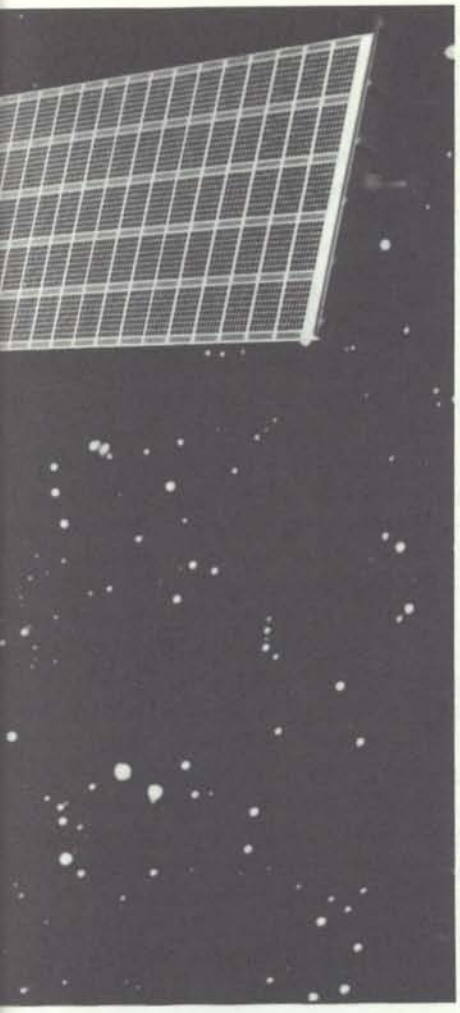
Sirio-2

L'échec du lancement de Sirio-2 le 10 septembre s'est produit après 3 ans et demi de préparatifs à peu près sans problèmes pour les missions MDD et LASSO et après une campagne de lancement quasi parfaite.

L'équipe Sirio-2 est rentrée en Europe le 14 septembre et le retour du modèle d'intégration de Sirio-2 a eu lieu une semaine plus tard.

Des dispositions ont été prises avec le Siège, l'ESOC et Telespazio pour régler les comptes concernant la campagne de lancement, la phase avortée du lancement et du début de fonctionnement en orbite, et enfin la phase d'exploitation devenue sans objet. Les utilisateurs de MDD et de LASSO, informés par télex de l'échec du lancement, ont immédiatement réagi en se déclarant fermement en faveur d'une mission de remplacement.

Des discussions préliminaires ont donc été entreprises pour examiner la possibilité de rendre apte au vol le modèle d'intégration de Sirio-2 et de trouver un créneau de lancement convenable. Les résultats de ces discussions ont conduit l'Agence à proposer une extension du programme Sirio-2 appelée 'Sirio-2B'. Une étude de faisabilité a été mise en route et le Conseil directeur du programme de satellite météorologique a autorisé l'Agence à demander à l'industrie de lui soumettre une proposition officielle. Cette proposition a été évaluée et présentée aux délégations le 7 décembre lors de la réunion du Conseil directeur en vue d'une décision définitive sur l'extension du programme.



reduced the available mass margin. The platform subsystems are now under control, but efforts are continuing to reduce the payload mass.

British Aerospace (BAe), the Prime Contractor, has decided to change from an AC power-distribution system to a DC system because of continuing problems encountered in engineering and implementing the AC system.

Improvement in the Telemetry, Tracking and Telecommand (TTC) antenna coverage is being considered in the context of Attitude and Orbit Control (AOCS) back-up mode work.

Preliminary Design Reviews (PDR) are being held for each of the items of platform equipment and the completion of detailed design work leading to the Development Baseline Reviews, and release of engineering-model manufacture will follow.

In the payload area, breadboarding work at equipment level has advanced and test results have become available, while some problems at subsystem and system level are still being addressed. The possibility of dual source procurement of the critical Travelling-Wave-Tube Amplifiers (TWTAs) is being considered.

Manufacture of the mechanical ground-support equipment has started, while the electrical ground-support equipment design work for equipment needed early in 1983 has progressed, with some support from ESA.

Good progress has been made in finalising the technical baseline documentation. Nearly all the system-level documents have been approved and are now subject to formal configuration control.

Negotiations have continued between ESA and BAe on the commercial and contractual aspects of the programme. Details of the Phase C/D contract are now under final negotiation, with the aim of achieving formal contract signature before the end of 1982.

Meetings have also been held between ESA and Arianespace to negotiate the terms of the contract for the Ariane-3 launch vehicle for L-Sat 1, and the technical annexes to the contract have essentially been agreed.

Sirio-2

The failure of the Sirio-2 launch on 10 September came at the end of 3.5 years of relatively problem-free preparations for the MDD and Lasso missions and after a nearly flawless launch campaign.

The Sirio-2 team returned to Europe on 14 September and the return transport of the Sirio-2 integration model (IM) took place one week later.

Actions were taken with CSG, ESOC and Telespazio to settle the accounts for the launch campaign, the aborted launch and early-orbit phase, and the suspended exploitation phase. The MDD and Lasso users were informed by telex of the launch failure and reacted immediately by expressing their strong support for a replacement mission.

Preliminary discussions were thus undertaken to examine the feasibility of rendering the Sirio-2 integration model flightworthy and finding a suitable launch slot. The results of these discussions induced the Agency to propose an extension of the Sirio-2 programme called Sirio-2B. A feasibility study has been undertaken and the Meteorological Satellite Programme Board authorised the Agency to request a formal proposal from industry. This proposal has been evaluated and presented to Delegations at the Board's meeting on 7 December for a final decision on the extension of the programme.

Remote Sensing

SAR-580 campaign
The technical problem identified in the digital processing has now been solved and 15 passes have been processed and distributed by DFVLR. It is planned to process a total of 100 passes at DFVLR before May 1983. In addition, RAE still has a potential of 150 h and a priority list is being established for processing in C- and X-band within this limit. The activities linked to the on-board calibration have been completed and the final report will be distributed in February 1983 with the data package.

ERS-1
The Preliminary Review (PR) took place from 17-19 November at Dornier System. The results are very encouraging and authorisation to proceed with Phase-B (definition phase) was given to Dornier. Certain points, however, still need to be clarified prior to the Intermediate Review, which is planned for 9-10 February 1983.

A modified ATSR (ATSR-M) has been recommended for possible inclusion in the ERS-1 mission.

Remote-sensing experiments for FSLP
NASA has decided to increase the Spacelab-One mission to 9 days' duration; the activities of the previous 7-day timeline will therefore be spread over a longer period, thereby increasing operational flexibility and the probability of successful experiment operation.

The 8th Investigators Working Group meeting took place in Huntsville from 30 August to 2 September, as a result of which launch is now scheduled for 30 September 1983 and flight simulations for August/September 1983.

Télédétection

Campagne SAR-580

Le problème technique identifié en ce qui concerne le traitement des données numériques est maintenant résolu; 15 passages ont été traités et leurs résultats diffusés par le DFVLR. Il est prévu que, au total, 100 passages seront traités au DFVLR avant mai 1983. En outre, le RAE dispose encore d'un potentiel de 150 heures et une liste de priorités est en cours d'établissement pour permettre le traitement des données en bandes C et X dans cette limite de temps. Les activités relatives à l'étalonnage à bord sont terminées et le rapport final sera diffusé en février 1983 en même temps que le lot de données.

ERS-1

La revue préliminaire a eu lieu du 17 au 19 novembre chez Dornier System. Les résultats en sont très encourageants et l'autorisation d'entreprendre les travaux de la phase B a été donnée à Dornier. Certains points restent cependant à clarifier avant la revue intermédiaire qui est prévue pour les 9 et 10 février 1983.

Un ATSR modifié (ATSR-M) a été recommandé en vue de son inclusion éventuelle dans la mission ERS-1.

Expériences de télédétection pour la FSLP

La NASA a décidé de porter à 9 jours la durée de la mission Spacelab-1; les activités antérieurement prévues pour 7 jours seront donc étalées sur une plus longue période, ce qui accroîtra la souplesse opérationnelle et la probabilité de succès dans la mise en oeuvre des expériences.

Le 8ème Groupe de travail des Investigateurs s'est réuni à Huntsville du 30 août au 2 septembre; à la suite de cette réunion, le lancement a été fixé au 30 septembre 1983 et des simulations de vol sont prévues pour août/septembre 1983.

Des modifications de dernière minute sur le matériel de la MRSE sont en cours d'investigation. A l'origine, il avait été admis que, en cas de panne d'alimentation des moteurs de l'antenne, celle-ci reviendrait à sa position de sécurité sous l'effet de la décélération de la Navette lors de la rentrée de celle-ci dans l'atmosphère. Mais cette solution ne peut plus être considérée comme sûre et il faudra trouver d'autres moyens de ramener l'antenne en position de sécurité.

Les activités concernant la chambre photogrammétrique se sont poursuivies conformément aux prévisions avec la livraison du dernier élément de matériel, le mécanisme de l'adapteur mécanique servant au montage de la chambre sur la fenêtre optique. La possibilité technique de stocker une troisième cassette de film a été démontrée, et la NASA a été invitée à ménager l'espace nécessaire par une petite modification de l'armoire à instruments, afin de permettre l'emport d'une troisième cassette dans le cas où l'on viendrait à disposer d'une marge de masse.

Spacelab

Le modèle d'identification a été utilisé avec succès, au KSC, pour vérifier le deuxième ensemble d'équipement électrique de soutien au sol (EGSE) et de servitude. Peu de problèmes se sont posés.

En ce qui concerne la configuration de vol Spacelab no. 1 (FU-I), les préparatifs pour l'installation dans le module de l'ensemble bâti et plancher sont achevés. On procède actuellement à l'installation des instruments NASA de vérification en vol. Des modifications mineures ont été effectuées sur FU-I. Les essais intégrés de niveau IV des expériences ont été menés à bien avec le matériel et le logiciel de soutien Spacelab. Les préparatifs sont actuellement en cours pour les essais de système du Spacelab intégré et de la charge utile Spacelab qui démarreront en janvier 1983.

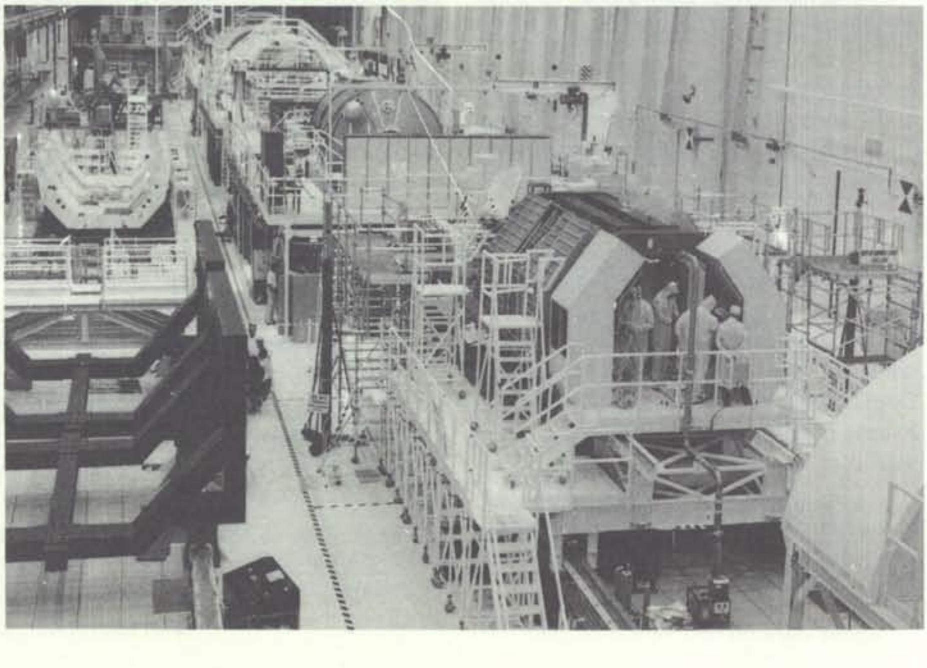
Le lancement de SL-1 est toujours prévu pour le 30 septembre 1983. Spacelab sera embarqué sur l'Orbiteur OV-102, 'Columbia'. La durée de la mission a été portée de sept à neuf jours grâce à l'adjonction à l'Orbiteur d'un cinquième ensemble cryogénique. En raison de l'utilisation de l'Orbiteur OV-102, l'atterrissage aura lieu à la base aérienne de Dryden, en Californie.

La configuration de vol no. 2 (FU-II) est actuellement entreposée au KSC, après inspection. L'organisation de la deuxième mission Spacelab (SL-2) commencera en mars 1983.

Le lancement de la deuxième mission Spacelab est toujours prévu pour décembre 1984.

Adaptateur des interfaces de processeur (PIA)

Ce dispositif, qui vient d'être ajouté au programme Spacelab, permet d'adapter un processeur décentralisé et autonome, faisant partie intégrante d'une expérience, au système centralisé de traitement des données et de télécommande du Spacelab.

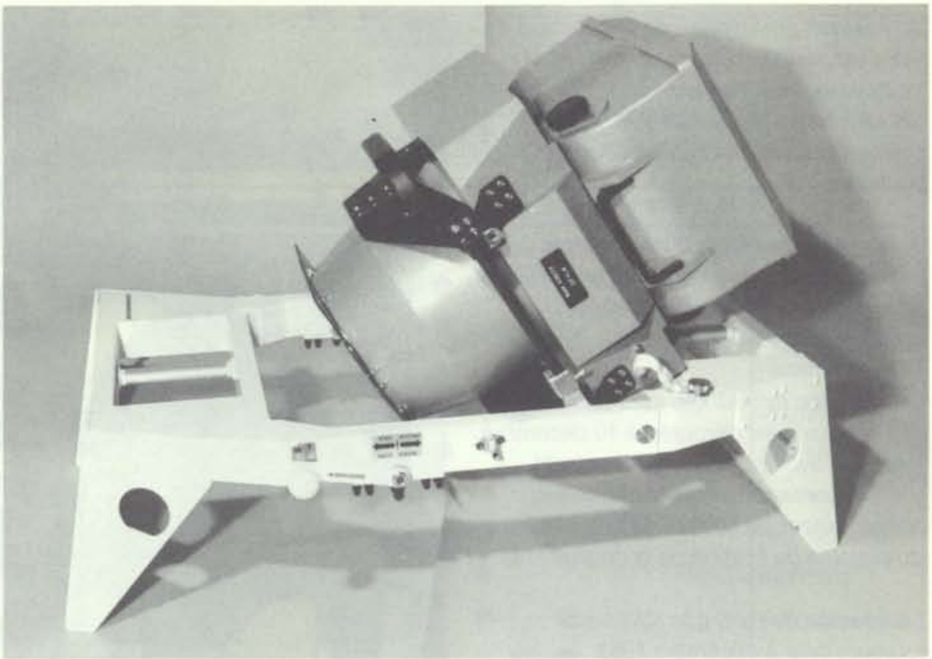


Spacelab-1 integration in progress at Kennedy Space Center, USA

Intégration de Spacelab-1 au Centre spatial Kennedy

La chambre photogrammétrique avec sa suspension

The Metric Camera, to be flown on Spacelab in September 1983, shown on its suspension mount



Last-minute hardware changes are under investigation for the Microwave Remote Sensing Experiment (MRSE). It had been originally assumed that, in the event of a power failure in the antenna motors, the antenna would return to its safe position due to the deceleration effect when the Shuttle enters the atmosphere. This can, however, no longer be considered sure and other means of returning the antenna to its safe position have to be found.

The Metric Camera activities continue according to plan, with delivery of the final hardware item, the mechanical adaptor mechanism for the camera mounting at the optical window, taking place. The technical feasibility of providing storage for a third film cassette has been established, and NASA has been requested to provide the storage via a small modification to the instrument rack, so that the option to include a third cassette remains, should a mass margin become available.

Spacelab

The Engineering Model has been used successfully at Kennedy Space Center (KSC) to validate the second set of Electrical Ground-Support Equipment (EGSE) and servicers. Very few problems have been encountered.

Concerning Flight Unit Configuration-One (FU-I), the preparations for installation of the rack and floor train in the module have been completed. Installation of the NASA Verification Flight Instrumentation is now proceeding. Some minor modifications have been implemented on FU-I. The integrated level-IV testing of the experiments with the supporting Spacelab hardware and software has been successfully completed. Preparations are now in progress for the system testing of the integrated Spacelab and Spacelab payload, which will begin in January 1983.

The launch of Spacelab-1 (SL-1) is still planned for 30 September 1983, and Spacelab will fly on 'Columbia' (Orbiter OV-102). The mission has been extended from seven to nine days by the addition of a fifth cryogenic energy kit in the Orbiter. The landing will need to take place at Dryden Air Force Base in California.

Flight Unit Configuration-Two (FU-II) is now in store at KSC, following completion of the inspection. Staging for Spacelab Mission-Two (SL-2) will start in March 1983.

The launch of the SL-2 mission is currently planned for December 1984.

Processor Interface Adapter (PIA)
The PIA, a late addition to the Spacelab programme, provides for the adaptation of a self-contained, decentralised processor, provided as an integral part of an experiment, to the centralised Spacelab Command and Dataprocessing System.

The PIA successfully passed a Preliminary Design Review in August, and design work is now proceeding towards a Critical Design Review in spring 1983.

Instrument Pointing System (IPS)
Design, analysis and development activities on the IPS are proceeding satisfactorily.

A quarterly progress meeting was held on 10 December 1982 with, as a primary aim, a review of the analysis work on the IPS's performance and the design of the payload clamp assembly.

Delivery of the IPS to NASA is still scheduled for December 1983.

Follow-on Production
Spacelab Follow-on Production activities, by which NASA purchases a second set of Spacelab equipment, are proceeding on schedule towards delivery of a variety of elements spread over the time period summer 1982 to summer 1984. A number of smaller units have been accepted and shipped to NASA in October/November.

The first two FOP pallets and two experiment racks have been completed. The racks have been accepted by NASA and shipped to KSC on 29 October. The two finished pallets are being held in storage at ERNO awaiting the next two pallets so that a single C5A aircraft can be used to transport them to the USA in early 1983.

Delivery of the IPS-FOP model is scheduled for December 1984.

FSLP

Major programme decisions have included extension of the mission from 7 to 9 days, and a change in the landing site from Kennedy Space Center (KSC) to Dryden Flight Research Center in California.

Un examen préliminaire de conception du PIA s'est déroulé avec succès en août et les travaux de conception sont actuellement en cours en vue d'un examen critique de la conception au printemps 1983.

Système de pointage d'instruments (IPS)
Les activités de conception, d'analyse et de réalisation se déroulent de façon satisfaisante.

Une réunion trimestrielle sur l'avancement des travaux s'est déroulée le 10 décembre 1982; elle avait pour principal objectif d'examiner les travaux d'analyse des performances de l'IPS et de la conception du système de fixation de la charge utile.

La livraison de l'IPS à la NASA est toujours fixée à décembre 1983.

Production ultérieure (FOP)
Le programme de production ultérieure du Spacelab, dans le cadre duquel la NASA achète un deuxième jeu d'équipements Spacelab, se déroule conformément au calendrier; la livraison de toute une série d'éléments est prévue entre l'été 1982 et l'été 1984. Un certain nombre de petites unités ont été acceptées et expédiées à la NASA en octobre/novembre.

Les deux premiers porte-instruments et deux bâtis d'expérience fabriqués dans le cadre de la FOP sont achevés. Les bâtis ont été acceptés par la NASA et expédiés au KSC le 29 octobre, quant aux deux porte-instruments, ils sont entreposés chez ERNO en attendant les deux prochains porte-instruments ce qui permettra de les expédier aux Etats-Unis début 1983 sur un seul vol de C5A.

La livraison du modèle FOP de l'IPS est prévue pour décembre 1984.

FSLP

Les principales décisions concernant le programme sont la prolongation de la durée de la mission, portée de 7 à 9 jours, et une modification du lieu d'atterrissage qui, au lieu du Kennedy Space Center, sera le Dryden Flight Research Center en Californie.

Des essais fonctionnels des expériences ont été effectués au KSC afin de vérifier les matériels ainsi que les équipements de soutien au sol et les interfaces de circulation des données. Ils ont été suivis d'un essai de séquences de mission comportant une simulation de différentes tranches de la mission et la vérification du fonctionnement de l'ensemble de la charge utile. La plupart des expérimentateurs étaient représentés au cours de ces essais et l'équipage du Spacelab y a été associé. Enfin, des opérations de remise en état et de maintenance ont marqué le bon achèvement de la phase d'intégration et d'essais de niveau IV au KSC.

Les préparatifs concernant le contrôle de la charge utile de la mission et la formation aux opérations de la charge utile pour les expériences européennes ont commencé au MSFC.

L'équipage du Spacelab et les expérimentateurs spécialistes de la science des matériaux se sont exercés à la conduite des expériences sur le modèle d'identification du bâti double de science des matériaux au DFVLR. Le personnel de contrôle au sol a participé au stage de formation.

Spacelab-1 Payload Specialist Ulf Merbold training at ESA/SPICE, Porz Wahn, Germany

Ulf Merbold, spécialist charge utile de Spacelab-1, au cours d'entraînement au SPICE à Porz-Wahn.

Une demande de prix a été envoyée pour les activités d'ingénierie et d'intégration concernant l'élément Sled de la charge utile à embarquer sur la mission D1.

Microgravité

Biorack
Le Conseil directeur du programme Spacelab a approuvé pour la mission D-1 une charge utile composée de 14 expériences, le choix de certaines de ces expériences dépendant des résultats d'un complément d'étude. Cette charge utile, présentée dans le tableau ci-contre, est

Manifest des expériences Biorack à bord de la mission D-1 du Spacelab, actuellement prévue pour juin 1985

Biorack experiment manifest for the Spacelab D-1 mission, currently scheduled for June 1985

EXPERIMENT	INVESTIGATOR	STRUCTURE	PROLIFERATION	FUNCTION	INTERACTION	DIFFERENTIATION	EMBRYOGENESIS		EFFECT OF	ORGANISM
48 F	M. BOUTEILLE	●							MICRO GRAVITY	PLASMA CELLS
14 CH	H. KELLER	●	-----	●					MICRO GRAVITY	LEUCOCYTES
39 F	G. PERBAL	●	-----	●					MICRO GRAVITY	LENTIL SEEDS
21 F	H. PLANEL	●	●						MICRO GRAVITY	PARAMECIUM
28 D	H.J. RHAESE		●	-----	-----	●			MICRO GRAVITY	BACTERIA
58 F	R. TIXADOR		●	●					MICRO GRAVITY	BACTERIA
18 D	V. SOBICK			●					MICRO GRAVITY	SLIME MOLD
32 CH	A. COGOLI			●	●				MICRO GRAVITY	LYMPHOCYTES
7 I	O. CIFERRI				●				MICRO GRAVITY	BACTERIA
52 NL	G.A. UBBELS				●	-----	●		MICRO GRAVITY	AMPHIBIAN EGGS
15 E	R. MARCO					●	●		MICRO GRAVITY	FRUIT FLY EGGS
18 D	H. BUCKER						●		RADIATION	STICK INSECT EGGS
19 D	H. BUCKER							●	RADIATION	NONE
27 D	D. MERGENHAGEN			●					ORBIT	GREEN ALGAE

SUBJECT OF INVESTIGATION: STRUCTURE, PROLIFERATION, FUNCTION, INTERACTION, DIFFERENTIATION, EMBRYOGENESIS

Functional testing of the experiments has been conducted at KSC to check out the hardware, together with the ground-support equipment and data interfaces. A mission sequence test has since been performed during which slices of the mission timeline were simulated, and the functioning of the whole payload verified. Most of the experimenters were represented during these tests and the Spacelab crew was involved. Final refurbishment and maintenance activities have successfully concluded the level-IV integration and test phase at KSC.

Preparation of the mission payload control and payload operations training for the European experiments has started at Marshall Space Flight Center (MSFC).

The Spacelab crew and the material science experimenters have operated the experiments in the engineering model of the Material Sciences Double Rack (MSDR) at DFVLR. This training included the ground-control personnel.

A Request for Quotation (RFQ) has been issued for the engineering and integration activities for the Sled payload element for the German Spacelab mission (D1).

Microgravity

Biorack

The Spacelab Programme Board has approved a payload for the D-1 mission of 14 experiments, a few of which are conditional to the outcome of further work. This payload, shown in the accompanying table, is highly varied both in terms of its scientific objectives and the number of different biological specimens used.

A formal System Design Review was held in November 1982 at which all parties concerned with the project, including experimenters, were present. The Review Board was satisfied with the design status and made a number of recommendations for detail design improvements in the forthcoming detailed design phase.

The design phase in industry of the glovebox started in November with Fokker (NL) as the contractor. Recent measurements with a first test-model thermal canister indicate that the problem of passively controlling the temperature of biological specimens during the launch and landing phases is less critical than previously feared. Further minor design improvements to the full-scale freezer/cooler test model have brought its performance within specification.

Improved Fluid-Physics Module (IFPM)

The Phase-B studies for the Improved Fluid-Physics Module are currently in progress. Thereafter it will be reviewed whether the IFPM can meet the German D-1 Spacelab mission schedule or will have to be flown on a later Spacelab mission, in which case the first Spacelab mission FPM will be refurbished and flown on D-1.

A call for experiments for the planned IFPM flight on D-1 has been issued and has resulted in nine experiment proposals. Studies of the technical feasibility of the proposals and a scientific assessment are underway.

Sounding-Rockets Programme

Six ESA experiments were flown on the Texus-VI flight, the Agency providing the funding necessary for 60% of the 240 kg payload. The Spacelab Programme Board has approved the ESA-proposed experiment selection for the 1983 campaign, during which two sounding-rockets (Texus 6/7) will be launched. During these flights four ESA experiments will use the Swedish furnace facility and seven ESA experiments will utilise the German multi-user facilities. The experiments are scientific investigations in the fields of metallurgy and fluid physics.

Eureca

The classes of payload elements to be flown on the first mission of Eureca and the experiment-selection procedure were approved by the Spacelab Programme Board in October. The study recommendations for microgravity multi-user facilities were also approved. The Phase-A studies of the carrier itself and of core payload for the first mission are progressing. The mid-term review was held on 14 December. The Phase-A studies for the carrier will end in February 1983. The various Phase-A studies for the core payload will be completed in the period January to June 1983.

Biorack experiment manifest for the Spacelab D-1 mission, currently scheduled for June 1985

Manifest des expériences Biorack à bord de la mission D-1 du Spacelab, actuellement prévue pour juin 1985

SUJETS D'ETUDE

EXPERIENCE	CHERCHEUR	STRUCTURE	PROFILERATION	FONCTION	INTERACTION	DIFFERENCIATION	EMBRYOGENESE		EFFET	ORGANISME
48 F	M. BOUTEILLE	●								CELLULES DE PLASMA
14 CH	H. KELLER	●	- - -	●						LEUCOCYTES
39 F	G. PERBAL	●	- - -	●						POUSSES DE LENTILLES
21 F	H. PLANEL	●	●							PARAMECIES
28 D	H.J. RHAESE		●	- - -	- - -	●				BACTERIES
58 F	R. TIXADOR		●	●						BACTERIES
16 D	V. SOBICK			●					MICRO-GRAVITE	PHYSARUM POLYCEPHALUM
32 CH	A. COGOLI			●	●					LYMPHOCYTES
7 I	O. CIFERRI				●					BACTERIES
52 NL	G.A. UBBELS				●	- - -	●			OEUFS D'AMPHIBIES
15 E	R. MARCO					●	●			DROSOPHILES
18 D	H. BUCKER						●			CRAUSIUS MOROSUS
19 D	H. BUCKER							●	RAYON-NEMENT	NEANT
27 D	D. MERGENHAGEN			●					ORBITE	ALGUES VERTES UNICELLULAIRES

largement diversifiée, tant en ce qui concerne ses objectifs scientifiques que le nombre des spécimens biologiques différents qu'elle réunit.

En novembre 1982, la conception du système a fait l'objet d'un examen officiel auquel ont participé tous les intéressés, expérimentateurs compris. La Commission chargée de l'examen s'est déclarée satisfaite de l'état d'avancement de la conception et a formulé un certain nombre de recommandations concernant des améliorations de détail à mettre en oeuvre au cours de la prochaine phase de conception détaillée.

La phase de conception industrielle de la boîte à gants, confiée à Fokker (NL) a démarré en novembre. Des mesures effectuées récemment sur un premier modèle d'essai du caisson thermique indiquent que le problème de la régulation thermique passive des spécimens biologiques au cours des phases de lancement et d'atterrissage est moins critique qu'on ne l'avait craint précédemment. De nouvelles améliorations de conception de caractère mineur apportées au modèle d'essai grandeur nature du congélateur/réfrigérateur ont porté ses performances aux valeurs spécifiées.

Module de physique des fluides amélioré (IFPM)

Les études de phase-B se poursuivent. Après cette phase, on examinera si ce module est compatible avec le calendrier de la mission Spacelab D-1 allemande ou si son embarquement doit être reporté à une mission Spacelab ultérieure, auquel cas le module de physique des fluides de la première mission Spacelab devrait alors être remis en état et embarqué sur D-1.

Un appel aux propositions d'expériences pour l'emport de l'IFPM prévu sur la mission D-1 a été lancé et a donné lieu à neuf propositions d'expériences. On procède actuellement aux études de faisabilité technique des propositions et à leur évaluation scientifique.

Programme de fusées-sondes

Six expériences ESA ont été embarquées sur le vol Texus-VI. L'ESA a participé pour la première fois à cette activité de fusées-sondes en assurant le financement de 60% de la charge utile de 240 kg. Le Conseil directeur du Programme Spacelab a approuvé la sélection des expériences proposées par l'ESA pour la campagne de lancement de 1983 au cours de laquelle deux fusées-sondes (Texus 6/7) seront lancées. Au cours de ces vols, quatre expériences ESA utiliseront le four suédois et sept les installations allemandes à utilisateurs multiples. Ces expériences consistent en recherche scientifique dans le domaine de la métallurgie et de la physique des fluides.

Eureca

Le Conseil directeur du Programme Spacelab a approuvé en octobre les éléments de charge utile qui seront embarqués sur la première mission d'Eureca ainsi que la procédure de sélection des expériences. Au cours de cette même réunion, le Conseil directeur a également approuvé les recommandations relatives à l'étude d'installations de recherche en microgravité à utilisateurs multiples. Les études de phase A du porte-instruments lui-même et du noyau de la charge utile pour la première mission se poursuivent. L'examen à mi-étude s'est déroulé le 14 décembre 1982. Pour le porte-instruments, les études de phase A se termineront en février 1983. En ce qui concerne le noyau de la charge utile, les différentes études de phase A seront achevées entre janvier et juin 1983.

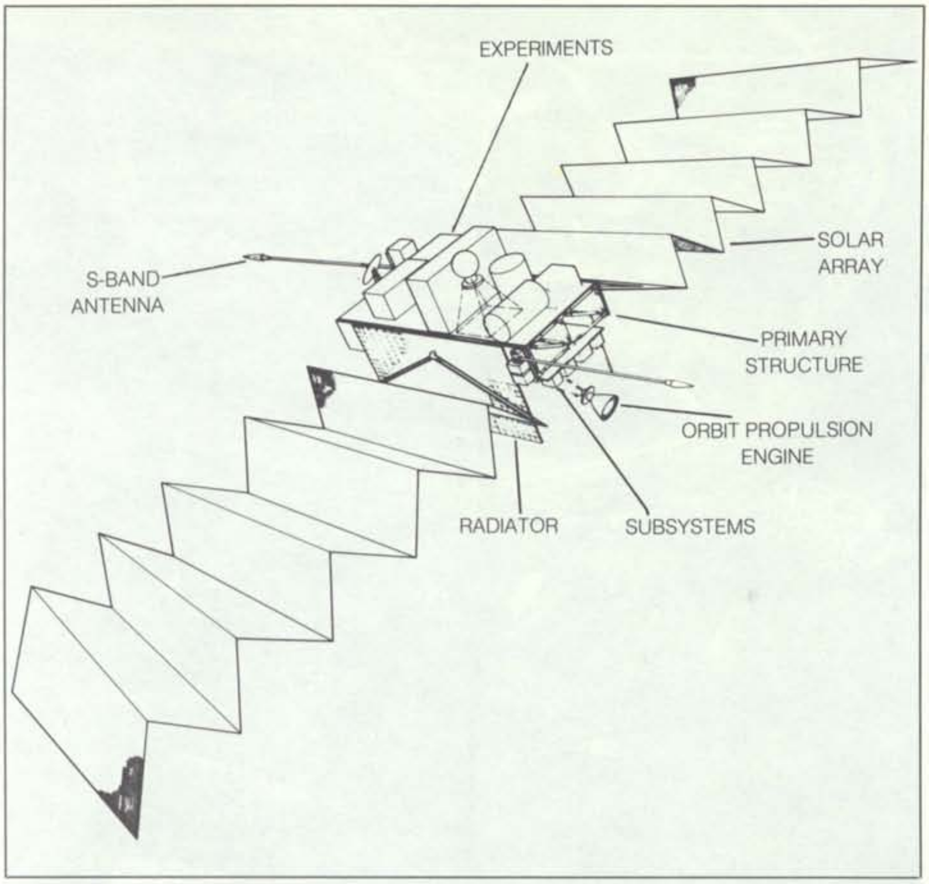
Ariane

Résultats des travaux de la Commission d'enquête et du Groupe de revue du programme

Le 10 septembre, les deux satellites européens (Marecs-B et Sirio-2) qui constituaient la charge utile d'Ariane L5 n'ont pu être mis en orbite à la suite d'une défaillance du lanceur qui s'est produite 9 minutes et 20 secondes après le décollage.

Une analyse des données de télémesure et de radar qui a été faite immédiatement après la défaillance indiquait que celle-ci était probablement due à une panne de la turbo-pompe du moteur du 3ème étage.

Cette première hypothèse a été confirmée par la Commission d'enquête instituée par les Directeurs généraux de l'Agence spatiale européenne et du Centre



Configuration inspirée du 'Double SPAS' de MBB et récemment retenue pour la plate-forme Eureca.

Configuration recently selected for the European Retrievable Carrier (Eureca), based on the MBB 'Double SPAS' proposal

Ariane

Findings of the Board of Enquiry and the Programme Review Group

On 10 September 1982, the two European satellites Marecs-B and Sirio-2, which constituted the Ariane L5 payload, failed to be placed in orbit because of a malfunction of the launcher 9 min 20 s after lift-off.

An analysis of the telemetry and radar data carried out immediately after the malfunction indicated that the latter was probably due to a breakdown in the turbopump of the third stage engine.

This initial hypothesis was confirmed by the Board of Enquiry set up by the Directors General of the European Space Agency and the Centre National d'Etudes Spatiales to determine the causes of this failure.

In its report, submitted on 15 October 1982, the Board of Enquiry states that, after examining all the available data, it forthwith concentrated on the turbopump. After studying the various possible causes of failure, it adopted as the most likely hypothesis damage to the turbopump gearing due to a combination of the following factors:

- insufficient lubrication of the gearing during the ground testing of the third-stage engine before its integration into L5;
- an unduly narrow operating-safety margin for the gearing due to an unfavourable combination of the various tolerances which, taken individually, were all within the specified manufacturing limits.

In the absence of specific telemetry data, an interruption of lubrication in the course of the flight could not be definitively ruled out, but seemed unlikely.

In the light of these conclusions, the Board made a number of technical recommendations for improving the performance of the gearing by specifying more precisely all the operations carried out on it.

Two types of recommendation were made:

- short-term measures comprising validation of the acceptance procedure and tightening up of quality control
- medium-term measures aimed at a new definition for the gearing.

It has accordingly been decided to dismantle the turbopumps already manufactured for the subsequent launches in order to implement these recommendations.

While the Board of Enquiry was at work, the Agency and CNES undertook a review of the Ariane programme. The Programme Review Group recommended:

- in the short term, debugging of the hardware for the L6 and L7 launchers
- in the medium term, essentially tightening up the technical management methods, with particular reference to quality control in the manufacturing processes.

The additional work resulting from the short-term recommendations leads to the launch of the ECS-1 and Amsat satellites by the L6 vehicle in the second quarter of 1983, subject to the findings of the L6 Flight-Readiness Review, to be held in January 1983 for the launcher less the third-stage, and in March for the third-stage alone. To minimise the impact on the launch schedule, it is planned to despatch the third stage by air and to speed up the launch rate by reinforcing the launch team in order to allow a launch to take place every two months.

Second Ariane launch pad under construction in Kourou, French Guiana

Le deuxième pas de tir Ariane en construction à Kourou, Guyane française

national d'Etudes spatiales pour rechercher les causes de cet échec.

Dans son rapport, remis le 15 octobre, le Commission d'enquête indique qu'après examen de toutes les informations disponibles, elle a rapidement concentré ses travaux sur la turbopompe. Après avoir étudié les différentes causes possibles de défaillance, elle a retenu comme l'hypothèse la plus probable une déterioration des engrenages de la turbopompe due à une combinaison des facteurs suivants:

- *une lubrification insuffisante des engrenages lors des essais au sol du moteur du 3ème étage avant son montage dans L5;*
- *une marge de sécurité de fonctionnement trop faible de ces engrenages due à une combinaison défavorable des différentes tolérances qui, prises individuellement, étaient toutes dans les limites prévues par le dossier de fabrication.*

En l'absence de données spécifiques de télémesure, une interruption de la lubrification au cours du vol n'a pu être exclue définitivement mais a semblé peu probable.

Se fondant sur ces conclusions, la Commission présente un certain nombre de recommandations techniques, destinées à améliorer la qualité de fonctionnement des engrenages en définissant avec plus de précision l'ensemble des opérations effectuées sur ceux-ci.

Deux types de recommandations ont été formulées:

- *des mesures à court terme consistant en une validation de la procédure de recette et le renforcement du contrôle de la qualité;*
- *des mesures à moyen terme dirigées vers une nouvelle définition des engrenages.*

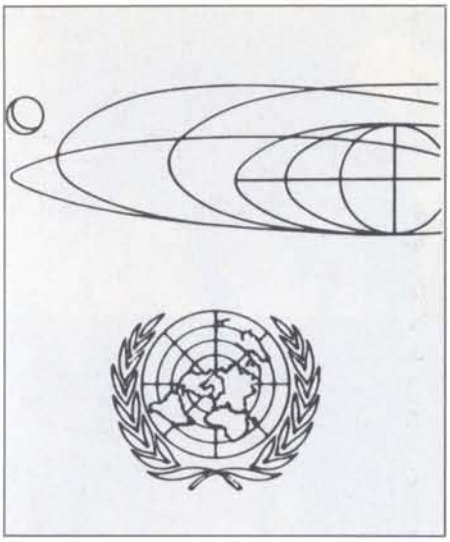
En conséquence, il a été décidé de démonter les turbopompes destinées au lancement suivants afin d'appliquer les recommandations.

En parallèle avec les travaux de la Commission, l'Agence et le CNES ont entrepris une Revue du programme Ariane.

Les recommandations du Groupe de Revue du programme consistent:
- *pour le court terme, en un assainissement des matériels implantés sur les lanceurs L6 et L7*
- *pour le moyen terme, essentiellement en un renforcement des méthodes de gestion technique, notamment en matière de contrôle de la qualité de fabrication.*

Les travaux supplémentaires découlant des recommandations à court terme conduisent au lancement des satellites ECS-1 et Amsat sur le lanceur L6 au cours du deuxième trimestre 83 sous réserve des conclusions de la Revue d'aptitude au vol du lanceur L6 qui aura lieu en janvier 83 (pour le lanceur hors 3ème étage) et en mars (pour le 3ème étage).

Afin de réduire les répercussions sur le calendrier des lancements, il est prévu de transporter le 3ème étage par avion et d'accélérer la cadence en renforçant l'équipe de lancement pour permettre un lancement tous les deux mois.



La Conférence UNISPACE '82: Les fruits de l'activité spatiale au service des hommes

J. Arets, Chef du Service des Affaires internationales, ESA, Paris

La Conférence UNISPACE 82 sur l'exploration et l'utilisation pacifique de l'Espace extra-atmosphérique a été organisée à Vienne par les Nations Unies dans le courant du mois d'août 1982. Elle a réuni pendant deux semaines les représentants de près de 100 Gouvernements ainsi que ceux de nombreuses Organisations internationales gouvernementales et non gouvernementales.

Le but de la Conférence était de faire le point de la technologie spatiale actuellement disponible, d'apprécier les applications qui en sont faites et d'examiner comment la coopération internationale pourrait être développée afin notamment que les fruits de l'activité spatiale soient répartis au bénéfice de tous et en particulier des pays en voie de développement.

Ce genre de Conférence comme toutes réunions des Nations Unies est tout d'abord un forum politique où les grands thèmes permanents de discussion entre les différents groupes de pays apparaissent en filigrane.

La différenciation entre les pays développés qui disposent de la technique spatiale et les pays en voie de développement qui ne l'ont pas est apparue clairement au cours des débats. Mais il convient cependant de noter parmi les pays en voie de développement, les efforts accomplis par certains d'entre eux pour être présents et jouer un rôle réel dans l'exploitation des activités de l'Espace.

On citera tout particulièrement l'Inde dont l'importance du programme spatial soutient la comparaison avec d'autres programmes émanant de pays qui disposent de moyens plus importants.

Les point saillants d'UNISPACE 82

Parmi les sujets auxquels la Conférence a consacré le plus de temps, figure tout d'abord le problème de la *militarisation* de l'Espace. Si toutes les Délégations acceptaient de reconnaître qu'il serait préférable que l'Espace ne soit jamais utilisé à des fins militaires, certaines souhaitaient insister beaucoup sur ce point alors que d'autres estimaient que ce sujet devait être traité dans d'autres enceintes – en particulier au Comité des Nations Unies pour le désarmement – et ne devait pas figurer à l'ordre du jour d'UNISPACE 82. Un compromis de dernière minute a permis de rédiger un texte acceptable pour tous qui indique l'inquiétude de l'humanité devant les perspectives de plus en plus menaçantes de militarisation de l'Espace et la recommandation 'énergique' aux organes compétents des Nations Unies de donner l'attention voulue et la priorité à l'examen de cet objet de 'profonde préoccupation'.

D'autres questions qui sont à l'ordre du jour du Comité de l'Espace depuis de nombreuses années ont fait l'objet de discussions et de textes de compromis qui ne résolvent pas davantage les problèmes. En ce qui concerne *l'orbite géostationnaire*, un texte équilibré montre le souci des pays en voie de développement de bénéficier de positions appropriées sur cette orbite mais aussi la perspective de progrès technologiques qui devrait permettre de satisfaire cette revendication sans gêner la réalisation des programmes des pays développés. La revendication des pays équatoriaux sur l'orbite géostationnaire a été évoquée par une simple référence à la nécessité de tenir compte de la 'situation géographique propre à certains pays'.

Dans le domaine de *l'observation de la terre*, la crainte des pays en voie de développement de voir la télédétection de leurs ressources naturelles profiter davantage aux pays développés qu'à eux-mêmes les conduit à demander que les données de télédétection relatives à leur territoire ne soient diffusées qu'avec leur accord préable. La mise en oeuvre d'un tel principe ne favoriserait certainement pas l'utilisation maximale des possibilités offertes par ces techniques de télédétection. Le souci des pays en voie de développement ainsi que

M. Willibald Pahr, Ministre autrichien des Affaires Etrangères (Président élu de la Conférence Unispace '82) et M. Javier Pérez de Cuéllar, Secrétaire Général de l'ONU, en compagnie de M. Erik Quistgaard, Directeur général de l'ESA, au cours de leur visite au Pavillon européen de l'Espace.

la nécessité pour l'opérateur de satellite de mettre à la disposition d'un pays les données primaires qui s'y rapportent sont explicités dans le rapport de la Conférence.

Enfin les discussions ont porté sur le rôle des Nations Unies et des Agences spécialisées. Les recommandations portent essentiellement sur l'exécution d'études et la mise en oeuvre d'un programme accru de *formation*. Enfin, il a été suggéré de mettre en place un Service international d'Informations spatiales dont la mission n'a pas encore été définie.

A côté de ces questions qui risqueraient de créer des tensions entre les participants à la Conférence, le rapport général contient de nombreuses indications sur les réalisations spatiales et les perspectives offertes à l'humanité par cette nouvelle technologie.

En résumé on peut considérer qu'une Conférence qui en deux semaines réunit les milieux politiques et scientifiques de tous les pays pour discuter de l'utilisation de l'espace, contribue à créer une *prise de conscience* des possibilités et des limites offertes par la technologie spatiale en tant qu'élément de développement économique et social de l'ensemble de l'humanité et surtout des plus démunis.

L'Espace n'est ni une panacée ni un facteur non relevant. La technologie spatiale, si elle est intégrée dans un processus général de développement, si elle est destinée à satisfaire les besoins réels et prioritaires, si elle est accompagnée de la formation de spécialistes des pays qui doivent en bénéficier, peut être utile.

Cette prise de conscience incite donc à la prudence, voire à une certaine lenteur. Elle ne devrait pas conduire à l'inaction. Que ce soit dans le domaine des télécommunications, de la télévision, de la météorologie ou de la télédétection, la difficulté ne consiste pas à mettre des moyens spatiaux à la disposition de ceux qui en ont besoin, elle réside dans la capacité de ceux-ci à l'utiliser pour leur propre développement. Les problèmes d'organisation sont plus compliqués que les questions techniques.

Le rôle de l'ESA

Au cours de la Conférence, l'existence de l'Agence spatiale européenne a été mentionnée à de nombreuses reprises comme un bon *exemple de coopération régionale* qui pourrait être imité dans d'autres parties du monde.

Dans de nombreux cas, les pays n'ont ni les moyens financiers ni les dimensions qui justifient de recourir individuellement aux techniques spatiales. La coopération internationale au niveau régional, et dans certains cas au niveau mondial, est indispensable pour assurer la meilleure utilisation des investissements dans la technologie spatiale.

A cet égard, les Etats européens jouent un rôle de pionnier. Ils ont créé une Agence qui constitue la plus importante organisation internationale de coopération scientifique et technique. Ils ont également créé EUTELSAT et s'apprêtent à créer EUMETSAT. Ils participent également à des Organisations de nature commerciale tels que INTELSAT et INMARSAT.

De plus, tant sur le plan national que dans le cadre de l'Agence, ils montrent une volonté de coopérer avec les pays qui ont des activités spatiales et aussi d'apporter une contribution pour permettre aux pays qui n'ont pas de programmes spatiaux d'accéder à l'utilisation de ceux-ci. Les contacts établis par l'Agence et certains Etats membres avec de nombreux pays en voie de développement manifestent cette volonté de coopération internationale qui ne pourra se développer harmonieusement que si elle profite équitablement à tous.

La cohésion de l'Europe

On ne peut parler d'UNISPACE 82 sans mentionner que l'Europe a donné à cette occasion une preuve éclatante de son existence qui résulte d'une remarquable manifestiation de cohésion entre les pays qui la composent.

Les Etats membres de l'Agence ont, au cours de nombreuses réunions du Comité Consultatif des Relations Internationales, discuté et préparé ensemble UNISPACE 82. Tous ont participé à la rédaction d'un document qui décrit l'ensemble de l'activité spatiale qui se déroule dans les Etats membres*. Ce panorama de toutes les activités entreprises montre bien aux autres pays que *l'Europe est un partenaire important, sérieux et ouvert à la coopération internationale* et que les pays qui composent l'Agence ont compris – tout en conservant certaines activités spatiales à l'échelon national – que l'union de leurs efforts constituent le seul moyen efficace de faire entendre leur voix.

De plus, 10 des Etats membres de l'Agence ont soumis ensemble au Secrétariat général de la Conférence un

* Voir document ESA BR-07: *Science & Technologie spatiales en Europe aujourd'hui*, disponible en français, anglais et espagnol.

Le 'Pavillon européen de l'Espace' au cours de la Conférence UNISPACE '82

'document national conjoint' qui indiquait des positions communes sur les différents points de l'ordre du jour de la Conférence. Cette marque de cohésion des pays européens a certainement constitué un facteur positif pour le succès de la Conférence et beaucoup de participants ont salué avec satisfaction l'émergence d'une Europe spatiale.

En outre, la mise en place d'un *'pavillon européen'* à l'Exposition organisée dans le cadre de la Conférence a constitué un succès incontesté pour l'Europe.

Toutes les activités spatiales européennes ont été regroupées dans un seul pavillon qui couvrait près d'un tiers de la surface totale de l'Exposition. Les 13 Etats membres et associés de l'Agence, ARIANESPACE, la Communauté européenne, EUTELSAT et l'Agence elle-même ont mis leurs efforts en commun pour présenter ensemble leurs réalisations, qu'elles se situent au niveau national ou à celui de la coopération régionale.

Plus de 150 000 visiteurs ainsi que tous les participants à la Conférence ont ainsi constaté la volonté de l'Europe d'être et de rester présente dans l'exploitation des techniques spatiales.

Enfin, les démonstrations organisées dans le cadre de la Conférence ont impliqué l'utilisation de divers satellites et services de l'Agence et ont prouvé concrètement que l'Europe spatiale existait.

Nécessité d'une coopération équilibrée avec les pays en voie de développement

A l'issue d'UNISPACE 82, on peut se demander si des résultats concrets se manifesteront ou si les Gouvernements s'empresseront d'enterrer sous le poids des belles paroles les perspectives de coopération internationale que la Conférence a permis d'entrevoir.

Il est de la compétence de l'Assemblée générale des Nations Unies d'entériner les idées contenues dans le rapport. Il appartiendra alors aux Etats membres des Nations Unies de faire en sorte que les propositions ne restent pas lettre morte en assurant sur une base volontaire le financement d'un certain nombre d'activités.

Sans doute, aucun Gouvernement ne manifeste-t-il d'enthousiasme lorsqu'il s'agit de verser des contributions et la crise économique actuelle ne favorise-t-elle pas les libéralités. Cependant, il est permis de penser qu'une coopération bien pensée entre les pays développés et les pays en voie de développement dans le domaine spatial pourrait se révéler mutuellement bénéfique.

Il n'est guère contesté par exemple que l'amélioration des télécommunications est un facteur de développement économique et social. Il est également admis que la technologie spatiale peut dans certains cas contribuer de manière décisive à cette amélioration. On admet généralement aussi que les pays qui disposent des technologies spatiales auraient intérêt à accroître le nombre d'utilisateurs et de développer ainsi le marché mondial dans ce domaine.

Pourquoi l'Europe ne ferait-elle pas preuve d'imagination et d'un peu d'audace en formulant des propositions de coopération équilibrée et portant sur des programmes d'envergure et à long terme dont la réalisation servirait autant les besoins des pays qui utiliseraient la technologie spatiale que ceux qui la leur fourniraient?

Treatment of Currency Exchange Operations by ESA

N.B. Shotton, Finance Department, ESA, Paris

The ESA Convention carried over the earlier provision of ESRO concerning an Accounting Unit based on gold, but added the possibility of adopting another definition, provided all Member States agreed. Taking advantage of this, since the beginning of 1976 the Accounting Unit has been equivalent to the European Unit of Account (now the European Currency Unit). Currently the annual fixed conversion rates are the averages for the month of June of the previous year, as determined by the Commission of the European Communities.

History of the ESA accounting unit
The Financial Protocol to the ESRO Convention provided for an Accounting Unit, based on a certain weight of fine gold, which was at that time equal to one United States Dollar. Conversion rates between national currencies and the Accounting Unit, and consequently between the currencies themselves, depended on the par values of the currencies announced to the International Monetary Fund by the countries concerned.

The first financial period for the preparatory commission that gave rise to ESRO began in 1961 and for several years the world enjoyed a period of financial stability. This was broken for the first time in November 1967 when Sterling was devalued, followed immediately by the Peseta and the Danish Crown. In spite of the requirements of the ESRO Convention, the budgets and accounts of the Organisation at this time were kept in French Francs, which was considered to be the working currency. The devaluation of the French Franc in August 1969 finally triggered the change to formal use of the Accounting Unit for the establishment of budgets and the maintenance of accounts.

For the next four years, each time that there was a change in the par value of a currency, the Organisation carried out a statistical exercise to determine the effect on the budget and made the necessary adjustments. For 1974, in order to eliminate the considerable effort involved in frequent budgetary revisions, a new system was introduced whereby the conversion rates were fixed for the whole year, a principle that has been maintained ever since.

Implications for the Agency's programmes
There are some 40 different programmes covered by the Agency's current budgets and since the bulk of them represent optional activities the mix of participants varies from programme to programme. Although the majority of programmes have the same general features as far as funding and cost sharing are concerned, there are a few that have special, individual characteristics. It is thus possible to offer the following classification:

- Third-party programmes
- The Ariane development programme
- Other programmes.

Third-party programmes
These programmes can be subdivided into two categories. Firstly there are activities performed for outside customers, such as consultancies, testing, or usage of the Information Retrieval Service. In these cases the amounts involved are small; individual customers simply pay the Agency's invoices, and no problems arise with work/cost sharing or currency conversions.

On the other hand there are also some substantial activities conducted for third parties, of which the most important is the Spacelab being built for NASA. Costs incurred on this project are invoiced in the currency of the prime contractor and his subcontractors. The billed amounts are remitted by the USA, in the currencies concerned, to the Agency, which then passes them on to the prime contractor. No Agency funds are thus involved, except for a small amount to cover the Agency's own internal costs – the 'ESA overlay' as it is called by NASA – and no currency-exchange operations are undertaken by the Agency. From a financial point of view the situation is simple for the Agency; currency exchanges are left to the customer, who thus bears the risk, although in this particular case as the US dollar has been appreciating since the start of the project it is quite possible that the ultimate cost in dollars will be lower than originally expected.

The Ariane development programme

The budget is divided into two parts:

1. Expenditure covering ESA internal costs and the costs related to programme facilities.
2. Direct expenditure covering industrial costs for the R and D work proper to the launcher itself.

Internal and facility expenditure

A percentage scale of contributions was laid down in the Arrangement setting up the programme and the Member States pay their contributions in their own currency into the Agency's general treasury. The funds are treated in the same way as for the 'other programmes' (see below).

Direct expenditure

The original intention was that each Member State would contribute in proportion to the value of work undertaken in its own country, so that there would be no need for any currency-exchange operations.

In practice, this has not happened and it has proved necessary to carry out a certain amount of currency purchases and sales. When these are effected, exchange differences inevitably occur because the daily market rates at which the operations are undertaken are different from the fixed rates at which the transactions are recorded in the Agency's books of account.

The conversion rates in use for the direct expenditure on Ariane development are, unlike those concerning the other Agency programmes, fixed for the duration of the programme at the rates prevailing on 1 January 1973, so they are currently nearly 10 years out of date. An indication of the extent to which the rates have moved during this period is provided by Table 1.

As can be seen from the final column, which shows the depreciation (–) or appreciation (+) of the currency concerned, there have been some very substantial changes, with the result that losses on currency-exchange operations have amounted to nearly 2 million Accounting Units since the start of the programme. Although this may be considered a substantial amount in absolute terms, it is quite modest in relation to the total cost of the programme in current-year Accounting Units, which is in the region of 900 million.

The question of how this loss is to be covered has already been solved. As the project is mainly undertaken by French contractors and covered by French contributions (approximately 70%), France has agreed to fund the shortfall represented by these losses.

Other programmes

This category in fact covers the majority of the Agency's programmes. The scale of contributions in the case of the mandatory activities is based on the national income of Member States and the resulting currency mix bears no relation to that in which the expenditure is incurred. For the optional programmes, the participants contribute in accordance with the interest that they have in the individual projects. The intention is often that, for expenditure other than the internal Agency costs, the contributions should correspond to the value of work done in each country.

One feature of ESA funding that appears to be particular to the Agency is that each participant pays its contributions entirely in its own currency. The earlier ESRO Convention did in fact provide for the possibility of asking Member States to pay in the currencies needed for the execution of the Organisation's tasks, but in practice there was considerable resistance to such proposals and the provision was dropped from the later ESA Convention.

As a result of this, the overall financial situation of the Agency is such that

Table 1 – Comparison of conversion rates

	Rate on 1 January 1973	Rate on 1 September 1982	Percentage difference
BF	48.65725	45.22510	+ 7.6
DKR	7.57828	8.24985	– 8.1
FF	5.55419	6.62402	– 16.2
DM	3.49871	2.35805	+ 48.4
LIT	631.31531	1329.54000	– 52.5
DFL	3.52277	2.57814	+ 36.6
PES	70.00000	106.73200	– 34.4
SKR	5.22542	5.82696	– 10.3
SF	4.08420	2.00846	+ 103.3
£	0.41667	0.54989	– 24.2
NKR	7.21500	6.34997	+ 13.6
US$	1.08571	0.94663	+ 14.7

currencies received do not correspond to the currencies actually spent. Table 2 shows the particular situation for 1981, but the picture is much the same each year.

As a result of this imbalance, the Agency is obliged to undertake exchange operations amounting to some 50 MAU to 80 MAU each year, representing something like 10% or more of total annual expenditure.

To achieve a maximum degree of flexibility, thereby avoiding the problems that would arise from the fragmentation of funds by having separate bank accounts for each of its programmes, the Agency manages its funds as a single general treasury. When currency-exchange operations are necessary, any resulting differences are considered to be for the account of all Member and participating States.

At one time the cumulative losses amounted to well over 20 MAU, mainly through large purchases of US Dollars in 1976, which were necessary to finance payments to NASA for launch services. Although small losses can be supported without serious effects on the treasury situation, at this level the situation is different and it was necessary to request additional financing from Member States to cover the deficit. This was done by amortising the losses over several years, the allocations to the different programmes being made by charging each budget in proportion to its size. No claim was made that this procedure resulted in a 'correct' charge to each budget, but at least it had the merit of being simple to administer.

It has been suggested that exchange differences should be attributed to the programmes that give rise to them, but application of this suggestion bristles with practical problems and would certainly be considerably more complicated than the simple method that has been adopted so far.

The existence of exchange differences springs from the fluctuating values of the national currencies of Member States and the situation is aggravated by the fact that the fixed conversion rates used by the Agency are always out of date – by six months at the beginning of a financial year and by eighteen months at year's end. In an effort to introduce an element of compensation, when fixed rates were introduced in 1974 a system of retroactive adjustment of contributions was adopted at the same time. This requires, among other things, that participating states pay their contributions (fixed in terms of Accounting Units) at the Common Market rate of conversion on the day that the monies are received by the Agency.

The system has not given universal satisfaction and is particularly disliked by those countries suffering from chronic depreciation of their currencies since, for them, it results in a constant requirement to pay additional contributions when the retroactive adjustment is applied nearly two years after the end of the financial year to which it relates.

One specific criticism that has been made against the system is that it is applied even where the contributions received are fully spent in the same currency. Reference to Table 2 shows that only in the case of the DM is there a near coincidence of receipts and payments. As the value of the DM changes, and the experience has been a constant appreciation over the years, so the Accounting Unit value of both receipts and payments changes. It is argued, however, that as there is virtually no cause for the DM to be involved in exchange operations, there is no call for the DM to be adjusted. A suggestion was put forward at one time that the retroactive adjustment procedure should only be applied to that portion of contributions not actually spent in the same currency and thus available for exchange. The proposal did not find sufficient favour, however, and was consequently not adopted.

Mention should be made here of the fact that the problems associated with differing rates of inflation and fluctuating currency values were the subject of long and exhaustive discussions over several years, including a study by IMF experts. In the end, however, apart from a few minor amendments, the existing procedures were retained.

Table 2 — Net expenditure and contributions by currency, in Accounting Units

Currency	Total net expenditure		Total contributions called-up		Expenditure/ contributions ratio
	MAU	%	MAU	%	
AUSTRAL. $	0.395	0.07	–	–	–
SCH	0.508	0.09	1.062	0.20	0.48
BF	8.613	1.62	19.451	3.58	0.44
CAN $	2.552	0.48	6.266	1.15	0.41
DFL	66.807	12.55	19.923	3.67	3.35
DKR	2.405	0.45	7.344	1.35	0.33
DM	130.478	24.51	133.336	24.52	0.98
FF	189.710	35.64	152.626	28.07	1.24
LIT	39.833	7.48	66.407	12.21	0.60
£ (EIR)	0.461	0.09	0.948	0.17	0.49
£ (GB)	53.738	10.10	92.601	17.03	0.58
NKR	0.201	0.04	0.936	0.17	0.21
PES	8.203	1.54	15.404	2.83	0.53
SF	6.520	1.23	13.847	2.55	0.47
SKR	9.416	1.77	13.575	2.50	0.69
US $	12.465	2.34	–	–	–
Various	0.017	–	–	–	–
Total	532.322*		543.726*		

* The difference between total contributions called up and total net expenditure is accounted for by budgetary underexpenditure, other income, opening and closing of bank balances and outstanding contributions at the beginning and the end of the year.

Conclusion

By way of conclusion, the principal features of the ESA system so far as currency-exchange operations are concerned can be summarised as follows:

1. Contribution scales are determined partly on a national-income basis and partly, as mutually agreed between the participants, as a function of interest in the individual programmes or the value of work to be carried out in the participating country.
2. Arising from 1 above, currencies received do not correspond to currencies spent, with the consequent necessity to undertake exchange operations.
3. With certain exceptions, funds are managed as a general treasury and no attempt is made to identify currencies sold with the programmes from which the funds are derived.
4. The use of rates fixed for the whole year and determined in the middle of the preceding year means that differences from current market rates can be considerable.
5. Exchange differences are kept outside the budgets until such times as their cumulative net amount becomes so large that there is a risk of treasury difficulties becoming unavoidable.
6. When differences are charged to the budgets, this is done in proportion to the expenditure in the budgets themselves.
7. In an attempt to compensate for the exchange differences, contributions are subject to a retroactive adjustment.

Fracture Control and its Application within the Agency's Programmes

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In the last two decades, manned space programmes, with all their associated safety issues, have boosted the role of fracture-control techniques for space applications. All payloads to be carried inside the cargo bay of the Shuttle, for example, are subject to stringent fracture-control requirements, to ensure the safety of the crew. It has long been accepted that there are always defects present in mechanical structures due to the rigours of manufacturing, transportation and testing. It is the science of fracture mechanics that has given us the ability to live with such defects without there being catastrophic structural failures.

In the past, many structural failures have occurred under low-stress conditions for seemingly inexplicable reasons. Several ships' hulls have failed suddenly while in harbour, and of the 2500 liberty ships built during the last war, 145 broke in two and almost 700 experienced serious structural failure. In the mid 1950s two Comet aircraft structures failed catastrophically while at high altitude. There have also been many railroad accidents caused by broken rails on bridges, etc. In many cases flaws and stresses have been proved to be responsible for the failures, with brittle fracture accompanied by very little plastic deformation.

Since the mid forties, the use of high-strength materials has increased considerably, these materials often being selected to realise weight savings. Simultaneously, stress-analysis methods that allow a more reliable determination of local stresses have been developed, permitting safety factors to be reduced and thereby resulting in further weight savings. Consequently, structures designed in high-strength materials now tend to have low safety margins. This means that service stresses, sometimes aided by an aggressive environment, may be high enough to induce cracks, particularly if flaws or high stress concentrations are already present. High-strength materials also have a low crack resistance (fracture toughness) and their residual strength once cracks form is low. Structures designed in high-strength materials can therefore fail when only small cracks exist, at stresses below the highest service loading for which they were originally designed.

It has been this phenomenon of low-stress fracture in high-strength materials that has fostered the development of fracture-control and fracture-mechanics research. The conventional design criteria based on tensile strength, yield strength and buckling stress are adequate for many engineering structures, but they are insufficient when cracks are present. As shown in Figure 1, most failures originate from local deficiencies already in the material or introduced during manufacturing.

Theoretical background

A crack can be stressed in three different modes, as illustrated in Figure 2. Normal stresses give rise to an 'opening mode' (mode I), in which surface displacements are perpendicular to the plane of the crack. Plane shear results in a 'sliding mode' (mode II), while a 'tearing mode' (mode III) is caused by out-of-plane shear. A superposition of all three modes describes the general case of 'cracking'. Mode I is technically the most important, because most failures are due to this type of cracking.

The key parameters for the understanding of fracture mechanics are:

(a) *Stress intensity factor*

The equation describing the elastic stress field around a 'through-the-thickness' crack in an infinite plate (Fig. 3) can be expressed as

$$\sigma_{ij} = \frac{K_I}{\sqrt{\pi r}} f_{ij}$$

where r is the distance from the crack tip.

Figure 1 – Results of an 'origins of failure' survey (Based on a study of 64 major cracking/failure problems on aircraft over a 6-month period)

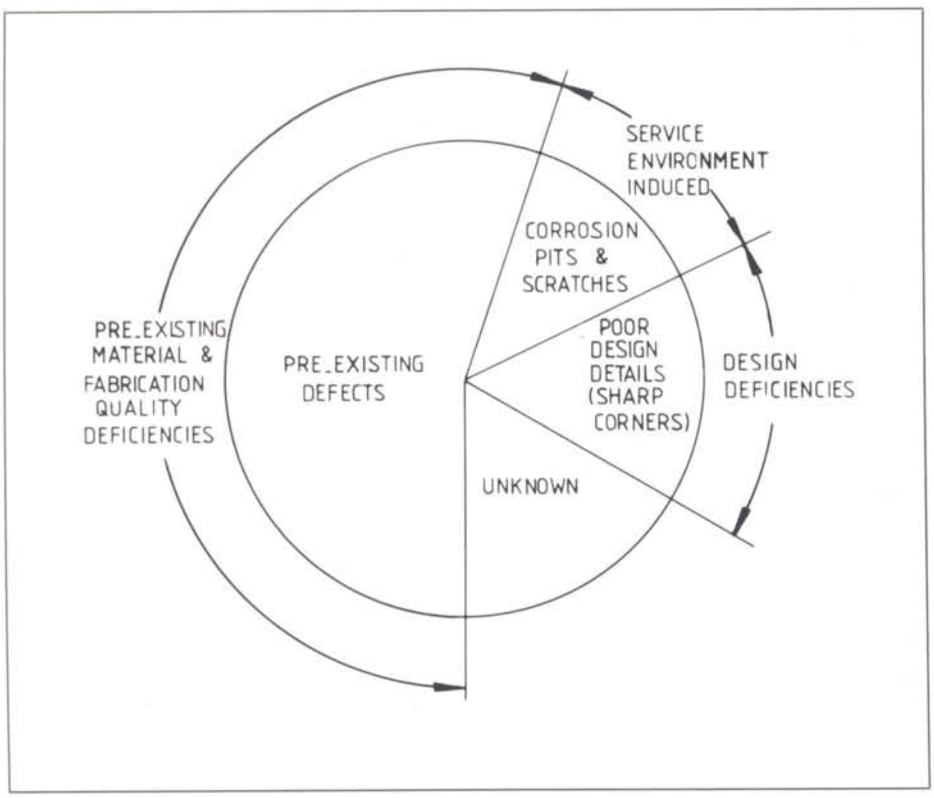


Figure 2 – The three modes of cracking

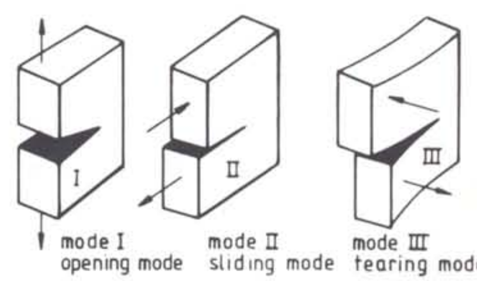


Figure 3 – Elastic stress at the tip of a crack in an infinite plate

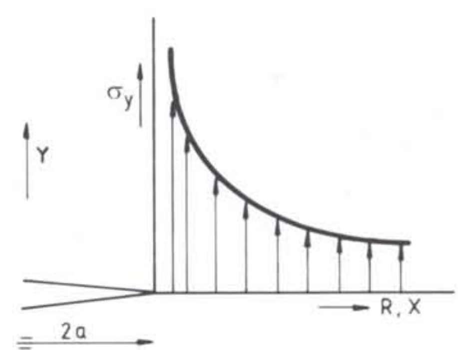
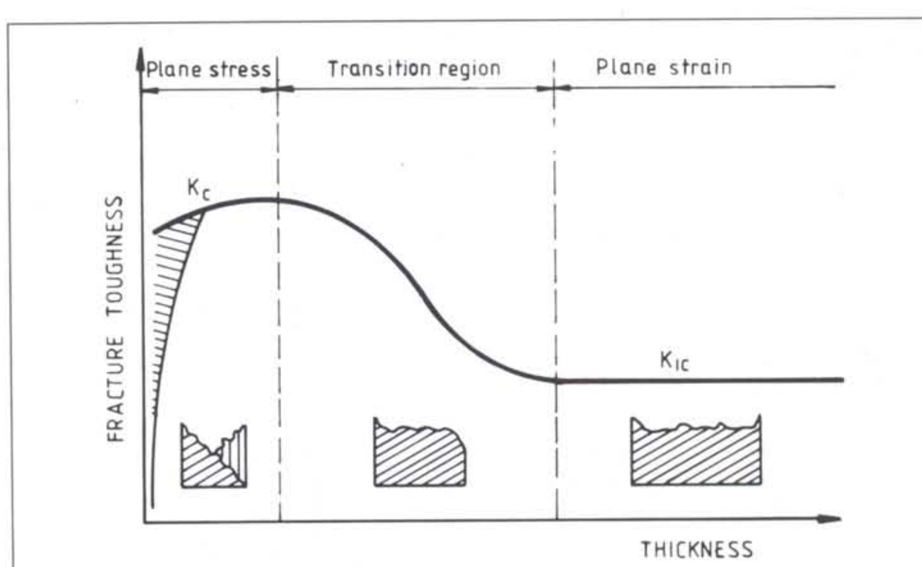


Figure 4 – Fracture toughness as a function of material thickness



K_I is the stress intensity factor for fracture mode I. It correlates the material properties, the crack geometry, and the stress field. K_I is the most important parameter in fracture mechanics and can be expressed in a general form as

$$K_I = Y\sigma\sqrt{\pi a}$$

where Y is a correction function that depends on the geometries of the crack and its surroundings, σ is the average stress at the crack section, and a is half of the crack length for through-the-thickness cracks or crack depth for surface cracks.

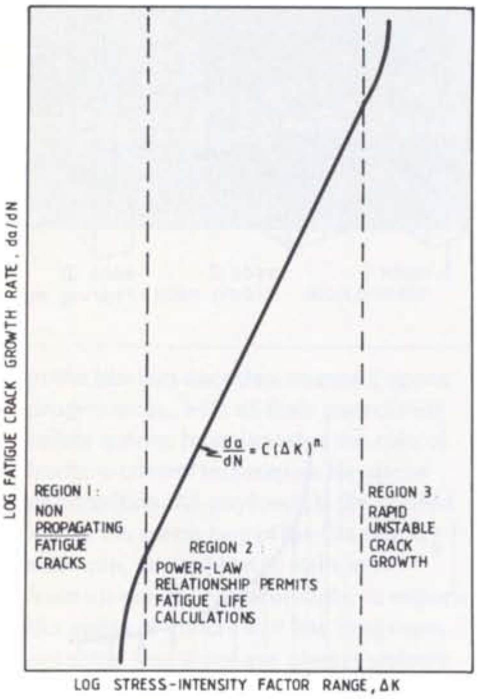
(b) *Fracture toughness*
During crack growth due to periodic loading, when the stress intensity factor K_I reaches its so-called critical value K_{IC} also known as the fracture toughness of the material, the crack starts to propagate very rapidly (many metres per second) up to complete failure.

Figure 4 shows the behaviour of fracture toughness as a function of material thickness. Only after a plain stress condition is reached in the material does the fracture toughness become independent of thickness and purely a property of the material itself.

(c) *Crack growth*
Defects present in a material tend to grow in complex fluctuating load environments. The associated fatigue-crack propagation behaviour can be divided into the three regions delineated in Figure 5.

In region 1 there is a stress intensity factor threshold K_{th} below which cracks do not

Figure 5 – Fatigue-crack propagation behaviour



propagate under cyclic stress fluctuations. In region 2 the fatigue-crack propagation behaviour beyond K_{th} can generally be expressed as:

$$da/dN = C(\Delta K)^n$$

where a = crack length, N = number of cycles, ΔK = stress-intensity factor fluctuation, and C and n are material constants.

In region 3, the fatigue-crack growth per cycle is higher than predicted for region 2.

The operating environment (temperature, humidity, etc.) has a strong influence both on crack growth and fracture toughness.

(d) *Non-Destructive Inspection (NDI)*
It is very important to be able to assess the presence of the defects in components and structures and many NDI methods have been developed (liquid penetrant, X-ray, ultrasonics, eddy current, acoustic emission, potential drop, etc.). Each has a favoured application based on the nature of the material, the component to be inspected and the type of defect present (surface flaw, inclusion, through-the-thickness cracks, etc.).

Fracture-mechanics analyses can then be used to analyse the impact of any defects revealed by the NDI on the life of the components.

Fracture-control planning
The safety and reliability of structures and correct prediction of their overall resistance to premature failure through brittle fracture, fatigue, or stress corrosion is best assessed by applying a 'fracture-control plan' in conjunction with fracture-mechanics studies.

Because failure in a structure is often the result of a complex interaction of metallurgical, mechanical and chemical parameters, a successful fracture-control programme is necessarily multidisciplinary in nature (Fig. 6).

Spacelab was the first ESA project to apply a fracture-control plan, primarily because this manned reusable space structure must remain 'safe' throughout its operational lifetime of 50 missions.

Spacelab structural safety is defined as the ability of the structure to prevent a catastrophic failure in flight, a characteristic that has been translated into two requirements for the primary structure:

- The structure must tolerate the presence and growth of undetected crack-like defects.
- The structural strength must never be degraded below a level sufficient to carry limit load/temperature.

These requirements have led to the adoption of two damage-tolerance design concepts for Spacelab:

- a fail-safe concept
- a safe-life concept.

The damage-tolerance design accounts for the presence and growth of any defects due, for example, to

Figure 6 – A typical fracture-control programme

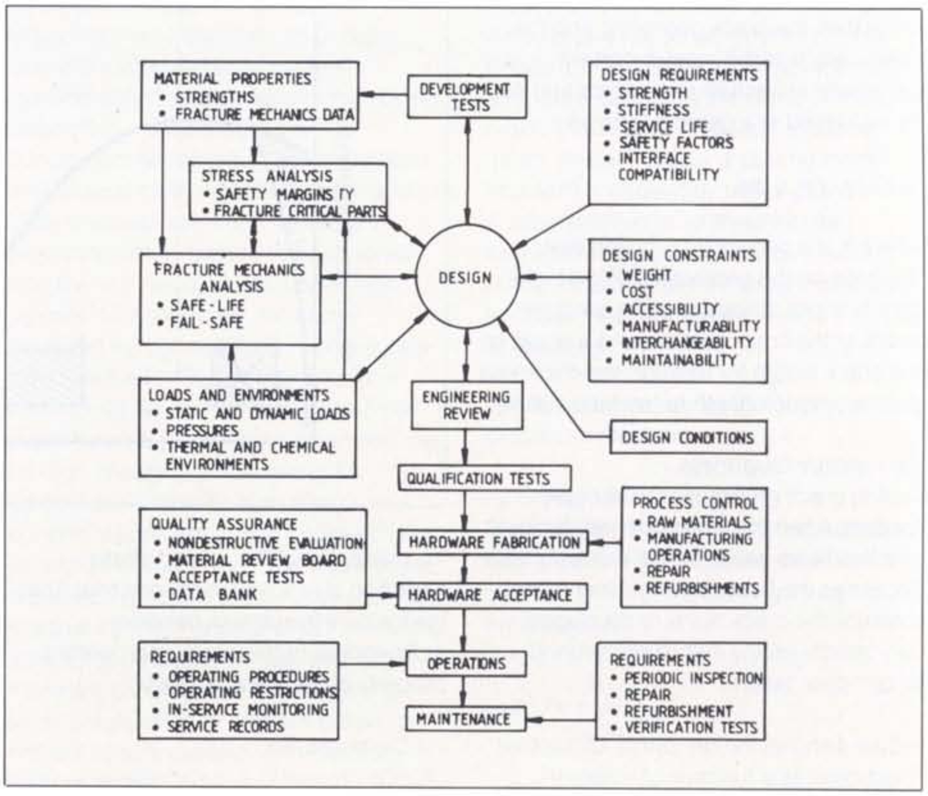
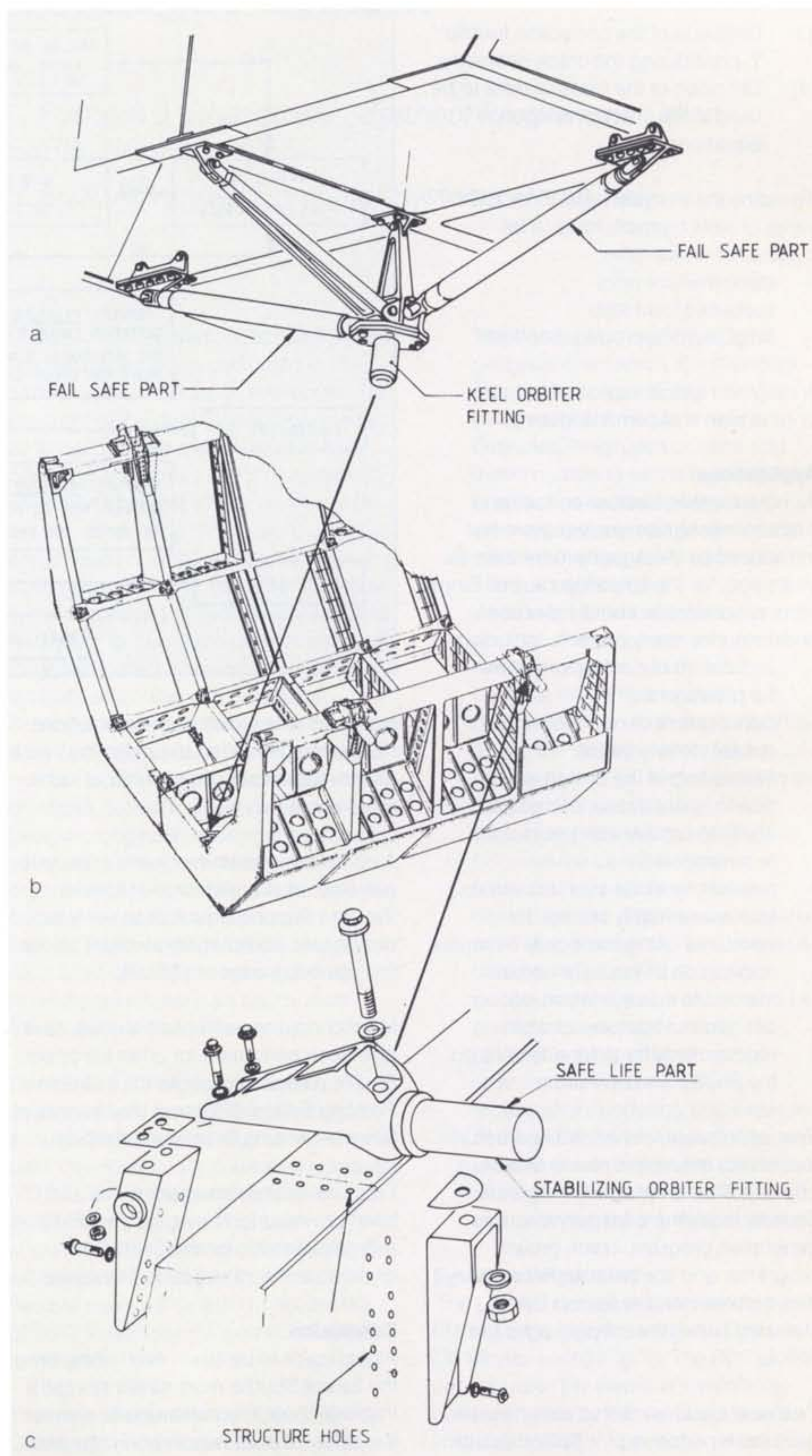


Figure 7a – Example of a fail-safe structural element

Figure 7b – The Spacelab pallet structure

Figure 7c – Example of a safe-life structural element



manufacturing and testing, and incorporates features that will prevent a catastrophic failure from occurring.

Figure 7a is an example of a fail-safe structure that forms part of the Spacelab pallets (Fig. 7b). It is deemed fail-safe because:

(i) a redundant load path has been provided

(ii) the loss or complete rupture of one of the struts does not degrade the strength of the assembly below the limit/load temperature level

(iii) the fatigue life of the remaining assembly is sufficient to allow time to detect the failure at a regularly scheduled inspection.

Figure 7c is an example of a safe-life element in Spacelab's pallet structure. This is a safe-life design because:

(i) the trunnion is a unique load path

(ii) an undetected defect at the most critical location and oriented in the most unfavourable direction, will grow sufficiently slowly to allow its detection at a periodic inspection.

Fracture-mechanics analysis is a mandatory element in the evaluation of a safe-life structure. For a re-usable space structure it generally consists of:

(a) Definition of possible crack locations, according to the fracture-control-plan logic and incorporating any cracking detected by NDI.

(b) Definition of a fatigue-load spectrum that simulates all the load events 'seen' by the crack during one mission, multiplied by the number of missions and by the fatigue scatter (latter set at 4 for Spacelab*).

* Average fatigue-crack-propagation rates are used since insufficient data are available for statistically valid lower bound properties for all structurally significant materials. To compensate for this lack of conservatism, the analytical life is set at four times the life actually required. This approach is applied for all Space Shuttle payloads.

(c) Definition of the correction function Y, considering the crack geometry.
(d) Definition of the material data to be used in the crack-propagation equations.

To define the material data, three basic series of tests normally have to be conducted on samples:
- static-fracture tests
- sustained-load tests
- fatigue-crack-propagation tests.

A simplified typical payload fracture-control plan is shown in Figure 8.

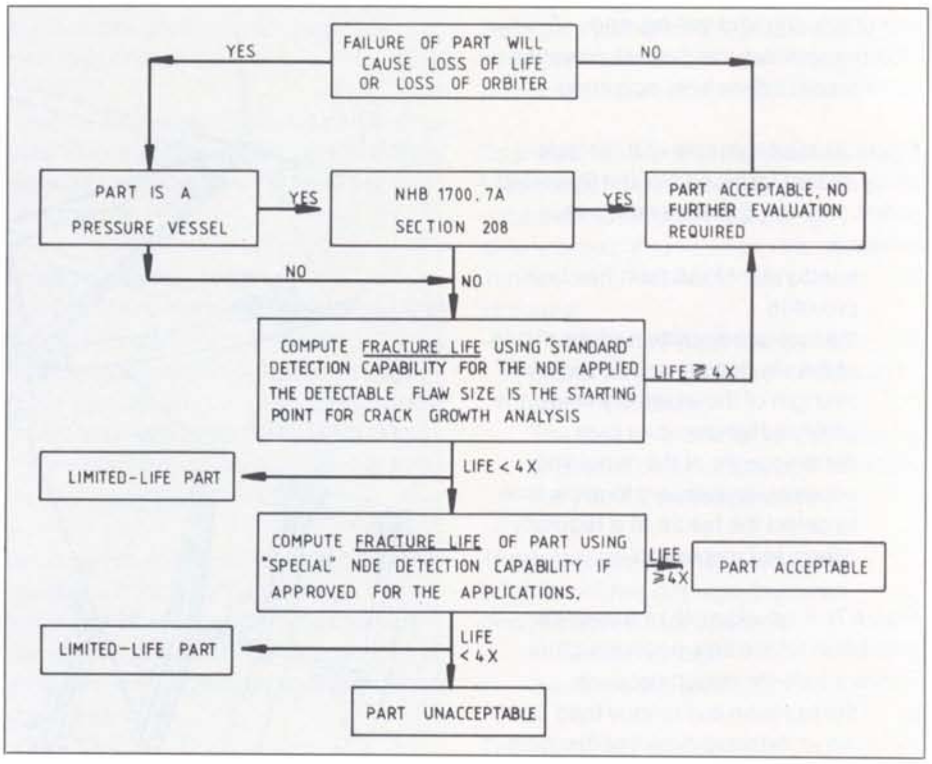


Figure 8 — Typical Space Shuttle payload fracture control plan

Applications

As noted earlier, fracture-control and fracture-mechanics analysis were first introduced by the Agency more than six years ago, for the Spacelab project. Since then, associated activities have been performed for many projects, including:
- verification of contractors' work
- life predictions
- development of new solutions for stress-intensity factor
- monitoring, in the design and development phase, of a project's ability to comply with structural requirements
- research work on such advanced topics as integrity control, for structures using composite materials; application of the finite-element method to crack analysis, etc.
- definition of fracture-control requirements for payloads to fly on the Shuttle and on Ariane.

Special software for performing fracture-mechanics analysis is now available in ESTEC's Structures and Configuration Section, including a fatigue spectrum generation program, crack-growth programs, and special subroutines to derive stress-intensity factors using standard finite-element packages like ASKA.

Extensive fracture-mechanics analyses have been performed for Spacelab with the in-house software to verify contractor work and new stress-intensity solutions have been generated to predict the crack-growth behaviour of some critical items more accurately.

A complete fracture-mechanics analysis has been performed for the Modular Payload Support Structure to verify its design and acceptability for flight on the first Spacelab mission (FSLP).

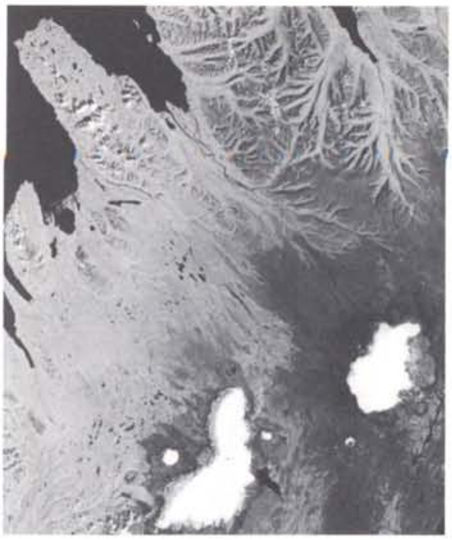
Monitoring and verification studies have also been performed for other European Shuttle payloads, such as the Instrument Pointing System (IPS) and the Microwave Remote-Sensing Experiment (MRSE).

Fracture-mechanics support has also been provided for the Agency's ISPM and L-Sat spacecraft, for the CHRESUS cryostat, and for the Space Telescope.

Conclusion

All payloads to be flown, even once, on the Space Shuttle, must satisfy stringent fracture-control requirements to ensure the safety of both vehicle and crew and successful completion of the mission. Shuttle-launched spacecraft such as L-Sat also have to be compatible with such requirements, though for this type of payload (spacecraft, experiment, etc) the fracture-control planning differs from that for Spacelab, because in general only one mission is to be performed. In the future, spacecraft will be larger and have longer lifetimes. Economic considerations will then encourage fracture control for very important components even on spacecraft to be launched by Ariane, to ensure structural reliability and mission success.

If fracture requirements are treated from the outset of a project in the same way as other structural requirements, there should be no major problems with their incorporation. Because of the increasing lifetimes foreseen for future generations of spacecraft and the growth in dimensions of space structures, it will be increasingly important to ensure maximum structure lifetimes for economic as well as safety reasons.



The Earthnet LEDA-2 Image Catalogue System

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S. Bizzi, Advanced Computer Systems, Rome, Italy

The 'products' of the Earthnet Programme Office currently include a wide selection of Landsat-generated data, in the form of Landsat-2 and -3 Multispectral-Scanner (MSS), Landsat-3 Return-Beam-Vidicon (RBV), and more recently Landsat-4 MSS and Thematic-Mapper (TM) imagery. Information on the availability of these MSS, RBV and TM sensor data received by Earthnet's Fucino (Italy) and Kiruna (Sweden) acquisition stations is maintained at the Earthnet Programme Office in the so-called LEDA (on-Line Earthnet Data Availability) database, which forms part of the ESA-IRS Information Retrieval System. The second-generation Earthnet Image Data Catalogue is now about to be put on-line via the IRS system. Called LEDA-2, it is installed on a local, dedicated computer system (PDP 11/34) and interfaced to the IRS system so that it can be accessed remotely by IRS users.

* Now with NATO, Brussels

The ESA-IRS Information Retrieval System is a database system dedicated to the handling of bibliographic references. The structure of the database is organised so as to optimise the searching of entries based on an enquiry of the type: 'search entries (references) whose keywords (few) are chosen among the keyword set (large) each of which is associated with (few) references'. For optimum efficiency in the processing of such an enquiry, it is necessary to 'invert' the original database (organising the keyword pointers to facilitate searching of the relevant database entries). In the case of an image data catalogue, which contains a large number of entries and where each entry or 'scene' contains a fixed set of attributes (latitude, longitude, missing lines, cloud cover, etc.), the above database organisation is not adequate, though it is possible to use it. A typical enquiry will request selected ranges of values for each attribute and processing will be slowed appreciably if an appropriate database structure is not set up.

The LEDA-2 Catalogue has been developed with the aim of optimising the enquiry response time. Furthermore, it has been developed on a dedicated computer (PDP 11/34) of the same type as is available at the Fucino Landsat acquisition station, thereby facilitating the exchange of Catalogue information. Remote users will be able to access the LEDA-2 Catalogue via their existing IRS terminals.

The main characteristics of the LEDA-2 Catalogue and the specialised enquiry language may be summarised as follows:

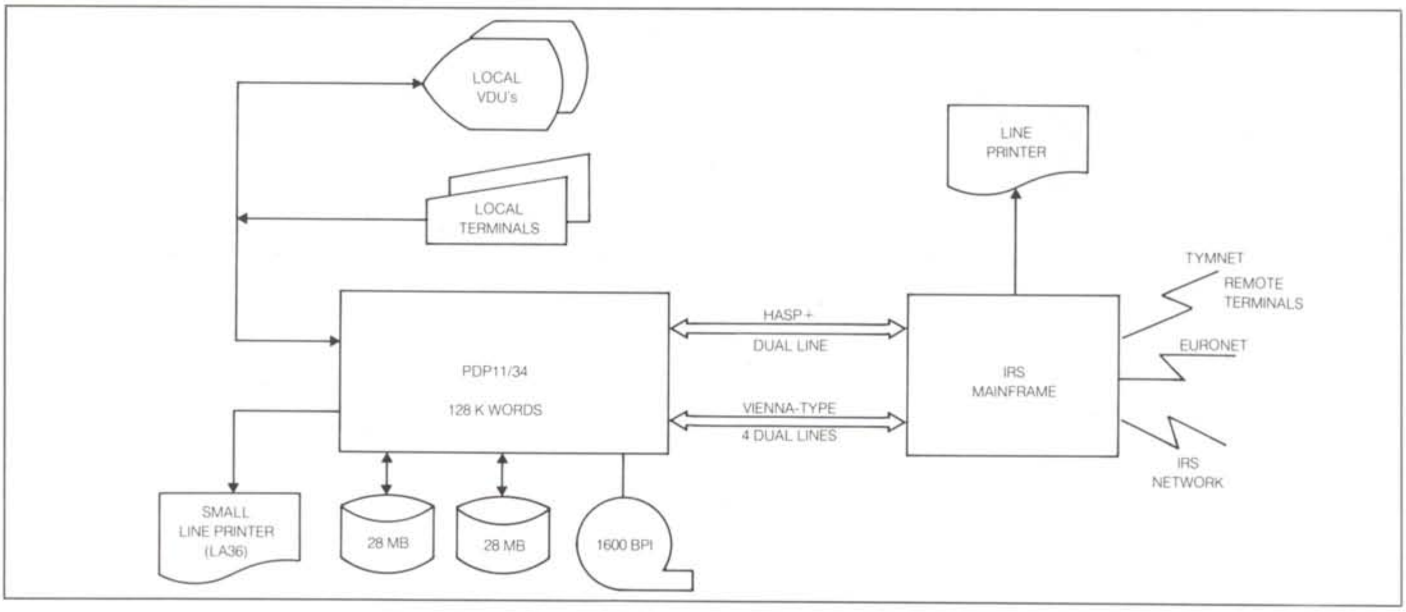
- The database is organised for a geographical search. It is therefore mandatory to specify the geographical area parameters (latitudes, longitudes or track and frame numbers) as the first selection criteria. The subset of entries covering the selected geographical area will then be easily accessible.
- The link between the latitude/longitude coordinate system and the internal scene geographical reference system, which is the Landsat World Reference System (WRS), is set up in tabular form. This allows the different WRSs for Landsats-1, 2, 3 and Landsat-4 to be handled without difficulty. This tabular technique is possible because the Landsat system maintains very stable orbital conditions; the WRS scenes acquired at 18-day intervals (16 for Landsat-4) correspond closely to the same geographical areas. It would also be possible to extend the same catalogue file structure to other spacecraft missions.
- Modification, updating and extension of the LEDA-2 Catalogue entries are allowed at run time as the catalogue structure does not require 'inversion' of any keyword parameter pointers.

System configuration

The LEDA-2 database is installed on a PDP 11/34 computer, with two disk units (28 Mbytes each) (Fig. 1). The PDP is connected to the Siemens mainframe computer used by IRS via two different links: the 'HASP+' connection is used mainly to exchange data files, while the

Figure 1 – The LEDA-2 computer architecture

Figure 2 – Process for identifying the subset of frames covering a particular geographical area ▶



'Vienna-type' connection* allows IRS users to interrogate the PDP 11/34 interactively.

The LEDA-2 Catalogue enquiry program contains about 1500 Fortran statements. The LEDA-2 Catalogue itself presently contains some 220 000 Landsat scenes.

Database structure
The reference unit in the LEDA-2 Catalogue is a Landsat scene or frame. A scene corresponds to a geographical area of some $185 \times 185\ km^2$ as seen by the Landsat system for about 25 seconds during an orbital pass.

A Landsat scene can be acquired by the Multispectral Scanner (MSS), by the Return-Beam-Vidicon (RBV), or by the Thematic-Mapper (TM) sensors, each of which have different characteristics. Each scene has a certain number of parameters (Table 1) associated with its image data to characterise:

- quality of acquisition
- usability
- means of archiving
- availability of products.

* See ESA Bulletin No. 32, p. 13

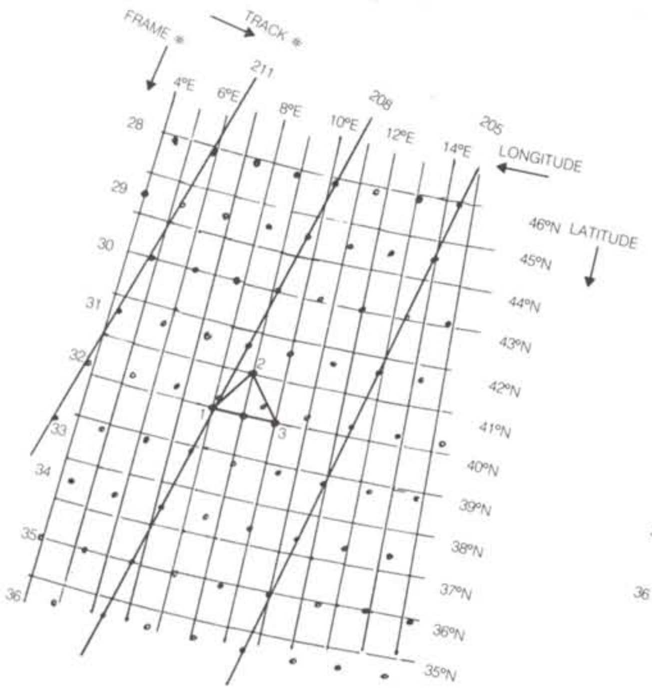
Because the orbital parameters of the Landsats are very stable, the same scene area is re-imaged every 18 days with Landsats-1, 2 and 3 and every 16 days with Landsat-4. Each scene is therefore assigned to a given 'track' (orbital path) and 'frame' (latitude interval). The WRS for Landsat-4 differs from that for Landsats-1, 2 and 3 because this latest spacecraft has different orbital parameters.

As an alternative to the WRS track/frame-number system, most users are also interested in addressing geographical polygons in terms of latitudes and longitudes of vertices.

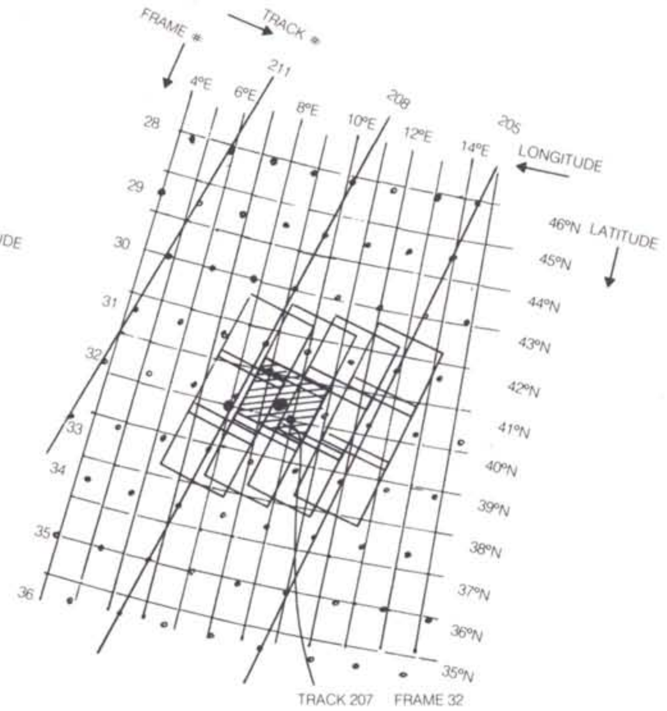
Given the above requirements, the LEDA-2 Catalogue file has been organised primarily into tracks and frames. If the latitude/longitude reference is used, a transformation is required to identify the relevant tracks and frames. The transformation is complicated by the fact that the adjacent scenes have side-overlaps varying from 14% at the equator to 85% at latitude 80°. The process for identifying the subset of frames covering a particular geographical area is illustrated in Figure 2.

As a given geographical area is covered periodically by the spacecraft passes it is possible, a priori, to compute the maximum number of synonyms for a given track/frame in a defined time span. This information is used to size the database. The data associated with a given track/frame scene are structured into two levels:

- The higher level (index file) contains very little space per entry (some 12 bytes) for all possible synonyms and is sized to accommodate new entry pointers in a random-access file. The total number of records in the index file is given by the total number of track/frame positions multiplied by the maximum number of synonyms in the database. The total number of index file records is currently about 8000 frames × 250 synonyms = 2 000 000 records, of which only 220 000 are filled with significant information. The index file is also used to pre-select catalogue entries in the lower level (main file) as it contains information on the most common selection parameters, such as mission number, station, date of acquisition, etc.
- The lower level (main file) contains 64 bytes per entry and is sized to accommodate all available image-data characteristic parameters in a random-access file (Table 1).



POLYGON OF COORDINATES (LAT, LONG):
1: (40.00, 8.00)
2: (40.00, 9.00)
3: (40.00, 10.00)

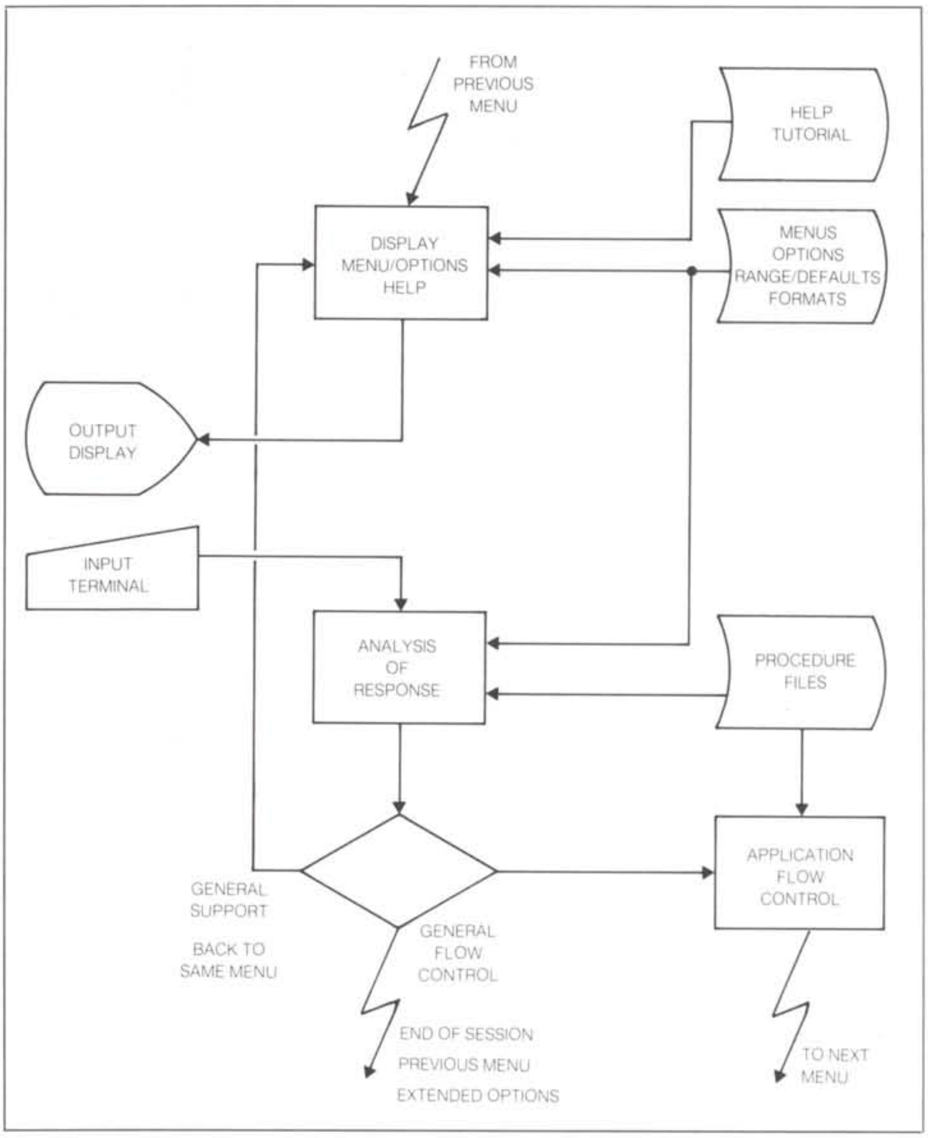


track 208	frames	31, 32
207		32
206		32

Table 1 — Definition of LEDA-2 entry qualifiers

Mission No.:	The Landsat mission no. indicates the spacecraft used to acquire the entry-defined scene. All Landsat missions are handled in the Earthnet Catalogue.
Station ID:	Fucino (Italy) is coded 'FO'; Kiruna is coded 'KI'.
Cycle No.:	Indicates the cycle number (18 days for missions 1, 2 & 3 and 16 days for mission 4) during which the scene was acquired.
Track No.:	WRS track no. The same geographical area has different WRS track numbers for missions 1, 2 & 3 and for mission 4.
Frame No.:	WRS frame no. As for Track no.
Sensor ID:	The sensor(s) used to acquire the defined scene. It is coded as: – 'M' if only MSS was acquired – 'R' if only RBV (mission 3) was acquired – 'T' if only TM (mission 4) was acquired – 'M + R'/'M + T' if MSS and RBV or MSS and TM were acquired simultaneously.
Acquisition Date:	The date of acquisition is coded as YYMMDD: after 1900 (72-99), month in the year (1-12), and day in the month (1-31).
Cloud Cover:	The cloud cover is estimated during the quick-look production in 10% of the top-left, top-right, bottom-left, and bottom-right quadrants of a scene. It is computed using MSS band-7 for missions 1, 2 or 3 or band-4 for mission 4.
MSS Visibility Vote:	It indicates to the operator assigned quality parameters to identify the level of MSS image contrast. 0 is very good, and 9 is very poor.
MSS Acquisition Vote:	It indicates the percentage of acceptable major/minor frame loss. 0 is no major/minor frame loss, 9 is barely sufficient (2 lines lost).
Latitude and Longitude:	It indicates the estimated location of the centre frame picture element.
Sun Azimuth and Elevation:	It indicates the computed Sun azimuth and elevation for the centre picture element.
RBV Visibility Vote:	As for MSS but for each of the four RBV quadrants that constitute an MSS scene.
TM Quality Votes:	To be defined.

Figure 3 – Composition of the modular operator interface package



Software structure

From the software point of view, the LEDA-2 database is an autonomous subsystem, driven by its own software package and user language.

The operator interface package is a compact modular set of subroutines which perform the following functions (Fig. 3):
- display menus and options to operator
- validate operator-entered parameters with respect to format and acceptability of values
- define and set defaults
- expand tutorial/help information when requested
- accept procedures, i.e. predefined sequences of command/parameter values, and run the catalogue enquiry in batch mode
- control the general flow of the enquiry in terms of: end of session, start of a new session, return to previous step, and acceptance of expanded option set.

All messages, options and parameters are stored on file and the information accessed by the program at run time.

The LEDA-2 enquiry strategy is shown in Figure 4. Three major steps are necessary to perform the enquiry:
- definition of geographical area
- definition of selection qualifiers
- retrieval of entry records and output presentation.

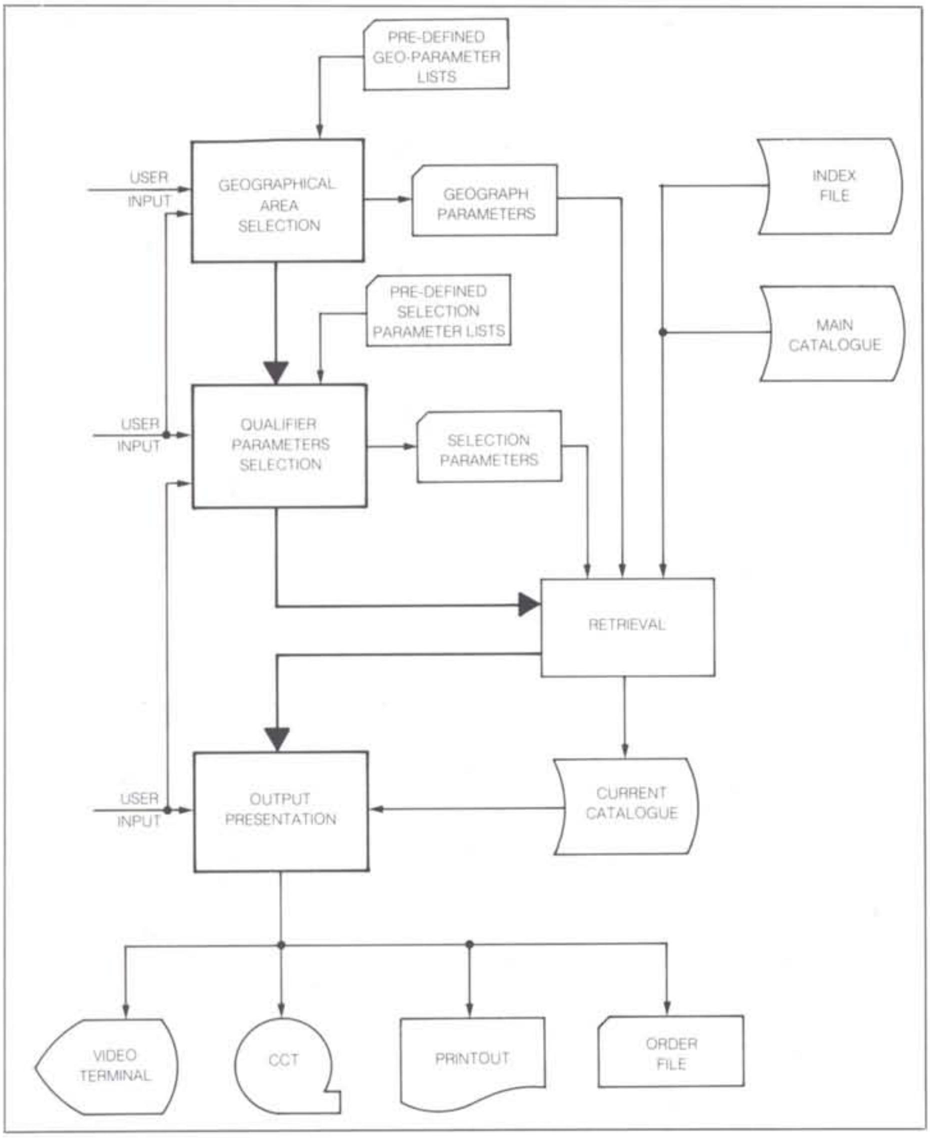
The geographical-area definition is obtained as the sum of successive selections using one of the following choices:
- latitude/longitude-defined geographical points, rectangles or polygons (note that a single geographical point may be covered by up to four adjacent frames)
- track/frame/defined geographical segments and rectangles
- predefined geographical coverage track/frame lists, which have been set up for the most commonly requested geographical coverage areas, including the European countries.

If required, all redundant frames in the geographical coverage list can be eliminated.

The selection-qualifier definition is performed by assigning validity ranges for any of the following parameters (as defined in Table 1):
- multiple ranges of time periods
- cloud-coverage range
- mission number(s) for Landsat-1 and/or 2, 3 and 4
- station code(s) for Fucino and/or Kiruna
- sensor code(s) MSS and/or RBV and/or TM (when available)
- acquisition and visibility vote range
- Sun elevation and azimuth range
- predefined selection-qualifier lists which have been set up for the most common selection parameters and which include the previous year's data, data on cloud-free periods, etc.

Once the set of selection qualifiers has been completed, the LEDA-2 strategy enquiry will extract from the main file all entries in the defined geographical

Figure 4 – LEDA-2 enquiry strategy



coverage area which match the logical 'and' of all selection-qualifier ranges. At the end of this step a Catalogue subset (called 'current catalogue') is generated and temporarily stored for further selections of output presentation. If the number of catalogue entries is large, or if the user is interested in extracting a subset of the previous selection processing, then the 'current catalogue' may be processed with a new set of selection parameters.

Finally, the current catalogue can be used for output presentation. The following functions are available:

- display of a page at a time of current-catalogue entries, including display of next page and previous page
- sort of a certain number of entries according to defined priorities
- generation of printouts for sorted entries or current catalogue
- marking of some displayed entries for ordering
- confirmation of ordering selections.

Operational aspects

As has been pointed out, the LEDA-2 Image Catalogue is based on interactive programs that allow the user to search the database for the availability of image data with predefined characteristics. Certain operational features are necessary to ensure an efficient database system in terms of both the acquisition/production station and the user community.

The updating of the database is the most critical aspect for those users wishing to know as quickly as possible whether a given scene has been acquired and how good it is. The LEDA-2 Catalogue is updated every few weeks as soon as station (Fucino, Kiruna) update tapes are available at Frascati. Rapid updating is performed using the Landsat MSS Quick-Look Computer Compatible Tape (CCT) product transmitted to Frascati via the SPINE system* (direct data transmission via the Agency's OTS experimental communications satellite) from the Fucino and Kiruna reception stations. The Landsat MSS Quick-Look CCTs contain selected full-pass image data with reduced resolution and arrive at Frascati within a few days of acquisition.

The system should be capable of performing updates within a few hours of data acquisition, if a direct link (i.e. telephone line) were available.

Search example

Figure 5 shows an example of search, based on the following statement of the problem:
'search all Landsat MSS or RBV cloud-free scenes covering the geographical triangle defined by the vertices (lat., long. in degrees): (40.00, 8.00) (41.00, 9.00) (40.00, 10.00) in the time periods (1.5.81, 1.7.81) and (1.3.82, 1.5.82).'

* See ESA Bulletin No. 32, pp. 11-15.

Figure 5 – Example of a LEDA-2 Image Catalogue search

```
WELCOME TO THE EARTHNET COMPUTERIZED CATALOGUE !
THIS CATALOGUE CONTAINS IMAGE INFORMATION FOR :

   SATELLITE : LANDSAT 1 , 2 , 3
   SENSORS   : M.S.S. , R.B.V.
   STATIONS  : FUCINO , KIRUNA

    MSS FUCINO LATEST ENTRY 17SEP82
    MSS KIRUNA LATEST ENTRY 30MAY82
    RBV FUCINO LATEST ENTRY 28JUL82

ENTER ACTIVITY MODE :

AVAILABLE OPTIONS : SI GS PE OH OD LI
TO ACCESS EXTENDED OPTIONS : %

DEFAULT : GS >
```

STEP 1: GEOGRAPHIC SELECTION

```
ENTER GEOGRAPHIC SELECTION MODE. THE RESULTING GEOGRAPHIC AREA IS THE
SUM OF SUCCESSIVE SELECTIONS. YOU MAY LOOP ON THE FOLLOWING CHOICES :

AVAILABLE OPTIONS : RT TF PN RF PO SH LI DE SC CS AC SE

DEFAULT : SE >
```

GEOGRAPHIC POLYGON AREA DEFINITION

```
PO

ENTER THE NEXT CLOCKWISE POINT OF POLYGON COORDINATES LAT,LON
(HUNDREDTHS OF DEGREE). AFTER THE LAST POINT ENTER <CR> :
4000,800+4100,900+4000,1000+

I NEED 10-20 SECONDS FOR GEOGRAPHIC COVERAGE COMPUTATION.

NUMBER OF LAST  SELECTED FRAMES :     4
NUMBER OF TOTAL SELECTED FRAMES :     4

ENTER GEOGRAPHIC SELECTION MODE. THE RESULTING GEOGRAPHIC AREA IS THE
SUM OF SUCCESSIVE SELECTIONS. YOU MAY LOOP ON THE FOLLOWING CHOICES :

AVAILABLE OPTIONS : RT TF PN RF PO SH LI DE SC CS AC SE

DEFAULT : SE >
```

SHOW LIST OF TRACKS/FRAMES

```
SH
TRACK = 206      FRAMES :  FROM    32 TO  32
TRACK = 207      FRAMES :  FROM    32 TO  32
TRACK = 208      FRAMES :  FROM    31 TO  32
```

STEP 2: IMAGE SELECTION PARAM.

```
ENTER IMAGE SELECTION PARAMETER :
THE IMAGE SELECTION IS MADE ON THE 'AND' OF ALL POSSIBLE PARAMETERS
DEFAULTS ARE ALREADY SET. YOU MAY LOOP ON THE FOLLOWING CHOICES :

AVAILABLE OPTIONS : DD SN CC MA MS MV ST RV EL LI AZ SH SC CS OU DE

DEFAULT : OU >
```

SET DATE LIMITS

```
DD

ENTER STARTING, ENDING DATE (YYMMDD,YYMMDD). TO RETURN TO MAIN MENU
ENTER <CR> :
810501,810701+820301,820501+

I NEED (ABOUT)     7  SECONDS FOR IMAGE SELECTION

NUMBER OF RETRIEVED IMAGES =     39
```

SET CLOUD COVER LIMITS

```
CC

ENTER 4 MSS QUADRANTS CLOUD COVER RANGE (4 MINIMA, 4 MAXIMA) :

DEFAULT VALUE(S) :     0,     0,     0,     0,     7,     7,     7,     7,
0,0,0,0,0,0,0,0

NUMBER OF RETRIEVED IMAGES =      5

ENTER FURTHER SELECTION MODE :

AVAILABLE OPTIONS : YE NO

DEFAULT : NO >
```

STEP 3: OUTPUT PRESENTATION ON TERMINAL

```
ENTER OUTPUT PRESENTATION MODE :

AVAILABLE OPTIONS : TT SR OH LP SE PS
TO ACCESS EXTENDED OPTIONS : %

DEFAULT : TT >

MIS TRK FRM CYC STZ SENS  DATE   CLOUD-COV  ACQ-VIS   RBV-VOTE  LINE NO.

  2-206- 32-129--KI M -  810616   0 0 0 0     0   0    0 0 0 0       1
  2-206- 32-129--FO M -  810616   0 0 0 0     0   3    0 0 0 0       2
  3-206- 32- 83--FO M+R  820409   0 0 0 0     0   3    0 0 0 0       3
  2-208- 31-128--FO M -  810531   0 0 0 0     0   3    0 0 0 0       4
  3-208- 32- 83--FO M+R  820411   0 0 0 0     0   3    0 0 0 0       5

.... END OF FILE ....
```

EXIT

```
EN

GOODBYE FROM THE EARTHNET COMPUTERIZED IMAGE CATALOGUE !

USED PDP TIME =    3 MINUTS AND  8 SECONDS
GIS  --  STOP
```

In Brief

ESA Awards Study Contracts for European Participation in the US Space Station Programme

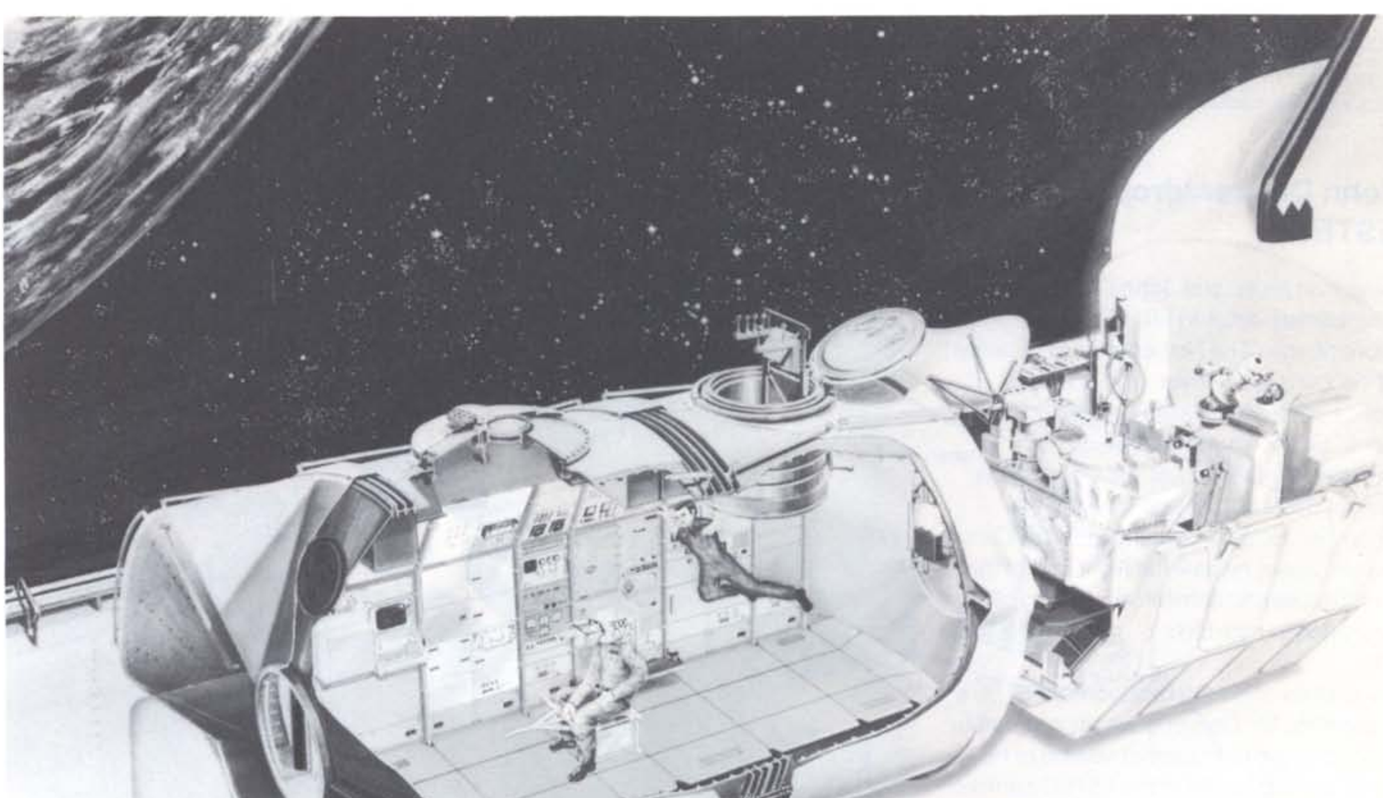
ESA has recently presented its Member States with a proposal for a study programme – the Space Transportation Systems Long Term Preparatory Programme (STS-LTPP) – for space transportation systems beyond Ariane-4 and the Spacelab Follow-On Development (FOD) Programme. A major element of the STS-LTPP concerns possible European participation in the future US space station programme.

An ESA Contract has already been awarded to DFVLR, to assess the European utilisation aspects of a manned space station.

With the objective of identifying other potential areas of European involvement, the Agency's Industrial Policy Committee has now authorised four further study contracts. The contracts have been awarded, in anticipation of STS-LTPP finalisation (funding for the programme should be approved at the latest by 15 December 1982), to the following:

- AEG-Telefunken (Germany) with Fokker (The Netherlands), BAe (United Kingdom) and CIR (Switzerland) as subcontractors
- Aerospatiale (France)
- Dornier System (Germany), with Sener (Spain) as subcontractor
- ERNO (Germany), with subcontractors: AIT (Italy), Matra (France), BTM (Belgium), Sabca (Belgium), Kamsax (Denmark), Dornier (Germany) and BAe (United Kingdom).

The studies, to be carried out over the next six to eight months, will cover such subjects as the electrical power supply to a station by solar arrays, use of Spacelab and European Retrievable Carrier (Eureca) spinoffs for such a station, and other peripheral elements e.g. self-propelled teleoperators and advanced pointing systems.



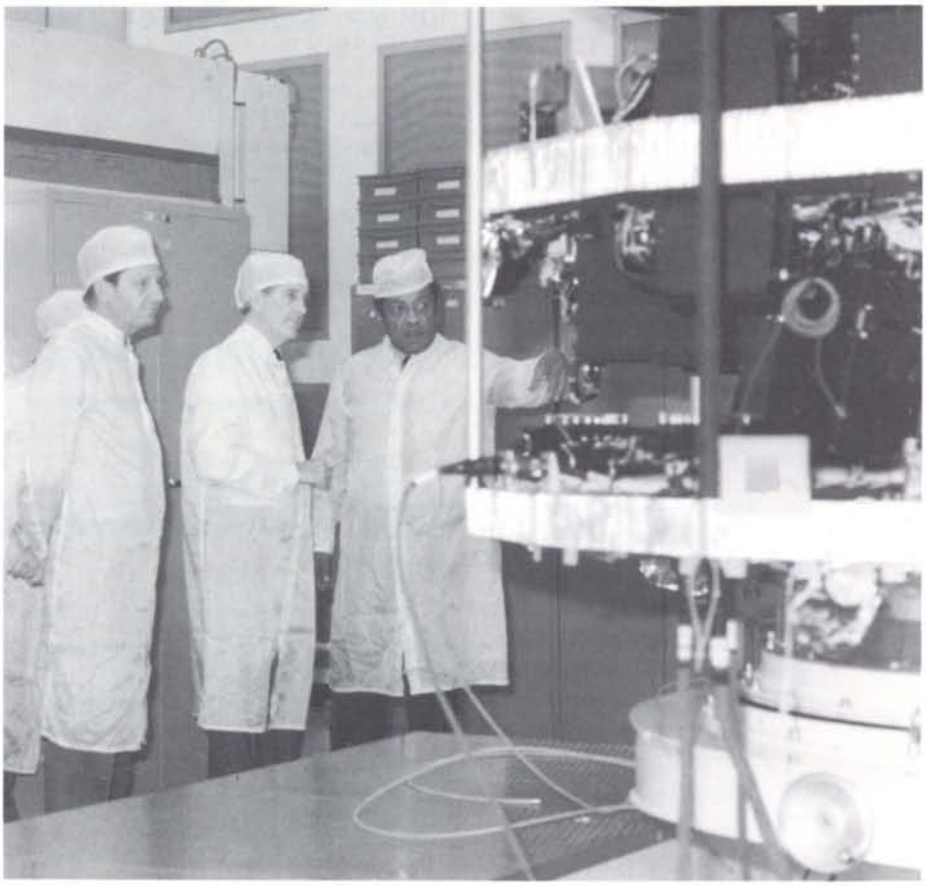
Spacelab

Visit to ESTEC by Parliamentary Under-Secretary of State

Mr. William Shelton, the Parliamentary Under-Secretary of State of the UK Department of Education and Science headed a group of British Government Officials who visited ESTEC on 22 September. The other members of the Group were: Mr. G. Holley, Private Secretary to Mr. Shelton; Prof. Kingman and Dr. H.H. Atkinson of the UK Science and Engineering Research Council; and Mr. C. Wilson, Commercial Counsellor at the British Embassy, The Hague. They were welcomed to the Establishment by ESA's Director General, Mr. Erik Quistgaard.

During their visit, presentations were given on: the Agency's structure, with particular emphasis on ESTEC; the evolution of the ESA Scientific Programme, including the candidate missions for ESA's next scientific satellite; scientific and industrial aspects of the Exosat, ISPM, Space Telescope, Giotto and Hipparcos satellite projects.

The party also made a tour of the ESTEC facilities, one element of which was a visit to see the flight unit of the Exosat spacecraft on the ESTEC Test Floor (see accompanying photograph).



Mr. George Scoon (right) of the Exosat satellite project explains the features of the satellite to Mr. William Shelton (centre) and ESA's Director General, Mr. Erik Quistgaard

John Denver 'drops in' at ESTEC

American music star John Denver was an unexpected visitor to ESTEC on 22 November. In The Netherlands for a series of concerts Mr. Denver, who is a keen space enthusiast, called and asked if he could be shown around the ESTEC facilities. During his visit, Mr. Denver was shown the test floor and the EMC chamber. He also visited the ESTEC Clean Room, where he saw the flight unit of the Exosat scientific satellite, which is to be launched in mid-1983.

As a token of his appreciation of ESTEC's hospitality, Mr. Denver gave an impromptu lunchtime performance of several of his most famous songs in the ESTEC canteen for the benefit of the staff.

John Denver during his visit to ESTEC on 22 November

'Call for Experiments' for Eureca Flight Issued

Eureca, the European Retrievable Carrier, is a reusable free-flying platform, which will be launched by the Space Shuttle. After release from the Shuttle's cargo bay at an altitude of approx. 300 km, Eureca will activate its own propulsion system and boost itself into a low-drag orbit of some 500 km (circular) altitude. It will operate there for a period of about six months.

Thereafter, a deboost manoeuvre to retrieval altitude will be initiated, and Eureca will rendezvous with the Shuttle and be returned to Earth.

The first Eureca mission is planned for 1987, and a series of subsequent flights are envisaged following the first, at the rate of one mission every two years.

The approved funding for the first Eureca mission covers the development of the Eureca carrier, up to six multiuser experiment facilities dedicated to microgravity research, integration of the payload into the carrier, launch and retrieval by the Shuttle, and orbital operations. Development costs for additional ('add-on') experiments and experimental hardware (e.g. samples) that will make use of the multiuser experiment facilities will rest with the individual experimenters.

This first mission has been conceived to offer European experimenters the opportunity to conduct research under microgravity conditions (10^{-5}g) for the major part of the mission. The experimental facilities offered will comprise a variety of furnaces and thermostats allowing the processing of metallurgical samples, crystal growth from the melt and from high and low temperature solutions, protein crystallisation, as well as investigations into plant growth, exobiology experiments, etc. About 90% of the first mission's resources will be reserved for microgravity-related research; the remainder (10%) is available for experiments from other disciplines such as space sciences, space technology, etc. The experiments from these disciplines must not disturb the microgravity environment required for the primary payload.

A Call for Experiments for the first Eureca mission is published on page 78 of this Bulletin.

This call is primarily open to proposers from the ESA Member States participating in the Eureca project: Belgium, Denmark, France, Germany, Italy, Spain, Switzerland and the United Kingdom. In addition, experimenters from Austria, The Netherlands, Sweden, Canada, Ireland and Norway are invited to submit proposals.

The deadline for the submission of proposals is 30 April 1983.

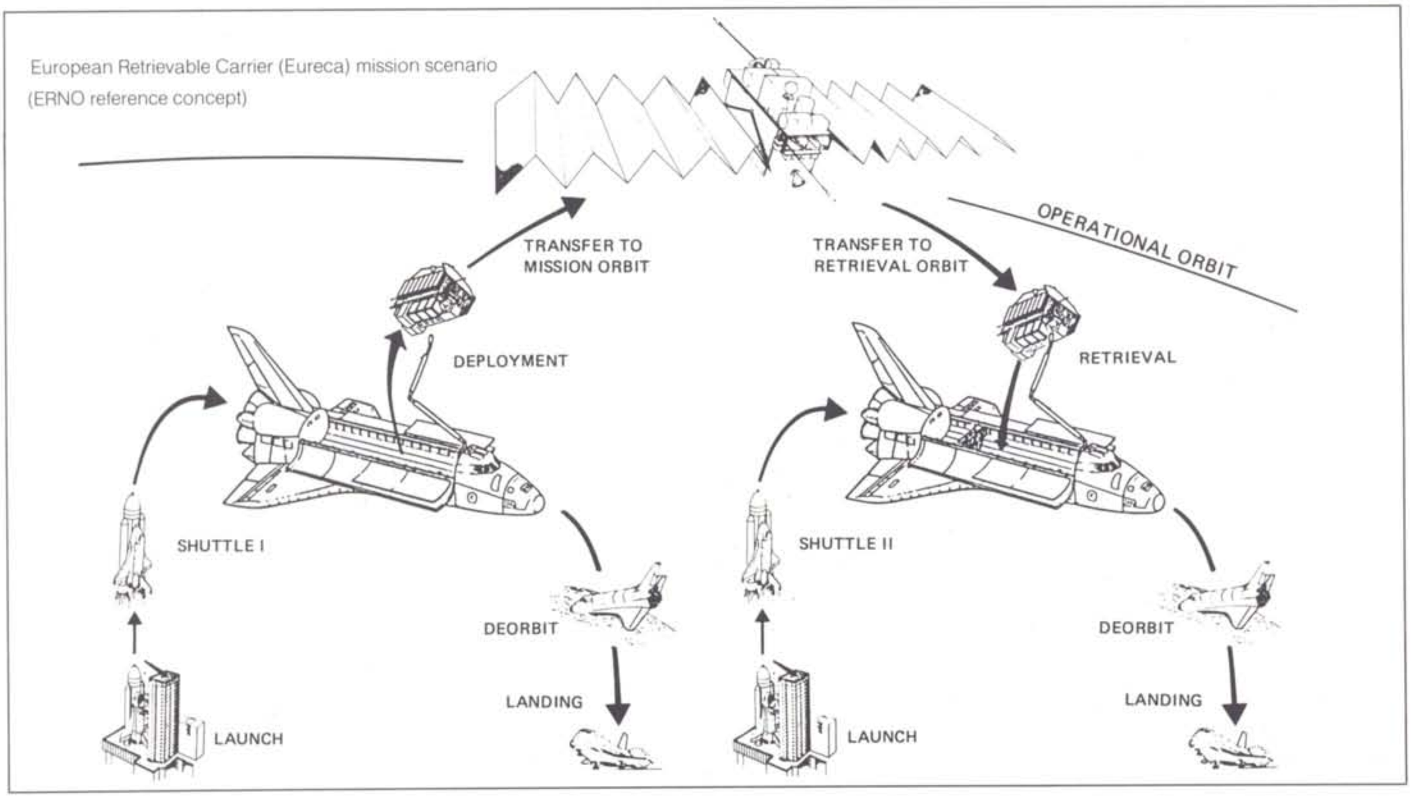
Further information and copies of the questionnaires to be completed in submitting a proposal, can be obtained from:

Directorate of Space Transportation Systems
Microgravity Office
European Space Agency
8-10 rue Mario Nikis
75738 Paris 15
France

Table 1 — Mission data

Mission duration	6 months
Operational orbit	500 km (circular)
inclination	28.5°
Launch vehicle	NASA Space Shuttle
Launch site	Kennedy Space Center (KSC)

European Retrievable Carrier (Eureca) mission scenario (ERNO reference concept)



Proposals for New Space Science Missions

Space scientists in European universities and research institutes recently provided an impressive demonstration of their determination to maintain their place in the forefront of space research. Twenty well-documented proposals for new space-science missions were made at the start of the new planning cycle, which will lead to the selection of one new project in 1984 or 1985.

The domains of scientific investigation covered by the proposals included:

- the internal structure of the Sun and the outflow of mass from the Sun
- the interplanetary medium between the Sun and the innermost planet Mercury, including a fly-by of Mercury
- several aspects of the science of Venus, Mars, Saturn and Saturn's moon Titan by means of spacecraft orbiting these planets
- a first close-up exploration of asteroids
- a study of the physics of the Earth's plasma environment
- a study of the galactic, extragalactic and cosmological emission at far-infrared and submillimetre wavelengths
- a study of nuclei of galaxies and quasars by means of very-long-baseline interferometry using an orbiting radio telescope
- a study of UV, X- and gamma-ray emissions of galactic and extragalactic plasmas
- UV spectroscopy complementary to IUE and the Space Telescope
- a study of stellar seismology, variability and activity.

Most proposals evolved from the combined efforts of a large number of scientists (up to 27 per proposal) drawn from different institutes in several countries, demonstrating the ability of scientists to cooperate effectively across national boundaries.

ESA selects its scientific projects by a process of successive elimination at pre-determined steps in a programme of scientific and technical studies. Regrettably, because of the limited resources available [in 1982 the Scientific Programme represented 14.7% of the total ESA budget of 690 MAU (730 million US$)], fifteen of the newly-proposed missions have had to be eliminated immediately, because only five could be kept in competition during the first study phase.

The selection of the five candidate missions to go forward into the first study phase was announced on 16 December 1982 following an evaluation by the Agency's scientific advisory bodies, which consist of independent European scientists.

The five proposals to be further evaluated are:

FIRST: a Far-Infra-Red and Submillimetre Space Telescope for the study of galactic, extragalactic and cosmological emission at far infrared and submillimetre wavelengths. The planned payload weighs in the region of 2000 kg. The main instrument is an 8 m deployable telescope.

XMM: an X-ray Multi-Mirror telescope spacecraft, designed to carry out X-ray surveys of galaxies and clusters as well as high-resolution X-ray imaging and spectroscopy. The payload, weighing some 2750 kg, consists of a cluster of 27 grazing-incidence imaging telescopes.

SOHO: a Solar High-Resolution Observatory for the investigation of the dynamics and mass loss of the Sun's outer atmosphere. The payload, weighing about 470 kg, includes a grazing-incidence spectrometer, a stigmatic normal-incidence spectrometer, EUV imaging telescopes, and a UV and white-light coronograph.

CLUSTER: an Earth's magnetosphere mission for three-dimensional study of plasma turbulence and small-scale structure in the magnetosphere. This mission involves a main spacecraft carrying a 56 kg payload, plus three companion spacecraft each with payloads of about 22 kg. The positions of this cluster of four satellites are to be carefully controlled as they pass through the many different regions of plasma surrounding the Earth.

AGORA: an Asteroid Gravity, Optical and Radar Analysis mission designed to study the properties of three main belt asteroids, e.g. regolith thickness, shape (and thus volume), mineralogy, topography and mass. The model payload weighs 100–230 kg and consists of a wide-angle camera, an infrared spectrometer, a radar altimeter and a number of experiments for cruise science; a high-resolution camera could also be included.

In addition to making specific recommendations for the five proposals noted above, ESA's scientific advisory bodies, prompted by the mission proposal for a VLBI radio-astronomy observatory in space (QUASAT), also recommended that the Executive initiate discussions with other agencies concerning the feasibility of setting up an international space-based VLBI (Very-Long-Baseline Interferometry) system for radio astronomy.

In connection with a proposal for a Saturn Orbiter and Titan probe, christened CASSINI, the advisory bodies felt that the Executive should initiate negotiations with NASA to determine a procedure that could lead to a cooperative approach to such missions.

Whilst examining another of the proposals (FLUTE-TRIO), the advisors also noted the very high scientific return that could be expected from optical interferometry in space. However, in view of the difficulties such a mission presents, they requested the Executive to identify the technical problem areas and to address them within the framework of the ESA Technological Research Programme.

A preliminary cost analysis of the five proposals recommended for further assessment indicates that the average cost per mission is about 250 MAU (1 AU = US$1.065 at 1982 exchange rates), i.e. 2.5 times the level of ESA's current annual scientific budget. In view of the very high cost of scientific projects nowadays, ESA will only be able to undertake one new project every 2.5 years unless the scientific budget is increased.

Meanwhile, the previous round of studies is nearing completion and will culminate in the selection of a new scientific project in March. A detailed presentation of the candidate missions:
Disco: Solar interior and heliospheric studies
ISO: Infrared Space Observatory
Kepler: Multi-disciplinary Mars orbiter
Magellan: Ultraviolet space observatory
X-80: X-ray spectroscopy/timing-transient satellite will be made at a scientific meeting in Scheveningen, The Netherlands, on 31 January and 1 February 1983.

Expositions 83

Nous donnous ci-dessous le calendrier des expositions auxquelles l'Agence participera en 1983, afin d'offrir aux lecteurs qui s'intéressent aux programmes spatiaux européens la possibilité de visiter les stands de l'Agence.

La *Rassegna elettronica* a lieu au Palais des Congrès (EUR) à Rome du 22 au 27 mars. L'Agence, tout en présentant ses activités et en s'efforçant d'associer l'industrie italienne à sa présentation, illustrera plus particulièrement le thème des 'Rencontres scientifiques internationales sur l'espace': coopération entre les pays industrialisés et les pays en voie de développement dans le domaine spatial.

Le *Salon international de l'innovation technologique*, appelé aussi *Flanders' technology* aura lieu à Gand, du 3 au 7 mai. Dans ce cas il s'agit pour l'Agence de présenter plus particulièrement des prototypes développés et brevetés par l'Agence afin de souligner leur intérêt non seulement pour les applications spatiales, mais aussi non spatiales: c'est-à-dire le domaine essentiel des transferts de technologie.

Parallèlement l'Université de Gand accueillerait une exposition générale sur les activités de l'Agence illustrées par des modèles grandeur nature de satellites.

Du 26 mai au 5 juin a lieu le *Salon international de l'aéronautique et de l'espace*, comme toujours au Bourget. L'Agence y occupera un pavillon de 600 m^2 qui abritera notamment le modèle de fonctionnement du Spacelab dans la configuration de la première mission: un module long et un élément de porte-instruments.

Autour de ce modèle grandeur nature, auquel le public aura accès, l'Agence réunira la présentation du programme Spacelab et celle des industries et organismes qui y participent. Le hall où apparaîtra ce modèle servira en outre aux différentes rencontres et conférences de presse qui seront organisées en prévision de la première mission du Spacelab (fin septembre). Le pavillon de l'Agence, ainsi que ceux du CNES et d'Arianespace, seront placés au pied de la maquette d'Ariane grandeur nature, créant ainsi au Bourget un véritable carrefour de l'Espace.

Telecom 83 prend cette année un relief particulier puisque cette exposition a lieu pour la première fois dans le nouveau Palais des Expositions et des Congrès de Genève, à côté de l'aéroport de Cointrin. Telecom, du 26 octobre au 1er novembre, est la grande rencontre internationale des télécommunications et 1983 est l'année mondiale des télécommunications. C'est aussi l'année où doit être lancé le premier ECS: c'est donc une occasion exceptionnelle pour l'Agence de présenter ses programmes d'applications et elle sera au rendez-vous avec des démonstrations de transmission par satellite et les modèles grandeur nature de ses satellites ECS, Marecs, L-Sat sur un stand de 350 m^2.

Les modèles auront été bien entendu présentés à la Rassegna et au Bourget avec ceux de Météosat et d'Exosat, avec les modèles à l'échelle de 1:10 d'Ariane ou de 1:15 du Spacelab, mais aussi avec de nouveaux programmes audiovisuels et de nouveaux mannequins parlants: les foules qui régulièrement visitent les stands de l'Agence meritent pour cette année 83 un effort tout particulier.

ESA Astronauts chosen for the German Spacelab Mission (D1)

Germany's Federal Minister for Science and Technology, Dr. Heinz Riesenhuber, announced on 17 December 1982 that Germany had nominated the two ESA astronauts, Dr. Wubbo Ockels and Dr. Ulf Merbold, as the prime and back-up Payload Specialists, respectively, for the German Spacelab Mission D1, to take place in June 1985. Two German national candidates, Dr. R. Furrer and Dr. E.W. Messerschmid, were named for the second Payload Specialist post.

The two ESA astronauts are now completing their training in preparation for the first European Spacelab mission, the Space Shuttle launch for which is scheduled for 30 September this year.

NOWCASTING II

The Second International Symposium on Nowcasting (Mesoscale Observations and Very-Short-Range Weather Forecasting)

The second International Nowcasting Symposium will be held in Norrköping, Sweden, on 3-7 September 1984 under the sponsorship of the International Association of Meteorology and Atmospheric Physics (IAMAP), the World Meteorological Organisation (WMO), and the European Space Agency (ESA). The title 'Nowcasting' is interpreted to include methods and systems for providing detailed observations and analyses of the current state of the weather, and for making site-specific forecasts over the period 0 to 12 hours ahead (both by simple extrapolation of mesoscale observations and by the application of mesoscale dynamical models). The aim will be to cover all aspects of local weather.

There will be invited and contributed papers covering the following major topics:

Mesoscale phenomena	– structure and evolution, dynamics
Observations	– observational methods and systems, analysis and interpretation
Forecasting	– extrapolation, physical models, numerical dynamical methods, total systems.

In addition there will be a discussion session on user requirements and the economic benefits of nowcasting.

Persons interested in attending should write to the Chairman of the Local Organising Committee, Dr S Bodin, Swedish Meteorological and Hydrological Institute, Box 923, S-601 19 Norrköping, Sweden. Overall numbers will be limited. Individuals wishing to show posters and companies wishing to mount trade displays should also contact Dr Bodin. There will be a conference fee of US $50.

Persons wishing to present a paper should submit an informative abstract to the Chairman of the Programme Committee, Dr K A Browning, Meteorological Office Radar Research Laboratory, RSRE, Malvern, Worcs., UK, WR14 3PS. Deadline for submission of abstracts is 1 November 1983. Papers that are accepted will be required in camera-ready form by 1 May 1984 for inclusion in a preprinted Proceedings volume to be published by the European Space Agency's Scientific and Technical Publications Branch.

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 85 and using the Order-Form on page 86.

ESA Journal

The following papers have been published in ESA Journal Vol. 6, No. 4 (December 1982):

A UNIFYING CONCEPT FOR FUTURE FIXED SATELLITE SERVICE PAYLOADS FOR EUROPE
LOPRIORE M, SAITTO A & SMITH G K

A LIGHTWEIGHT, LOW-COST, MAGNETIC-BEARING REACTION WHEEL FOR SATELLITE ATTITUDE-CONTROL APPLICATIONS
ROBINSON A A

A SPACEBORNE EXPERIMENT TO DETERMINE THE RADIATION SENSITIVITY OF MICROWAVE BIPOLAR TRANSISTORS
GIBSON M H, STRIJK S J G & ADAMS L

ESABASE, A COMPUTER-AIDED ENGINEERING FRAMEWORK FACILITATING INTEGRATED SYSTEMS DESIGN
DE KRUYF J, FERRANTE J G & DUTTO E

COMPUTER SIMULATION OF FLUID-PHYSICS-MODULE OPERATIONS ON THE FIRST SPACELAB FLIGHT
MARTINEZ I

LAUNCH-VEHICLE SIMULATION FOR UNIAXIAL TRANSIENT VIBRATION TESTING OF SATELLITES
GIRARD A & MICHEL S

DYNAMIC QUALIFICATION OF SPACECRAFT BY MEANS OF MODAL SYNTHESIS
BERTRAM A & CONRAD P

Special Publications

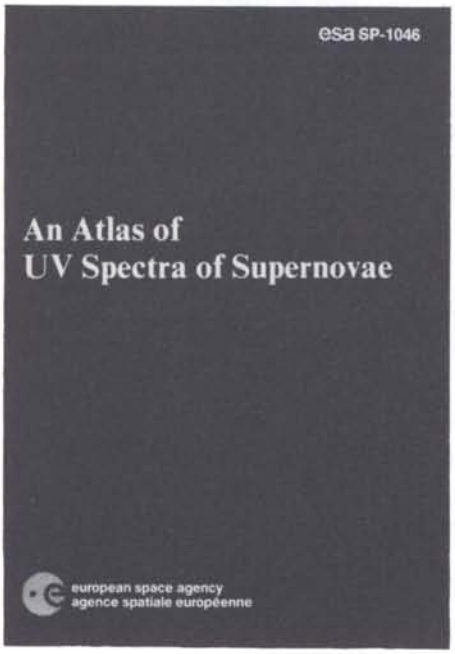
ESA SP-1046 // 224 PP
AN ATLAS OF UV SPECTRA OF SUPERNOVAE (DEC 1982)
BENVENUTI P ET AL (EDITOR BATTRICK B)

ESA SP-170 // 206 PP
PROCEEDINGS OF THE SECOND ESTEC SPACECRAFT ELECTROMAGNETIC COMPATIBILITY SEMINAR, HELD AT NOORDWIJK, THE NETHERLANDS, ON 11-13 MAY 1982 (JUL 1982)
BURKE W R (ED)

ESA SP-178 // 323 PP
SPACECRAFT MATERIALS IN A SPACE ENVIRONMENT (JUL 1982)
DAUPHIN J & GUYENNE T D (EDS)

ESA SP-179 // 700 PP
FIABILITE & MAINTENABILITE/RELIABILITY AND MAINTAINABILITY (SEPT 1982)
GUYENNE T D (ED)

ESA SP-180 // 154 PP
ZERO-G SIMULATION FOR GROUND-BASED STUDIES IN HUMAN PHYSIOLOGY, WITH EMPHASIS ON THE CARDIOVASCULAR AND BODY FLUID SYSTEMS
LONGDON N (ED)



ESA SP-186 // 171 PP
FOURTH ESTEC SPACECRAFT POWER-CONDITIONING SEMINAR (SEPT 1982)
BATTRICK B & ROLFE E (EDS.)

ESA SP-189 // 232 PP
THE SCIENTIFIC IMPORTANCE OF SUBMILLIMETRE OBSERVATIONS (AUG 1982)
DE GRAAUW T & GUYENNE T D (EDS)

Scientific & Technical Memoranda

ESA STM-222 // 49 PP
A NEW APPROACH TO THE PERFORMANCE EVALUATION OF SATELLITE PROPELLANT STORAGE SYSTEMS (MAY 1982)
ERICHSEN P

ESA STM 225 // 44 PP
EVALUATION OF VARIOUS SOLAR-CELL-TO-INTERCONNECTOR WELDS BY MEANS OF SCANNING LASER ACOUSTIC MICROSCOPY AND METALLOGRAPHY (AUG 1982)
DUNN B D

ESA STM-226 // 35 PP HELIOMAGNETISM, GEOMAGNETISM, AND THE EARTH'S ATMOSPHERE (OCT 1982)
PAGE D E

Scientific & Technical Report

ESA STR-210 // 72 PP
COMPUTATION OF THE EARTH'S RADIATION BUDGET FROM SPECTRAL RADIANCE MEASUREMENTS OF THE SATELLITE METEOSAT (NOV 1982)
GUBE M

Contractor Reports

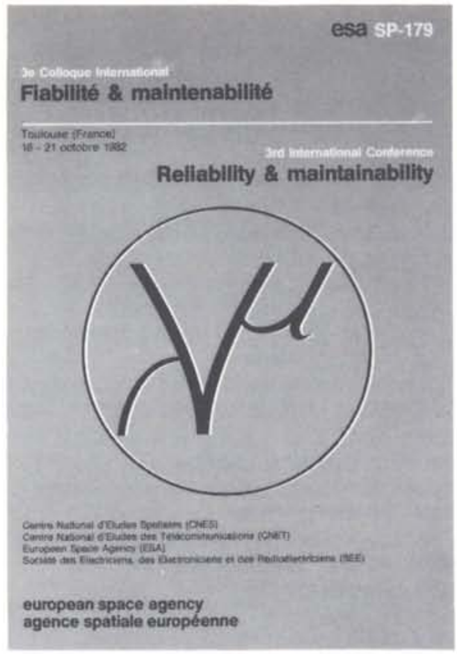
ESA CR(P)-1580 // 136 PP
RADAR ALTIMETER PHASE-A STUDY SIGNAL PROCESSOR SIMULATION – FINAL REPORT (JAN 1982)
SELENIA, ITALY

ESA CR(P)-1581 // 36 PP
ACTIVE MICROWAVE INSTRUMENT OPTIMISATION STUDY – FINAL REPORT (NOV 1981)
MARCONI, UK

ESA CR(P)-1582 // 100 PP
STUDY ON THE SYNOPSIS OF SATELLITE SCATTEROMETERS FOR C-BAND AND KU-BAND – FINAL REPORT (DEC 1981)
DORNIER SYSTEM, GERMANY

ESA CR(P)-1584 // VOL 1: 250 PP // VOL 2: 68 PP
INVESTIGATION FOR AN AUTOMATED ELECTROMAGNETIC FIELD GENERATING SYSTEM – FINAL REPORT AND ANNEX (UNDATED)
AERITALIA, ITALY

ESA CR(P)-1585 // 170 PP
PHASE-1 REPORT OF STANDARDISATION PROGRAM ON DESIGN ANALYSIS AND TESTING OF INSERTS IN NONMETALLIC SANDWICH COMPONENTS (DEC 1981)
ERNO, GERMANY



ESA CR(P)-1586 // VOL 1: 55 PP
GUIDELINES FOR SELECTION OF FIBRE-REINFORCED COMPOSITE MATERIALS FOR SPACECRAFT APPLICATIONS (JAN 1982)
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GUIDELINES FOR THE USE OF KEVLAR-ARAMID REINFORCING FIBRES IN SPACECRAFT CONSTRUCTION (JAN 1982)
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GUIDELINES FOR USE OF SUPERPLASTIC FORMING OF METALS IN SPACECRAFT CONSTRUCTION (JAN 1982)
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GUIDELINES FOR THE USE OF BERYLLIUM IN SPACECRAFT APPLICATIONS (JAN 1982)
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SPECTROSCOPIC INVESTIGATIONS OF A FIELD-EMISSION-GENERATED RADIATIVE ZONE – MASS SPECTROSCOPIC MEASUREMENTS – FINAL REPORT (OCT 1981)
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DEVELOPMENT OF A REVERSE RANKINE CYCLE HEAT PUMP FOR SPACE USE: DESIGN AND TESTING OF THE ENGINEERING MODEL OF THE VAPOR COMPRESSOR – FINAL REPORT (SEP 1981)
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EVALUATION OF THE FAIRCHILD TYPE 5512 TDI CCD IMAGE ARRAYS – FINAL REPORT
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FUTURE LAUNCHING SYSTEMS – FINAL REPORT (JUN 1981)
AEROSPATIALE, FRANCE

ESA CR(P)-1600 // 207 PP
APPLICATION OF LINEAR ANALYTIC SYSTEMS THEORY TO ATTITUDE CONTROL (OCT 1981)
APPLIED SYSTEMS STUDIES, UK

ESA CR(P)-1601 // VOL 1: 375 PP
PRELIMINARY STUDY OF AN AEROMARITIME NAVIGATION SYSTEM MAKING USE OF SATELLITES (FEB 1982)
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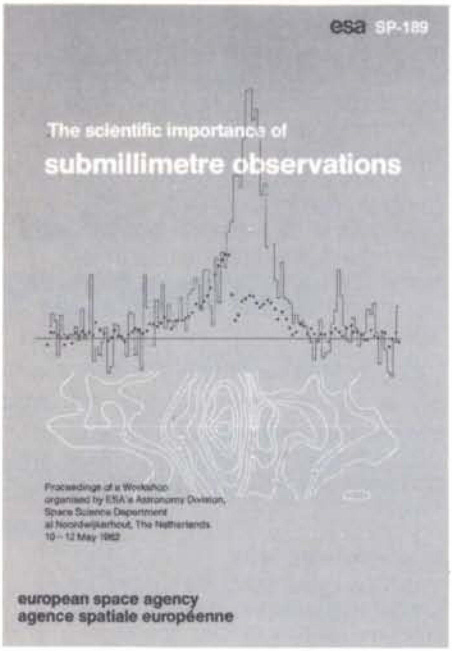
ECONOMIC ASSESSMENT OF A EUROPEAN REMOTE-SENSING SATELLITE SYSTEM FOR AGRICULTURAL APPLICATIONS – VOL 1: SUMMARY; VOL 2: MAIN REPORT (JAN 1981)
DECON RAUMFAHRT-CONSULTING GMBH, GERMANY

ESA CR(P)-1607 // 138 PP
EVALUATION STUDY OF SPACECRAFT MICROCOMPUTER MODULE SYSTEM APPLICABILITY TO THE MODULAR ATTITUDE CONTROL SYSTEM – FINAL REPORT (FEB 1982)
BADG, UK



ESA CR(P)-1608 // VOL 1: 30 PP / VOL 2: 145 PP / VOL 3: 132 PP / VOL 4: 70 PP
PRELIMINARY STUDY OF THE DYNAMIC CONTROL OF LARGE SPACECRAFT – VOL 1: EXECUTIVE SUMMARY; VOL 2: FINAL REPORT; VOL 3: CASE STUDIES; VOL 4: LITERATURE SURVEY (NOV 1981)
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STUDY OF THE EVOLUTION OF STRUCTURAL ACOUSTIC DESIGN GUIDES – FINAL REPORT (NOV 1981)
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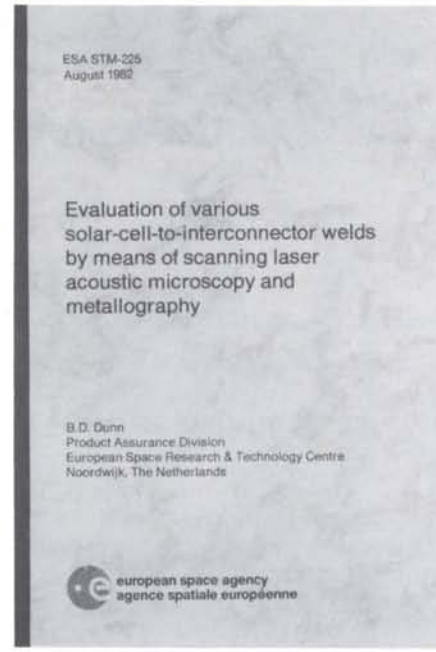

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STUDY OF HIGH STABILITY STRUCTURAL SYSTEMS – PHASE-A FINAL REPORT (DEC 1981)
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ETCA, BELGIUM

ESA CR(X)-1594 // 283 PP / 138 PP / 248 PP
OCEAN COLOUR MONITORING – ETUDE PHASE-A RAPPORT FINAL – VOLUME 1: DOSSIER DE SYNTHESE; VOLUME 2: ANNEXE I; VOLUME 3: DOSSIER DE SYNTHESE DE L'ADVENANT [MAR (VOLS 1 & 2) & NOV (VOL 3) 1981]
AEROSPATIALE, FRANCE

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ASTP 20/30 GIGAHERTZ ADVANCED REPEATER – FINAL REPORT (DEC 1981)
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IDTS FORMATTER MULTIPLEXER – FINAL REPORT (MAR 1982)
MSDS, UK

ESA CR(X)-1602 // 143 PP
FAISABILITE D'UNE EXPERIENCE DE TELEMETRIE LASER SUR ERS-1 (DEC 1981)
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DELFT UNIV., NETHERLANDS

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LEWICKI MICROELECTRONIC, GERMANY

ESA CR(X)-1611 // 58 PP
DESIGN OF AN ENGINEERING MODEL STANDARD MINI-RTU MODULE – FINAL REPORT (NOV 1981)
SAAB-SCANIA, SWEDEN


ESA STM-226
October 1982

Heliomagnetism, geomagnetism, and the earth's atmosphere

D.E. Page,
European Space Research & Technology Centre
Noordwijk, The Netherlands

european space agency
agence spatiale européenne

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DEFINITION OF A MEDIUM-THRUST EARTH-STORABLE BIPROPELLANT ENGINE FOR FUTURE APPLICATIONS – EXECUTIVE SUMMARY (FEB 1982)
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MULTIPLE PROCESSOR MACHINE FOR IMAGE PROCESSING – VOL 1: EXECUTIVE SUMMARY; VOL 2: MAIN REPORT (JAN 1982)
NORSK DATA AS, NORWAY

ESA CR(X)-1623 // 283 PP
TECHNOLOGY STUDY OF THE SPACELAB PALLET PAYLOAD RADIATOR – INTERIM REPORT PHASE 1 (APR 1982)
FOKKER BV., NETHERLANDS

ESA CR(X)-1625 // 317 PP
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DESIGN OPTIONS AND TECHNOLOGICAL CONSTRAINTS FOR RADAR ALTIMETERY FROM SATELLITES – FINAL REPORT (FEB 1982)
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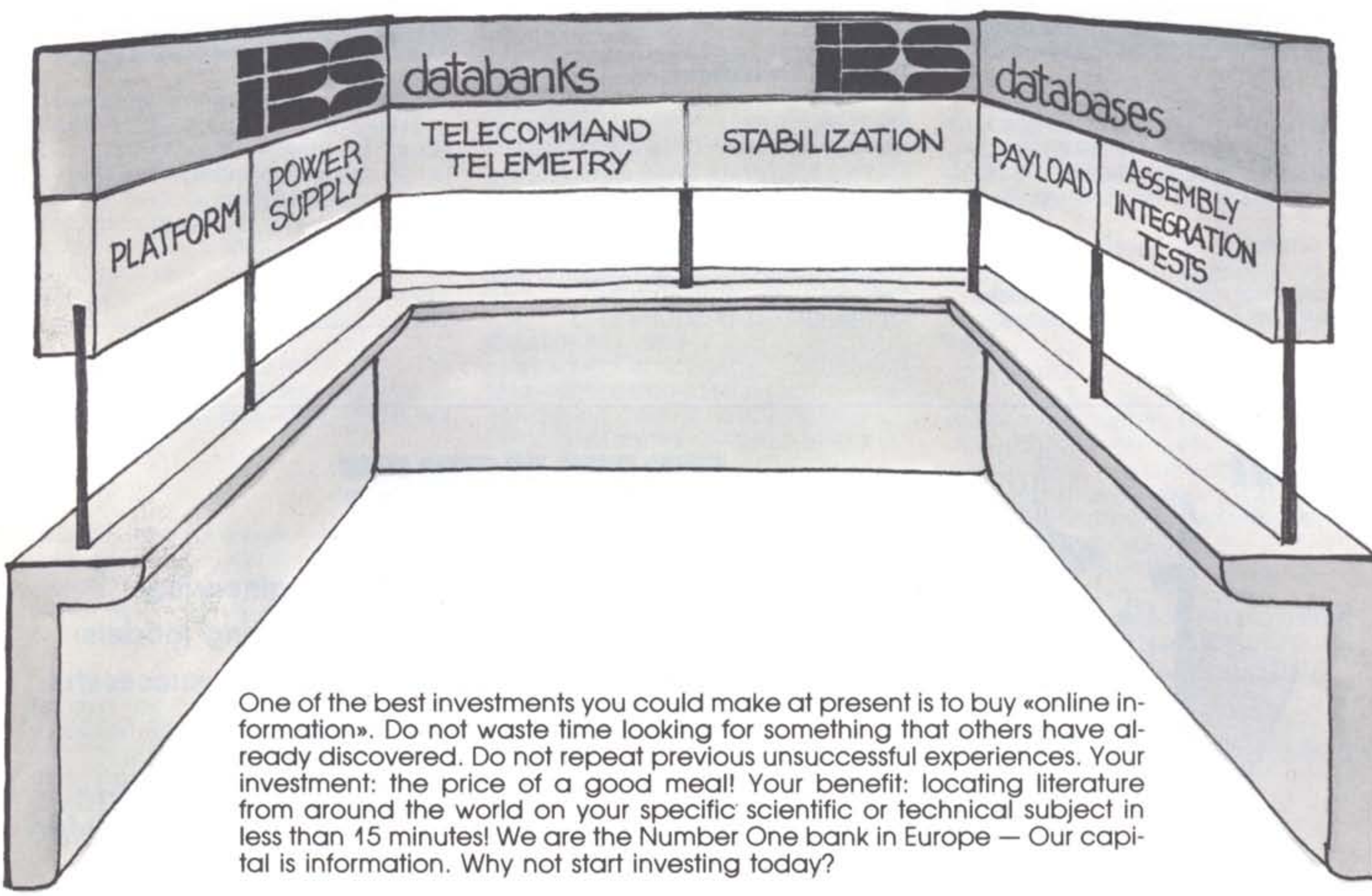

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