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august 1994

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european space agency
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european space agency

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

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

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

ESRIN, Frascati, Italy.

Chairman of the Council: P.G. Winters

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agence spatiale européenne

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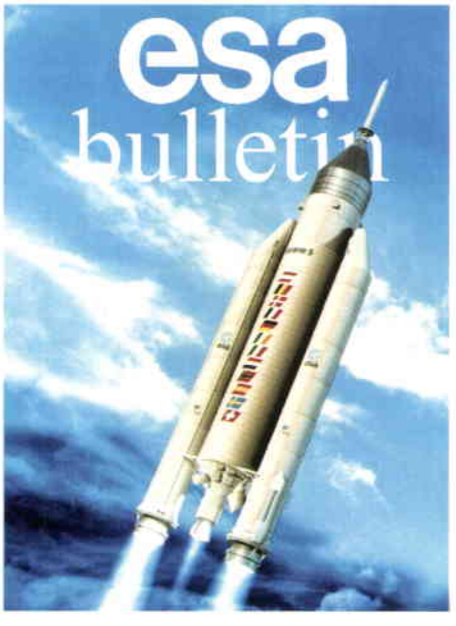
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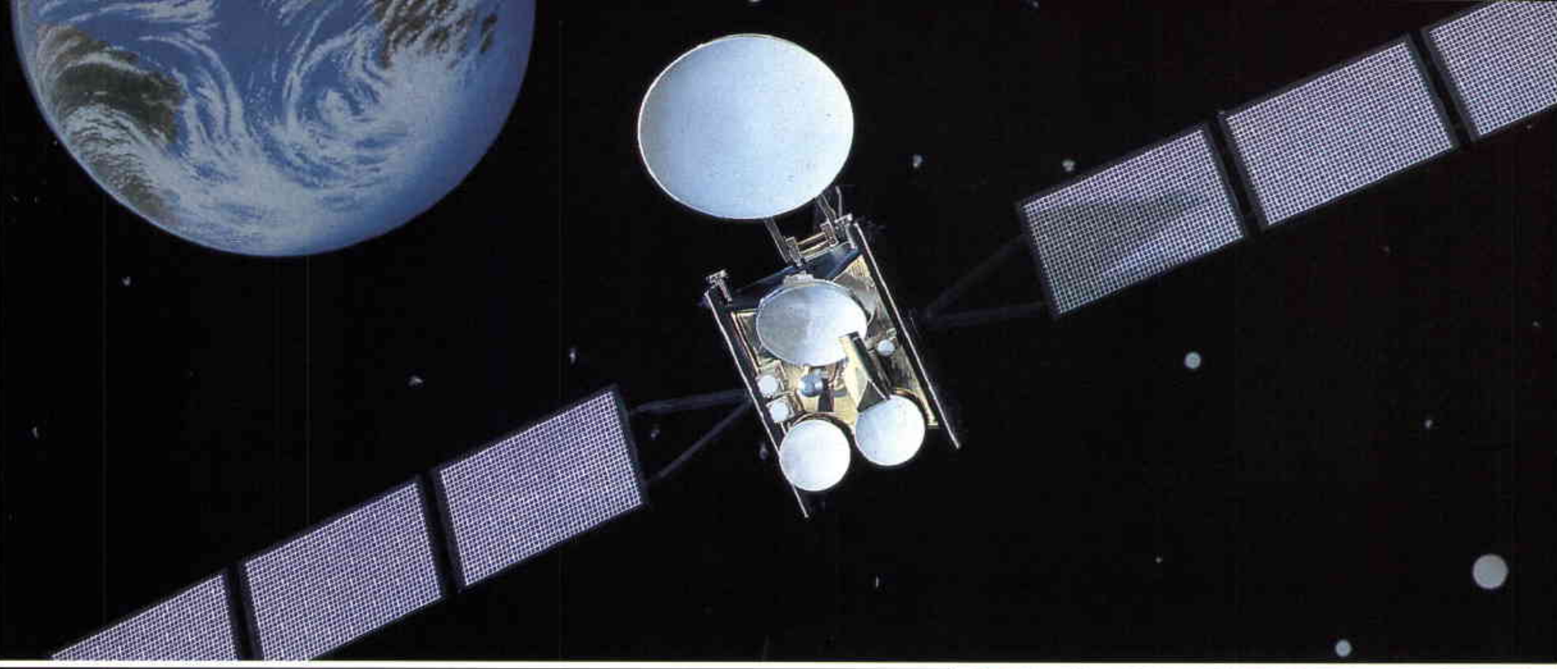

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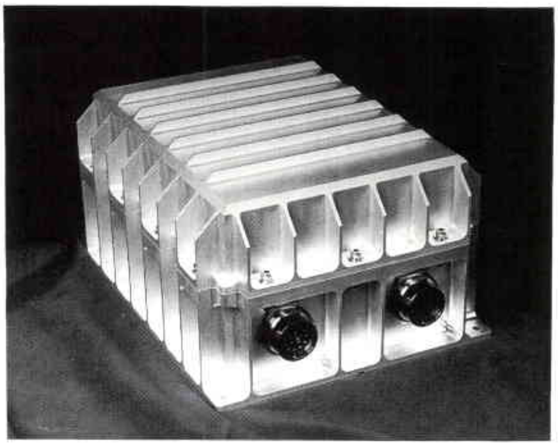

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'Integral' – A Challenging Scientific Mission

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The spectroscopic study of atomic and molecular lines in the infrared, optical and ultraviolet regions of the electromagnetic spectrum has provided us with knowledge and understanding of the physics of normal stars. Spectral lines in the gamma-ray region are produced by new and different processes. These include radioactivity, nuclear excitation, electron – positron annihilation and radiation in the vicinity of magnetic fields. Gamma-ray lines are indicators of all these processes and have now been observed at astrophysical sites. They provide powerful diagnostics for the high-energy processes occurring in some of the most violent and exotic objects in the Universe.

The key features of the Integral satellite will allow us to study in great detail these, and other sites of key interest in today's astrophysical research, with high sensitivity combined with very good energy resolution and very good imaging capabilities (in order to avoid source confusion) using two main instruments, an 'Imager' and a 'Spectrometer'.

The goals of gamma-ray astronomy

Gamma-ray photons carry the highest form of energy of any electromagnetic radiation known today. Space detectors have measured gamma-rays with energies more than 10^{12} times that of the photons of visible light. Because of their penetrating nature, i.e. low interaction with matter, these high-energy photons reach us from the most distant (and oldest) parts of the Universe, and they also carry information from closer regions like the Centre of our Galaxy, which are obscured by dense regions of molecular clouds and gas that are opaque at most other wavelengths.

Owing to the high-energy processes that are closely connected with the creation of gamma-ray photons, gamma-ray astronomy provides us with information about some of the most exotic objects in the Universe, such as black holes. Although radiation cannot escape from such an object, we 'see' a black hole by observing radiation from matter that is accelerated to extreme energies by the enormous gravitational field near a black hole, emitting gamma-rays during the process. Massive black holes, more than a million times the mass of our Sun, are believed to power the enormous energy outputs of quasars and other active galactic nuclei.

One of the most striking characteristics of the sky at gamma-ray energies is its dynamic variability. Two exposures of a given region of the sky will, in many cases, give different results. Variability of the gamma-ray emission provides information about the parent object. X-ray novae, for instance, have energy spectra that extend into the lower part of the gamma-ray spectrum. These novae can be observed several times per year and – at their peak brightnesses – are the brightest X-ray sources in the sky. Their intense, hard emission is believed to originate from an instability in the disk surrounding a black hole with stellar mass. This disk contains matter accreted by the black hole from a nearby companion star. Recently, gamma-ray line emission has been detected from such an X-ray nova.

The explosion of a supernova (type II) is another example of a very dynamic event: a star with more than 10 times the mass of the Sun explodes because it has collapsed under its own gravitational pressure after its nuclear fuel has been exhausted. The end result of such an explosion is either a black hole or a neutron star at the centre of the supernova explosion. The layers of the star undergo extreme temperature increases, thereby creating new heavy chemical elements, some of which are unstable isotopes that are characterised during radioactive decay by the emission of gamma-ray line photons.

More than seven years ago, a supernova was discovered in our nearest 'galactic neighbour', the Large Magellanic Cloud. The short (by astronomical standards) distance of 180 000 light years and the availability of modern detectors made it possible, for the first time, to detect gamma-ray lines from such a supernova, providing concrete evidence that new elements are indeed created in this explosion.

The creation of elements in our Galaxy can be traced via the gamma-ray emissions of radioactive isotopes. For example, the isotope '26' of aluminium, having a lifetime of 10^6 years, emits a characteristic line with a photon energy of 1.8 x 10^6 eV (1.8 MeV), or approximately 1 million times more energy than visible light. The High Energy Astronomical Observatory (HEAO-3) detected this line in 1980, and recently the Comptel instrument on the Compton Gamma-Ray Observatory generated a first map of this emission. Future investigations with Integral may allow us to clearly identify some of these sites of element building within our Galaxy.

Gamma-ray instrument evolution

The history of gamma-ray space-science missions is summarised in Figure 1.

In general, the development of new space-science instruments has to fulfil basic boundary conditions, the most important of which are scientific requirements and technical feasibility, the latter also taking launcher capabilities (mass) and associated costs into account.

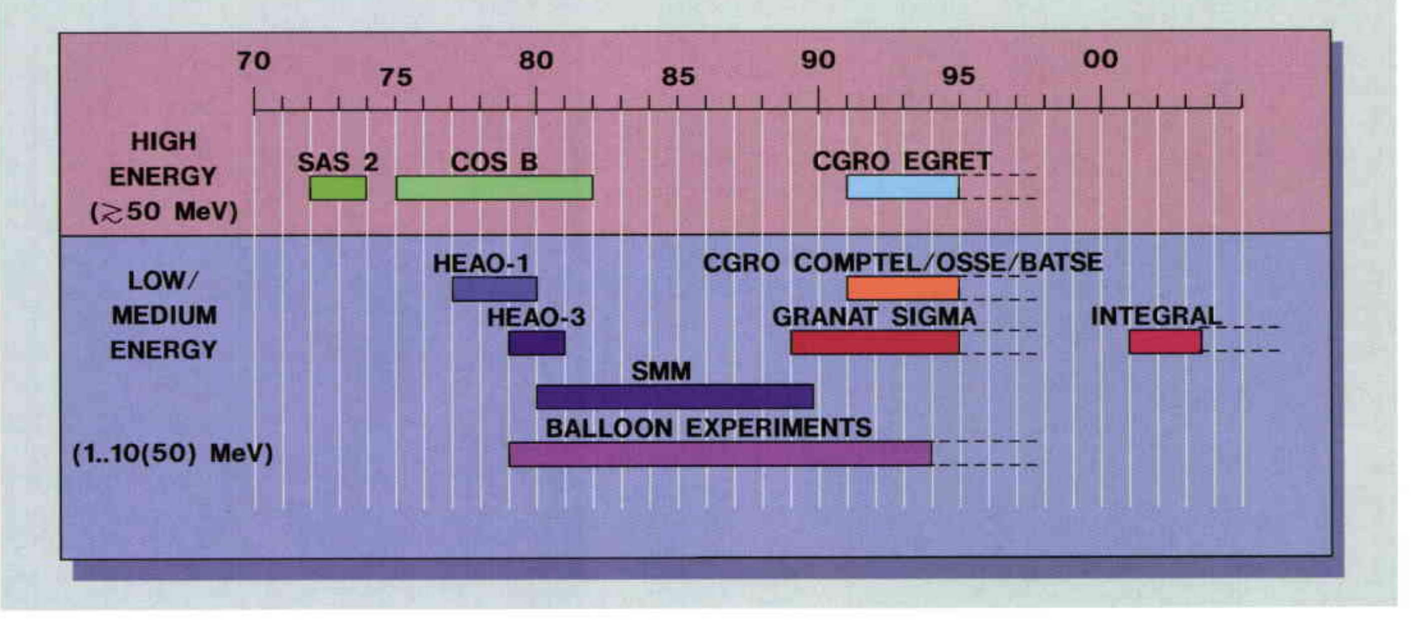
Detection of gamma-ray photons in the energy range above 1 keV – Integral's energy range extends from 10 keV up to 10 MeV – involves the measurement of the energy exchange (or energy loss) between the photons and the mass of the detector. The scientific advantage of the 'penetrating power' (low interaction with matter) of gamma-ray photons leads directly to difficulty in measuring them with a suitable detector. Mainly, it is the kinetic energy of the incoming photon, transferred to charged particles, which is dissipated and measured in the detector.

The most important energy-loss processes – in the energy range of interest to Integral – are the photoelectric effect (interaction of gamma-ray photons with bound electrons of the detector crystal), pair production (annihilation of gamma-ray photons in the vicinity of a nucleus producing pairs of electrons and positrons), and Compton scattering (elastic scattering of gamma-ray photons with free electrons). The energy dependency of the total cross-section for all three energy-loss processes is dependent on the detector material: for CsI and Ge (as proposed for Integral), the photoelectric effect dominates below about 100 – 300 keV, the pair production process above about 10 MeV, while the Compton effect is the dominating process in between.

Typical detector materials are scintillation substances (e.g. caesium iodide: CsI), where the amount of energy loss is measured through ionisation and scintillation of the detector material (via photodiodes or photomultipliers), and semiconductor materials (e.g. germanium: Ge), where electron-hole pairs are created and registered through external electrical fields. CsI is fairly cheap in large-volume production and has a good light output with 40 keV energy resolution at 1 MeV, thereby making it a good material for imaging telescopes with fairly large detector pixel arrays, where each pixel is produced from a say 1 cm x 1 cm x 3 cm CsI bar. Ge has a superb energy resolution (actively cooled at a temperature of 80 K) of 2 keV at 1 MeV, and is the prime material used for spectroscopy detectors.

Key design parameters for high-energy telescopes have to take into account that the best sensitivity with a minimum of radiation background is required for a mission that will produce first-class scientific results during the first decade of the next century. In the Integral energy range, the signal-to-noise ratio of typical gamma-ray measurements is of the order of 1%, indicating the

Figure 1. History of gamma-ray missions



need for very careful detector design and background reduction in order to extract the maximum of information.

The sensitivity of gamma-ray measurements is basically proportional to the background counting rate and inversely proportional to the detector area and length of observing time. Reduction of background noise, increased detector area, and long observations are therefore required to achieve good sensitivity. Long, and uninterrupted, observations can be achieved using high eccentric orbits (see below). The detector area can be maximised, but a minimum thickness of typically a few centimetres of high-atomic-number (i.e. high Z) material is needed to achieve sufficient stopping power: with a diameter of the order of 1 m, this translates immediately into a rather heavy detector array weighing approximately half a ton (including shield; see below).

For background noise, which has to be minimised to achieve good sensitivity, an anti-coincidence (or 'veto') system is usually employed using BGO (Bismuth Germanate Oxide) crystals, a material with high mean Z and high density. The system flags (vetoes) charged particles, but is also used to minimise the effects of gamma-ray radiation not coming from the source under investigation.

For the imaging detector, the key components of the background noise are cosmic diffuse gamma-rays, atmospheric gamma-rays, gamma-rays produced in the material of the spacecraft and instrument, cosmic-ray-induced spallation products within the material of the detector, interactions within the detector between locally produced photons and atmospheric albedo neutrons, and events derived from protons trapped within the Earth's radiation belts. Elastic scattering from neutrons is a small effect due to the large mass of the caesium nuclei. Gamma-rays from diffuse cosmic radiation or locally created gamma-rays enter the detector either through the aperture (viewing direction) or leak through the shield. Clearly, a thick and massive shield reduces many unwanted components, but such a massive structure exposed to particles and radiation from space is itself a source of (often time-delayed) secondary photon and particle emission too. In other words, it is important to optimise the shield thickness. For the imager, the anti-coincidence system will be designed using 3 cm-thick BGO and employing an outer ring of the CsI detector pixels as a guard ring.

The key background components affecting the spectrometer detector are: the cosmic diffuse background (mainly through the aperture), neutrons which elastically scatter off germanium nuclei in the detector and transfer recoil energy to the nuclei, neutrons and protons interacting in the detector and producing beta-unstable radio-nuclides which decay (delayed), and shield leakage (background from cosmic diffuse gamma radiation and locally produced photons). To optimise the sensitivity of the 350 cm^2 Ge detector area (approx. 8 cm thick), a BGO shield of approximately 7 cm thickness will be used for the spectrometer, resulting in a mass of some 800 kg for the detector assembly (including shield and structure).

To these detector assemblies, coded-mask subsystems (each about 150 kg) need to be added to allow imaging in the high-energy domain. Coded masks in the high-energy range consist of high-Z material (e.g. tungsten) a few centimetres thick, in which holes are arranged in a special pattern in order to produce a 'shadowgram' of the source on the detector array (see below).

Detailed feasibility studies have shown that, in order to achieve the scientific goals set for Integral, two separate instruments need to be designed, one optimised for imaging and the other for spectroscopy. This means, however, that each instrument needs its own aperture and shielding subsystems, which add to the total mass. The combined weight of the two main instruments for Integral – Imager and Spectrometer, including electronics boxes, coolers and harness – has been estimated during the study phase to be about 2000 kg.

Comparison with experiments being flown in space today, namely the Comptel instrument aboard CGRO and the French Sigma telescope on the Russian Granat spacecraft, shows that those single instruments (using NaI crystals) are in the 1300 – 1500 kg range. Earlier studies (e.g. the ESA Grasp candidate mission submitted in 1988) proposed saving some mass by combining the imaging and spectroscopy detectors into one common (and smaller) detector assembly and using common shield and aperture systems. This resulted in a total mass for Grasp of about 1000 kg, but with significant reductions in scientific capabilities, stemming from poor individual optimisation for imaging and spectroscopy (mask pattern, detector pixel size, shielding), and much more complex technical and programmatic interfaces.

In summary, a scientific mission with the objectives that have been set for Integral, and one which must make significant progress vis-a-vis existing or previous missions in the field of 10 keV to 10 MeV astronomy, requires an instrument complement that results in a total payload weight of around 2 tons.

The programmatic challenge

The Integral payload, at about 2 tons, will be the heaviest ever flown on an ESA scientific mission. As overall programme cost tends to be correlated with overall spacecraft mass, it is a considerable challenge to accommodate Integral as a medium-size mission within ESA's 'Space Science: Horizon 2000' long-term plan. In order to meet the budgetary constraints of a medium-size mission, the programme policy chosen was one of concentrating development effort on areas specific to Integral and to share that effort with partners.

This approach has resulted in the following programme set-up:

Each Integral scientific instrument is provided, as for all ESA scientific missions, by a collaboration of scientists headed by a Principal Investigator (PI) with national-organisation funding. Although Integral is an observatory-type mission for the science community at large, a certain portion of the observation time is guaranteed to these PIs in return for the instruments that they are providing.

Russia, eager to continue its gamma-ray astronomy activities beyond its Granat mission, have offered to participate in the Integral Programme by providing the launcher (a Proton) in return for observation time. Use of the Proton launcher would enhance the scientific return from the mission as it could place Integral into an orbit with unconstrained observing time. However, due to uncertainty about whether the Proton system will still be operational in 2001, Ariane-5 is being retained as the alternative launcher for Integral.

The USA may contribute one or two additional ground stations to enhance spacecraft coverage. They also intend to participate in the instrument collaborations.

The service module of the Integral spacecraft is a re-build of that developed for the XMM project. This is feasible because the requirements of the two missions in terms of orbit, power, data rates and pointing are very similar. Moreover, the time span of only 1.5 years between the XMM and Integral schedules will allow the necessary continuity in hardware procurement fromindustry.

As XMM will be launched on an Ariane-5, re-use of the XMM service module also facilitates keeping it as the alternative to the Proton launcher for Integral.

The mission profile

Gamma-ray astronomy can be performed outside the Earth's atmosphere either below or above the Earth's radiation belts. For Integral, a High Eccentric Orbit (HEO) allowing observations above the radiation belts, i.e. above a height of 40 000 km, has been chosen. The orbit must be optimised for:

- maximum time above 40 000 km
- minimum exposure to radiation belts in terms of overall dose and proton fluence.

The optimum orbit depends on the launcher characteristics. The operational orbits selected for the Proton launch and the Ariane-5 alternative are shown in Figure 2.

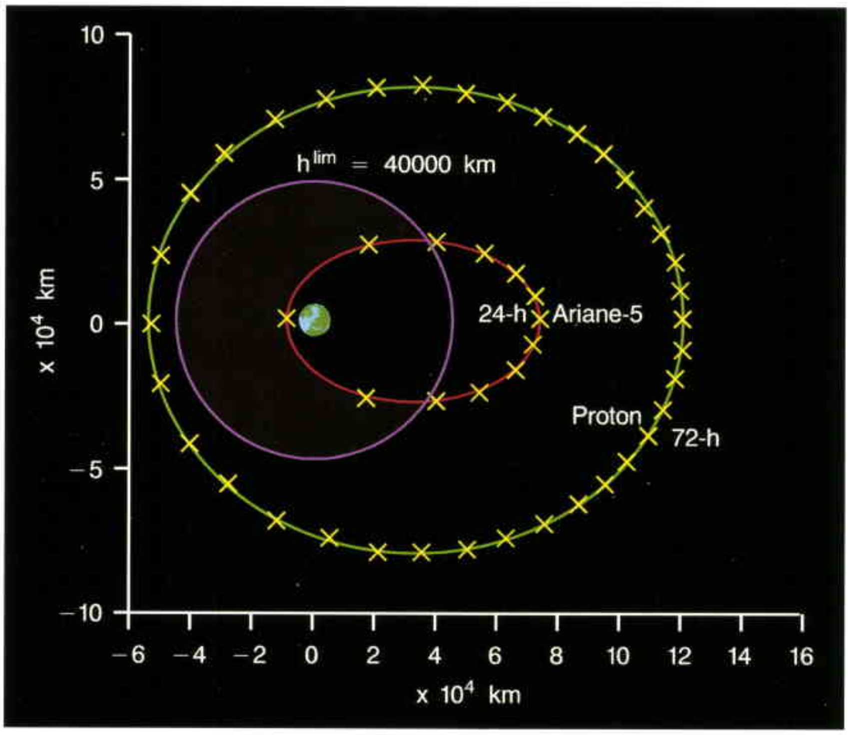


Figure 2. Integral orbits

The Proton orbit has a period of 72 h, a perigee of 48 000 km and an apogee of 115 000 km. As this orbit lies entirely outside the radiation belts, the observation time is 100% and the radiation dose is minimal. Full ground coverage can be achieved with three ground stations, and about 85% coverage with two stations.

The Ariane-5 orbit has a period of 24 h, a perigee height of 4000 km and an apogee height of 68 000 km. The apogee is in the Northern Hemisphere, to give visibility from a European ground station. The observation time above 40 000 km is 16.6 h per 24 h orbit (69%). One station provides up to 21 h of coverage. Because the spacecraft is passing through the radiation belts at each perigee, the radiation dose is significant – about one order of magnitude higher than that in the Proton orbit. The high inclination of 65° minimises exposure to the Earth's proton belt, whilst giving good orbit stability. The resulting trapped proton fluence is low compared to that originating from solar flares.

Table 1. Integral's orbit characteristics

	Proton orbit	Ariane-5 orbit
Apogee	115 000 km	68 000 km
Perigee	48 000 km	4 000 km min
Inclination	51.6 deg	65 deg
Argument of perigee	270 deg	270 deg
Orbital period	72 h	24 h
Time above 40 000 km	100%	69%
Ground station	Villafranca Goldstone (TBC) Canberra	Villafranca
Radiation dose (4 mm Al shielding)	10 krad	150 krad

Integral's orbit and mission characteristics are summarised in Table 1.

The payload

The Integral science payload complement, as established during the mission study phase (so-called 'Phase-A'), consists of two main instruments, the Imager and the Spectrometer, and two monitoring instruments, the X-Ray Monitor and the Optical Transient Camera.

These instruments have been carefully chosen to complement each other:

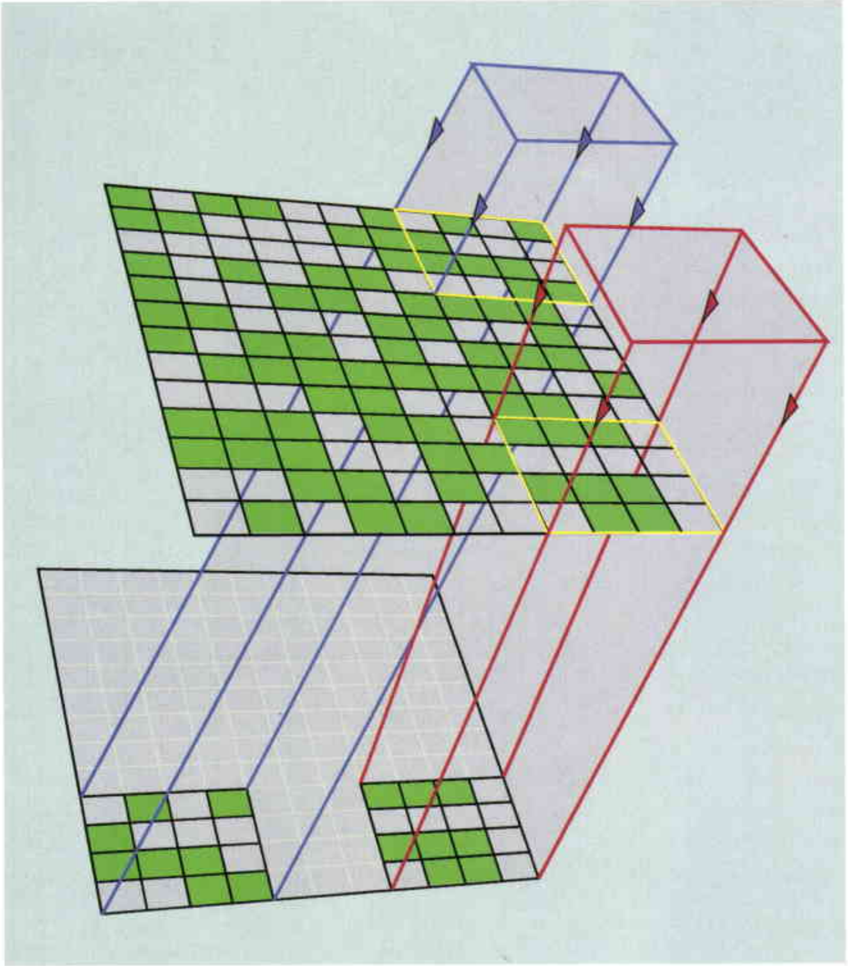


Figure 3. The operating principle of a coded-mask telescope

- The Imager's high angular resolution (17 min) and modest energy resolution ($E/\Delta E$ = 20) is complemented by the Spectrometer's modest angular resolution (1.4 deg) and high energy resolution ($E/\Delta E$ = 500).

- The energy range of the Spectrometer (15 keV – 10 MeV), and particularly that of the Imager (70 keV – 10 MeV), will be extended to lower energies by the X-Ray Monitor (4 – 100 keV), which has excellent angular resolution (3 min).

- The Optical Transient Camera is intended to measure any optical emission accompanying gamma-ray bursts or other transients observed with the main instruments.

All four instruments are co-aligned and will observe the same region of the sky simultaneously. The measurements of all four instruments will be made available to users as comprehensive data sets for each target.

The Imager, Spectrometer and X-Ray Monitor share a common principle for producing images – all three are coded-mask telescopes. At moderate X-ray energies, it is still possible to form images using mirrors and standard optics principles, but above an energy of about 10 keV it becomes difficult or even impossible to make suitable mirrors. Coded-aperture imaging offers a means of producing images which avoids this limitation.

With coded-mask imaging, a mask with opaque and transparent regions (the 'coded mask') is placed in front of a position-sensitive photon detector (Fig. 3). A coded-mask telescope is basically a pinhole camera, but with a larger aperture (i.e. many pinholes) in order to cope with the low gamma-ray fluxes. A beam of photons incident on the mask will be absorbed where it strikes opaque areas, thereby casting a shadow onto the detector. For a point source of photons, the registration of the shadow on the detector may be used to determine the direction of the source. A collection of point sources casts overlapping shadows and, provided the mask pattern is suitably chosen, the directions of the point sources may be determined by correlation techniques. Similarly, a complex field can be imaged by determining the contribution of each pixel in the source to the combined 'shadowgram'.

The coded-mask technique offers a second important advantage for gamma-ray astronomy; namely, in addition to imaging, it provides close-to-ideal background subtraction. In the reconstruction of the intensity from a particular region of the sky, the difference is taken between the signal in all those detector elements that have a clear view of a source at the position under consideration, and that from detector elements for which the source is obscured by opaque regions of the mask. Thus, the detector background is measured exactly contemporaneously, using a subset of the detector elements intermingled with those observing the source.

The detectors must have a spatial resolution matching the resolution of the coded masks and the corresponding shadowgram:

- The Imager detector assembly consists of a three-layer scintillator array, each consisting of 2800 CsI scintillator/photodiode elements.

- The Spectrometer detector assembly consists of an array of nine large-volume germanium detectors. These detectors have to be kept at an operating temperature of about 85 K by mechanical Stirling coolers.

- The X-Ray Monitor detector is based on a multi-wire proportional counter.

As Figure 4 shows, the payload module consists basically of an equipment platform accommodating the detector assemblies and an empty box supporting the 'upper floor' with the masks at a height of about 4 m.

The spacecraft
The overall spacecraft configuration resulting from the Phase-A study is shown in Figure 5. It consists of two separate modules, the Service Module (SVM) and the Payload Module (PLM). ESA will be responsible for the overall spacecraft design and the procurement of the SVM and PLM, as described below.

The **Service Module** provides the following functions:

- solar power generation
- power conditioning and control
- telecommunications
- data handling
- attitude and orbit control
- structural support
- thermal control.

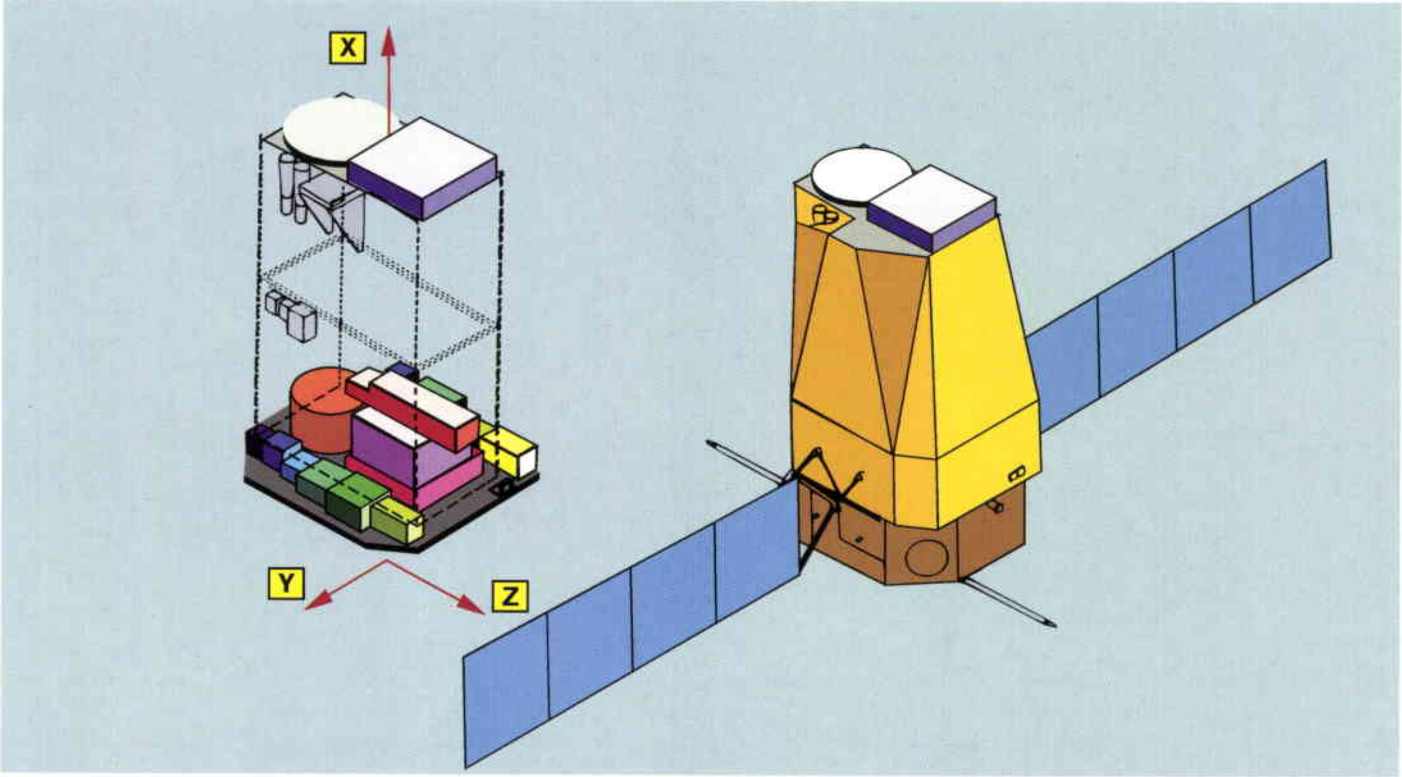


Figure 4. Integral's payload configuration

Figure 5. Overall Integral spacecraft configuration

The configuration of the Integral SVM, developed from that for XMM, is very much driven by the fact that the central area has to house the XMM mirrors.

The **Payload Module** has to accommodate the Integral payload, but must also interface with the SVM. The resulting overall PLM configuration is shown in Figure 6. It consists of:

- the equipment platform carrying the instrument detectors and instrument electronics units
- the mask support structure carrying the instrument coded-aperture masks about 4 m above the detectors
- the thermal-control hardware enclosing the PLM

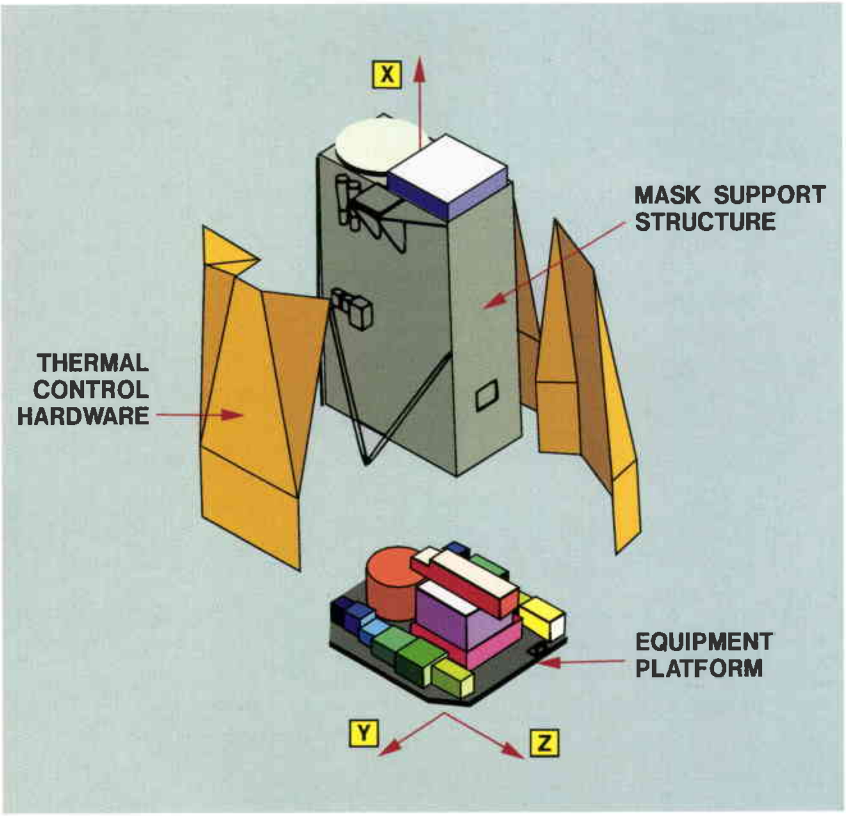


Figure 6. The Integral Payload Module – Exploded view

- the payload interface units, such as a Power Distribution Unit (PDU) and a Remote Terminal Unit (RTU)
- the star trackers, requiring co-alignment with the instruments and a free field of view
- the harness connecting spacecraft as well as payload units.

Simplicity of the interface between the SVM and the PLM has been a major design driver. The electrical interface is basically reduced to a power bus and a data-handling bus. The modular approach has been conceived to allow parallel development, assembly, integration and testing of the SVM and PLM.

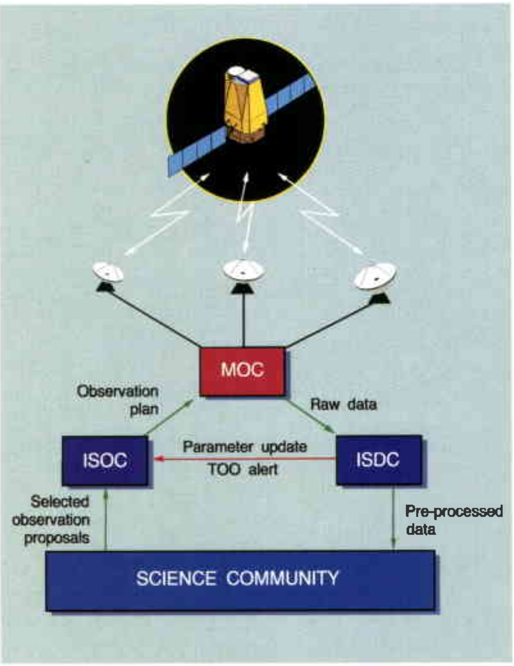


Figure 7. The Integral ground segment

The main characteristics of the Integral spacecraft are summarised in Table 2.

The ground segment

As shown in Figure 7, the ground segment consists of three main elements: the Integral Science Operations Centre (ISOC), the Mission Operations Centre (MOC), and the Integral Science Data Centre (ISDC):

- The ISOC will process the successful observation proposals into an optimised Observation Plan, which will consist of a timeline of target pointings plus the corresponding instrument configuration.
- The MOC will implement the Observation Plan within the spacecraft system constraints into an operational command sequence. In addition, the MOC, which will be at the European Space Operations Centre (ESOC) in Darmstadt (D), will perform all of the classical spacecraft operations and maintenance tasks.
- The ISDC will receive the science telemetry plus the relevant ancillary spacecraft data from the MOC. Taking into account the instrument characteristics, the ISDC will convert these raw data into physical units. Final data products will be distributed to the observer and archived for later use by the science community.

ESA is responsible for the ISOC and the MOC. The ISDC will be the responsibility of the ISDC Principal Investigator and his collaborators.

Mission implementation

The various phases in the implementation of the Integral Programme are shown in Figure 8.

The Integral project is presently issuing the Announcement of Opportunity (AO) for the payload instruments, the Science Data Centre and the mission scientists. In about a year's time, immediately after final payload selection, the Invitation-to-Tender (ITT) will be issued to Industry. Phase-B is planned to start in the first half of 1996, leading to the commencement of Phase-C/D in mid-1997.

The first half of Phase-C/D will concentrate on the structural/thermal model, in parallel with the engineering model. The second half will be devoted to the flight model, culminating in the launch of Integral in the first half of 2001.

The nominal mission duration will be two years. Consumables and life-limiting items will be sized to allow extension of the mission to five years in total.

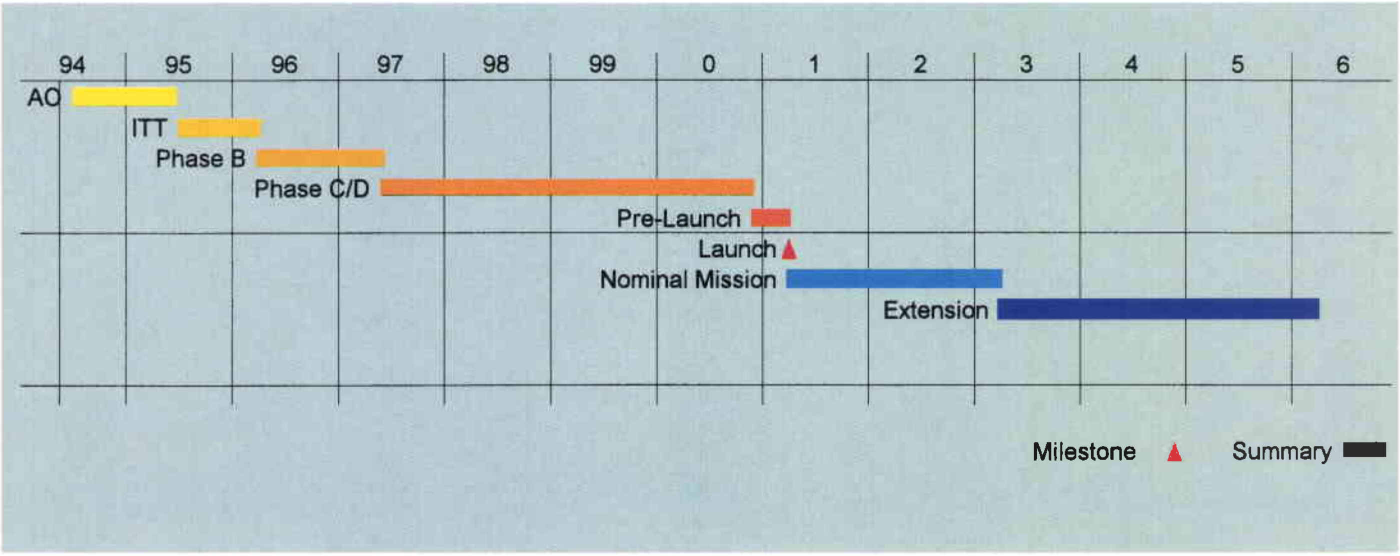


Figure 8. The various phases in the Integral Programme

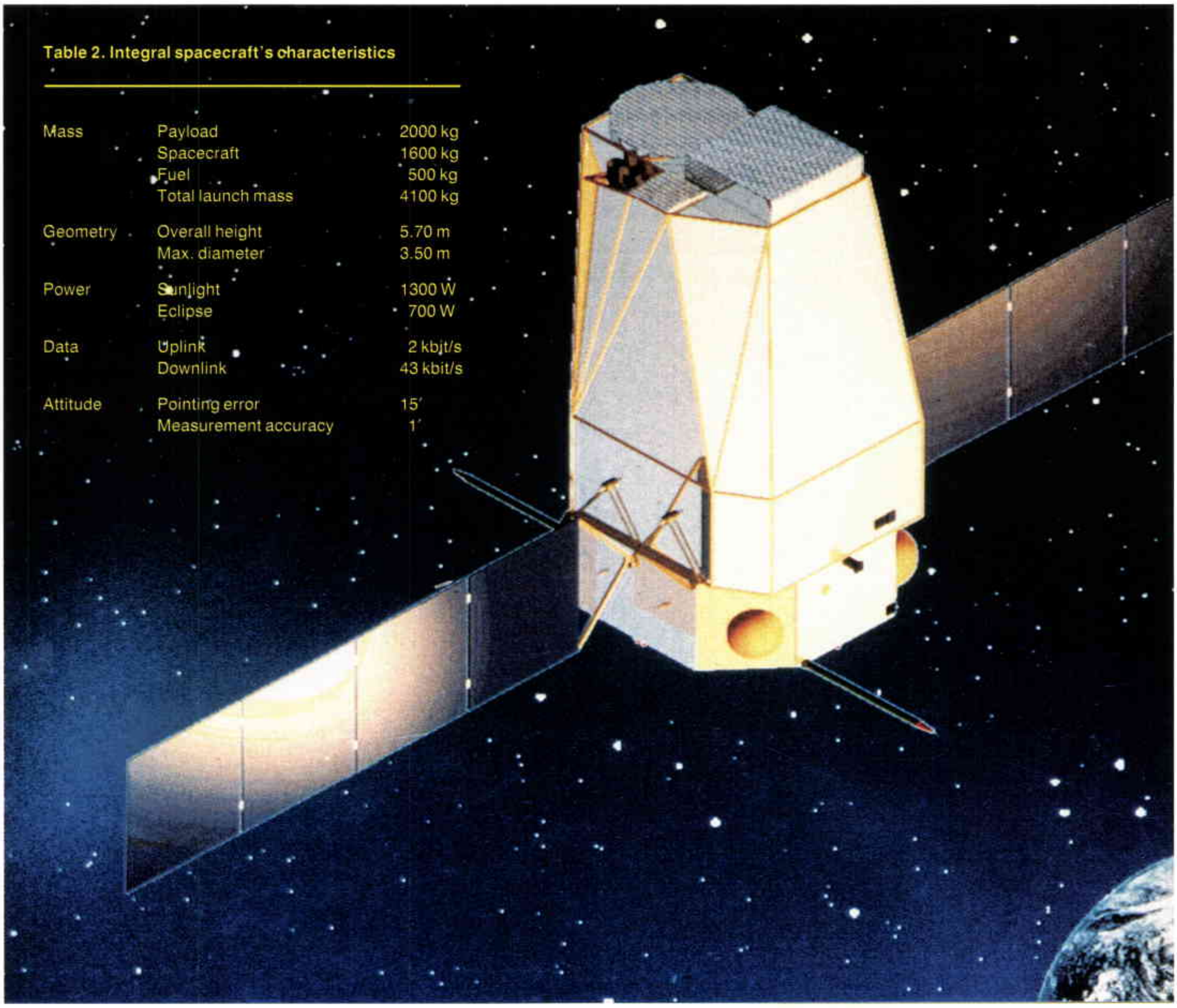


Table 2. Integral spacecraft's characteristics

Mass	Payload	2000 kg
	Spacecraft	1600 kg
	Fuel	500 kg
	Total launch mass	4100 kg
Geometry	Overall height	5.70 m
	Max. diameter	3.50 m
Power	Sunlight	1300 W
	Eclipse	700 W
Data	Uplink	2 kbit/s
	Downlink	43 kbit/s
Attitude	Pointing error	15′
	Measurement accuracy	1′

Figure 1. An aerial view of the launch facilities, seen from the north

The Ariane-5 Launch Facilities

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New ground facilities dedicated to the launching of the Ariane-5 vehicle are now under construction at the Guiana Space Centre, Europe's spaceport in Kourou, French Guiana. They will be one of the most modern and functional ground infrastructures in the world and will provide the facilities for at least 100 commercial launches, with the first flight at the end of 1995. Although they have been custom designed for the new, heavy-lift Ariane-5 vehicle, they will fulfil the requirements of the Ariane-5 development programme, namely a greater launch rate, reduced vulnerability to accidents, and reduced launch costs.

Evolution of the launch complex design

To date, two launch complexes for the Ariane family of vehicles have been built within the framework of the Ariane development programme, at ESA's Guiana Space Centre in Kourou, French Guiana. The first one was used to launch Ariane-1, -2 and -3 between 1979 and 1989. The second one has been used to launch Ariane-3 and -4 since 1986 and is still being used. A third launch complex, dedicated to the launching of the new Ariane-5, is currently under construction.

The design concept behind the launch facilities has been evolving since the design of the first launch complex, based on experience gained and to improve the product's quality, availability and operational flexibility and thus reduce launch costs. The main criteria for the evolution have been:

- to increase the launch rate
- to reduce vulnerability to a launcher accident on the launch pad or at lift-off
- to optimise the operational activities
- to adapt the facilities to Ariane launch vehicle changes
- to exploit the experience acquired during previous developments.

The launch complexes, which are financed and owned by ESA, have been designed and built by the French Space Agency, CNES, on ESA's behalf. During the commercial utilisation phase, Arianespace, the European launch services operator, is responsible for the operation of the facilities that interface directly with the launcher, i.e. the launch complexes or ELAs (Ensembles de Lancement Ariane), and with the payloads, i.e. the EPCU complex (Ensemble de Préparation des Charges Utiles).

The Ariane launcher family is continuously being modified to meet commercial needs in order to stay competitive. In addition, the launch facilities have to be upgraded through new and optimised investments which represent between 10 and 15% of the development costs of the respective launch vehicles. An Ariane launch campaign in Guiana includes all operations from the arrival of elements (stages, vehicle equipment bay, fairing, spacecraft, etc.) until the launch vehicle is ready for lift-off, and ends with the actual launch and the orbiting of the spacecraft.

Launch complex No. 1 — ELA1

The design of the first launch complex, ELA1, began in 1973, soon after the Ariane programme was approved at the European Space Conference in Brussels. The main design criteria were:

- a capacity of four launches a year, which was at that time the maximum foreseeable rate
- the existing facilities in Guiana which one of ESA's forerunners, the European Launcher Development Organisation (ELDO), had built for the Europa 2 vehicle, had to be used. Those facilities in fact had only been used once, for a launch in November 1971.

That launch site was thoroughly modified and adapted to Ariane. Since all campaign operations had to be performed sequentially on the launch site itself, the number of possible launches was limited to one every two months, which was thought to be more than enough at the time.

The first Ariane launch took place from ELA1 on 24 December 1979, and the complex then remained operational until the launch of the last Ariane-3 vehicle in mid-1989. The servicing tower was dismantled in 1991.

During its lifetime, ELA1 provided very acceptable and competitive conditions for 25 launches, but some improvements were required:

- the launch rate was limited
- hazardous and sensitive facilities were located too close to the launch pad
- there were two main disadvantages to re-using the Europa 2 facilities: it was difficult to integrate equipment inside the umbilical mast (which holds and protects the electrical and fluid links between the launcher and the ground facilities) making maintenance more complex, and the orientation of the launcher and the mast relative to the dominant winds was not optimal, limiting the acceptable wind speed at lift-off to 9 m/s.

Launch complex No. 2 — ELA2

The design, construction and validation of the second launch complex, ELA2, were carried out between 1981 and 1985. The design was based on the following requirements:

- compatibility with the Ariane-3 and Ariane-4 family of vehicles
- a doubling of the ELA1 launch rate, narrowing the interval between launches to one month and allowing 10 launches per year
- greater operational flexibility, maximum accessibility, reduction of constraints and a general optimisation of the operations.

The required improvement in the launch rate was achieved by separating geographically the preparation area from the launch area, enabling two launch campaigns to be undertaken at the same time. When the stages of the first vehicle have been erected, assembled and checked in the preparation area (in the first weeks of the campaign), the vehicle is rolled out on its mobile launch platform to the launch area for the remaining part of the campaign. While it is undergoing mating and checkout of the payload, countdown and finally, the launch, the stages of the second vehicle can be assembled in the preparation area. After the launch of the first vehicle, the launch pad is then refurbished in preparation for the second vehicle.

With this separation, the launch rate increased to one per month, thus doubling the capacity of the ELA1 at a cost that is only 30% higher. Arianespace has in fact recently shortened the minimum period between Ariane-4 launches to 18 working days (i.e. three to three and a half weeks), to cope with increasing commercial demand.

Experience gained with ELA1 was fully used in the design of ELA2:

- The launch pad was better oriented relative to the dominant winds, and the acceptable wind speed at lift-off has consequently increased to 14 m/s.
- Accessibility of equipment inside the umbilical tower was maximised.
- All servicing and control equipment that was not absolutely necessary in the launch area was moved to a safe distance, thus allowing access to the equipment until just a few minutes before lift-off, and also reducing vulnerability in the event of an accident during the launch.

ELA2 has been operational since March 1986. The pad has been adapted to the Ariane-4 launcher, which made its maiden flight in June 1988. Arianespace will continue to use the facility until about 1999, by which time it will have launched about 100 vehicles at a rate of 8 to 10 per year.

Some small disadvantages, however, still remain:

- Despite a clear improvement over ELA1, vulnerability to an accident at lift-off is still relatively high.
- Although it offers great advantages, separation into two areas has the disadvantage that the umbilicals have to be disconnected from the upper stages in the preparation area and reconnected in the launch area. The new links then have to be checked again, and the total time lost is about 36 hours.
- The computerised control system for monitoring and controlling launcher propellants, fluids and electrical systems during checkout and countdown operations is still too centralised. In particular, non-separation of servicing from launch vehicle parameters leads to some operational constraints.

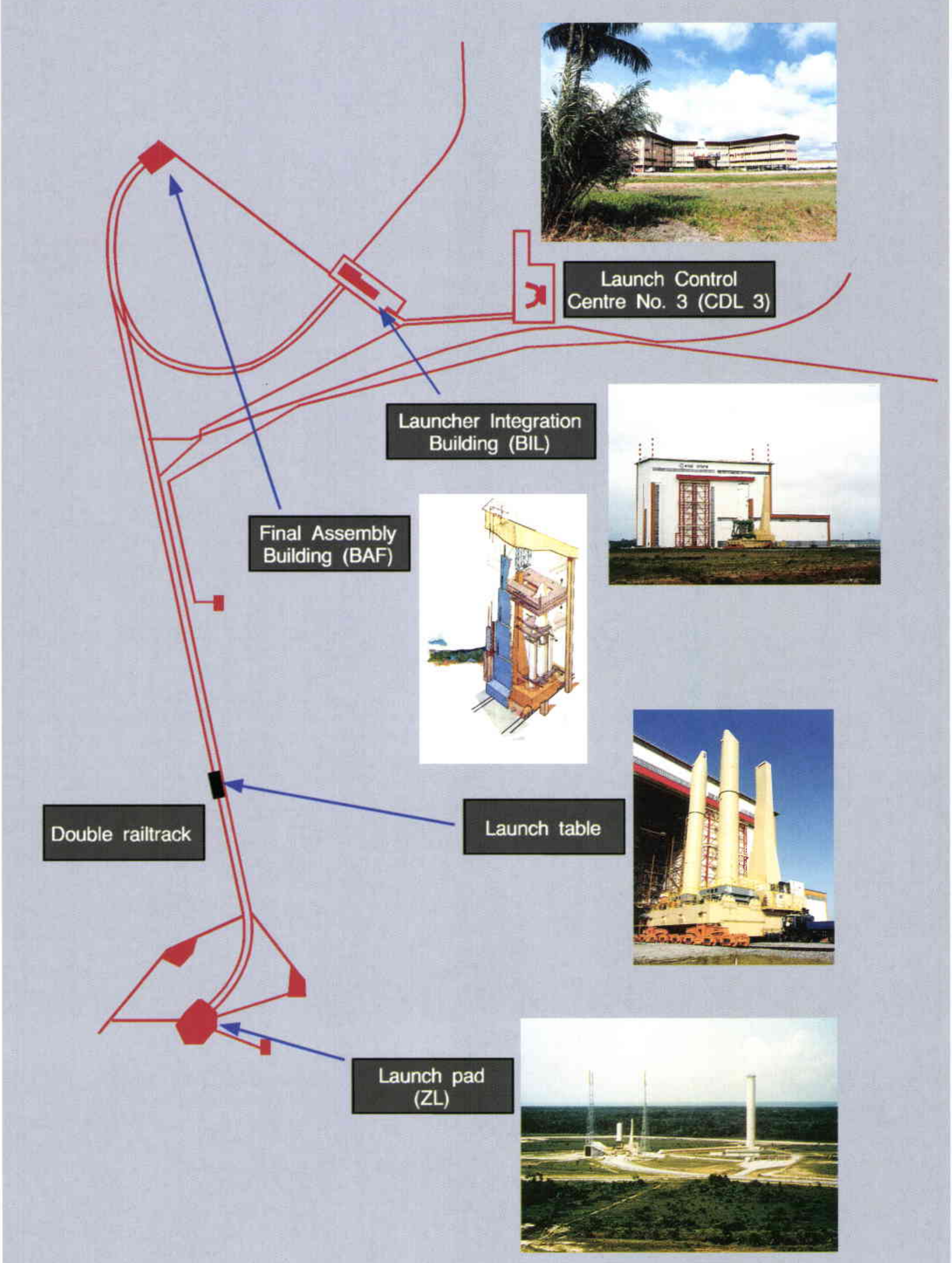
ELA2 is nevertheless a high-performance launch facility which is well suited to the most complex version of the Ariane-4 vehicle, the 44L, with seven liquid-fuelled stages.

Design and operations philosophy of the Ariane-5 ground facilities

The design of the Ariane-5 ground facilities began in 1987, upon ESA's approval of the Ariane-5 development programme. There were five major requirements:

- custom designed and built for the Ariane-5, a heavy-lift vehicle which is based on a different concept than its predecessors (One main, 155-tonne cryogenic stage, flanked by two solid propellant boosters weighing 230 tonnes each. On top of the main stage are the conventionally liquid-fuelled upper stage, the vehicle equipment bay, the payloads and fairings.)

Figure 2. Components of the Ariane launch area No. 3, ELA3



— a capacity of eight launches a year with a one-month interval between launches
— a low vulnerability, particularly in the event of a launcher explosion during the countdown or lift-off phase (In the case of an accident, the maximum amount of time foreseen to return the site to operational status is six months.)
— good availability, safety, reliability and maintenance, the first two criteria having priority
— optimisation of the cost of launch operations
— local manufacture of most of the propellants, in order to avoid transporting large, hazardous items across Europe and the Atlantic Ocean.

The philosophy behind the Ariane-5 ground operations is closely linked to the design of the launch site, and is based on the following principles:

— Full mechanical integration is performed at the Launcher Integration Building, without any intermediate functional checks so that the functional checks can be carried out in parallel on all the sub-assemblies.
— Electrical checkout equipment and procedures used at ELA3 for the launcher stages are identical to those used by the manufacturing contractors in Europe, thus allowing comparisons and the optimisation of procedures.
— Operations and checkouts are highly automated to improve reproducibility and safety.
— The launcher is fully checked out at the Launcher Integration Building prior to payload integration.
— The roll-out to the launch area takes place just before the final countdown for main-stage fuelling, thus limiting the time that the launcher is exposed to the outside environment. In addition, the vehicle can remain in the launch area if the launch is delayed, provided that no work on the launcher or its payloads is needed.

The Ariane-5 dedicated grounds cover about 2100 hectares and include the following units (Fig. 1):

— the booster area, comprising the Solid Propellant Plant, the Booster Integration Building, the test stand, and booster recovery and expertise facilities (see ESA Bulletin No. 75, The Ariane-5 Booster Facilities)
— the Ariane launch complex No. 3 (ELA3) (Fig. 2), which includes four main installations (the Launch Control Centre, the Launcher Integration Building, the Final Assembly Building, and the launch pad No. 3) and will be equipped with two mobile launch platforms or launch tables.
— Other systems, like fluids production and processing, remote checkouts and railtracks.

Construction work on ELA3 began in mid-1988. Some of the facilities are already being used for the development and qualification of the Ariane-5 launcher elements and stages:

— boosters are being tested at the booster test stand, where seven to eight tests are being carried out between 1993 and 1995
— cryogenic main stage 'hot tests' are being performed using the launch pad as the test stand. This eliminates the need for a stage test stand in Europe, and at the same time allows the qualification of the ground facilities, procedures and operating teams. Development and qualification tests are scheduled in 1994 and 1995.

The first two Ariane-5 qualification flights are scheduled for late 1995 and early 1996. The operational lifetime of Ariane-5 is expected to last until at least 2015.

Fluids manufacturing and processing facilities

The Ariane-5 main stage will carry about 130 tonnes of liquid oxygen, 14 times the volume of the present Ariane-4 third stage. A production plant, which was already on the ELA2 site for Ariane-4, has been upgraded to Ariane-5 requirements. It liquefies air to produce liquid oxygen (LOX) and liquid nitrogen (LN_2). It can produce 14 m^3 of LOX and 60 m^3 of LN_2 per day. The liquid oxygen is stored in five mobile tanks with a capacity of 140m^3 each and a sixth tank with a capacity of 20m^3. The nitrogen production capacity will soon be doubled to cope with increasing needs at the Guiana Space Centre's different sites. On the same site, air and helium are compressed and fed into special underground networks (Fig. 3).

The Ariane-5 will also carry 13.5 times the volume of liquid hydrogen that the present Ariane-4 carries (27 tonnes on an Ariane-5 as opposed to 2 tonnes on an Ariane-4). The traditional procurement of imported hydrogen containers was not suited to Ariane-5 needs in terms of logistics, economy and safety and it was found that the best solution was to invest in a new, on-site, highly automated liquid hydrogen production plant (Fig. 4). The new plant, which has been operational since 1992, produces liquid hydrogen by reforming methyl alcohol. It can produce up to 33 m^3 per day, to feed five 320 m^3 mobile storage tanks. Before each launch, three of the tanks are transported by road to the launch area, a distance of about 2.5 km. Specially-designed trailors equipped with a hydraulic hoisting system and rolling on eight axles (a total of 64 wheels), carry the tanks. After launch, these tanks are carried back to the production plant and reconnected to recover the 'boil-offs'. This recovery drastically reduces fluid loss during transport and transfer.

Launch complex No. 3 — ELA3

The basic concept used in the design of ELA2 has also been used for ELA3: separate preparation and launch areas. This concept has been adapted to the Ariane-5 vehicle, which is larger but simpler in design than Ariane-4.

Experience gained from ELA2 has been fully exploited in the design of ELA3:

- Vulnerability to accidents has been significantly reduced by simplifying the launch area: ELA2's sensitive mobile servicing gantry, which provides access to the vehicle at different levels and protects it from the weather, has been replaced by a fixed Final Assembly Building (BAF), located beyond the safety distance from the launch pad. The launch vehicle is only rolled out from the BAF to the launch area on its mobile platform for the final countdown (about eight hours before lift-off).
- The umbilical disconnection and reconnection process has been eliminated by using a simplified umbilical tower fixed on the mobile launch platform. The umbilicals follow the launcher from the beginning to the end of operations. This change was possible because the upper part of Ariane-5 is simpler than the Ariane-4's, and most of the umbilical connections can be made directly between the launch platform and the lower part of the vehicle.

Figure 3. The underground helium storage network being built (Photo: Bernard Paris)

- The computerised servicing checkout systems (remote monitoring and command of ground energy supply, air conditioning, fire detection and other systems) are independent of the launch vehicle checkout (remote control of vehicle fuelling, pressurisation, on-board electrical sytems and countdown procedures until lift-off).

Built near the ELA2 site, ELA3's two areas are:
- the launcher preparation area, which is composed of three operational buildings: the Launcher Integration Building (BIL), the Final Assembly Building (BAF), and the Launch Control Centre (CDL3)
- the launch area (ZL3).

The launch area is located about 1800 m to the north of the preparation area. The Launcher Integration Building is about 400 m from the Control Centre and 600 m from the Final Assembly Building. These distances are based on the results of safety studies performed during the early design phase and take into account pyrotechnics regulations.

The twin railtrack connecting the Launcher Integration and Final Assembly Buildings follows a curved path and is 1200 m long. The same track continues beyond the Final Assembly Building to the launch area, a distance of 2700 m.

Launcher Integration Building (BIL)

The Launcher Integration Building (BIL) is a steel structure that is 127 m long, 31 m wide and 58 m high (Fig. 5). It is divided into three parts: a storage hall, a main-stage erection hall, and an integration hall.

Figure 4. The liquid hydrogen plant which produces liquid hydrogen for both the Ariane-4 and Ariane-5 programmes (Photo: Bernard Paris)

Figure 5. The Launcher Integration Building (BIL) with the storage hall in the foreground. A mockup of the lower composite has been rolled out of the integration hall on a mobile launch platform. In the background, the Final Assembly Building is under construction (September 1993) (Photo: Bernard Paris)

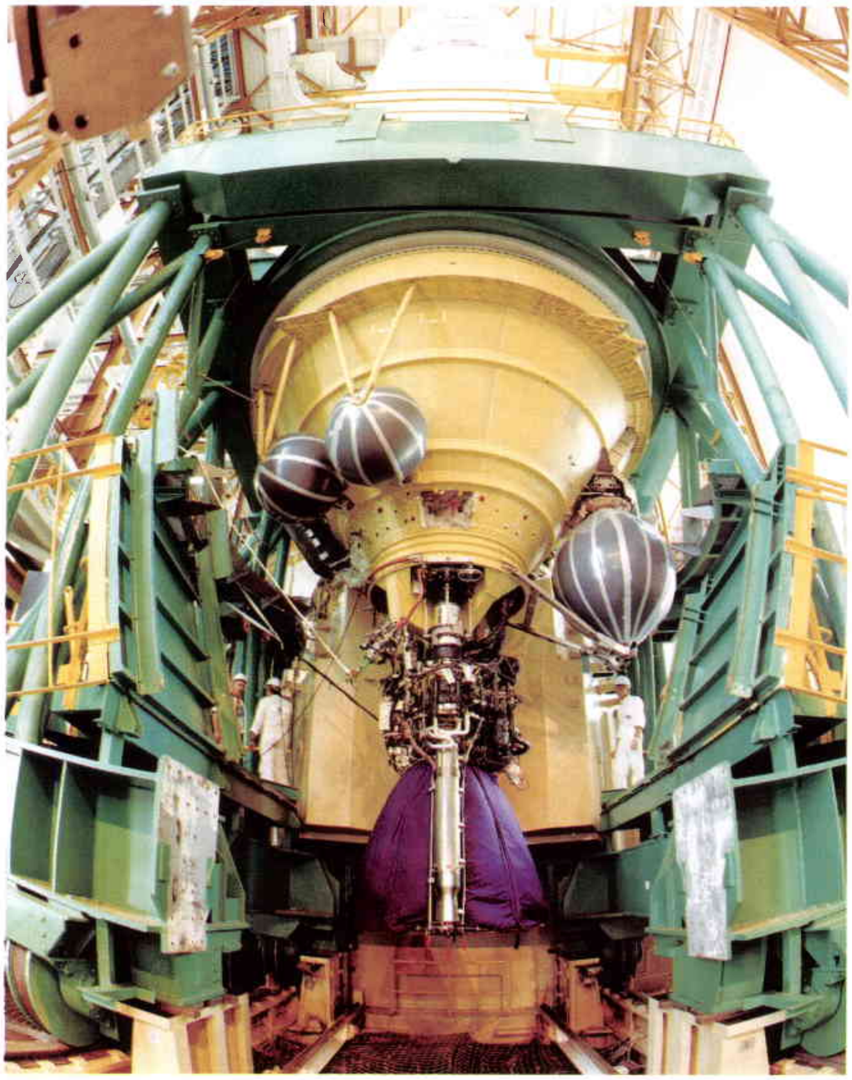


Figure 6. The 'battleship' version of the cryogenic main stage being assembled in the Launcher Integration Building. This reinforced stage will be rolled out to the launch pad for static hot firing tests ('battleship test campaign')

Storage hall
Upon their arrival from Europe after being transported by sea and road, the 30 m-long cryogenic main stage, the vehicle equipment bay and the upper stage, are stored in their shipping containers in the storage hall. The cover of the cryogenic main-stage container is removed, and the main stage is lifted out of its container and onto the erection supports. This hall is covered but not air-conditioned.

Main-stage erection hall
The main-stage erection hall is located in the rear part of the storage hall. It is fitted with a gantry for the erection of the main stage from the horizontal transport position to the vertical assembly and flight position. This hall is also covered but not air-conditioned.

Integration hall
The integration hall is separated from the erection hall by a sealed sliding door. Another door allows the boosters to be rolled in from the Booster Integration Building, in the vertical position on their transport trolley. Integration takes place on the mobile launch platform, i.e. the launch table. This hall is air-conditioned.

A seven-tiered steel structure, built above the launch table, provides access to the different levels for assembly and checkout operations. Special holding arms keep the main stage in a precise position during integration, until the mechanical connections to the boosters are made.

A third sliding door allows the whole lower composite (the main stage plus the upper stage, the vehicle equipment bay and the boosters mated on the launch table) to be rolled out in the launch position.

Operations performed
The operations performed in the Launcher Integration Building take 13 days and include:

- mechanical integration of the main stage (Fig. 6), upper stage, vehicle equipment bay and solid boosters on the launch table
- electrical and pneumatic connection of the umbilicals
- leak checks and functional checkouts
- installation of pyrotechnic and additional equipment, dynamic flight control and overall electrical checkout, and preparation for transfer to the Final Assembly Building.

Roll-out is carried out in a no-voltage configuration, with automated monitoring of pressure inside the main stage, to preserve the integrity of the common bulkhead between the oxygen and hydrogen tanks.

Final Assembly Building (BAF)

The Final Assembly Building (BAF) is a steel structure that is 85 m long, 52 m wide and 83 m high, and is fully air-conditioned.

It is divided into four main parts:

- The *payload encapsulation hall,* which is air-conditioned in the Category 100 000 with respect to cleanliness.
- The *integration hall* (Fig. 7) which has a lower part that allows access to the lower composite, in the same way as in the BIL, and an upper part, also Category 100 000, that allows access to the vehicle equipment bay, the payloads and the fairing. For the most common type of launch, one with a double payload, the lower payload is lifted through a clean chimney and mated directly onto the vehicle equipment bay. The upper composite is then mated on top.
- Other facilities are the *clean storage area*; the *main airlock* for receiving payloads and small launcher items; and the main vertically-sliding door which is 24 m wide and 62 m high to allow the vehicle to be rolled in and out.

Operations performed

The operations performed in the Final Assembly Building take eight days and include:

- roll-in from the Launcher Integration Building into the integration hall; mating of the upper payload onto the 'Speltra', a flight structure for multiple payloads, in the encapsulation hall

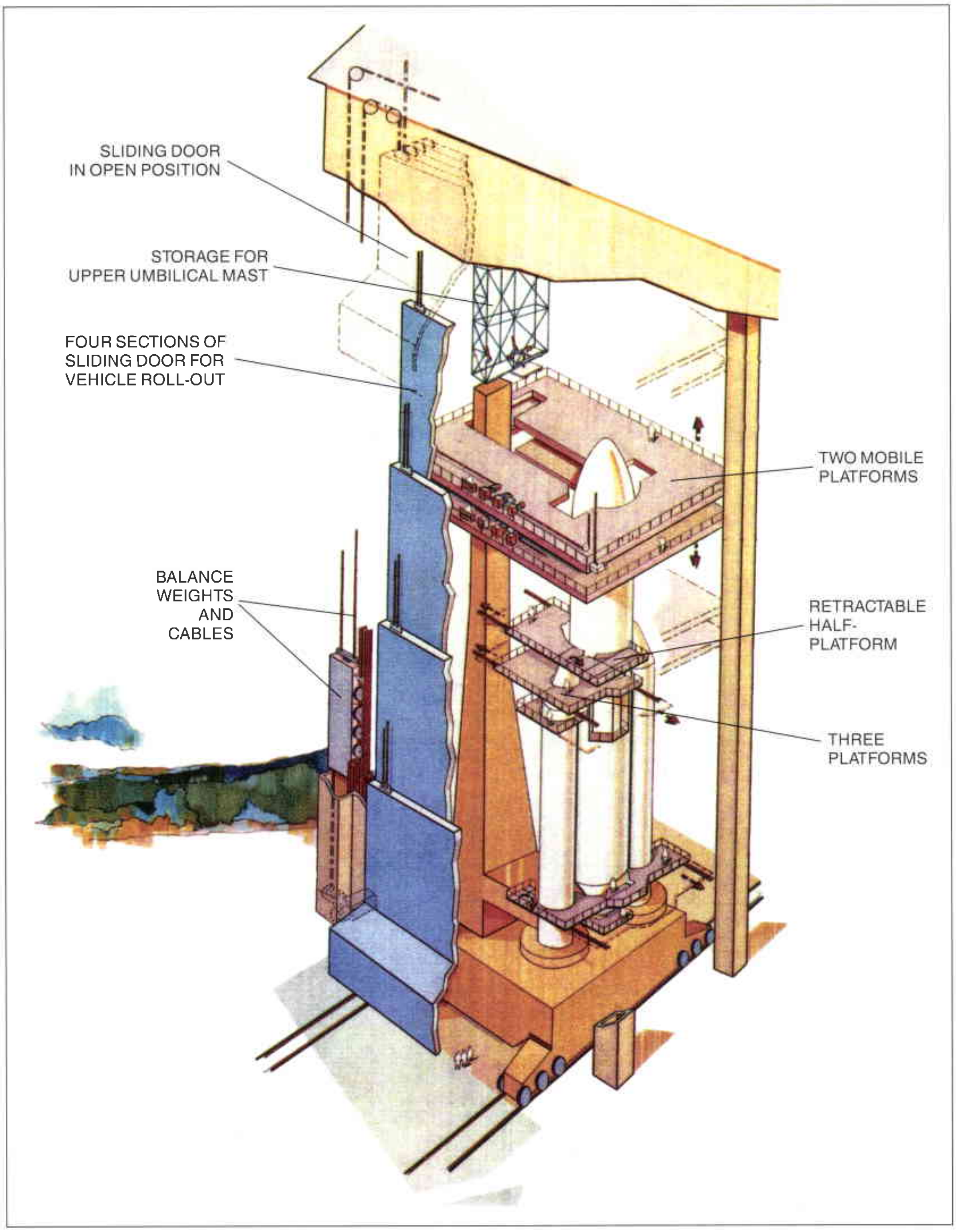


Figure 7. An artist's impression of the integration hall in the Final Assembly Building, with a launcher mounted on the mobile launch table, and staff on mobile access platforms working at different levels

Figure 8. Launch Control Centre No. 3, which includes two identical control rooms and three payload control rooms

Figure 9. Technicians use the utilities checkout system to monitor all sytems that do not directly interface with the vehicle, such as power, air conditioning and fire detection systems

- main-stage purging; assembly of the two fairing half-shells onto the Speltra, thus making up the upper composite; and transfer of the lower payload to the main airlock
- upper and lower payload checks; hoisting of the lower payload and mating on the launcher
- hoisting and mating of the upper composite; and preparation of the upper stage, solid boosters and main stage
- fitting of flight batteries on the stages and the vehicle equipment bay; payload checks; and final inspections
- loading of the upper stage with mono-methyl hydrazine (MMH) (automated and remotely controlled from the Control Centre) and the attitude control system with hydrazine (manually); and a dry run of the general launch countdown to check range safety interfaces and tracking and telemetry stations
- automated and remote loading of the upper stage with N_2O_4; payload arming; and upper part inspection

- launcher arming; remotely controlled pressurisation of the main stage and booster high pressure vessels; and remotely controlled loading of the main-stage liquid helium sphere
- roll-out to the launch area.

Many of these operations form part of a typical launch countdown sequence, which is usually carried out on the pad. However, in order to reduce launcher vulnerability and keep the launch pad as simple as possible, the operations are carried out in the BAF at a safe distance from the pad.

Construction of the BAF started in mid-1993 and should be completed during the first quarter of 1995.

Launch Control Centre and checkout systems

The Launch Control Centre (CDL3) (Fig. 8) is made up of two main areas:

- an office and computer area
- an area housing two fully independent vehicle checkout control rooms (allowing the monitoring of two launchers simultaneously), and three payload control rooms. That area is reinforced to protect personnel and equipment during a launch.

The checkout systems are used for remote control and command of electric and fluid processes, both for the ground facilities and on the launcher itself. Four main sub-assemblies have been developed:

- the utilities checkout system
- the operational checkout systems
- the upper section checkout system
- the payload checkout systems.

Utilities checkout system

The utilities checkout system (CCS) (Fig. 9) is used to monitor and control remotely the site's power, air conditioning, fire and gas detection systems. These controls are needed on a permanent basis, and have no direct link to the launch vehicle. The fully backed-up system includes several consoles in the Control Centre connected to front-end processors located in each ELA3 building and inside the launch table, and a 'supervisor' that automatically detects malfunctions and switches to the back-up system. In case of a technical alarm during non-working hours, the system uses the paging network to notify the appropriate on-call technicians.

Operational checkout systems

The operational control and checkout systems (CCO) (Fig. 10) are two independent command and control chains for the management of the launch vehicle's fluid and electrical systems until lift-off, and the corresponding ground interfaces. Each system has a dedicated control room in the

Control Centre, and can be connected to either launch table, thus allowing the monitoring of two launch campaigns simultaneously (with one vehicle in the Launcher Integration Building, and the other in the Final Assembly Building or in the launch area). The system architecture includes front-end processors located inside the launch table and in the launch area terminal building, processing units located in the Control Centre, and networks and dialogue peripherals to complement the control room consoles.

Each of the two operational control systems is fully backed up, and includes an independent safety chain that allows a return to a safe configuration, independently of the hardware and software status of the functional systems. On yet another level, a fully independent manual system can override the automated systems to restore a safe environment in case of failure, in particular through cryogenic main-stage draining.

A new philosophy has been adopted for the Ariane-5 checkout systems, representing an innovation in the Ariane programmes. A whole 'family' of checkout systems is being developed using the same specifications for the 'stage' checkouts in Europe and in Guiana, as for the CCO in Guiana. This approach has two main objectives:

- to minimise development costs
- to ensure that controls among the different checkout systems are standardised, so that the same stage-level tests performed at the production sites in Europe can be repeated during the launch campaign in Guiana and can be compared in a coherent way.

Upper section checkout system
This system is used for the functional checkout of the upper composite wiring before and after the integration of each unit, i.e. the Speltra, fairing, and payload adaptors.

Payload checkout systems
The payload checkout systems allow permanent control and command of the spacecraft during assembly and roll-out operations. They are provided by the spacecraft manufacturers.

The main checkout system is located in the S1, a payload processing facility 20 km from ELA3. The checkout terminal equipment (COTE) is located closer to the spacecraft: in the S3 payload fuelling facilities during fuelling or apogee motor integration, and in the Final Assembly Building and inside the launch table during payload encapsulation, roll-out and countdown. The COTE is monitored through remote consoles located in S3 or in the Control Centre. During roll-out operations, the remote consoles are linked to the COTE by radio frequency links.

Figure 10. One of the two dedicated control rooms with the operational control and command system consoles (Photo: Bernard Paris)

Launch tables and launch zone
The ground facilities include two identical launch tables, allowing a minimum interval of one month between two consecutive launches. Each table is a mobile launch platform serving as a support for the vehicle from the beginning of integration until lift-off, and accommodating fluids, checkout, power supply and air-conditioning systems. Each table is a steel structure which is 25 m long and 21 m wide, and weighs about 1000 tonnes without the launcher. It travels along a twin railtrack on 16 two-axled bogies at a maximum speed of 4 km/h, and is pulled by two special tractors. The tables also incorporate the umbilical mast and all the ground-to-onboard electrical and fluid connections.

The launch area (ZL3) (Fig. 11) is of a very simple and flat design, and is used only for the final countdown. It comprises:

- a concrete launch pad foundation to anchor the launch table. The foundation has a central flame trench with a water-cooled steel deflector for the cryogenic main stage engine. This trench is flanked by two covered, curved trenches for the two solid-propellant boosters. The outlets of the trenches are flooded with water to reduce noise. Test campaigns have been carried out in Europe with small-scale models of the Ariane-5 vehicle and the launch area in order to simulate and optimise the noise reduction systems
- a low terminal building adjoining the pad, housing the electrical, command and fluid equipment, and the ground-to-table interfaces (Fig. 12)
- mobile tanks for storing liquid oxygen, hydrogen and nitrogen, located about 200 m from the pad

Figure 11. A lower composite mockup being rolled away from Launch Pad No. 3. Between the lightning protection towers (on left, with red tops) is the low terminal building which houses the electrical command and fluid equipment, and the ground-to-table interfaces. One of the two deflectors for solid booster exhaust can be seen on the left (below the lightning tower), and the water tower is in the centre of the photo. The Atlantic Ocean is only a few kilometres to the north. (Photo: Bernard Paris)

Figure 12. Inside the low terminal building, with the cryogenic feeding lines and all electrical and control systems for an automated, remote countdown management from the Control Centre (Photo: Bernard Paris)

— a pool for burning the vented gaseous hydrogen, a water tower feeding the various deluge operations, and four lightning protection towers.

Operations at the launch area include, after roll-out and reconnection of the table:

— remote controlled countdown operations: six hours for purging, loading, topping up and pressurising the main stage with liquid oxygen and hydrogen; and activating and checking the on-board electrical circuits
— final synchronised sequence: a six-minute, fully automated, sequence of controls and commands carried out by the operational checkout system and synchronised with the overall range countdown.

Range modernisation

In addition to the investments in the dedicated Ariane-5 facilities, the CNES support systems at the Guiana Space Centre are being upgraded or replaced by systems that are more modern and reliable and which are compatible with Ariane-5. ESA is financing the majority of the project while CNES is performing the engineering, procurement and implementation.

A modernisation programme, called CSG 2000, began in 1991. It includes:

— *Tracking and flight path quick-look display*: upgrading of radars, and renewal of data processing systems in order to ensure a lifetime until the year 2010 or 2015, to improve flight safety performance and to reduce running costs.

- *Ground communications system:* renewal of the operational and business communications systems, based on a fibre optic network with central configuration management, which will include new telephones, faxes, intercoms, and data and video terminals.
- *Telemetry and flight termination systems:* adaptation of the processing system to the Ariane-5 telemetry format; upgrading of antennae; extension of data storage, data transmission and remote control of ground stations. For launches into Geostationary Transfer Orbit (GTO), ground stations are located in Kourou, Natal (Brazil), and Ascension Island. A fourth station will be located in either East or South Africa.
- *Weather forecasting, safety and operations coordination:* construction of a new mission control centre (called Jupiter 2) with more reliable, automated configuration and count-down management systems; development of new planning software and general space-port-wide safety coordination; improvement of weather observation, statistics storage and forecast systems.
- Other new investments including photo and video systems (including infrared tracking cameras), construction of a large conference room, a new space museum, new launch observation sites, and new back-up energy supply and air conditioning installations.

These projects are being implemented without hindering current Ariane-4 launch operations. Some of the projects are partially implemented and qualified, and are gradually providing support to Ariane-4 missions.

Testing and qualification of the ground facilities

The use of the launch pad as a test stand eliminates investment in a special test stand in Europe but, on the other hand, scheduling of ground and flight hardware qualifications is more interdependent and has to be done more carefully. Each subsystem is tested at the supplier's premises in Europe before it is shipped to Kourou. Another test is performed at the subsystem level after installation in Kourou (called Phase 1), and is followed by a series of tests (Phases 2 to 5) in which more and more subsystems and more and more automated control and command systems are added, before the actual, global system test (such as a hot test of the cryogenic main stage on the launch pad) is performed.

In 1991, the utilities checkout system was installed and checked; it has been operational since that October. In 1992 and 1993, the first fuelling tests of a main-stage mockup (called the 'battleship' version) were performed on the launch pad. They validated the ground systems and manual procedures for handling liquid oxygen, liquid hydrogen, nitrogen, and helium. Related systems were also tested: venting and burning of the Vulcain engine cooling hydrogen, fire extinguishing, water deluge (Fig. 13) and associated control and command systems.

In 1994, the first operational control and command system (CCO) is being installed and tested, to allow the first main stage hot tests ('battleship' campaign) in the same year. One maturation (M) and one qualification (Q) campaign are scheduled for late 1994 and early 1995 using flight-type main-stage reservoirs and the Vulcain engine. During these campaigns, nominal as well as some non-nominal situations such as an aborted launch are rehearsed, and the performance of the backup and the safety systems is verified.

A major mechanical validation campaign, called MDO1 was performed in September 1993 in the Launcher Integration Building (Fig. 5), with the integration of two boosters and one main-stage mockup of the mobile launch platform. Three more major mechanical validation campaigns are scheduled before the launch campaign for the first flight (in 1995). They will involve, apart from the Launcher Integration Building, the Final Assembly Building and the launch pad.

Closing remarks

The Ariane-5 ground facilities and range modifications will be ready for the first Ariane-5 launch at the end of 1995. Before that time, the facilities will be used for static test firings of the solid boosters and the cryogenic main stage. They will also be used for Ariane-5's two qualification flights. The total investment is expected to be roughly one billion ECUs, which includes the cost of operations and testing until the first commercial flight in 1996. The facilities are then expected to be used commercially for at least 100 launches. The aim is to retain, with Ariane-5, the 50% share of the commercial launch market that Arianespace currently enjoys with Ariane-4.

The ground facilities will satisfy all of their design requirements. The objective of eight launches per year with the possibility of two successive launches one month apart, will be easily achieved because two launch campaigns can be conducted simultaneously with, for instance, one launcher in the preparation phase in the Launcher Integration Building while a second one is in the Final Assembly Building and launch area. This is possible because ELA3 has two operations rooms, two launch tables and two operational checkout systems.

Figure 13. Testing the water deluge system on the launch pad. A booster mockup (in beige) on its launch platform is on the far right. The three trenches for the exhaust from the main engine and the two solid boosters are at the bottom centre

A low vulnerability rate has also been achieved through the very simple design of the launch area, stripped of all but the most essential equipment, and through the use of mobile storage facilities and two launch tables. Good reliability, maintenance, availability and safety have been made possible by building redundancy into the fluids process and operations command and control systems, and by setting up safety systems that are completely independent of the operational systems. The very high degree of automation in operations also makes for considerable gains in availability during countdown and safety since the risk of human error has been drastically reduced.

During the Ariane-5 development phase (until and including the second qualification flight in 1996), CNES and its European subcontractors are operating the ELA3 facilities. The industrial structure for the subsequent, commercial phase, i.e. the companies or groups of companies that will be responsible for the maintenance and operations of the various systems, is now being established. Arianespace will manage the operation. The industrial organisation must take into account the resources and synergy needed for the overlap phase between 1996 and 1999 during which the ELA2 and ELA3 complexes will operate simultaneously to ensure a smooth transfer from Ariane-4 to Ariane-5. Special production facilities, such as the booster area and the liquid hydrogen and oxygen plants, are operated under direct industrial responsibility.

The short duration of launch operations (22 working days) contributes to the objective of reducing launch costs by 10% compared to the cost of launching the most powerful version of Ariane-4 (the 44L version). This short launch-campaign is possible because of the design of the facilities and the way operations and the principles that apply to them are organised: automation, checks done in parallel for all the stages and the fact that checks done in Europe can also be performed in Kourou.

With minor modifications, these facilities can also be compatible with Ariane-5 crewed and cargo missions — now under study — to future space stations.

Simulation of the Landing of a Re-Entry Vehicle Using Eurosim

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A flight simulator that reproduces the landing of an unpowered winged vehicle in real time, was developed on Eurosim, ESA's European Real-time Operations Simulator. The simulation can be run in either an automatic mode in which the performance of various landing strategies can be assessed, or in a semi-automatic mode in which a pilot can land the plane manually and the man-machine interface can be tested. The simulator proved to be a useful testbed for evaluating the Eurosim facility and some of its recently-improved features.

Introduction

Eurosim, the European Real-time Operations Simulator developed by ESA, is a generic facility for the development of real-time simulators. Until recently, Eurosim applications have been mainly related to the real-time simulation of in-orbit technology, such as rendezvous and docking of two spacecraft, and manipulations with a robot arm. A new application in the area of landing technology, however, has been jointly developed by ESTEC and the Japanese Space Agency, NASDA.

This simulator reproduces in real time the flight phase of an unpowered winged vehicle as it re-enters the atmosphere and lands, and more specifically the terminal phase from an altitude of 24 kilometres and a Mach of 2.5 until the vehicle's touchdown on the runway. The work was undertaken in cooperation with Tatsushi Izumi of NASDA's Tsukuba Space Center during his one-year stay at ESTEC.

A research entry vehicle, which had been developed in previous ESA Technological Research Programme studies, was used in the simulation. All the flight phases of a landing approach were replicated: the supersonic glide, the energy-management turn, and the final phase with steep slope, pre-flare and final flare. A guidance strategy was implemented and its performance was evaluated with respect to typical perturbations: atmospheric changes, winds, aerodynamic uncertainties, and navigation errors. A man-machine interface was also developed to allow the manual control system used in the landing of the spaceplane to be studied.

In addition to enabling the landing technologies to be analysed, this simulator has proven to be a useful testbed for evaluating the Eurosim facility and some of its features, like the graphic user interface, post-simulation data analysis, and hardware-in-the-loop, that have been recently improved.

The Eurosim facility

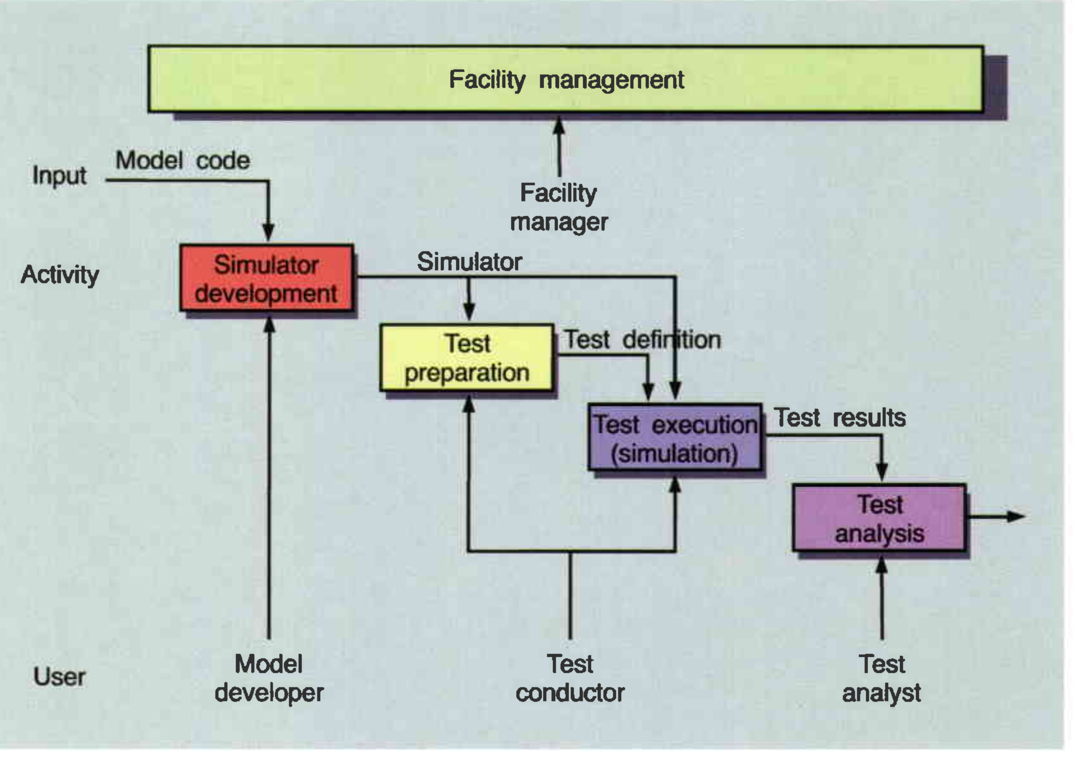
The operational version of Eurosim was developed for ESA by Fokker Space and Systems through funding from the Netherlands Agency for Aerospace Programs (NIVR).

A real-time simulation environment

Eurosim is a complete real-time simulation environment, supporting the user from the initial task of developing an application model that replicates a real world system, to the final task of analysing the simulation results. Figure 1 shows the activities performed within the Eurosim environment:

— *Simulator development:* The user, who does not have to be a simulation specialist, develops or is involved in the development of the source code for an application model and the associated files such as geometry data for image generation, definition of the operator screen, and interfaces with hardware devices.

Figure 1. Process for developing and testing a Eurosim simulation



— *Test preparation:* The user defines the test conditions for a particular simulator, i.e. the initial conditions, the simulation scenario (including failures), stimuli (to replace real world inputs) and the data recording requirements.

— *Test execution:* The test conductor is responsible for controlling the execution of the simulation run according to the predefined scenario. The test conductor can also modify the scenario at any time while the test is running, for example, to introduce failures.

— *Test analysis:* The results of the simulation run are processed and analysed, and images from the simulation run can be replayed.

— *Facility management:* The facility and the various applications are maintained under configuration control. This includes a library of all validated application models, which can be accessed and reused by any simulation developer.

All phases of the simulation lifecycle are supported by graphically interactive tools.

A generic simulation environment

The facility can support a wide variety of application models. It is an 'open' simulation platform, which means that the user can integrate into Eurosim an application model developed using a facility other than Eurosim. For instance, the model source code can be automatically generated by a design tool outside the Eurosim environment and 'ported', with a minimum amount of effort, into the real-time simulation environment. In addition, since one of the objectives of the facility is that the developer should not have to be a simulation expert, most of the details relating to the writing of the simulation will be hidden to the developer.

To allow an open interface, the application model must fulfil two conditions:

— It must be written in Fortran, C, C++, Ada or a combination of those languages.

— It must comply with the Application Programming Interface (API), a standard currently being developed by ESA for its real-time simulators. The API will be part of the Model Interface Control Document for real-time facilities, enabling the exchange of model software between facilities or the use of different development tools.

A reconfigurable simulation environment

Eurosim is a reconfigurable environment both from a software and a hardware point of view. Software reconfiguration means that the same piece of software can be reused for different types of applications. Once a model software has been implemented and validated in Eurosim, it is stored in a library where it can be accessed by any future project.

Hardware reconfiguration is an essential aspect of Eurosim. Through the use of standard interfaces, it is possible to incorporate a user such as a pilot in the system (called 'man-in-the loop') and test different types of scenarios. Hardware can also be included in 'the loop'. Eurosim can then be used, for example, to test an on-board computer and to verify the behaviour of flight-standard hardware. It can also be linked to other simulators, to allow an on-line exchange of data between complementary simulation facilities. Eurosim can thus support a test on a dedicated test bench by providing simulated data for the missing components.

The layout of a typical Eurosim simulator is shown in Figure 2. Such a generic, reconfigurable facility can be adapted as a project evolves, from the design phase through to the operations phase. For example, a basic simulator developed during the design phase of a project can evolve into a full, high-fidelity software simulator. Later, hardware items can be incorporated into the system as they become available and, eventually, the simulator can be used to support integration, validation and operations.

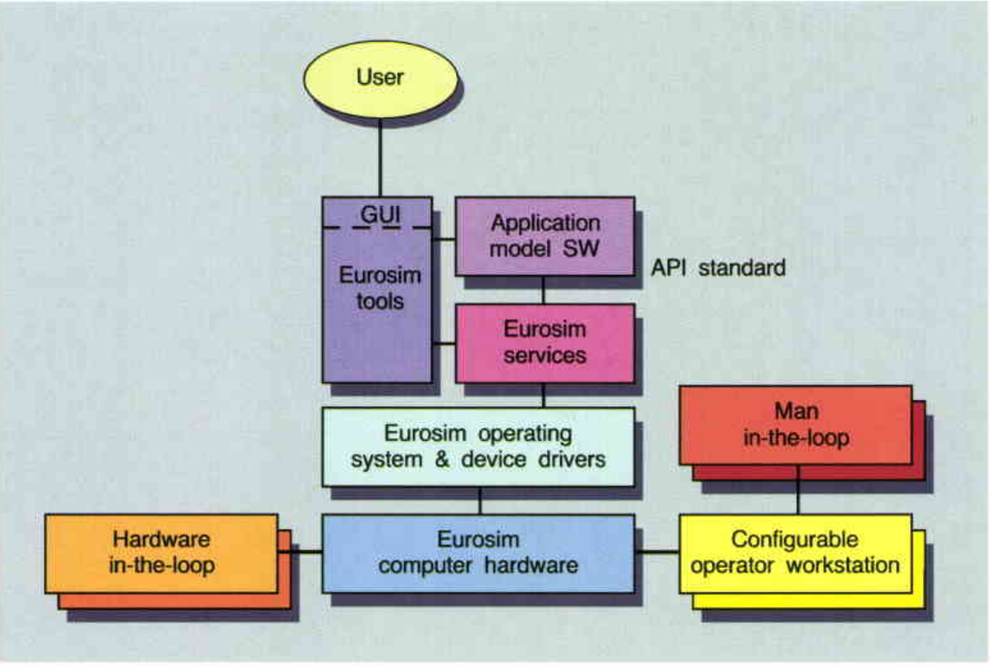


Figure 2. Layout of the Eurosim simulator

Landing guidance strategy

When a spaceplane is flying in orbit, it is travelling at a very high speed, at around 7 kilometres per second, and at an altitude of 400 km. As it prepares to return to Earth, it must re-enter the atmosphere (at an altitude of 120 km) and decelerate and descend very quickly, landing on a runway within two hours (or 30 minutes after re-entering the atmosphere). As it re-enters, the spaceplane becomes very hot because it has to dissipate its high kinetic energy. Thus, this phase is called the 'hot hypersonic flight phase'.

The computerised control system that guides the spaceplane during the landing, i.e. the terminal guidance system, therefore has two important functions. First, it has to correct the spaceplane's energy error, i.e. its actual energy compared to its optimal energy, at the end of the hot hypersonic phase. Secondly, it has to control precisely the spaceplane's position and velocity until the touchdown on the runway.

The energy management technique that was selected for the simulation is based on a classical turn on a predefined, circular track to align the spaceplane with the runway axis before landing. The turn is used to manage the spaceplane's energy. Its angle is dependent on the spaceplane's energy level.

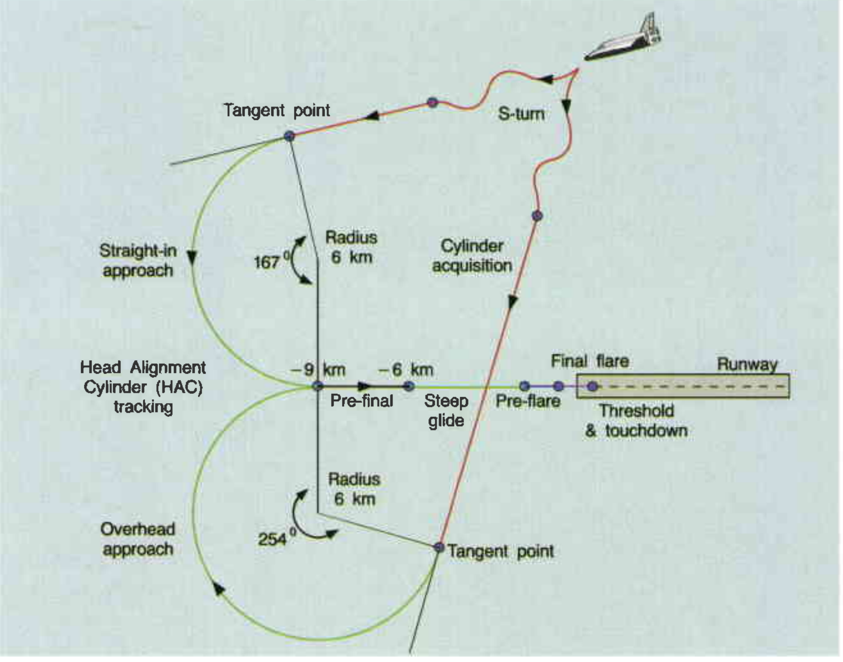
Horizontal trajectory

Figure 3 shows a typical horizontal trajectory for the spaceplane's terminal approach. Several sub-phases can be distinguished:

— *S-turn:* At the end of the hypersonic phase, if the spaceplane's energy exceeds a predefined limit, the spaceplane executes an S-shaped turn in order to dissipate that excess energy.

— *Cylinder acquisition phase (or supersonic glide):* The spaceplane glides toward a tangent point at which it will begin a second turn. One of two strategies is then used depending on the energy level: the spaceplane uses a 'straight-in' approach, making a turn of less than 180 degrees from the tangent point or, when more energy must be lost, an 'overhead' approach, making a turn of more than 180 degrees from the tangent point.

Figure 3. The spaceplane's horizontal trajectory during the terminal approach and landing. Two approach strategies are shown: a straight-in approach (top) with a turn of less than 180° starting from the tangent point, or an overhead approach (bottom) with a turn of more than 180°, used to lose more energy



— *Heading Alignment Cylinder (HAC) tracking:* The spaceplane flies in a large circle, as if it is flying around a cylinder. The purpose of the 'cylinder tracking' is to manage the energy level and to align the spaceplane with the runway.

— *Pre-final phase:* When the spaceplane is directly aligned with the runway, at a distance of about 9 km from its target, the runway threshold, it begins its transition to the final phase.

— *Final phase:* At 6 km from the runway threshold (Fig. 4), the spaceplane goes into a steep glide, with a slope of about 20 degrees. At an altitude of 230 metres, it initiates a 'pre-flare', where its nose is pulled up to lower the spaceplane's speed. At an altitude of 15 metres, the spaceplane goes into a second flare, the 'final flare' and, only 15 seconds before touchdown, the main landing gear is deployed and the spaceplane then touches down.

Vertical guidance
The vertical guidance system must ensure a smooth transition between two guidance methods: an energetic guidance method during the hot hypersonic flight (where it relies on an energy formula) and a geometric one during the terminal phases (where it shifts to using position coordinates) — the end objective is to land on a geometric target, the runway.

To ensure a smooth transition, there are two intermediate modes of vertical guidance: geometric altitude tracking and reference energy tracking. They are complemented by another method, dynamic pressure control. Dynamic pressure has to be maintained between a minimum and a maximum limit. Otherwise, the spaceplane would either not be able to reach the runway or would exceed its structural limit and become disabled.

The vertical guidance system controls the vertical load factor and the spaceplane's speed brakes, mobile surfaces that act as brakes in the same way as the spoilers on a standard aircraft's wings do.

Special attention is paid to the design of the guidance system for the final flare, the most important phase for an accurate landing. The accuracy of the measurement of the altitude and of the vertical speed are vital. In addition, the 'ground effect', where air compressed between the spaceplane and the ground, usually when the spaceplane is at an altitude of less than 10 metres, tends to push the plane back up, has to be compensated for in order to avoid a crash due to a 'pitch-down' perturbation.

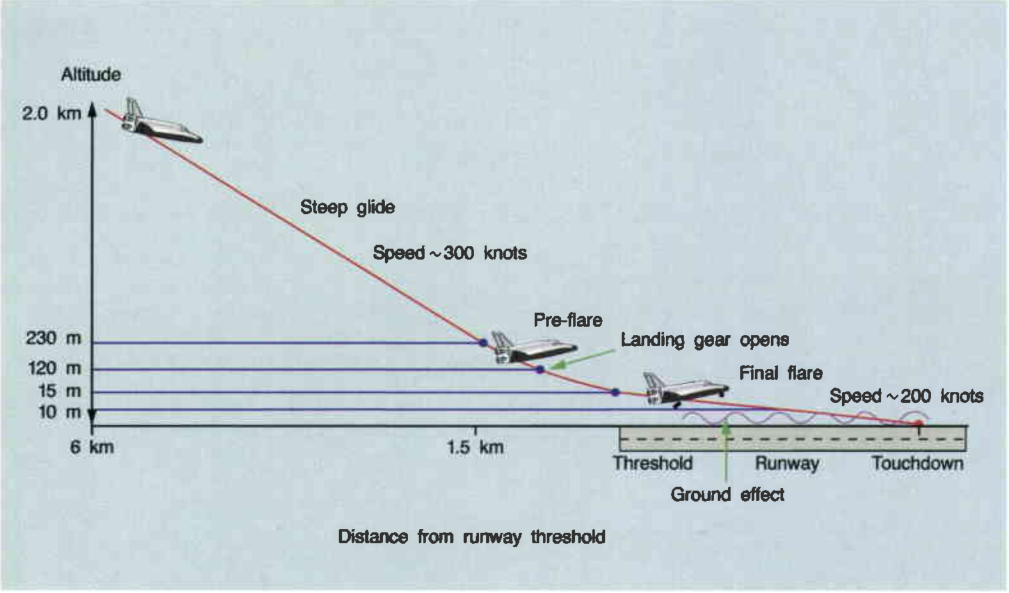


Figure 4. The vertical trajectory during the final landing phases

Guidance strategy
The guidance system must involve algorithms to account for and remove initial perturbations induced by winds, errors in the atmosphere model, and aerodynamic and navigation errors. There are two types of guidance systems: horizontal and vertical.

Horizontal guidance
During the various flight sub-phases, the horizontal guidance system computes the required bank angle for the vehicle to achieve an S-turn (to ensure that, upon completion, the excess energy is dissipated), the tracking of the tangent point, the cylinder tracking and finally the tracking of the runway centreline.

Evaluation of Eurosim's landing strategy
General description of the simulator
As shown in Figure 5, the guidance strategy is implemented in the Eurosim environment along with a flight mechanics propagator which simulates the environment, a simplified navigation estimator which identifies where the spaceplane is, and an attitude controller. Together, those systems ensure that the approach and landing are reproduced in a realistic way and in real time.

Two possible simulation modes are introduced: an automated mode in which the guidance, navigation and control (GNC) system controls the spaceplane during the landing, and a manual mode in which a human can override the automatic system and control the spaceplane during the approach and landing.

The flight simulated in this exercise was a typical one: the spaceplane executes an overhead strategy starting at an altitude of 24 km, a ground speed of 600 m/s and a distance of around 50 km from the runway. Typical landing conditions were also used:

- a touchdown point on the runway's centreline, at a distance of 400 m from the threshold
- a touchdown speed of 200 knots ± 20 knots (100 m/s)
- a vertical descent speed of 1 to 3 m/s
- a typical pitch attitude of 5 to 10 degrees.

Evaluation of the automated landing mode

Eurosim's well-designed user interface enables the performance of the guidance system to be evaluated in the presence of typical perturbations, including:

- dispersions of the position/velocity/energy at the end of various key phases of the flight: the hot hypersonic phase, HAC tracking, and the steep slope
- wind models derived from NASA models
- position/velocity navigation estimate errors
- errors in the prediction of the aerodynamic properties of the spaceplane
- ground effect models.

The analysis confirmed some anticipated findings:

- *S-turn:* It has proved to be a useful manoeuvre for coping with unexpected, initial conditions at the end of the hot hypersonic phase.
- *Winds:* This perturbation is the most difficult one to compensate for. It is a main contributor to landing errors.
- *Ground effect:* The 'robustness of guidance' with respect to ground effect is an important design driver for the final flare phase.
- *Navigation error:* An error in the measurement of the altitude appears to be a critical point for the guidance system.

Evaluation of the manual landing mode

The manual mode was designed to be used in two ways: by a pilot on board the spaceplane to override the automatic GNC and land the spaceplane, or as a back-up means for a pilot on the ground to remotely take over the operation of the spaceplane and land it. The spaceplane would be equipped with on-board cameras that enable the pilot on the ground to control the plane as if he is in it.

To test the manual system and the man-machine interface, the following equipment was installed in a mock-up of a cockpit (Fig. 6):

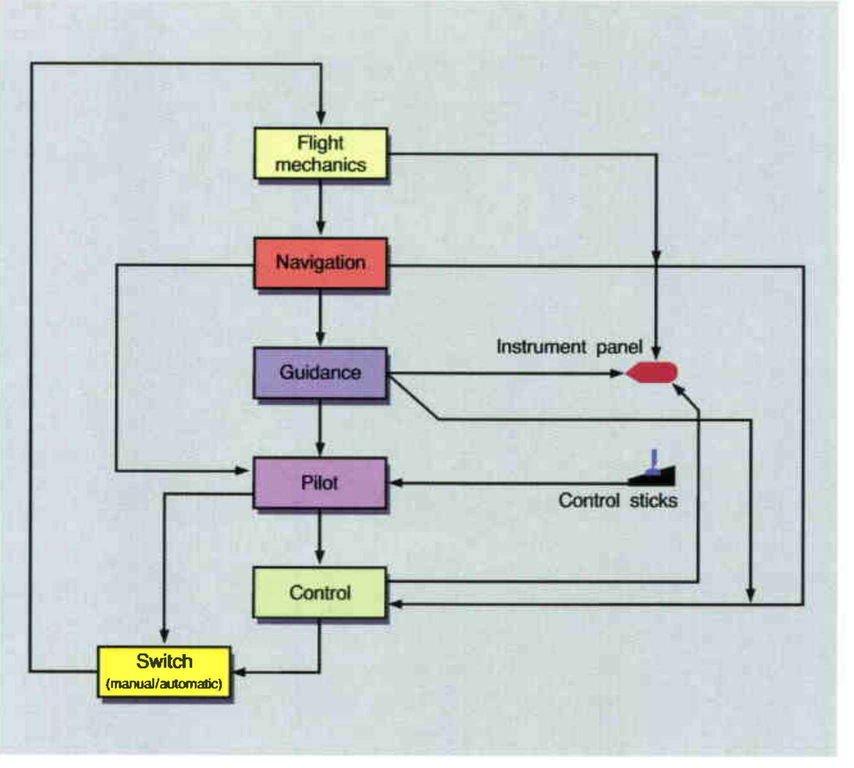


Figure 5. Block diagram of the simulation

- two control sticks that the pilot uses to command the spaceplane
- a computer screen for landscape visualisation, a head-up display (HUD) that indicates the spaceplane's actual and optimal data (Fig. 7 and 8) and an instrumentation panel.

The left control stick is used to control the speed brakes (or equivalently the speed of the spaceplane). The right stick has two control functions:

- the stick's 'pitch' axis controls the vertical acceleration
- the stick's 'roll' axis controls the bank angle of the spaceplane.

Figure 6. The cockpit mock-up with a screen displaying the guidance system and the instrument panel (see the larger screen in Fig. 7 and 8), and a control stick that the pilot uses to control the spaceplane (the second stick is not visible)

HEAD-UP DISPLAY (IN YELLOW)

INSTRUMENT DISPLAY

Figure 7. The screen as the pilot sees it during the cylinder tracking phase, with a visualisation of the local landscape (top), a simplified model of the head-up display (top, yellow overlay), and the instrumentation panel (bottom)


SPACEPLANE SYMBOL

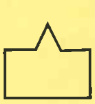

ENVELOPE SYMBOL

Figure 8. The screen showing a simplified model of the head-up display during the final phase before landing on the runway

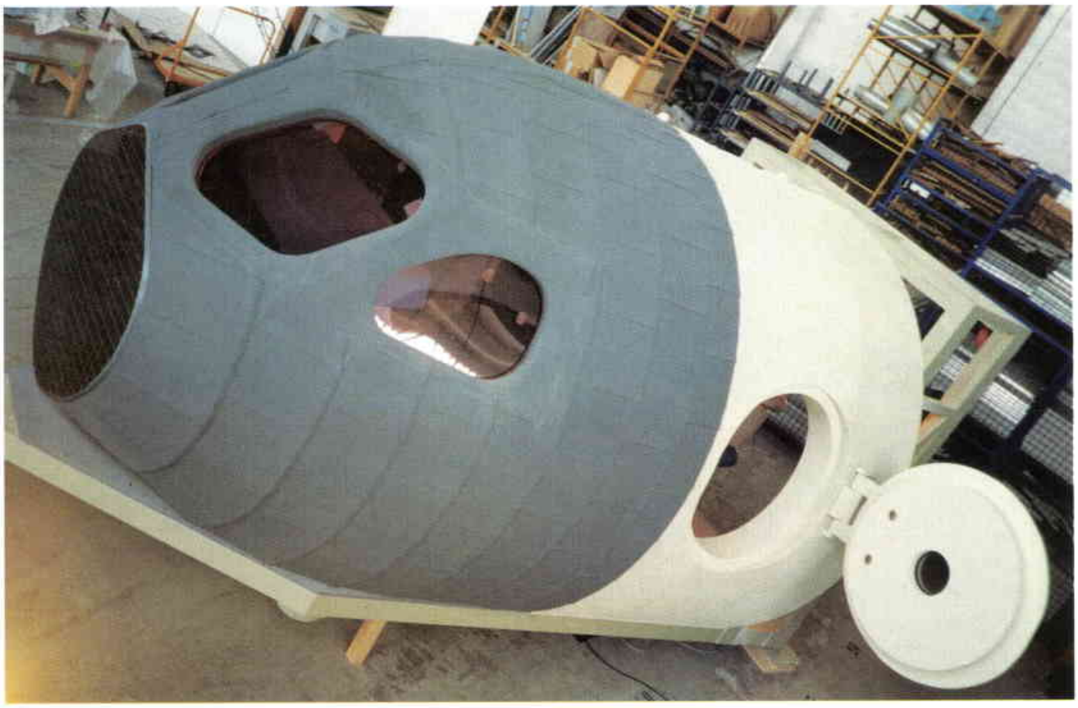


Figure 9. The more advanced, reconfigurable mock-up now being built for a project with the Technical University of Delft (NL)

To control and land the spaceplane successfully, the pilot must perform the following using the control sticks:

— Keep the arrows that are displayed on either side of the HUD, within the semi-circles. The left vertical line represents the vertical acceleration and the right one represents the speed brake position. The semi-circle is the guidance command, and the arrow is the pilot command.

— Keep the cross displayed in the middle of the HUD, inside the 'envelope' symbol (which indicates the ideal attitude as computed by the guidance system).

The circle at the bottom of the HUD indicates the spaceplane's imaginary crash point.

In addition, an instrument panel provides the pilot with standard flight information: altitude, load factor, air speed, vertical speed, Mach, roll and pitch, heading, speed brake activation, and guidance messages (the guidance mode and the flight phase). The evaluation, however, shows that the pilot is usually too busy monitoring the head-up display and using the control sticks to look at the instrumentation panel.

Conclusion

The development of this new application using Eurosim has demonstrated the facility's generic capability: GNC specialists, who are not necessarily real-time simulation experts, can implement their own code in the simulator environment.

By imposing modularity of the software code and stressing model software reusability, this simulator can now be adapted to simulate different types of vehicles such as a re-entry capsule or a return stage of an advanced launcher.

In addition, the experience gained in this project will be valuable in other projects. This simulator will be reused in a project with the Technical University of Delft (NL). The university will study different types of control strategies for re-entry vehicles and advanced man-machine interfaces, using a new and more advanced reconfigurable mock-up (Fig. 9).

Acknowledgement

The authors would like to thank Patrick Feuillet for his help during the development of the simulator, and Silicon Graphics Inc. for providing the image generator which allowed quick prototyping.

Intellectual Property Rights and Space Activities

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Intellectual Property Rights (IPRs) raise a number of important legal questions with regard to space activities. These questions, which concern, for example, ownership of intellectual property, infringement of IPRs, sharing of IPRs, protection of data, and transfer of IPRs, have to be addressed before any international cooperative effort that can result in inventions or an infringement of IPRs can be implemented.

A first analysis of the complex environment of the activities performed in Outer Space has been presented and discussed during the first ECSL/Spanish NPOC Workshop on IPRs in Outer Space, which was held in Madrid in May 1993. At that Workshop, the participants, who addressed the issues in the European context, expressed their interest in continuing the study and in broadening its scope beyond Europe. Consequently, a Seond Workshop, even more international in scope, is being organised at ESA Headquarters in Paris at the end of 1994.

What are Intellectual Property Rights?

The Law of Intellectual Property relates to protection for creations of the human mind. Intellectual property laws typically grant to the author of the intellectual creation a set of exclusive rights for exploiting and benefitting from the creation, which are limited in scope, duration and geographical extent.

The policy behind protecting IPRs has at least two aspects. Firstly, intellectual property protection is intended to encourage the creativity of the human mind for the benefit of the public, by ensuring that the advantages derived from the exploitation of the creation will, if possible, inure to the creator himself, in order both to encourage the creative activity and to afford the investors in research and development a fair return on their investments.

The second policy consideration is to encourage the publication, distribution and disclosure of the creation to the public, rather than keeping it secret. It also encourages commercial enterprises to seek out creative works for profitable exploitation.

ESA's IPR policy

The European Space Agency, as an R&D organisation, seeks to extend technical knowledge and to develop new technologies. It develops facilities for conducting experiments, either itself or by third parties. At the same time, however, it develops facilities for operational use (space applications), improving product quality, diversifying activities, extending expertise, using more modern and complex management methods, and improving competitiveness.

As an inter-governmental body, ESA has certain general obligations to fulfil, including protecting the interests of its Member States without discriminating between them.

On the basis of principles laid down in its Convention, ESA has drawn up a number of rules governing intellectual property: contract regulations, provisions in the implementing rules of optional programmes, and clauses contained in international agreements.

Article III of the ESA Convention (Information and Data) establishes the principle that Member States and the Agency shall facilitate the exchange of scientific and technical information pertaining to the fields of space research and technology and their space applications. It also stipulates that any scientific results shall be published or otherwise made widely available, after prior use by the scientists responsible for the experiments.

Given the diversity and abundance of intellectual-property provisions, the need to standardise them into a single document soon became apparent.

In 1989, the ESA Council adopted a set of rules on information and data (ESA/C(89)95 Rev. 1), based on Article III of the Convention. The document contains five chapters setting out the basic principles concerning the various sources of information and data, i.e. ESA staff, contractors and experimenters.

Status of intellectual inventions and creations produced by ESA staff members

A number of intellectual inventions or creations exploited or used by the Agency and its Member States stem from work done by ESA staff members. Various provisions in the ESA Staff Regulations establish who owns intellectual property rights to such creations, the status of the inventor or creator, and how to treat inventions or works produced within the Agency.

Rule 4.2 of the Regulations lays down the following principles:

- Before being appointed by the Agency, staff members must declare any intellectual property rights to inventions or creations acquired within the scope of their previous duties. The Director General determines whether the holding and exploitation of those rights are compatible with future employment in the Agency. The exercise of such rights by future staff members must be compatible with ESA activities and their duty of loyalty to the Agency (Rule 3), which bars them from having – without the Director General's permission – any paid occupation outside the Agency, and from directly or indirectly holding such interests in commercial firms as could, by their nature, compromise their independence in the discharge of their duties in the Agency.

- Throughout their period of appointment, staff members must declare any invention or creation resulting from employment in the Agency. The same applies to technical or scientific works and inventions effected outside the scope of their duties. Where an invention is concerned, the Director General takes a decision on how to proceed, after consulting the ESA Patents Group.

- Lastly, after termination of appointment, a staff member wishing to use or exploit the intellectual property rights stemming from inventions or creations produced in the course of his activities in the Agency must notify the Director General, who may require those rights to be transferred to the Agency or authorise concurrent exploitation by the Agency and the staff member. This obligation continues to apply for three years after departure from the Agency.

The principles summarised above are repeated Chapter I of the Council document on information and data.

Status of intellectual inventions and creations produced by contractors

The Agency assigns numerous R&D tasks to private or public bodies such as universities, research laboratories and firms specialising in the space field. To that end, it concludes with these partners research contracts under which the contractors are bound to make available to the Agency any resulting inventions or technical data under free, non-exclusive and irrevocable licences.

The intellectual property clauses contained in such contracts are based on Chapter II of the Rules on Information and Data (ESA/C(89)95, Rev. 1) and the special conditions applicable to intellectual property rights and other related rights applicable to study, research and development contracts (Clauses 36 to 42 of the General Clauses and Conditions for ESA Contracts, ESA C/290 Rev. 5).

The contract binds the parties in a number of respects:

- Before the research contract is concluded, the contractor must declare to the Agency any intellectual property rights held in respect of previous inventions and related technical data. The Agency may then disclose them for its own purposes provided it obtains the prior agreement of the contractor/owner, and provided that the information and inventions are legally protected.

- Once the contract has been concluded, inventions or technical data resulting from the research work are owned by the contractor, who may or may not protect them by registered patent, or legal title affording similar protection, and exploit them. In exchange, the ESA and its Member States may use the inventions or information under free, irrevocable and non-exclusive licences. The Agency reserves the right of reproduction, i.e. the right to manufacture or have others manufacture the products or inventions resulting from the research work.

- Throughout the duration of the contract, the contractor must inform the Agency of any further technical data and inventions in the space sector resulting from execution of the contract.

- Lastly, the contractor or the Agency may transfer the research results outside the territories of Member States or participants, in accordance with the procedure laid down in Chapter IV of ESA/C(89)95, Rev. 1. Such transfer takes the form of a standard document, filled in by the Agency and the contractor, indicating the use and destination of the property to be transferred, the programme under which it was developed, and the nature and remuneration required in return.

Forms of intellectual property

Patents

Protection for inventions is provided through the granting of patents to inventors and their successors in title. A patent confers on its owner the right to exclude others from making, using, selling or importing products or processes incorporating the technology that is covered by the claim of the patent. The rights under a patent are limited to the territory under the control of the government that issues the patent, and may be enforced only in that territory.

Every year, ESA files about 20 patent applications relating to inventions made by staff members. A special internal group, called the Patents Group, studies the request submitted by the staff member to file a patent application. It assesses both the patentability of the innovation, as well as ESA's interest in the granting of a patent, which is determined by the practical use that the Agency will actually make of the product or process. A 'Catalogue of ESA Patents' (ESA SP-1131) is available (from ESA Publications Division) which is regularly updated.

Copyrights

Intellectual property also covers those rights protecting the financial and moral interests of authors.

There are two main systems for copyright protection:

1. The latino–germanic system

In France, as in Italy and Germany, the work is protected by the author's rights, provided it is original, regardless of the form of expression, merit, or destination of the work. None of the national patent offices requires the obligatory filing of a work. The latino–germanic system acknowledges two main categories of rights:

- *Moral right*, which has several characteristics: it is inalienable, in other words it cannot be yielded or sold, perpentual because it is still valid even after the death of the author, and finally imprescriptible, i.e. it is maintained even when the work has fallen into disuse.

  The moral right affords the author the right of disclosure, which gives him the right to decide whether or not to expose his work to the general public, and the right of withdrawal of the work from public use against payment of compensation for damages caused to any person who has previously received proper authorisation to use the work. Furthermore, the moral right includes the right to claim authorship of the work (have the name of the author and the title of the work mentioned in connection with the use of the work), and the right to object to unauthorised modification of the work.

- *Economic right*, which implies that the owner of the author's right may grant all public use of the work conditional on payment of remuneration. There are three main prerogatives:

  – The Right of Reproduction: The making of one or more copies of a work or of a substantial part of it in any material form, for indirect transmission to the general public.
  – Public Performance Rights: This is understood as meaning a performance of a work, direct or indirect, which is presented to listeners or spectators not restricted to specific persons belonging to a private group and which exceeds the limits of usual domestic representations.
  – Finally, the author is the beneficiary of a 'droit de suite'. This is the right granted to the author and his heirs to claim a share of the proceeds of each public resale of his work.

A European Union Directive of 29 October 1993 has harmonised the duration of the protection of author's right and copyright to 'the duration of his/her lifetime and for 70 years following his/her death'.

This protection is recognised for all work still protected in a given Member State's territory. Consequently, the Directive has the effect of prolonging the duration of protection for works which were already in the public domain, since certain Member States of the European Union recognise a delay of 50 years after the author's death.

Once the economic rights have lapsed, the work becomes public property, meaning that anyone can exploit the work free of charge without having first to obtain authorisation (nevertheless, the citation of the author may be imposed).

2. The anglo-american system

There is no concept of 'moral right' under the legislations of either of these States because works of the mind are protected in terms of their economic value in themselves and for themselves. In the United States, a work can only be protected when filed with a national copyright office. The protection of rights covers a period of 28 years from the day of publication of the work, with the option of renewal of protection for an equal period.

In Great Britain, on the other hand, the protection of the work is not subject to the completion of formalities, and the period of protection lasts for the lifetime of the author and for 50 years following his/her death.

In ESA, the following types of work, performed by ESA staff members, are covered by copyright: all the original publications, such as books, newsletters, brochures, etc.; audiovisual works; photographic works of any kind; technical works such as drawings, illustrations and plans.

Trademarks
The trade mark is a symbol that distinguishes the products and services of a given manufacturer or retail merchant from those of another.

As for patents, the trade mark confers on its holder the exclusive monopoly of exploitation. The holder is also under an obligation to make use of the trade mark and to pay annual installments in order to maintain his/her rights. The period of protection of the monopoly can be anything from 7 to 20 years and can be renewed indefinitely.

The choice of trade mark
In principle, there are no restrictions imposed on the choice of mark. One can choose:

- a nominal trade mark, which can be an invented word, or a patronymic name
- a representational mark or emblem; in other words, something appealing to the senses such as sight or hearing (aural trade mark), or
- a complex trade mark combining a nominal mark and a representational mark. This option is, however, subject to limitations due to certain characteristics which the mark has to fulfil:

  - the mark must be distinctive. This means that no visual signs can be used to depict the product or service in question. Neither can it be descriptive; in other words, the mark must show the composition or nature of the product or service
  - the chosen symbol should not be deceptive, leading to confusion in the mind of the general public as to the origin or nature of the product or service
  - the chosen mark must be original.

ESA trade marks
ESA, which has no commercial remit, has chosen to protect the names of its programmes by means of registered trade marks for those programmes that are conceived and developed with a view to future commercialisation by a company set up for that purpose (e.g. as under the Ariane Programme, which is currently the only example).

In practice, ESA's Legal Department pays attention to and investigates the following before filing a trademark:

(i) The name of the trademark should be distinctive through its novelty and originality, so that it cannot be contested by a third party owning priority rights in respect of the mark chosen.

(ii) The decision on which countries and classes of products and services for which protection is to be sought should be made in the light of the programme's potential.

(iii) An active policy has to be undertaken to detect any unauthorised use by third parties. In these cases, the possibility of legal proceedings – if amicable arrangements are not sufficient to safeguard ESA's interests – have not to be excluded.

(iv) A list of criteria has to be established for granting the use of the ESA mark to third parties.

(v) Arrangements have to be formulated for transferring ownership of the mark to a company that is exploiting the programme commercially.

Currently, ESA owns the following trademarks: **ARIANE; ARTEMIS; ESAQUEST; EARTHNET; ERS; HERMES; IRS; OLYMPUS; EUROPE'S SPACEPORT;** and **METEOSAT** (this last mark was registered by ESA in 1983 in France and Germany. In October 1991, the rights thereto were transferred to Eumetsat. ESA retains the right to use the mark for its own purposes).

Activities in outer space and IPRs
Copyright protection for satellite-broadcasting and remote-sensing activities
With regard to satellite broadcasting, it is the European Union which plays an important role by creating an environment in which trans-frontier broadcasts will not be hampered by legal uncertainties. The European Union has just adopted the final version of a Directive on coordinating copyrights and neighbouring rights for cable transmissions and satellite broadcasting in the Union. These rules will take effect in 1995.

Protection of remote-sensing data is a subject that was initially taken up by a study commissioned by the European Centre for Space Law (ECSL) in 1989, and was followed up by a joint ECSL/ESA/European Commission study. Here, the main issue was whether remote-sensing data could be protected under existing copyrights in the European States. This question is important for ESA in order to establish a controlled flow of the data gathered by the ERS satellites and to stimulate private investment in the remote-sensing activities. The results of the study indicated clearly that existing copyright laws did not offer adequate protection and that additional actions were needed.

Patent protection and microgravity activities
The main legal issues are:

(a) Which European patent laws protect the research process conducted in space and the results of such research achieved in space? Can an infringement occurring in outer space give rise to liability under patent laws?
(b) What would be the legal consequences of an invention being developed in space?

When trying to answer question (a), one has to bear in mind that European national regulations dealing with industrial property are not concerned with the actual location of the invention's conception. It is therefore irrelevant under this regulation where the invention was made and one may apply for a patent with regard to inventions made in outer space under any national or European system. The location could, on the other hand, prove to be relevant where the patent law of a given country provides that for certain types of inventions, i.e. those relating to technologies having a direct bearing on national security, the first application for a patent must be filed in the country where the invention was made. This provision has the purpose of allowing security clearance for the invention before it is published or filed in a foreign country.

As regards the use of a nationally protected invention in outer space, or the infringement that may result from that use, the situation is different. An authorised or non-authorised use will not bear the legal consequences in those European States that have not recognised the object located in outer space, where the use is made, as being an extension of their territory.

In principle, national patents are enforceable only within the territorial boundaries of a given country. The same principle applies within the framework of the European Patent Convention, which allows for (Art. 64 EPC) the acquisition of a 'bundle' of national patents of the countries party to the Convention, indicated in the application; the patent therefore has the effect of a national patent in each of the countries mentioned in the application.

Outer space, similar to the high seas and Antarctica, is not subject to national appropriation and does not fall under any national sovereignty. This implies that outer space cannot be appropriated by use or claim or any other means (Art. II of the Outer Space Treaty). However, a State retains jurisdiction and control over objects it sends into outer space (Art. VIII of the Outer Space Treaty). With regard to the applicability of national patent regulations, problems occur when an invention is used or infringed in outer space, because these regulations are only applicable in the territory of the specified State which, by definition, excludes the extra-territorial areas of outer space.

This situation led to the amendment of the patent law in the United States. The legislators made this law also applicable to inventions in outer space when such inventions take place onboard space objects coming under the jurisdiction or control of the United States. As we will see later, the same approach inspired the German ratification of the Space Station IGA.

Turning to question (b), no provision contained in European legislation or regulations would retain the location of the conception of an invention as a criterion for granting a patent application. However, a distinction is made in US patent law between foreign inventive activity and domestic inventive activity. In contrast to the patent laws of most countries, where the patent is awarded to the first person to file a patent application on the product or process, a patent will be issued under US law to the first person to invent the product or process he claims in his patent. The first to invent is said to have 'priority' over others claiming the same invention. Priority is determined by reference to certain key events such as conception, reduction to practice, and diligence.

Another important characteristic of US patent law concerns activities considered to be 'prior art'. Patent law distinguishes between domestic and foreign activity for the purpose of determining what falls under the category of prior art. For instance, patents and printed publications, no matter where they originate, are prior art, but items previously known, used or invented are considered to be prior art only if they occur within the United States.

Finally, the definition of infringement contained in US patent law as being the unauthorised conception, use or sale of an invention within the United States, creates the same problems of applicability of patent law as in other countries.

The example of the Space Station

The Inter-Governmental Agreement (IGA) on the International Space Station*, signed on 29 September 1988 by countries representing four partners – the USA, Japan, Canada and ten ESA Member States – is probably the most complex and interesting example of a long-term international cooperative endeavour in space.

The intrinsic characteristics of the exploitation and utilisation of the International Space Station generate corresponding legal implications. Such characteristics include:

- the Station will be 'permanently inhabited', by a multinational crew
- the Station will be located in outer space
- the multi-purpose scientific and commercial utilisation of this facility as a research laboratory, as a factory for manufacturing materials, and as a service station for supplying or repairing satellites.

The agreement between the Partners, described in the IGA, is based on a system that is complex to manage and which has been the subject of lengthy discussions. These discussions touched upon, inter alia, the registration, jurisdiction and control of flight elements considered as space objects under Article VIII of the Outer Space Treaty.

These discussions focussed especially on the necessity of complying with one of the fundamental principles of outer space law, which is stated in Article II of the Outer Space Treaty, under which outer space is not subject to national appropriation in whole or in part.

The solution that has been accepted by the signatories of the IGA is that each 'Partner' will register each element it provides as a space object, thereby establishing its jurisdiction and control over such elements, i.e. the ability to issue regulations and have them enforced. The same principle applies to persons onboard the Space Station who are nationals of the Partner States.

This why Article 1 of the IGA, which defines the scope of the Agreement and its purpose – to establish 'a long-term international cooperative framework ... for the development ... and utilisation of a ... Space Station for peaceful purposes' – should be read in conjunction with Article III of the Outer Space Treaty, which stipulates that the exploration and use of outer space shall continue in the interests of maintaining peace and promoting scientific cooperation at international level. Similarly, the possibility of exercising jurisdiction and control over Space Station elements (Article 5 of the IGA) does not infringe upon Article II of the Outer Space Treaty, which bars any claim of sovereignty over outer space.

The IGA and the provisions pertaining to IPRs: specific issues for the European Partner

Article 21 of the IGA aims at resolving issues relating to IPRs developed or used onboard the Space Station, on the basis of the principles explained above.

The two main questions dealt with in the IGA are the aquisition of IPRs over results obtained from activities carried out onboard the Space Station, and the protection against infringement of IPRs (granted on Earth) that may occur onboard the Space Station. The fundamental principle laid down in the IGA is that the part of the Space Station complex in which the invention was made is deemed to be an extension of the territory of the State that registered that element.

The approach adopted by the Space Station Partners raises a general question about the applicability of the jurisdiction and control criteria to solve the problem of the territorial application of patent laws and a number of questions relating to the European Partner States.

Firstly, Article 21.2 of the IGA establishes a legal fiction regarding the ten European Partner States: these States are deemed to be located on a single territory which is subject to one set of regulations. It goes without saying that the ten European Partner States that are signatories of the IGA are not located on a single and unique 'territory'. A consequence of the legal fiction is therefore that, in order to implement the IGA, the European Partner States will have to establish IPR provisions at national level which are not only compatible with those established in the other European

* The current Partners of the IGA are envisaging changes in the existing legal framework. In fact, on 6 December 1993, the Space Station Partners invited Russia to be a Partner in the detailed design, development, operation and utilisation of the Space Station. Russia has accepted the invitation via a Diplomatic Note dated 17 December 1993.

Partner States, but also appropriate for responding to the needs expressed in the IGA, a process that could be described as a standardisation of legal texts.

The process of legal harmonisation called for by the IGA imposes a certain burden on the signatory States. As a first step, the States concerned will have to proceed with the identification of possible obstacles to be surmounted if harmonisation is to be achieved and, as a second step, they must assess the results of the harmonisation process already underway in Europe in the field of IPRs in order to determine whether such a process can influence or respond to the need for the protection of IPRs designed or used onboard the Space Station.

The procedures applicable to the ratification of treaties differ from State to State and one has to bear this simple fact in mind when considering the implementation of IGA provisions. The ratification procedure can involve transforming provisions provided by the IGA into national law (by legislative process) or incorporating these provisions without recourse to any procedure whatsoever – in which case the IGA enters into force, bypassing the legislative process of the State (immediate validity).

The Space Station IGA has, to date, been ratified by six European States: Germany, The Netherlands, Norway, Denmark, Spain and Italy. Germany exercised the right laid down in Article 21.2 of the IGA by enacting legislation on 13 July 1991 for the purpose of ratifying the IGA. Article 2 of this legislation stipulates that for the purposes of German copyright and industrial patent legislation, an activity occurring in or on an ESA-registered element is deemed to occur within German territory. The remaining provisions of Article 21 of the IGA are considered to be self-executing, and for this reason Germany has not felt it necessary to enact further legislation.

The other European States, having ratified the IGA, did not consider it appropriate to enact legislation and have given immediate and direct validity to the provisions of the IGA. The United Kingdom, for its part, has informed ESA that it intends to enact legislation in line with the provisions of Article 21 of the IGA and is currently studying the scope of changes to be made to its national law in order to ratify the IGA.

The IGA entered into force on 30 January 1992, the conditions prescribed in its Article 25(a) having been fulfilled with the ratification by Japan and the acceptance by the USA. The IGA has not yet entered into force for Canada and the European signatory States, these two Partners having so far failed to ratify it.

The IGA will enter into force for the European Partner only when it is ratified by four States contributing at least 80% to the Columbus Development Programme. At present, the six signatory States who have ratified the IGA contribute to a level of 77.5% to the Columbus Programme, whose objective is to implement the European part of the Space Station cooperation. Therefore, ratification by France or Belgium will be needed to permit the entry into force of the IGA for the European Partner.

The necessary harmonisation process referred to above is obviously not made easier by the procedural aspects, i.e. the numerous procedures which need to be carefully monitored and guided in order to transform the legal fiction of the IGA into reality.

The lack of coordination regarding solutions adopted or to be adopted by the ten European States could significantly affect the development of a legal system that is uniformly applicable to the design and utilisation of IPRs onboard the Space Station. For this reason, to provide an adequate framework for the protection of rights provided for in the IGA, ratification of the IGA by all the European States through the same procedure as followed by Germany would be a worthwhile development.

Conclusion

In conclusion, the role of Intellectual Property in space activities in general, and in those of ESA in particular, is important in order to protect and promote the results of R&D and to encourage industry to select creative works for exploitation.

The policy developed by ESA in this field is in line with the main characteristics of Intellectual Property, i.e. it encourages publication, distribution and disclosure of the innovation to the public, in order to stimulate the improvement of scientific knowledge.

The example of the International Space Station shows that new actions have to be undertaken in order to arrive at a coordinated and harmonised legal framework for the IPRs of the ESA Member States.

The Materials Challenges Facing Europe

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Many of the newly emerging structural materials are at a difficult cross-roads, with reductions in aerospace budgets placing severe constraints on both their development and usage. There are simply too many materials chasing too few applications. Great care has therefore to be taken in the coming years to ensure that Europe does not lose its expertise in what could well prove to be an important technological spin-off area for the longer term.

Introduction

It takes typically ten years to establish acceptance of a material for aerospace applications. Space applications, by comparison, require rather small volumes of such materials and so manufacturers cannot therefore rely on space alone for their business. In addition, emerging materials tend to be much too expensive in the shorter term for a particular application when compared with established materials, the development costs for which have already been wriitten off. The experience gained in using an established material is another important factor.

Consequently, there is an urgent need to find ways and means of reducing such costs, which involves promoting broader access to the emerging technology. The establishment of a bigger market and a better sharing of development costs would seem to require improvements in technology transfer. Forums for co-operation and cross-fertilisation must be exploited to identify a wider range of opportunities to extend the use of new materials and their applications technology.

There has already been some success in the transfer of technology of structurally related space application materials to other disciplines. These include the use of high-modulus, carbon-reinforced plastic in ground-based applications, surgical uses for shape-memory alloys, and industrial use of rocket-motor static seal technology.

In March this year, ESA co-sponsored a Symposium, with BRITE/EURAM, EUREKA and SAMPE, with a view to stimulating such collaboration. Russian contributions were also actively encouraged. The figures used to illustrate this article are drawn from the Proceedings of that Symposium. ESA continues to support such bodies as AECMA and has its own Advanced Structural Materials Information Exchange Group, which endeavours to coordinate such activities. It has been active in stimulating and reviewing information for ESA's Structural Handbooks.

In the short term, the thrust must be to conserve and consolidate the most promising developments and to foster the widespread and cost-effective utilisation of this materials technology.

Future space applications

As materials reach an appropriate stage of development, they can be candidates for use in:
- spacecraft structures
- structural elements of payload and service equipment (antennas, solar arrays, optical equipment such as mirrors and benches, fuel tanks, etc.)
- launchers and re-entry vehicles (rocket-motor components, thermal-protection systems, integral tanks, air-breathing engines, etc.)
- Space Station, interplanetary satellites, and eventually Moon bases; all of these are likely to require the use of very light materials for the construction of antennas, heat shields, dwellings, meteoroid protection systems, etc.; retention of material properties over many years will be an important issue.

'Smart structure' developments are expected to find application in the realisation and maintenance of reflector profiles, dimensional stability of optical payloads, active noise and vibration control, and in-orbit health monitoring and possibly control of unmanned spacecraft. The ability to monitor the health of large cryogenic composite fuel tanks is a typical long-term objective.

High-stability structures

Long-life orbiting structures will require dimensionally stable materials. To date, such needs have largely been met with carbon-fibre epoxy resin composites (CFRP), but the existing epoxy composites may not sustain such requirements for larger components and extended lifetimes under thermal cycling.

Opportunities exist to replace first-generation CFRP with stronger ultra-high-modulus CFRP materials utilising cyanate ester or toughened epoxy resin systems. The cyanate esters offer reduced moisture absorbency and better resistance to micro-cracking under severe thermal cycling.

A recent ESTEC study showed that low instances of micro-cracking could be achieved in the thermal cyclic range of – 180°C to + 130°C.

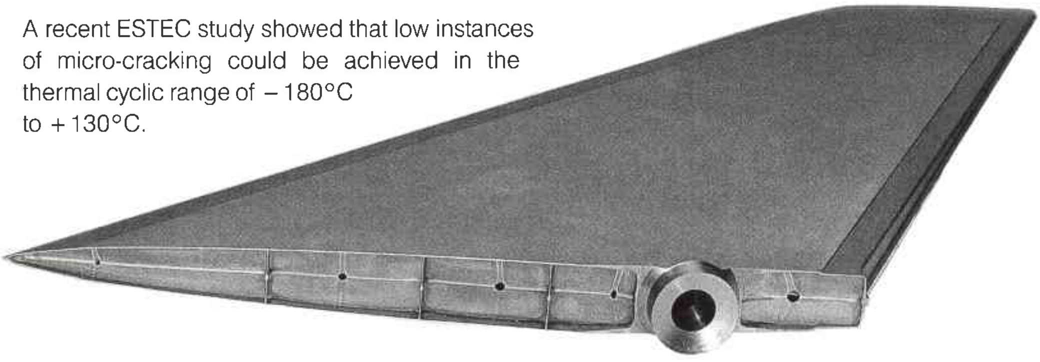


Figure 1. Extensive use of diffusion bonding and superplastic forming is made in the manufacture of the Rafale fighter's highly loaded titanium canard. This incorporates a diffusion-bonded spigot and a hexagonal corrugated core structure. A substantial mass saving is realised compared with other manufacturing methods (Photo courtesy of Dassault Aviation)

However, the precise 'prepreg' processing conditions applied by individual contractors have proved very influential in determining the integrity of the thin (300 micron) 0°/90° laminates.

Optical structures require a high degree of dimensional stability, so that the propensity of CFRP to outgas moisture and micro-crack may prove unacceptable. Composites with more stable matrices such as metals and ceramics are proposed as solutions here, particularly for Low Earth Orbit (LEO) applications.

Carbon-fibre-reinforced magnesium and aluminium composites have received attention by offering opportunities for a high degree of Coefficient of Thermal Expansion (CTE) control. Considerable efforts have been expended in developing processing techniques to overcome the difficulties of fibre-matrix reactions and poor transverse strengths. The isssue of galvanic corrosion remains, but may be overcome if the composite is coated and always kept in a controlled low-moisture environment.

Carbon-fibre/ceramic-matrix composites (C – C and C – SiC), which have been developed for high-temperature applications, can be modified for use in optical structures such as mirrors and optical benches. They offer very high stiffness and the stability of materials that have been processed at high temperatures well beyond those likely to be experienced by orbiting structures. However, all such ceramic- and metal-matrix composites are very expensive to produce.

LEO and the environmental stability of materials

There is concern that polymeric materials in particular may experience accumulated physical damage during prolonged use on low-Earth-orbiting structures. Contributing conditions include the hard vacuum, radiation, thermal cycling and micrometeoroid impacts, coupled with atomic-oxygen attack. These provide conditions for progressive surface degradation, which may be significant over a 25-year lifetime compared with the 5 to 7 years of exposure typical of today's orbiting spacecraft.

Experiments aboard the US Long-Duration Exposure Facility (LDEF) and Europe's own Eureca retrievable platform have quantified the levels of erosion that can be experienced by uncoated CFRP. In the worst case, some 100 microns of composite, equating to a single ply, can be removed in just 5 years of exposure to atomic oxygen. For typically thin constructions, the integrity of the structure would be lost before the end of the spacecraft's intended service lifetime. Such erosion can be avoided by adopting one or more of the following options: protective metallic coatings, shielding or reduced angle of incidence to atomic-oxygen flux.

A more ambitious option is to use Anoxic Siloxane 'composites' (described in detail by S. Palsule in ESA Journal No. 2, 1993). These materials have silicon instead of carbon in their molecular structure and it is converted to a non-volatile silicon oxide by the atomic-oxygen flux. A type of 'passivating layer' can be formed which is stable in vacuum and inhibits further penetrative oxidation. Siloxanes can therefore be exploited in the first instance as coatings. They are currently being evaluated as matrices for structural composites with carbon-fibre reinforcement.

High-temperature applications

Within Europe, high-temperature structural materials development has received an impetus in recent years from the Hermes, Sänger and Hotol spaceplane programmes. The potential materials for such applications now include new titanium alloys, Super-Plastically Formed/Diffusion Bonded (SPF/DB) titanium, titanium-matrix composites (TMC), nickel alloys, beryllium and ODS aluminium alloys, as well as the more well publicised C – C and C – SiC ceramic-matrix composites. The metallic materials offer capabilities in the 300 to 1000°C range, whilst Ceramic Matrix Composite (CMC) materials in various selected forms can sustain temperatures of 1500 to 2000°C. The issue of oxidation protection for prolonged use is not to be underestimated. Elaborate protective coatings are expensive to apply and increase the complexities of joining, inspection and verification.

With C – SiC, more recent developments have concentrated on reducing the very high processing costs associated with chemical vapour deposited or infiltrated (CVD/CVI) C – SiC by switching to quicker processing routes such as siliconising, polymer pyrolysis and melt infiltration. All of these materials can provide technical solutions in some form for applications experiencing operating temperatures beyond the capabilities of polymer composites and aluminium alloys. Each material has its own particular attributes and drawbacks, not least in who retains the capabilities to design and manufacture with a specific material.

For the high-temperature composites with continuous fibres, the material microstructures are very complex, as are the progressive modes of failure through multiple crack formation. The integrity of such materials under harsh oxidising conditions remains to be fully resolved, since they are often operating close to their physical limits and experiencing micro-structural changes during use.

The short- to medium-term future of many high-temperature materials is very uncertain due to the very limited commercial applications available. In space programmes, the shorter-term opportunities have diminished to primarily those associated with re-entry vehicles, launcher propulsion systems, and planetary probes. Some C – SiC may be used in optical structures. The volume of material used in these outlets will, however, be insufficient to guarantee the commercial viability of all such materials.

The other industrial opportunities for the new materials lie with gas-turbine engine development, high-energy braking systems, and electrical power generation. These applications have different service requirements, however, making the likelihood of common material usage somewhat tenuous.

An obvious conclusion from all of this is that future space programmes using modest quantities of materials cannot readily expect commercial sourcing to a unique specification. The result could be considerable expense in fabricating a limited number of items especially for space application.

Joining technologies for airframes and tanks

With the application of new materials comes the requirement to fabricate structures from them with efficient joining techniques. The assembly costs for such large structures have also to be weighed carefully, particularly for a launcher like Ariane-5, with its many cylinders, bulkheads, frames, adapters and panels. Even with established materials such as aluminium alloys (2219,7475) and steels (D6AC), useful advances can be made by applying modified techniques. For the aluminium alloys, this includes spin-forming/Tungsten Inert Gas (TIG) welding (Ariane-5 tanks), cold forging and machining (Ariane-5 booster separation motors), shot peening/rolled/forged and TIG welding (Ariane-5 tank bulkheads) and electron-beam welding. This, in turn, could lead to the next generation of tank constructions based on cold-formable and SPF/DB titanium alloys, weldable lithium containing aluminium alloys (2195, Weldalite), and filament-wound CFRP constructions. Such technologies could save up to 2 tons on an Ariane-5 vehicle, but the extra development costs would have to be properly identified.

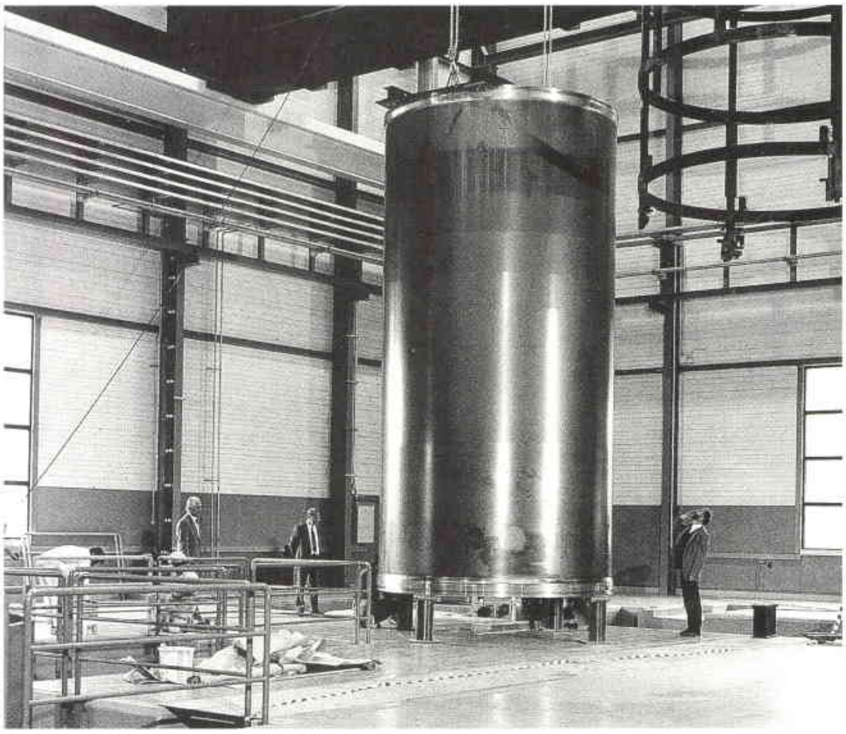


Figure 2. Spin-rolling facilitates the production of very large, seamless, stiffened cylindrical parts, as illustrated by this 6.2m-long Ariane component (Photo courtesy of MAN, Germany)

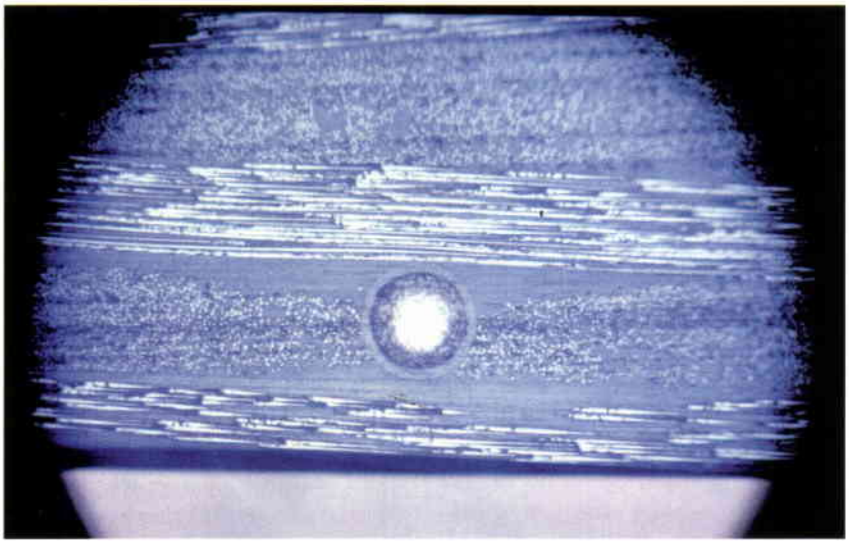
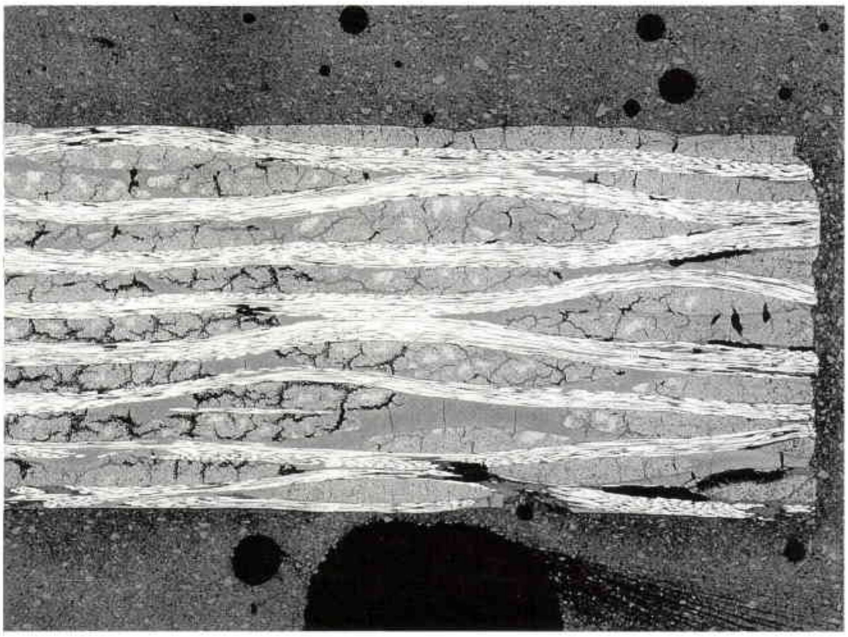


Figure 3. Optical fibres embedded in a woven CFRP skin (Photo courtesy of Westland, UK)

Figure 4. The effects of ageing on bismaleimide CFRP after 100 h at 250°C (mag x20). (Photo courtesy of Short Bros., UK)



Where high-temperature materials are to be applied, the main issues relate to connecting hot outer surfaces to cooler underlying airframe structures. Joints may be static or may consist of movable parts and seals. ESTEC-funded programmes have evaluated fasteners made made of C – C, C – SiC, coated nobium alloys and nickel alloys. All can sustain the temperatures involved, but the issue of oxidation and protecting threaded fasteners requires further investigation, as do the appropriate inspection techniques.

In preliminary studies, the use of castable inorganic cements has been demonstrated for a configuration representative of a CMC thermal-protection shingle mounting. By careful design, the cement is injected into a cavity where it solidifies and provides a mechanical taper to lock the shingle in place. The cement sustains any applied loads by compression, for which it is well-suited, as opposed to the shear that bonded joints experience. As ceramic composites are low strain to failure materials, it is preferable to configure joints to operate in compression and not in tension or shear.

Inspection

There are now a large number of established Non-Destructive Testing (NDT) techniques for inspecting assembled composite and light-alloy structures. To these have been added modified systems for ceramic and metallic composites, where the defects and features of interest may be similar, but on a smaller scale and in mediums of different signal attenuation and energy absorption. Greater emphasis is now being placed on non-contact and non-coupled (no water) techniques as means of examining assembled configurations. Ultrasonic inspection has always been popular, but is usually a contacting/coupled method. It is now giving way to techniques such as: laser ultrasound, eddy currents, shearography, electronic speckle thermography, transient thermography, photothermal thermography and stimulated infrared thermography in addition to holographic interferometry, neutron magnetic resonance, and neutron absorption, X-ray techniques based on radioscopy, beta-particle backscattering, refractography, micro-focussing and and tomography have contributions to make for high-temperature composites such as coated C – C and C – SiC. For high-resolution inspection of ceramic composites, computerised tomography is gaining acceptance.

Whilst all of these techniques have something to offer in providing various degrees of resolution, the types of defect and damage that need to be detected remain unchanged. For polymer composites, the critical defects are de-laminations and impact damage, with supporting evidence required to confirm low porosity, correct fibre alignment and no disbonds. With ceramic composites, acceptable porosity levels can be higher, but any variations in bulk density and thickness need to be quantifiable. Severe delaminations and excessive microcracking are the main features to be looked for before confirming material integrity.

Possible space applications of smart-structure technology

This is a rather special and emerging structural-materials development area and often involves the embedding of sensors, detectors and optical fibres in a composite structure. In conjunction with the use of these devices, passive or active control over the structure's behaviour can be achieved using a controlling network. The realisation and maintainance of large deployable reflector profiles could be one such application, while the possibility of monitoring the health of such items as large cryogenic fuel tanks would be a typical longer-term objective. Some more specific examples are given below.

Sensors and actuators

These are likely to be critical constituents of a smart structure. In any space application, they will have to require a very minimum of the spacecraft mass, volume and electrical power budgets. They will have to work for a minimum of five years, and probably much longer in some project applications. They will have to survive the launch environment and the longer-term effects of the in-orbit environment. Some typical sample problems that may have to be addressed are:

- What are the advantages of optical fibres/sensors over conventional measurement systems?
- Do they accurately measure the parameter of interest?
- Can the optical signal analyser be readliy accommodated in a spacecraft system?
- Is there sufficient redundancy to compensate for failed sensors?
- Can the sensors (actuators) respond within the required time interval?
- Can the actuators provide the required force and displacement?
- Will actuators/sensors designed for in-orbit operation be compatible with the structure manufacturing process and survive the launch environment?

Clearly, the importance of some of these questions will be application-dependent, but some general feeling of confidence in the use of 'off-the-shelf' items has to be established before the introduction of optical fibres into composite space structures can be seriously entertained. Work of a similar nature is probably needed for actuators. Westland Aerospace (UK) are conducting practical investigations into the problems of and solutions for realising embedded optical fibres. Some additional work has been conducted for ESA by Dornier (D).

Antenna technology

Current antenna reflectors in Europe rely almost entirely on the use of stiff polymer composite face sheet/honeycomb-sandwich core constructions, where the required surface profile has been realised during manufacture. For most present applications, this will suffice up to a diameter of about 3 m, but where larger diameters are required, the reflector must be stowed compactly during launch and subsequently unfurled once in orbit. This necessitates alternative forms of construction, of which mesh antennas are a typical example. American and Russian versions have been flown and similar technology has also been developed in Europe.

One of the main problems that has to be resolved for unfurlable antennas is the assurance that the necessary surface profile can be realised after deploying the reflector in the zero-gravity conditions of space. Clearly, if the shape can be 'tuned' by the use of sensors and actuators in orbit, this would reduce the complexity of ground testing and perhaps even simplify the method of construction. The challenge is to demonstrate a reliable, cost-effective system whilst not placing additional pressures on the resource budget identified for the 'passive' configuration. The shape could, of course, be realised using various thin-shell and membrane concepts, of which the mesh configuration is just one example.

A study being undertaken by ERA (UK) and Dornier (D) includes some initial assessments of 'smart' technology for antennas and will examine the potential of the competing transducer systems for shape control. A breadboard configuration using co-located piezo-electric transducers for strain control is being developed. In practice, it is difficult with most currently marketed transducers to realise efficient thermal strain control because of the high coefficient of thermal expansion of the transducer material.

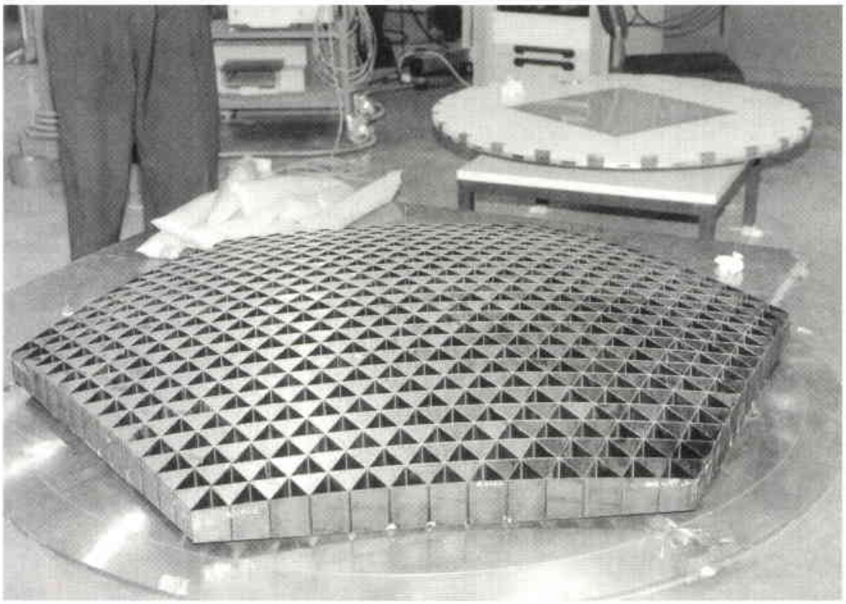


Figure 5. Machined all-CFRP core for a highly dimensionally stable reflector (Photo courtesy of Dornier, Germany)

Micro-vibrations

The presence of micro-vibrations emanating from on-board sources such as reaction wheels, stepper motors, mechanical relays, etc., can disturb experiments requiring zero-gravity conditions, or can cause jitter that disturbs the imagery of optical payloads.

Considerable information has been gleaned from a micro-accelerometer package flown on the Olympus spacecraft for in-orbit health monitoring/vibration control. Work is continuing to develop smart systems that will employ automatic signal-recognition techniques and exploit both passive and active methods of vibration reduction. For example, many optical payloads employ isostatic mounts to avoid distortions due to quasi-static loads. These are often in the form of flexures. They also provide the sole path for in-orbit vibration transmission. Investigations are planned into the use of passive or active damping systems at these locations to eliminate the unwanted vibrations.

Active noise and vibration control

Achieving sufficient low-frequency noise reduction through a launcher payload fairing is a difficult task and liable to involve a substantial mass penalty. The use of active control systems employing embedded piezo-ceramic transducers is the subject of current investigations, which it is believed can lead to a more mass-efficient system.


Figure 6. C/SIC air-intake ramp which operates at 1200°C (Photo courtesy of Dornier)

In future air-breathing launchers, similar techniques could be used to reduce the risk of acoustic fatigue in the air intake.

Availability of materials technology

The space industry remains conservative in its selection of materials. Preference has traditionally been given to proven materials with multiple sourcing. These criteria can be fulfilled by steels and aluminium alloys as the established materials of construction. Fibre-reinforced epoxies (e.g. CFRP) in laminate or sandwich-panel form are now in common use, after twenty years of development and progressive application.

Recent discontinuation of some industry-standard ultra-high-modulus CFRP prepregs has served to demonstrate the vulnerability of the space industry because it purchases relatively small quantities. With more ambitious space programmes, particularly those requiring high-temperature materials, there is a likelihood that only single sourcing will be available for a specific material or processing technology. It is already the case that the immediate commercial availability of some advanced materials is in considerable doubt; this includes thermoplastic/bismaleimide/polyimide composites, aluminium-lithium alloys, particulate- and fibre-reinforced aluminium composites and titanium-matrix composites. There are not enough immediate applications to sustain present commitments in ceramic-matrix composites such as C – SiC, where initial funding from spaceplane programmes has now been scaled down.

There will be an increasing commercial tendency to consolidate on those materials and process technologies for which there are the largest markets. In this respect, future space programmes may be confined in their ambitions to using materials which are not necessarily ideal for the application, but are at least available and not overly expensive.

The potential for the application of smart structures and their related technologies is evident, but faces a range of interdisciplinary problems. It seems likely that 'partially smart' techniques may well be the first applications. As with more conventional structures, their evolution and introduction will depend on their cost-effectiveness and reliability. This applies to the constituent embedded sensors, actuators and the like, and their use of spacecraft resources. These will have to be traded against the capabilities of traditional methods.

L'Agence spatiale européenne dans le mouvement d'élargissement des Organisations européennes*

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Par élargissement on vise tout aussi bien l'accroissement du nombre d'Etats membres d'une Organisation que l'établissement de relations institutionnelles entre l'Etat non membre et l'Organisation sous une forme prévue par la Convention de ladite Organisation ou sous une forme apparue à cet effet.

La dislocation de l'ex-URSS, l'apparition d'Etats indépendants en Europe centrale et orientale a naturellement posé la question des relations entre ces Etats et les organisations existantes en Europe de l'Ouest, pour des raisons de reconnaissance démocratique, ou d'assistance technique, financière.

Qu'entendait-on par Europe? On se référait à la définition issue du Conseil de l'Europe. Chaque Organisation avait bien sûr son propre système d'adhésion et ses propres définitions d'Etats membres.**

Pour les raisons précitées, les nouveaux Etats ont cherché à entrer dans le cercle des Organisations européennes, économiques, culturelles ou scientifiques, techniques. La Russie constitue un cas particulier en raison de son potentiel, de son poids sur la scène internationale, de ses réalisations en matière spatiale.

On examinera quelques réponses: celle du Conseil de l'Europe, de l'OCDE, de l'UEO, de l'Union européenne, celle d'autres Organisations techniques, avant de se pencher sur la situation de l'ESA et de tirer quelques conclusions en forme d'interrogations.

I. Chaque Organisation développe son propre schéma de coopération en fonction de sa Convention, ses buts.

Dans certains cas le rattachement d'un nouvel Etat ne peut se faire que de manière progressive. Les demandeurs se trouvent devant des statuts de participation différents.

A. Le Conseil de l'Europe – les invités spéciaux

Aujourd'hui le Conseil de l'Europe regroupe 32 pays. Fondé par le Traité de Londres de 1949 entre dix pays: Belgique, France, Luxembourg, Pays-Bas, Royaume-Uni, Danemark, Norvège, Irlande, Italie, Suède, il s'est élargi à d'autres pays: Grèce, Turquie, Islande, Autriche, Allemagne, Chypre, Suisse, Malte, Portugal, Espagne, Liechtenstein, Saint-Marin, Finlande (1988), Hongrie (1990), Pologne (1991), Bulgarie (1992), Estonie, Lituanie, Slovénie, Slovaquie, République tchèque et Roumanie en 1993.

Plusieurs pays veulent entrer; certains ont le statut d''invité spécial', ce sont des pays de l'ancienne Europe de l'Est qui étaient communistes jusqu'en 1988. Ils peuvent participer à certaines réunions et apprendre: ce sont l'Albanie, la Belarus, la Bosnie-Herzegovine, la Croatie, la Lettonie, la Macédoine, la Moldavie, la Russie et l'Ukraine, neuf pays qui se rajouteront un jour aux actuels pays membres.

Enfin, le Saint-Siège et Israël ont le statut d'observateur.

B. L'OCDE – le partenaire en transition

Elle a développé une nouvelle définition: celle de 'partenaire en transition'. Actuellement quatre pays ont reçu ce statut: la République tchèque, la Slovaquie, la Hongrie, la Pologne. (L'OCDE a un 25° Etat membre, le Mexique, depuis le 18 mai 1994.)

Avec chacun de ces partenaires, un mémorandum d'accord est conclu qui définit les conditions privilégiées de la coopération. Ce statut conduit implicitement à terme à l'adhésion à la Convention (contrairement au

* Cet article reflète les vues personnelles de l'auteur.

** La Convention de l'ESA parle de coopération européenne, d'effort spatial européen, d'un programme spatial européen. A partir de la date d'entrée en vigueur de la Convention, tout Etat peut adhérer à la Convention.

statut de membre associé à l'ESA, voir ci-dessous).

Lors de la prochaine Conférence ministérielle de l'OCDE (juin 1994), la République tchèque, la Hongrie et la Pologne vont poser acte de candidature pour adhérer à la Convention de l'OCDE. La Résolution 9265 du Conseil de l'OCDE définit les grandes lignes de la notion de partenaire en transition; elle devrait être révisée et être rendue plus restrictive pour faire face à une prolifération des demandes d'adhésion à la Convention.

C. L'Union de l'Europe occidentale – les partenaires associés*

Un premier pas a été la Déclaration de Petersberg du 19 juin 1992 relative à l'élargissement de l'UEO aux autres pays de la Communauté européenne et/ou de l'OTAN; la Grèce deviendra membre, la Norvège, la Turquie, l'Islande, membres associés. Le Danemark et l'Islande sont observateurs.

Le 9 mai dernier, le Conseil de l'UEO, d'une part, et la Bulgarie, l'Estonie, la Hongrie, la Lettonie, la Lituanie, la Pologne, la Roumanie, la Slovaquie, la République tchèque, d'autre part, se sont mis d'accord sur un statut d'association au terme duquel les neuf pays précités deviennent 'partenaires associés' (et non pas 'associés partenaires' – nuance importante!): l'Islande, la Norvège et la Turquie l'étaient déjà. Les neuf nouveaux associés siègeront à certaines réunions du Conseil de l'UEO (sans droit de vote) et à diverses réunions de travail. Cette initiative devrait permettre selon le communiqué final, de contribuer concrètement à préparer ces Etats à leur intégration et à leur adhésion à terme à l'UEO. L'association avec l'UEO n'est pas proposée à la Russie contrairement au 'partenariat pour la paix' établi dans le cadre de l'OTAN (Voir pages suivantes: Extraits des Déclarations de Petersberg et du Kirchberg).

D. L'Union européenne

Ses membres devraient passer à 16 en 1995 avec l'adhésion de l'Autriche, de la Norvège, de la Suède et de la Finlande. Des contacts ont lieu avec d'autres pays mais surtout l'Union conclut de nombreux accords économiques avec ces divers pays. L'Union européenne avec ses ressources devient le passage obligé de la construction d'une 'autre' Europe. Là intervient la proposition du rapport Rovsing d'établir un Conseil spatial européen afin d'assurer la cohérence des actions et une complémentarité des institutions. Les relations avec les pays d'Europe centrale et orientale devraient être l'un des premiers thèmes de ces relations.

E. Les Organisations scientifiques et techniques

(i) **Le CERN** comporte aussi la Hongrie, la Pologne, la République tchèque et la Slovaquie et reflechit a la possbilité de créer une catégorie de 'membre associé'.

(ii) **Eutelsat** comprend 42 membres. On y note la présence de tous les pays de l'ex-bloc communiste qui sont devenus directement membres à part entière.

(iii) **Eumetsat** comprend 16 Etats membres; pour l'instant aucun pays de l'ex-bloc de l'Est n'a fait acte de candidature.

II. L'Agence spatiale européenne**

On ne prendra pas en compte l'élargissement par l'unification de l'Allemagne. La Finlande va passer du statut de 'membre associé' à celui de membre à part entière au 1er janvier 1995 au plus tard en application de l'accord d'adhésion signé le 22 mars 1994. L'Agence comptera alors 14 Etats membres, un Etat non membre coopérant, le Canada, ainsi que divers Etats liés par un accord-cadre de coopération : la Hongrie (signé le 10 avril 1991), la Pologne (signé le 28 janvier 1994), la Roumanie (entré en vigueur le 6 juillet 1993), la Grèce (signé le 4 juillet 1994), chacun de ces accords étant signé pour cinq ans.

Des contacts avaient été pris avec l'ex-Tchécoslovaquie. L'Agence a par ailleurs reçu une demande de la part de l'Ukraine de conclusion d'un accord de coopération touchant à plusieurs domaines.

On rappellera enfin l'accord-cadre conclu en avril 1990*** avec l'ex-Union soviétique, repris par la Russie (note diplomatique du 28 avril 1992), un nouvel accord-cadre de coopération devant être négocié en 1995. L'accord-cadre de 1990 constitue la base juridique de conclusion de plusieurs arrangements spécifiques.

A. Les bases

On se souvient que:

(i) le Conseil avait établi, en 1985, un groupe de travail pour définir les grandes lignes

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* Stavros Kyrimis: L'UEO examinée à la luminière du droit des Organisations internationales. Mémoire de DEA, Université de Paris I, juin 1994

** G. Lafferranderie: The enlargement of the European Space Agency – Legal issues. *Journal of Space Law* – Vol. 15, No. 2, pp. 119–130.

*** G. Lafferranderie: La nouvelle donne de la coopération en matière spatiale entre l'Union soviétique et l'Agence spatiale européenne. *Annales de Droit aérien et spatial* 1991-381

Déclaration de Petersberg

19 juin 1992

Membres associés
Les autres Etats européens membres de l'Alliance atlantique qui ont accepté l'invitation à devenir membres associés, pourront, bien que n'étant pas parties au Traité de Bruxelles modifié, participer pleinement aux réunions du Conseil de l'UEO - sous réserve des dispositions prévues à l'article VIII du Traité de Bruxelles modifié - de ses groupes de travail et des organismes subsidiaires, compte tenu des dispositions suivantes:

— à la demande de la majorité des Etats membres, ou de la moitié des Etats membres dont la Présidence, cette participation pourra être limitée aux membres de plein droit;
— ils auront la possibilité d'être associés à la cellule de planification par une procédure de liaison permanente;
— ils auront les mêmes droits et responsabilités que les membres de plein droit pour les fonctions relevant d'instances et d'institutions auxquelles ils appartiennent déjà et qui seraient transférées à l'UEO;
— ils auront droit à la parole mais ne pourront pas bloquer une décision faisant l'objet d'un consensus entre les Etats membres;
— ils pourront s'associer aux décisions prises par les Etats membres; ils pourront participer à leur mise en oeuvre à moins de décision contraire prise par la majorité des Etats membres ou par la moitié des Etats membres dont la Présidence;
— ils participeront, sur la même base que les membres de plein droit, aux opérations militaires de l'UEO pour lesquelles ils engagent des forces;
— ils accepteront dans son intégralité la section A de la partie III de la Déclaration de Petersberg qui formera un élément du document d'association;
— ils seront raccordés au système de télécommunications (WEUCOM) des Etats membres pour les messages relatifs aux réunions et activités auxquelles ils participent;
— ils seront invités à apporter une contribution financière aux budgets de l'Organisation.

Activités spatiales
Pour des raisons pratiques, les activités spatiales demeureront restreintes aux membres actuels jusqu'à la fin de la période expérimentale concernant le centre satellitaire se terminant en 1995. Pendant cette phase, les nouveaux membres et les membres associés seront tenus informés des activités spatiales de l'UEO. Des dispositions appropriées seront prises pour permettre aux membres associés de participer aux activités spatiales ultérieures au moment où seront adoptées les décisions relatives à la poursuite de ces activités.

Mandat
C. Les Ministres ont chargé le Conseil permanent de prendre des dispositions pour entamer les discussions avec les Etats concernés.

Les Ministres ont confirmé leur souhait de conclure les accords nécessaires avant le 31 décembre 1992.

Déclaration du Kirchberg

9 mai 1994

Document sur un Statut d'Association à l'UEO pour la République de Bulgarie, la République de Hongrie, la République de Lettonie, la République de Lituanie, la République de Pologne, la Roumanie, la République Slovaque et la République Tchèque

Le Conseil des Ministres de l'UEO et les Ministres des Affaires étrangères et de la Défense de la Bulgarie, l'Estonie, la Hongrie, la Lettonie, la Lituanie, la Pologne, la Roumanie, la République Slovaque et la République Tchèque se sont mis d'accord sur le présent statut, aux termes duquel la République de Bulgarie, la République d'Estonie, la République de Hongrie, la République de Lettonie, la République de Lituanie, la République de Pologne, la Roumanie, la République Slovaque et la République Tchèque deviennent Associés partenaires de l'UEO; ce statut comprend les éléments ci-après.

Ce statut n'entraîne aucune modification du Traité de Bruxelles modifié.

1. Ces pays pourront participer aux réunions du Conseil compte tenu des dispositions suivantes:

   — Ils pourront prendre part aux débats mais ne pourront pas bloquer une décision faisant l'objet d'un consensus entre les Etats membres.

   — Afin de permettre à l'UEO de répondre pleinement à son rôle de composante de défense de l'Union européenne et comme moyen de renforcer le pilier européen de l'Alliance atlantique, ainsi que de traiter toute autre question dans une configuration appropriée, des réunions du Conseil seront convoquées conformément aux dispositions actuelles, sur la base des procédures arrêtées à Rome le 20 novembre 1992 dans le Document portant sur les membres associés de l'UEO et la Déclaration sur les observateurs à l'UEO.

Ils seront régulièrement informés au Conseil des activités de ses groupes de travail et pourront être invités à y participer sur une base ad hoc.

Ils pourront avoir une procédure de liaison avec la Cellule de planification.

2. Ils pourront s'associer aux décisions prises par les Etats membres en ce qui concerne les missions suivantes, qui sont cités dans la Partie II, paragraphe 4, de la Déclaration de Petersberg: missions humanitaires ou d'évacuation de ressortissants, missions de maintien de la paix, missions de forces de combat pour la gestion des crises, y compris pour le rétablissement de la paix.

Ils auront la possibilité de participer à leur mise en oeuvre ainsi qu'aux exercises et à la planification y afférents à moins de décision contraire prise par la majorité des Etats membres ou par la moitié des Etats membres dont la Présidence. Ils seront invités à fournir des données sur des forces, qu'ils pourront en outre proposer pour des opérations particulières.

Lorsqu'il sera décidé qu'ils peuvent prendre part à de telles opérations de l'UEO en engageant des forces, ils auront les mêmes obligations que les autres participants ainsi que le droit d'être inclus dans les structures de commandement et le processus de décision du Conseil y afférent. Les modalités précises de leur participation à chacune de ces opérations de l'UEO, y compris leurs droits et obligations, seront arrêtées au cas par cas.

du statut de membre associé; c'est sur la base de ces lignes que l'Agence avait conclu l'accord d'association avec la Finlande en 1986, accord reconduit en 1991 (cf. ESA/LEG/88 & ESA/LEG/138);

(ii) le Conseil a, en octobre 1992, endossé certaines procédures de coopération concernant le 'développement de la coopération avec les pays d'Europe centrale et orientale';

(iii) le Conseil, réuni au niveau ministériel en novembre 1992 à Grenade, a adopté la Résolution no. 2 sur la coopération internationale et la Résolution no. 3 traitant de la Russie. Le paragraphe 7 de la Résolution no. 2 se lit comme suit : *'NOTE avec intérêt les réalisations de nombreux pays en particulier ceux situés en Europe centrale et orientale, dans les domaines de la recherche et du développement en matière spatiale, et SOUHAITE que l'Agence continue d'entretenir et de développer des relations avec ces pays.'*

Les Etats membres de l'Agence ont voulu eux aussi participer à l'effort européen en vue d'assurer la reconstruction des pays d'Europe centrale et orientale.

Les activités poursuivies par l'Agence intéressent ces pays qui ont une expérience spatiale résultant de leur coopération passée avec l'Union soviétique et qui disposent de personnel de haute qualité.

Différents domaines de coopération ont été identifiés avec certains pays : Sciences, Observation de la Terre et Télécommunications par satellites. La formation aux techniques et méthodes occidentales constitue une condition préalable à la réalisation de coopérations plus ambitieuses.

Il appartient aux pays de cette région de définir eux-mêmes leurs projets et leurs ambitions dans le domaine spatial.

La situation économique de ces pays ne leur permettra pas d'envisager, dans un proche avenir, des coopérations qui soient financièrement parfaitement équilibrées.

L'Agence, dans cette perspective, devra rechercher – au-delà des moyens limités dont elle dispose – une coordination avec des institutions qui ont pour mission d'aider ces pays (Union européenne, BERD, etc.). Dans un proche avenir, la coopération pourrait se traduire par:

- des cours de formation,
- un intéressement de groupes scientifiques à l'exploitation des programmes scientifiques de l'Agence,
- des projets pilotes utilisant les données du satellite ERS,
- la démonstration de l'utilité des satellites européens de télécommunications.

A plus long terme, ces pays – en fonction de leurs intérêts spécifiques – pourraient prendre part à certains programmes de l'Agence (sur la base de l'article XIV.2 de la Convention).

B. L'article XIV de la Convention

Cet article demeure la base juridique pour tout accord; il n'est nullement nécessaire de l'amender. Il permet d'établir un accord-standard (dit 'accord-cadre); c'est alors à cet accord de définir les relations souhaitées et possibles, le mécanisme, etc. Même si le Conseil a adopté un standard, il n'est pas interdit de penser que son contenu pourrait évoluer (voir pages suivantes). L'article XIV.2 concerne la participation aux programmes facultatifs, participation qui paraît pour l'instant pour la plupart des pays difficile compte tenu des obligations financières et du niveau industriel requis du demandeur.

Enfin, l'article XIV.3 et le statut de membre associé: les grandes lignes de ce statut ont été adoptées par le Conseil le 23 octobre 1985 (cf. ESA/C(85)116). Ce statut est découplé de celui de l'adhésion. L'association n'est pas un préliminaire. L'adhésion requiert toujours un vote séparé. Mais l'association suppose un certain niveau industriel de la part du demandeur, c'est un statut taillé au bénéfice de l'Agence.

Les lignes directrices essentielles du **statut de membre associé** sont les suivantes:

Le membre associé est tenu de participer aux dépenses inscrites au budget général de l'Agence, au titre des études de projets futurs – documentation – Earthnet – frais communs fixes – et de tout autre poste que le Conseil pourra définir. L'Etat non membre contribue à ces dépenses sur la base de son revenu national moyen aux coûts des facteurs.

L'octroi du statut de membre associé ne préjuge pas de la décision du Conseil sur une demande de participation à un programme facultatif en application de l'article XIV.2 de la Convention. Les droits et obligations en tant qu'Etat participant sont définis par un accord distinct.

Le membre associé dispose du statut d'observateur auprès du Conseil (pour les points d'intérêt commun). Sur autorisation du Président, il peut prendre la parole, présenter des observations et, le cas échéant, faire des propositions sur les points d'intérêt commun. Il peut être invité à assister à certaines réunions d'organes subsidiaires pour des points d'intérêt commun. Il ne dispose pas du droit de vote.

Le membre associé peut avoir accès aux moyens et services de l'Agence pour ses propres besoins si le fonctionnement régulier des activités et programmes de l'Agence ou des Etats le permet. Il supporte les coûts encourus par l'Agence conformément aux règles et procédures en vigueur. Le membre associé peut se voir confier l'exécution de travaux aux fins de programmes de l'Agence, sans disposer de garantie de retour industriel pour sa participation financière. Le membre associé favorise l'utilisation pour ses propres besoins des systèmes de transport spatiaux européens et des moyens et produits de l'Agence.

Aussi la base des relations avec les pays de l'ex-Europe de l'Est devrait se trouver dans l'article XIV.1. L'accent est par exemple mis sur les programmes de formation, organisation de cours, échange de personnel. Il faut noter que l'accord-standard n'évoque pas de statut particulier au sein du Conseil (observateurs), ni d'une adhésion possible ultérieure, ni de versement d'une contribution à l'Agence. L'accent est mis sur l'information.

L'accord-standard peut être suivi d'arrangements détaillés si un projet d'intérêt commun a été identifié. Pour l'instant aucun arrangement détaillé n'a été négocié; l'accord-standard a pour premier objectif la mise en place d'une structure nationale. Cet accord-standard actuel fait parfois penser aux accords-chapeau passés par le CERS/ESRO dans les années 70; accord d'échange d'informations et de personnes et consultations périodiques.

La réponse aux demandes de l'Europe de l'Est ne saurait donc être unique. Elle dépend des objectifs différenciés de chaque Organisation, politique, culturel, recherche. Chacune de ces Organisations a su démontrer sa capacité à s'adapter, sa flexibilité. Il est vrai qu'on peut traiter chaque aspect par lui-même mais comme contribuant à la réussite d'ensemble.

On ne peut non plus omettre de veiller à ce que chaque arrivée ne vienne fragiliser l'édifice construit. En matière de recherche et développement, d'activités spatiales, l'arrivée de nouveaux membres n'ayant pas encore acquis le niveau industriel suffisant et voulant se réclamer, sans période transitoire, d'un statut identique à celui des Etats membres, n'irait pas dans le bon sens. C'est d'ailleurs ce qui ressort de l'expérience d'autres Organisations et leur statut de partenaire en transition par exemple.

Que peut-il se passer? L'entrée d'un nombre important de pays d'Europe centrale et orientale pourrait être mise à profit pour revoir l'harmonisation entre les diverses Organisations. L'argument que telle Organisation comprend des pays non membres de telle autre devrait tendre à disparaître. Mais comment accommoder la spécificité propre à chaque Organisation, nécessaire pour refléter les diverses possibilités de coopération et la conduite organisée d'une politique européenne ? Ne touche-t-on pas par là aux règles de fonctionnement de chaque Organisation? Faut-il se lancer dans un travail titanesque de réforme de plusieurs Conventions? Peut-on arriver à une structure politique et en même temps capable de gérer des programmes pointus avec des membres à niveau technique et économique fort différent? On le voit, le défi est immense. Un premier pas serait de profiter de l'opportunité de la reconduction des accords-standard ('cadré') pour leur conférer un contenu plus adéquat et tenant compte de l'expérience des autres Organisations, d'assurer peut-être une progression en tenant compte du statut de membre associé.

ANNEXE

Eléments de l'accord-standard ('cadre') (Article XIV.I de la Convention)

ARTICLE 1
Objectif
Les Parties affirment leur désir de renforcer et d'élargir dans leur intérêt mutuel la coopération existant dans le domaine des utilisations pacifiques de l'espace extra-atmosphérique en créant, avec le présent accord, un cadre de nature à développer plus avant cette coopération.

ARTICLE 2
Domaines de coopération
1. Les domaines de coopération dans le cadre du présent accord peuvent englober un élément ou une combinaison des éléments ci-après :

(a) consultations périodiques au niveau de l'exécution sur des projets d'intérêt mutuel en vue de définir des objectifs et de faire des propositions sur la meilleure façon de coordonner des moyens et de réaliser des activités. La coopération à de tels projets serait fixée d'un commun accord par les Parties et porterait sur différents domaines dans lesquels les Parties mènent des activités spatiales tels que la science spatiale, l'observation de la Terre, les télécommunications et la recherche en microgravité;
(b) attribution de bourses permettant aux bénéficiaires de l'une ou l'autre Partie de suivre une formation ou d'entreprendre d'autres activités scientifiques ou techniques auprès d'institutions choisies par la Partie offrant la bourse;
(c) échanges d'experts qui participeront à des études;
(d) conférences et symposiums communs;
(e) activités communes en relation avec la promotion de l'utilisation des produits et des services réalisés dans le cadre des programmes de l'Agence.

2. En vue de réaliser la coopération prévue dans les domaines énumérés au paragraphe précédent, les Parties sont convenues de faciliter l'échange de savants et d'ingénieurs. L'Agence s'engage en outre à offrir l'accès à son réseau ESIS pour ce qui est du courrier électronique et des échanges de données.

3. D'autres domaines et formes de coopération peuvent être ajoutés d'un commun accord à ceux qui sont mentionnés dans le présent article.

ARTICLE 3
Modalités d'exécution

1. Chaque Partie désigne un représentant chargé d'étudier et de définir des propositions d'activités en coopération, de suivre leur exécution et de prendre des mesures pour aider à développer plus avant ces activités en coopération. C'est par ces représentants désignés que passent normalement les propositions des Parties en matière de coopération.

2. Des groupes de travail communs peuvent être constitués pour étudier en détail des propositions dans des domaines que les Parties leur confient et leur faire des recommandations.

3. Pour la mise en oeuvre des domaines de coopération définis à l'Article 2 du présent accord, les Parties s'entendent sur des modalités d'exécution spécifiques, ce qui peut donner lieu à la constitution d'un groupe de travail. Pour le Gouvernement de ...., c'est.........................ou une agence habilitée par ....qui est autorisé à conclure de tels arrangements pour le compte du Gouvernement.

4. Des réunions spéciales des représentants désignés en vertu des dispositions de l'Article 3.1. sont convoquées, en principe tous les deux ans, pour revoir l'exécution du présent accord.

5. Le Gouvernement de .... s'engage à fournir une assistance administrative pour l'exécution du présent accord, en ce qui concerne en particulier l'entrée et la sortie des personnes ainsi que l'importation et l'exportation de biens se rapportant à des projets dont les Parties conviennent, y compris en ce qui concerne leur exonération des charges s'appliquant normalement à l'exportation et à l'importation.

6. Dans l'exécution des obligations qui lui incombent en vertu du présent accord, chaque Partie assume normalement ses propres dépenses.

ARTICLE 4
Information

1. Les Parties se tiennent mutuellement informées de l'ensemble de leurs activités et programmes respectifs et de leur avancement.

2. Les Parties échangent des informations techniques et scientifiques d'intérêt mutuel sur la science, la technologie et les applications spatiales en se communiquant des rapports et notes techniques et scientifiques, en accord avec leurs règles respectives sur la divulgation des informations et des données.

3. Les informations scientifiques et techniques obtenues par l'une des Parties au cours d'expériences ou de projets menés en commun sont mises à la disposition de l'autre Partie, sous réserve de l'observation des règles dont elles peuvent convenir mutuellement concernant la divulgation des informations et des données.

4. Si l'une des Parties fournit à l'autre des biens, des données ou des informations, la Partie qui les reçoit leur accorde un degré de protection en matière de propriété intellectuelle au moins équivalent à celui dont ils bénéficient en vertu du système juridique de la Partie qui les fournit. Les mesures particulières que cette dernière juge nécessaire de prendre pour atteindre ce degré de protection font l'objet d'un accord commun.

The Second Euro – Latin American Space Days

V. Hood
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In November 1991, ESA and the Brazilian Space Agency (INPE) organised a 'Euro – Latin American Space Days' conference, which was intended to be a one-off event to encourage the development of trans-Atlantic relations in the area of space technology and its applications. That first meeting proved to be such a great success – despite some trepidations beforehand that the delights of the venue, Rio de Janeiro, might prove more enticing than space topics – that the Argentinian Delegation invited ESA to hold a Second Euro – Latin American Space Days in Buenos Aires, in May (from 9th to 13th) this year.

European politicians, scientists, engineers, astronauts, industrialists and students rubbed shoulders with their counterparts from Argentina, Brazil, Chile, Colombia, Mexico and Venezuela at this year's Euro – Latin American Space Days. They were organised by ESA and the Argentinian National Space Agency (CONAE), with co-sponsorship from ASI (Italy), CDTI (Spain), CNES (France) and DLR/DARA (Germany). The conference programme covered manned space activities, remote-sensing applications, space science, telecommunications, tele-education, space technology, industrial activities and space teaching in schools.

With the aim of encouraging young people to take an interest in the world of space activities, ESA, CONAE and EURISY organised a competition for 15 – 18 year olds from Latin America and ESA's Member States, inviting them to write a short science-fiction story in not more than ten pages. Some 90 entries were received from Europe – France, Spain, Ireland, the United Kingdom and Finland – and from Latin America – Argentina, Brazil, Colombia and Mexico.

Five finalists from Europe and six from Latin America were selected and invited to attend the Space Days in Buenos Aires to receive their certificates from ESA Astronaut Claude Nicollier and French Astronauts Jean-Pierre Haigneré and Claude André-Deshays. The two winners, Paul Barry (Ireland) and Lucia Gagliardini (Argentina), will also be invited to attend an Ariane launch, in Kourou, French Guiana, at a later date.

Argentina's President Dr. Carlos Raoul Menem, inaugurated the conference proceedings, flanked by Dr. Conrado Varotto, President of CONAE and Mr Marius Le Fèvre, Director of ESTEC, ESA's Research and Technology Centre in The Netherlands (Fig. 1). They had earlier met the

Figure 1. Dr. Carlos Raoul Menem, the President of Argentina, flanked by Dr. Conrado Varotto (left), President of CONAE, and Mr Marius Le Fèvre (right), Director of ESTEC

Figure 2. Some of the Competition Winners being congratulated by President Menem. From left to right: Paula Petroni (Argentina), Jonothan Grimaud (France), Nadia Marconi (Argentina), Martin Bollrover (UK), Lucia Gagliardini (Argentina), and Paul Barry (Ireland)

competition winners (Fig. 2) and the astronauts. Claude Nicollier presented the President with a souvenir of the occasion and gave a short speech in Spanish.

Claude Nicollier subsequently reported on his activities during the Hubble Space Telescope Servicing Mission, and Jean-Pierre Haigneré on his experiences of flying with the Russians.

At the end of the morning, the astronauts presented the certificates to the competition winners, before Conrado Varotto, Marius Le Fèvre and the Spanish Secretary of State for Defence, Mr Antonio Flos Bassols, formally opened the Exhibition (Fig. 3) accompanying the conference – the Space Days were then well and truly under way!

The Space Days, once opened, assumed an inertia of their own. Daily, and sometimes even hourly changes, had to be made to the evolving programme, catering to the needs of the three-hundred attendees. The quality of the presentations was uniformly high, and new contacts were forged and old contacts renewed, especially among the industrialists. The competition winners mingled with the conference participants and, despite the language problems, became fast friends during the course of the week.

Remote-sensing applications took pride of place at this year's Space Days, with presentations on geology, natural hazards, glaciology, interferometry, oceanography, agriculture, forestry, land use and cartography. The Latin American countries presented their planned space programmes and aspirations. The Panel sessions on space science and space technology were also well-attended, as were the industrial sessions.

Telecommunications and tele-education were popular themes, as this is a rapidly expanding area of activities in Latin America. The Argentinian domestic satellite programme 'Nahuelsat' was highlighted as a prime example of Euro – Latin American cooperation. The spacecraft itself is being built by a European Consortium involving DASA (D), Alenia (I) and Aerospatiale (F).

A number of social activities that accompanied the Space Days provided opportunities for discussions in more relaxed surroundings and provided a further impetus for international contacts.

Figure 3. Opening of the Exhibition by, from left to right: Mr Antonio Flos Bassols, Spanish Secretary of State for Defence, Dr. Conrado Varotto, President of CONAE, and Mr Marius Le Fèvre, Director of ESTEC

THE BANANA SANDWICH

PAUL BARRY

He reached up with both hands and slowly adjusted his hat, pulling it lower over his eyes. Eyes which were cold and calculating, softened only by an almost suppressed gentleness. He smoothed out his long military uniform, his medals of honour clinking as he did so. Then he stood rigidly, staring out into the darkness around him. Faint sounds floated towards on the soft breeze; the slamming of a door, the laughter of young lovers, the straining voice of a long ago star, the jingle of money. And slowly they faded away, leaving only the General and his thoughts. Today, after twelve hours of secret consultation between the world's major powers the devastating news had been released - but not to civilian personnel. It had all begun long ago during the industrial revolution. Tonnes and tonnes of noxious gases - sulphur, nitrogen and carbon had been released to float up until they were trapped beneath the ozone lair. Each day since more and more damaging gases had accumulated, and when the CFCs finally joined the fray they overcame the resourcefulness of nature. Small at first but then growing larger and larger a hole appeared above the Antarctic. Global warming was hardly noticeable then, but now the hole was over 500 kilometres wide. Now the effects were obvious. The world's oceans had risen two inches in the last six months - the reality had finally hit home. Despite the gravitational effects of the moon the oceans tidal configuration began to change. Half of Holland disappeared in less than a week, and all countries began an uphill battle to keep their coastal regions. But far worse than this was the effect these currents had on the moon. Its orbit slowly began to change to match the oceans currents once again. A change that was predicted to take a year and a day, and on that day life on earth would cease to exist as it had before. The moon would become locked in a perpetual eclipse. It would block out all the suns rays. Only once every two years for a couple of seconds would the moon move slightly allowing life giving rays through, but until then the earth would be bathed in everlasting night. The plants would wither and die. The strain on the world's resources would be phenomenal. Society would never survive such a crushing blow. It's collapse would be inevitable, and the confusion that followed, incomprehensible. That appeared to leave only one option. To damage the ozone lair to an even greater extent, hoping more tidal changes would once again affect the moons orbit. An option with near fatal consequences.

The General frowned and stroked his chin - what could be done? He was no newcomer to astronomy, having devoted much of his life to the study of the great celestial bodies. He almost relished the challenge before him. It was back to basics. Man against nature. The greatest minds of humankind pitted against a fate worse than death. The General folded his arms and continued to contemplate the night. He remained there, deep in thought for hours, until the sun's feeble morning light made the dew glisten on the grass at the General's feet. Then he turned away and tucked his hands into his pockets. His right hand closed over something metallic. He withdrew his banana sandwich from deep within his pocket, it was covered in tinfoil. With one swift motion he unwrapped his sandwich, crumpled the tinfoil into a ball and contemptuously cast it aside. Caught in a ray of light it gleamed like a shooting star as it tumbled to the tarmac and bounced away. It rolled for a moment before coming to a stop, and lay there shining like neatly polished silver. While he chewed on his banana sandwich he considered the small metallic ball, and realised its profound importance. "Eureka! I have discovered it ! " he cried, throwing his hat high into the air. The cadet core looked on in stunned amazement. Then as his hat returned to earth the General caught it with a flourish, smoothed back his hair, and strode towards his office. Salvation was at hand.

His underlings snapped to attention as he threw open the door and strode into the reception area. " I want Professor Einstien on line one, that Greek guy, Dimetreous Archemidis on line two, Gallileo on line three, the President line four and the Pope on five. And be quick about it, I know how to save the world!! " With that he disappeared into his office and locked the door behind him.

" Oh, my hero " sighed Valerie, the secretary with the utmost admiration. She knew she must not fail him and began the formidable task of contacting the important people he required. Throughout the day there was a constant flow of people into the General's office. All left burdened with responsibility, but their eyes gleamed with hope. Valerie could almost imagine the General's words to them. He spoke with a passion few could resist. By 9A.M. the entire army base was on full alert and alive with activity. Whole divisions went out to scavenge the refuse sites, factories were occupied and normal daily routines were completely upset. And through it all the general sat there, his office an island of calm in the raging sea of chaos.

" Professor Einstien, this little problem we face, I think I know the answer. Listen to this....."

" Dimetreous Archemidis? Light! Talk to me about light! "

" Gallileo, how are things? Good, good. I need magnification. I need to know more about glass. Like in a telescope? No, not quite, but similar, very similar."

"Yes Mr. President I want that authority "

" Well.. your Grace, it's like this......"

The day was cold and bleak, bleaker even than the meeting place. Positioned on a sheer cliff the grey and white building offered no warmth or welcome. Pale light glowed in the window and shadows danced against the glass. Inside the stage was set, the actors ready. Only moments to go before the curtain was due to rise. These precious moments were all the General needed. He sensed the tension - no, he could smell it. Five people knew of the plan, that left only 495 to convince. He saw fear, expectation, despair and hope in the sea of faces arrayed before him. His speech had to exploit this. He breathed deeply, prepared himself well. In his mind he saw the curtain rise, the lights go on. He gripped the edges of the podium tightly. The show was about to begin.

" Ladies and gentlemen we are faced with a grave problem. As you know we now have only 359 days before disaster strikes. 359 days before life as we know it will cease to exist. Something must be done. And this is what I propose we do. The sun's rays will still shine on one face of the moon. We must gather this light and transfer it to earth. How? First we must maintain the light's intensity. The light reflected from the moon is too weak. We must cover half of the moon's surface with tinfoil! Yes ladies and gentlemen, tinfoil! And this light will be trapped beneath three layers of glass, all of different densities. The reflective index of the inner layer being greater than that of the two on either side, and the glass will be formed into prisms to insure the critical angle of incidence is maintained. The result - TOTAL INTERNAL REFLECTION. The technology of fibre optics. Now we can control the light. The light of hope and salvation. It will bounce around to the other face of the moon, our face. The sun's life giving rays need not be taken from us. They will pour over our world, being more valuable to us than anything imaginable. And you alone have the power to do this. Our world balances precariously between life and death, and you have the power to tip the scales. Do not stand idly by and watch billions perish. Support my plan. I know it will work. "

The silence was deafening. The room was utterly quiet. The General retreated from the podium, hoping he had done enough. Had his words swayed them ? Only time would tell. The General sat outside, waiting. Time went by, and the minutes dragged on into hours. Then slowly the great doors opened. The General looked up. The pope smiled. He had their support !!

Within a week the Central Committee for the Earth's Salvation had been created. It consisted of five great men, the five men who had supported the Generals plan in the first place. And of course the council was headed by the General himself. They were faced with a mighty challenge - covering 3394.34 square miles of the moon's surface with tinfoil, and then three layers of glass. They debated long and hard, hidden away from the world for twelve agonising days. Upon reaching a decision they acted immediately and their directive was clear and concise, with no need for clarification. The tinfoil factories were crewed by military personnel, working 26 hours a day to ensure maximum productivity. Millions of tonnes of sand was taken from the Libyan and Nuben deserts to the Committee's headquarters at Buenos Aires.

A massive satellite station expansion program was launched. Every day new parts, personnel and materials were sent into space with the goal of creating a satellite station of unimaginable proportions. Big enough to accommodate over 300 skilled workers, big enough to harness the energy of the sun for power. Big enough to manufacture miles upon miles of glass. With the pope's blessing the rolls of tinfoil were launched up into the heavens while the public could only watch and wait, wondering what was happening. 238,857 miles from earth Captain Armstrong awaited the arrival of the rolls of tinfoil. His hand picked squad of a hundred men and women waited with nervous anticipation. They were responsible for five billion lives, for if they failed all hope would be lost, and the earth doomed. For four long months they worked painstakingly, spreading out the tinfoil with infinite care. Every precaution was taken to insure it was neither ripped nor torn. Then it was sprayed with a transparent lacquer, to strengthen and protect it. They had done their part, only the glass remained.

With 239 days to go the General unveiled Ariane Two. It was a chaotic joining of all the space satellites, combined with kilometres of new chambers, walk ways, and workshops. Ariane Two: The General called it a creation of " unsurpassable importance ". And it was he who piloted the first great cargo rocket, the Gaberial into space to deliver a substance now more precious than diamond - sand! With an unlimited supply of power at the General's fingertips he began supervising the creation of the first layer of glass. This layer, like the others was to be made up of one thousand prisms. And when the first prism was finished the General and Captain Armstrong strapped on their booster packs and made ready. Each carried a long steel pole, topped with a hard glass suction pad. In Armstrong's ear the countdown began.

" T minus ten, nine, eight "

Seven seconds later the air lock doors hissed open and out they floated. They pushed before them the prism that had just been finished. It was still quite warm and soft, not yet having hardened. Once, twice, three times they fired their rockets to maintain the correct course. Then they were over the target zone, frantically trying to follow the instructions.

" Left, left, right, down, no! no! Up, more right! Not left, right! "

Dozens of voices shouted, ranted and raved at them, only seconds remained...

" Now!! " they cried in unison.

The General and Armstrong drove the prism onto the moon's surface and held it there. Then they waited. The glass cooled and hardened, becoming one with the tinfoil. Armstrong removed the steel poles and the suction pads completed the perfect shape. It glowed like a beacon in the sun's light and the General's heart swelled with pride. Instinctively he knew everything was going to be alright.

Over the next 200 days the Generals plan became a reality, piece by piece, layer by layer. It covered completely one half of the moon's surface. With only a little time remaining the General and Captain Armstrong laid the final prism. The last pieces of the plan fell into place. 366 days after the plan's realisation the moons new orbit was established. A moon covered with strange glass shapes. A moon which glowed as brightly as the sun ever had !!!

Two men and a woman sat around a beautiful marble table, sipping their after dinner coffee. Frank adjusted his tie and looked at his companions before speaking

" By far my worst patient. That's the story he told me, word for word. And he believed it! I had no choice but to institutionalise him. He was beyond even my skill, completely insane. "

Catherine tilted her head to catch a ray of autumn sunlight and ran her fingers through her luxurious chestnut brown hair.

" And what was his name? " she asked

" Adrian Foley...but he thought he was John the Baptist. He "explained" to me how the General was actually Jesus, and in the second coming saves the world!" Frank chuckled, remembering the story " John the Baptist, the second coming, he had lost it completely "

The conversation left Adrian Foley and moved on to other patients and events. As usual at 6PM they finished their coffee, paid the bill and tipped the waiter. They stood talking for a moment in the cool evening before going to their separate cars and driving home. Frank sat behind the wheel of his new B.M.W., he switched on the radio and started the engine. He began reversing but stopped abruptly. His arms fell limply to his sides, he sat there, stunned. The voice came on the radio for a second time.

" This is a national emergency - America needs your tinfoil......."

PAUL BARRY

EL PLANETA GRIS

LUCIA GAGLIARDINI

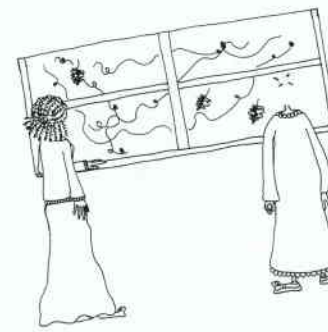
- Es tan hermoso el otoño.....

-- Tan hermoso como fugaz y ni siquiera tan hermoso como lo fue en aquellas épocas, en las que había más árboles que fábricas, en las que los pájaros que emigraban eran muchos y no unos pocos que lograron sobrevivir al descuido de los humanos.

--Ya basta mamá, ya hemos discutido demasiado sobre el tema y bién sabes que tanto yo como muchos otros hacemos hasta lo imposible para luchar contra estos problemas .

--Lo se, lo se ...

El silencio entró en la habitación . Ursula miró nuevamente hacia la ventana y cerró los ojos, entando dormir . Ana su hija le besó la frente y se retiró sin hacer ruido .



Ursula y Ana, junto con Eliseo constituyen una familia típica, que nunca se ha diferenciado del resto. Viven en un barrio burbuja, que cuenta con su propio suministro de aire puro, de casas blancas y techo de tejas, cerca de una plazoleta artificial. Como casi todos, para poder caminar de un barrio a otro, adquieren sus pulmones portátiles en la gran fábrica. Ellos los prefieren sin fluorecencias ni luces. Eliseo se compró uno azul hace ya un mes y aún lo conserva, Ana tiene uno con flores y Ursula uno naranja. Además todos poseen porta-pulmones para usar en ocasiones especiales.
Son dueños de un auto volador de color verde, que Ursula eligió. Ella es una mujer muy especial, madre de Ana y suegra de Eliseo. Tiene una mirada profunda, sus grandes ojos marrones describen toda su vida. Ursula es uno de los pocos sobrevivientes de la época de la gran transición, período de fuertes cambios aquí en la tierra, época en que las aguas dejaron de ser potables y el aire respirable.

Que sea una de las pocas sobrevivientes no quiere decir que los demás ya no estén sino que simplemente han "olvidado". Ana es bastante reservada, sus ojos irradian chispas y bajo ciertas luces parecen de color naranja, como los de las palomas. Canta maravillosamente y dedica su vida al análisis de la tecnología y su efecto en el medio ambiente. Eliseo es un hombre alto y delgado, tan delgado que parece mecerse como un junco con el viento.

Un día, cuando Ana y Eliseo preparaban el desayuno, el timbre sonó con fuerza y una carta se escurrió bajo la puerta. La abrieron al instante, era de Aldo el hermano de Ursula.

Querida familia:

Aquí en el campo estan sucediendo cosas extrañas, les pido que vengan lo antes posible, no puedo dar mas datos por el momento.
Los quiere siempre.

Aldo

Las miradas se entrecruzaron, pero terminaron juntándose en los grandes ojos de Ursula. Ella tomó un trago de café y habló.

- que suerte, tenía ganas de ver a mi hermano, dejar un poco esta gran ciudad.
- pero ¿a qué se habrá referido con "cosas extrañas"?, dijo confundido Eliseo
- quien sabe, quizá sea sólo una excusa para vernos nuevamente, -se quedó un rato pensativa - aunque no lo creo

Ana limpió la mesa. Canturreba una suave melodía, de pronto los miró a ambos:

- hoy a la tarde tengo tiempo para llevar a revisar el auto y comprar lo necesario.

A la tarde del día siguiente ya casi todo estaba listo para partir. Ellos nunca habían sido de llevar mucho equipaje y ésta no era una excepción. Aunque estaban todos dispuestos a ir en el auto se palpaba un aire tenso. Solo serían unos días, o al menos eso pensaban. El motor arrancó sin hacer ruido y livianos como plumas avanzaron hasta los límites del barrio burbuja. Allí se detuvieron para un control, había un robot plateado que vigilaba a todo aquél que entraba y salía y proveía tubos portátiles de ozono y otras cosas.

Fuera el mundo era terrible, el sol había arrasado con todo y la tierra se encontraba partida aquí y allá y parecía salir humo del interior. Pocas veces se veían personas por esos lados. La desolación estremecía a todo aquél que por allí circulaba. Dentro del auto nadie miraba el paisaje, todos estaban ensimismados. El tío Aldo siempre les había parecido una persona rara, le tenían mucho aprecio. El era de inventar historias, contar chistes y al igual que Ursula era uno de los poco sobrevivientes.

Después de la gran transición el olvido se había promovido por todos los medios posibles: radio, televisión, cines, grandes pantallas en las calles. Tanto se insistió que casi todos olvidaron. Se pretendía generar un hueco en la historia, que las nuevas generaciones no supiesen nada de los hechos. La realidad era que el gran desastre era sólo culpa de los humanos, y más particularmente de algunos que de otros y de eso algunos consideraban que era mejor que nada se supiese.

Después de varias horas de viaje, el sol ya oculto y la luna apenas observable, se detuvieron a dormir en un refugio del pueblo burbuja de Calis. Se trataba de un pueblo que se encontraba a mitad de camino entre la ciudad y el campo. Estaba habitado por la nueva generación y era frecuentado por habitantes de otros pueblos. Se despertaron a la salida del sol y después de desayunar café y panes de miel continuaron . En Calis, lejos de la gran ciudad y su influencia, no era habitual la comida envasada y artificial. Sus habitantas y los viajeros disfrutaban de sus alimentos y nada querían saber de frutas comprimidas y envasadas en fuentes de plástico.

Llegada la noche divisaron los límites de la burbuja de las flores done vivía Aldo. Se veía oscura, salvo por unas luces que iluminaban la puerta y una pantalla encendida que controlaba la entrada. Al instante vieron la figura de Aldo que levantaba los brazos saludando.

-Que pasa? fue lo primero que peguntaron.

- nada grave, mañana descansados hablaremos, primero hay que cenar y dormir, respondió Aldo.

Al día siguiente Aldo se despertó junto con el sol, era una mañana hermosa y fresca. Mientras lo otros dormían preparó el desayuno. Al rato se depertaron y Aldo les relató la siguiente historia.

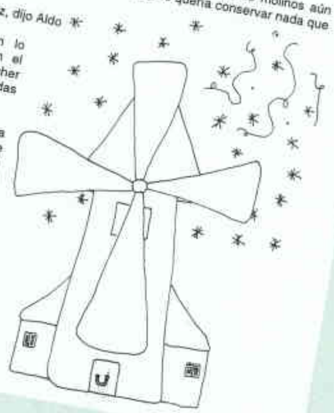
-Vi como luces en el cielo, luces que no eran estrellas ni naves, todo era como una niebla luminosa y a veces hasta creí ver como ojos oscuros observando - Mientras hablaba le brillaban los ojos, más que temeroso parecía estar fascinado. - la he visto moverse de un lado a otro, incluso dos días atrás me quedé hasta que se desvaneció junto a la noche.

Ninguno de los tres interrumpió hasta que terminó su relato. Fue entonces cuando se amontonaron las preguntas. Pero Aldo solo dijo que ya lo verían con sus propios ojos.

Luego del desayuno fueron hacia el molino, era uno de los pocos molinos aún existentes a pesar de la oposición del gobierno. que no quería conservar nada que fuera anterior a la transición.

- desde aquí veremos la luz, dijo Aldo

A la tarde todos llevaron lo necesario para alojarse en el molino. Esperando el anocher conversaron de cosas pasadas y comentaron novedades.



La noche era oscura, no había luna y las estrellas se veían de maravilla, cada vez parecían ser más. En las primeras horas de oscuridad se divirtieron descubriendo constelaciones, pero ya entrada la noche observaban en todas direcciones buscando la famosa luz. El molino era alto, rectangular, en la parte de abajo se abría en tres salas y en la cima tenía un techo triangular.

Ellos se encontraban en un cuartito ubicado en lo alto que tenía cuatro ventanas,

Cada uno miraba por una distinta. La noche pasaba y no había noticias de la gran luz, cuando de pronto Eliseo pegó un grito. Todos lo miraron y se dirigieron inmediatamente hacia la ventana. El asombro los había invadido, en el horizonte hacia el este se veía una gran nube luminosa como la que había descripto Aldo y de vez en cuando aparecían unos ojos redondos y negros que se desvanecían al instante.

- definitivamente no tiene nada que ver con las naves nuestras, comentó Ana y a su vez es demasiado bello para ser contaminación espacial.

- lo se - dijo Aldo - es la nube mas extraña y hermosa que he visto en mi vida.

Los cuatro se quedaron observando hasta la salida del sol.

Se despertaron ya pasado el mediodía y miles de ideas se les cruzaron por la cabeza.

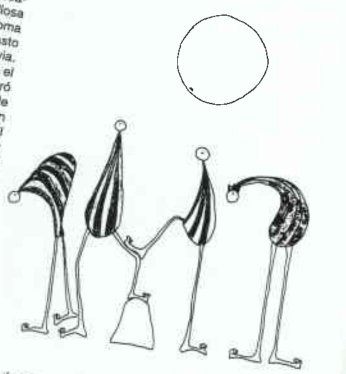
- creo que son seres de otros planetas dijo Aldo mientras tomaba el desayuno

- estoy dé acuerdo contigo agregó Ursula.

Nadie más hizo comentario alguno, todos pensaban en lo que debían hacer. Durante la tarde Aldo trajo lintemas y faroles de distintos tamaños y colores. Los limpiaron y verificaron que cada uno funcionase.

Entrada la noche se colocaron en sus puestos. Nuevamente por la ventana que daba al este Eliseo vio la luz. Entonces bajaron del molino y comenzaron a juguetear tratando de llamar su atención. Bailaban de aquí para allá con las diferentes luces, pero no lograron su objetivo. Entonces, Aldo sacó su auto pintado de amarillo, fosforecente y enceguecedor, provisto de luces de colores y dio vueltas una y otra vez. Mientras los otros observaban, la gran luz poco a poco comenzó a sentirse aludida. En realidad no eran las luces ni el amarillo fosforecente lo que le despertó la atención, sino el suave movimiento con que Aldo desplazaba el auto de un lado para el otro. Por la agilidad con que iba y venía, parecía correr como el viento. Cada vez aparecían más ojos en la gran nube y ahora no desaparecían inmediatamente sino que se quedaban más y más tiempo.

Lentamente, la nube se fue acercando y sin notarlo quedaron rodeados de una bruma brillosa y húmeda, tenía un aroma fresco como el del pasto luego de una fuerte lluvia. La nube descedió hasta el suelo donde se concentró formando una especie de flor. Sorprendidos vieron un ojo que los miraba. El ojo comenzó a elevarse y pudieron ver como de esa bella flor salía una cabeza, un cuerpo, un ser extrañísimo y no sólo uno, salieron cinco. Eran ovalados a rayas y puntiagudos hacia la parte superior, donde se conectaban con una cabeza redonda y blanca, ésta tenía un único punto negro que parecía un ojo.



Ursula estaba boquiabierta y los demás ni hablar, todos apretujaditos, uno contra otro observaban el maravilloso espectáculo. De pronto, se adelantó uno más corpulento cuyo ojo negro se veía más profundo, más tallado y en cuya cabeza había una corona verde. Los otros murmuraban cosas inentendibles pero éste en vos clara y fuerte dijo.

- "Saludamos a los seres de dos ojos"

Aldo estaba petrificado y no sabía cómo hacer para que su cerebro le enviara una orden coherente a su cuerpo. Ursula continuaba con la misma cara de antes, prácticamente no pestañaba. Ana y Eliseo estaban tomados de la mano y las piernas les temblaban.

El señor de la corona repitió:

-saludamos a los seres de dos ojos y esperamos que con cortesía nos saluden

Aldo pronunció un dificultoso "hola", al cual Ursula agregó un repiqueteo de dientes.

-Creía que los seres de dos ojos eran de lengua mas suelta- dijo el señor- pero por lo visto se nota que están aún dormidos, quizá debamos regresar luego.

- No dijo Aldo, es que estamos desconcertados, no los esperábamos y nos sorprendió esta visita, no se si usted y sus compañeros nos entienden.

- Yo entiendo, en cuanto a mis compañeros, ellos sólo hablan la lengua de los verdes

- ¿los verdes?

- sí del pasto, las plantas y los árboles, algunos conocen la lengua del viento y la lluvia. De todas formas, ¿cómo es que no nos esperaban? ¿acaso no fueron ustedes los que enviaron las señales?

- sí pero, es decir, como explicarle, no supusimos que vendrían.

- Comprendo, ustedes los seres de dos ojos tienen la costumbre de actuar sin medir las consecuencias

- las consecuencias, pensó en vos alta Aldo.

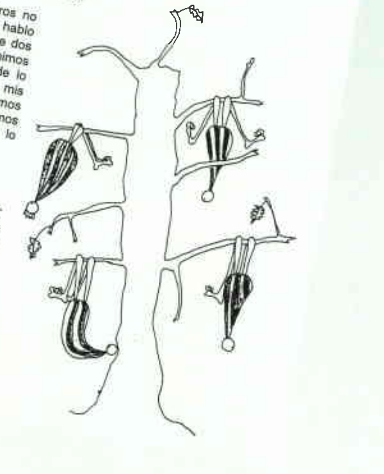
- No se preocupe acá nosotros no provocaremos ningún daño, hablo en general mi querido ser de dos ojos. En realidad nosotros venimos a ayudar. Pero es mucho de lo que debemos hablar y mis compañeros y yo estamos cansados por lo tanto dormiremos primero si ustedes nos lo permiten.

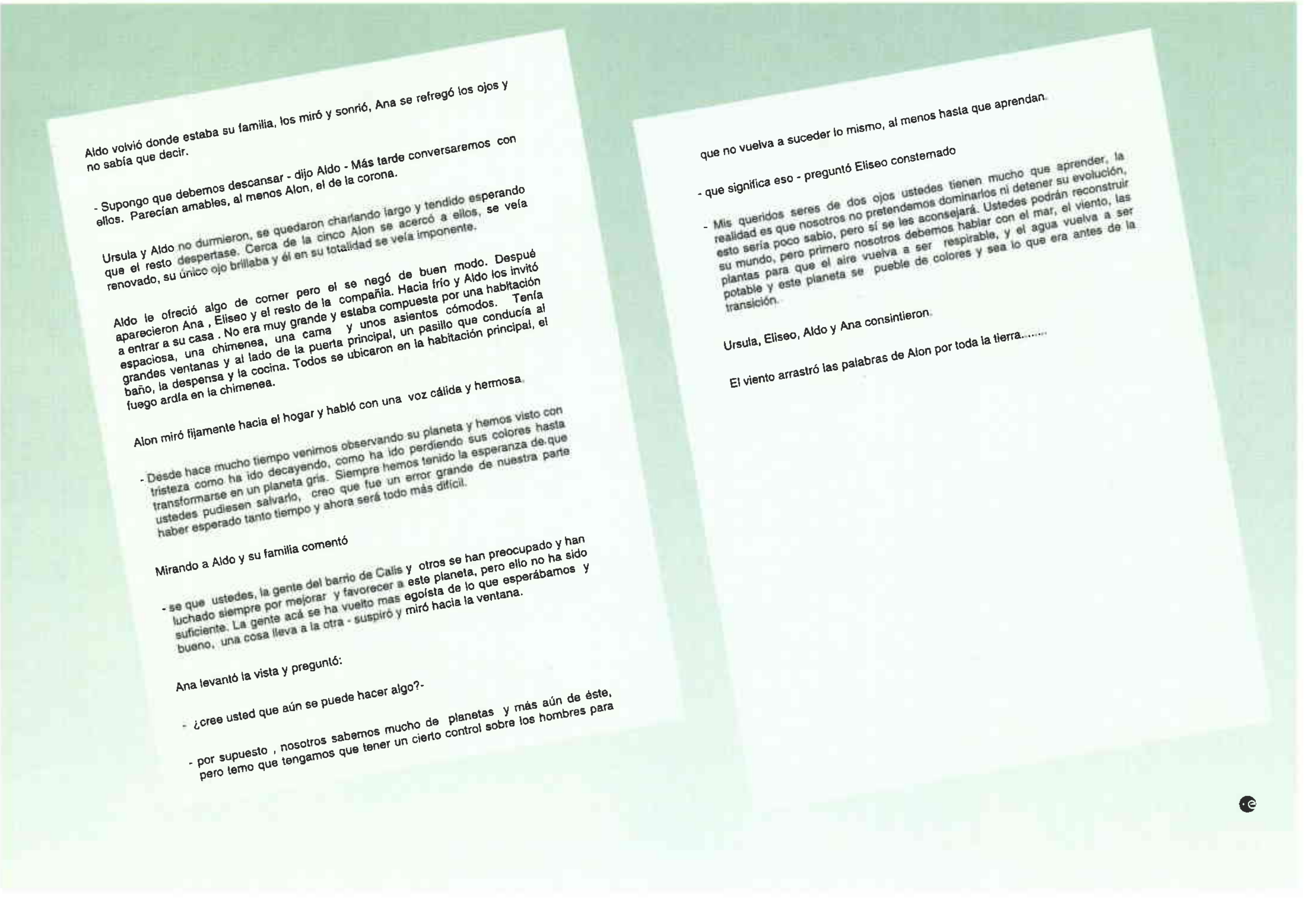
- por supuesto, pero...

- nuevamente despreocúpese, nosotros dormimos colgados de los árboles, si usted tiene uno, eso será suficiente.

- sí, por favor acompáñenme.

Aldo comenzó a caminar mientras los otros tres se quedaron quietos junto al molino, los extraños lo siguieron y pronto todos se encontraron colgados cabeza abajo de un árbol.




Aldo volvió donde estaba su familia, los miró y sonrió, Ana se refregó los ojos y no sabía que decir.

- Supongo que debemos descansar - dijo Aldo - Más tarde conversaremos con ellos. Parecían amables, al menos Alon, el de la corona.

Ursula y Aldo no durmieron, se quedaron charlando largo y tendido esperando que el resto despertase. Cerca de la cinco Alon se acercó a ellos, se veía renovado, su único ojo brillaba y él en su totalidad se veía imponente.

Aldo le ofreció algo de comer pero el se negó de buen modo. Despué aparecieron Ana , Eliseo y el resto de la compañia. Hacia frío y Aldo los invitó a entrar a su casa . No era muy grande y estaba compuesta por una habitación espaciosa, una chimenea, una cama y unos asientos cómodos. Tenía grandes ventanas y al lado de la puerta principal, un pasillo que conducía al baño, la despensa y la cocina. Todos se ubicaron en la habitación principal, el fuego ardía en la chimenea.

Alon miró fijamente hacia el hogar y habló con una voz cálida y hermosa.

- Desde hace mucho tiempo venimos observando su planeta y hemos visto con tristeza como ha ido decayendo, como ha ido perdiendo sus colores hasta transformarse en un planeta gris. Siempre hemos tenido la esperanza de que ustedes pudiesen salvarlo, creo que fue un error grande de nuestra parte haber esperado tanto tiempo y ahora será todo más difícil.

Mirando a Aldo y su familia comentó

- se que ustedes, la gente del barrio de Calis y otros se han preocupado y han luchado siempre por mejorar y favorecer a este planeta, pero ello no ha sido suficiente. La gente acá se ha vuelto mas egoísta de lo que esperábamos y bueno, una cosa lleva a la otra - suspiró y miró hacia la ventana.

Ana levantó la vista y preguntó:

- ¿cree usted que aún se puede hacer algo?-

- por supuesto , nosotros sabemos mucho de planetas y más aún de éste, pero temo que tengamos que tener un cierto control sobre los hombres para que no vuelva a suceder lo mismo, al menos hasta que aprendan.

- que significa eso - preguntó Eliseo consternado

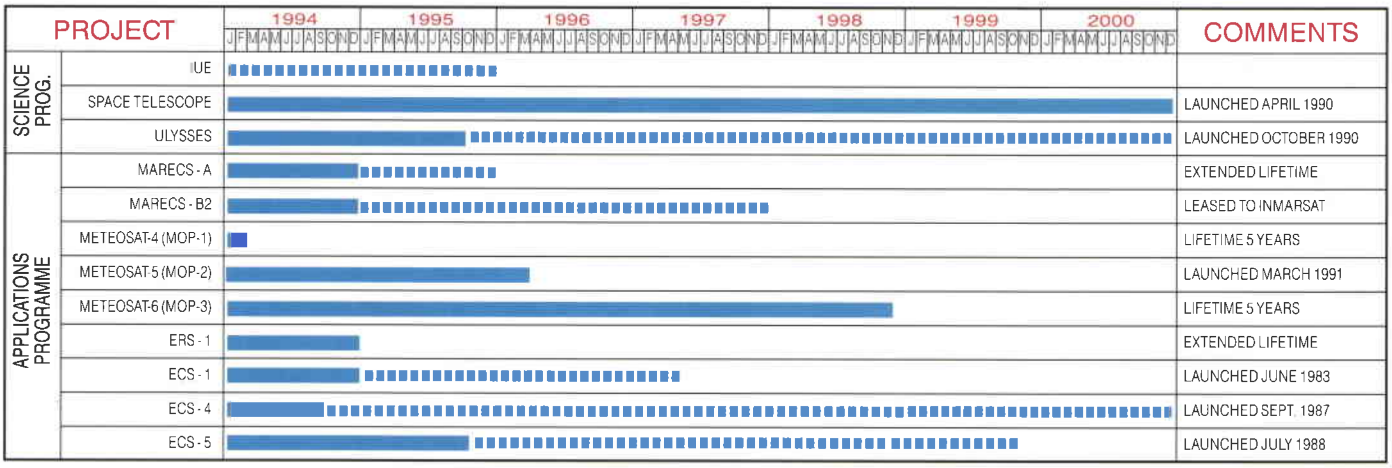
- Mis queridos seres de dos ojos ustedes tienen mucho que aprender, la realidad es que nosotros no pretendamos dominarlos ni detener su evolución, esto sería poco sabio, pero sí se les aconsejará. Ustedes podrán reconstruir su mundo, pero primero nosotros debemos hablar con el mar, el viento, las plantas para que el aire vuelva a ser respirable, y el agua vuelva a ser potable y este planeta se pueble de colores y sea lo que era antes de la transición.

Ursula, Eliseo, Aldo y Ana consintieron.

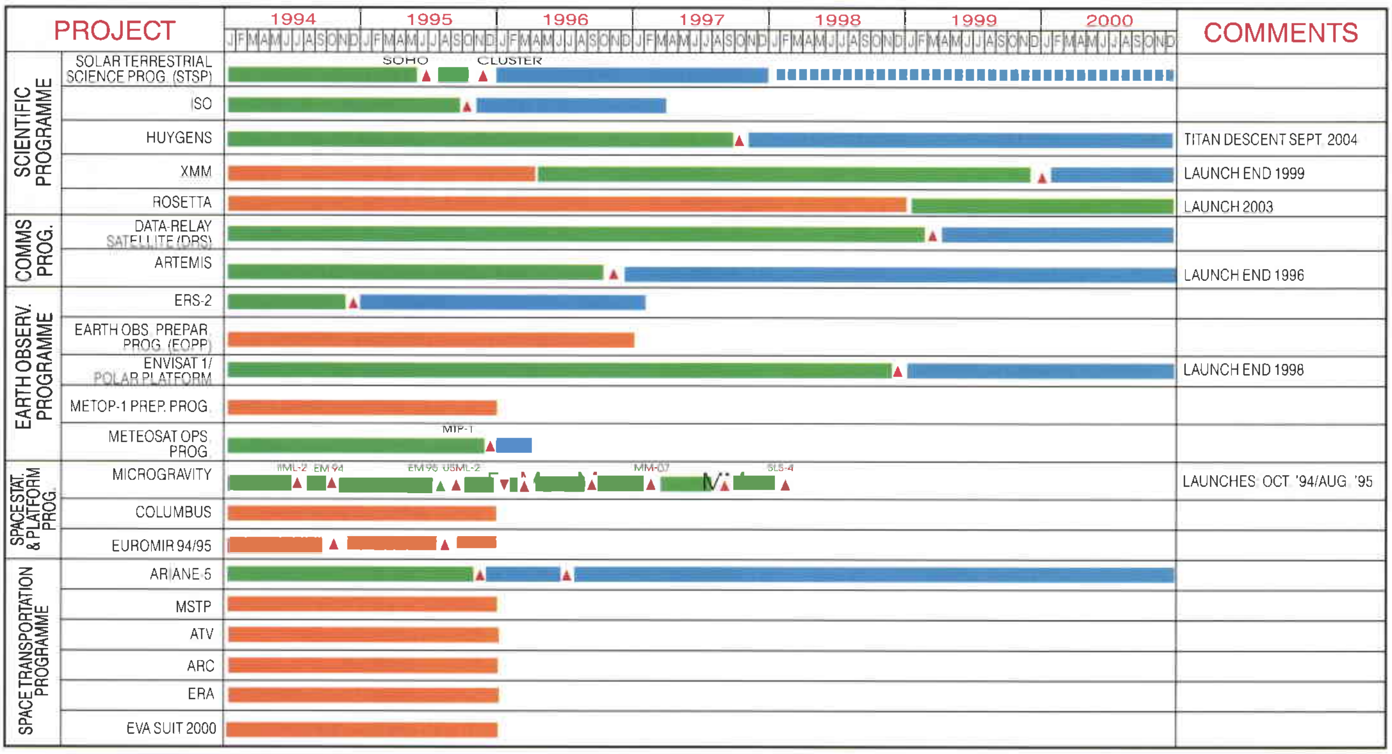
El viento arrastró las palabras de Alon por toda la tierra.......

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

In Orbit / En orbite



Under Development / En cours de réalisation



DEFINITION PHASE
MAIN DEVELOPMENT PHASE
LAUNCH/READY FOR LAUNCH
OPERATIONS
ADDITIONAL LIFE POSSIBLE
RETRIEVAL

Ulysse

Ulysse, qui se trouve maintenant au coeur de la phase scientifique de sa mission, poursuit sa course sans problème: tous les instruments et sous-systèmes de la sonde spatiale fonctionnent bien. Celle-ci a entamé le 26 juin dernier, pour la première fois dans l'histoire, le survol des régions polaires du Soleil. Ce survol des régions australes, d'une durée totale de 132 jours, se fera à des latitudes solaires supérieures à 70°. Lors du survol du pôle, la distance entre Ulysse et le Soleil dépassera à peine 2 UA (unités astronomiques).

La sonde a fonctionné de façon nominale au cours du trimestre écoulé, sans donner signe des perturbations du type nutation qui s'étaient produites dans les débuts de la mission et qui devraient normalement se reproduire à la fin de 1994 et en 1995. Une 'Revue des opérations en haute latitude' s'est déroulée avec succès au Jet Propulsion Laboratory (JPL) de Pasadena (Etats Unis) le 21 mars. Son objectif principal était de permettre une bonne interface opérationnelle entre le Réseau de l'espace lointain (DSN) de la NASA, les ordinateurs opérationnels du JPL et la station sol de l'ESA à Kourou. La station de Kourou complétera la couverture que doit assurer le DSN tout au long de la période pendant laquelle devraient se reproduire ces phénomènes de nutation, afin d'assurer la continuité de la liaison montante r.f. nécessaire au bon fonctionnement du système Conscan embarqué, dont on se servira pour corriger la nutation au cas où elle réapparaîtrait.

L'analyse des données scientifiques se poursuit, suscitant le plus vif intérêt pour les résultats qui commencent à apparaître sur les très hautes latitudes, avec en particulier un élément inattendu: la persistance de l'augmentation des flux de particules chargées à haute énergie, lors de chaque rotation solaire. Ces variations avaient déjà été constatées aux latitudes inférieures, mais on pensait qu'elles disparaîtraient au fur et à mesure que la sonde s'approcherait du pôle.

Cluster

Le prototype de vol (PFM) a subi avec succès le programme d'essais d'ambiance et est en cours de préparation en vue des essais ultimes de compatibilité électromagnétique. A la suite de ces essais, le satellite et la charge utile seront remis en état et préparés pour le lancement.

Après avoir subi avec succès les essais en vibrations en empilement avec le PFM à la fin mai, la deuxième unité de vol (F2) est en cours de préparation en vue du programme d'essais thermiques prévu à la fin juillet.

Tous les essais électriques au niveau système ont été exécutés sur la troisième unité de vol (F3) dont on prépare l'expédition chez IABG à Munich (D), pour le programme des essais d'ambiance.

La procédure d'intégration de la quatrième unité de vol (F4) au niveau des sous-systèmes a été menée à bien et l'intégration ainsi que la série d'essais de la charge utile ont démarré.

La NASA a livré à ce jour quatre enregistreurs à bande aux normes de vol qui ont été installés sur les quatre satellites. Les modèles d'identification des mémoires à état solide ont subi avec succès des essais au niveau système sur PFM et F2, démontrant ainsi que le concept de technologie mixte est viable.

Le prototype de vol (PFM) et la deuxième unité de vol (F2) en cours des essais, chez IABG à Munich (D)

Cluster PFM and F2 flight models under test at IABG, Munich (D)

Les quatre premiers modèles de vol seront livrés selon le calendrier prévu.

Fin juin, l'ensemble des équipements des charges utiles aux normes de vol aura été livré, l'accent principal portant désormais sur la définition du concept détaillé de l'exploitation en vol des charges utiles des quatre satellites. Les travaux du secteur sol se poursuivent normalement, l'équipement de station sol constituant l'élément le plus critique pour tenir la date de lancement de Cluster.

En ce qui concerne le système d'accès aux données scientifiques de Cluster (CSDS), les travaux suivent leur cours, la première livraison de logiciels d'interfaces utilisateurs aux centres de traitement des données étant prévue en juillet. Le Centre commun des opérations scientifiques (JSOC) a mené à bien la définition des programmes d'ensemble de télécommande des charges utiles et est

Ulysses

Now in its prime scientific phase, the Ulysses mission continues to run smoothly and all instruments and spacecraft subsystems are working well. On 26 June the spacecraft began its historic first polar pass, during which it will spend a total of 132 days above the Sun's southern polar regions at heliographic latitudes higher than 70°. During the polar pass, the distance from Ulysses to the Sun will be just over 2 AU (Astronomical Units).

Spacecraft performance has been nominal during the last quarter, with no evidence of the nutation-like motion that occurred early in the mission and which is predicted to return in late 1994 and 1995. A successful 'High Latitude Operations Review' took place at the Jet Propulsion Laboratory in Pasadena (USA) on 21 March. The prime purpose of the Review was to ensure a smooth operational interface between NASA's Deep Space Network (DSN) and operations computers at JPL, and ESA's Kourou ground station. The Kourou station will supplement the scheduled DSN coverage during the period when nutation is expected to be present. This is necessary in order to provide the continuous radio-frequency uplink required for operation of the on-board Conscan system, which will be used to suppress the nutation should it reappear.

Analysis of the scientific data continues, with keen interest in the results from the highest latitudes now emerging. An unexpected feature of these high-latitude data is the continued presence of increases in the fluxes of energetic charged particles once per solar rotation. Such increases were seen at lower latitudes, but were expected to disappear as the spacecraft moved poleward.

Cluster

The protoflight model (PFM) has successfully completed the environmental test programme and is being prepared for the final EMC and magnetic tests. Following these tests, the spacecraft and payload will be refurbished and prepared for launch.

The F2 spacecraft is being prepared for the thermal test programme scheduled for late July, having successfully completed the stack vibration tests with the PFM in late May.

The F3 spacecraft has completed all system-level electrical tests and is currently being prepared for shipment to IABG in Munich (D) for the environmental test programme.

The F4 spacecraft has completed subsystem integration and the payload integration and test sequence has started.

To date, four flight-model tape recorders have been delivered by NASA and one has been installed on each of the four spacecraft. Engineering models of the solid-state memories have been successfully tested on PFM and F2 at system level, thus proving that the mixed technology concept is viable. The first four flight models will be delivered on schedule.

All payload flight-model equipment will have been delivered by the end of June, the main emphasis now being on defining the detailed payload flight operations concept for the four spacecraft.

The ground segment continues on schedule with the ground-station equipment being the most critical for achieving the Cluster launch date.

Progress is being maintained on the Cluster Science Data System (CSDS), with the first delivery of the User Interface to Data Centres scheduled for July. The Joint Science Operations Centre (JSOC) has completed the definition of the overall payload command schedules and is now engaged in defining the telemetry parameters for health and safety monitoring of the payload.

The Cluster declared launch-readiness date of 1 December 1995 is being maintained. An advancement of the date to October 1995 for a launch on Ariane flight A501 can be accommodated within the current schedule. This will be confirmed before the end of 1994.

ISO

Overall progress on the project is good, working towards the approved September 1995 launch date.

Scientific instruments

The flight-model scientific instruments have been installed in the flight-model satellite hardware and thoroughly tested. The performance of three of the instruments was extremely good, but the ISOPHOT focal-plane unit showed some anomalous filter-wheel movements and therefore had to be replaced by the spare unit, which is of improved design. The ISOPHOT unit removed from the satellite is being refurbished to become the new spare unit.

Testing and calibration of all other spare scientific-instrument units is nearly complete.

Satellite

The payload module, with the scientific instruments, has been fully tested and showed good performance. A major project hurdle was passed when the straylight test showed that the 'darkness' inside the payload module is better than specification, viz. darker than one tenth of the zodiacal background. The successful outcome of this very critical test is a major confidence booster in the programme.

The payload module has since been opened to remove hardware needed to perform the straylight test and to exchange the ISOPHOT focal-plane unit. The payload module has now been re-integrated, closed and cooled and is being tested before final delivery to ESTEC by the end of June.

The service module is being readied for final testing at ESTEC before mating with the payload module in the summer. The complete flight-model satellite will then be subjected to a final series of system tests, which will last until early 1995.

Considerable progress has been made in improving the pointing performance of the star tracker. The latter has passed its qualification tests. Further work is underway to obtain a charge-coupled device with better imaging performance.

maintenant engagé dans la définition des paramètres de télémesure destinés à assurer la surveillance de l'état de fonctionnement et de sécurité de la charge utile.

La date du 1er décembre 1995 retenue pour l'aptitude au lancement de Cluster reste inchangée. Dans le cadre du calendrier actuel, il est possible d'avancer cette date à octobre 1995 en vue d'un lancement sur le vol Ariane A501. Ceci sera confirmé avant la fin de 1994.

ISO

L'ensemble du projet progresse de façon satisfaisante, en vue de la date de lancement approuvée de septembre 1995.

Instruments scientifiques

Les modèles de vol des instruments scientifiques ont été mis en place sur le modèle de vol du satellite et ont fait l'objet d'essais approfondis. Les résultats de ces essais ont été particulièrement bons pour trois des instruments. Cependant, les disques à filtre de l'unité au plan focal ISOPHOT ayant présenté quelques mouvements anormaux, cette unité a dû être remplacée par le modèle de réserve, de conception améliorée. L'unité ISOPHOT, retirée du satellite, subit actuellement une remise en état afin de devenir à son tour le modèle de réserve.

Les essais et l'étalonnage de tous les autres instruments scientifiques de réserve sont pratiquement achevés.

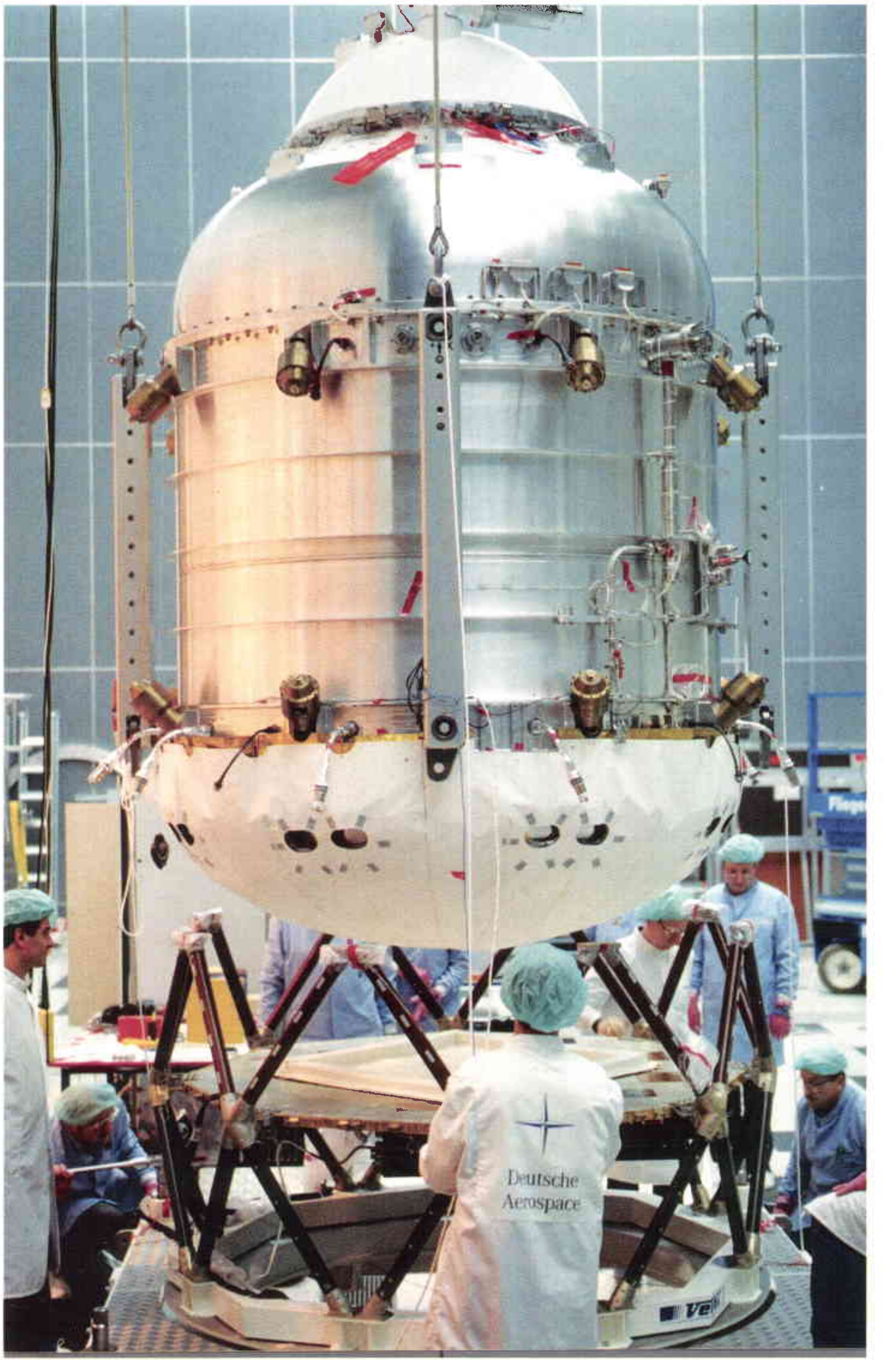
Satellite

Le module de charge utile équipé des instruments scientifiques a subi avec succès des essais complets. Une étape importante a été franchie avec les essais en lumière parasite qui ont révélé que "l'obscurité" à l'intérieur du module était supérieure aux spécifications, c'est-à-dire supérieure à un dixième de la lumière zodiacale. Les résultats positifs de ces essais particulièrement critiques sont très encourageants pour la suite du programme.

Le module de charge utile a été ouvert depuis lors pour en retirer le matériel nécessaire à la réalisation des essais en lumière parasite et pour changer l'unité au plan focal ISOPHOT. Le module a été remonté, fermé, refroidi et subit maintenant des essais avant sa livraison définitive à l'ESTEC, à la fin du mois de juin.

Le module de servitude est actuellement préparé en vue des derniers essais à l'ESTEC avant d'être assemblé durant l'été au module de charge utile. Le modèle de vol complet du satellite sera alors soumis à une série d'essais système qui dureront jusqu'au début de l'année 1995.

Des progrès considérables ont été réalisés en ce qui concerne l'amélioration des caractéristiques de pointage du suiveur stellaire. Ce dernier a en effet subi avec succès les essais de qualification. Les travaux continuent afin d'obtenir un dispositif à couplage de charges présentant des caractéristiques techniques améliorées en matière de prise d'images.



Le module de charge utile ISO aux essais chez Deutsche Aerospace, Munich (D)

ISO payload module under test at Deutsche Aerospace in Munich (D)

Ground segment
Spacecraft flight operations development is proceeding satisfactorily. Work on the science operations is moving towards preparation for overall integration and testing of the ground segment.

A major step forward has been the successful completion of critical interface tests between spacecraft and science operations development software. These tests will be repeated in the summer with the ground station at Villafranca, near Madrid (E).

Observation preparations
The initial planning of observing proposals for the guaranteed observing time – over one-third of the mission – has been completed. Approximately 13 000 observations are planned for this time. The 'Call for Observing Proposals' for the remaining time was released in April, with responses due in August.

Huygens

The first major checkpoint for the hardware production phase of the project was successfully passed with the completion of the Mechanical Hardware Design Review in late May. This review concentrated on the subsystems design and unit test results for mechanical and thermal subsystems and interfaces. It also determined the readiness of the support systems for the start of the Structural/Thermal/Pyro Model (STPM) probe assembly. Integration of the STPM is now proceeding, with the first system-level tests planned to start in August. The electrical subsystems manufacture and testing is progressing and the subsystems will also be subject to evaluation at an Electrical Hardware Design Review, scheduled for October 1994. This review will precede the system-level activities of the engineering-model probe.

The technical difficulties alluded to previously have been partially resolved. The contamination issue (burn-off and depositing of thermal-protection materials during 30 s of Titan atmosphere entry) can be overcome by using an ejectable experiment cover. Later vibration testing of batteries has also given some encouraging results.

Studies to investigate the consequences of launching Cassini/Huygens with the Space Shuttle instead of a Titan/Centaur launcher have been concluded and the findings presented to a high-level mission scrutineering panel. The Shuttle launch scenario was not found to be a suitable alternative and in mid-April NASA confirmed a Titan/Centaur as the nominal launcher.

Heat shield for the Huygens Probe (photo courtesy of Aerospatiale)

Le bouclier pour la sonde 'Huygens'

Rosetta

Following the interest shown by national agencies in cooperating in the provision of a Surface Science Package (SSP), the Agency has re-examined the resources available for such additions to the baseline Orbiter.

The mass resources were found to be marginal for a mission to Comet Schwassmann-Wachmann 3, as presented to the Agency's Science Programme Committee in November 1993, and other mission opportunities have therefore been re-evaluated. A mission to Comet Wirtanen, studied as a part of the original Phase-A, was found to release sufficient dry mass at launch to offer the possibility of accommodating two SSPs. Such a configuration would give the flexibility to meet the many conflicting scientific requirements for the SSP, such as Lander/Penetrator, long-term/short-term measurements, etc. The one drawback to this alternative mission is an increased mission duration of two years, with a comet perihelion on October 2013 and a planned rendezvous in late 2011. The mission was discussed with the Rosetta Science Definition team in late April, however, and received preliminary scientific endorsement.

The launch date for the mission to Comet Wirtanen would be January 2003, with a back-up possibility in November that same year.

The re-appraisal of the baseline mission, together with the study of the accommodation of two SSPs, has meant a delay in the schedule for release of the Announcement of Opportunity (AO) for both the Orbiter payload and Surface Science Package. It is now intended to release the combined AO in March 1995 and schedule formal payload/SSP selection for the February 1996 meeting of the Agency's Science Programme Committee. The remainder of the project schedule is maintained unchanged.

EOPP

Solid Earth
The preliminary studies for the potential ESA/Russian Space Agency cooperative Experiment on Time, Ranging and

Secteur sol

Les activités de développement relatives aux opérations en vol du satellite se poursuivent de façon satisfaisante. En ce qui concerne les opérations scientifiques, les travaux s'acheminent vers la préparation de l'intégration et des essais d'ensemble du secteur sol.

La réussite des essais critiques d'interface entre le véhicule spatial et le logiciel de développement des opérations scientifiques a fait franchir un grand pas en avant. Ces essais seront repris cet été à la station sol de Villafranca, dans les environs de Madrid (E).

Préparation des observations

La première phase de planification des observations proposées dans le temps d'observation garanti, qui représente plus d'un tiers de la mission, a été menée à bien. Environ 13 000 observations sont prévues cette fois. L'Appel aux propositions d'observation' pour le temps restant a été lancé en avril, les réponses étant attendues pour le mois d'août.

Huygens

La première étape majeure de la phase de production du matériel a été franchie avec l'achèvement de la Revue de la conception du matériel mécanique à la fin du mois de mai. Cette revue portait essentiellement sur la conception des sous-systèmes et les résultats des essais individuels des interfaces et sous-systèmes mécaniques et thermiques. Elle a également établi à quel moment les systèmes de soutien seraient prêts pour l'assemblage du modèle structurel/thermique/pyrotechnique (STPM) de la sonde. L'intégration du STPM suit actuellement son cours et le début des premiers essais système est prévu pour le mois d'août. La fabrication et les essais des sous-systèmes électriques avance et la qualité des sous-systèmes fera l'objet de la Revue de conception du matériel électrique prévue pour octobre 1994. Cette revue précédera les activités au niveau système du modèle d'identification de la sonde.

Les problèmes techniques évoqués précédemment ont été en partie résolus. Il sera possible de remédier à la contamination (combustion et dépôt de matériaux de protection thermique sur la sonde au cours des 30 secondes de l'entrée de Titan dans l'atmosphère) par l'installation d'un capot éjectable sur l'instrument. Les derniers essais en vibration des batteries ont donné des résultats encourageants.

Les résultats de l'étude portant sur les conséquences du lancement de Cassini/Huygens par la Navette spatiale au lieu d'un lanceur Titan/Centaur ont été présentés à un Comité de revue de la mission. L'idée du lancement par la Navette n'a pas semblé être la solution adéquate et la NASA a confirmé à la mi-avril que le lanceur nominal serait un Titan/Centaur.

Rosetta

Compte tenu de l'intérêt qu'a suscité auprès des organismes nationaux la perspective d'une coopération à la fourniture d'un ensemble d'instruments scientifiques d'étude de surface (SSP), l'Agence a réexaminé les ressources disponibles pour inclure ce type d'équipement dans l'orbiteur de référence.

Les ressources de masse qui ont été présentées au Comité du programme scientifique de l'Agence en novembre 1993 ont été jugées trop justes pour une mission vers la comète Schwassmann-Wachmann 3, de sorte que d'autres possibilités de mission ont été évaluées. Il est apparu qu'une mission vers la comète Wirtanen, étudiée au titre de la phase A d'origine, autoriserait une masse sèche au lancement suffisante pour pouvoir accueillir deux SSP. Une telle configuration offrirait la souplesse nécessaire pour satisfaire aux nombreux impératifs scientifiques contradictoires des SSP, comme ceux qui ont trait au module d'atterrissage et au pénétrateur, ainsi qu'aux mesures à long terme et à court terme, etc. L'inconvénient de cette solution est d'accroître la durée de la mission jusqu'à deux ans, le périhélie de la comète se situant en octobre 2013 pour un rendez-vous prévu fin 2011. Cette mission a toutefois été examinée avec l'équipe de définition de la mission scientifique Rosetta fin avril et a reçu une approbation préliminaire sur le plan scientifique.

La date de lancement de la mission vers la comète Wirtanen serait janvier 2003, avec une possibilité de réserve en novembre 2003.

La réévaluation de la mission de référence et l'étude d'installation de deux SSP se sont traduits par un retard du calendrier de lancement des avis d'offre de participation (AO), tant en ce qui concerne la charge utile de l'orbiteur que l'ensemble d'instruments scientifiques d'étude de surface. Il est maintenant prévu d'envoyer un double avis d'offres de participation en mars 1995 et de programmer la sélection officielle de la charge utile et des SSP pour la réunion de février 1996 du Comité du programme scientifique de l'Agence. Le reste du calendrier du projet reste inchangé.

EOPP

Solide terrestre

Les études préliminaires relatives au projet d'expérience sur le mesure du temps et des distances et sur le sondage atmosphérique (EXTRAS), à mener en commun par l'ESA et l'Agence spatiale russe, se sont poursuivies. Il ressort de l'examen des réponses reçues à un avis d'offre de participation pour la fourniture des instruments qu'il serait intéressant d'embarquer l'horloge atomique ultrastable à maser à hydrogène, un PRARE modifié (PRARE-Time) pour des mesures de télémétrie et de transfert de temps et un ensemble de détection laser et de comptage d'événements dénommé T2L2 (Transfert de Temps par Liaison Laser). L'architecture et la programmatique de cette expérience ont été établies à l'issue d'une étude de faisabilité au niveau système, tandis que des études scientifiques ont permis d'affiner les objectifs fixés par les groupes de travail scientifiques.

L'expérience consolidée a été présentée à l'EOSTAG à sa réunion de mai pour être évaluée et faire l'objet d'une recommandation à la réunion du juin du Conseil directeur du programme d'observation de la Terre de l'Agence.

Météosat de deuxième génération (MSG)

Le niveau de souscription au programme a atteint le seuil requis, ce qui a permis de lancer les activités industrielles de phase B à la mi-avril. D'autres activités MSG prévues dans le cadre de l'EOPP vont maintenant être transférées progressivement au programme MSG.

Atmospheric Sounding (EXTRAS) have continued. Following the responses to an Announcement of Opportunity for the provision of the instruments, interest has been shown in flying the ultrastable, atomic H-maser clock, a modified PRARE ('PRARE-Time') for ranging and time transfer, and a laser detector and event counter called 'Time Transfer by Laser Link', or 'T2L2'. A system feasibility study has established the architecture and programmatics of the Experiment, while scientific studies have refined the objectives set forth by the Science Working Groups.

The consolidated experiment has been presented to the EOSTAG at their May meeting for assessment and recommendation to the June meeting of the Agency's Earth-Observation Programme Board.

Meteosat Second Generation (MSG)

The level of subscription to the Programme has reached the required threshold, enabling the industrial Phase-B to be kicked-off in mid-April. Other MSG activities within EOPP will now be phased out and transferred to the MSG Programme.

Metop-1

Several candidate satellite configuration options were discussed at a mid-term presentation held at ESTEC on 29/30 March. They included satellites compatible with Ariane-5 only, and others compatible with both Ariane-4 and Ariane-5.

The second part of the Phase-A is devoted to estimation of the costs of the Ariane-5-only satellite candidate and to the consolidation, development and costing of the Ariane-4/5-compatible satellite selected.

The latter is a smaller, more affordable satellite, including a de-scoped payload and without DRS, but one that still completely fulfils the meteorological and climate mission objectives of the programme and is based on the European heritage of the ERS, Spot and Envisat polar-orbiting satellites.

Intense interface activities with the numerous instruments have continued leading to, among other essential results, valuable inputs for the development of the ESA MIMR and ASCAT instruments.

Coordination activities with the partner agencies Eumetsat, NOAA and NASA have taken place.

The transition to the Metop Preparatory Programme is proceeding as planned.

Campaigns

The final EMAC flight programme for 1994 was agreed at the second experimenters meeting on 17/18 February. First measurements have now been performed with ROSIS and ESAR.

Envisat-1/Polar Platform

Preparations for the Envisat Mission System Preliminary Design Review (EMS-PDR), covering all aspects of the Envisat-1 mission, including the Polar Platform and the ground segment, are proceeding according to plan. The review will take place in June/July 1994, prior to holding an EMS-PDR Board Meeting at the end of July.

Polar Platform

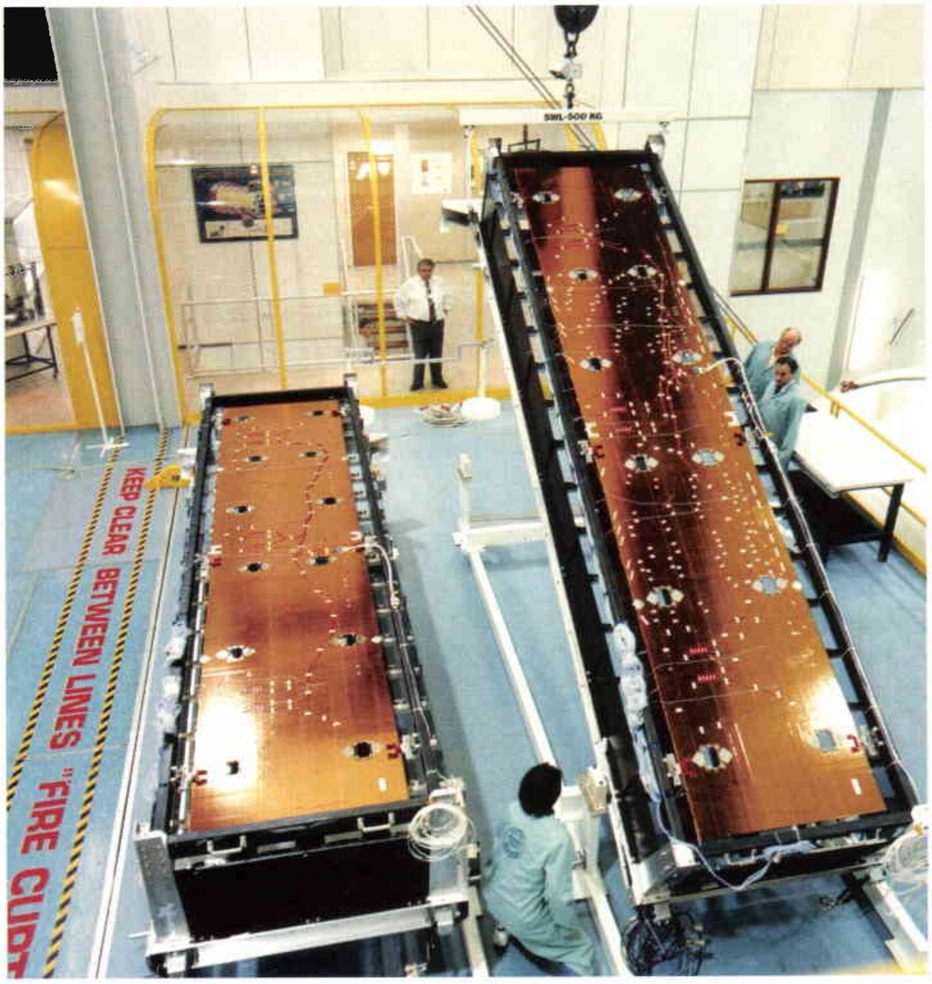
Following the request by the ESA Council to reduce the Polar Platform development costs, intense efforts have been made to identify cost savings, and several de-scopings have been introduced, whilst limiting as far as possible the additional risk taken.

The Polar Platform development activities are generally proceeding well. A number of development tests have been completed satisfactorily (Radio Frequency Mock-Up Test No. 2 at BAe, and Battery Compartment Thermal Test in ESTEC).

The structural-model Service Module has been delivered to BAe for further integration activities and preparation for a launch-vehicle separation test later in the year. The Payload Module structure manufacturing is continuing, with some delays.

Polar Platform solar arrays being prepared for testing at ESTEC

Panneaux solaires pour Plate-forme polaire en préparation pour essais à l' ESTEC



Métop-1

Plusieurs options de configuration du satellite ont été examinées lors d'une présentation à mi-parcours, qui a eu lieu à l'ESTEC les 29 et 30 mars. Elles comprenaient des satellites compatibles uniquement avec Ariane-5 et d'autres compatibles à la fois avec Ariane-4 et Ariane-5.

La deuxième partie de la phase A est consacrée à l'estimation des coûts de l'option de satellite compatible uniquement avec Ariane-5, ainsi qu'à la consolidation, au développement et au chiffrage des coûts du satellite choisi, compatible avec Ariane-4 et Ariane-5.

Il s'agit, dans ce dernier cas, d'un satellite plus petit, d'un coût plus abordable, comprenant une charge utile revue à la baisse, sans DRS, mais qui puisse encore satisfaire intégralement les objectifs du programme en ce qui concerne les missions météorologiques et climatologiques en utilisant les acquis des satellites européens en orbite polaire ERS, Spot et Envisat.

D'importants travaux ont été poursuivis sur les nombreuses instruments/satellite, ce qui s'est traduit notamment par la mise au point de données précieuses pour la réalisation des instruments MIMR et ASCAT de l'Agence.

Des activités de coordination ont été conduites avec les partenaires de l'Agence, à savoir Eumetsat, la NOAA et la NASA.

La transition vers le programme préparatoire Métop se déroule conformément aux prévisions.

Campagnes

Le programme définitif de vols EMAC pour 1994 a été entériné lors de la deuxième réunion des expérimentateurs, qui a eu lieu les 17 et 18 février. Les premières mesures ont été conduites avec les instruments ROSIS et ESAR.

Envisat-1/Plate-forme polaire

Les préparatifs de la revue de définition préliminaire au niveau système de la mission Envisat (EMS-PDR), couvrant tous les aspects de cette mission, y compris la plate-forme polaire et le secteur sol, se déroulent selon le plan. La revue aura lieu en juin/juillet 1994, précédant la réunion de la Commission de revue de EMS-PDR qui se tiendra à la fin du mois de juillet.

Plate-forme polaire

Le Conseil de l'ESA ayant demandé que les coûts de réalisation de la plate-forme polaire soient réduits, d'importants efforts ont été faits afin de rechercher des possibilités de réduction des coûts; quelques réductions de programme ont déjà été mises en place, tout en limitant autant que possible la prise de risques supplémentaires.

Les activités de développement de la plate-forme polaire se déroulent de façon satisfaisante dans l'ensemble. Plusieurs essais de mise au point ont été menés à bien (essai n° 2 de la maquette de fréquence-radio chez BAe et essai thermique du boîtier des batteries à l'ESTEC).

Le modèle mécanique du module de servitude a été livré à British Aerospace en vue des phases d'intégration et des préparatifs de l'essai de séparation du véhicule de lancement qui doit être mené plus tard dans l'année. La fabrication du modèle mécanique du module de charge utile se poursuit, avec du retard cependant.

La fabrication des équipements du modèle d'identification progresse. Toutefois, deux éléments d'importance majeure connaissent des difficultés: le mécanisme de pointage d'antenne (APM) du DSR et le mécanisme d'entraînement du réseau solaire (SADM). Leur conception fait actuellement l'objet de nouvelles études.

La négociation de tous les sous-contrats avec le contractant principal est maintenant achevée et l'on s'efforce de mettre un point final au contrat pour l'ensemble de la Phase C/D avec British Aerospace.

Envisat-1

La consolidation de la base de référence technique a progressé, toutes les revues de conception préliminaire des instruments étant achevées. Quelques problèmes ponctuels sont apparus à propos de certaines définitions d'interface et du fonctionnement des instruments dans des conditions de mission particulières. Dans tous les cas, des actions ont été définies pour résoudre ces problèmes, le cas échéant en coordination avec les groupes consultatifs scientifiques.

Du côté de la gestion, la consolidation des activités du consortium industriel a progressé en dépit de quelques difficultés. Une des tâches déjà attribuées a dû faire à nouveau l'objet d'un appel d'offres. On espère maintenant que tout sera terminé avant la fin du mois de juin, avec le choix d'un nouveau contractant.

Secteur sol

Après plusieurs itérations avec les participants aux programme, le concept du secteur sol d'Envisat a été consolidé et est considéré comme prêt à être approuvé.

Sur la base de ce concept, la phase de consolidation des systèmes des données de charge utile a reçu son feu vert avec l'attribution deux contrats en parallèle à deux consortiums, l'un dirigé par Matra Marconi System, l'autre par Thomson-CSF.

Recherche en microgravité

Les travaux préparatoires de quatre installations d'expérimentation de l'ESA destinées à la mission Spacelab IML-2, qui doit avoir lieu en juillet 1994 – le Biorack, le dispositif bulles, gouttes et particules, le dispositif point critique et l'installation de cristallation des protéines de pointe – sont à un stade avancé. Avec les expériences qui leur sont associées, ces quatre installations de l'ESA constituent environ la moitié de la charge utile scientifique (37 expériences de l'ESA sur un total de 77) de cette mission Spacelab conduite par la NASA.

Vingt-neuf expériences de recherche en microgravité ont été mises au point pour le vol Euromir-94 qui aura lieu en septembre prochain. En outre, un certain nombre d'installations d'expériences de physiologie humaine et un four pour la science des matériaux sont également en cours de réalisation pour la mission Euromir-95.

Manufacture of engineering-model equipment is in progress. Some difficulties are being experienced with two major mechanisms: the DRS Antenna Pointing Mechanism (APM) and the Solar-Array Drive Mechanism (SADM). Both are undergoing redesigns.

All subcontracts with the Prime Contractor have now been negotiated and effort is concentrated on finalising the overall Phase-C/D contract agreement with British Aerospace.

Envisat-1

Progress has been made in the consolidation of the technical baseline with all the Instrument Preliminary Design Reviews having now been completed. Specific problems have been identified concerning certain interface definitions and instrument performance under particular mission conditions. In all cases, actions have been defined to overcome the problems identified, in coordination with the Science Advisory Groups whenever appropriate.

On the management side, consolidation of the Industrial Consortium activities has progressed, albeit with some difficulties. In one case, the allocated task had to be reopened to industrial competition. This is now expected to be finalised by the end of June, with the selection of a new contractor.

Ground segment

After several iterations with the programme participants, the Envisat ground-segment concept has been consolidated and is considered ready for approval.

Based on this concept, the Payload Data Segment Consolidation Phase has been kicked off with parallel contracts awarded to two consortia, one led by Matra Marconi System and the other by Thomson-CSF.

Microgravity

Preparation of four ESA experiment facilities for the IML-2 Spacelab mission in July 1994 – Biorack, the Critical Point Facility, the Bubble, Drop and Particle Unit, and the Advanced Protein Crystallisation Facility – is at an advanced stage. These four ESA facilities and the associated experiments constitute about half of the scientific payload – 37 ESA experiments out of a total of 77 – of this NASA Spacelab mission.

Twenty-nine microgravity experiments have been developed for the Euromir '94 flight, which will take place in September 1994. A number of facilities for human physiology and a materials-science furnace are also under development for the subsequent Euromir '95 mission.

Columbus

Columbus Orbiting Facility

Negotiations with the Prime Contractor concerning the contractual and funding arrangements for continuation of industrial activities over the period 1994/1995 have been finalised. The associated Statement of Work and distribution of industrial tasks in line with slightly revised geographical return targets have also been agreed. The agreement covers completion of the rundown of industrial effort over the first half of 1994, and continuation of industrial activities at a reduced level of spending through March 1995.

The EuroColumbus shareholders have proposed that, as of 1 July 1994, the industrial prime contractorship for the Columbus Space Segment be taken over by DASA-ERNO.

Following the Columbus Utilisation Workshop, held in Frascati in April, industry has continued with the system-level definition and assessment of the Columbus Orbiting Facility (COF) configuration concept options presented during the Workshop. Status reviews of these configuration options, including an initial assessment of programmatics aspects, are planned in May and June. This includes definition of a 'low cost' COF option, based on a 'design to cost' approach against a predefined target price.

Work has continued with NASA to prepare the necessary changes to ISS system- and segment-level specifications to bring them into line with the revised Concept of Utilisation and Operations. These updated specifications are currently planned for release in late May/early June. With their formal release, the role of Ariane-5/ATV, together with the distributed operations concept for the COF and inclusion of the European DRS system, will be fully reflected in all system-level documents of the programme.

Preparations are in progress for the next meeting of the International Interface Working Group (IIWG), to be held in Bremen during June. The primary objective of this meeting is to update the bi-/multi-lateral Interface Control Documents (ICDs).

Complementary Columbus Orbiting Facilities (CCOF) items

Early delivery items

Finalisation of agreements with NASA and RKA with respect to CCOF items proposed as 'early deliveries' to the American and Russian segments of the International Space Station Programme Alpha (ISSA), in return for early utilisation access for Europe, is in progress. The candidate items currently still under consideration are:

for the US segment

Laboratory support equipment:
- Freezer
- Glove box
- Hexapod

System items:
- Mission database

for the Russian segment
- Core Data Management Sub-System (DMS-R) for the Russian Service Module.

The decision to proceed, or otherwise, with development of those items is conditional upon approval by the ESA Council in June.

Columbus Orbital Facility (COF) enhancements

A number of potential enhancements to the basic COF are currently under assessment, in line with the ongoing Columbus utilisation reassessment activities. The main items presently under consideration for study/pre-development during 1994/1995 are:

- addition of an External Platform
- definition and technology aspects of a Data Relay Satellite terminal
- implementation of the Ground Software Reference Facility.

Implementation of the above is also subject to ESA Council approval in June.

Columbus

Elément orbital Columbus

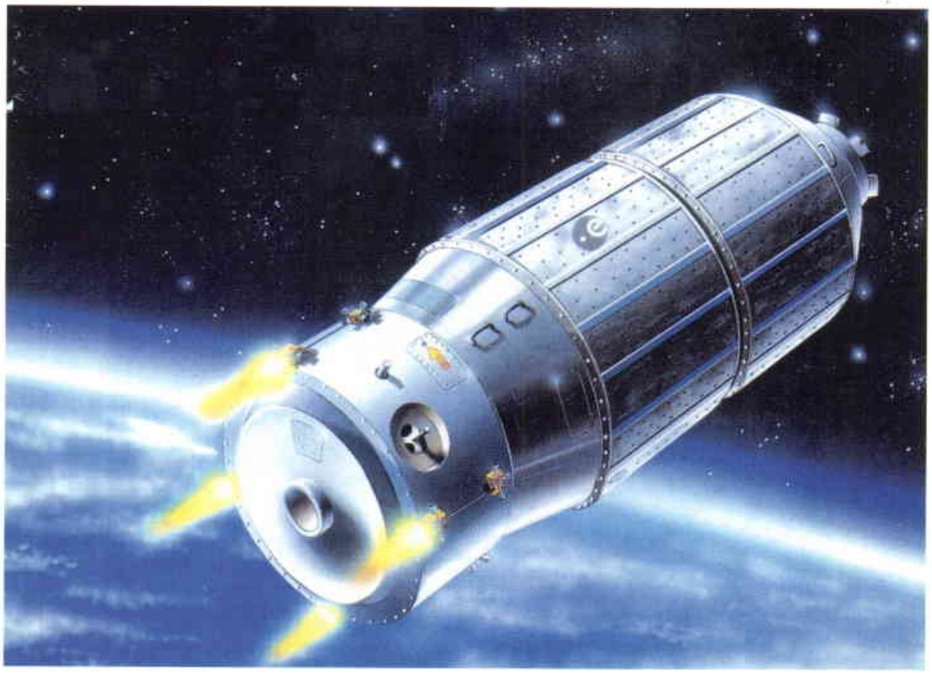
Les négociations avec le maître d'oeuvre en ce qui concerne les dispositions contractuelles et les modalités de financement pour la poursuite des activités industrielles sur la période 1994-1995 ont été menées à terme. Un accord a également été conclu sur le descriptif des travaux correspondant et sur la répartition des tâches industrielles en fonction d'objectifs de retour géographique légèrement révisés. Cet accord porte sur l'arrêt de certaines tâches industrielles au cours du premier semestre 1994 et sur la poursuite d'activités industrielles jusqu'en mars 1995 avec un niveau de financement réduit.

Les actionnaires d'EuroColumbus ont proposé que la maîtrise d'oeuvre industrielle du secteur spatial de Columbus soit transférée à DASA-ERNO à compter du 1er juillet 1994.

A la suite de l'Atelier sur l'utilisation de Columbus, qui s'est tenu à Frascati en avril, les industriels ont poursuivi la définition et l'évaluation au niveau système des options de configuration de l'Elément orbital Columbus (COF) présentées au cours de l'Atelier. Des revues d'avancement de ces options de configuration, comprenant une évaluation initiale des aspects programmatiques, sont prévues en mai et juin. Il s'agira entre autres de définir une option COF 'à faible coût', basée sur une méthode de conception en fonction d'un objectif de coût défini à l'avance.

Les travaux se sont poursuivis avec la NASA pour préparer les modifications à apporter aux spécifications de l'ISS aux niveaux système et composante afin de les mettre en accord avec le concept révisé d'utilisation et d'exploitation. Il est actuellement prévu de diffuser ces spécifications actualisées fin mai / début juin. Avec cette diffusion officielle, le rôle de l'ensemble Ariane-5/ATV, ainsi que le concept d'exploitation décentralisée du COF et l'inclusion du système DRS européen seront intégralement pris en compte dans tous les documents relatifs au programme au niveau système.

Des travaux préparatoires sont en cours pour la prochaine réunion du Groupe de travail international sur les interfaces (IIWG), prévue à Brême au cours du mois de juin. Cette réunion a pour principal objectif de mettre à jour les documents de contrôle des interfaces (ICD) bilatéraux et multilatéraux.



Vue conceptuelle de l'ATV (véhicule de transfert automatique)

Artist's impression of the Automated Transfer Vehicle (ATV)

Eléments des installations orbitales complémentaires Columbus (CCOF)

Eléments à livrer à court terme

La mise au point finale d'accords avec la NASA et la RKA est en cours en ce qui concerne les éléments CCOF qu'il est proposé de livrer à court terme aux Etats-Unis et à la Russie pour être intégrés à leurs contributions respectives au programme de Station spatiale internationale Alpha (ISSA) en échange d'un accès rapide à la Station accordé à l'Europe. Les éléments candidats actuellement envisagés sont les suivants:

pour la partie américaine:

équipements de soutien de laboratoire:

- *congélateur*
- *boîte à gants*
- *Hexapod*

éléments système:

- *base de données mission*

pour la partie russe:

- *sous-système principal de gestion de données (DMS-R) pour le module de servitude russe.*

La décision de poursuivre ou non le développement de ces éléments dépend de son approbation par le Conseil de l'ESA en juin.

Eléments complémentaires de l'Elément orbital Columbus (COF)

Un certain nombre d'éléments complémentaires potentiels du COF de base font actuellement l'objet d'une évaluation, en accord avec les activités de réévaluation en cours de l'utilisation de Columbus. Les principaux éléments pour lesquels il est actuellement envisagé de conduire des travaux d'étude ou de prédéveloppement en 1994/1995 sont les suivants:

adjonction d'une plate-forme extérieure,
définition et aspects technologiques d'un terminal pour le satellite de relais de données,
mise en oeuvre du banc de référence de développement au sol de logiciels.

La mise en oeuvre des ces éléments devra également être soumise à l'approbation du Conseil en juin.

Programme MSTP

Technologie

Les travaux se sont poursuivis sur le projet de démonstrateur de rentrée atmosphérique (ARD). L'équipe industrielle a affiné la définition technique du véhicule de rentrée, une capsule d'environ 3t, qui a été accepté comme passager APEX sur le vol V502 d'Ariane 5. Les industriels ont soumis une offre pour la

Manned Space Transportation Programme

Technology

The effort to advance the Atmospheric Re-entry Demonstrator (ARD) project has continued. The technical definition of the re-entry vehicle, a capsule weighing about 3 t, has been further advanced by the industrial support team. The capsule has been accepted as an APEX passenger for Ariane-5 flight V502. Industry has submitted an offer for the development of this vehicle, which has been negotiated to meet the conditions for placing the contract.

Other main technology tasks being defined concern the study of capsule impact damping systems, parachute/parafoil landing concepts and the preparations for aerothermodynamic activities tailored to re-entry capsules.

System studies

Top-level system studies, jointly performed with Columbus, have been started to evaluate the technical and programmatic coherence of the planned programme elements. An effort has been initiated to render the individual development budget profiles compatible with the projected budget constraints. Other system activities concern the establishment of mission and system-requirement documentation.

CTV (Crew Transport Vehicle)

The two parallel industrial phase-zero studies are close to completion. Industry has consolidated their choices made for the system concepts and has performed preliminary vehicle design analysis. A major concern is the ability to meet landing-site requirements, particularly for ground landing in continental Europe, resulting from a lack of experience with heavy-load parafoil systems.

Servicing elements

ERA and EVA

A joint development programme has been established with Russia, which has also formally confirmed its need for these elements for the assembly of its part of the Space Station. Proposals for the early delivery of these elements have been established which form part of the overall plan, currently in preparation, to be submitted to the ESA Council in June 1994.

ARC (Automated Rendezvous and Capture)

The development work foreseen within the ARC demonstration has been re-defined to become an ATV pre-development activity for rendezvous equipment.

ATV (Automated Transfer Vehicle)

In response to the Request for Proposal for Phase B, a single offer has been received from a group of leading space firms with DASA as prime contractor. This offer has been evaluated and is being negotiated. The Phase-B for the ATV should start in July.

The results of the industrial activities performed to consolidate the mission capabilities of the ATV vehicle have been incorporated into a review of the requirements and of the configuration, which will be completed in June.

Cooperation with Russia

Exchanges of items beneficial to either Russia or ESA for the MSTP have been further defined and have been integrated into an overall plan. Apart from the cooperative development of ERA and EVA, it covers equipment for the improvement of Soyuz and Progress, such as rendezvous equipment similar to that required for the ATV and CTV. However, an overall imbalance and the need to increase the budget already in 1994 to meet the Russian need dates, makes it difficult to maintain all of these items. A decision will be taken by the ESA Council at its June meeting. An effort is also being made to explore the prospects for longer-term cooperation with Russia.

Cooperation with the USA

The ATV has been recognised as an element to be integrated into the Space Station operations and utilisation plan. NASA supports the definition of mission and interface requirements as well as the ATV configuration review.

The CTV has been introduced to NASA and discussions have started regarding its role for Space Station.

Euromir '94/'95

Preparations for the Euromir-94 mission, which will start on 3 October and last for one month, are well advanced. Activities are concentrated now on the acceptance and delivery of the flight hardware, as well as crew training, flight procedure and timeline verification, and the collection of medical data on the astronauts and cosmonauts selected for the first mission.

In preparation for the flight operations, the satellite-based communication stations at ESTEC, EAC Cologne, SCOPE Toulouse, Star City and the Russian Operations Centre (ZUP) have become operational and are already being used for inter-establishment communication, data exchange and mission simulations.

The Russian prime and back-up crew for the Euromir-94 flight, as well as the head of the Russian cosmonaut training centre in Star City, attended the 'International Luftfahrt Ausstellung (ILA)' in Berlin on 30 May, where Ulf Merbold was nominated prime crew member and Pedro Duque as back-up for the Euromir-94 flight.

The Principal Investigators selected for the Euromir-95 flight, a 4.5 month flight from 18 August 1995 onwards, have been given an extensive briefing on the Mir system characteristics and documentation requirements. Work on the procurement of the experimental facilities and associated software required has started and first drafts of the basic documents – namely the detailed test specifications for the experiments and the associated equipment (about 52 documents in total) – are in preparation and are being translated into Russian.

réalisation de ce véhicule, offre qui a fait l'objet de négociations afin d'être conforme aux conditions de passation du contrat.

Les autres grandes tâches technologiques en cours de définition portent sur l'étude du système d'amortissement des chocs de la capsule, les concepts d'atterrissage avec différents types de parachutes et les préparatifs des activités aérothermo-dynamiques spécifiques aux capsules de rentrée.

Etudes système

Les études système de haut niveau qui ont été engagées conjointement avec le programme Colombus ont pour objet d'évaluer la cohérence technique et programmatique des éléments de programme projetés. Un effort a été fait en vue de rendre les profils de payement des différents travaux de développement compatibles avec les contraintes budgétaires prévisionnelles. Parmi les autres activités système figure la préparation de la documentation sur les impératifs système et mission.

CTV (véhicule de transport d'équipages)

Les deux études industrielles de phase zéro menées parallèlement sont pratiquement terminées. Les industriels ont consolidé leur choix quant aux concepts système et ont procédé à une analyse préliminaire de la conception du véhicule. L'une des questions importantes à traiter est celle de l'aptitude de la capsule à satisfaire aux impératifs d'atterrissage, particulièrement en cas d'atterrissage au sol en Europe continentale, du fait de notre manque d'expérience des systèmes de parachutes-voiles pour les charges lourdes.

Eléments de desserte

ERA et EVA

Le programme de développement conjoint a été établi avec la Russie, qui a dans le même temps formellement confirmé qu'elle avait besoin de ces éléments pour l'assemblage de sa partie de la Station spatiale. Pour la livraison rapide de ces éléments, les propositions qui ont été faites ont été intégrées au plan général en préparation qui sera soumis à la prochaine session du Conseil de l'Agence de juin 1994.

ARC (Rendez-vous et capture automatiques)

Les travaux de développement prévus au titre de la démonstration de l'ARC ont été redéfinis et sont devenus une activité de pré-développement de l'ATV pour les équipements de rendez-vous.

ATV (véhicule de transfert automatique)

En réponse à l'appel d'offres relatif à la phase B, une seule proposition a été reçue; elle émane d'un groupe d'entreprises aérospatiales en flèche, piloté par la DASA. Elle a été évaluée et fait actuellement l'objet de négociations. La phase B de l'ATV devrait débuter en juillet.

Les résultats des activités industrielles menées afin de consolider les capacités de l'ATV en termes de mission ont été incorporés à une revue des impératifs et de la configuration, qui sera achevée en juin.

Coopération avec la Russie

Les éléments à échanger dans l'intérêt de la Russie ou de l'ESA pour le MSTP ont été définis de façon plus précise et intégrés en un plan d'ensemble. Outre la mise au point en coopération de l'ERA et des EVA, il s'agit d'équipements qui complètent les vaisseaux Soyouz et Progress, comme par exemple des moyens de 'rendez-vous', similaires à ceux de l'ATV et du CTV. Toutefois, le déséquilibre général existant et le besoin d'augmenter le budget dès 1994 afin de respecter les délais de livraison impératifs en Russie rendent difficile de conserver ces éléments en totalité. Le Conseil de l'ESA devra prendre une décision lors de sa session de juin. Les conversations portent également sur les perspectives d'une coopération à long terme avec la Russie.

Coopération avec les Etats-Unis

Il a été officiellement reconnu que l'ATV serait intégré au plan d'exploitation et d'utilisation de la Station spatiale. La NASA appuie la définition de la mission et les impératifs d'interface, ainsi que la revue de configuration de l'ATV.

Le CTV a été présenté à la NASA et des discussions ont été entamées en ce qui concerne son rôle dans la Station spatiale.

Euromir '94/'95

Les préparatifs de la mission Euromir-94, qui débutera le 3 octobre et durera un mois, sont bien avancés. Les activités se concentrent maintenant sur la recette et la livraison du matériel de vol, ainsi que sur l'entraînement de l'équipage, la vérification des procédures de vol et des séquences opératoires et la collecte de données médicales sur les astronautes et les cosmonautes choisis pour cette première mission.

Les stations de télécommunications par satellite de l'ESTEC, de l'EAC à Cologne, du SCOPE à Toulouse, de la Cité des Etoiles et le Centre de contrôle russe sont entrés en service afin de préparer les opérations en vol et sont déjà utilisés pour les communications entre établissements, les échanges de données et les simulations de la mission.

Les membres russes de l'équipage d'Euromir-94 et leurs doublures, ainsi que le chef du centre russe d'entraînement des cosmonautes situé à la Cité des Etoiles, ont assisté le 30 mai au Salon de l'Air et de l'Espace ILA, à Berlin, au cours duquel Ulf Merbold a été désigné astronaute titulaire pour la mission, avec Pedro Duque comme doublure.

Les chercheurs principaux choisis pour la mission Euromir-95, qui durera 4 mois et demi et débutera le 18 août 1995, ont été informés dans le détail des caractéristiques du système Mir et des besoins en matière de documentation. Les travaux relatifs à l'approvisionnement des installations expérimentales et des logiciels associés ont débuté et les avant-projets des documents de base — à savoir les spécifications détaillées des essais à mener pour les expériences et les équipements s'y rapportant, soit quelque 52 documents au total — sont en train d'être rédigés et traduits en russe.

In Brief

ESA Astronauts Train for Approaching EuroMir Missions

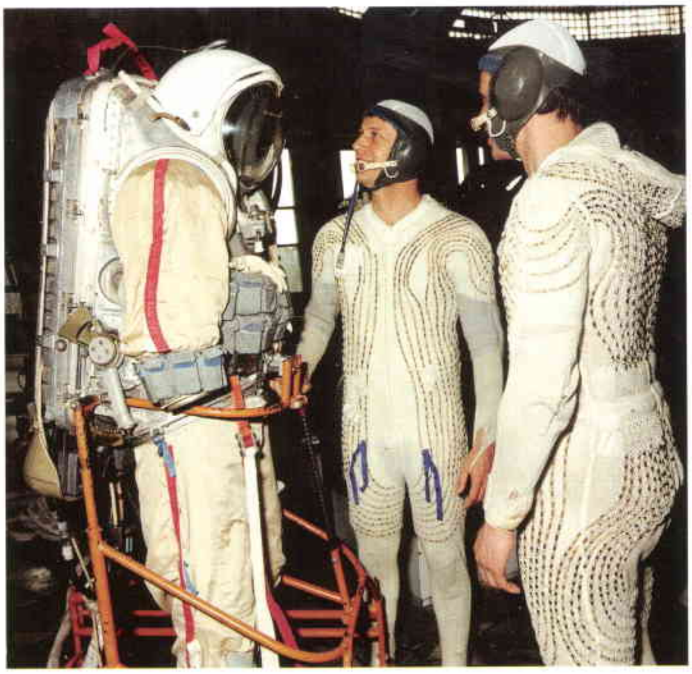
The four ESA astronauts training for the EuroMir missions are continuing their intensive preparations, mainly at Star City near Moscow and at ESA's European Astronaut Centre (EAC) in Cologne, Germany.

The first mission, EuroMir-94, will last 30 days and will take place this October. The second one, Euromir-95, will last up to 135 days and will begin in August 1995.

The astronauts during their training at Star City. From left to right: Ulf Merbold and Pedro Duque, who are training for the EuroMir-94 mission, and Thomas Reiter and Christer Fuglesang, who are training for the EuroMir-95 mission

The astronauts have two hours of Russian language classes every day. They find that the language is the greatest obstacle in their training.

Ulf Merbold (left) and Pedro Duque (right) during communications and operations training in a mockup of the Soyuz space capsule. The crew of three cosmonauts will spend the take-off and landing in the Soyuz in this position, in a custom-fitted, basket-like seat



Reiter (centre) and Fuglesang (right) in cooling suits worn under the special spacesuit (left) during training in the pool. Water is pumped through coils in the cooling suit to keep the astronaut cool while he works underwater in the watertight EVA suit

Merbold Selected as ESA Astronaut for EuroMir-94

Ulf Merbold has been selected as the ESA astronaut who will fly on the EuroMir-94 mission this October. The Director General of ESA, Jean-Marie Luton, made the announcement at a press conference at the ILA'94 Berlin Airshow on 30 May.

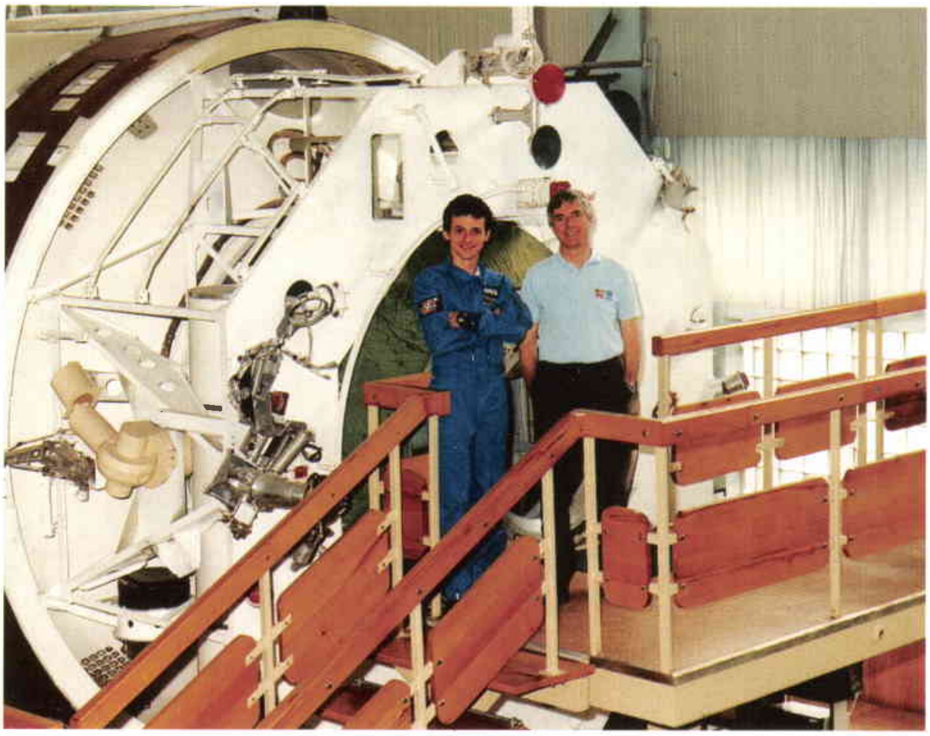
The 30-day mission onboard the Russian Space Station Mir is scheduled to be launched on 3 October and will carry about 30 experiments for scientists from ESA Member States. The other two members of the three-member crew will be Russian cosmonauts. As the Research Cosmonaut, Merbold will be fully responsible for the experimental programme and for selected tasks to be performed on some Soyuz and Mir systems. He will also be involved in the final mission preparation, mission execution and post-mission activities.

Merbold and another ESA astronaut, Pedro Duque, have been training for the mission since August 1993 while two other ESA astronauts, Christer Fuglesang and Thomas Reiter, are preparing for the EuroMir-95 mission.

Duque has been named to the back-up crew along with two other Russian cosmonauts. That crew, which is being trained in parallel with the prime crew, must be ready to fly in case a member of the prime crew cannot. About three weeks before the launch, the flight readiness of both crews will be assessed, and the prime and back-up crews will be confirmed.

The back-up ESA astronaut will also play an active role in the experimental programme, acting as Crew Interface Coordinator at the Mission Control Centre in Kaliningrad, Russia, to ensure the flow of communication between the ground crew and the Mir crew, and the performance of the experiments.

Merbold has already flown twice as an ESA astronaut, on STS-9/Spacelab-1 in 1983 and on STS-42/IML-1 in 1992. In addition, he has supported two Shuttle missions from the ground, as Back-up Payload Specialist and Crew Interface Coordinator during D-1 in 1984, and as Science Coordinator of D-2 in 1993.



Pedro Duque (left), the back-up ESA astronaut, and Ulf Merbold (right), the ESA astronaut on the EuroMir-94 mission

Duque was selected for the ESA astronaut programme in 1992. He completed basic training at the European Astronaut Centre and at the Cosmonaut Training Centre in Star City, Russia, and received his certification as a European Astronaut in December 1993.

ESA Astronaut to Fly on ATLAS-3 Mission

ESA astronaut Jean-François Clervoy has been selected by NASA to fly on board Space Shuttle 'Atlantis' on flight STS-66 this October. The mission, named ATLAS-3 (Atmospheric Laboratory for Applications and Science), is one in a series of flights to study the Sun's energy and its effects on the Earth's climate and environment.

The ATLAS-3's payload will include a significant ESA contribution and a large input from European scientists. In addition, the mission will involve the deployment and retrieval of the Cryogenic Infrared Spectrometer Telescope for the Atmosphere (CRISTA), which will explore the variability of the atmosphere.

As a mission specialist, Clervoy's main task will be to operate the Shuttle's robot arm to deploy the CRISTA-SPAS experiment and retrieve it again at the end of the mission. Clervoy, of French nationality, was selected to join ESA's astronaut corps in 1992. He has been training as a mission specialist, together with another ESA astronaut Maurizio Cheli, at NASA's Johnson Space Flight Center in Houston since mid-1992

ESA astronaut Jean-François Clervoy, who will fly on ATLAS-3 in October

2nd Workshop on Intellectual Property Rights and Space — From a Global Perspective

Following the success of the first Workshop on Intellectual Property Rights and Space Activities, which addressed issues from a European perspective, ESA and the European Centre for Space Law are organising a second workshop, this time with a worldwide perspective. It will be held in Paris on 5 – 6 December.

Intellectual property rights with regard to space activities raise a number of important legal questions, for example, with respect to ownership of intellectual property and protection of data. The objective of the second workshop is therefore to present a first analysis of legal and policy issues with regard to intellectual property rights and space activities in a world context. Invited experts, representing the major spacefaring nations, will present an overview of the different ways in which they deal with intellectual property issues. The purpose is to inform and stimulate awareness of the issues among representatives of public and private bodies such as the World Intellectual Property Organisation, the European Patent Office, and the European Commission, and intellectual and industrial law firms, and to promote the need for an indepth, worldwide study on the possibility of elaborating a more harmonised legal environment.

Admittance to the workshop will be free of charge, but only a limited number of participants can be accommodated. For more information, contact:

Valérie Kayser
Executive Secretary
European Centre for Space Law
8-10 rue Mario-Nikis
75738 Paris Cedex 15
Tel: (33) 1 42.73.76.05
Fax: (33) 1 42.73.75.60

Ariane Launches Resume

Ariane-4 launches resumed on 17 June with Flight V64, followed by Flight V65 only three weeks later, on 8 July. Arianespace is planning to launch one flight every three weeks to make up for time lost after all launches were postponed pending the results of an investigation into the loss of Flight V63 in January.

On the first flight, the Ariane 44LP rocket (the version with two solid and two liquid strap-on boosters) placed three satellites into Geostationary Transfer Orbit (GEO). The Intelsat 702, the first of the Intelsat VII generation spacecraft, will provide international and regional communication services in the Atlantic Ocean region. The other two satellites launched, STRV 1A and 1B, are small US/British satellites dedicated to technology demonstration and scientific investigation. An original launch attempt on 4 June had to be rescheduled after one of two robotic fuel lines failed to detach just seconds before launch.

On the second flight, an Ariane 44L (the version with four liquid strap-on boosters) placed two telecommunications satellites for use in the Asia Pacific region into GEO. The PanAmSat 2, the first of the PanAmSat second generation satellites, will provide US communications and video broadcasting over the Pacific Ocean region, and the BS-3N will ensure that direct broadcast television services continue for NHK/Japan Satellite Broadcasting in Japan.

Communications Technology to Address Chernobyl Problems

Space communications technology developed by ESA is helping Ukraine to minimise the risk of radioactive contamination. In a pilot project, trucks transporting nuclear waste are now being equipped with mobile terminals that transmit the location of the truck as well as the radiation level of its load via satellite to a control centre. Such mobile links are of vital importance to the transport of dangerous goods in the Ukraine because no public, land mobile networks are available.

Typical mobile Prodat equipment that is installed in a truck, including the antenna (centre, back) and the keyboard which the driver uses to send and receive messages

With its five nuclear power stations and six large nuclear waste storage facilities, Ukraine is active in the transport of nuclear waste. In addition, the shutdown of the Chernobyl plant, now being discussed by the European Union and the G-7 countries, would involve the transport of large volumes of nuclear waste to storage facilities.

Two Prodat-2 terminals were installed in May 1994, and two more are being sent to Ukraine to expand the scope of the project. Prodat-2 terminals, which use ESA's Marecs-A satellite for this project, provide very secure links, are interconnectable with a wide range of public networks and offer a very short response time. They were developed by FIAR of Italy under ESA contract. The pilot project in Ukraine is being undertaken jointly by ESA, FIAR, the Ukranian Space Agency, the Ministry for Chernobyl, and the Institute of High Technology in Kiev.

The Ukranian authorities are very satisfied with the performance of Prodat-2 and are proposing to use the system for other purposes. For example, helicopters will now be equipped with Prodat terminals to allow them to transmit environmental data in real time, for instance, to emergency response teams, in the case of an accident.

From Ariane to the Channel Tunnel ...

In the public's mind, ESA programmes are associated with satellites, the Ariane launchers, and advanced space science research. ESA is thus seen as advancing scientific knowledge about the universe, developing the technical capabilities of the European space industry, and establishing services, such as telecommunications and weather forecasting, that are of direct and daily use to the public.

ESA's activities, however, have another effect which is too often neglected: the stimulation of industry all over Europe. A recent, independent study has determined that for every 100 ECU that ESA spends on contracts with the European space industry, there is an economic spin-off worth 320 ECU. Part of this involves the transfer of technology developed for space to non-space sectors.

Industrial companies have also realised over the last 20 years that they can — and must — improve the efficiency with which they introduce new technology into their products. Technology transfer, the process of taking innovations from one domain and applying them to another, can provide a company with a leading edge. Technology developed for space and its extreme environment can provide such an edge.

The following are a few examples of spin-offs or technology transfer successes from space in Europe over the past 10 years:

— *Staples made of Shape Memory Alloys used in bone repair*
A group of materials, known as Shape Memory Alloys, that 'remember' a shape that they had, through special processing, were developed for use as small linear actuators in prototype space equipment. They are now being used as staples for repairing human bones.

These staples are positioned close to the bone fracture site in two pre-drilled holes. Body temperature then brings back the original 'memory', producing the heat input to cause the two 'legs' of the staple to draw together. This then brings together the ends of the broken bones, which not only reduces the time required for the bone to mend but can also assist with both axial and angular alignment.

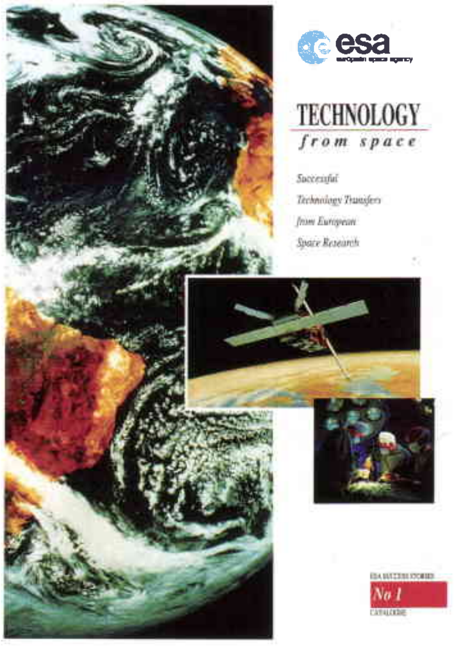
— *Lightweight electromagnetic interference filter/connectors*
The protection of electronic equipment and the environment from electromagnetic interference is necessary in many fields, particularly in space. It can interfere with the operation of equipment and can also disrupt communications. Traditionally, filters have been used to resolve the problems, but driven by weight considerations, a company developed a wide range of combined filter/connectors for the Ariane rocket that optimise filtering and are easy to implement. They have been adapted for various applications, most notably for use in the Channel Tunnel.

— *Fire protection materials used in Channel Tunnel*
During the launch of an Ariane rocket, extremely high local temperatures are generated. This led to the development of a family of fire-proofing materials to protect sensitive equipment in the rocket. Those materials are now being used on the ground for applications where high thermal protection is required, for example, to protect sensitive equipment in the Channel Tunnel trains.

Many more technologies that have been successfully transferred are described in the 'ESA Success Stories Catalogue'. To request a copy, contact:

Pierre Brisson
ESTEC
Postbox 299
2200 AG Noordwijk, The Netherlands

Tel: (31) 1719-84929
Fax: (31) 1719-17400:



Second International Microgravity Mission Flown

On 8 July, the Space Shuttle 'Columbia' took off from Kennedy Space Center to begin the 14-day second International Microgravity Laboratory (IML-2) mission.

Like its predecessor, IML-1, this mission is almost completely dedicated to research in microgravity. More than 200 scientists from 15 countries are taking part in the mission. ESA has provided about 50% of the payload and four of the 19 on-board facilities.

During the mission, ESA's European Space Operations Centre (ESOC) in Darmstadt, Germany, is providing the scientific community with a means to communicate remotely with the experiments. It is acting as a communications hub linking the NASA Payload Operations Control Center (POCC) at the Marshall Space Flight Center in Huntsville, Alabama, to European user centres in Belgium, France, Germany, Italy and the Netherlands.

The Shuttle is planned to land at Kennedy Space Center on 22 July.

A View from the POCC

One of the ESA facilities onboard the IML-2 flight is the Biorack — a multi-purpose and highly adaptable facility for the investigation of the effects of microgravity on cells, tissues, plants and other biological samples. The Biorack on IML-2 contains three incubators, a glovebox and a cooler-freezer unit that allows crew members to grow, handle and preserve biological samples for later investigation on Earth. This is the third time that the Biorack has flown.

During the mission, the Payload Operations Control Center (POCC) is staffed around the clock by four members of the Biorack Ground Team (BGT). Their tasks include replanning experiment operations and procedures, and communicating changes and comments from the principal investigators to the crew.

The following is a report from ESA's Project Scientist in the POCC.

The Biorack, with two incubator drawers and the cooler/freezer (top) open

Day 8 of the mission

Some of the BGT members arrived in the Payload Operations Control Center (POCC) two days before the scheduled launch date to set up the ground support equipment, which is mostly computers used for data acquisition and storage, and prepare everything for the mission.

The Biorack was activated five hours after launch, at 0/05:28 Mission Elapsed Time (MET), and both Incubators A and C as well as the new Biorack Cooler operated nominally. The loading of experiment containers holding biological samples into the Biorack started about seven hours after launch and was completed at 0/09:32 MET.

During the last steps of the first activity with the Adhesion experiment (at 0/12:38 MET), however, Centrifuge 1 in Incubator C malfunctioned and stopped running! This potentially very critical problem was quickly and very simply overcome by performing a malfunction procedure which called for the crew to put an elastic band around the two centrifuges, so that the operating one (Centrifuge 2) would drive the non-working one (Centrifuge 1). This contingency configuration only resulted in minor changes to the crew procedures. The elastic band was removed four days later, at 4/13:43 MET since only one centrifuge is needed in Incubator C for the rest of the mission.

Since then everything has been running smoothly. Eleven experiments have been nominally completed, and there is no reason to believe that the remaining ones will not also be completed successfully.

Claude Brillouet
Biorack Project Scientist
POCC, MSFC
Huntsville, Alabama

Satellite Transmissions to Eastern Europe Studied

The University of Plymouth (UK) has recently completed a study on ESA's behalf on the potential for satellite transmissions to Eastern Europe. Following a needs and feasibility analysis, 24 live programmes and 37 taped programmes were transmitted to Eastern European countries via ESA's Olympus satellite's steerable Ku band transponder.

The live programmes, transmitted from the University's television studio to the Institute of Radioelectronics in Kharkhov, the Ukraine, were on two subjects in great demand in Eastern Europe, business and computing. A unique feature of the project was that a fully interactive link with Kharkov was established using ESA's CODE information and dissemination system on a VSAT network. It enabled staff at the Institute to communicate live with the studio, using both voice and computer.

The taped programmes were specially edited from live news transmissions by the University of Oxford Language Centre and were on such topics as the weather, farming and railways. They were received in Poland, Hungary, Bulgaria, Czech Republic, Slovak Republic, Romania and several areas of the former USSR.

The project was deemed to be a success and, given the demand for up-to-date information on business and technology, plans are now being made to continue transmissions on the widebeam of the Eutelsat satellite and possibly on Eastern European satellites.

ESA/Japan Talks Held

The 19th annual meeting between ESA and Japan was held in ESA Headquarters in Paris on 6 – 8 June. The previous meeting had been in Tokyo in 1993.

The two parties discussed the progress made in their respective space programmes over the past year, and expressed their intention to pursue more active and closer cooperation. The main areas of common interest are space science, telecommunications, Earth observation, space transportation, a space station, space experiments, product assurance and network operations.

Issues discussed included:

- Space science
  Negotiations with Japan's Institute of Space and Aeronautical Science (ISAS) for the establishment of a cooperative framework for the enhanced utilisation of ESA's Infrared Space Observatory (ISO) through extended operations, are in the final stages.
- Telecommunications
  A Memorandum of Understanding on a joint optical link experiment between ESA's Artemis satellite and NASDA's Optical Inter-orbit Communications Engineering Test Satellite (OICETS) has been finalised. Both ESA and Japan have also investigated other areas of potential cooperation.
- Earth observation
  A reciprocal agreement on data exchange between ESA's ERS-1 satellite and NASDA's JERS-1 satellite has been satisfactorily implemented. Arrangements for the commercial distribution of data from the two satellites were discussed. ESA and NASDA have also investigated potential cooperation on ERS-2 and the Advanced Earth Observing Satellite (ADEOS), scheduled to be launched in 1996, and in missions after the year 2000.
- Space experiments
  Both sides reviewed the flight opportunities for microgravity experiments. They agreed to further investigate experiments proposed for NASDA's Engineering Test Satellite (ETS) VII, which is scheduled to be launched in 1997.

The next ESA/Japan meeting, the 20th, is scheduled to take place in Japan in 1995.

ESA and Greece Sign Cooperative Agreement

ESA and the Government of Greece signed an agreement in Athens on 4 July for cooperation in space research. This reflects ESA's political desire to expand its cooperation with other, non-member European States.

The five-year agreement involves regular exchanges of information, visits, awarding of fellowships, joint symposia, and access to databases and laboratories. It also outlines a mechanism for selecting and executing joint projects of mutual interest.

ESA has maintained informal relations with the Hellenic National Space Committee, which oversees Greece's space programme, for several years and has recently agreed to provide consultancy support to Greece's Hellas-Sat project.

J.-M. Luton (left), ESA's Director General, and G. Simitis (right), the Greek Minister of Industry, Energy and Technology, sign the agreement on cooperation in space research. J. Charalambous (seated), the Greek Minister of Transport and Communications, looks on.

Lunar Samples Available for Education and Research

NASA has several programmes that provide lunar materials for education, research, and public display. These samples are available for loan to Europeans.

Educational thin sections

NASA has prepared a package containing 12 thin sections of lunar material that are representative of the lunar collection, and a disk of six small, encapsulated lunar samples, which is available to colleges and universities offering a curriculum in the geosciences. Training materials, including a video tape and a workbook, accompany the package.

College or faculty members requiring further information should contact:

Lunar Sample Curator
SN2
NASA/Johnson Space Center
Houston, TX 77058-3698
USA
Fax: (713) 483-2911

Educational disks

Small samples of representative lunar rocks and soils, embedded in acrylic disks, are available for short-term loan to qualified school teachers. Each teacher must participate in a brief training programme before receiving a disk.

For further details, contact:

L.B. Bilbrough
FEE/Elementary & Secondary Education
NASA Headquarters
Washington, DC 20546
USA
Fax: (202) 358-3048

Samples for research or public display
Through other programmes, NASA also provides lunar samples to approved investigators for both basic studies in planetary science and applied studies in lunar materials beneficiation and resource utilisation. It also lends rock samples for public display. For more information, contact:

Dr. James L. Gooding
Lunar Sample Curator
SN2
NASA/Johnson Space Center
Houston, TX 77058-3696
USA
Fax: (713) 483-2911

Prof. Hubert Curien, Co-Chairman of the International Lunar Workshop, addresses the participants

International Lunar Exploration Effort Proposed

Upon the invitation of the Swiss Government, ESA held an international workshop to consider the implementation of internationally coordinated programmes for robotic and human exploration of the Moon. Representatives from space agencies, scientific institutions and industry from around the world met in Beatenberg, Switzerland, from 31 May to 3 June, to discuss the plans.

The workshop participants stressed the opportunities offered by the exploration and utilisation of the Moon, and recognised its potential as a natural long-term space station. There is a great interest in the science of the Moon (illuminating the history of the unique Earth-Moon system), science from the Moon (for astronomical projects), and science on the Moon (biological reactions to low gravity and the unique radiation environment).

It was agreed that the time is right, scientifically and technologically, for a lunar programme implemented in evolutionary phases. The first phases would involve using orbiters and landers with roving robots to explore the Moon's resources. The participants felt that this was within the capabilities of the various individual space agencies technically and financially. The benefits, however, would be greatly enhanced by close inter-agency coordination.

The participants also concluded that existing international space treaties already provide the necessary legal framework for scientific exploration and economic utilisation of the Moon, including the establishment of permanent scientific bases and observatories.

A second International Lunar Workshop will be held in mid-1996 to review progress and plans.

Symposium on High-Latitude Heliosphere Held

The launch on 6 October 1990 of the joint ESA-NASA Ulysses mission marked the start of a new era in the study of the heliosphere. For the first time since the dawn of the space age, in situ observations of heliospheric fields and particles are being made above the Sun's polar regions and over the full range of heliographic latitudes. From shortly after launch to the present, Ulysses has returned a data set of unprecedented completeness with which to study the properties of the solar wind, the heliospheric magnetic field, locally accelerated and solar energetic particles, cosmic rays, as well as important interstellar constituents, dust and neutral helium. The spacecraft also carries instrumentation to detect solar X-rays and cosmic gamma rays, and a radio science investigation to probe the solar corona.

'The High-Latitude Heliosphere' was the topic of the 28th ESLAB Symposium held in April in Friedrichshafen, Germany, and organised by ESA's Space Science Department. Attended by 130 scientists from Europe, North America and Africa, the symposium was directed toward placing the results obtained to date by Ulysses in the context of the current knowledge of the three-dimensional heliosphere. An equally important goal was to set the scene for the pass over the southern solar pole that Ulysses will make between June and November of this year (see 'Ulysses Scientists to Celebrate First Polar Pass').

Topics covered during the three-day meeting included the global structure and dynamics of the heliosphere (in particular the solar wind and the heliospheric magnetic field), the relationship between heliospheric and coronal structure at high latitudes, heliospheric particle acceleration and propagation, cosmic ray modulation, radio and plasma waves in the three-dimensional heliosphere, cosmic dust and interstellar gas in the heliosphere, results from the out-of-ecliptic phase of the Ulysses mission, and correlated ground- and space-based observations.

The scientific programme consisted of a number of invited topical review papers, with over 70 contributed oral and poster papers. More than 50 of the papers discussed results from Ulysses.

L.A. Fisk delivered the symposium's keynote address. He pointed to four unifying themes in the study of the Sun and the heliosphere in three dimensions:

- overall morphology
- the origin and propagation of cosmic rays
- interstellar gas and its history in an ionised state
- the source terms of the solar wind and related coronal processes.

Fisk commented that the degree of progress made in each of these areas as a result of Ulysses will determine how kindly history will judge the mission. He stressed that the measurements made during the prime mission of Ulysses apply only to solar minimum conditions, and that polar passes at solar maximum are essential in order to complete the picture.

In his summary talk at the closing of the symposium, M. Lee commented on the very impressive simplicity of the solar wind observed by Ulysses above the southern polar coronal hole. He stressed however that the fundamental problem of how the Sun's corona is heated is still far from being solved. Returning to Fisk's four themes, Lee gave his assessment of the progress made based on the results presented at the symposium. A clear winner was the category 'general morphology', followed closely by 'interstellar gas'.

In summary, this symposium very successfully achieved its goal of setting the scene for Ulysses' forthcoming polar passes. In addition, a strong case was made for continuing the Ulysses mission until 2001, i.e. for a second solar orbit, in order to obtain high-latitude observations at solar maximum.

R. Marsden

Ulysses Scientists to Celebrate First Polar Pass

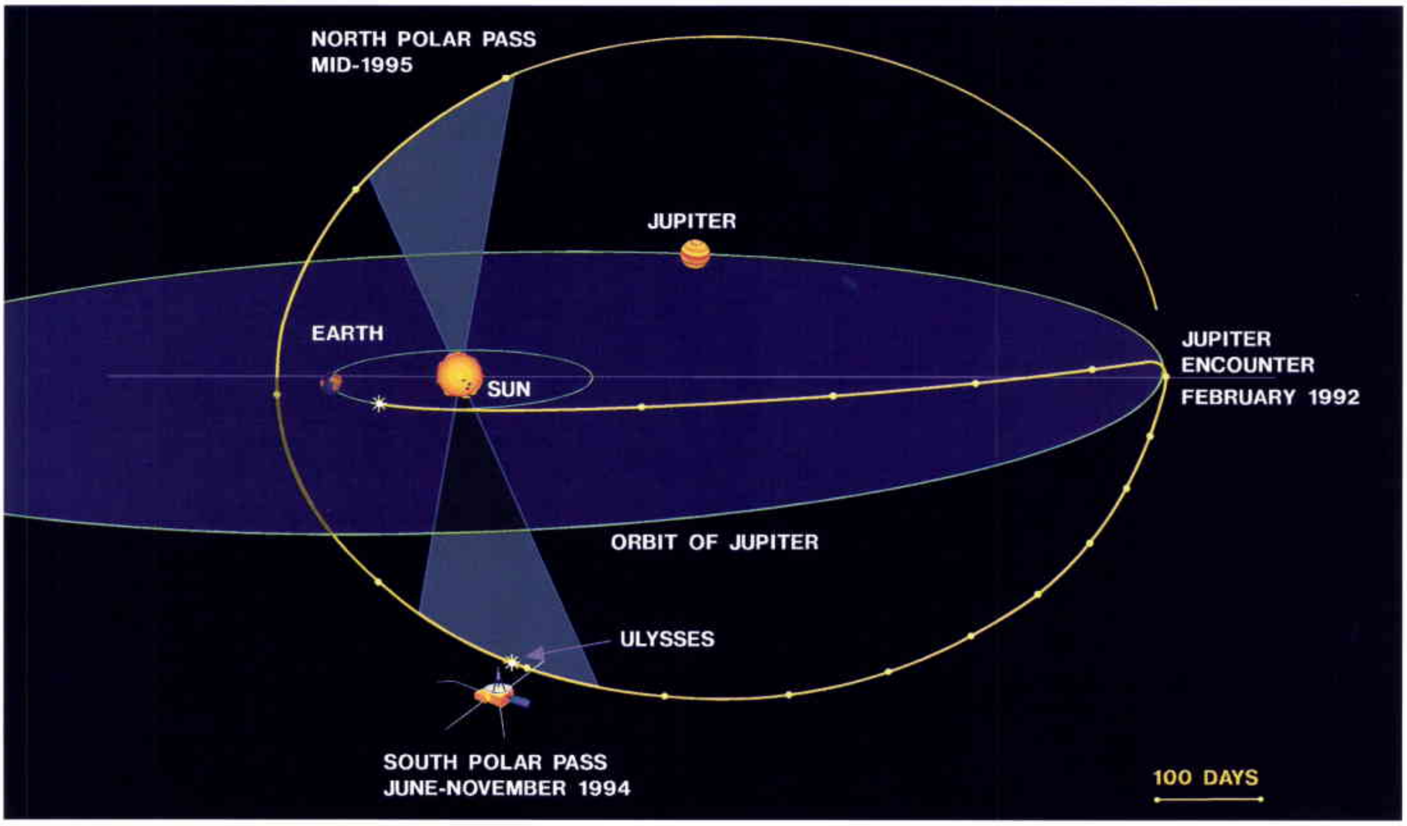
On 13 September, after a journey of almost four years and 2000 million kilometres, ESA's Ulysses spacecraft will reach its maximum latitude during the first polar pass. From this unique vantage point, 80.2 degrees south of the Sun's equator, the scientific instruments onboard the spacecraft will obtain the first-ever measurements of the Sun's environment above the poles.

To celebrate this important milestone in the highly successful mission, the Ulysses science teams will gather at ESTEC in Noordwijk, The Netherlands, in the week of 12 September. For this closed workshop, the ESTEC conference centre will be transformed into a scientific laboratory, with each one of the Ulysses teams occupying its own dedicated work area. Computer connections will be established so that data from the various experiments can be transferred from the investigators' home institutes to workstations installed at ESTEC.

Although not likely to achieve quite the same impact with the public as a planetary or cometary encounter, the Ulysses Polar Pass is nevertheless a first in the history of space exploration, and the success of the mission is a tribute to all those in industry, the scientific institutions, and ESA who have contributed to the project. In short, an event worthy of celebration!

R. Marsden

The Ulysses orbit and the spacecraft's position on 13 September 1994 (80.2 degrees south of the Sun's equator)



Thirty Years Since the Birth of ESRO and ELDO

The births of the European Launcher Development Organisation (ELDO) on 29 February 1964 and the European Space Research Organisation (ESRO), just three weeks later, on 20 March 1964, marked the beginnings of the European endeavour in space. The European Space Agency, formed on 30 May 1975 by the merger of ESRO and ELDO, is the legacy of the handful of European 'space pioneers' whose far-sighted endeavours brought those two Organisations into being in the early sixties.

ESRO's early years

The birth of the European movement towards cooperative space research can be traced back to August 1959, when Prof. Edoardo Amaldi of Italy and Prof. Pierre Auger of France talked together in the Luxembourg Gardens in Paris about collaborating on artificial earth satellites. The following January, at a Committee on Space Research (COSPAR) Meeting in Nice, further discussions on the possibilities of a cooperative European venture in space research were held with other scientists, and the first clear concept for a European Organisation was born. In April 1960, at the invitation of The Royal Society, a more formal meeting in London was attended by scientists from ten European countries (Belgium, Denmark, France, Germany, Italy, The Netherlands, Norway, Sweden, Switzerland, and the United Kingdom).

These various discussions culminated, in June 1960, in the formation in Paris of a study group known as the Groupe d'Etudes Européennes pour la Recherche Spatiale (GEERS); Sir Harrie Massey (UK) was elected Chairman and Prof. Pierre Auger was appointed Executive Secretary. The group's brief was to consider the establishment of a Preparatory Committee to investigate a joint European programme for space research and the terms of reference for such a Committee.

As a result of the study group's work, an Intergovernmental Conference was convened at the premises of CERN in Meyrin, near Geneva, on 28 November 1960. It was attended by officials from the 10 nations that had taken part in the earlier discussions, plus Spain, with Austria present as an Observer. On 1 December 1960, the last day of the Conference, the 11 participating nations signed the 'Meyrin Agreement', setting up a 'Preparatory Commission to study the possibilities of European collaboration in the field of space research' (Commission Préparatoire Européenne de Recherches Spatiales, or 'COPERS').

COPERS' primary function was to draft a convention, a scientific and technical programme, a budget, financial rules, staff regulations and agreements with other organisations interested in space research, and to prepare for an Intergovernmental Meeting to establish the Organisation.

The Meyrin Agreement on COPERS entered into force on 27 February 1961, with the approval of six 'Member States', whose financial contributions constituted the necessary 70% of the proposed first-year budget of $192 838. Although originally intended to last only one year, the Agreement was extended several times and COPERS continued to function until the European Space Research Organisation (ESRO) came into being on 20 March 1964.

ELDO's early years

Following its decision in early 1960 to halt development of the Blue Streak missile, the British Government invited a number of European countries to cooperate in a European Organisation for the joint construction of a heavy satellite launcher, which would use Blue Streak as its first stage. In January 1961, the UK authorities submitted more detailed proposals to the European states, in answer to which France suggested that a French rocket be used as the second stage of the planned vehicle. Subsequently these two Governments invited Belgium, Denmark, Italy, The Netherlands, Norway, Spain, Sweden and Switzerland to discuss the setting up of a European Organisation. As a result, a conference was held from 30 January to 2 February 1961 in Strasbourg. Turkey attended as Observers.

It was established that the Organisation's initial programme would be to develop a three-stage launcher and an initial series of satellite test vehicles. The first stage would be built by the UK, the second stage by France, and the third stage and the test satellite by the other members. Test firings would take place from Woomera in Australia.

Following the Strasbourg Conference, the British and French Governments went ahead with the drafting of a Convention, and this led to the convening of a Conference at Lancaster House in London on 30 October 1961. This was attended by representatives from Australia, Belgium, Denmark, France, Germany, Italy, The Netherlands, Spain and the United Kingdom. Norway, Sweden and Switzerland sent Observers.

It was decided at the Lancaster House Conference that the development and construction of the third stage of the proposed launcher would be carried out under German leadership. The first series of satellite test vehicles would be Italy's responsibility, while the down-range guidance system would be supplied by Belgium. The long-range telemetry links and auxiliary ground equipment were to be provided by The Netherlands.

The Convention for the Establishment of a European Organisation for the Development and Construction of Space Vehicle Launchers (ELDO) was eventually opened for signature in London and on 29 March 1962 seven countries signed it: Australia, Belgium, France, Germany, Italy, The Netherlands, and the United Kingdom. Denmark was granted Observer status.

The ELDO Convention entered into force on 29 February 1964.

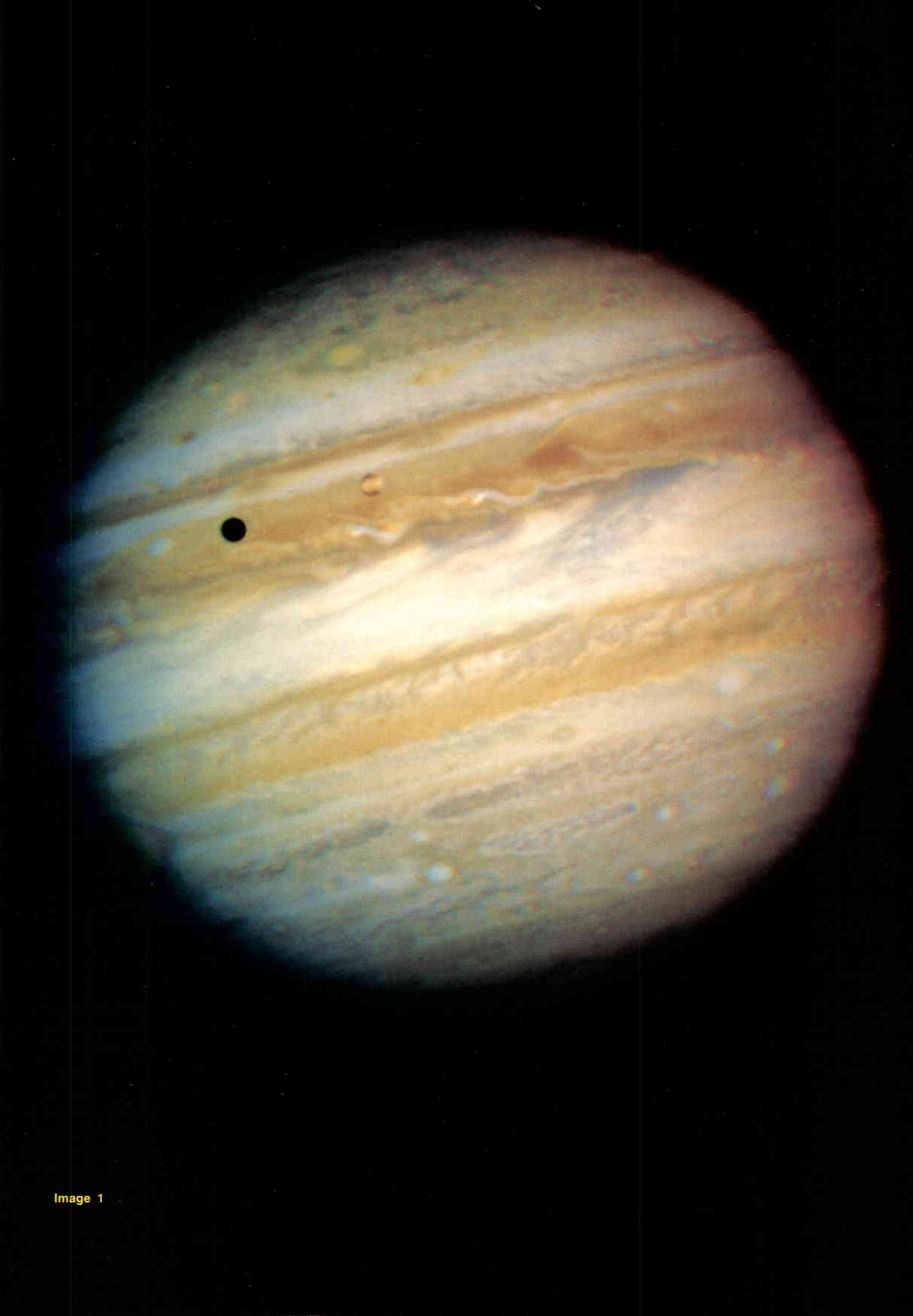


Image 1

Comet Shoemaker-Levy's Collision with Jupiter – As Seen by the Hubble Space Telescope

A rare cosmic event occurred in July when, over a period of seven days, starting on 16 July, the fragmented comet P/Shoemaker-Levy 9 collided with the planet Jupiter. The Hubble Space Telescope (HST) was directed to provide intensive monitoring of this momentous event.

The accompanying HST images were kindly provided by Dr. F. Duccio Macchetto, Head of the ESA Science Programmes Division at the Space Telescope Science Institute (STSI) in Baltimore (USA).

Image 1
An image of Jupiter taken prior to Comet Shoemaker-Levy's arrival, on 18 May 1994, by HST's Wide Field and Planetary Camera-2 (WFPC-2), when the giant planet was 670 million km from Earth. This 'true-colour' picture was assembled from separate HST exposures in red, blue, and green light. Jupiter's rotation between exposures created the colour fringes on either side of the planet's disk. The dark spot on the disk is the shadow of Jupiter's inner moon Io, which can be seen just to the upper right of the shadow.

Credit: H.A. Weaver & T.E. Smith (STSI) and J.T Trauger & R.W. Evans (JPL)

Image 2
Composite of separate HST images of Jupiter and Comet Shoemaker-Levy. Jupiter was imaged on 18 May 1994 from a distance of 670 million km. When the comet was observed on 17 May, its train of 21 icy fragments stretched across 1.1 million km of space, or three times the distance between the Earth and the Moon. The apparent angular size of Jupiter relative to the comet, and its angular separation from the comet when the images were taken, have been modified for the purposes of this illustration.

Credit: H.A. Weaver & T.E. Smith (STSI) and J.T. Trauger & R.W. Evans (JPL)

Inset:
The 'original' image of Comet Shoemaker-Levy taken on 17 May 1994, with six separate WFPC-2 exposures in red light spaced along the comet fragment train.

Credit: H.A. Weaver & T.E. Smith (STSI)

Image 3
This HST image (WFPC-2) of the full disk of Jupiter, acquired on 22 July, shows numerous Comet Shoemaker-Levy impact sites. The Fragment A impact site is on the lower left limb. From left to right, the features are: the A site; the E-F complex near the white oval southwest of the Red Spot; the dispersing H site to the southeast of the Red Spot; and the Q site, near the eastern edge. Comet fragment A impacted on 16 July, E and F on 17 July, H on 18 July and Q on 20 July.

Inset:
The A site as imaged in the higher resolution WFPC mode one orbit (about 47 min) later, when the planet had rotated about 50 deg.

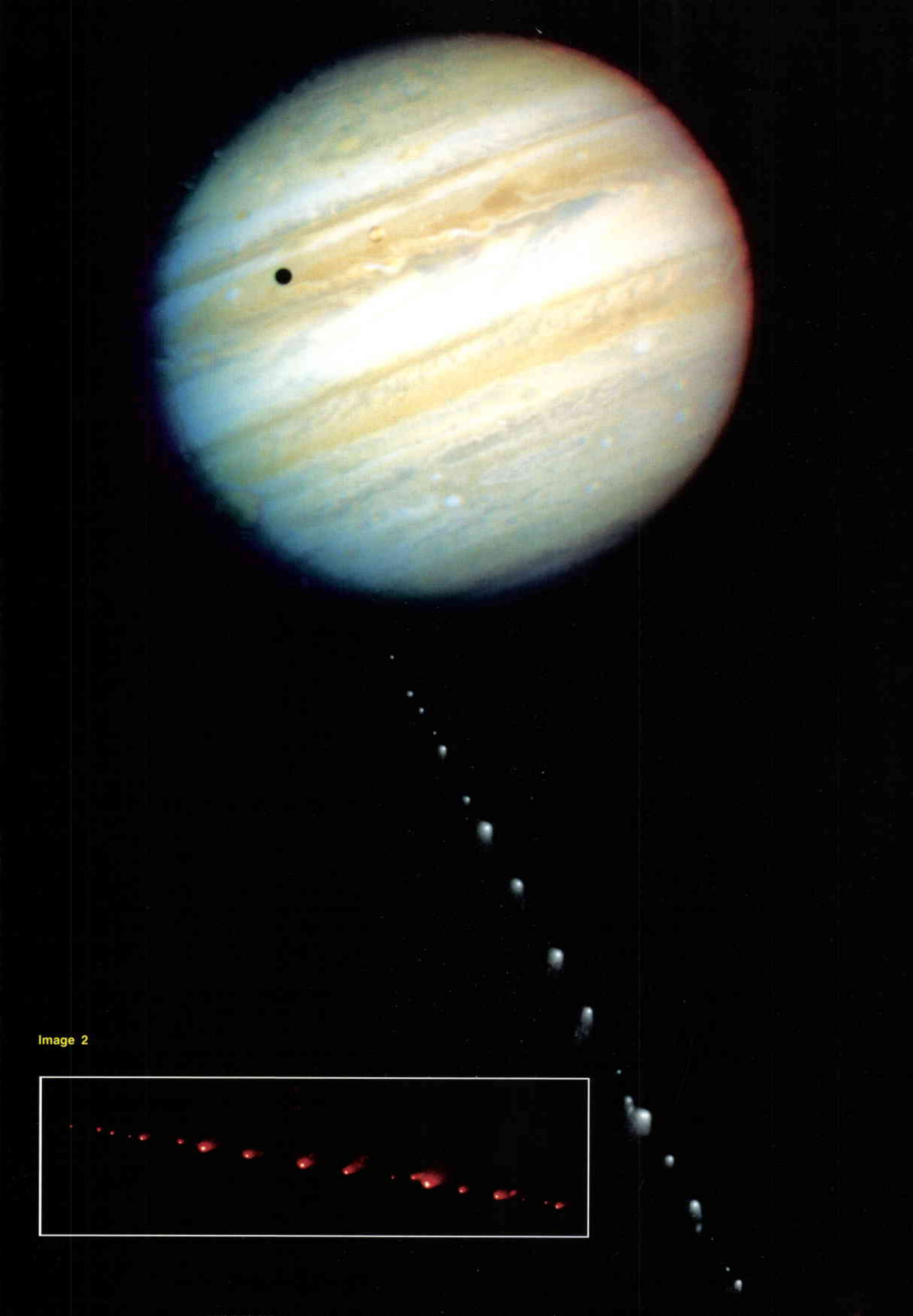
Credit: HST Comet Team

Image 4
This HST image (WFPC-2) shows the impact sites of Comet Shoemaker-Levy fragments D and G. The large feature was created by the impact of fragment G on 18 July. It entered Jupiter's atmosphere from the south at a 45 deg angle and the resulting ejecta appear to have been thrown back along that direction. The smaller feature to the left of the fragment G impact site was created by fragment D's impact some 20 h earlier.

This image was taken 1 h 45 min after fragment G hit the planet. The central dark spot at the G impact site is 2500 km in diameter. The surrounding thin dark ring is 7500 km in diameter. The dark thick outermost ring's inner edge has a diameter of 12 000 km, which is about the size of the Earth!

Credit: H. Hammel, MIT

Image 5
Eight impact sites are visible in this HST image. From left to right, they are the E/F fragment complex (barely visible at the edge of the planet), the star-shaped H site, the impact sites for tiny N, Q1, small Q2, and R fragments, and on the far right limb the D/G complex. The D/G complex also shows extended haze at the edge of the planet. The smallest features in this image are less than 200 kilometres across.



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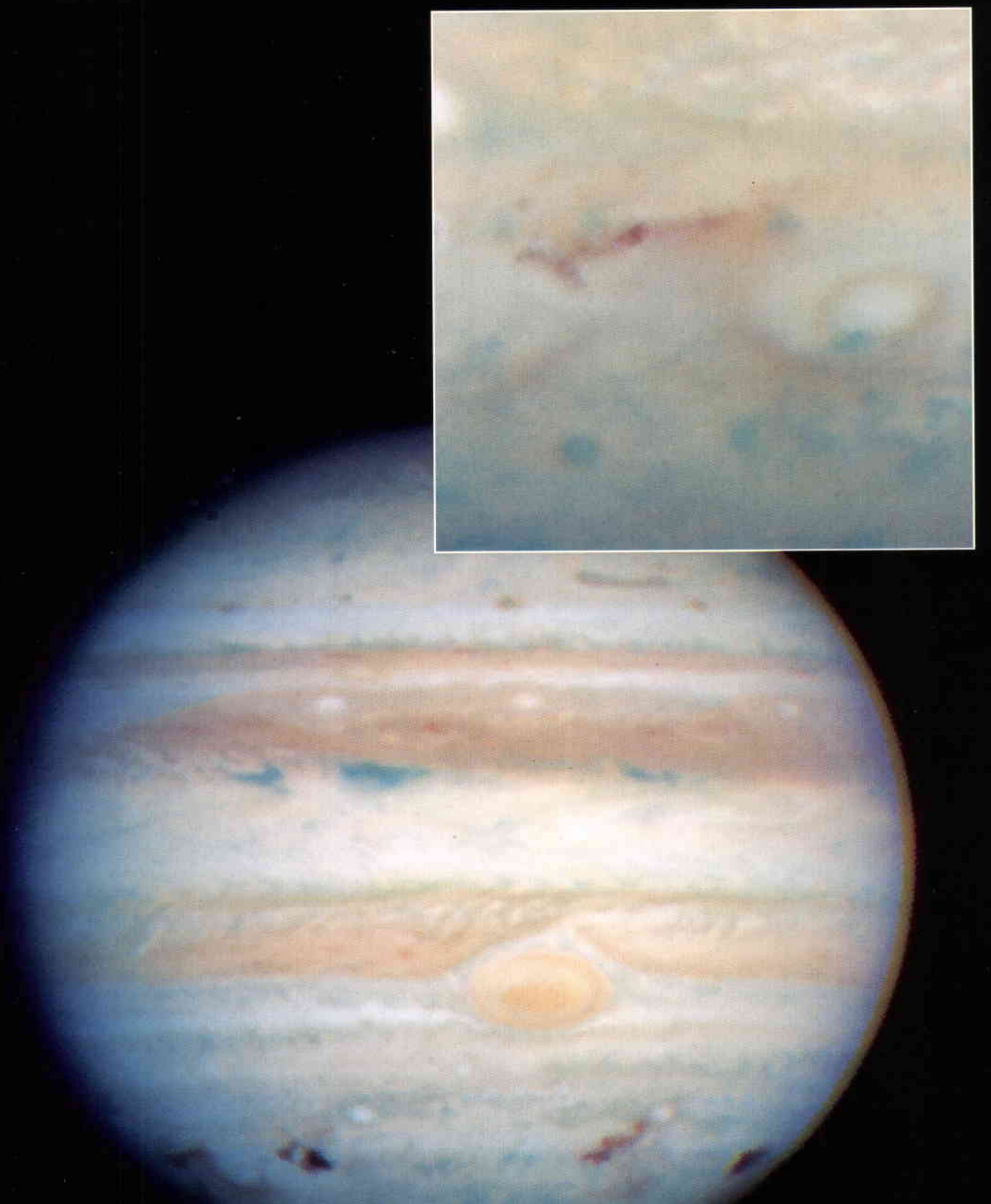

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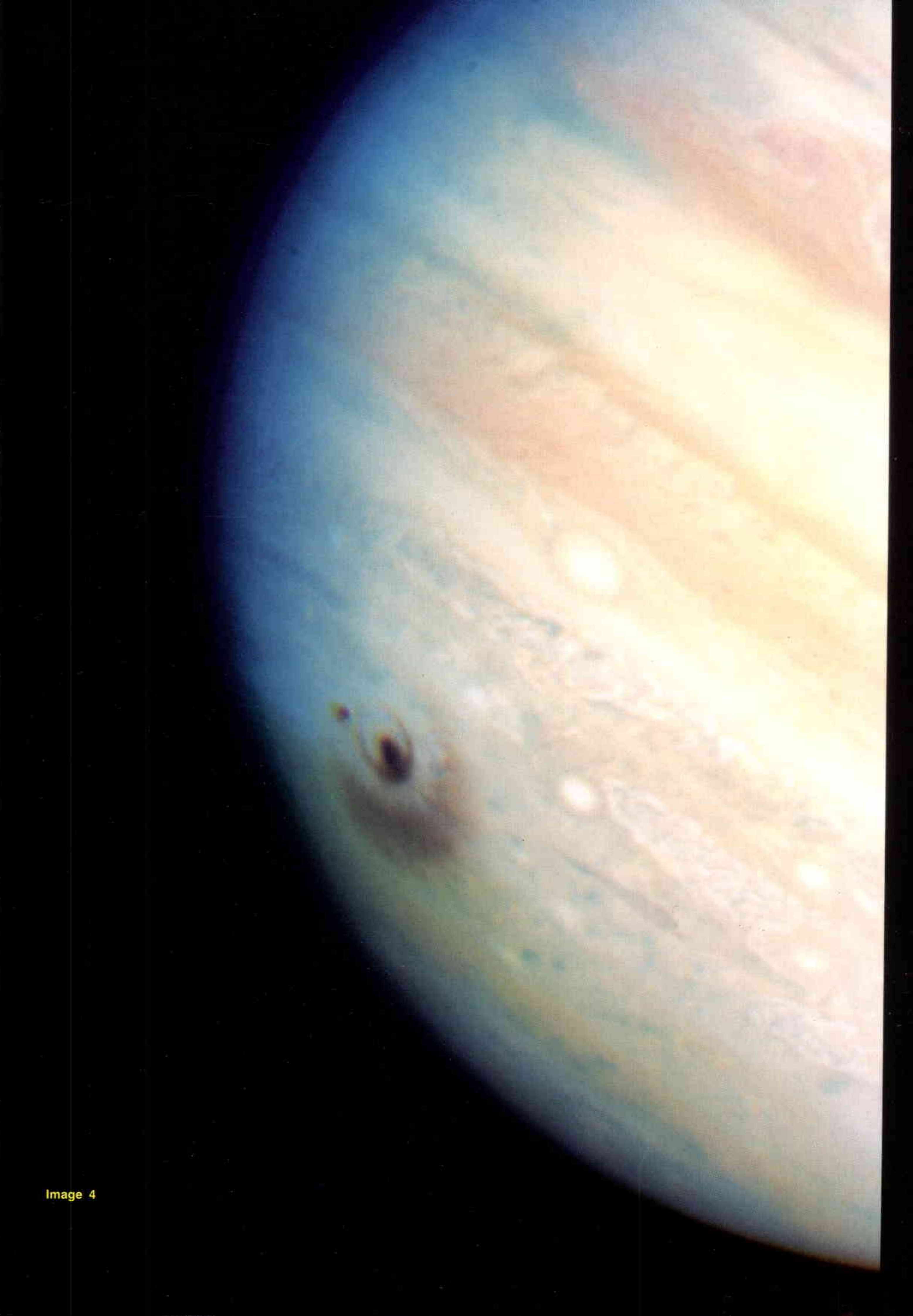

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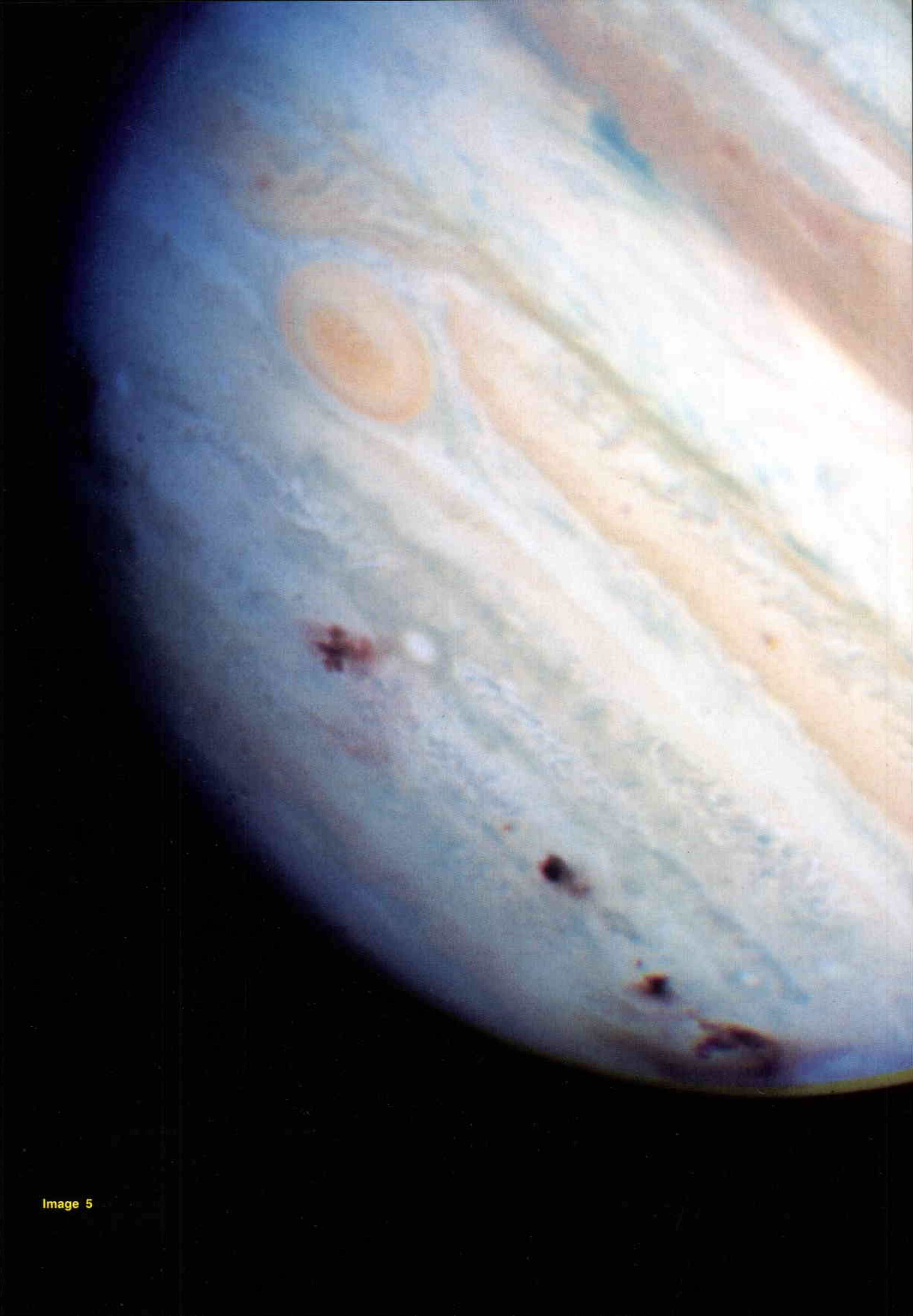

Image 5

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R.D. LORENZ

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A. HAHNE ET AL.

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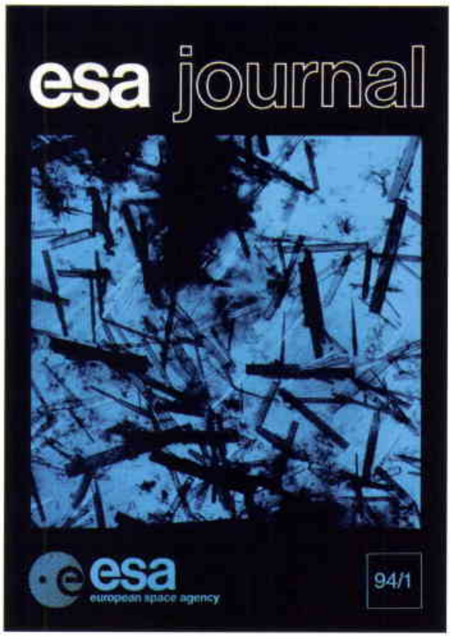

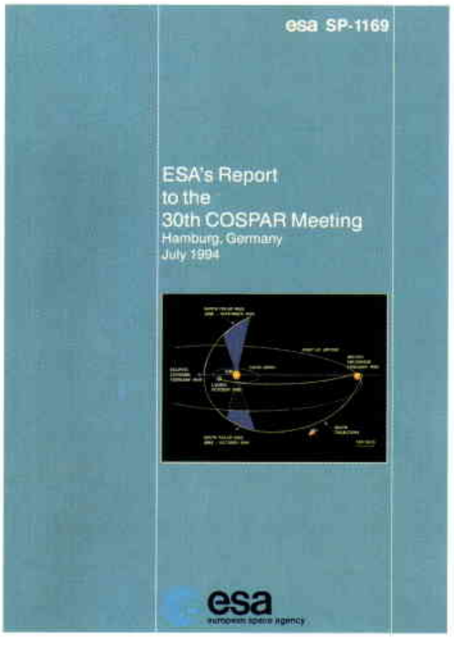

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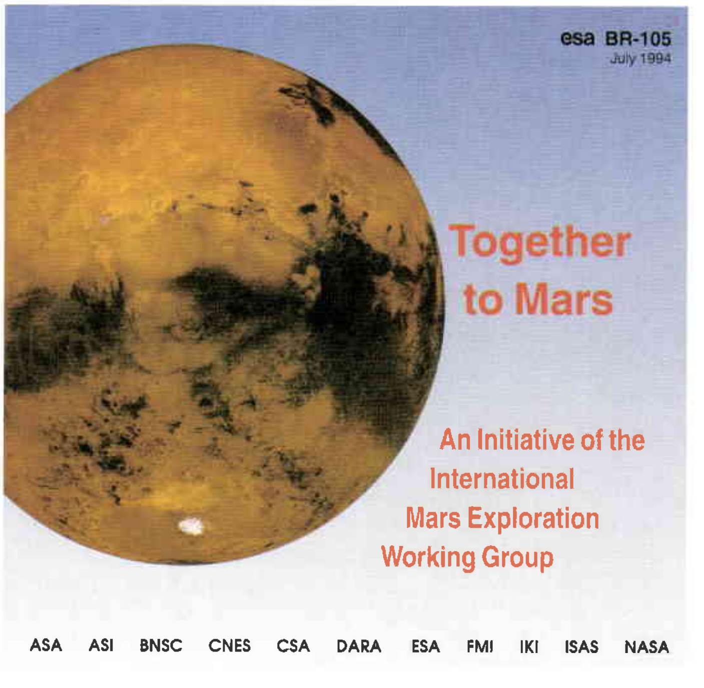
L. SEBESTA



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(EDS. T.D. GUYENNE & N. LONGDON)

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(ED. M. PERRY)

REACHING FOR THE SKIES
(Quarterly Newsletter on ESA's Launchers)
— No. 11, May 1994 (NO CHARGE)
(EDS. N. LONGDON & T.D. GUYENNE)

ESA Procedures, Standards and Specifications

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MATERIAL, MECHANICAL-PART AND PROCESS SELECTION AND QUALITY CONTROL FOR ESA SPACE SYSTEMS AND ASSOCIATED EQUIPMENT
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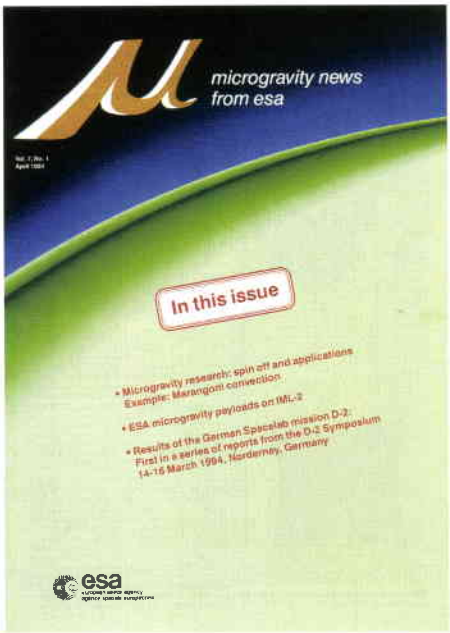

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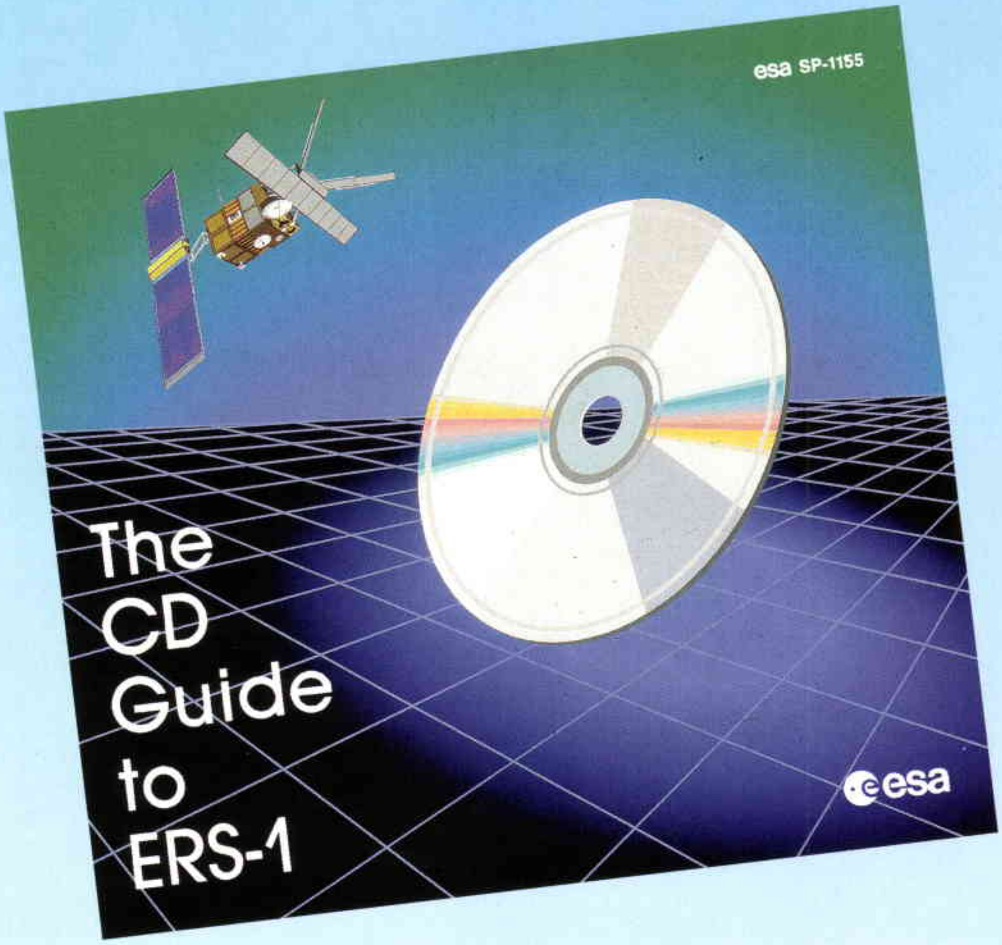

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A CD drive connected to a Macintosh, DOS PC (incl. MS Windows) or Sun Sparc station is required to access the disc.

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GIOTTO, das spektakulärste Raumprojekt seit der Mondlandung und ein Glanzstück der europäischen Raumforschung, wird von dem versierten Autor Nigel Calder spannend dargestellt.

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Der Übersetzer hat in Zusammenarbeit mit dem Autor und den wissenschaftlichen Projektleitern bei der ESA den Text für die deutsche Ausgabe aktualisiert und ergänzt.

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