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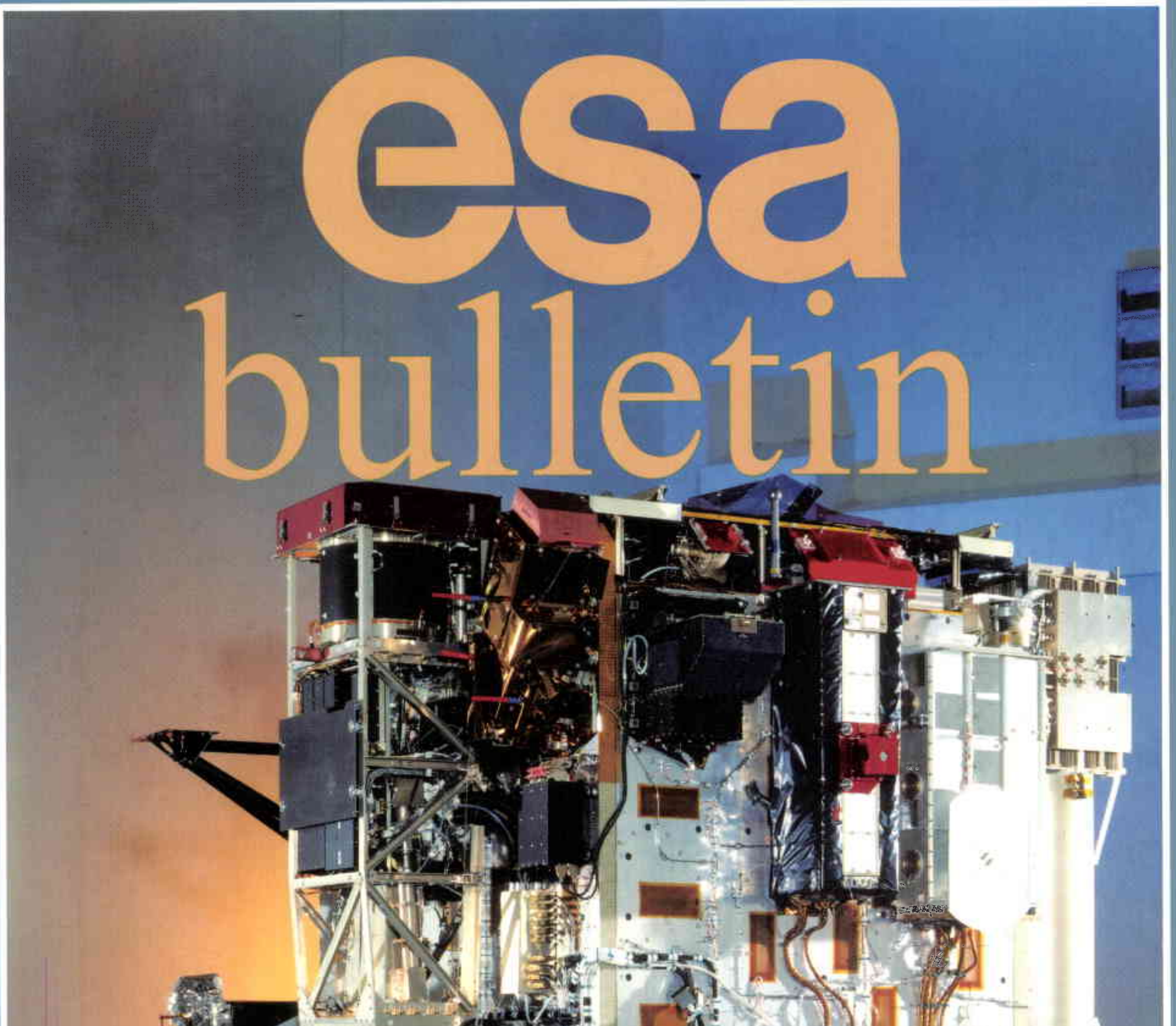

number 80

november 1994

esa
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.

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agence spatiale européenne

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

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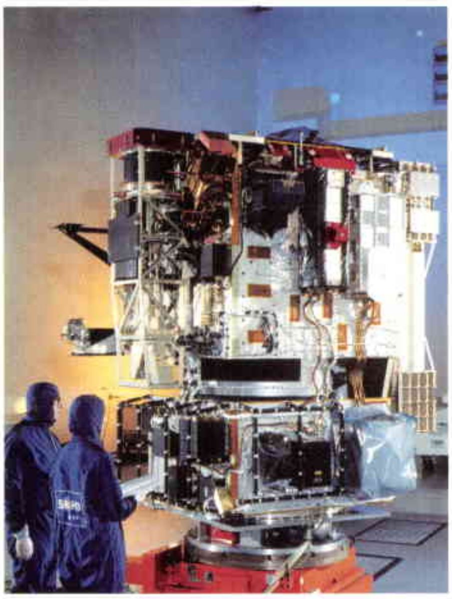

Cover: The Soho flight-model Payload Module, photographed at Matra Marconi Space in Portsmouth (UK)

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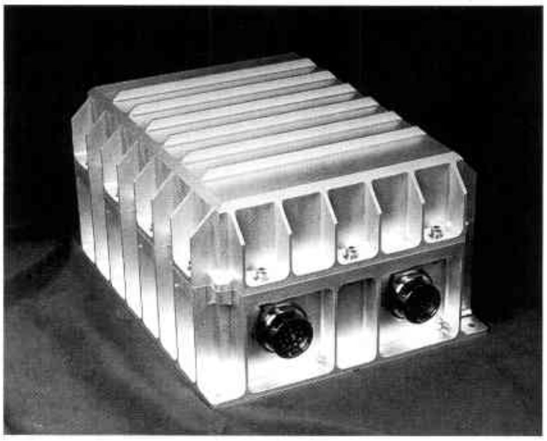

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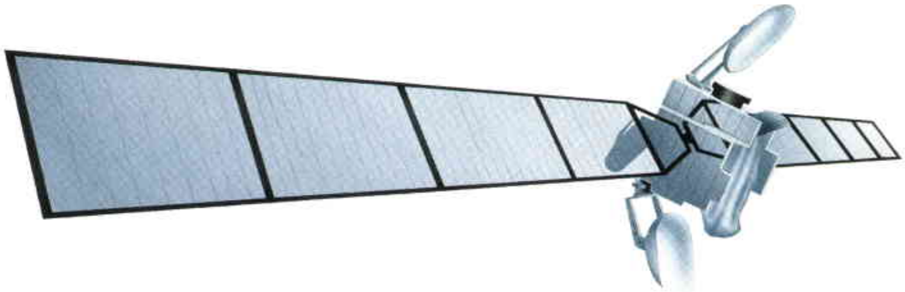

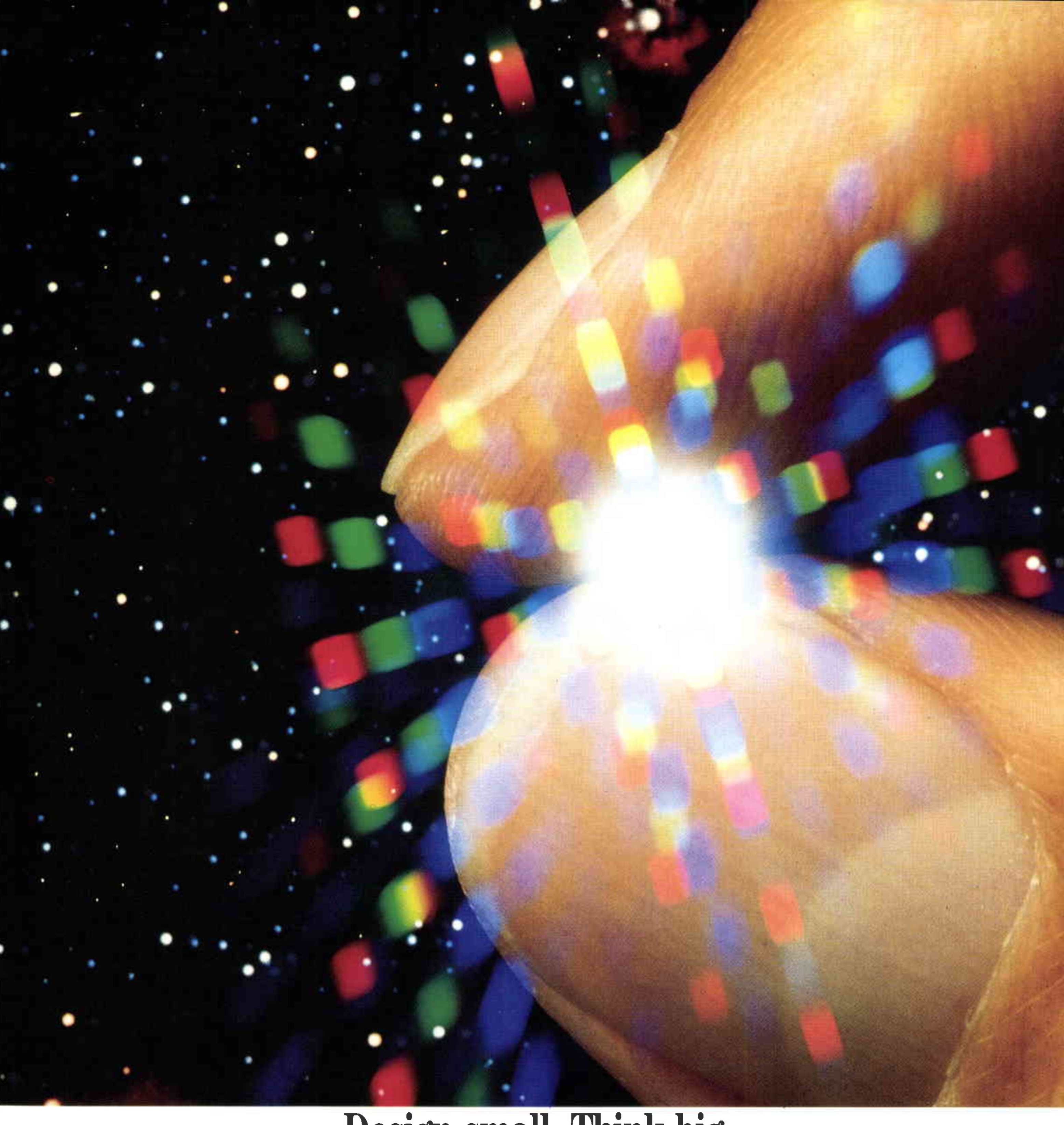

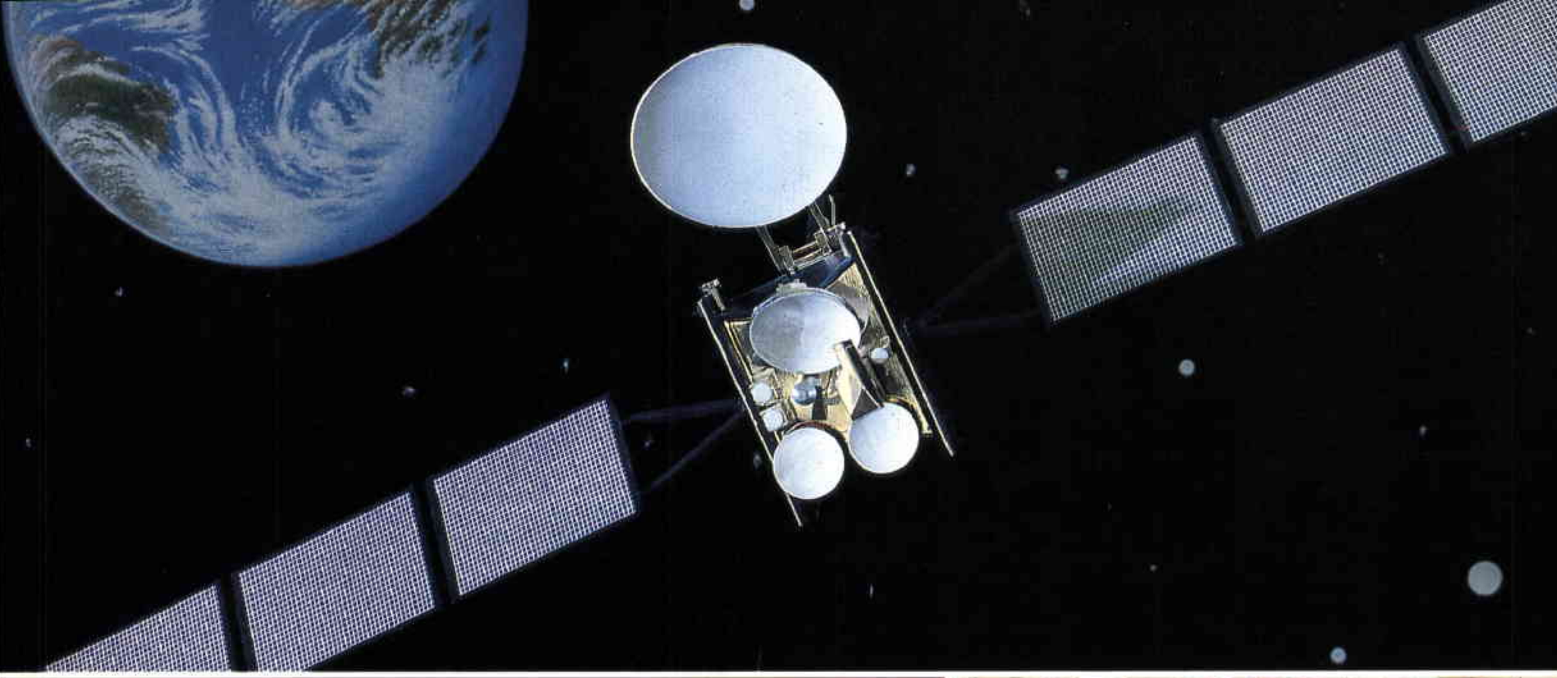

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Small Satellite Missions in the Context of the ESA Scientific Programme

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The merits of Small Satellite missions have been assessed by the Agency's Scientific Projects Department looking, specifically from the science viewpoint, at means for implementing such missions in the complex environment within which multi-national agencies such as ESA must operate.

Introduction

During the early phases of the space age, satellites tended to be small, being limited by both the available technology and launch capability. As the technology improved and as launchers became more powerful, the size of the payloads naturally grew apace. In the expanding economies of the time, there was a public desire to explore the new environment, and a feeling that space activities were at the cutting edge of engineering and scientific development. Funds were therefore made available to support the growth. The much-changed environment of today – an austere funding climate – is now encouraging a strong user interest in cheaper and more frequent missions, an interest that is forcing the established space agencies to rethink their approach to spacecraft procurement and mission design.

The ESA Science Programme has a strong interaction with the scientific community and is well aware of the latter's wishes. Consequently, the Agency has expended considerable effort in recent years on exploring several options for small scientific satellite missions, but so far without reaching any definite conclusions as to how to implement such missions in the context of the ESA scientific programme.

Historical background

The first relevant mention of small missions was associated with the approval of the Space Science:Horizon 2000 strategic plan for European space science, in 1985. Within this plan, a small-mission programme was foreseen in addition to the use of the Space Station and the European Retrievable Carrier 'Eureca'. As a consequence, consideration was given to the possible procurement of ESA's Cluster-mission spacecraft using similar procurement rules to those employed for the AMPTE mission. It was concluded at that time, however, that the changes needed to apply a similar 'small satellite' approach to Cluster were too wide-ranging and so different from current practice that they were unlikely to be approved by the ESA funding authorities in time for that mission. The Cluster project has therefore proceeded along more classical lines.

Nevertheless the Agency, ever mindful of the need to increase the frequency of mission opportunities, continued to seek, in accordance with the planned objectives of the Horizon 2000 plan, means of introducing smaller, cheaper missions into its programme. A special users group was set up within the Science Directorate to identify means of increasing the number of flight opportunities and to foster interest in and develop an approach by which small missions and individual payloads could be flown at low cost. At that time, flight opportunities on Space Station/Columbus and Eureca were being given high priority, as well as potential small 'self-contained' missions.

In 1990, the Pinkau Committee, which had been conducting a policy review of the ESA Science Directorate, confirmed that small missions should be included in the ESA programme with the promise that 10 MAU of savings would be freed for that purpose. One idea was that Member States could procure missions under the overall management of the Agency, but without the normal constraints such as an equitable geographical return on an individual-mission basis.

Later that year, therefore, the Agency issued a 'Call for Ideas' for small missions in an attempt to assess the potential interest. Some 52 proposals were received and evaluated by the ESA advisory groups. From this menu, two missions were selected for further study by way of being good typical examples of small missions in

two different areas of science:
- SOLID, a mission to measure solar oblateness, irradiance periodicities and diameter variations, and
- CUBE, a mission to survey the cosmic ultraviolet background.

The aim of the study was to explore technical feasibility, to verify the scientific return, and to assess the potential cost.

The response to the Call for Ideas and the resulting study of the SOLID and CUBE examples showed that there were some genuine, scientifically justifiable, small-mission ideas seeking a launch opportunity (Table 1), and so in March 1992 a Workshop was organised to explore the possibilities further.

From the study, and also from the conclusions of the Workshop, however, it emerged that there were a number of fundamental technical, managerial and policy subjects that had to be addressed before such a programme of missions could be considered for practical implementation. They included the need for a European small launcher, the constrained industrial procurement policy applied by the ESA Member States (the 'geographical return'), and the need for a more flexible personnel policy within the Member States, ESA, and Industry.

All of this led ESA to the conclusion that the setting up of a small-mission programme would be a lengthy process, precluding any short-term start to such a programme. Nevertheless, in recognition of the community interest, it was proposed that ESA would continue to consider small-satellite programmes within the Member States and would pursue small-mission opportunities with the Member States on a case-by-case basis. In addition, the Agency included a specific request for small-mission proposals in its November 1992 'Call for Mission Proposals'.

Although some 13 small-mission proposals had been received for consideration by April 1993, and were carefully evaluated by both the ESA Science Working Groups and the ESA Space

Table 1 — Design characteristics of the proposed SOLID and CUBE missions

Parameter	SOLID	CUBE
Mission type	Solar Physics	Astronomy
Objectives	To measure solar oblateness; the ratio of radius variations; periodicities in solar irradiance and solar diameter variations	A survey of the cosmic ultraviolet background
Payload	Solar Diameter Sensor (SDS)	Long slit imaging spectrograph 1200—1800Å
	Solar Irradiance Measurement (SIM)	Broadband 2' camera 1350—1900Å
Orbit	700 km Sun-synchronous	700 km circular equatorial
Launch mass	140 kg	186 kg
Payload mass	40 kg	50 kg
Dimensions: Length Diameter	1.8 m 1.1 m	1.5 m 1.36 m
Power	0.8 m^2 array, 80 W (BOL), 65 W (EOL)	2 m^2 array, 200 W (BOL), 140 W (EOL)
Data rate	10 kb/s on board, 500 Mb onboard memory. 1.7 Mb/s downlink (max)	26 kb/s onboard, 260 kb/s calibration mode, 1.7 Mb/s downlink (max)
Spacecraft type (3-axes, spinner, etc.)	3-axes, 2 arc-min LOS pointing, 0.5 deg in roll. Cold gas jet, reaction control subsystem	3-axes, slow scanning and pointing modes of operation. Cold gas jet, reaction control subsystem
Launch vehicle	Pegasus	Pegasus
Other features	Uses instrument as primary attitude sensor	Orbit tracking to <10 km. Experiment operation during eclipse only

Science Advisory Committee, none were recommended for further study.

Current developments

Today, the term 'small satellite' means different things to different people and, depending on whom you ask, can range from the extremely simple to the relatively complex. If the individual scientist is asked to propose a small mission, many replies will be received. If, however, a group of scientists is asked, a discussion is started on the relative merits of small satellites, but without having a proper definition of what truly constitutes a small-satellite mission.

Having asked the individual (via a Call for Proposals) and having asked the group (via the ESA Advisory Bodies), the Agency now finds itself in the middle of such a discussion and faced with the questions:

- How do we define small?
- What should a small-mission programme contain?
- How would it be implemented?

In order to answer them, the ESA Science Directorate is presently making a wide-ranging study of the issues involved – both scientific and organisational (see panels on following pages) – with a view to developing a Directorate policy towards the procurement of small satellites for, or by, the European scientific community. This study, which will eventually embrace a wide cross-section of the European scientific community, is being carried out in three distinct phases, as shown in Figure 1.

The first phase of activity has now been completed. During this phase, several meetings have taken place within ESA, each concentrating on a particular topic:

- Definition of 'small satellites'
- The sounding-rocket experience
- Experiment selection
- Review of procurement approach
- Launcher options
- The legal framework
- Small-satellite operations.

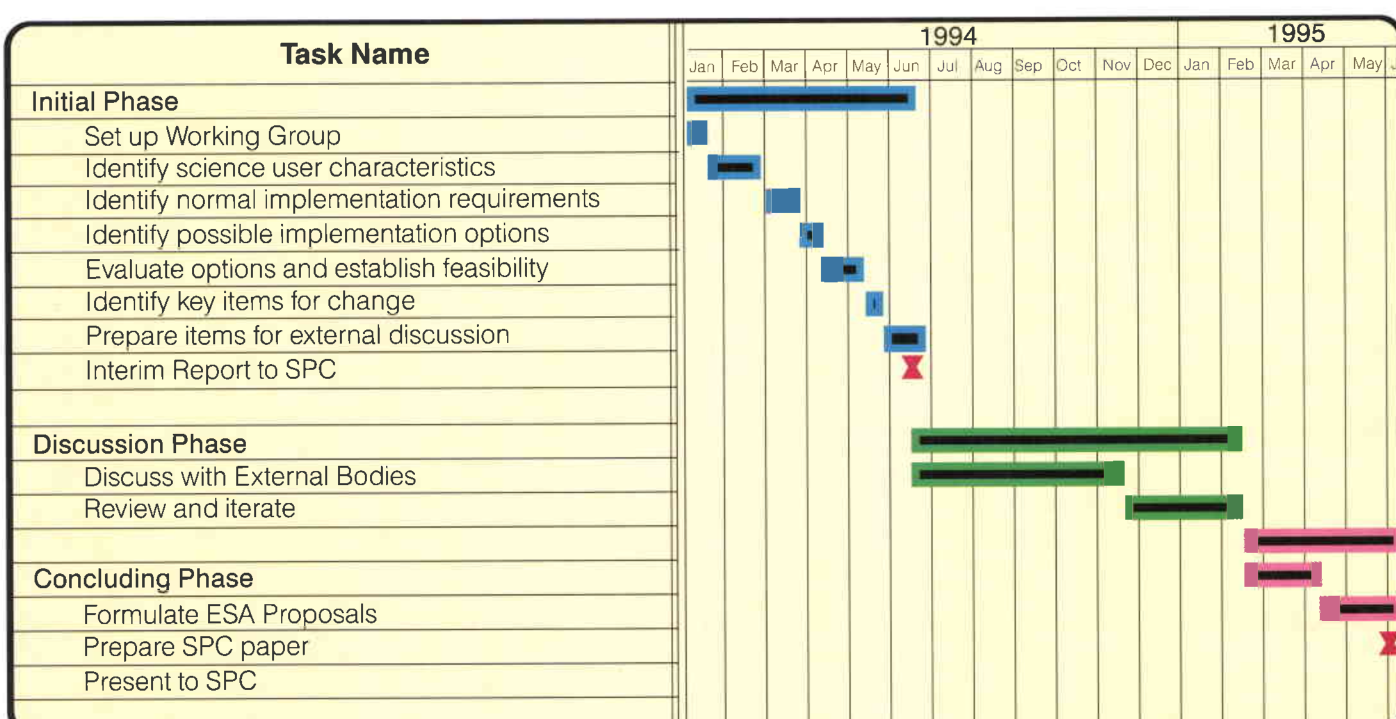
The initial findings can be summarised as follows:

Definition of 'small satellites'

This topic has proved to be the most elusive in that, despite all the studies made in the Executive and elsewhere, and the plethora of opinions expressed, there is still no universally accepted definition of what constitutes a 'small satellite'. Some authors use mass, others cost and short development times, while still others use relative complexity. The conclusion of the group is that the best criterion for defining a small mission is cost, from which all other parameters may be inferred.

As a reference for discussion, a total mission cost of about half a medium-mission budget, i.e. less than 160 MAU, has been assumed as the small-satellite threshold. Other, lower, financial thresholds could also be considered. One such set of parameters derived using this approach is shown in Table 2. It is consistent with the current definition of a small science mission.

Figure 1



Science-Related Issues

ESA has a wide customer base – the scientific community – which needs to be supported. How can a small-mission programme help in this respect?

The main argument is that a small-mission programme should be used to enhance the total programme. However, it is not obvious that a small-mission programme will satisfy more of the ESA community. With a small mission every two to five years, only a few additional Principal Investigators (PIs) will have a flight opportunity.

Related questions are:
- *Would the scientists not selected continue to support the programme?*
- *Would the science be complementary to the main programme's science, replace it, or simply a 'nice to have' adjunct?*

In the latter case, can the diversion of the funds be justified as, due to the fixed level of funding available, the main programme of activity would be delayed to accommodate the small-mission funding?

The answers to these questions need careful assessment by the community, so that there is a full understanding of what small missions mean and so that the benefits and the drawbacks are understood and accepted by all interested parties.

How many small missions can reasonably be expected over say a ten-year period?

It has been suggested, without confirmation, that funding to a level of about 25 MAU per year could be appropriate. Assuming this, probably between two and five small missions could be flown over a ten-year period, in addition to the normal series of Cornerstones and medium-size missions in Horizon 2000.

What is the scientific merit of one 'ten-PI mission' costing 500 MAU, as opposed to ten 'one-PI missions' costing 50 MAU each?

One answer could be that it provides greater diversity and more opportunities within a given field of science. By working together to satisfy a set of common mission objectives, the contributions of the individual PIs should be greater than the sum of their individual efforts. Good examples of such cooperation are ESA's Soho and Cluster missions, which accommodate some 21 PIs in a coordinated programme of activity. These PIs were chosen with complementarity in mind. If the individual payloads were to be flown as individual 'small' missions, it is most unlikely that all of the elements would fly in the same time period, with a consequent loss in overall scientific return.

While this is a rather specific example, and recognising that a small-satellite programme could be structured to give coordinated science results, it nevertheless serves to highlight the need to ensure that the limited funds that may be available for small missions are used effectively. The chosen missions must enhance the overall science return and provide opportunities at the individual level that are at least as good as those presently provided by the larger missions.

How would missions be selected?

There are several options that need to be studied. One of these is that a complete programme of missions could be selected. This would allow coordinated science with maximum commonality of hardware and test facilities within a well-defined programme of activity. An argument against such a block selection is that it would in effect become a single mission with limited flexibility to adapt to new scientific requirements.

An alternative approach could be to fix the spacecraft design at the start and to offer PIs fixed accommodation and resources. Then, some flexibility may be possible in that the experiments could be selected during the programme and not all at the start. An advantage of this approach would be that all spacecraft hardware would be identical.

Organisational Issues

The procurement of small satellites by ESA is not a technical issue, but one of organisation and management.

There is no doubt that Europe has the knowledge and expertise to procure small satellites — given the mandate and appropriate tools to do so. The experience gained during the sounding-rocket programme of the late sixties is still relevant, the key issues being small co-located teams, simple build procedures, use of standard kits of parts, and access to a cheap and reliable launcher.

To implement a small-satellite programme, many changes to current practice would be needed to approach the sounding-rocket philosophy. These changes would require the attention and approval of the ESA Council to ensure compliance with European policy. Careful preparation is needed to ensure that the proposed changes are indeed appropriate. The present study will specifically challenge established practice to prepare for eventual discussion at Council level.

ESA is a multi-national organisation which must be impartial when dealing with national/industrial authorities.

Being impartial implies that well-established procedures are instituted. Such procedures may not be appropriate to small-satellite programmes as they are presently geared towards the large-scale procurement that have, until now, been the dominant element in European space activity. The question that arises is: To what extent must the procedures be changed to facilitate the implementation of small missions, but at the same time retain impartiality?

Having answered that, the next question is:

Does the working environment need to be changed to allow for small missions, and if so what elements should be changed and by how much?

Changes may be wide-ranging and fundamental, including new working practices, new mission-selection procedures, and a new approach to the management of industrial contractors, all of which would require careful consideration before implementation.

Which launchers will be available to ESA?

This is presently an open question. Many free-market options are available, or are expected to be available in the near-term. Whether or not free access to this market will be allowed for European small-satellite missions is a point for discussion at national level, taking into account the existing launch capability and potential new European developments.

How would small satellites be operated?

The questions here are:
- *To what extent is the existing mission-operations infrastructure suitable for small-satellite operations?*
- *Can it be adapted easily?*
- *Would it not be better to leave the operations to the science community? If so, could they cope with the increased responsibility that this would imply?*

Finally, a commonly heard remark is that:

'ESA Member States should be left to carry out small missions on a national basis, as they are better equipped to deal with their own community and are not so constrained by industrial policy as ESA'.

This might be true for the larger nations, but the smaller nations may not have the infrastructure needed to design, build and launch a small mission. For them, ESA could perhaps provide access to flight opportunities for individual scientists in the smaller countries either through an ESA programme or by acting as a 'go-between' for national programmes.

Table 2 — Small science satellite characteristics

Cost	<160 MAU in total
Mass	«1000 kg
Orbit	LEO equatorial or polar
Launcher	Pegasus/Taurus/LLV class
Payload instruments	Use of existing technology
Spacecraft subsystems	— Standard with minimum development during project — Limited redundancy — Modular design and construction — Commonality of modules from project to project
Software	Common for development and operations as far as possible; the EGSE software could be the basis for the operations software, or vice versa
Procurement	Single contractor with a minimum of industrial structure, or ESA in-house
Management	— Project manager has control of all funding (including PI funds) — Integrated team, including PI's, co-located or ESA delegation of project to National Authorities or other parties — Reduced formal paperwork (specifications, PA/QA) — Reduced model philosophy — Use of commercial or MIL parts — No industrial return constraints — Foreign purchase allowed when cost-effective
Schedule	3 years from instrument selection

Table 3 — Principal Characteristics of the Sounding Rocket Programme

Organisational	— Team at ESTEC with capability to integrate and test full payload system — Rocket motors purchased from Industry — Launch campaigns organised by ESOC
Science Instrument selection	— AO's issued about twice per year — Initial payload screening made by ESTEC in-house team — Several programme options proposed to Launch Programme Advisory Committee — SPC approval
Industrial aspects	— ESTEC-held stocks of standard units — Difficult payloads integrated in-house; otherwise industry could bid on non-competitive basis (pre-shared on basis of tender) — All industry proposals evaluated by team, no independent evaluation — Development phase agreement to launch 6—9 months
Key cost savers	— Very limited paperwork — No formal configuration control — No PA for in-house build, minimal for industry build — No geographical distribution constraints

The sounding-rocket experience

The sounding-rocket model is a good starting point for any discussion of small satellites in the context of the ESA Scientific Programme as, over the period 1968 – 1972, some 183 launches were conducted with a 75% success rate. The procurement approach taken is summarised in Table 3.

Many of these early concepts could be applied today to a small-satellite programme, given the will to take the risks and to accept this level of success rate. It is worth noting that, although it was accepted initially that the sounding-rocket programme was a 'high-risk' venture, failure was treated sufficiently seriously that additional costs were eventually incurred in an attempt to preclude future failures!

Experiment selection

The selection of the PIs would be simplified. It could be the case, for example, that proposals that did not meet the technical constraints would not be accepted for scientific evaluation. The project team would be responsible for the initial screening (the sounding-rocket approach). Another constraint could be that only instruments that used established payload technology would be considered, to avoid development risks and consequent programme delays.

Review of procurement approach

The current approach to procurement will certainly need to be modified if small satellites are to be procured by ESA. To this end, some suggestions are to:

- reduce the requirement for an equitable industrial return
- leave science operations to PIs
- ensure a minimum of operations interaction with the spacecraft
- reduce the procurement time-cycle
- guarantee a long production run (at least five missions?)
- pre-procure a number of units/subsystems for a series of missions
- accept risk by means of a reduced model and testing philosophy, reduced redundancy, and the use of MIL-standard components.

The practicality of these suggestions needs careful assessment by all interested parties.

Launcher options

This aspect is the most uncertain as the only assured source of suitable small launchers so far is the United States, although there have been discussions on the possible use of Russian vehicles launched from European launch sites. In addition, a possible European small launcher is under study, but it is in a very early stage of definition. Ariane is not really a suitable vehicle in this context, as launch opportunities would be dictated by the availability of space with the 'big users' (shared launches); it could, however, be considered for 'one-off' types of small mission, using the triple-launch configuration.

For the moment, therefore, the conclusion is that launchers such as LLV, Taurus and Pegasus would be the most viable.

The legal framework

Successful implementation of a technically- and cost-effective small scientific satellite programme would require, a priori, a critical examination of the procedures under which the hardware and services, including launches and ground services, are procured. Above all, a rapid decision-making process must be ensured so the development work is not hindered or complicated. Other elements that need to be considered are: the access to small launchers; ESA's role vis-a-vis that of the Member States and Industry; and the timing and conditions of approvals.

A detailed examination of the various applicable texts – in particular the ESA Convention, the terms of reference of the Agency's Science programme Committee (SPC) and Industrial Policy Committee (IPC), and the General Clauses and Conditions of Contract – will have to be made. If necessary, changes or waivers will have to be agreed.

Small-satellite operations

The operations process from inception to execution needs to be kept simple. Options range from full, but simplified, involvement of ESA's European Space Operations Centre (ESOC), to complete delegation of the task to the PIs. The decision as to where the boundary point lies will be determined by the level of responsibility that ESA has for a particular mission.

Conclusion

While the ESA Science Programme Directorate has, as yet, no fixed policy on the practicality and potential for the introduction of a small-satellite programme, there is a recognised need to reduce the overall costs of missions, which would allow more flight opportunities and a small-spacecraft programme. Studies are therefore continuing, together with an exhaustive dialogue in the coming months with all potential participants – in the agencies, industry and institutes – to arrive at a definitive conclusion. If a small-satellite programme does emerge, all well and good, but even if it does not the European scientific community and ESA's delegate bodies will at least have a better idea of what can and what cannot be done within the boundaries of the ESA Science Programme. Any necessary changes will have been quantified and the basic data will be available for continued reference.

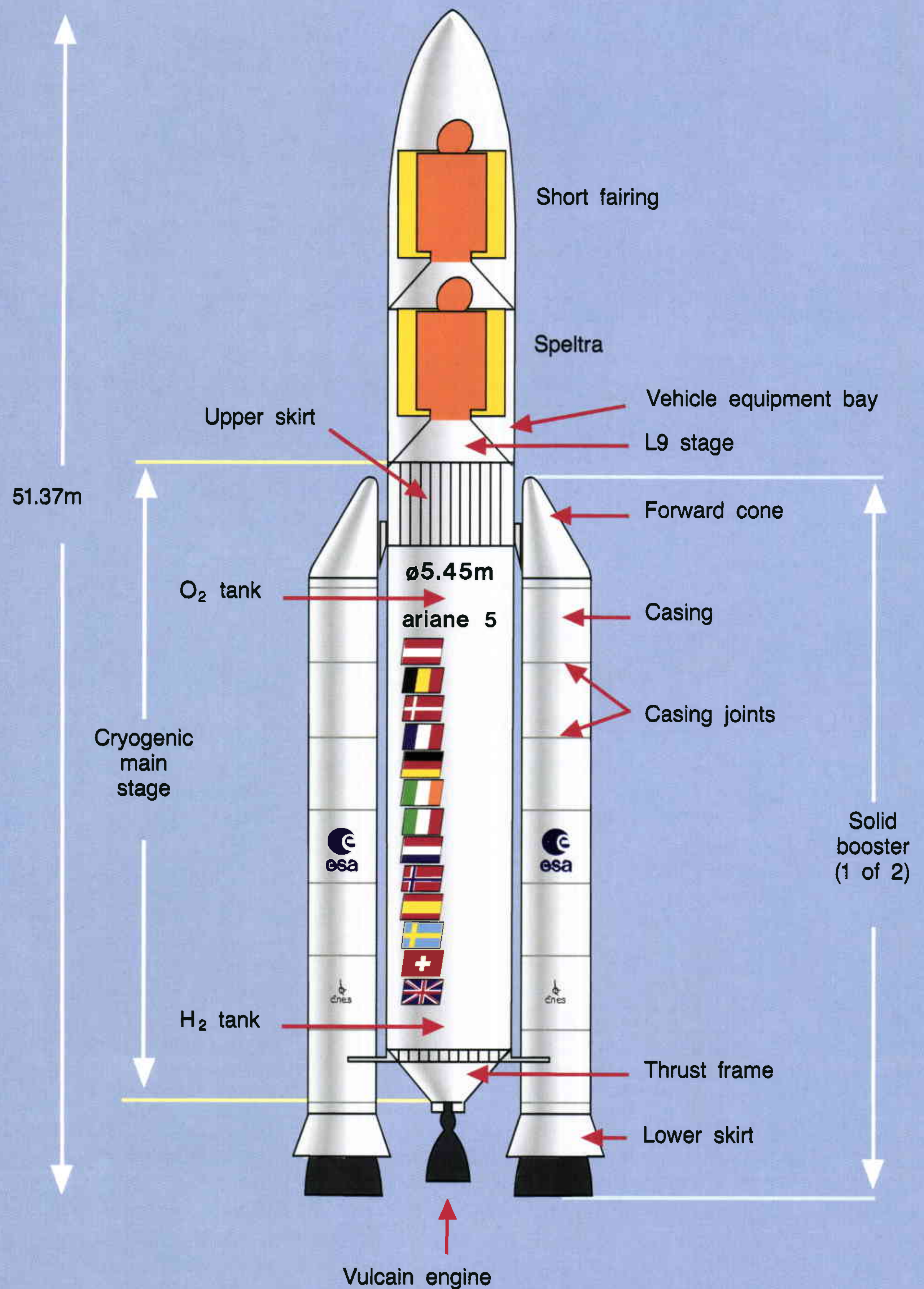


Figure 1. The components of the Ariane-5 launcher

Status of Ariane-5 Main Development Tests

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The Ariane-5 launcher is now in the qualification phase of its development programme. That phase mainly involves the testing of the various components of the launcher. Testing is well underway. Upon the successful completion of all tests, the launcher will be ground qualified and ready for two demonstration flights in 1995 and 1996 that will mark the end of the Ariane-5 development and the start of the operational life of the launcher.

Note: For background information on Ariane-5 and the testing campaign, see ESA Bulletins 68 (November 1991) and 69 (February 1992).

Introduction

The development programme for the Ariane-5 launcher began in 1988 and since then, the configuration of the launcher has changed greatly in response to the evolution of system requirements. The main configuration parameters are currently frozen. The critical design review has already taken place and the qualification phase is now underway.

The launcher qualification can be divided into two parts. The first part consists of the test and analysis activities that will permit ground qualification. The second part includes the first two launches, which will mark the end of the development of the launcher and the start of the operational phase.

The ground qualification, in turn, is made up of qualification programmes at the different launcher-element levels. The status of the individual programmes varies, some are nearing completion while others are less advanced. All however are progressing in keeping with the general planning which foresees a first demonstration launch at the end of 1995.

The status of the main testing activities for the various launcher elements is summarised here. The main elements of the launcher are shown in Figure 1.

Figure 2. Preparing for the testing of the booster joints

Booster testing

Two large and very powerful solid boosters will provide the main propulsion during the first two minutes of Ariane-5's flight. The structural qualification of the booster involves the testing of its casing, joints, lower skirt and forward cone. Firing stage tests are also part of the qualification.

Being made of steel and carrying 236.5 tonnes of solid propellant, the booster's casing is mainly dimensioned by the pressure achieved during the combustion of the propellant. Therefore the most relevant tests of the casing are two hydraulic pressure tests performed until the casing ruptures. In both tests, the safety margin obtained has been shown to be about 1.4 times the maximum operating pressure.

The design of the booster's joints has been of particular concern since the beginning of development because of the catastrophic problems that the Space Shuttle 'Challenger' encountered. A testing programme using flat-plate connections was undertaken to optimise the design by changing the initial gaps, missing pin, etc. Pressure tests were then performed with two full-scale cylinders and closed domes using different load cycles under nominal and downgraded conditions (Fig. 2).

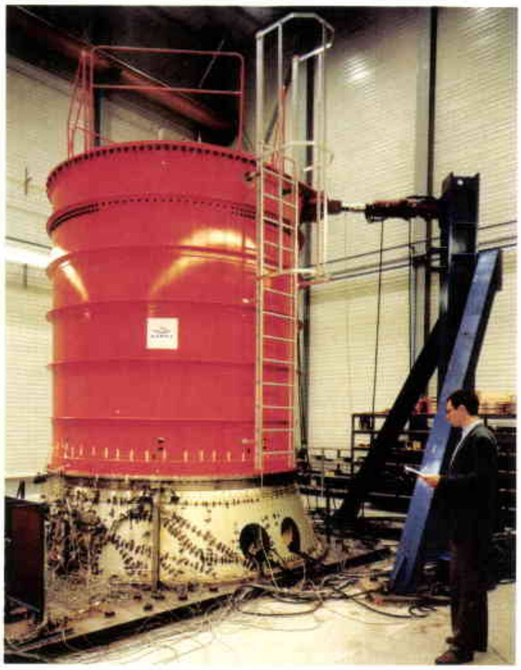

Figure 3. Test set-up for the static test of the booster's lower skirt (on bottom)

Finally, the casing rupture tests mentioned above have demonstrated the safe behaviour of the joints.

Lower skirt and forward cone

The booster's lower skirt supports the launcher while the launcher is waiting to be fired. The stiffness and strength tests of the lower skirt have been completed, and the safety margins obtained were found to be suitable (Fig. 3).

Work on the forward cone is not as advanced. This structure transmits thrust to the launcher main body and provides for aerodynamic booster shaping. Combustion pressure oscillation detected during the booster firing tests required the late introduction of a softening device to attenuate the transmission of the low-frequency thrust oscillation to the main launcher body. The definition of this device is now being finalised, and the configuration of the forward cone can then be frozen.

Figure 4. M3 booster firing test in Kourou in June 1994, with flight-type hardware and the booster supported in its flight position

Booster firings

Firing tests began using a reduced-scale configuration of the booster, composed of a forward segment, a central segment and an aft segment. The purpose was to begin testing the booster's internal ballistics. The results showed the presence of combustion pressure oscillation and, as previously mentioned, a softening device has had to be introduced in the booster to cryogenic stage interface.

The full-scale tests are performed with the booster in a vertical position in a test-stand, with the nozzle firing downward. The tests can be divided into two parts:

— Development tests intended to characterise the operation of the engine and to adjust the specifications: the first test, the so-called B1 test, performed with a heavy-walled casing before the development of the casing is completed, and the M1, M3, M4 and M5 tests performed with a flight-type casing (M2 experienced manufacturing problems and thus it was dedicated to system and material testing).
— Qualification (Q) tests for the proper qualification of the booster. Two entire flight solid-propellant stages will be used.

The aim of the B1 test was to verify the behaviour of the nozzle and the segmented propellant configuration. The test was successful: the proper behaviour of the internal ballistics, the thermal protection and the nozzle actuation was demonstrated. It also confirmed the level of thrust oscillation of about 4%.

After demonstrating the satisfactory behaviour of the casing and joints, and after the success of B1, the next firing test, the M1 firing, was authorised. That test was performed using flight-type hardware but as in B1, the forward cone was replaced by a structure allowing the thrust reaction along the booster axis. The firing was well performed and showed a thrust oscillation of about 3%, lower than in B1.

During the subsequent M3 test (Fig. 4) and the M4 test, the booster was supported laterally, as it will be in flight. Another M test will still be performed before the two Q firings that mark the end of the qualification phase.

Cryogenic stage testing

The cryogenic main stage stands 30 metres high and carries 156.2 tonnes of liquid oxygen and hydrogen. It is ignited at lift-off and provides the only thrust after booster separation. Its main elements are the oxygen and hydrogen tanks, the upper skirt, the thrust frame and the Vulcain engine.

The development of the Vulcain engine is in itself a complete programme and thus it is not described here. The tests, however, are ongoing and hours of firings on several engines in two test benches are accumulating (Fig. 5).

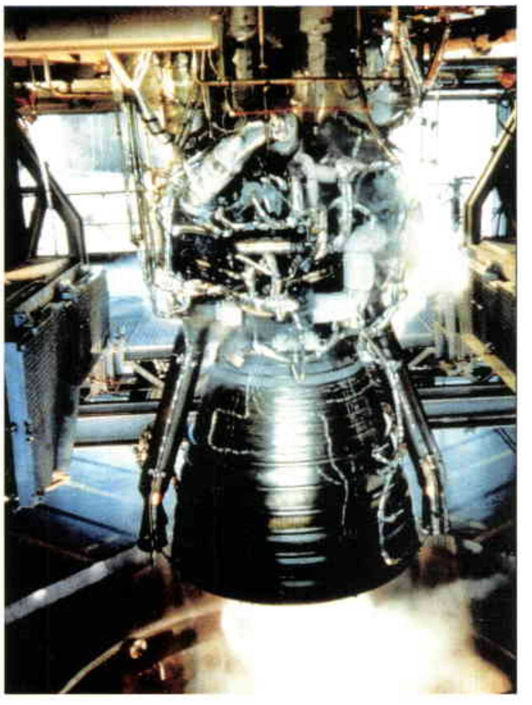

Figure 5. The Vulcain engine during a firing test

Main tanks

The two main tanks, the oxygen and hydrogen tanks, are made of 2219 welded aluminium sheets with a common bulkhead and spherical domes. As with the testing of the booster casing, the most relevant test of the tanks relates to their pressure performance. The test, which has already been successfully performed, has validated the tanks' dimensioning, and has provided the information required for a future mass-saving analysis.

Upper skirt and thrust frame

The upper skirt provides the link between the cryogenic stage and the upper composite. The qualification tests of the skirt have been completed (Fig. 6). The rigidity and safety margins were found to be well in accordance with predictions. As the structural margins obtained were higher than necessary, a mass-saving analysis has been performed.

The thrust frame supports the Vulcain engine. Its configuration has evolved several times because of its complexity and the great number of interfacing elements, but its design is now frozen (Fig. 7). A vibration test was performed to confirm the acceleration levels at the different equipment locations. Rigidity and strength tests are being prepared and an acoustic test is also planned.

Stage test

The stage tests will start with the 'Battleship' (BS) version at the Ariane-5 launch facilities in Kourou, French Guiana. This version consists of two industrial cryogenic tanks, a lower part of a flight representative stage and the main functional electrical equipment. The main purpose of this campaign is to test the stage

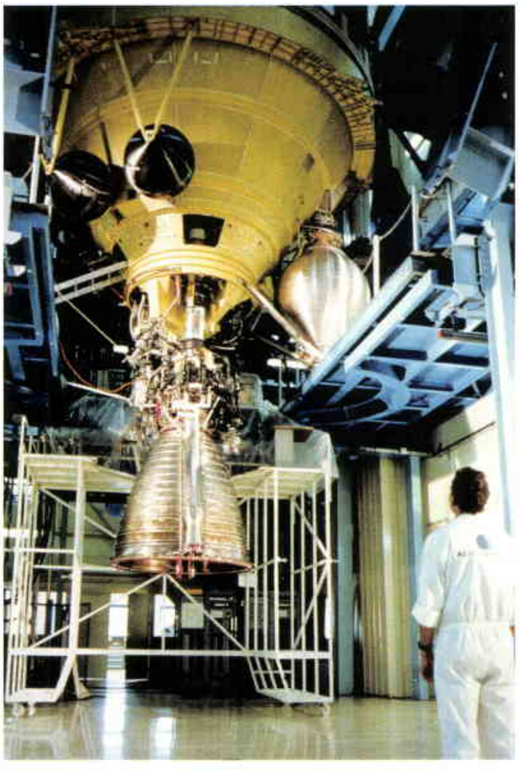

Figure 6. The cryogenic stage's upper skirt during a static test

Figure 7. The cryogenic stage's thrust frame (yellow) with the Vulcain engine installed (silver cone)

Figure 8. The vehicle equipment bay and L9 stage awaiting the combined vibration test

functions that will be used for the M and Q tests, to validate the electrical interfaces as well as the ground equipment and operating procedures. The complete stage qualification includes BS, M and Q tests.

Upper composite testing

The upper composite includes the fairing, the Speltra, the vehicle equipment bay and the L9 stage. Although each element of the launcher must be qualified individually, some tests are performed using a combination of several structures.

Combined tests

Since the upper composite is not a unit, testing of each structure can be difficult without proper representation of the adjacent structures. Therefore, some tests are performed with a combination of two or more structures. This is the case for the vibration and shock tests of the vehicle equipment bay with the L9 stage (Fig. 8) and the shock test of the Speltra with the fairing pyrotechnic system.

However, the most important test in terms of structures contribution will be the shock and acoustic test using the vehicle equipment bay, the L9 stage, the Speltra and the upper skirt of the cryogenic stage.

Fairing

The fairing structure is made in two halves: it will open to allow the payload to be released into orbit. It also protects the payload and provides for the launcher aerodynamic shaping. Two qualification models of the whole structure have been manufactured. One of them has been used for two in-vacuo separation tests (Fig. 9), and is now being used for the acoustic tests with a third separation test envisaged afterward. The second model has been used for the static tests which have been successfully completed.

Speltra

The Speltra is used for multiple satellite launches. It is located above the vehicle equipment bay. It holds one of the payloads while it supports the fairing and another payload. The stiffness and strength tests have already been completed (Fig. 10). A shock test with a horizontal separation system of the fairing has also been performed, and finally the separation tests will finalise the qualification phase.

Vehicle equipment bay

The vehicle equipment bay is a structure containing the launcher's main electrical boxes. A major testing activity concerning this structure has been the shock programme performed to

Figure 9. The two halves of the fairing during a separation test

Figure 10. Preparing for the Speltra static tests

properly define the dampers of the equipment platform (see 'Shock Induced at Separation' below).

Preparations for the static tests were already being made when the system tests confirmed the presence of radial deformations induced by eccentric transmission of the booster thrust. That implied that a change in the design of the lower part of the structure was required. In addition, the strength tests will be performed with an upper skirt model instead of a simple adjacent structure, to properly introduce the booster loads.

L9 stage

The structure of the L9 stage has undergone major modifications throughout the development process. Presently, the configuration is frozen and the static tests are under preparation.

A development model of this structure was used during the shock tests of the full-scale vehicle equipment bay. A model of the complete stage is shown in Figure 11.

Successful firing tests with the Aestus engine have been performed. Stage firing tests followed, with the last one being undertaken on 5 October 1994 and lasting for 1075 seconds.

System mechanical testing

The system mechanical activities include static and modal tests and acoustic and shock programme testing. Their results allow the verification of the system mechanical inputs and the validation of the dynamic mathematical models that will be used in the remaining system studies.

Static and modal testing

The tests have been divided into three campaigns corresponding to the different main launcher assemblies: the cryogenic stage, the upper composite and the booster.

Three kinds of tests have been performed with the cryogenic stage: stiffness tests, overflux tests (non-homogeneity of stress distribution), and modal testing. In general, the stiffness and overflux obtained in testing are in agreement with predictions.

The upper composite tests have been performed with the vehicle equipment bay, the upper stage, the Speltra, spacecraft mock-ups and an adjacent structure at the lower interface. The same three types of tests as for the cryogenic stage have been performed: stiffness, overflux and modal tests. The stiffness found in testing is globally higher than foreseen, as are the radial deformations. The frequency is as expected.

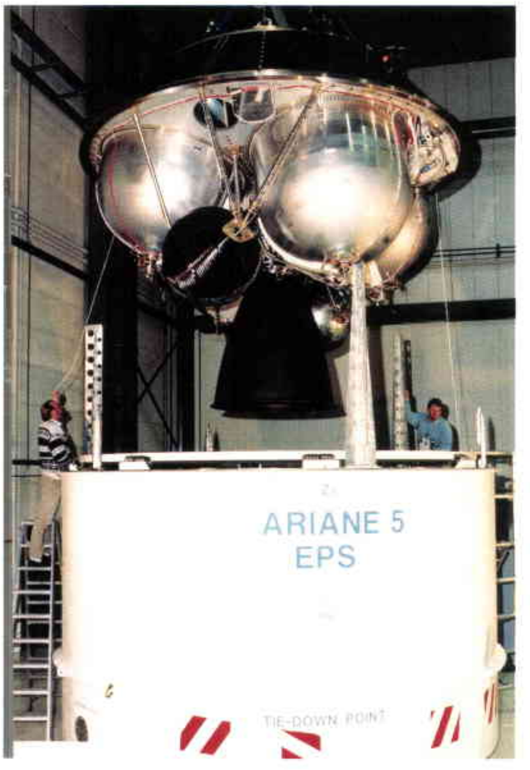

Figure 11. The L9 stage being installed in its container

The test campaign relating to the booster has been performed using the third full-scale test model (M2) with a reinforced upper structure and a representative thrust frame. Lateral modal tests have been performed in a clamped configuration. The results correlate well with the predicted characteristics of the first modes.

Acoustics

Maintaining the acoustic environment inside the spacecraft compartments, fairing and Speltra at the time of launch is a problem that had to be addressed from the beginning of launcher development. Experience with previous launcher programmes showed that this question required an early effort to characterise the external sound field and the acoustic behaviour of the upper structures.

The external field has been defined using test data obtained with reduced-scale models. Water injection at different locations on the launcher pad was tested at the same time as a method of attenuating the high levels of sound expected.

Fairing acoustic tests are being performed. The test article is one of the two full-scale structures used in the fairing qualification, equipped with foam panels including special acoustic absorbers (resonance cavities). The use of helium for noise attenuation is also being evaluated.

Another test campaign with the upper structures is planned. The test configuration includes the vehicle equipment bay, the upper stage and the Speltra from the upper part of the launcher, and

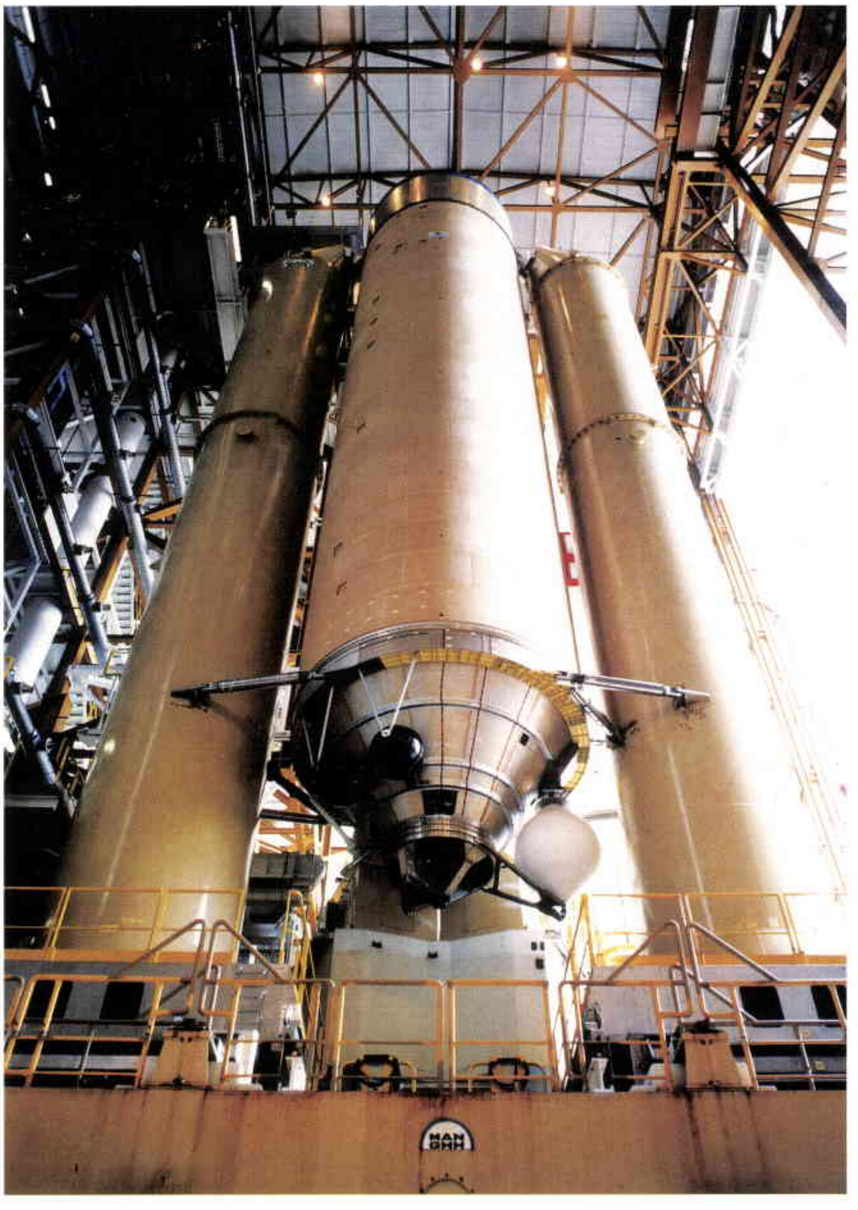

Figure 12. MDO1 campaign: the cryogenic stage and booster mock-ups in the integration building

the upper skirt of the cryogenic stage. The aim of this campaign is to evaluate the vibro-acoustic performance of the structures and the supported equipment.

Shock induced at separation

The shock produced at the time of the pyrotechnic separations has also been taken into account very early in the development, especially for the vehicle equipment bay. Shock induced at separation appears at the upper and lower interfaces between the boosters and the main launcher body, at the vehicle equipment bay where the upper composite separates, in the lower part of the Speltra and at the fairing horizontal and vertical separation planes.

Testing of flat articles was initiated as part of the shock evaluation programme for the vehicle equipment bay. It was very soon realised that the accelerations induced at the equipment level were very high and that a damper was required. Such a system was implemented at the interface between the platform support and the cone and was validated through testing.

The fairing-separation shock was measured in an early test using a cylinder with a height of 2 metres and a diameter of 5.4 metres. The levels transmitted from the fairing's horizontal separation system through the Speltra cone to the payload adaptor have been measured on the qualification structure of the Speltra with the fairing system.

Shock testing is also to be performed with the upper structures and cryogenic skirt, the configuration already mentioned in relation to the acoustic tests. Shock will be induced at the booster to cryogenic skirt level, vehicle equipment bay separation system and Speltra horizontal pyrotechnic chord device.

Operational deployment

In order to validate the mechanical integration of the launcher (at the Guiana Space Centre), the following test campaigns are scheduled:

- MDO1 for the boosters and cryogenic stage
- MDO2 for integration of the vehicle equipment bay and the L9 stage on the lower composite
- MDPH to validate the integration of the fairing, SPELTRA and payloads.

The first MDO1 test campaign took place in September 1993 (Fig. 12).

Conclusion

With the configuration of the Ariane-5 launcher now frozen, the testing activities required in the ground qualification phase are proceeding without any major problems. The flight elements for the first two models are now being manufactured to be ready for the flight part of the launcher qualification in 1995.

Micrometeoroids and Space Debris – The Eureca Post-Flight Analysis

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The retrieval of Eureca has given the Agency a rare opportunity to study the fluxes and resulting effects of meteoroid and space-debris impacts on exposed spacecraft surfaces in Low Earth Orbit (LEO). With its fixed Sun-pointing attitude, large areas of identical surface materials, and 1992 – 1993 exposure period, Eureca has provided impact data that are complementary to those from LDEF. The detailed optical survey of all outer Eureca surfaces, which was the first main task of the impact analysis, has now been completed.

Introduction

Every spacecraft in Earth orbit is exposed to a flux of space debris and meteoroid particles. Currently more than 7000 large man-made objects orbiting in near-Earth space can be tracked from the ground with radar or by optical means. A much larger number of smaller man-made debris items and micrometeoroids that are orbiting the Earth cannot be detected from the ground. These particles are a hazard for both long-term missions and large spacecraft.

While the risk of collision with a large piece of debris or a large meteoroid is very small, particles less than one millimetre in size cause craters visible to the naked eye. Typical impact velocities are 10 km/s for space debris and 20 km/s for meteoroids. Larger particles can penetrate the outer shielding of a spacecraft and can damage its internal equipment. As a result of this threat, designers have to consider the risk of particle impacts in the planning of every space mission. In addition, particle fluxes in space are also of considerable scientific interest.

Knowledge of the solid-particle population of millimetre- and micron-sized particles is gained either from dedicated space experiments or through the analysis of material that has been returned from space. After just a short period of exposure to the space environment, surfaces are covered with impacts from small pieces of debris and meteoroids. Investigating the nature and the morphology of the impact features on ESA's European Retrievable Carrier 'Eureca' is therefore an exercise crucial to the understanding of the meteoroid and the evolving debris environments. This activity extends the analyses that NASA performed in the late eighties on the Solar Max, Palapa and Westar satellites and the Long-Duration Exposure Facility (LDEF), after they too had been recovered from space.

Compared to LDEF, Eureca has a large Sun-pointing surface, resulting in different types of meteoroid and debris impact signatures. Impact data from the Eureca post-flight analysis will therefore contribute to the validation and improvement of the current meteoroid and debris models for low Earth orbit.

Eureca's configuration

Figure 1 shows Eureca in the cargo bay of Space Shuttle 'Atlantis' prior to launch. The external surface of the Carrier, which provides accommodation and resources for 1000 kg of payload, is almost entirely covered by thermal Multi-Layer Insulation (MLI) blankets. The only exceptions are the radiators and some boxes mounted on the bottom of the spacecraft, which are painted, and the solar-array wings. The total area of the exposed external surface is about 140 m^2, including 99 m^2 of solar arrays (front and back surfaces), which span 20 m tip-to-tip when deployed.

The Shuttle Atlantis lifted off on 31 July 1992 and subsequently released Eureca into a nearly circular orbit, with a 508 km initial altitude and 28.5 deg inclination. The Carrier was retrieved again in June 1993, after 326 days of space exposure. Throughout the mission, it had been in

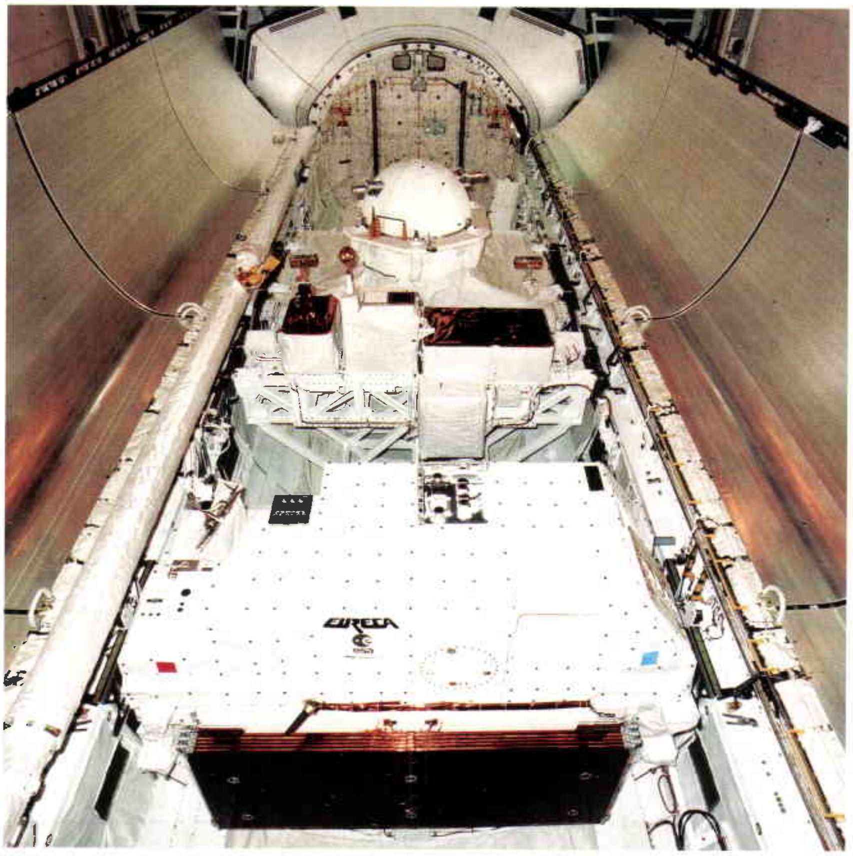


Figure 1. The European Retrievable Carrier 'Eureca' in the payload bay of the Space Shuttle prior to launch (STS-46)

pointing towards the Sun and its 'y-axis' in the orbital plane (Fig. 2).

The impact analysis programme

In early 1993, the Agency initiated a Post-Flight Investigation Programme to make a detailed analysis of the effects of long-duration exposure to space on the Eureca hardware. It included a micrometeoroid and debris analysis of all of the Carrier's exposed surfaces, with the goal of:

- recording the impact features
- analysing the impacts and assessing the damage caused by space debris and meteoroids
- validating and improving current models of meteoroid and debris populations in Low Earth Orbit (LEO).

The main steps in this micrometeoroid and debris analysis were:

- a first optical survey of the spacecraft immediately after retrieval
- a detailed optical survey of the solar arrays and radiators
- a chemical and morphological analysis of selected samples
- evaluation of results and construction of a database
- validation and updating of meteoroid and debris flux models.

Having retrieved Eureca, on 1 July 1993 the Space Shuttle 'Endeavour' landed at Kennedy Space Center (KSC), where a full inspection of the Carrier's upper surface was made in the Orbiter Processing Facility. Eight days later, Eureca was placed in its transport container, which provided an opportunity to make the first full visual and photographic survey of the complete spacecraft.

The general impression was that there had been a significant change in the colours of the exposed surfaces, where outgassing products had been deposited on the thermal blankets. Areas of paint delamination and many micro-meteoroid impacts were clearly visible.

On 14 July, Eureca was transported to the Astrotech Facility in Titusville (Florida) in order to depressurise the Carrier's propulsion and attitude-control systems, to remove the remaining propellant, and to remove the payloads. During that payload de-integration, the 35 m^2 of thermal blankets that had covered the majority of Eureca's external surfaces were removed and put at the disposal of the micrometeoroid and debris investigation team for scanning. The other main exposed surfaces were the solar-array panels, the two scuff plates used for protection and housing Eureca in the Shuttle's payload bay, the two ESA logo plates, and the grapple fixture.

Over a six-week period during the summer of 1993, an investigation team formed by Prof. T. McDonnell of Unispace, led by T. Stevenson and made up by B. Carey (SAS), S. Deshpande (Unispace), W. Tanner (Unispace) and C. Maag (T&M Engineering), inspected and scanned the thermal blankets, the two scuff plates, the two ESA logo plates, and the grapple fixture. The

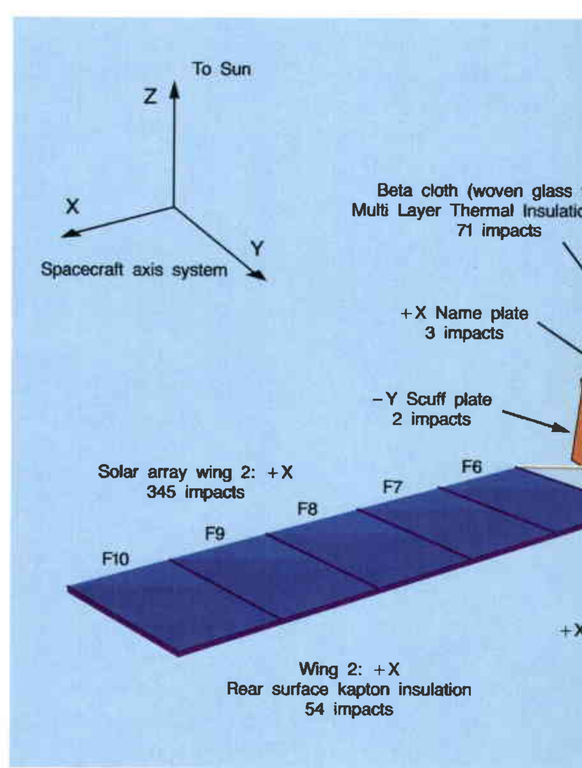


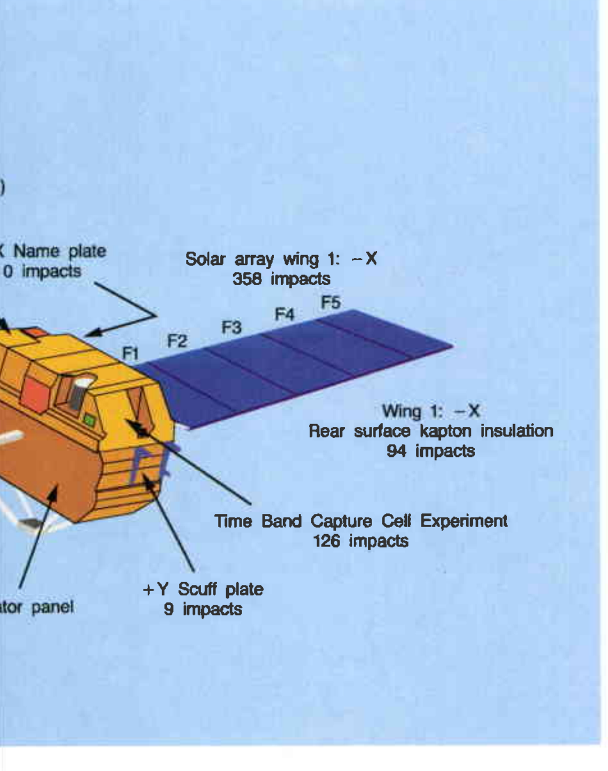
Figure 2. The Eureca spacecraft's configuration, and the numbers of impact events recorded on its various components

Eureca solar arrays were not deployed at Astrotech: they were scanned at Fokker, in The Netherlands, between December 1993 and March 1994, by the same team that had worked on the thermal blankets, who were joined by J.C. Mandeville (ONERA).

The scanning procedure
The best methodology for crater location and identification proved to be visual inspection under good illumination by an experienced observer. Often this procedure was used to identify sites for magnified inspection at high resolution in a later stage.

Scanning at Astrotech
The thermal blankets were visually examined and those containing impacts were set aside for scanning with the aid of a Photometric CCD camera system linked to an Apple Macintosh II running a commercial software package, to record the digital images. Standard lenses could be attached to the CCD camera and thus a low-resolution scan (10 cm x 10 cm field of view) made of the entire sample to identify features to be revisited for recording at higher resolution (1.5 cm x 1.5 cm FOV).

The thermal blankets have an outer layer made of Beta-cloth, which is a very fibrous synthetic material. Scanning this cloth proved to be difficult because only features larger than 100 microns penetrating the outer layer could be recognised as hypervelocity impact sites. During the scanning, the investigation team took 3445 low-resolution and 100 high-resolution images of sites of special interest.



Scanning at Fokker
The solar arrays were the largest exposed surfaces on Eureca, having a total area of about 99 m^2. The glass-covered cells mounted on the front side of the solar arrays are very sensitive 'impact detectors' in that impinging particles shatter the glass and cause a damaged area much larger than the central crater size. Impact features caused by particles as small as 10 microns are visible to the naked eye on the solar-array cover glasses. On the rear side of the array, only impacts from much larger particles are visible because the panels are covered by Kapton foil and other more ductile material.

The solar-array survey was documented with a Nikon 35 mm camera for the global scanning (24 cm x 16 cm or 24 cm x 17.5 cm field of view), and with an HIROX microscopy system with 20 – 100x magnification zoom optics for the detailed appraisal. The images were again acquired and stored on a PC equipped with picture-archiving software. The left-hand strip of each solar panel was scanned recording all features that could be detected with the naked eye under optimal illumination, which corresponded to a pit diameter of about 50 microns. Due to the high number of very similar impact features on the solar-cell glasses, the remaining swaths were scanned recording high-resolution pictures of impact features with a minimum size of about 650 microns, which is half of the solar-cell electrode spacing.

Approximately 3000 low-resolution images from both the front and rear faces of the solar arrays have been transferred to Photo-CDs. All of the high-resolution images of selected impact sites have been transferred to CD-ROM.

Results
An overview of the results is presented in Table 1 in terms of total crater counts. The distribution of the numerous impact events recorded is shown in Figure 2.

Table 1. Total crater counts

Solar Array					
Front		Rear (Kapton)		Rear (wiring)	
Circular	Elliptical	Circular	Elliptical	Wires	Interconnect
478	225	120	15	1	8
Other Surfaces					
TICCE (Exp.)					
Mesh	Foil	Beta-Cloth (MLI)	ESA Logo (aluminium)	Scuff Plate (aluminium)	Radiators (aluminium)
24	94	71	3	11	=5

Figure 3. Typical thermal-blanket puncture hole

Main-body survey

The main results of the Eureca main-body survey are as follows:

- 71 confirmed impact sites on the thermal blankets
- 3 impacts on one of the two ESA logo plates, including a 2 mm-diameter hole as the largest impact site
- 11 confirmed impact sites on the two scuff plates.

Figure 3 shows a typical impact hole in the thermal blanket. The weave structure of the outer Beta-cloth layer, which is 200 microns thick, is clearly visible. There are up to 20 layers of aluminised Kapton behind the Beta-cloth. Figure 4 shows the 2 mm impact hole through one of the ESA logo plates, which are made of painted aluminium.

Solar-array survey

More than 1000 impacts are visible to the naked eye on the front side of each wing. The impact features range in size from about 100 microns, to the largest crater which is 6.4 mm across (Figs. 5 – 7).

A typical impact feature can be described via the following parameters:

- Pit diameter: dark area usually with a raised rim. The pit dimensions reflect the projectile's size. Typically, a projectile is 2 or 3 times smaller than the pit diameter.
- Shatter diameter: area of finely shattered glass immediately surrounding the pit.
- Conchoidal spallation diameter: zone surrounding and including the shatter zone, with radial and circular cracking. The conchoidal damage zone usually determines the visible impact feature size.

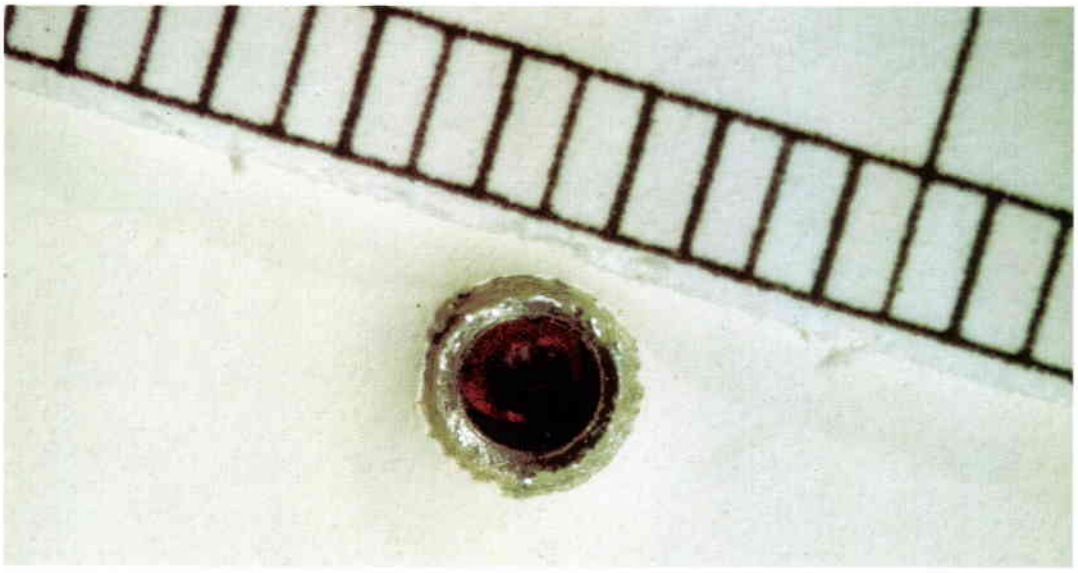


Figure 4. A 2 mm impact hole in one of the aluminium ESA logo plates

– Maximum diameter: diameter of maximum detected damage at an impact site.

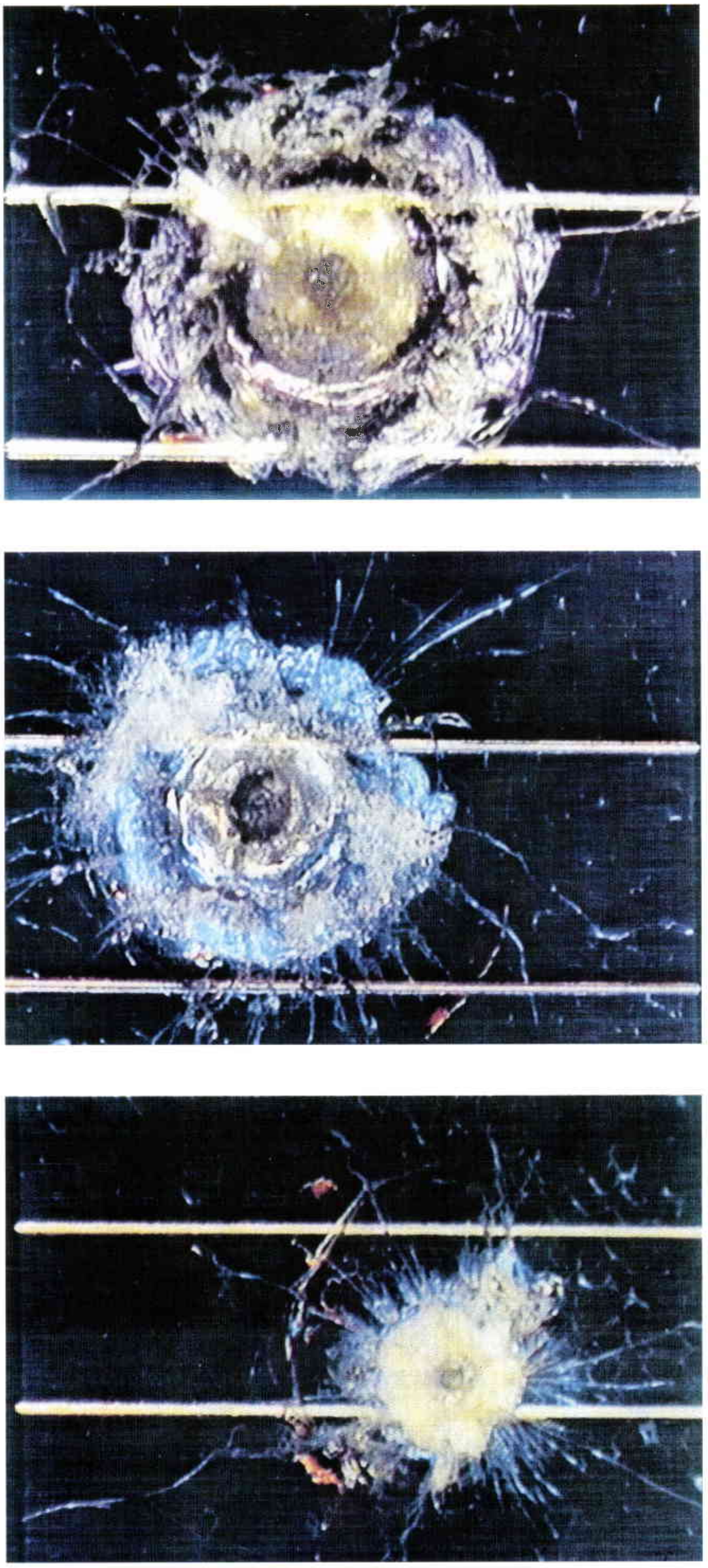
Figure 8 shows the spatial distribution of impacts on the front side of the 10 solar-array panels, for two surveys with different limiting crater sizes. Panels F1 and F6 were the closest to the Carrier's main body, while F5 and F10 were the furthest away. Fluxes of the higher resolution scan (upper curve), which include smaller impacts, appear to increase towards the spacecraft, whilst the larger impact features are fairly evenly distributed.

Comparisons indicate that, in terms of feature sizes larger than about 0.5 mm, Eureca encountered a higher impact flux than the LDEF. Some caution is required in interpreting these data, however, because of the low total number of impacts. To make a true comparison with the LDEF data, calibration tests are needed to translate the Eureca thermal-blanket and solar-cell data to aluminium targets. These tests are currently in process.

Overall damage assessment

Impact damage to Eureca hardware caused no system or subsystem failures. This is partly because the multi-layer (MLI) structure retains particles up to a certain size very efficiently. The critical size for complete penetration of the 20 layers of insulation was only exceeded in two places, luckily causing no further damage at either site. Any loss in thermal-control function due to the particle impacts was negligible.

As far as the solar arrays are concerned, due to the massive redundancy and cross-strapping, even the most extensive form of damage – for example if a cell was completely cracked perpendicular to the current flow – would have caused only a small power loss. There is no evidence to suggest that extreme damage of this sort occurred anywhere on the Eureca arrays. Rather, it was confined to localised shattering of cells and cell cover glasses, thereby removing a tiny fraction of the sunlight-collecting area (curiously, it is possible to increase the output of solar cells slightly by introducing centres of scattering which bring in Earth albedo radiation not normally seen by Sun-pointing arrays). A significant number of impacts penetrated cells, and in some cases the structure. Despite the large number of impact sites recorded, their overall effect at system level was trivial. There is, however, evidence from elsewhere to suggest that impacts may cause electromagnetic and shock effects such as those seen on ESA's Giotto spacecraft during its Comet Halley encounter and on the Olympus geostationary telecommunications satellite. No link has yet been established between the failures seen on Eureca and the disruptive effect of any impact. Nevertheless,



Figures 5 — 7. Typical solar-cell impact features

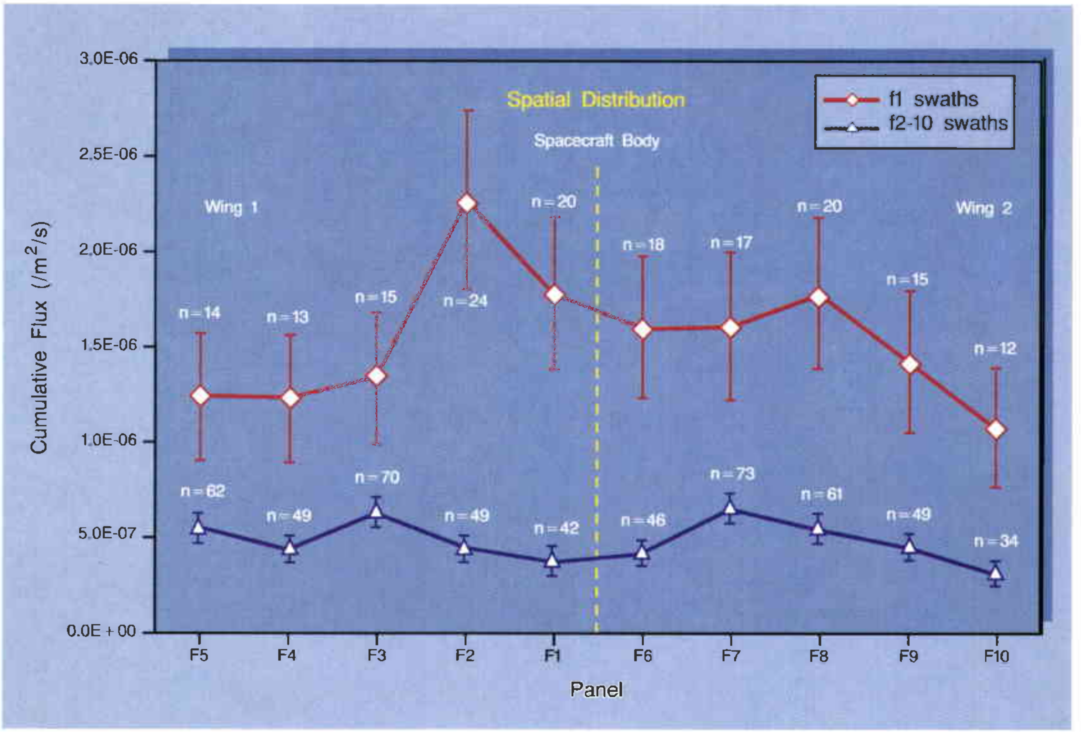


Figure 8. Spatial distribution of the impacts on the front side of the ten solar-array panels

work in this field continues, and definitive results may depend upon further measurements of in-orbit phenomena.

Conclusion

The main findings of the detailed visual survey of Eureca's external surfaces can be summarised as follows:

- There was no functional failure on Eureca that could be related to an impact.
- On the front sides of the solar arrays, more than 1000 impact features can be seen with the naked eye.
- 71 impact punctures in the outer layer of the thermal blankets were detected on the main spacecraft body (non-penetrating impacts could not be detected on these surfaces). Three impacts were found on the ESA logo plate and 11 more on the scuff plates.
- The impact features identified range in size from 100 microns to several millimetres. The largest crater diameter on the solar arrays is 6.4 mm. The largest feature on the main body is a 2 mm hole in the ESA/ERNO logo plate.
- A surprisingly high proportion of the impacts on the solar-cell cover glasses – about 30% – show signs of directionality by having a non-spherical crater shape.

All images and data have been stored on Compact Disc (CD) or magnetic tape, and will be made available to both the engineering and scientific communities.

Questions like the number of Eureca impact features that can be related to natural micrometeoroids and the number caused by man-made debris are still being investigated. It is planned to use the ESABASE/DEBRIS analysis tool developed at ESTEC to compare the observed impact data with the predictions of the current reference flux models. It will also allow the micrometeoroid and space-debris fluxes to be computed in the future for user-specified spacecraft geometries and mission parameters.

Presently, additional analyses are being carried out on the thermal-blanket impact holes to identify the chemical composition of the impact residues with a view to distinguishing between meteoroid and space-debris damage. Impact calibration tests are also being performed, on both thermal-blanket and solar-array samples, to relate the observed impact features to the parameters of the impacting particles. These tests will allow the Eureca survey results to be compared with existing flux models.

A similar post-flight analysis has just been started by ESA for the Hubble Space Telescope solar array that was retrieved during the first HST servicing mission in December 1993.

Once the Eureca and HST studies are complete, the present meteoroid and debris flux models will be re-examined and, if shown to be necessary, updated and/or refined.

The DICE Multi-site Satellite Videoconference System

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In the early 1980s, the European Space Agency and a number of its partners in industry and academia, recognised the value of satellite communications in the growing field of video-teleconferencing. It was decided to develop and demonstrate equipment and techniques that could become the platform on which an eventual, operational European Satellite Videoconference Network could be established. A project, called Direct Inter-establishment Communications in Europe (DICE), was initiated on an experimental basis as part of the utilisation programme of ESA's Olympus satellite. The subsequent product and service development have led to the establishment of a high-quality video-conference service, using commercial satellite capacity based on European technology.

Development of the DICE system

The DICE concept was driven by a number of key requirements. Firstly, the system should exploit the inherent advantages of satellite communications in comparison to terrestrial communications:

- It should permit direct communication between user premises without the need for long, terrestrial tails.
- It should permit a number of users (up to four locations) to communicate simulta-neously with each other, without the need for circuit switching. This requirement should produce as much as possible the same natural atmosphere as at a round-table discussion.
- It should be very flexible in design and allow easy and fast installation, particularly in areas where the communications infrastructure is poor.
- It should allow the use of several transmission speeds: low data-rates for economy and high data-rates for users requiring superior quality transmissions.

Secondly, it must be easy to use:

- It should not require specially built conference rooms, but be able to fit into the existing user environment.
- The sound system should be of a high quality and resistant to misuse and even misalignment. This requirement stemmed from ESA's previous experience in mounting satellite communications and broadcasting demonstrations in which the user's perception of an event was found to be critically dependent on the sound quality to a much greater extent than on the video quality.
- A multi-point conference should be possible without switching. Terrestrial communications systems are essentially of a point-to-point nature. When a conference between multiple sites is needed, the interconnections between sites become complex and to enable all speakers to participate, it is usually necessary to switch between sites.

Development of a a viable system based on the above requirements was undertaken. Indoor videoconference equipment suitable for use in a normal office environment was developed (by Joanneum Research, Austria) and resulted in a range of products that achieve high quality coupled with ease of operation. The Earth station and modem facilities required for the system were developed by Matra Marconi Space (UK), TRL (UK), and Newtec (B).

Following the initial experimental phases of the project, development has been concentrated in two main areas:

- Broadening the product range for the indoor equipment
- Developing and introducing automatic network control.

This second feature has, in particular, enabled the monitoring of each station's status and the control of access to the satellite to be regulated on a network-wide basis.

The DICE network
DICE was originally deployed in 1990 as an experimental system using the Olympus satellite. For the first three years, it was operated in the 20/30 Ghz frequency bands. Earth stations for the system were located at ESTEC in The Netherlands; Joanneum Research in Graz, Austria; Matra Marconi at Portsmouth in the United Kingdom; Newtec in Belgium; British Aerospace at Stevenage in the United Kingdom and Matra Marconi at Toulouse in France. During those three years, the experiment operated successfully and considerable experience was obtained both in the technical and operational areas.

During that experimental phase, the system was demonstrated to the public at several large international conferences: the IAF Congress in Dresden in 1990 and in Graz in 1993; TELECOM-91 in Geneva and TELECOM-92 in Budapest; and the Olympus Conference in Seville in 1993. In addition, trans-Atlantic links were made during the World Environmental Conference in 1991 to and from Rio de Janeiro via Olympus's 20/30 GHz payload.

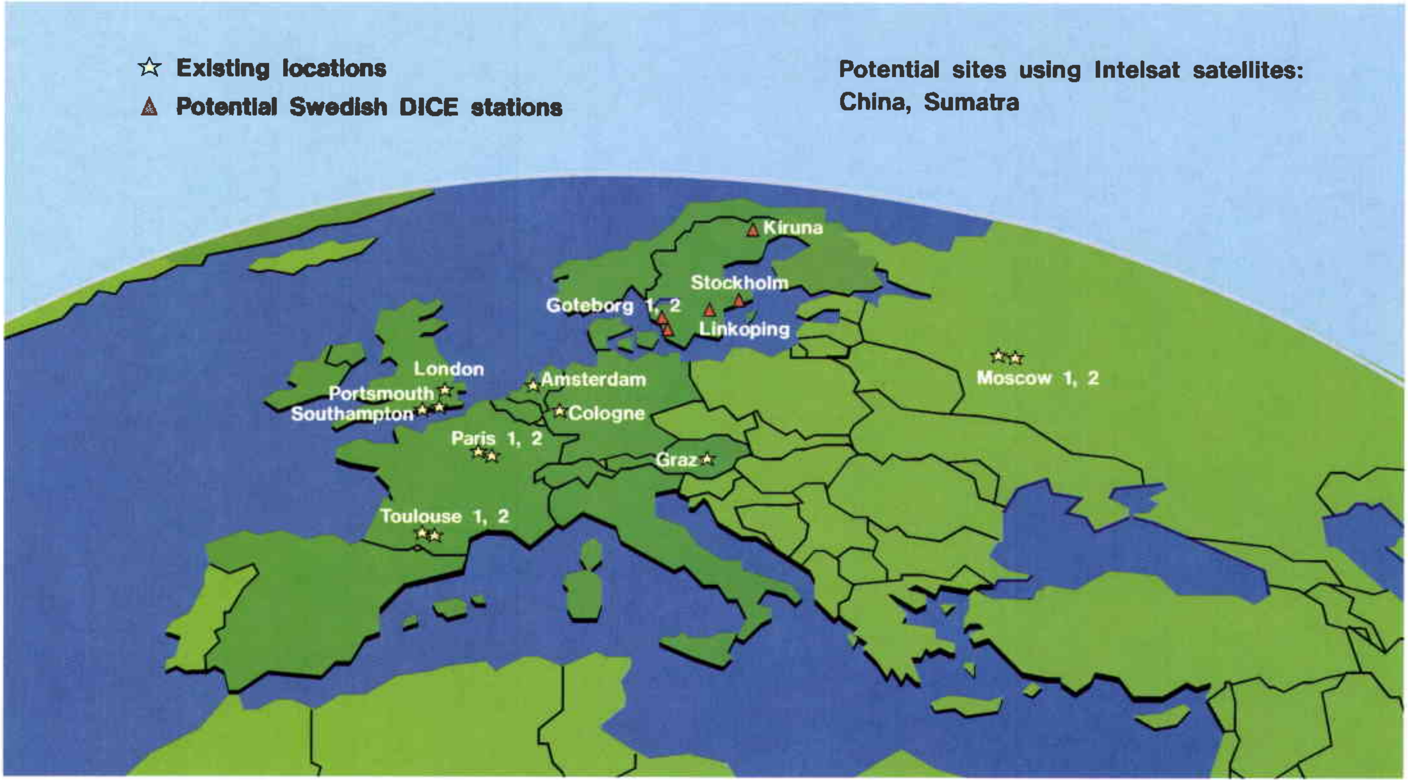
The most spectacular applications were during the Austrian AustroMir-91 and the German Mir-92 missions to the Russian Space Station 'Mir'. The Mission Control Centre near Moscow was connected via satellite and DICE to several sites in Western Europe. Experimenters were able to monitor the conduct of space experiments and speak interactively with the astronauts on board Mir. In addition, discussions between German, Russian and Austrian high-level politicians were conducted via DICE during the missions.

Following the end of the Olympus programme in 1993, ESA leased Ku-band capacity on a Eutelsat satellite and transferred DICE operations to that capacity. The existing sites were modified to work in the Ku band 14 GHz up path/11 GHz down path and the Earth stations had to be replaced at each location.

The network was put on a more operational footing and Matra Marconi took over the system as service provider. That company was also encouraged to form a commercial alliance with Joanneum Research, whereby Matra Marconi would supply the Earth stations and the overall service provision and Joanneum would supply the indoor videoconferencing equipment.

This arrangement has worked well and there are now numerous DICE sites throughout Western Europe and in Russia (Fig. 1). The sites in Russia and Germany were established when ESA became involved in the EuroMir project with Russia (Fig. 2). To allow all the control centres associated with the mission to maintain contact with each other, DICE was selected to provide simultaneous multi-point links using video, voice and data services.

Figure 1. Location of DICE installations in Europe and Russia



In addition, discussions have recently been held with the Swedish Space Corporation, which operates a network of four video-teleconference sites in Scandinavia, concerning the possibility of joining the two systems together to make an overall European network of stations.

The whole network operation and management operation is now being made commercial. ESA will continue to provide development support to bring new products and service improvements into the system. However, the deployment of new stations and the sale of the standard service will be a task for the companies involved.

Figure 2. A DICE Earth station being installed near Moscow

DICE equipment
In a DICE teleconference, any four sites may be simultaneously linked by satellite with 'continuous presence' video, audio, computer graphics and data facilities. With 'continuous presence', all participants can see and hear each other throughout the videoconference. This helps to create an environment similar to that of a conventional round-table meeting. Notes and sketches may also be distributed using the document transmission facilities. Figure 3 shows a typical DICE conference in progress.

The audio and video system
In the standard DICE configuration, the videoconferencing equipment is housed in two compact, transportable roll-about units, one for the video and sound, and the other for the graphics. In this way, videoconferencing facilities can be easily and quickly set up in ordinary offices, meeting rooms or laboratories.

Particular attention has been paid to the sound system for DICE. By using special desktop microphones, a 7 kHz bandwidth audio channel and acoustic echo suppressor, it has been possible to achieve a good sound quality that is resistant to the local environment. The system is therefore not sensitive to the type of room used and provides a relaxed atmosphere for the users. The picture quality available is consistent with the best commercially available encoders/decoders (codecs).

The picture quality is regularly upgraded to incorporate the latest codec technology available on the market. The transmission speed can be set to a wide range of bit rates, from 64 kbit/s up to 2048 kbit/s. The bit rate normally used is 384 kbit/s.

Features of the current DICE equipment:

- Multiple locations, continuous presence
- All parties can speak freely to each other (there is no switching)
- A normal office environment can be used (a special studio is not required)
- Three different versions are available: a roll-about system, a special conference room system, and a PC-based desktop system
- Uses the international CCITT H.320 (H.261) compression standard
- High-quality video reception (128 – 2048 kbit/s)
- High-quality sound system with acoustic echo canceller
- Unique interactive computer graphics system for high-resolution document dissemination
- Uses small Earth terminals (VSATs)
- Transmission in Ku- or Ka-band
- Compatible with terrestrial networks such as E1, fractional E1, ISDN 6 and ISDN 2.

Figure 3. A DICE videoconference in progress, using the conference-room version of the system

A desktop version has recently been added to the DICE range of equipment (Fig. 4). It is based on a standard, tower-type personal computer (PC) into which the video, audio and graphics equipment is integrated. The PC's video monitor is adapted to become a multimedia monitor by the addition of a small camera, dual loudspeakers and a microphone. All the equipment is integrated into a unified design. The PC's screen functions in a Windows environment and is able to provide, on one screen, single or multiple pictures from up to three remote locations as well as remote graphics. DICE's continuous presence capability is thus available with the desktop version, when required.

Another product in the DICE equipment range, the conference room system, is designed for use in existing conference rooms. In this version, all the electronic equipment is housed in a small cabinet which can be stored in a corner of the room. The conference room's existing audio system is used to interface with the DICE system. This enables all of the room's audio facilities, such as simultaneous translation, to be used without modification. If the room does not have an audio system, radio microphones are provided for table use so that trailing wires are avoided. Video is displayed on standard monitors or via the room's existing projection system. The camera is wall-mounted and uses a remote-controlled pan/tilt head. As with all DICE equipment, the equipment is very simple to install and operate. Cabling has been minimised so that the conference room decor and atmosphere are not disturbed.

DICE uses the latest technology in video compression. The codec boards, fully compliant to the international H.320/H.261 videoconferencing standard, are integrated in a PC into which the software configuration is loaded. This allows easy adaptation to special user requirements and future enhancements. Up to three codecs can be installed in each PC.

Figure 4. The desktop version of the DICE equipment, showing two remote sites simultaneously

All user equipment is connected by fibre-optics cable to the indoor equipment that is part of the VSAT (modems). The fibre interfaces are installed in the codec. No heavy linking cables are needed, which makes the system easy and straightforward to set up and use.

The graphics system

In contrast to conventional videoconference systems in which document cameras are used, DICE has special computer graphics facilities for document transfer during a meeting. The system can be used as a high-quality fax machine to broadcast sketches, drawings or text to the remote screens or printers for reproduction. A resolution of up to 300 dpi is supported. The local mouse position is sent to the remote stations and displayed there to support interactive discussions. Documents can be scanned in or, if already available in electronically readable format, directly transferred as files. DOS and UNIX file formats are supported. A selective ARQ protocol has been implemented for efficient use of the satellite channel and error-free transmission. A 64 kbit/s data channel multiplexed with digital video and audio in the codec is used. To minimise transfer times, data compression techniques are used.

Electronic viewgraph presentations are also possible on a multi-site basis. The transparencies to be used in the presentation are transferred page by page before the meeting, stored on each remote station's local disk, and retrieved from the local disk during the presentation. Using clicks of the mouse, the presenter may flip both forward and backward through the pages, without any significant transmission delay.

The transmission system

The majority of the Earth stations for the system have been manufactured and installed by Matra Marconi Space. The Matra Marconi Ku-band VSAT Earth station is coupled to three satellite modems, all of which are remotely controlled from a Station Supervisory Unit (SSU) and a data receiver/demodulator.

The VSAT

The VSAT consists of a Radio Frequency (RF) unit, Intermediate Frequency (IF) unit and Solid State Power Amplifiers (SSPA). The RF unit is positioned at the focus of a 2.4 meter, offset-fed antenna. Together with the SSPA, this produces 8 watts of power giving an EIRP of 57.7 dBW. The RF unit also contains the LNB and, together with the antenna and feed, gives a G/T of 24.4 dB/K.

The IF unit is an up-and-down converter from 70 MHz to the L-band and vice versa. It also contains a monitor and control microprocessor that can be controlled locally or by remote control over the satellite link via the Station Supervisory Unit.

Table 1. Summary of the VSAT parameters

	Transmit	Receive
Transmit power (EIRP)	57.5 dB/W	
Figure of merit (G/T)		24.4 dB (1/K)
RF frequency range	14.0—14.5 GHz	12.5—12.75 GHz
IF frequency range	70 ± 18 MHz	70 ± 18 MHz
Tuning	1 MHz steps	1 MHz steps
Tuning in the modems	22.5 kHz steps	22.5 kHz steps
IF interface level	−30 dBm	+22 dBm

Table 1 provides a summary of the VSAT parameters.

Satellite modems

For a four-way conference, three satellite modems are necessary. The modems are standard IBS types with a 70 MHz interface. They are variable in rate, ranging from 64 to 2048 kbit/s, and provide QPSK half-rate forward error correction (FEC) Viterbi encoding/decoding.

Station Supervisory Unit (SSU)

The SSU is the remote controller of the VSAT. It receives commands from a Network Management and Control Centre (presently located in Portsmouth, UK) on a 9.6 kbit/s carrier which is received at the VSAT by a data receiver/demodulator. The SSU was developed by Matra Marconi Space and has proven most successful in the field. The unit supports a number of multi-drop buses that are used to control the VSAT, the three modems and a third separate bus, which could be used to control any other customer-furnished equipment.

The status of the units connected to the SSU is monitored and passed back to the control centre, using the IBS Engineering Service Circuit (RSC) of the satellite modems. This means that a separate carrier for status monitoring is not required.

Frequency plan and link performance

The DICE network is presently using fractional transponder capacity on Channel 41 of Eutelsat II-F4 at 7° East. According to the lease arrangement, one sixteenth of the transponder bandwidth and power, corresponding to 2.25 MHz and 27.76 dBW respectively, is available to the satellite network. The transmission system has been designed such that the available transponder resources are used in a well-balanced fashion, taking into account reasonable size of the Earth-station antenna and transmit power and a satellite link margin of approximately 2 dB.

In a total bandwidth of 2.25 MHz, four carriers with an information bit rate of 384 kbit/s can be allocated, which enables one four-site or two independent point-to-point videoconferences. Each carrier is QPSK modulated with a half-rate forward error correction (FEC) and occupies a bandwidth of 536 kHz, with a 16/15 overhead rate for the engineering channel.

The required link performance (Eb/No $\geqslant$ 7dB) and propagation margins of 2 dB, can be achieved with Earth-station antenna diameters of 2.4 m and a transmit power of 8 watts, which can be considered as a good compromise between Earth station investment and transponder lease cost. The satellite link performance is, to a large extent, determined by interference noise caused by other users operating on the cross-polar transponder or on adjacent channels, or even on adjacent satellites in the same frequency band.

Future developments

The DICE network is fulfilling a valuable function by interconnecting numerous European establishments. However, it can only continue to be successful if it grows and accommodates more videoconference addresses.

To this end, the DICE participants are actively discussing with other European satellite videoconference operators the possibility of integrating their networks with DICE so as to form a network of major proportions. Compatibility trials have already taken place and have shown that such interactivity is possible. The establishment of an overall operating organisation to run the system is now being considered.

Improvements to the connectivity to the terrestrial system, the ISDN, are also currently underway. Satellite videoconferencing can provide a powerful overlay to the terrestrial network by extending its reach to areas not presently covered. Conversely, the ISDN will greatly increase the videoconference locations accessible from DICE.

A further useful feature now being introduced, is to add automatic scheduling to the system's Network Management Control Centre (NMC). Reservations for videoconferences can then be programmed into the NMC, together with the network configuration required. At the appointed time, the NMC will automatically configure all stations participating in the conference and switch them on. At the end of the session, they will automatically be switched off.

Conclusions

The DICE system has been a valuable spin-off from the work carried out in ESA's Olympus utilisation programme. It is an operating system with many sites, it has a good reputation for quality of sound and video, and the level of convenience that it provides to users continues to be demonstrated daily.

As codecs continue to develop, it is foreseen that their price will fall, allowing further reductions in the cost of videoconferencing. Also, with the launch of more commercial satellites such as PanAmSat 3 and Orion, it is expected that space segment costs will also decrease. Depending on the distance between the two communicating sites, satellite time is already cheaper than time on the terrestrial-based system ISDN 2. The crossover point at present is approximately 1000 km depending on the carrier and the routing. It is forecast that the ISDN prices will also fall so it will be interesting to watch the development of future tariffs.

It is most probable that the terrestrial and the satellite-based systems will continue to co-exist, each providing service in the areas in which it offers particular advantages and with considerable interconnectivity between them.

A Security Policy for ESRIN's Services

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ESRIN provides a large number of online services to users all over the world via a complex telecommunications network. As the number of services offered grows and their geographical coverage expands, the network becomes increasingly vulnerable to a security threat.

ESRIN has therefore developed a security policy to protect all of the resources connected by the network. Operational roles and responsibilities for security have been established, and measures to heighten awareness of an installation's security exposure have been implemented. In addition, the ESRIN networks have been reorganised based on an assessment of each host computer's required security level. Further measures, such as authentication and access control measures, will be phased in as deemed necessary.

Introduction

Access to application services on a computer system is normally controlled by the system using traditional operating-system protection measures. Those measures are in accordance with predefined policies that vary from maximum openness to strictly controlled identity- and role-based access.

The introduction of computer networks adds a new dimension to the problem of securing access to computer services. The security of worldwide interconnected networks becomes increasingly important as a service's geographical coverage grows and it becomes more exposed to 'attacks' by 'hackers' who, safely sitting in their offices or homes anywhere in the world, can wander through 'cyberspace', bypassing all barriers and posing a serious threat to the integrity and privacy of computer systems and the networks.

Network operators will face a great fight in the years to come as they attempt to secure their networks. Unfortunately, the efforts of those responsible for fighting against 'trespassers of the computer frontier' are not always duly acknowledged by the general public. The victims of computer crime try to avoid any publicity as well as the embarrassment and negative effect of being known as the subject of an attack, thus revealing the vulnerability of their installations. This makes computer crimes harder to fight since it involves fighting an unknown enemy. In addition, a romantic halo surrounds the hackers: they appear to be freedom fighters. A few recent books describing some real incidents, however, have tried to shed light on the computer hacking 'underculture', revealing the true, more prosaic side of what is now considered to be a criminal activity.

ESRIN, the ESA establishment located in Frascati, Italy, is particularly concerned about network security. ESRIN is responsible for the provision of user services associated with data and products from many Earth observation and astronomy satellites, with bibliographic information on space and space-related domains and with information systems in support of ESA activities. To do so, ESRIN operates a complex telecommunications network that connects the establishment with a large number of ground facilities and user entities distributed all over the world, offering on-line access to a number of services. ESRIN is also responsible for the European nodes connected to international Earth observation and scientific networks.

By definition, these services are open to any users in the world. Therefore, the problems of network and system security, not only for the ESRIN facilities but also for the other entities linked to it through the network, are of prime concern.

ESRIN has therefore established a consistent security policy to protect all the resources connected by the network, in keeping with the general principles on protection of information assets defined by ESA. The focus is on network security since the network is considered to be the medium through which attacks on the resources and services offered by ESRIN may originate, and is thus the most appropriate place to 'build fences'. The policy is outlined here.

A plan for the implementation of the security policy has also been developed and some aspects are now being implemented. Increasingly sophisticated security measures will be phased in as deemed necessary based on the assessed risk to which the establishment is exposed. Such an 'evolution path' includes the protection of individual pieces of information with the establishment of a number of security levels and the classification of resources and host computers with respect to them. This evolution will occur in accordance with the general guidelines laid down by ESA's Risk Management Office through its Data Security Programme.

The ESRIN environment
Users of ESRIN services are mainly interested in the following domains:

— Earth observation from space
— Astronomy and astrophysics
— Bibliographic information on space-related matters

The ESA services available through the ESRIN networks

— **Information Retrieval Service (IRS),** the European on-line host for the provision of information to the scientific, technical, industrial and institutional communities primarily in the ESA member states. With some 100 databases on a broad range of subjects, but with an emphasis on aerospace and environmental data, and with its powerful search capabilities, IRS provides rapid access to vital information for industry, business, research establishments and academic institutions everywhere.

— **European Space Information System (ESIS),** the European on-line service to the astronomical and space physics communities, which provides homogeneous access to scientific data, including images, spectra and other data products from a wide range of space-based missions. A bibliographic archive of astronomical and space physics journals and periodicals is also available, together with analysis tools.

— **Earth Observation Guide and Directory Service (GDS),** a new on-line information resource describing Earth observation data, systems and applications. It carries details about ESA's remote sensing programmes and satellite missions and provides material of interest to those working with data products from those missions. GDS also carries information for newcomers who are interested in the science and exploitation potential of Earth observation. The information is accessible in the form of full text documents, images, graphics, audio and animated sequences. The service is also a network entry-point from which a large number of related, international information systems can be located and, in many cases, also accessed.

— **Ionia 1 km AVHRR Global Land Data Set Net Browser (Ionia),** a series of tools that provide the NOAA/AVHRR satellite data sets archived and maintained at ESRIN. Thousands of quick-looks are available on the ESRIN server, and additional features allow inventory searching, and displaying and selection of retrieved data.

— **ESRIN ERS Central Facility (EECF),** which provides access to the ERS Interface SubSet **(ERSISS)**, the gateway to the services offered by the ESA European Remote Sensing Satellite (ERS) mission. ERSISS handles the ERS telecommunication traffic and provides access to the catalogue of global products and to the status of user requests for global products. It provides also access to the ERS Central User Service **(ERSCUS)**, which handles the user requests and the world-wide catalogue for the ERS Synthetic Aperture Radar (SAR) image data. ERSCUS supports the preparation of the SAR payload activity plan for future acquisitions and SAR products distribution through Eutelsat satellite links; it also generates operational work schedules for the other ERS ground segment facilities around the world and shows the ERS Global Activity Plan (GAP).

— **Earth Observation Catalogue and Browse Services (EPOCAT),** which provides the on-line access to the catalogues of non-ESA Earth observation satellite missions, like Landsat, TIROS, and SPOT, whose data are acquired, handled and stored by ESA facilities and the ESRIN network of national ground stations. For the ESA European Remote Sensing Satellite mission ERS-1, the service allows also on-line access to low-resolution SAR images (UILR) from the ESA ground station in Kiruna, to quick-look altimeter data products (QLOPR) generated by the German Processing and Archiving Facility at DLR, Germany, to the ERS-1 Global Activity Plan, to the orbit information of relevance of SAR data for interferometric applications.

— **On-line Documentation Services,** through which users can access and download electronically documents related, for instance, to ESA Invitations to Tender and to the Columbus programme.

— **Value Added Services (VAS),** such as electronic mail, directory, file transfer, bulletin boards, newsletters, conferences and gateway facilities for mail and file transfer.

— Technical documentation on the Columbus programme
— ESA's industrial invitations to tender
— ESA legal documentation.

The user communities are widely spread out and are located around the world. They include users with very different hardware and software capabilities, and with varying levels of knowledge, ranging from those who are very familiar with computing and networking to those who do not have any modern tools available at their site. Therefore, ESRIN is bound to offer a widely ranging and flexible support.

In general, ESRIN's tasks include the management of the facilities to acquire, process, archive and distribute satellite data and other space-related information, and the provision of comprehensive data retrieval and dissemination systems with specialised functions to support operations on catalogues, directories and inventories, correlation of data, and simultaneous and coordinated access to different remote archives. Electronic mail services are also offered.

The infrastructure of hosts and networks at ESRIN has grown rapidly in the last decade, in parallel with ESRIN's increasing responsibility to support user interface and data handling tasks. In particular, the development of the ground segment for ESA's ERS-1 Earth observation satellite has meant at least a ten-fold increase in the complexity and scope of the ESRIN responsibility. Moreover, in order to prepare for the upcoming, even more complex Earth-observation missions like Envisat, ESRIN started last year to revise and redesign much of its telecommunication infrastructure.

Since its telecommunication links must be worldwide, ESRIN is actively working with the European Union on the establishment of a European network for the exchange of environmental data, as well as with the international Committee for Earth Observation Satellites (CEOS) on the interconnectivity and interoperability of networks, databases, directories, inventories and catalogues among the agencies and entities associated with Earth-observation satellite data.

ESRIN's services are made available on-line to users around the world via the Data Dissemination Network (DDN), by means of the ESRIN telecommunication infrastructure (Fig. 1). In particular, the DDN provides the 'highway' for the transport of two types of data traffic:

— intercentre traffic, i.e. traffic between ESRIN and a large number of institutes, facilities, archives, ground stations and data centres to gather the data

— user-access traffic, i.e. traffic created by end users (both local and remote) accessing the ESRIN-provided services and retrieving data.

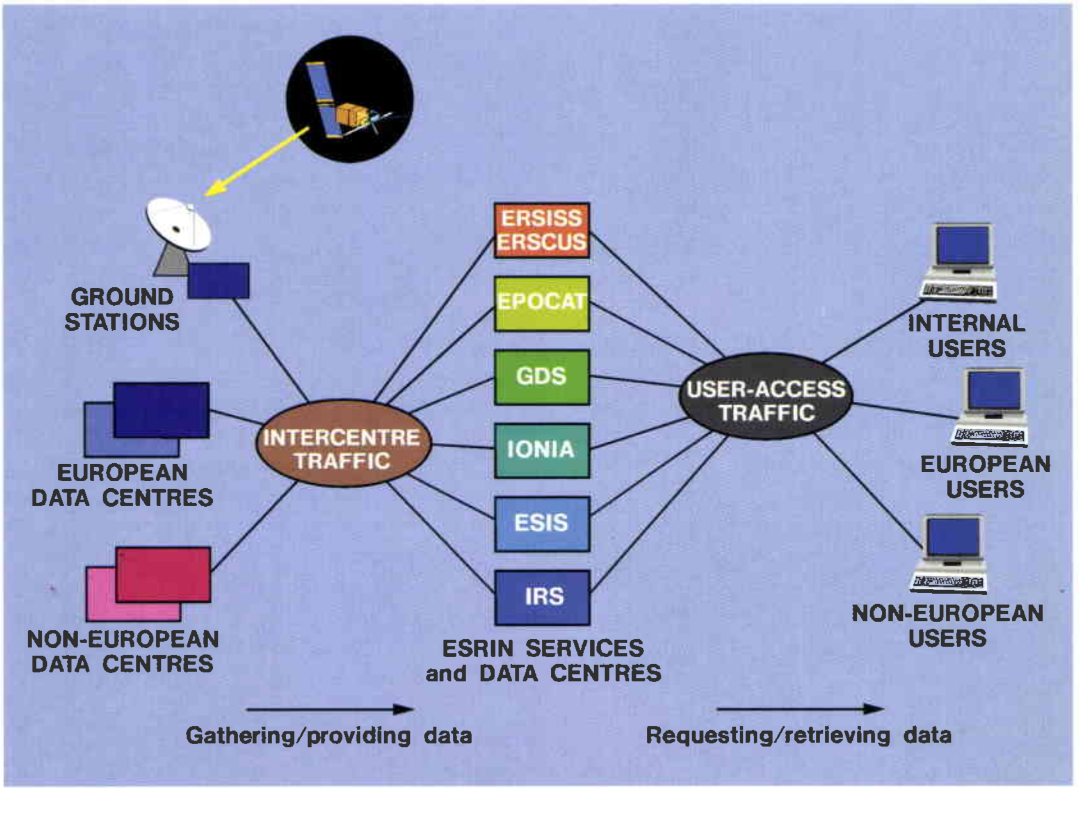

Figure 1. The Data Dissemination Network (DDN) via which ESRIN's services are made available on-line to users around the world

The DDN traffic is related to:

— interactive applications, mainly relating to users consulting databases, catalogues, inventories, guides, directories, and literature
— file transfer applications, for product acquisitions, transfer and delivery, for archive and catalogue updates, and for exchange of documents
— client-server applications, for adding to the above usage patterns the capability to optimise the distribution of applications between collaborating workstations.

The DDN includes a Local Area component, which covers the whole ESRIN site and provides connectivity to all hosts and terminals on site, and a Wide Area component, made up of 'access points' located in ESA Member States and interconnected by international research networks such as Internet and SPAN.

Figure 2. Selection menu of the ESRIN Data Dissemination Network, when accessed from the X.25 public network

Welcome to the
Data Dissemination Network
of the European Space Agency

Please type the name of the service required, followed by CR:

ESAIRS	Information Retrieval Service
EMITS	Electronic Mail Invitation to Tender System (VT100 and TTY)
EMITSWIN	Electronic Mail Invitation to Tender System (Windows)
GDS	ESA Earth Observation Guide and Directory Service
DODIS	Official Document Distribution Service (VT100 and TTY)
DODISWIN	Official Document Distribution Service (Windows)
CUIS	Columbus Utilisation Information System (VT100)
CUISWIN	Columbus Utilisation Information System (Windows, Macintosh)
ESALEX	ESA Legal Text Service (VT100 and TTY)
EECF	Ers-1 European Central Facility
ERSUS	Ers-1 User Services
VAS	OSI Value Added Services
QUIT	Exit

An access point is a host computer with a well-known address to which users in one country can connect. It links all relevant local institutes and concentrates the traffic of all national users. Remote users accessing ESRIN services via the DDN remote access points or via the Internet are presented with a menu listing all the available services and requesting the user's choice (Fig. 2).

The requirement to provide 'open' access to an external user (i.e. a non-ESRIN user) on a host computer supporting one or more user services through a network, may seem to contradict the need for basic measures to control the access to the information resources. In fact, a totally uncontrolled access could create problems not only to local systems but also to the systems 'downstream' on the network that the local host provides further access to. This issue is of particular concern for the Earth-observation systems, where a user is supposed to be able to access the system without restrictions and with as user-friendly an interface as possible.

Up to now, the networks have not imposed any restrictions on the accessibility of the services, that is, no security checks have been performed at the network level. Instead, the 'user validation' has been performed directly at the application level by the hosts supporting the services, under their responsibility. This is achieved by restricting the service to 'registered' users, for example, by requesting user identification and the proper password at the time of log-in. The service of on-line jumping to other remote hosts requires special security measures and should be limited to identified users. In some other cases, hosts do not perform any check on a user's eligibility for services and make services available to 'anonymous' users. This is the case with services available via World Wide Web (WWW) (e.g. X-mosaic), Gopher, or Z39.50 (WAIS).

The classification of hosts and services currently in operation at ESRIN with respect to the category of the accessible services and related restrictions is given in Table 1.

Additional security measures at the network level, beyond those at the application level just described, must be introduced to provide adequate security.

Network vs. application security

A distinction should be made between a) the network connecting the host computers to one another, and b) the resources present on such host computers and made available to remote users through the network itself.

The network provides the basic connectivity among access points, to which the host computers are attached. The network is composed of hardware components and logical pieces that provide the routing among them from one source to a destination access point.

There are three different kinds of access to a service through the network:

— user-to-computer: a user logs in either directly or through the network
— user-to-service: a user logs in to the application
— user-to-resource: a user, who is logged in to an application, accesses the resources it makes available.

Such accesses are traditionally mediated through security measures that check each user's identity against a registry in which the identity of those users who are authorised to access a computer, a service, or an individual resource are stored, usually associated with additional information (e.g. passwords) used to authenticate the users (level R, registered users). When the user has been identified, all the user's actions can be traced and accounted for.

However, users who are not registered or known can gain access to systems and services (level A, anonymous users). For example, non-registered users (behind which anybody, even a hacker, may be hiding) can connect to a service anonymously when access is open to all (e.g. an anonymous FTP), or by means of particular, well-known user names related to the service being offered (e.g. WWW or GDS).

Access by unknown users is not necessarily harmful if their activities can be limited to a previously defined, well-known subset of all possible system commands (this limited functionality is often characterised as a 'captive account'). Malicious intruders, however, can exploit the weaknesses of the operating system and gain access to the basic system from confined applications, thus proceeding into uncontrolled environments where they could possibly cause harm.

In other cases, unknown users can gain access to a system by guessing the names and passwords of legitimately registered users. This can be achieved when the passwords selected by the legitimate users are weak, being either obvious or well-known. This is particularly harmful because, once they are logged on, the intruder is disguised by the identity of an innocent user, so any harm they create will be attributed to somebody else.

Therefore, appropriate security measures are required even if the official policy for information management is to provide the utmost openness. Security measures, in fact, do not necessarily mean closing the doors of a system, but carefully checking who gets in and for what purpose.

Table 1. Hosts and services currently in operation at ESRIN, and their restrictions on access

Host	Accessible services	Service	Restriction
ERSCUS	— Core services (e.g. Global Activity Plan (GAP), work scheduling)	T	R
	— User services (e.g. catalogue search, order status)	T	R
ERSISS	— Access to the catalogue of global products and to the status of global product orders	T	R
	— User request via file, transfer of the Global Activity Plan (GAP) file	FT	R
	— Access to ERSCUS	T	R
EPOCAT	— Access to LEDA catalogue (Landsat, TIROS, SPOT, Nimbus CZCS, MOS, JERS-1 satellites)	T	A
	— ERS on-line file server (read-only) for:	FT	A
	— Low-resolution SAR images (Kiruna station UILR)		
	— Quick-look Altimeter products from D-PAF (QLOPR)	FT	R
	— Global Activity Plan (GAP)	FT	A
	— Orbit information for interferometry (INSAR)	FT	R
ESAIRS	— Access to research & development databases (locally loaded and/or accessible via automatic gateways)	T	R
GDS	— General menu for services provided	E	A
	— Access to guide information stored locally	E	A
	— Access to selected information stored locally	E	A
	— Search on IDN directories	T	A
	— Access to other hosts, only for alpha-numeric users, by on-line jumping to:	T	A
	— IRS (file Inspec)		
	— LEDA catalogue (all data)	T	A
	— Remote hosts on SPAN*	T	A
	— Remote hosts on X.25 PSPDN*	T	A
	— Provision of references (addresses) for connection to remote hosts on Internet	E	A
	— FTP access to software, bulky ancillary data, etc.	FT	A
ESIS	— Browsing images, spectra, time series, bibliographic information and abstracts	E	
	— File transfer of the above for both types of service:	FT	
	— access as ESIS clients		R
	— via WWW/NCSA-MOSAIC		A

* with explicit agreement of remote hosts

Type of service:
- T Interactive Application
- FT File-transfer application
- E Client-server application

Restriction:
- R Registered users only
- A Anonymous users

ESRIN's security measures

The security policy established by ESRIN requires three types of security measures:

— Organisational measures, to establish operational responsibilities and roles
— Measures to heighten awareness of a particular installation's security exposure and watch for intrusions
— Measures to actually protect against intruders.

Many of these have already been implemented. Others will be implemented only if deemed necessary based on the assessed risk to which the network is exposed.

Organisational measures

The first step when dealing with security is to establish the responsibilities of those empowered to deal with security matters.

At ESRIN, the Information Security Office (ISO), the technical focal point for all network, computer and information security-related matters, monitors the security of the network and computer installations and issues instructions to counter risks and exposures. With the ISO's support, the ESRIN management coordinates the application of the policies and guarantees their uniform enforcement throughout the establishment. In turn, an officer from each division is appointed to a Security Advisory Board that ensures the necessary consensus for all security measures. The security officers guarantee the application of the measures in each division.

Awareness measures

The security of the system must be constantly monitored, and a general awareness of security issues and threats maintained. Only when the real risks are known and quantified in terms of economic loss, can an effort (in terms of manpower and procurement of monitoring and enforcement tools) be justified to management.

Each system manager regularly follows a routine security 'checklist' to ensure that the appropriate levels of checks against the known vulnerabilities are in place. The items to be checked include the choice of passwords, the levels of file protection, and the boundaries of free-access captive accounts. The ISO regularly distributes advisory notes from the international security community, in particular from the Computer Emergency Response Team (CERT) (at Carnegie-Mellon University, USA), to increase the system managers' awareness and help in coping with newly discovered weaknesses. Modern legislation is also increasingly aware of computer security and the lack thereof, and now offers instruments for action, including at the legal level if necessary.

In order to assess the risks and the seriousness of an attack, system managers routinely monitor access by both external and internal users to the systems under their responsibility, and report any incidents or suspected incidents to the ISO. This also applies to the managers of the network itself, since network resources like modems, routers, management stations, and the access lines, as well as information like the routing tables and the network-level access control lists, are at the core of the security of the whole site.

Protection measures

Since the network is the most likely medium through which intruders can penetrate a system, the network is an appropriate place to enact basic security measures.

Protection measures at the network level have already been implemented at ESRIN. They include:

- Maintenance of access control lists based on the addresses identifying the calling entities
- Reorganisation of the physical layout of the networks and computer attachments (see 'Reorganising ESRIN's network' below)
- Deactivation of some kinds of access, for example, those originating from certain countries or troubled areas.

At the network level, however, only the addresses of calling parties are visible, so any measure enforced at that level can be applied to addresses only, and is transparent to the identities in application and human terms of the called and calling parties, as well as to the application semantics. In other words, protection at the network level cannot be a substitute for application-level protection, which must be addressed separately.

Protection measures at the application level include:

- Routine measures to ensure that user-chosen data are not introducing weaknesses (e.g. periodical password changes, and use of hard-to-guess, inobvious passwords).
- Accountability measures to ensure that all accesses, including unrestricted accesses, can be traced, and that the accessors and their actions can be identified. In other words, ESRIN's external access policy is evolving from full openness to 'accountable' openness.
- Authentication measures to control user-to-computer and user-to-application types of access. These measures can range from, in increasing order of sophistication, generic user names to a fully integrated, cryptographically-strengthened, user-ID plus password that is checked against a unified user registry.
- Authorisation (or access control) measures to control individual, authenticated users'

access to individual resources, with the association of access control lists to resources, to then be checked against user privileges at access time.

The first two measures have already been implemented at ESRIN. For the last two, the authentication and authorisation enhancement measures, the level of sophistication that will actually be implemented will be a direct function of the assessment of the risks.

Reorganising ESRIN's network

As stated before, the network is the primary point of access where basic security measures can be enacted. Enactment of network-level protection measures is the first step to achieving adequate, overall security for any installation. To this end, the network structure at ESRIN has been reorganised according to two main criteria, accessibility and operativity, as follows:

— *Accessibility:* A network (and the host computers attached to it) is considered to be 'accessible' if it must be able to be reached from outside ESRIN.

  A logical 'firewall' has been installed to prevent external accessors from reaching particular networks (and host computers) within the establishment (Fig. 3). The existence of a firewall at the network level does not imply that whatever is on the 'outside' of the wall is abandoned to the incursions of hackers: appropriate security measures at the application level protect those host computers and their information.

— *Operativity:* A host computer is considered to be 'operational' if it offers an operational service. It is considered to be 'non-operational' if it is used only for system development or office support. (The operativity of a service or of a host computer is not directly related to its security, but is mentioned to provide a complete picture of the reconfiguration of the ESRIN network).

Four categories of networks have therefore been created (Fig. 4). Depending on the nature of the activity performed on each host computer at ESRIN, that host computer is being assigned to one (and only one) of the network categories. To perform the transition, two procedures are used, one makes a computer accessible and the other makes a computer operational. The procedures include a number of tests and some formal constraints.

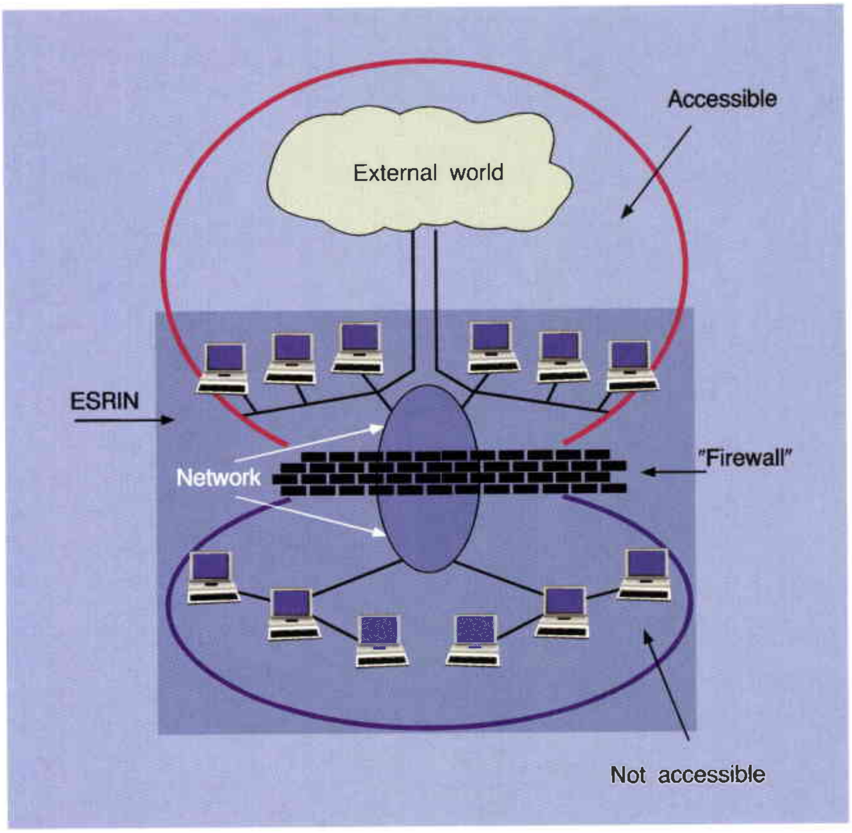

Figure 3. A logical 'firewall' separates ESRIN's systems and services that do not have to be accessible to the external world from those that must be accessible

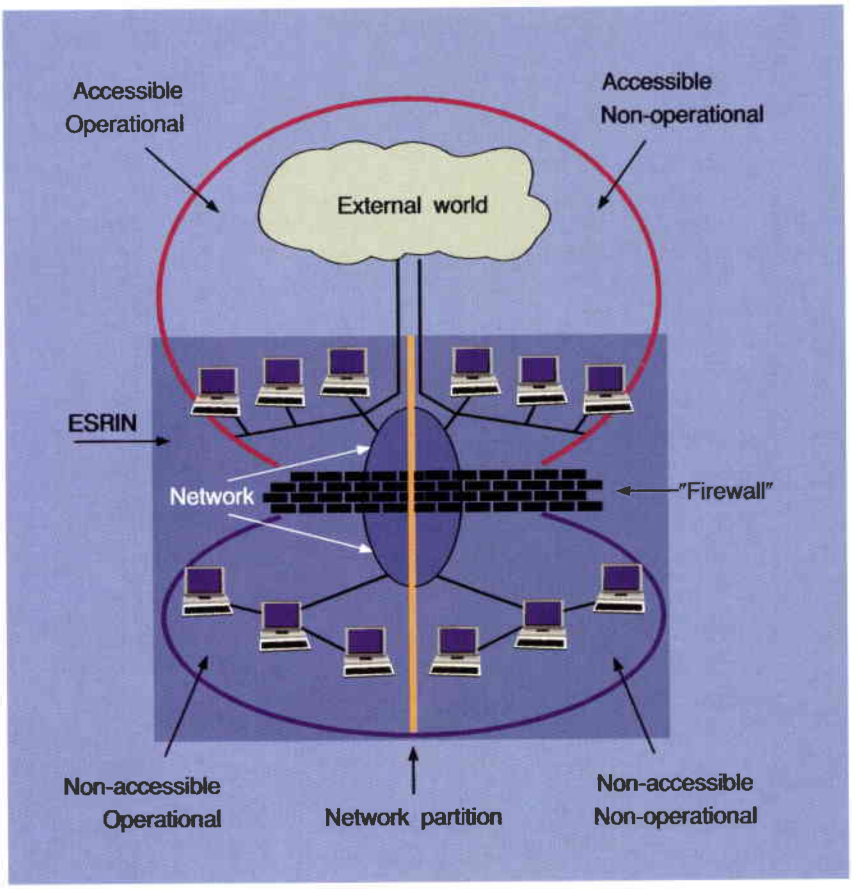

Figure 4. Four categories of network have been created. All host computers offering an operational service, whether they are accessible or non-accessible, are connected to different networks than those used for development or office support (non-operational)

Table 2. The elements of ESRIN's new network security policy

Organisational measures:
— Formal responsibility scheme for all network, computer and information security-related matters
— Security Advisory Board, with representatives from each division of ESRIN
— Information Security Office (ISO).

Awareness measures:
— A security checklist which network managers must follow
— Accesses routinely monitored and suspect cases reported to the ISO
— Risk level assessed by the ISO, based on violation reports.

Protection measures:
— Measures for accountable openness
— Evaluation and scaled enactment of authentication measures
— Evaluation and scaled enactment of access control measures.

Logical reorganisation of ESRIN's networks:
— Construction of a security 'firewall' within the ESRIN network installations
— Formal procedure to make particular host computers (and services running on them) accessible from the outside.

Summary and conclusions

The elements of ESRIN's new security policy are summarised in Table 2.

The key to success in rendering secure a complex establishment like ESRIN from the information services point of view is to make the staff aware of the risks involved and of their personal responsibility in complying with the relevant security regulations in their daily activities, as stated by ESA's policy on the protection of computer operations. This has to happen with managerial support and with the staff's full consensus, without limiting their personal freedom with respect to professional activities and contact with the external world. One of the Information Security Office's tasks is therefore to run an awareness campaign targeted at the individual users, and aimed at garnering the maximum level of compliance with the defined rules.

Acknowledgement

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Improving the Cost Effectiveness of Mission Operations Systems through Integration and Re-use

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Operations systems for spacecraft missions have been expensive to implement because much of the software for such systems has been rewritten for each new mission. With the trend toward more complex spacecraft and more ambitious mission goals, the situation could worsen. At ESOC, the Advanced Systems and Technology Programme (ASTP) is funding a series of studies called the Advanced Technology Operations System (ATOS) studies. The aim is to develop the design basis for mission operations systems using advanced technologies such as knowledge-based systems (KBS).

In the first of these studies, ATOS-1, techniques for integrating heterogeneous advanced applications have been defined and prototyped. Such techniques enable the re-use of separately-developed applications and allow for the integration of large units of software. Software for spacecraft mission operations systems can be produced more cost effectively by making re-use and integration easier. Furthermore, these techniques can be of general application in the software industry.

Introduction

In the last decade, the fields of control systems and operations systems, which include nuclear power stations, avionics systems and process control in general, have seen a strong trend toward greater automation. Some reasons for this are:

- To reduce the operator workload (and possibly thereby reduce the number of operators and the associated costs)
- To allow the operator to concentrate on decisions that have to be made by a human
- To increase safety and reliability by reducing opportunities for human error.

This automation is achieved using computer software to perform certain actions and even to take (or propose) decisions, for example, in response to a failure. The technologies involved include knowledge-based systems (KBS) which 'reason' using an 'inference engine' to solve a problem on the basis of a set of formally expressed 'rules'.

This trend is also affecting spacecraft mission operations systems, particularly as spacecraft are becoming increasingly complex and mission goals are becoming more ambitious, thereby making the problems of planning and performance of mission operations more demanding. The advanced technology of KBS could help to solve some of these problems. Additionally, despite greater demands on such systems, economic conditions impose the need to reduce the rather high costs of implementing the operations systems for new missions. The reason for these high costs has been the need to develop substantial amounts of new software for each mission. Better re-use or adaption of existing systems and system components could therefore improve cost-effectiveness.

At ESA's Space Operations Centre, ESOC, KBS has been applied in a number of studies to specific areas of mission operations, producing a number of independent prototype KBSs. However, the various prototypes developed use different KBS tools and knowledge representations, which means that they could not easily be made to work together. This led to the need to find a solution to the integration problem without imposing a common knowledge representation on all applications. This became an important driver for ATOS-1, the first study in a series of Advanced Technology Operations System studies.

Background

The integration problem for mission operations systems is part of a general problem in software development. The interface between software components, in particular, presents a major difficulty in the integration of complex systems.

The software integration problem

Large and complex software systems are becoming more common. Mission control systems are a good example of this. Other examples are multi-media applications, CAD (Computer Aided Design), CIM (Computer Integrated Manufacturing), telecommunications, and process and environmental control systems.

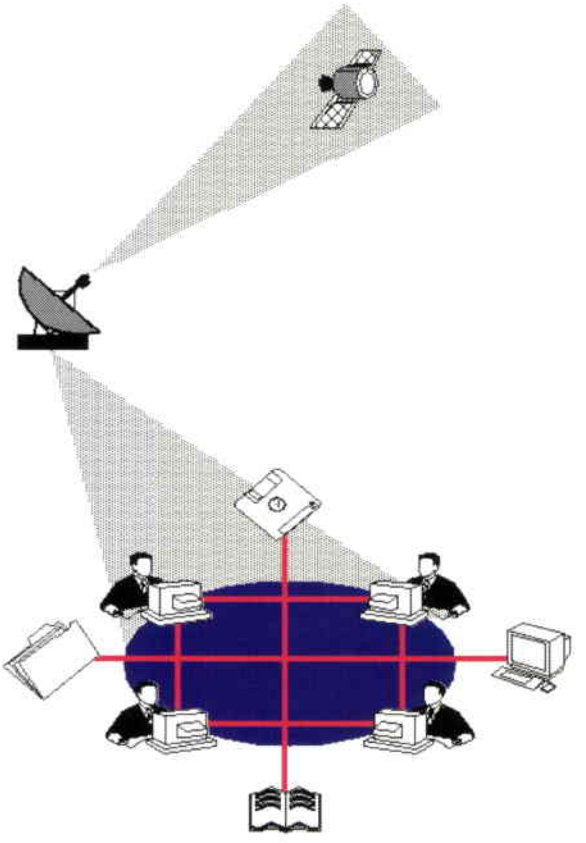
There are two problems in the integration of software: the relative immaturity of software production and the problem of providing interfaces for software modules.

The 'software crisis'

Integration of computer hardware has evolved in a much better way than software integration has.

Some forty years ago, a computer was a monolithic structure of valves and other electrical components. Now, when computer manufacturers design a new machine, they do not build a unique machine from the ground up using a collection of diodes, resistors and transistors. Rather, they assemble the machine from standard components whenever possible. They only design new components when doing so would, for example, give them a proprietary edge. Furthermore, the components are used to construct larger components. The package that results from such layered building is not a closed system. This is assisted by the existence of mature standards at each layer, allowing easy interchange of the components.

However, on the software side, there has not been a corresponding development. The step from assembly to procedural languages gave us a slight increase in the size of software components, i.e. a line of procedural code is the equivalent of several lines of assembly, but does not bring us much further than the diode/resistor/transistor level in terms of the hardware analogy. The advent of non-procedural languages such as Prolog and LISP was again an improvement, in certain ways, although its equivalence to procedural languages is hard to measure. The appearance of libraries or software modules also allowed for a higher level of integration, but nothing to rival the reusability of hardware components.



The Advanced Technology Operations System (ATOS-1)

The gap between the development of hardware and software is known as the 'software crisis'. It manifests itself in the difficulty of producing good 'industrial strength' (i.e. reliable) software, at least on a large scale.

Many new software engineering techniques have been heralded as the solution to the software crisis yet none of them have managed to solve the problem. At most, one is usually offered a better set of libraries with interfaces that are easier to use. However the problem of building a large system from many components where there may be a 'combinatorial explosion' of logical paths through the system and interfaces, remains the major obstacle.

The interface problem

All modern methods for breaking down complex software systems into a set of sub-problems (which are called modules, subject areas, work packages, etc.), use the 'divide and conquer' approach. Each of these sub-problems is then pursued as a separate development task.

At the end of the development, the sub-solutions must be integrated together to provide the overall solution (or the system). Integration involves communication between the sub-solutions and for that there must be an agreed interface. In practice, the agreement, implementation and testing of the interfaces is a tedious and often difficult task. Also, because they are peer-to-peer interfaces (Fig. 1), each interface may need to be modified every time a new functionality or sub-solution is added. The interfaces in a system can work against reusability of its components by being too numerous and complex.

The integration problem for mission operations systems

As stated earlier, a spacecraft mission operations system is a good example of a complex system that has to be of 'industrial strength' for reasons of safety and reliability. A spacecraft mission operations system comprises the set of facilities needed to carry out all the mission operations. Mission operations can be split into three areas:

- *Mission preparation:* The tasks for the preparation and configuration of the Mission Control System (MCS) prior to the start of the mission, as well as the setup (and subsequent maintenance during the mission) of the basic reference mission knowledge (spacecraft databases, mission schedules, etc.)
- *Mission planning:* The planning and scheduling of mission operations activities.
- *Mission operations:* All tasks involved in monitoring, control and reporting of the mission.

In general, each of these areas will be supported by independently developed software, possibly running on different platforms. Furthermore, these areas are linked together. For example, mission preparation produces the database for operations; mission planning produces the plan of operations to be executed by mission operations; and the progress of mission operations results in updates to the plan.

The trend towards greater automation in mission operations leads to the introduction of knowledge-based elements. The information to be shared then becomes more complex: instead of being tables, databases, or operating procedures, it becomes facts and rules.

There are a number of considerations with mission operations systems:

- Because such systems are large and difficult to implement, as many components as possible must be re-used to avoid loss of investment.
- The required capabilities change during the working life of the system, for example, as new missions are undertaken, as users' needs change, or as new supporting technology such as platforms or networks is introduced.
- The various applications making up the whole system are frequently inflexible, with, for example, rigid and restricted interfaces between the planning system and the control system, making fast response in the event of failures cumbersome, if not impossible.

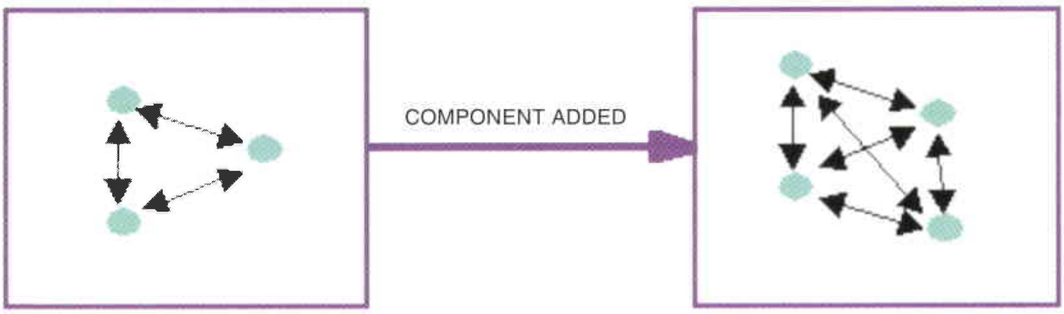


Figure 1. Peer-to-peer communication between software components. The addition of a new component can mean modification of all component interfaces.

- The applications also make use of knowledge or information about the spacecraft, the ground systems and the operational procedures. Parts of this are held centrally, but a significant amount of such knowledge is held locally in the applications themselves, using their own representation or conventions. This leads to potential duplication and inconsistency of knowledge.

These problems demand solutions, particularly since budget restrictions no longer allow the luxury of reimplementing large parts of systems for new missions.

Solution: The ATOS-1 approach

A combination of the following two approaches will aid in addressing those problems:

- Implementation of unified generic components from which specialised application software can be built.
- Use of principles of federation to integrate heterogeneous components into a single system.

Generic systems and components

Generic systems have been used at ESOC for some twenty years in the area of spacecraft control. These have included the Multi-Satellite Support system and, in the 1980s, the first generation of the Spacecraft Control Operations System (SCOS-I). These were table-driven systems, providing the capability to adapt data structures and configurations to new missions. However, changing or adding functionality was always cumbersome.

In the current state-of-the-art, development of generic components or systems follows the object-oriented programming approach to the fullest extent. General classes of objects are defined. The properties of the general classes can then be 'inherited' by more specialised classes/objects adapted for the task at hand. These specialisations may override or add functionality to the parent class or classes. An important feature of this approach, in contrast with the older functional-based software engineering technology, is that the general classes are not modified and a developer wishing to reuse them does not need to understand their internal operations. Only the 'differences' from the general class are implemented in the specialised classes thus reducing the amount of coding. Furthermore, the benefit from the improvement of a class can be passed on to all specialisations of the class (by recompilation) without the need to modify the specialised classes.

The new generation of ESA Spacecraft Control Operations System (SCOS-II) uses the object-oriented technology. In SCOS-II, the basic functions of spacecraft control and monitoring are implemented as an object-oriented class library, from which mission systems can be built. Specialisation to meet mission needs can be provided using 'implementation by difference' based on the aforementioned inheritance property of object-oriented systems. In this way, SCOS-II will in due course provide a very useful set of reusable building blocks for mission control systems.

The generic approach works well in clearly understood and bounded application domains, such as spacecraft control. If it is extended to a large domain, such as the whole of mission operations, however, it breaks down, mainly because of the problem of developing and integrating large generic systems.

Federation
Although development from generic components is a very good approach, the resulting components (i.e. specialist applications) must eventually be integrated. This is not a straightforward task because of, among other reasons, the 'interface problem'.

There is no generic interface mechanism for software components, unlike for hardware components which have the Small Computer Systems Interface (SCSI), for example.

ATOS-1 uses a federation-enabling technology. It simplifies the 'interface problem' by adopting a client-server approach (Fig. 2) instead of a peer-to-peer approach. Each component (or client) has only to provide an interface to the ATOS-1 infrastructure (or server). In effect, this extends the object-oriented philosophy to the level of complete applications by providing a standard interface to them. A developer may use this interface without knowing any implementation details of the other, individual applications. This makes the possible size of software components much larger than that provided by any given set of libraries (libraries contain classes, sub-routines, etc., which are relatively small units of code).

ATOS-1 and mission operations
From the point of view of mission operations, an ATOS-1 system may be seen as a group of applications, known as ATOS Application Modules or AAMs, that share information and communicate with each other to carry out the mission operations tasks. As shown in Figure 3, each AAM has its own knowledge base. The Mission Information Base (MIB) is the union of the knowledge bases of all the individual AAMs. The scope of the MIB is thus very broad and encompasses all available mission-related information, including design information, mission operations schedules, and documentation.

The AAMs, which manage components of the MIB, may be physically distributed, may use different approaches to structuring knowledge

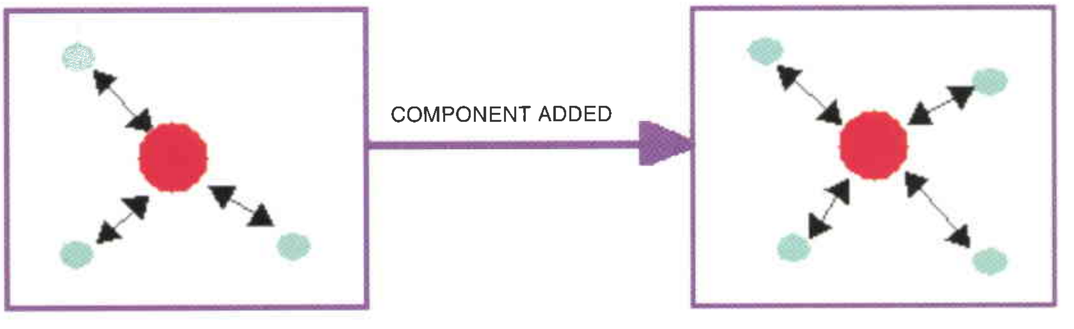


Figure 2. Client-server communication between software components. The addition of a new component means that only the interface with the new component must be provided.

(e.g. relational, object-oriented, or rule-based approaches) and may use different tools for storing and manipulating knowledge.

The ATOS-1 concept: sharing of knowledge between applications

ATOS-1 seeks to provide access to data belonging to applications written in different

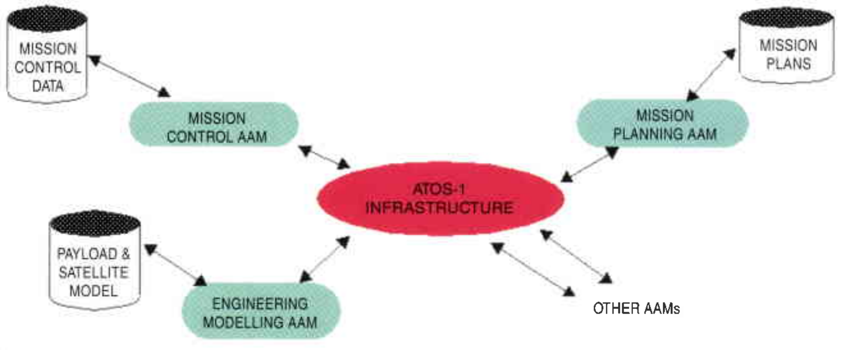


Figure 3. The ATOS infrastructure and ATOS Application Modules (AAMs)

languages and using different storage techniques. To make this possible, the following are necessary:

- A mutual understanding of concepts and technical terms (the ontology)
- A common language for representing knowledge (the Knowledge Interchange Format or KIF)
- Translation capabilities between the common language and internal AAM languages
- A protocol (or packaging) for run-time communication (the Knowledge Query and Manipulation Language or KQML)
- A physical method of transferring messages (the infrastructure).

An exchange of knowledge between two AAMs is illustrated in Figure 4. (This approach and the terms used are derived from the DARPA Knowledge Sharing Effort, funded by the Defence Advanced Research Projects Agency and carried out at Stanford University, USA.)

The ontology of shared knowledge

AAMs must be able to share knowledge. For example, plans, the results of mission planning, are inputs into mission execution; and details of a detected anomaly are used for fault diagnosis. To share the knowledge, AAMs must have a common understanding of concepts and terms. This is provided by the ontology (Fig. 5).

The most basic use of the ontology is as a paper standard where the terms of the problem domain are defined. If there is a standard definition of the terms 'resource', 'schedule' and 'activity', AAMs designed to comply with the standard are guaranteed to use these terms in a common way.

In addition, an AAM's knowledge structures can be automatically derived from the ontology. The ontology is written in a formal language (rather than, for example, in English). It can therefore be translated into the particular computer-processable knowledge structures used by an AAM. This approach gives greater assurance that the AAM complies with the ontology and it can also reduce the effort required to develop the AAM.

Messages

AAMs communicate with each other via the ATOS infrastructure. Communication is performed through messages that are expressed in a high-level message language called Knowledge Query and Manipulation Language or KQML. The content of the KQML message can be in any language that the communicating AAMs understand but will usually be in the Knowledge Interchange Format (KIF). In general, a statement may have different meanings. For example, the statement 'Switch No.1 on' could be a question, 'Is Switch No. 1 on?' or an assertion, 'Switch No.1 is on'. KQML allows the distinction to be made by using the terms 'Query' and 'Assert' respectively. A knowledge interchange interface is added to the applications; it carries out conversion of information between the internal AAM knowledge representation and KIF.

The functions of the infrastructure

The ATOS infrastructure is the 'glue' that binds AAMs: it permits them to exchange knowledge.

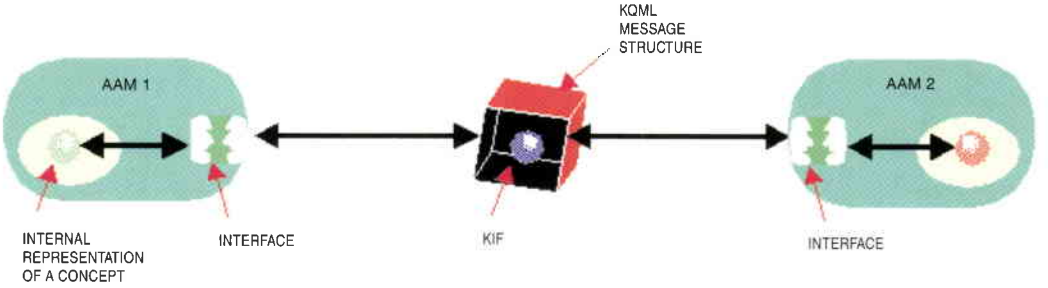


Figure 4. Knowledge sharing with ATOS-1: A concept or technical term, expressed in AAM 1's internal language, is translated into a common language (KIF) so that it can be understood by AAM 2.

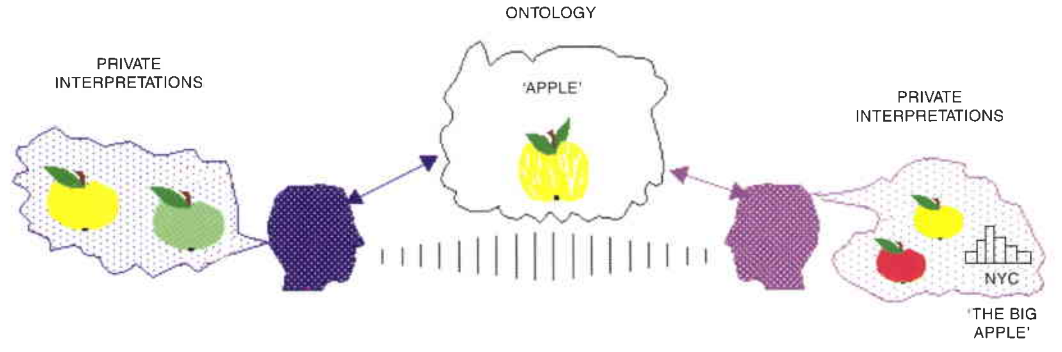


Figure 5. Ontology — an agreed meaning. When two people discuss an 'apple', each person can interpret the word in several ways. One person (on left) understands yellow apples and green apples, while the other person (on right) thinks of yellow apples, red apples and 'The Big Apple', i.e. New York City. The ontology defines the agreed understanding, and all users basing their interpretation on this ontology will understand that the common definition of 'apple' is 'yellow apple'.

The infrastructure 'facilitates' the integration of AAMs by:

- *Routing a message* to the AAM that provides the information or service required by the message. This is known as content-based routing, where the sender does not have to know which AAM will receive the message.
- *Maintaining links* between information items in different components of the MIB.
- *Detecting significant changes* in the state of the MIB and informing the AAMs accordingly.
- *Controlling access* to the information and services provided by the AAMs.
- *Maintaining a timetable* that describes which AAMs can use which services of other AAMs and when. This timetable is updated by a mission planning AAM.
- *Logging messages*, as requested.
- *Buffering messages* before they are read.

Development of prototypes

ATOS-1 is not just a paper study. From the outset, it was planned that prototypes would be developed to prove the feasibility of the concepts and the architecture. The prototypes fall into two categories:

- A prototype of the ATOS-1 infrastructure
- Prototype AAMs that run on the ATOS-1 infrastructure.

ATOS-1 infrastructure

ATOS-1 is intended to run on a network of UNIX workstations where the infrastructure runs on a dedicated machine, as depicted in Figure 6. The database system, Oracle, is used to store the infrastructure information and the metabase. An object-oriented database could also be used for this. Lower-level communication is handled by a simple communications protocol.

Prototype AAMs

In 1992, ESOC undertook a project to determine the feasibility of a modelling approach to spacecraft control. Two contractors, ITV (Karlsruhe) and Siemens (Austria), developed the Automatic Mirror Furnace (AMF) Expert SYStem

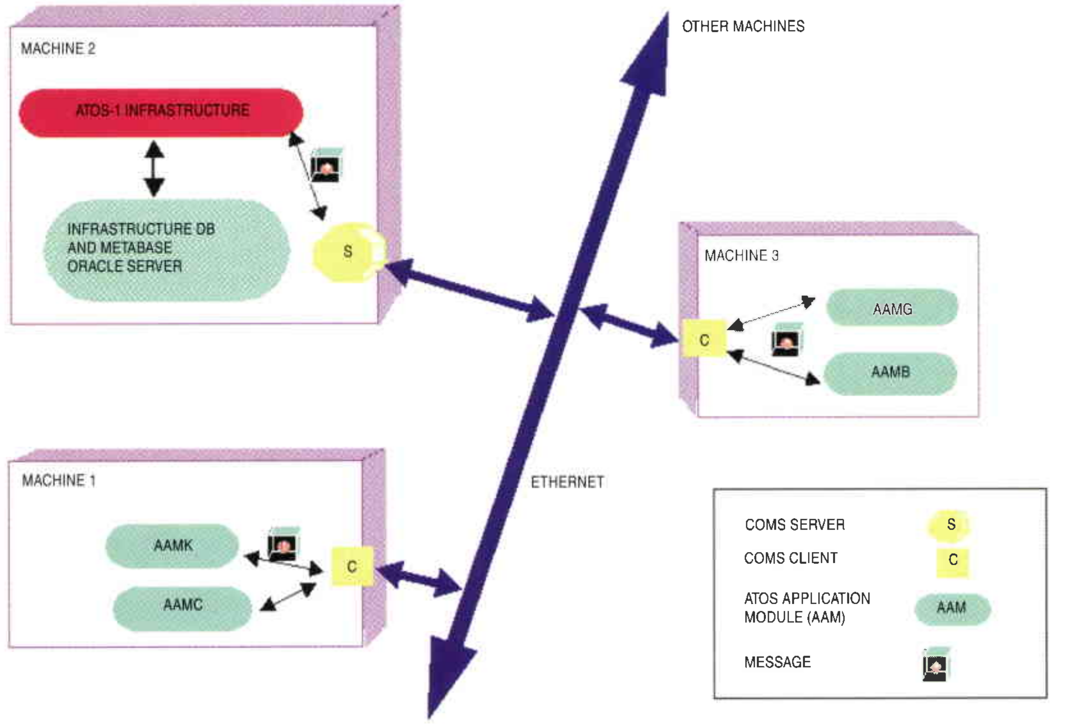


Figure 6. Physical architecture of ATOS-1

(ESYS) for the AMF, the most complex payload on the Eureca satellite. AMFESYS maintains a model of the AMF, time-synchronised with the stream of spacecraft telemetry packets coming from the orbiting spacecraft. The model provides a consistent set of reference 'telemetry-parameter' values that are used to detect abnormal values in the real spacecraft telemetry. Divergence of the modelled state from the spacecraft state are corrected by a rule-based diagnosis module.

The prototype AAMs are derived directly from AMFESYS. It has three parts: a Modelling AAM, a Monitoring AAM and a Diagnostic AAM (Fig. 7). The Modelling AAM maintains a model of the AMF which the Monitoring AAM compares with telemetry from the spacecraft. If a significant discrepancy is detected, the Diagnostic AAM performs a rule-based diagnosis of the fault and then corrects the model.

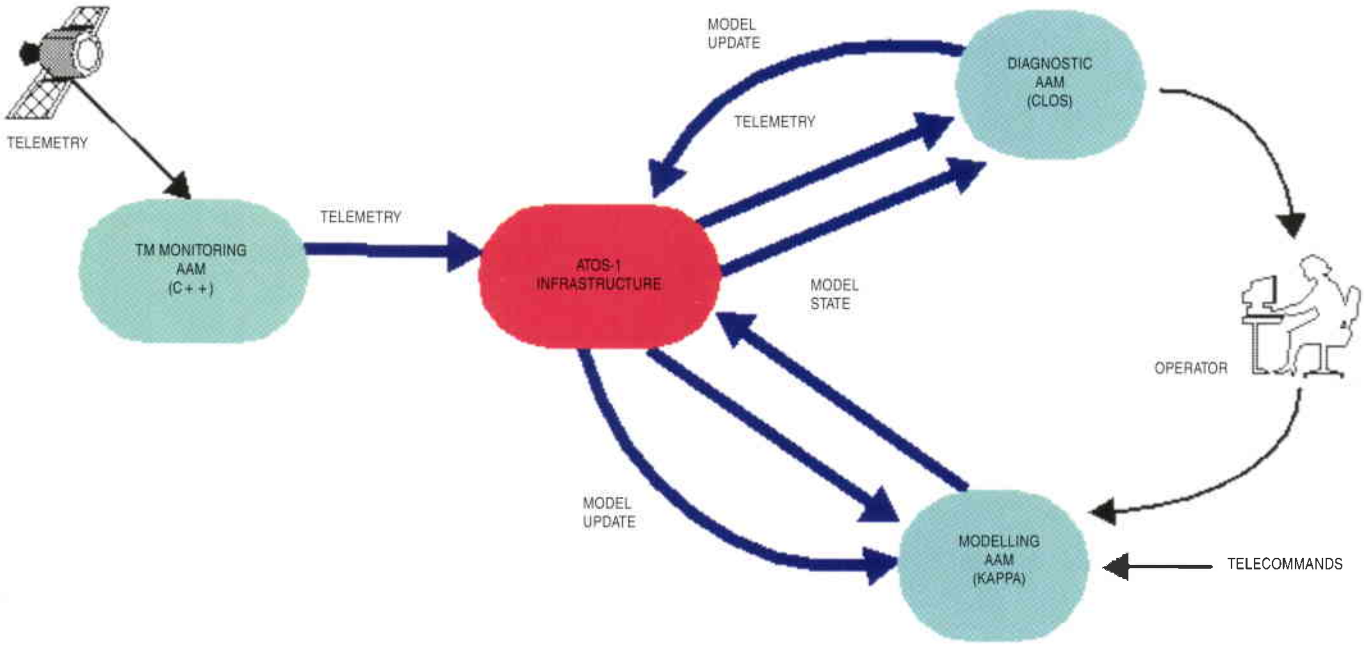


Figure 7. Architecture of AMFESYS, a prototype with three AAMs built to demonstrate the viability of a modelling approach to spacecraft control

Each of the three AAMs uses a different approach to structuring knowledge. C++, Common Lisp Object System (CLOS) and Kappa are used. They interact with each other via the ATOS infrastructure. The ontology defines the structure of the AMF.

ATOS and CORBA
Object inter-operation technologies are currently the subject of much interest, again because of the potential they offer for software re-use and integration. The Common Object Request Broker Architecture (CORBA) is a widely adopted standard in this area and many implementations claim compliance with it. CORBA-compliant systems may be seen as having similar goals as ATOS-1, i.e. to allow multiple applications to share information.

CORBA records the interfaces of the different objects in its system but does not use these to perform content-based routing of messages as ATOS does because, in the classical object model, the identifier of the receiving object must be known before a message can be sent.

ATOS could make use of CORBA as a low-level communications system. This would then yield an Object Request Broker or ORB per machine, which would serve all of the AAMs on that machine. The ATOS infrastructure would run on a machine also accessible through an ORB (Fig. 8).

On the other hand, CORBA does have features that are lacking in ATOS, such as transparent distribution of objects (across a network). It is also an emerging standard for object inter-operability. Combining CORBA and ATOS could be mutually beneficial. However, this would require significant work and, in view of the instability of CORBA (the specification itself is due for a major revision), it is not envisaged for the near-future.

Conclusion
A two-fold approach to the 'software crisis' as it affects the field of mission operations systems, is proposed:

— To build certain generic components
— To allow a federated approach to the integration of applications by use of a common infrastructure (ATOS-1) to allow (indirect) inter-application communication.

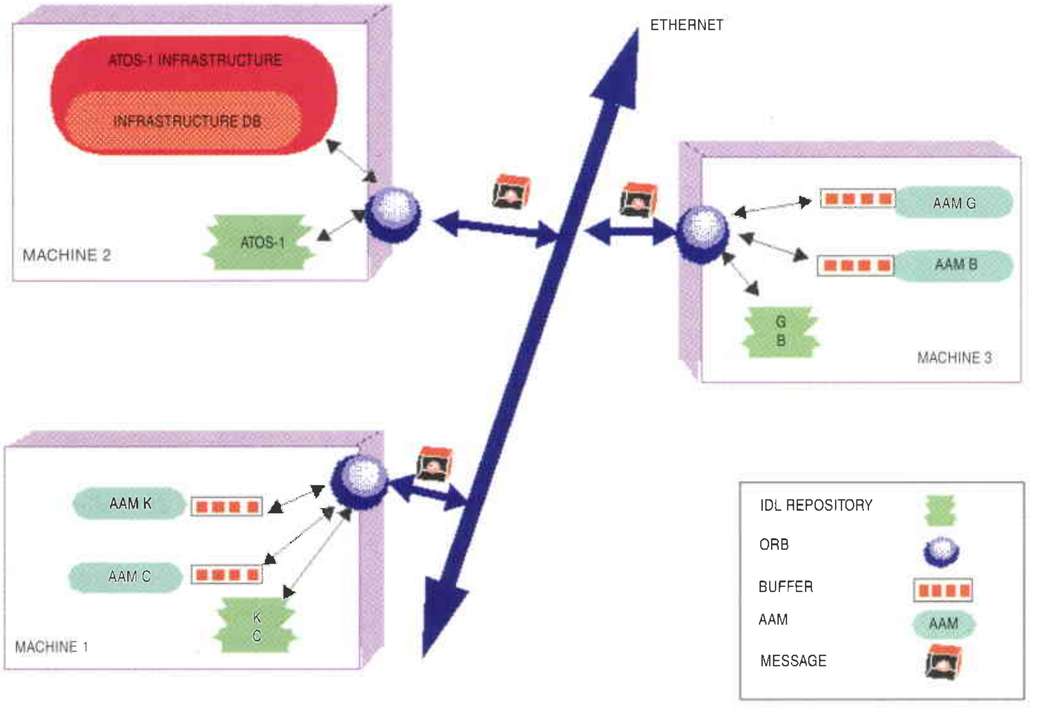


Figure 8. ATOS architecture based on Common Object Request Broker Architecture (CORBA)

Clearly, if the AAMs themselves are generic in their own domains, this combined approach has great power.

During the ATOS-1 project, prototypes of critical elements of the ATOS infrastructure were made. Prototypes of three AAMs have been developed to demonstrate the viability of a system constructed according to the ATOS philosophy. Furthermore, an Architectural Design Document for the full infrastructure has been written and formally reviewed.

The complementarity of the ATOS-1 integration approach with that of another standard, CORBA, has been discussed and the two approaches could be combined to exploit their individual strengths.

The work undertaken as part of the ATOS-1 study may have benefits not only in the space industry but in any application area where there is a need to integrate disparate software components in the building of complex or large systems. Such integration could allow greater re-use of complex components, leading to cost savings as well as more powerful and automated systems.

The ATOS-1 study will be completed in the fourth quarter of 1994. The next slice, ATOS-4 (also funded by ASTP), will begin at about the same time. In that study, an operations system will be developed using the ATOS-1 prototype infrastructure and the SCOS-II spacecraft control infrastructure. ATOS-4 will, in particular, seek to demonstrate the validity of using knowledge-based and other advanced technology in an operational environment.

Acknowledgements
This work was funded by ESA's Advanced Systems and Technology Programme (ASTP) which is managed by ESA's Directorate of Telecommunications. ASTP promotes the development of new technologies for the space domain, with the aim of helping European industry to develop marketable products based on these technologies. The ATOS-1 project was carried out by a consortium composed of Logica UK Limited, GMV (Spain) and SAS (Belgium).

High-Temperature Insulations

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When a high-speed vehicle flies in a planetary atmosphere, kinetic energy is dissipated in the form of heat. Thermal-protection concepts which involve re-radiating a major amount of this aerothermal heat to the environment depend on stable, high-emittance surfaces in combination with highly efficient thermal insulation. In recent years, considerable progress has been achieved in Europe in the field of flexible external insulations and high-temperature multilayer insulations.

Introduction

The dissipation of the kinetic energy of atmospheric entry or from vehicles flying hypersonically results in significant aero-thermodynamic heating of all external vehicle surfaces. Typically, the maximum heating rates of vehicles ascending or returning from low Earth orbits remain below 1 MW/m^2, whereas for lunar return or some planetary missions such levels are greatly exceeded.

To maintain appropriate temperatures for equipment, payloads and structures in this hostile thermal environment, an efficient Thermal Protection System (TPS) is required. In practice, two fundamentally different concepts are applied:

- Ablators swallow a considerable fraction of the penetrating heat pulse by means of endothermic chemical decomposition of the material, and eventually via phase changes. As a result of this process, the major part of the virgin thermal-protection material is transformed into char, and only a small residual part insulates the space vehicle from the hot char. The aerodynamic surface shape might be affected by ablator shrinkage (caused by spallation or other erosion mechanisms) or by char swelling. Such shape changes and the temperature range of application depend on the main plastic constituents, the reinforcement and the aerothermodynamic environment. As an example, arc-jet tests showed no surface recession of AQ60 (selected for the Huygens Titan entry probe) up to 1 MW/m^2. Such surface stability is produced by the silica fibre reinforcement of the ablator, because the phenolic resin matrix decomposes already below 800°C.

- Re-radiative thermal-protection systems were primarily developed for extended flight durations. Thus, their insulating capability must be better than those of ablators and their surface must maximise the re-radiation of the incident aerothermodynamic heat to the atmospheric environment. Such concepts can be realised either as high-temperature insulations more or less directly exposed to the hot airflow, or as thermal insulations covered by some high-temperature structural material, a solution that avoids direct exposure of the insulation to the airflow. Exposure to the airflow implies more stringent structural-integrity needs for the insulation. Re-radiative thermal-protection systems maintain their aero-dynamic shape.

This article focuses on high-temperature insulations used in re-radiative TPS concepts, and reports on their current development status in Europe.

Review of high-temperature insulations

Re-radiative thermal-protection systems are primarily applied on reusable vehicles. Depending on the expected temperature levels, two basic material systems are used for the TPS of the US Space Shuttle Orbiter, as well as for Russia's 'Buran' spaceplane:

- Reinforced Carbon-Carbon (RCC or C/C) is used at all locations where the predicted surface temperatures exceed 1260°C, i.e. for the nose cap and the leading edges of the wings. The colder aluminium airframe behind the RCC nose cap and leading edges is protected by means of silica/ceramic-fibre insulations against the heat originating from these hot structural elements.

- The Reusable Surface Insulation (RSI) is applied to most of the surface where the predicted temperatures are lower. The RSI usually consists of rigid ceramic tiles or flexible blankets.

The rigid tiles are made from high-purity (99.8%) silica fibres, which are rigidly interconnected in a high-temperature sintering process. Tiles with densities of 144 and 352 kg/m^3 have been realised. The exposed tile surface is covered with a thin glassy coating, which is black for the space vehicle's hottest areas and white elsewhere. This coating extends to tile surfaces in the gap between the tiles, thereby leaving only a small tile area uncovered. The tiles are bonded via a layer of nylon felt to the aluminium airframe with a silicone adhesive. The nylon felt acts as an elastic strain-insulation pad.

The flexible blankets (FRSI) were originally made from a Nomex felt. A white silicone elastomer coating provided the required thermo-optical properties and the water-proofing. The blankets were bonded directly to the aluminium airframe with a silicone-based adhesive.

More than 60 successful Orbiter flights and the Buran flight have validated this thermal-protection concept. The RSI has evolved during its use on the Shuttle. Firstly, rigid ceramic tiles with greater mechanical strength and higher application temperatures were developed, by adding alumino-boro-silicate fibres to the silica fibres before the sintering step. Secondly, advanced flexible blankets (AFRSI) have been realised by replacing the Nomex felt by a silica felt. The thermal endurance was significantly enhanced in this way, from 370 to some 650°C. The AFRSI blankets replaced the original rigid tiles for large leeward surface areas of the Orbiter, resulting both in reduced fabrication/ installation time and costs, and lower TPS weight.

The recent Japanese OREX-capsule flight also used re-radiative thermal-protection techniques, with rigid ceramic tiles for the front shield, C/C for the nose cap, and C/C shingles covering a high-temperature ceramic-fibre insulation elsewhere (Fig. 1).

One of the major goals of the OREX flight was the experimental validation of TPS materials and constructions for later application on the planned Japanese spaceplane. However, as a spin-off, it demonstrated in addition that re-radiative TPS could be applied on capsules returning from low Earth orbit. Such alternatives to ablative solutions were proposed by NASA/JSC for the Assured Crew Return Vehicle (ACRV), and are also being studied by ESA.

Another benefit of the OREX flight was its feasibility demonstration of an advanced RSI concept with C/C shingles covering a high-temperature insulation. Such an approach, but with C/SiC shingles and ultra-lightweight insulation packages, was investigated by analyses and ground testing in the framework of ESA's Hermes development programme. Known

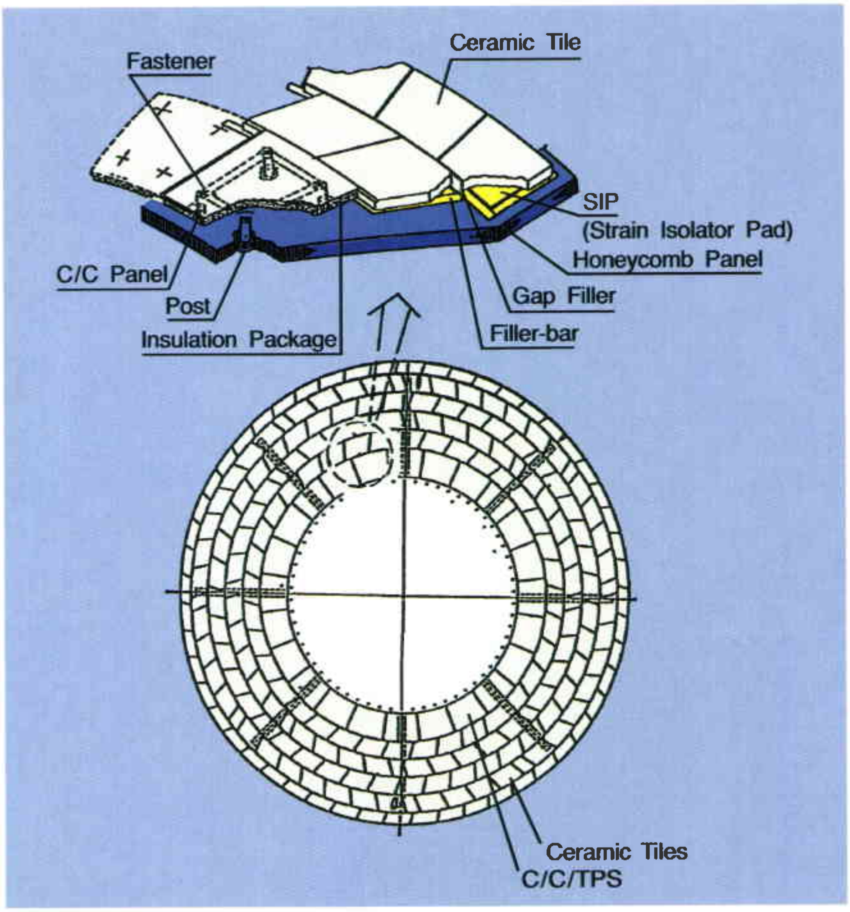


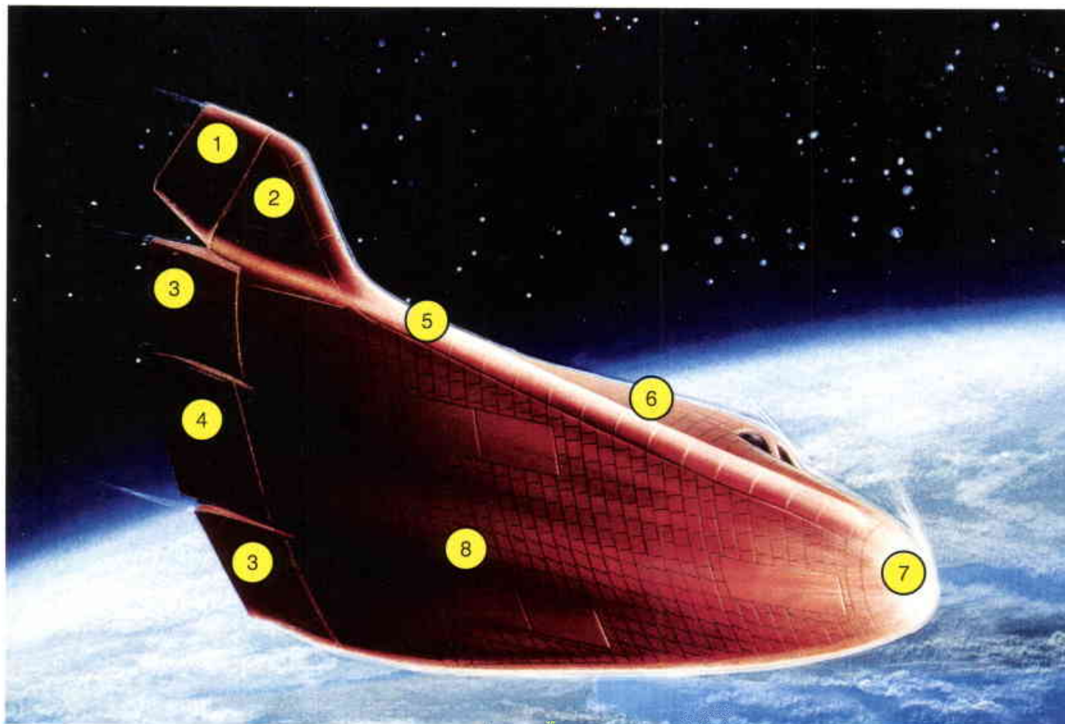
Figure 1. OREX thermal-protection concept (courtesy of NASDA)

as 'Rigid External Insulation' (REI), it was considered for the European spaceplane's lower surface and for the cabin region (Fig. 2).

During trade-off and development studies, it was found that high-temperature multilayer insulations – also known as Internal Multiscreen Insulations (IMI) – provide the most thermally efficient high-temperature insulation package beneath the C/SiC shingles.

IMI-type insulations promise an evolutionary improvement in the high temperature insulation package between C/SiC shingles (or other hard covers) and the aluminium primary structure. The reason is that heat transfer by radiation

Figure 2. Hermes' thermal-protection architecture



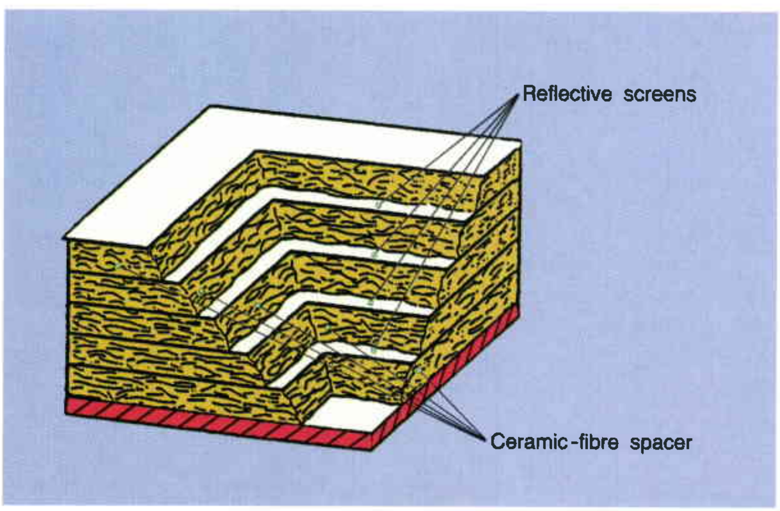


Figure 3. High-temperature multilayer insulation concept

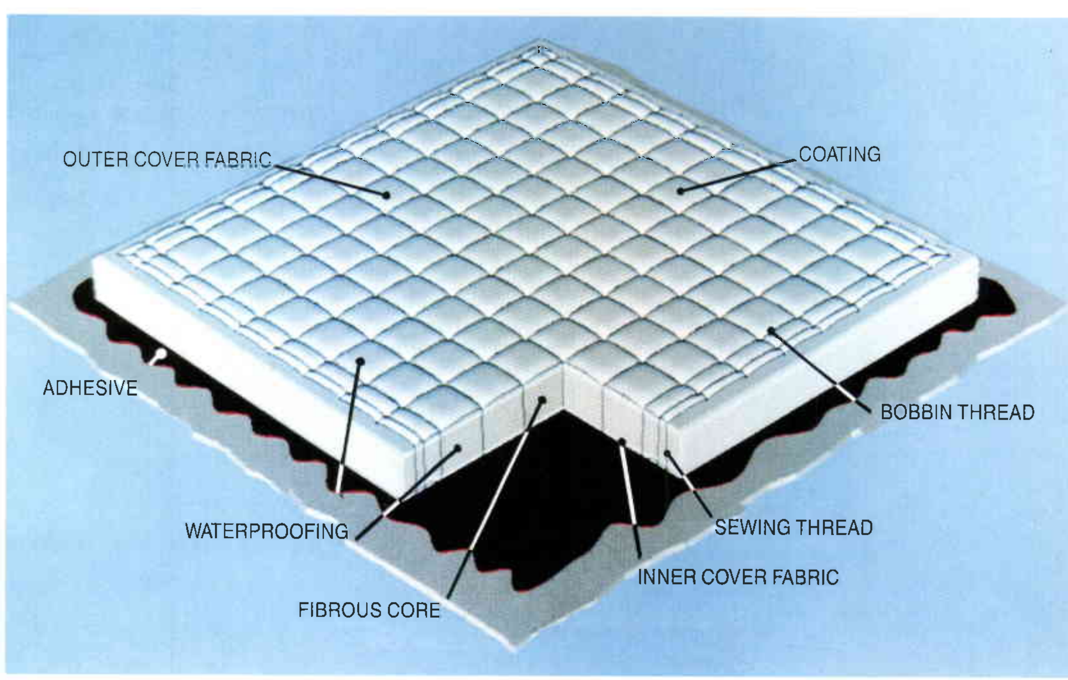


Figure 4. Concept of a flexible microfibre insulation blanket

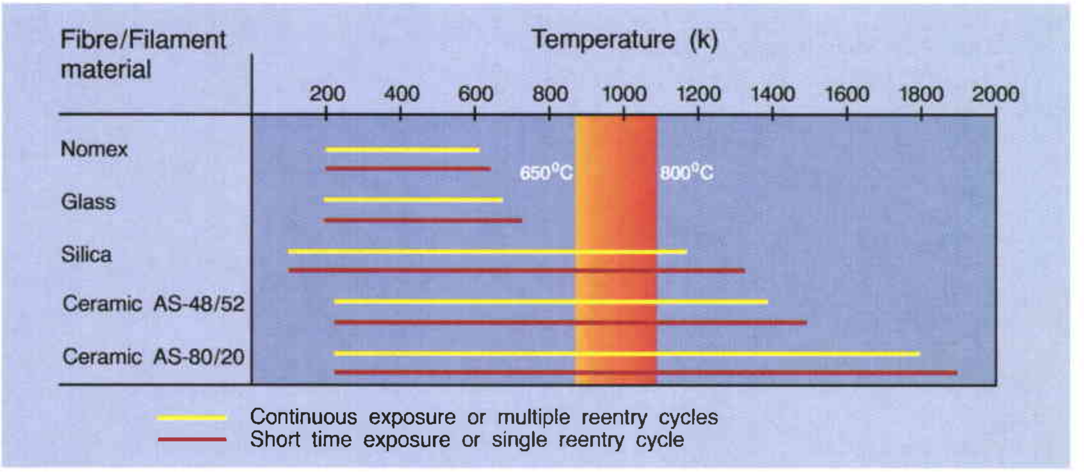


Figure 5. Material/ component selection guide

becomes dominant in low-density ceramic-fibre insulations above some 600°C. Therefore the implementation of reflective screens (Fig. 3) produces a strong reduction in heat radiation. The IMI concept relies accordingly on a core of stacked reflective foils separated by low-density ceramic-fibre fleeces. For handling purposes, the core might be enclosed in a bag, which consists of ceramic fabric if the IMI cannot be integrated directly with the shingle.

The Hermes-driven high-temperature insulation development effort also included use of the Flexible External Insulation (FEI) concept for large areas of the spaceplane's leeward surface. FEI thermal protection is an assembly of quilted blankets that are bonded to the substructure of the spaceplane or capsule by a silicone adhesive. As shown in Figure 4, each individual blanket is composed of a silica-fibre-fleece insulation core, embedded between outer silica-/ABS- and inner glass-fabrics and fixed by a square sewing pattern. Silica-, ABS- or glass-threads are used to realise this sewing pattern.

The FEI is quite similar to the AFRSI which has already performed well on the leeward surfaces of the Shuttle Orbiter and on Buran. Several US and European studies identified that flexible external insulations could also be applied to the rear sides of expendable capsules.

In the following, the development status of both high-temperature insulations – FEI and IMI – is described in more detail.

Developments in external flexible insulation

The expected temperature range to be endured provides the first criteria for the selection of materials/components (Fig. 5). Products made from S-glass can be applied up to 380°C. In the temperature range between 380 and 800°C, silica fibres, threads and fabrics are preferred due to their favourable low density and low thermal conductivity. For temperatures beyond 800°C or in contaminated environments, other ceramic materials are a better choice. As a general rule, the temperature durability increases with the alumina content of the fibre, thread or fabric.

Extensive characterisation testing for threads and fabrics has demonstrated the superiority in strength terms of ABS material for temperatures above some 500°C. However, their thermal properties are inferior to those of silica products, and consequently it was confirmed that silica-based products provide the best compromise up to some 700°C under moderate mechanical loads.

The thermal-insulation function is dominated by the microfibre insulation core. The total heat transfer in this core consists of heat radiation and conduction both by the enclosed gas and by the fibres. However, for the core densities envisaged (80 – 120 kg/m^3), the conduction via the fibres is almost negligible. The core's resistance to radiative heat transfer depends on fibre diameter, material and orientation. Silica fibres of roughly 2 microns diameter would provide maximum

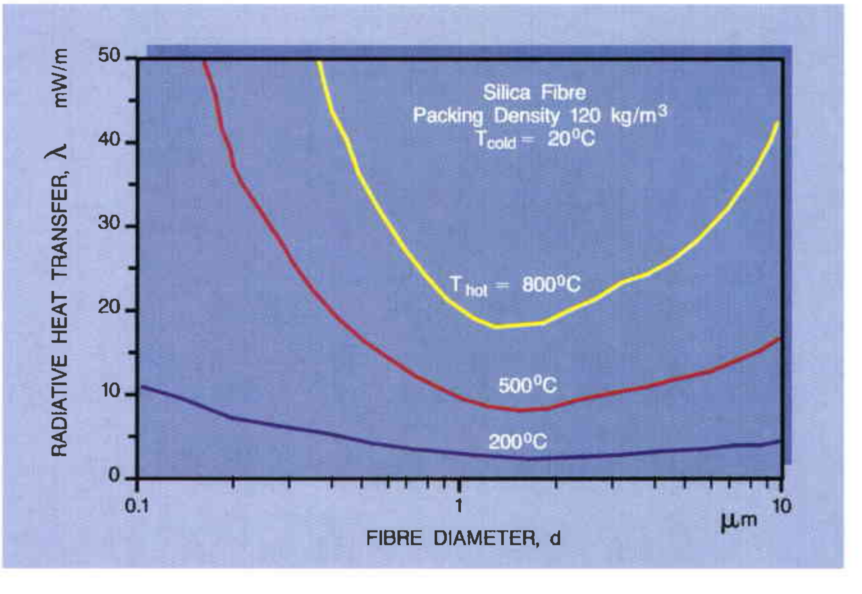


Figure 6. Mass-related resistance to heat radiation as a function of the diameter of the fibres used for the blanket's core

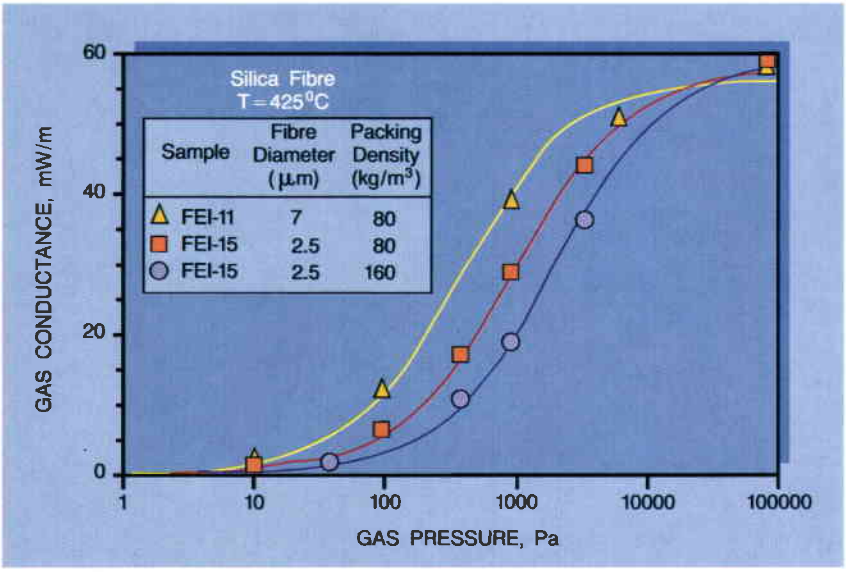


Figure 7. Gas conductance as a function of pressure

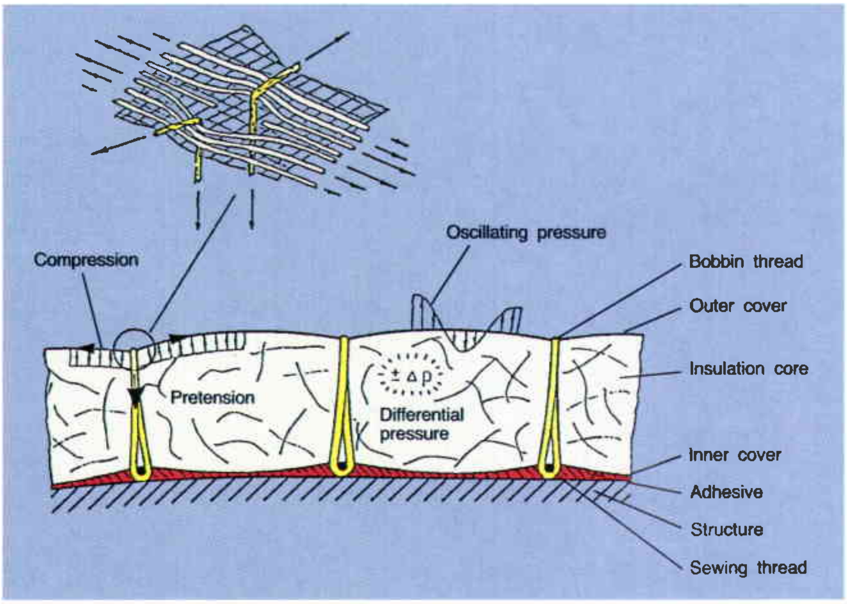


Figure 8. Schematic of the structural load system

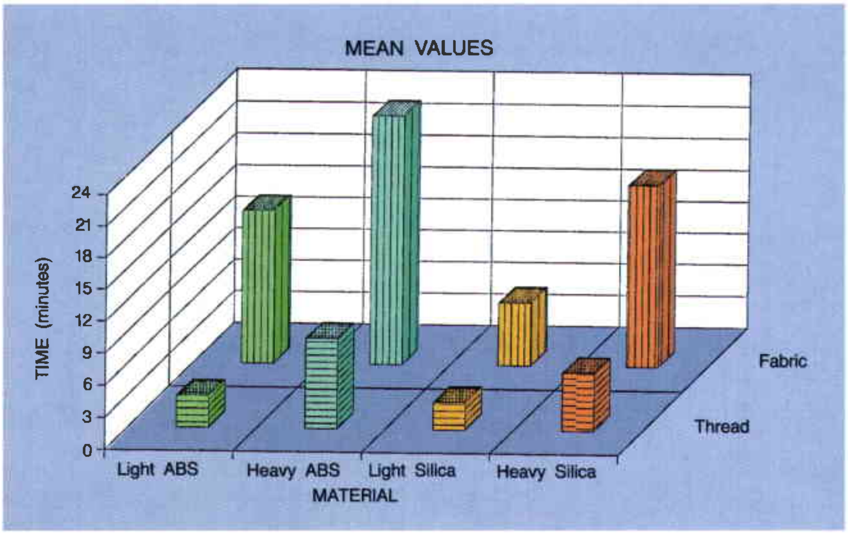


Figure 9. Acoustic performance as a function of component material (time to first failure at 168 dB)

resistance (Fig. 6). In practice, silica fibres in the 2 – 3 micron and around 9 micron size range are easily available from suppliers.

For capsule applications, alumina-based fibres could become necessary. Such fibres are available with diameters of 3 to 5 microns.

In Figure 7, the theoretical contribution of the gas conduction in different fibre fleeces is compared with experimental values at different gas pressures. Generally, it falls dramatically with reduced pressure. Again, 2 micron fibres are found to be thermally more effective.

As the FEI forms the outer surface of the re-entry vehicle, it is exposed to dynamic forces from static pressure, aero-acoustics and aero-elastic loads (Fig. 8). The bobbin threads and the outer fabric are obviously the most heavily loaded elements in this application.

In view of the fatigue behaviour, it is considered favourable to keep the bobbin thread under tension load at all times. This is achieved by compressing the insulation core to the specified density during the manufacturing process. The resulting compression stiffness of the core and the membrane stiffness of the outer fabric are the major parameters affecting the response to dynamic excitations.

During FEI blanket development, problems with fatigue under high acoustic loading (OASPL 168 dB) had to be overcome. The first blankets failed under long-duration acoustic loading caused by breakage of the sewing threads. Selection of more suitable ABS materials (Fig. 9) for blankets exposed to the highest mechanical loads has allowed them to sustain these extreme loading for more than 15 min, which exceeds the envisaged cumulative acoustic exposure time for the spaceplane's design life of 30 flights.

The low emissivity of the outer fabric would result in unfavourable external surface temperatures during re-entry.Therefore, a thin high-emissivity, low-catalycity coating is applied, which also improves the fabric's erosion resistance.

By employing all of the material components and developments mentioned above, medium-sized blankets with good performances can now be manufactured in varying thicknesses by DASA in Germany (Fig. 10).

Developments in high-temperature multi-layer insulation

Returning to the design concept presented in Figure 3, silica- or alumina-based fibres can be chosen for the spacer fleece between the reflective foils depending on the temperature range to be endured. The C/SiC shingles provide mechanical protection against the airflow. Consequently, one can choose fleeces with a much lower density for the IMI than for the FEI.

The thermal-improvement potential of IMI-type products is illustrated in Figure 11, where the radiative 'conductivities' of an IMI-type insulation (density around 35 kg/m^3) and a conventional high-performance fibre felt (100 kg/m^3) are compared, with the thermal conductivity of air as a reference. Above some 600°C, the thermal conductivity of the IMI-type insulations is lower than those of conventional fibre felts. In addition, the IMI-type insulation's mean density is much lower. Thus the product $\lambda.\rho$, commonly taken as a measure of an insulation's thermal efficiency, is lower over the whole temperature range.

IMI-type insulations can be tailored for a wide range of transient re-entry load cases by judicious choice of the spacer density and number of screens. Quite a high number of reflective screens is required for low-density spacer felts, which implies a need for lightweight screens. These could take the form of noble-metal-coated ceramic substrate foils, made from short-alumina-fibre reinforced alumina.

Attention has to be paid during foil manufacture to the development of procedures that minimise surface micro-cracking. Foil masses range between 30 and 45 g/m^3, depending on the surface-quality requirements. The impressive flexibility of the finished product (Fig. 12) greatly facilitates the assembly of the IMI package.

Gold and platinum were selected as the base materials for the reflective coatings. To stabilise the noble-metal films against agglomeration at high temperatures, diffusion-blocking coatings are applied. Gold is totally resistant to high-temperature oxidation and very low emissivities have been measured (Fig. 13), but its applicability is limited to about 1000°C. Platinum coatings show slight oxidation at the highest temperatures but, due to the volatility of the oxides, no surface contamination occurs. Their maximum utilisation temperature is therefore around 1450°C for long-term applications, and even higher for short exposure times.

Compressed low-density spacers tend to exhibit strong creep behaviour at high temperatures. Procedures have been developed in Europe that significantly reduce this effect (Fig. 14), which would otherwise lead to plastic deformation of the IMI after just a few reentry flights. Mechanical

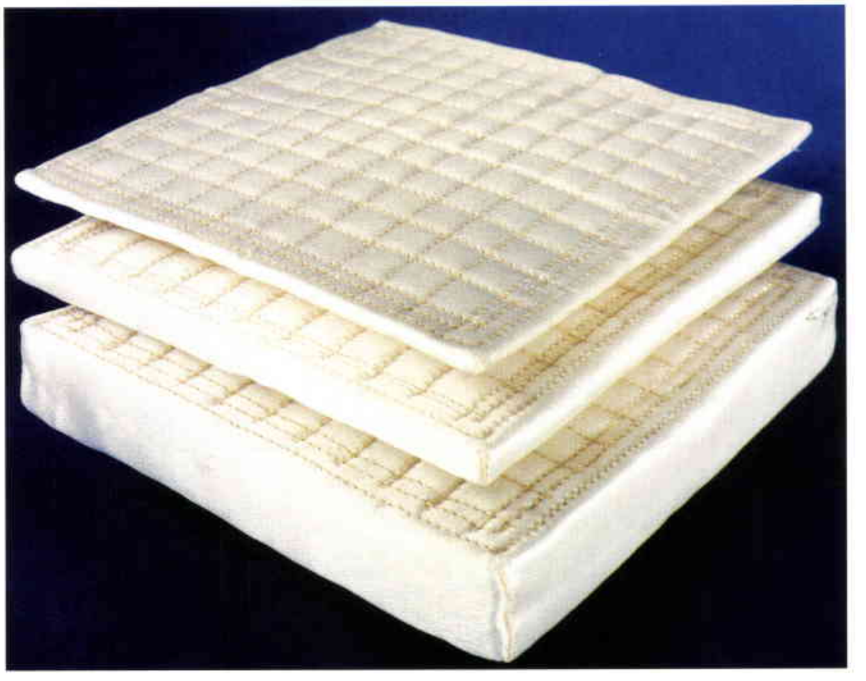


Figure 10. Flexible External Insulation (FEI) blanket sample

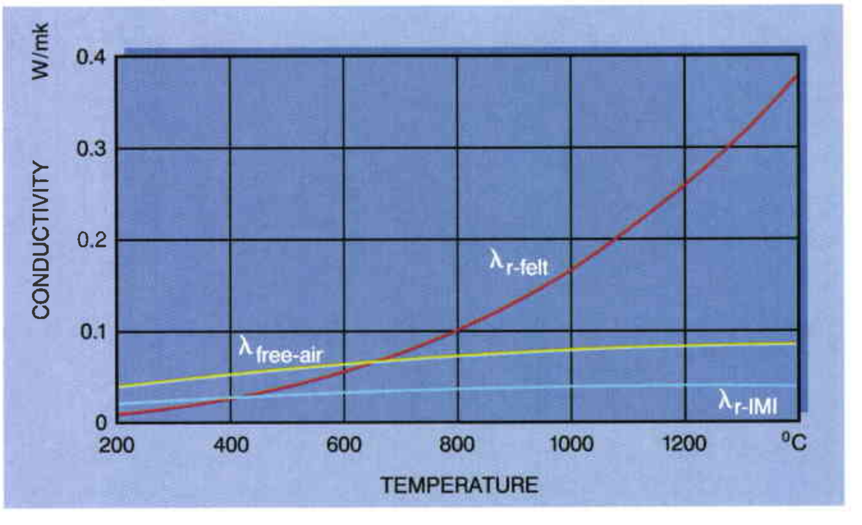


Figure 11. Conductivities of felt- and IMI-type insulations as a function of temperature

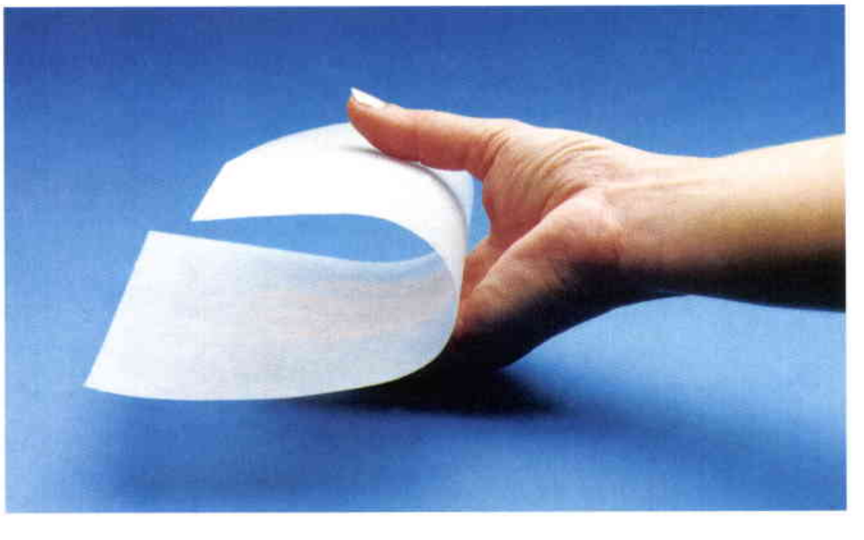


Figure 12. The ceramic substrate foil after firing

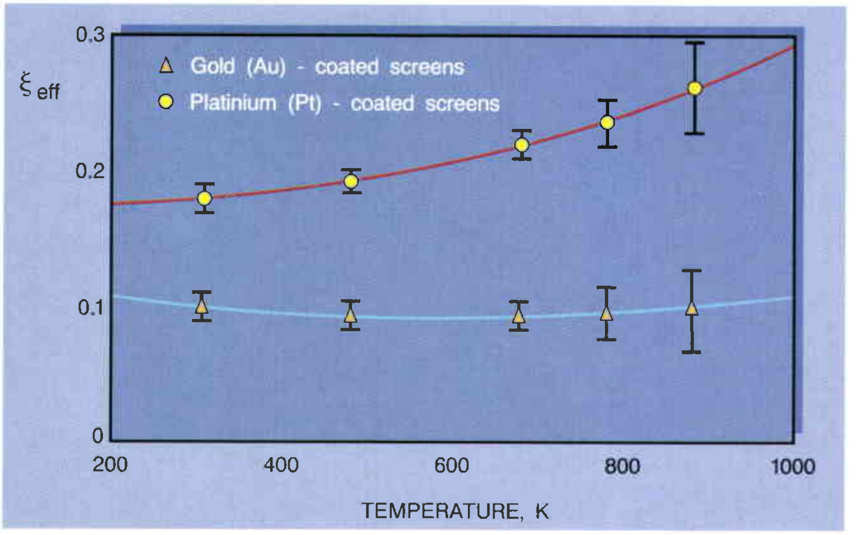


Figure 13. Effective emissivities of gold- and platinum-coated screens (measured at ZAE in Würtzburg, Germany)

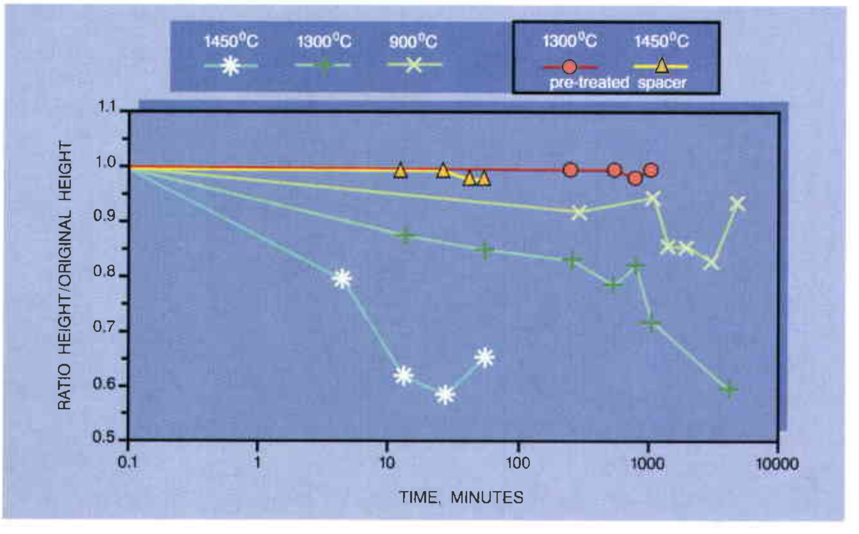


Figure 14. Spacer resilience as a function of mechanical loading before and after manufacturing improvement

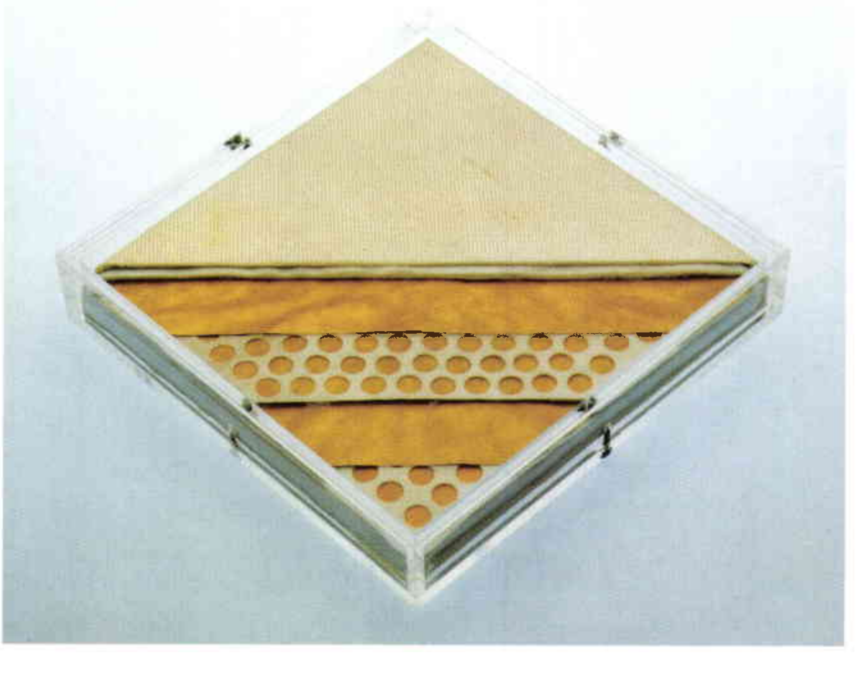


Figure 15. High-temperature multilayer insulation demonstration sample

testing has demonstrated the very favourable damping behaviour of the IMI and shingle/IMI systems when exposed to acoustic loads.

All in all, the manufacture of IMI packages has been well-mastered in Europe, by MAN. Figure 15 shows the various elements in such a modern sample of high-temperature multilayer insulation.

Conclusion

High-temperature insulation for space vehicles has made enormous strides over the last few years thanks in large part to the efforts of European industry. Both FEI- and IMI-type insulations have been extensively ground-tested and can thereby be considered 'pre-qualified' for a spaceplane-type application and are reusable for several missions.

Both types of insulation have been 'mastered' to the extent that they can now be tailored to different hypersonic flight environments. Enhancement of FEI insulations for still-higher temperature applications and their potential use for capsules is presently being investigated in the framework of ESA's MSTP technology programme. NASA is currently investigating the potential of IMI insulations for its Delta-Clipper re-usable launcher.

Responsabilité juridique internationale et activités de lancement d'objets spatiaux au CSG

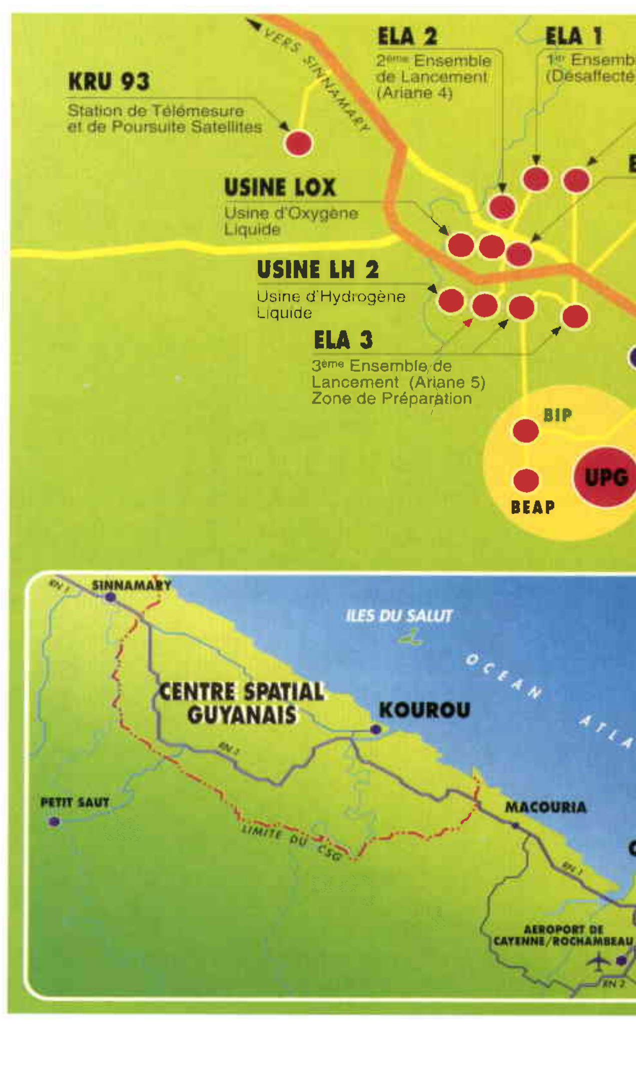
G. Lafferranderie, Conseiller juridique, ESA

... 3, 2, 1, 0, mise à feu! Le compte à rebours est terminé, l'angoisse commence, une immense lueur dessine la forêt guyanaise, un grondement assourdissant, le sol se met à trembler. Ariane s'élève lentement. Des milliers d'ingénieurs l'ont dessinée, ont mis au point des pièces infimes et décisives; la volonté politique l'a portée, ... et quelques juristes devant une feuille blanche ont lancé des formules, prévoyant divers cas de figure, y compris en matière de responsabilité pour dommages — mieux vaut ici aussi prévenir que guérir. La découverte, c'est aussi la complexité juridique d'un lancement. Les étages d'Ariane ont été acheminés jusqu'au Port Spatial de l'Europe que le visiteur du début des années 1970 a du mal aujourd'hui à reconnaître.

Le lanceur est érigé, vérifié; le ou les satellites passagers également testés dans l'EPCU (ensemble de préparation des charges utiles) sont placés sous coiffe, encore des essais, le lanceur rejoint la zone de lancement, etc. Je ne vais pas vous décrire toutes ces opérations. J'espère que vous arriverez à reconnaître sans mon aide les équipes du CNES, d'Arianespace, des clients, les industriels responsables du lanceur, ceux qui veillent sur le satellite, les quelques représentants de l'ESA sur le site dont les cheveux blanchissent au vue de toute cette agitation qu'il faut coordonner. A-t-on les liaisons avec Natal, Ascension et Libreville? Ne croyez pas que le juriste ne soit pas saisi lui aussi d'une certaine fébrilité. Il jette encore un oeil sur sa collection de textes fondamentaux, Accords, Résolutions, Déclarations, se remémore les interprétations, ad referendums, des uns et des autres.

Décollage, Ariane s'élève, prend de la vitesse suivie par les radars. Séparation des propulseurs d'appoint, du 1er étage, de la coiffe, du 2ème étage, 3ème étage, satellisation — une explosion, mais de joie (ce ne fut pas toujours le cas). Voilà, le CSG a bien rempli son rôle une fois encore; le juriste range ses textes fondamentaux.

Avant d'analyser les multiples textes juridiques qui interviennent dans cette construction, un mot sur le CSG, Port Spatial de l'Europe et sur les activités de lancement. Un lancement c'est d'abord un ensemble constitué d'une zone de lancement et d'installations-sol, de préparation du lanceur et des satellites. Le département français de la Guyane a été retenu comme site de lancement en raison d'un certain nombre d'avantages comme la proximité de l'équateur qui permet de profiter de la vitesse de rotation de la Terre et de réduire les manoeuvres en orbite, d'où un gain de poids et un allongement de la durée de vie du satellite; l'ouverture sur l'océan réduit les risques en cas de retombée et permet les lancements sur un large éventail



d'azimut (du Nord à l'Est); l'absence de cyclones et de tremblements de terre. Le site retenu en 1964, opérationnel en 1968 a vu d'abord l'installation par le CNES d'un pas de tir Diamant et de fusées-sondes puis d'Europa, la fusée développée par le CECLES/ELDO. Le CSG c'est aussi une surface de 900 km^2 avec 50 km de côtes, un effectif de quelque 1100 personnes.

La Figure 1 illustre l'implantation des divers moyens au CSG. A l'intérieur du périmètre du CSG a été créé par un Accord avec l'ESA sur l'ancien site de la base de l'ELDO, l'ensemble de lancement Ariane (ELA). Dépendantes de l'autorité fonctionnelle et opérationnelle du CSG mais extérieures, nous trouverons d'autres installations soit sur territoire français soit sur territoire non français, les stations aval (Fig. 2).

Actuellement les activités du CSG sont totalement axées sur le programme Ariane:

- l'ESA est propriétaire des installations de production, de préparation et de lancement (ELA et EPCU) et conduit les lancements de développement;
- la commercialisation, la production opérationnelle et les lancements opérationnels sont de la responsabilité de la société Arianespace, société privée de droit français, créée en 1980, qui exploite et maintient les installations de lancement (ELA, EPCU) mises à sa disposition par l'Agence;
- le CNES met en oeuvre les moyens techniques et logistiques du CSG nécessaires aux lancements (de développement ou opérationnels), assure leur maintenance et a la responsabilité globale de la sauvegarde et de la sécurité du Centre.

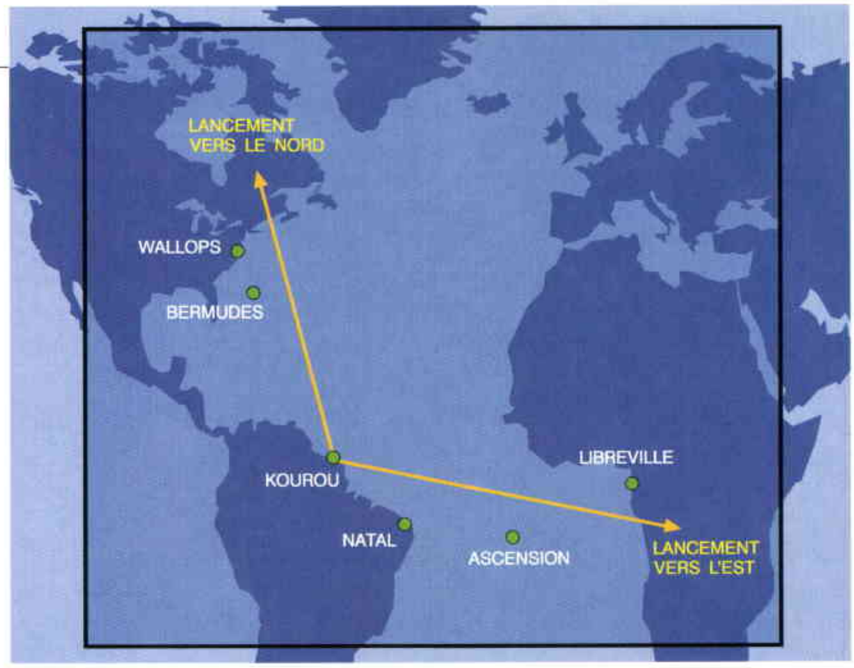


Figure 2

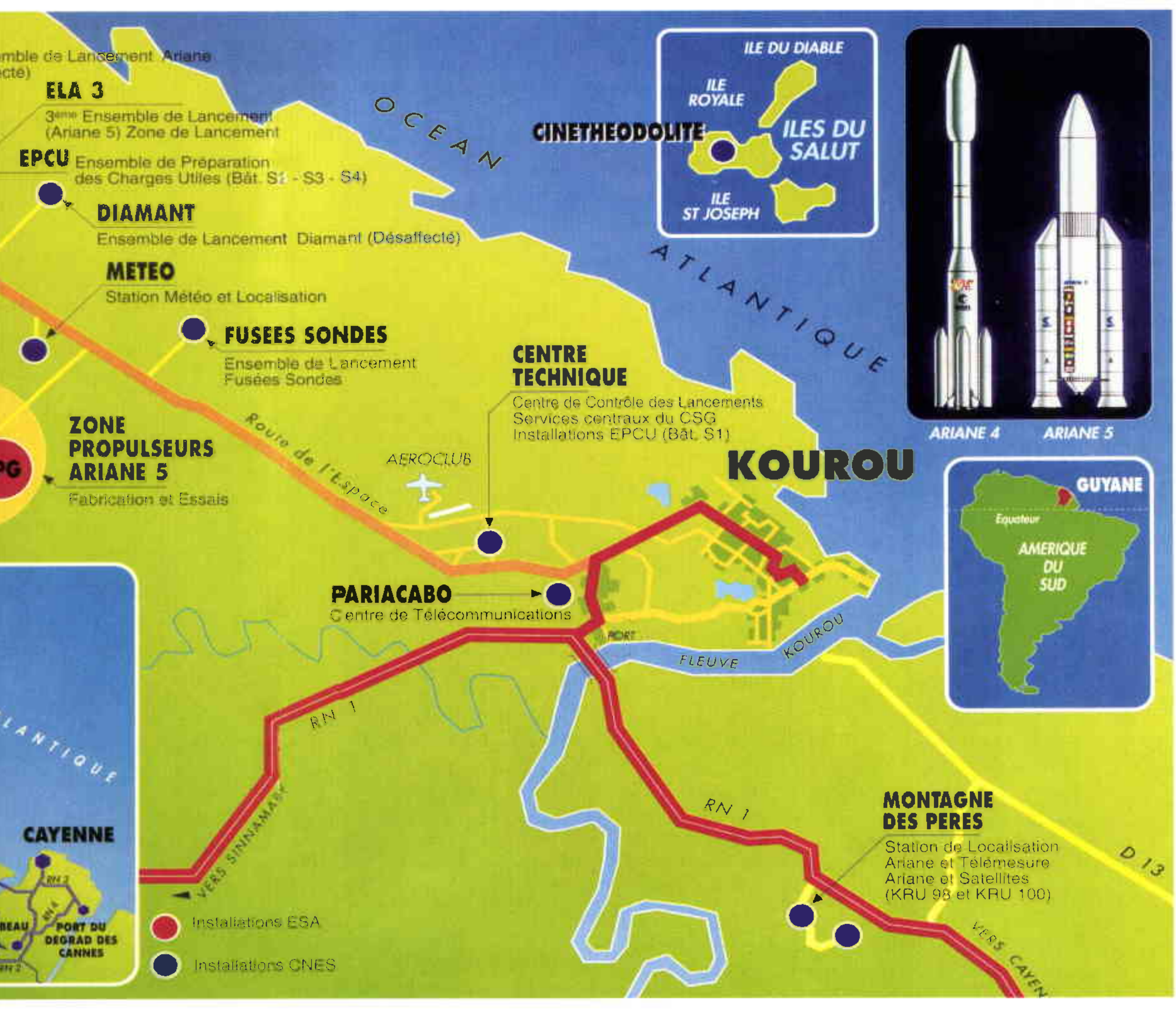


Figure 1

Nous verrons tout d'abord les grands principes en matière de droit international pour dommages causés par les objets spatiaux puis la façon dont ces principes sont distribués entre les divers acteurs*.

I — Les grands principes du droit de l'espace

A. Le Traité sur l'Espace

La pierre angulaire du droit de l'espace et des activités spatiales est constituée par le Traité sur l'espace extra-atmosphérique, la Lune et les autres corps célestes *(le Traité sur l'Espace)* mis au point dans le cadre des Nations Unies.

L'article VII du Traité sur l'Espace entré en vigueur le 10 octobre 1967 énonce le principe de base suivant:

'Tout Etat partie au Traité qui procède ou fait procéder au lancement d'un objet dans l'espace extra-atmosphérique, ... et tout Etat partie dont le territoire ou les installations servent au lancement d'un objet, est responsable du point de vue international des dommages causés par ledit objet ou par ses éléments constitutifs, sur la Terre, dans l'atmosphère ou dans l'espace extra-atmosphérique, ... à un autre Etat partie au Traité ou aux personnes physiques ou morales qui relèvent de cet autre Etat'. La responsabilité de droit international (liability) est attribuée par le Traité à l'Etat.

Il ne faut pas omettre de rapprocher pour disposer d'une vue d'ensemble, l'article VI du même Traité au titre duquel *'des Etats parties au Traité ont la responsabilité internationale des activités nationales dans l'espace extra-atmosphérique, ..., qu'elles soient entreprises par des organismes gouvernementaux ou par des entités non gouvernementales et de veiller à ce que les activités nationales soient poursuivies conformément aux dispositions énoncées dans le présent Traité ...'.*

Quelle place est faite aux Organisations internationales? Selon l'article XIII *'Les dispositions du présent Traité s'appliquent aux activités poursuivies par les Etats parties au Traité ... que ces activités soient menées par un Etat partie au Traité seul ou en commun avec d'autres Etats, notamment dans le cadre d'organisations inter-gouvernementales internationales...',* mais l'organisation internationale ne pouvait être partie elle-même au Traité, de quelque manière que ce fût.

B. La Convention sur la responsabilité pour dommages

La Convention sur la responsabilité pour dommages causés par le lancement d'objets spatiaux entrée en vigueur le 1er septembre 1972 et dont il fallut plusieurs années pour finaliser quelques dispositions sur les différends, explicite le mécanisme de mise en oeuvre de l'article VII du Traité.

Selon l'article 1 de la Convention, le terme *lancement* désigne également la tentative de lancement (un tir avorté comme le premier tir de développement d'Ariane-1).

L'expression *Etat de lancement* désigne:
— un Etat qui procède ou fait procéder au lancement d'un objet spatial;
— un Etat dont le territoire ou les installations servent au lancement d'un objet spatial;

ce qui sous-entend que dans certains cas il peut y avoir plusieurs Etats susceptibles d'apparaître comme Etats de lancement, et donc l'existence d'un lien entre l'Etat qui procède au lancement et qui pour cela doit disposer (non pas nécessairement être propriétaire) d'installations de lancement et l'Etat souverain du territoire; ces installations peuvent très bien se situer sur un territoire sous la souveraineté d'un autre Etat (cas du Kenya et de la plate-forme San Marco ou encore du site de Baikonur situé au Kazakhstan et exploité par la Russie). L'Etat de lancement en question peut très bien aussi utiliser les installations pour exécuter un lancement au bénéfice d'une personne ayant une nationalité différente des Etats mentionnés ci-dessus.

On verra qu'un Etat dont le territoire ou les installations servent au lancement d'un objet spatial est réputé participant à un lancement commun. Pour s'exempter de cette responsabilité ou la limiter, l'Etat dont le territoire ou les installations auraient été utilisés n'a comme recours que de conclure un accord spécial avec l'Etat qui procède au lancement.

On ne se livrera pas à une exégèse de cette Convention; retenons quelques principes. La Convention distingue deux situations et deux régimes de responsabilité.

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* Cf.: *Ariane en Guyane* (édité par le CSG, juin 1992).
J.-M. Desobeau: *CSG* (La Documentation Guyanaise Saga, juillet 1990).
Plaquettes ESA: — *Le deuxième ensemble de lancement Ariane (ELA-2) à Kourou, Guyane française.*
— *Centre Spatial Guyanais - Port Spatial de l'Europe.*

Un Etat de lancement a la responsabilité absolue de verser réparation pour le dommage causé par son objet spatial à la surface de la Terre ou aux aéronefs en vol, une responsabilité dite objective, ou pour risque, qui ne demande pas la démonstration de la faute.

En cas de dommage causé ailleurs qu'à la surface de la Terre, à un objet spatial d'un Etat de lancement par un objet spatial d'un autre Etat de lancement, ce dernier n'est responsable que si le dommage est imputable à sa faute.

On laissera à part le cas d'un dommage visé par l'article IV de la Convention qui mélange responsabilité absolue et responsabilité pour faute.

C. La situation des Etats membres et de l'ESA vis-à-vis la Convention sur la responsabilité

Les Etats membres de l'ESA sont parties au Traité sur l'espace et à la Convention sur la responsabilité pour dommages. En outre l'un d'eux, la France, dispose d'une base de lancement, le CSG. Très tôt le problème s'est posé des relations entre la France et l'Organisation procédant à des lancements. Aussi les délégations membres de l'ELDO et de l'ESRO ont été les initiatrices aux Nations Unies d'une clause permettant à une Organisation internationale intergouvernementale qui se livre à des activités spatiales de déclarer accepter les dispositions d'une Convention, l'Organisation ne pouvant alors prétendre ni la signer ni y adhérer. La formule retenue se retrouve dans l'article XXII de la Convention sur la responsabilité internationale pour dommages (cf. Annexe 1).

Les conditions étant remplies, l'organisation (le CERS/ESRO) a donc déposé la Déclaration reproduite en annexe. Dès lors par Etat de lancement au titre de la Convention sur la responsabilité, on est autorisé à lire aujourd'hui l'ESA, celle-ci disposant d'installations de lancement (ELA) et procédant à des lancements de qualification. Cette conséquence conduisit le Conseil à adopter en décembre 1977 une Résolution sur la responsabilité juridique de l'Agence (Annexe 3).

II. Application des principes

A. La situation juridique au CSG — les intervenants

Le CSG est situé sur le territoire de la France, Département de la Guyane, partie au Traité et à la Convention sur la responsabilité pour dommages,

- ce qui fait de la France un Etat de lancement, Etat du territoire;
- un lancement utilise les moyens du CSG (télémesure, radar, propriété du CNES), deuxième raison pour être Etat de lancement.

Mais le lancement s'opère à partir d'une *base de lancement* (le CSG) (il faut distinguer entre base de lancement (launch range) et *ensemble de lancement* (launch site) (ELA): ce fut d'abord ELA-1, aujourd'hui ELA-2, bientôt ELA-3, réalisé par l'ESA et propriété de l'ESA (financé au titre d'un programme facultatif alors que tous les Etats membres contribuent au financement du CSG). Ce qui fait de l'ESA un Etat de lancement. Les lancements de développement sont effectués pour le compte de l'ESA elle-même, avec ses installations et celles du CNES. Le lancement est conduit par les équipes du CNES. Le 'passager' peut être un satellite préparé par un expérimentateur bénéficiant de conditions financières favorables d'un lancement de développement.

On rencontre une autre situation: les lancements commerciaux effectués par la Société privée Arianespace:
- lancement utilisant l'Ensemble de lancement de l'ESA, effectué à l'aide des moyens du CSG mis en oeuvre par le CNES (personnel et biens);
- lancement effectué pour un client qui peut être soit l'ESA (satellite d'un programme scientifique ou d'applications) ou un Etat membre de l'ESA, y compris la France, soit un Etat non membre de l'ESA, société américaine, japonaise, brésilienne , etc... ou une autre organisation européenne (Eumetsat, Eutelsat, ce qui soulève le problème de la préférence du lanceur Ariane, un autre sujet).

Dans ce cas le Gouvernement français et l'ESA sont réputés Etats de lancement en application de la Convention sur la responsabilité. Il y aura bien sûr l'entité qui procède au lancement, Arianespace dans le cas d'un lancement commercial, et l'entité qui fait procéder au lancement, le client (comme la société ou l'organisation propriétaire du satellite). Voilà l'écheveau qu'il faut débrouiller par une série d'instruments juridiques cohérents et sur une solution aussi claire que possible:

- entre le Gouvernement français et l'ESA pour ce qui concerne le territoire de la Guyane et pour ce qui concerne l'implantation et l'utilisation des installations (CSG/ELA) sans oublier les installations de l'Agence situées sur d'autres territoires (Brésil, Ascension, Gabon);

— entre les Etats membres de l'ESA eux-mêmes (Résolution de décembre 1977, Arrangement Ariane) et la phase de développement (APEX);
— entre les Etats participants à la phase commerciale (Déclaration) et entre l'Agence et Arianespace (Convention);
— entre Arianespace et le client (contrat).

Quelles sont les solutions retenues?

B. Territoire et installations — le principe de garantie

Avant même la Convention sur la responsabilité de 1972, l'Europe, en l'espèce l'ELDO, avait installé une base de lancement en Guyane française à Kourou (la BEC ou Base équatoriale du CECLES). A cet effet le Gouvernement français et l'ELDO avaient conclu le 25 novembre 1970 un Accord sur la construction et l'utilisation de cette Base, située dans le périmètre du CSG. Cet Accord garantissait à l'ELDO la libre utilisation de la base. L'Organisation de son côté garantissait le Gouvernement contre:

— toute perte ou tout dommage subi par le Gouvernement et résultant de quelque manière que ce soit d'une activité exercée en Guyane par l'ELDO ou pour son compte (le CNES);
— toute responsabilité en ce qui concerne les réclamations dirigées contre le Gouvernement français au sujet de pertes, dommages ou préjudices et résultant d'une activité exercée en Guyane par l'Organisation ou pour son compte.

L'arrêt des activités de l'ELDO, la décision de construire le lanceur Ariane (l'Arrangement de 1973), aboutirent à la négociation de deux nouveaux Accords entre la France et l'ESA, l'Accord sur le CSG et celui sur l'ELA. Bien sûr tous deux contiennent des clauses sur la responsabilité internationale: l'article 13 de l'Accord CSG et l'article 14 de l'Accord ELA. L'Accord CSG a été récemment renégocié (Annexes 4A&B) et l'Accord ELA devrait également être mis à jour (Annexe 5).

L'Agence garantit le Gouvernement français contre toutes réclamations pour tout dommage, préjudice ou perte subi par un Etat membre de l'Agence ou par un Etat tiers ou par un de leurs ressortissants du fait de l'exécution au CSG d'un programme de l'Agence, à moins que le préjudice ou dommage résulte d'une faute lourde, acte ou omission délibérée d'un fonctionnaire ou agent du Gouvernement français.

L'article 11 de l'Accord CSG 1993-2000 approuvé par le Conseil le 24 juin 1993 et signé le 29 novembre 1993 (Annexe 4B) reprend les dispositions majeures en leur apportant certaines précisions: la référence à la Résolution de décembre 1977, à la société Arianespace, à l'utilisation des moyens du CSG par un Etat non membre, limitation stricte aux vols de développement de l'Agence. Le Gouvernement français garantit à son tour l'Agence, ses Etats membres, du fait de l'exécution au CSG d'activités de la société Arianespace.

Les droits d'accès et d'utilisation du CSG conférés à l'ESA par l'Accord CSG ont fait l'objet d'échange de lettres par lequel l'ESA autorise la Société Arianespace à faire usage de ces droits (ceci bien sûr après accord du Gouvernement français et repris par une disposition spécifique de l'Accord CSG, qui envisage le cas dans lequel les biens sont utilisés au bénéfice d'un Etat non membre de l'Agence (cf. l'article 5 § 3 de l'Accord CSG). On peut aussi se trouver dans la situation où des installations du CSG seraient utilisées pour une satellisation par un lanceur tiré à partir d'un avion ayant décollé du territoire américain par exemple (Programme Pégasus).

Ce principe de la garantie par l'Agence est rappelé dans l'article 14 de l'Accord ELA (appel aux biens du CSG). L'Agence est seule responsable dans le cas où ses activités ne demandent pas la mise en oeuvre des moyens du CSG.

L'on sait que les moyens mis en oeuvre par le CSG aux fins de l'exécution d'un lancement Ariane peuvent se situer sur un autre territoire — le cas des stations aval (au Brésil, Ile d'Ascension, Côte d'Ivoire puis Gabon). L'Etat du territoire souhaitera également disposer d'une garantie de l'ensemble des Etats membres de l'ESA, ce que lui accordent les accords conclus. Certes l'intervention de l'Etat du territoire dans l'utilisation des moyens limitent la garantie de l'Agence (cf. article 11 de l'Accord avec le Brésil sur la station aval de Natal).

C. Développement et production du lanceur Ariane

Le développement du lanceur Ariane a été entrepris sous le couvert de l'article VIII de la Convention du CERS/ESRO; un Arrangement a été conclu en 1973 entre les participants (les Etats membres qui demandaient l'aide de l'Organisation) et entre eux et l'Organisation. Un texte, très court, stipule l'obligation pour les participants d'indemniser le CERS/ESRO pour toute obligation qu'elle vient à encourir si sa responsabilité internationale est engagée du fait de l'exécution de la phase de développement du programme. Phrase qui laissait ouverte la possibilité que l'Organisation soit directement et comme entité distincte saisie d'une demande en réparation. Phrase qui reconnaissait une obligation de garantie des Participants vis-à-vis des Etats membres non participants. La réparation reçue ne tombait pas dans le budget général mais était portée en recette du budget du programme.

Ce même principe sera constamment repris par les Déclarations des programmes de développement suivants, Ariane-2-3, Ariane-4, Ariane-5 ou encore par les Déclarations sur les programmes ESA, suivant en cela les principes de l'Annexe III de la Convention de l'Agence.

Aussi, avec l'acceptation de la Convention sur la responsabilisé internationale pour dommages, le programme Ariane, le CSG et l'ELA, il était devenu impérieux que soient clarifiés les mécanismes de garantie, de procédure dans le cas de réclamation. Ce fut l'objet de la Résolution sur la responsabilité juridique de l'Agence adoptée par le Conseil le 13 décembre 1977 (cf. Annexe 3).

Cette Résolution a pour objet de régler les conséquences *internes* de la responsabilité juridique de l'Agence dans le cas où l'exécution de ses programmes et activités cause des dommages à l'un de ses Etats membres, à un Etat participant, à un Etat tiers.

L'Agence indemnise les Etats membres et Etats participants pour la responsabilité juridique encourue par eux, dans le cas où ces Etats sont tenus responsables en tant qu'Etats de lancement, dans le cas où l'Agence s'y est engagée en vertu d'un accord particulier.

Toutefois, la Résolution reprend une disposition de l'Accord CSG en prévoyant le cas d'un Etat membre ou participant qui rend des services et apparaît lui aussi comme Etat de lancement; dans ce cas cet Etat supporte la responsabilité dans le cas où le dommage est dû à une faute lourde, acte intentionnel ou omission délibérée de sa part.

La Résolution décrit en détail la procédure à suivre et le rôle de l'Agence dans la conduite des débats, rôle essentiel notamment par l'adoption de directives. Important également de noter que par cette seule Résolution du Conseil tous les Etats membres et participants s'engagent à être liés par toute décision judiciaire, sentence arbitrale. Cette Résolution demande que dans tout accord de participation à un programme facultatif, un Etat participant non membre de l'Agence déclare expressément accepter les principes contenus dans cette Résolution.

Les Accords d'adhésion à la Convention de l'Agence conclus avec l'Autriche, la Norvège et enfin avec la Finlande répondent à cette demande en stipulant que l'adhérent a pris connaissance et accepté les actes juridiques conclus (ce qui couvre les Résolutions).

Enfin la Résolution énonce un certain nombre de principes; lorsque l'Agence rend un service de lancement (police d'assurance), lorsque des services de lancement sont rendus par un Etat non membre ou non participant au programme considéré.

Les lancements de développement ont demandé l'adoption d'un règlement pour l'emport de capsules passagers (ainsi pour Ariane-1 et Ariane-4) et la conclusion d'Accords d'emport de passagers expérimentaux (par exemple Accord avec Amsat, Accord avec l'Inde pour l'emport de l'expérience Apple sur le vol de développement L03, etc.)

Le règlement APEX pour l'emport de capsules passagers par Ariane-1 se limite à prévoir un recours réciproque pour des dommages dont soit l'expérimentateur soit le CERS/ESRO (ESA) est responsable. Il n'est nullement prévu que l'Etat dont l'expérimentateur relève ait la qualité d'Etat de lancement. Les accords passagers se limitent à la renonciation réciproque à recours sauf faute lourde, défaillance de l'autre partie.

D. Les lancements de production

Ceux-ci sont assurés par le société Arianespace qui fournit le lanceur et les services et passe un contrat de lancement avec un client (ce client pouvant être l'ESA, pour un satellite d'application ou scientifique) un Etat membre, un Etat non membre, un organisme relevant de leur juridiction, ou une organisation internationale. Arianespace utilise alors des biens propriété de l'ESA (l'Ensemble de lancement Ariane: ELA) et des biens propriété du CNES (moyens techniques et logistiques du CSG) et les services de ce dernier au CSG. Il peut donc y avoir concours d'Etats de lancement au sens de la Convention sur la responsabilité pour dommages.

Par une *'Déclaration'* (la première établie en 1980, la deuxième en 1990), certains Etats membres de l'Agence ont confié à la société Arianespace la fabrication et le lancement des lanceurs Ariane développés par l'Agence et qualifiés; en outre cette Déclaration demande à l'Agence et à Arianespace de conclure un Accord (Convention) pour mettre en oeuvre la Déclaration.

Bien qu'utilisant la même dénomination, la Déclaration n'est pas à confondre avec une Déclaration relative à un programme facultatif de l'Agence et fondée sur les dispositions de la Convention de l'Agence, son Annexe III en particulier. La Déclaration sur la production (Annexe 6) est un accord international en elle-même, en forme simplifiée puisqu'elle ne fait pas l'objet d'une procédure de signature mais d'acceptation écrite. La Déclaration se réfère expressément tant à la Convention de l'Agence qu'au Traité sur l'Espace; les autorités françaises ont été appelées à donner toutes assurances aux autres Etats membres de l'Agence devant la possibilité de voir leur responsabilité recherchée en tant que réalisateurs des installations de lancement (ce point fut abordé lors des réunions de présentation et d'explication de la Déclaration sur la production en février 1980).

Aussi la Déclaration sur la production dispose qu'*'en cas de recours intenté par les victimes de dommages causés par les lancements Ariane, le Gouvernement français supportera la charge financière de la réparation de ces dommages'* (garantie au bénéfice des Etats membres, partie ou non de la Déclaration sur la production). Arianespace est invitée à contracter une police d'assurance à hauteur de 400 MFF, la couvrant ainsi que l'Agence et les Etats membres de l'Agence (on retrouve la politique suivie par le Gouvernement américain pour les vols commerciaux de la Navette). Au-delà de 400 MFF, le Gouvernement français assure l'indemnisation du dommage.

La Convention entre l'Agence et Arianespace (signée le 24 septembre 1992) rend Arianespace responsable pour tout dommage causée par elle-même ou par des tiers aux biens de l'Agence ou des Participants qui ont été mis à sa disposition. Arianespace renonce à tous recours à l'encontre de l'Agence pour tout dommage direct ou indirect subi par elle-même dans le cadre de la production et des opérations de lancement à l'occasion de l'utilisation de biens de l'Agence.

Cette Convention (article 16) entre l'Agence et Arianespace formalise que *'Sous réserve de l'approbation du Gouvernement français, l'Agence autorise Arianespace à exercer, dans la mesure nécessaire à la production et au lancement des lanceurs Ariane, les droits d'accès et d'utilisation accordés à l'Agence ..., les prestations assurées par le CSG au profit de l'Agence ... sont transférées à Arianespace, aux fins des lancements Ariane, contre versement par cette dernière d'une redevance ....'*. La garantie accordée à l'Agence par le Gouvernement français dans le cas de recours formé contre celle-là en réparation de préjudices résultant des activités conduites sous la responsabilité d'Arianespace au CSG est traitée dans le cadre des Accords concernant le CSG conclus entre l'Agence d'une part, le Gouvernement français et le CNES d'autre part.

On ne peut que s'attendre à ce que les contrats de lancement conclus par Arianespace contiennent des dispositions de mise en oeuvre des principes de responsabilité ci-dessus. Le contrat de lancement est un contrat de moyen; Arianespace s'engage à faire ses meilleurs efforts.

Arianespace souscrit une assurance protégeant les parties pour la responsabilité des dommages survenant à des tiers après le lancement (l'assurance prend effet avec le lancement et a une durée de 36 mois).

Chaque partie au contrat est responsable des dommages corporels et matériels et de tout préjudice causé par elle-même à des tiers à l'occasion de l'exécution du contrat. Chaque partie garantit l'autre contre les conséquences des demandes en indemnisation d'un tiers y compris dans le cas où la demande est basée sur un dommage causé par l'autre partie.

Conclusion

Le feu de Vulcain a emporté Ariane dans les cieux. Que va-t-elle devenir, se demande notre juriste en contemplation devant une pluie d'étoiles filantes. *'Et maintenant que vais-je faire?'* pourrait-il chantonner. Un lanceur, songe-t-il, c'est encore des débris spatiaux qui vont s'éparpiller tout autour de la Terre. Il y a peut-être là quelque chose à étudier. Un lanceur, c'est aussi un moyen de transport vers cette Station spatiale internationale dont les feux ne sont pas encore allumés. Le CSG, c'est aussi l'exemple pour d'autres sites de lancement et pourquoi pas pour une base de lancement sur la Lune? En définitive, il ne s'agit que de coopération internationale bien comprise, 'pour le bénéfice de l'humanité toute entière' comme le dit le Traité sur l'Espace.

ANNEXES

1. Article XXII de la Convention sur la responsabilité internationale pour dommages
2. Déclaration relative à la Convention sur la responsabilité internationale pour les dommages causés par des objets spatiaux
3. Résolution sur la responsabilité juridique de l'Agence (décembre 1977)
4A + B. Accord CSG — article 13 et articles 5 & 11
5. Accord ELA — article 14
6. Déclaration sur la production (articles III.9 et IV.1)

Annexe 1 — Convention sur la responsabilité internationale pour les dommages causés par des objets spatiaux

Article XXII

1. Dans la présente Convention, à l'exception des articles XXIV à XXVII, les références aux Etats s'appliquent à toute organisation internationale intergouvernementale qui se livre à des activités spatiales, si cette organisation déclare accepter les droits et les obligations prévus dans la présente Convention et si la majorité des Etats membres de l'organisation sont des Etats parties à la présente Convention et au Traité sur les principes régissant les activités des Etats en matière d'exploration et d'utilisation de l'espace extra-atmosphérique, y compris la Lune et les autres corps célestes.

2. Les Etats membres d'une telle organisation qui sont des Etats parties à la présente Convention prennent toutes les dispostittions voulues pour que l'organisation fasse une déclaration en conformité du paragraphe précédent.

3. Si une organisation internationale intergouvernementale est responsable d'un dommage aux termes des dispositions de la présente Convention, cette organisation et ceux de ses membres qui sont des Etats parties à la présente Convention sont solidairement responsables, étant entendu toutefois que:
a. Toute demande en réparation pour ce dommage doit être présentée d'abord à l'organisation; et
b. Seulement dans le cas où l'organisation n'aurait pas versé dans le délai de six mois la somme convenue ou fixée comme réparation pour le dommage, l'Etat demandeur peut invoquer la responsabilité des membres qui sont des Etats parties à la présente Convention pour le paiement de ladite somme.

4. Toute demande en réparation formulée conformément aux dispositions de la présente Convention pour le dommage causé à une organisation qui a fait une déclaration conformément au paragraphe 1 du présent article doit être présentée par un Etat membre de l'organisation qui est un Etat partie à la présente Convention.

Annexe 2 — Déclaration relative à la Convention sur la responsabilité internationale pour les dommages causés par des objets spatiaux (déposé le 26 septembre 1976)

L'Organisation Européenne de Recherches Spatiales créée par une Convention ouverte à la signature à Paris le 14 juin 1962, conduisant à compter du 31 mai 1975 ses activités sous le nom d'Agence Spatiale Européenne,

Rappelant qu'elle a pour tâche d'exécuter à des fins exclusivement pacifiques, pour le compte et au nom de ses Etats membres, des programmes de recherche et de technologie spatiales et de leurs applications spatiales,

Ayant pris acte des dispositions de la Convention sur la responsabilité internationale pour les dommages causés par des objets spatiaux annexée à la Résolution 2777 (XXVI) de l'Assemblée Générale des Nations Unies, entrée en vigueur le 1er septembre 1972 et en particulier de son Article XXII,

Tenant compte de l'établissement de règles et procédures contribuant à renforcer la coopération internationale dans le domaine spatial et assurant une pleine et équitable indemnisation des victimes de dommages causés par des objets spatiaux,

Considérant que la majorité de ses Etats membres est partie au Traité sur les principes régissant les activités des Etats en matière d'exploration et d'utilisation de l'espace extra-atmosphérique, y compris la Lune et les autres corps célestes ainsi qu'à ladite Convention,

DECLARE ACCEPTER les droits et obligations prévus dans ladite Convention,

CONSTATE qu'en application de l'Article XXII, paragraphe I, les références faites aux Etats parties dans ladite Convention lui soit applicables à la date de la présente Déclaration.

Annexe 3 — Responsabilité juridique de l'Agence

Le Conseil de l'Agence, réuni le 13 décembre 1977,

CONSIDERANT que l'exécution d'un programme ou d'une activité de l'Agence peut entraîner la mise en oeuvre de la responsabilité juridique de l'Agence, de ses Etats membres et des Etats participant à un de ses programmes,

DESIREUX de définir les principes applicables dans le cas où la responsabilité juridique de l'Agence, d'un Etat membre ou d'un Etat participant à un de ses programmes se trouve engagée, ainsi que les modalités de la répartition de la charge financière,

(...)

CONVIENT d'adopter les principes suivants:
La présente Résolution a pour objet:

(A) de régler les conséquences internes de la responsabilité juridique de l'Agence dans le cas où l'exécution, par elle-même ou pour son compte, de ses programmes spatiaux et activités spatiales, cause des dommages (expression qui, au sens de la présente Résolution, couvre les décès, blessures, pertes et préjudices)

(i) à l'un de ses Etats membres,

(ii) à un Etat participant à l'un de ses programmes spatiaux ou activités spatiales (ci-après dénommé 'Etat participant'),

(iii) à un Etat tiers,

ou à une personne physique ou morale qu'un de ces Etats peut représenter;

(B) de définir les directives à suivre par l'Agence vis-à-vis d'organismes qui lui procurent un service de lancement ou auxquels elle fournit une prestation.

A – I

1. L'Agence indemnise les Etats membres et les Etats participant à ses programmes spatiaux et activités spatiales pour la responsabilité juridique encourue par eux à l'occasion de l'exécution de ces programmes et activités:

(a) dans le cas où ces Etats sont tenus pour responsables en tant qu''Etats de lancement' au sens de la Convention des Nations Unies;

(b) dans le cas où l'Agence s'y est engagée en vertu d'un Accord particulier conclu entre elle et l'Etat concerné.

2. Toutefois, si un Etat membre ou un Etat participant rend des services à l'Agence pour l'exécution des programmes spatiaux ou activités spatiales de cette dernière et notamment apparaît à ce titre comme 'Etat de lancement' au sens de la Convention des Nations Unies, cet Etat est tenu de rembourser à l'Agence le montant de la réparation mise à la charge de celle-ci lorsque le dommage résulte d'une faute lourde, d'un acte intentionnel ou d'une omission délibérée de la part de cet Etat ou de personnes agissant pour son compte.

II

1. Quand une demande en réparation de dommage causé par un objet spatial de l'Agence est présentée à celle-ci, l'Agence mène la procédure.

2. (a) Dans le cas où une demande en réparation est adressée à un Etat membre ou à un Etat participant à un programme de l'Agence, cet Etat consulte l'Agence sans retard, et

(i) celle-ci, si le droit applicable l'y autorise, peut se joindre à la procédure et elle peut se substituer à l'Etat mis en cause si celui-ci le lui demande;
(ii) tout Etat membre ou un Etat participant peut se joindre à l'Etat mis en cause ou à l'Agence pour prendre part à la procédure si le droit applicable l'y autorise;

(iii) tout Etat mis en cause suit les directives définies conjointement entre l'Agence et ces Etats en ce qui concerne tant la procédure que les règlements.

(b) Un Etat membre ou un Etat participant à un programme présente toujours, en premier lieu, à l'Agence sa demande en réparation.

3. Tous les Etats membres ou Etats participants et l'Agence sont liés par toute décision judiciaire, sentence arbitrale rendues ou par les règlements négociés entre les Etats intéressés avec l'accord de l'Agence qu'ils se soient joints ou non à la procédure pertinente.

III

1. Le montant de la réparation fixée est payé par l'Agence sous réserve que les dispositions contenues dans le paragraphe II.2 aient été appliquées.

2. L'Agence avance les fonds nécessaires au règlement des réparations mises éventuellement à la charge d'un Etat membre ou d'un Etat participant à la suite d'une procédure ou de règlements, si cet Etat lui en fait la demande et si les dispositions visées ont été observées. Si ledit Etat a versé la somme fixée comme réparation mise à sa charge ou comme règlement négocié avec l'accord de l'Agence sans avoir reçu d'avance, l'Agence la lui rembourse intégralement. Le Conseil arrêtera les dispositions détaillées d'application du présent paragraphe.

3. Quel que soit le plafond convenu au sujet de leur participation, les dépenses exposées par l'Agence au titre de la réparation de dommages sont mises à la charge des Etats participant au programme considéré, au prorata de leur contribution financière audit programme, à la date du dommage, si celui-ci se produit pendant le programme, ou à la date de l'achèvement du programme si le dommage se produit après cette date. Dans le cas où le risque est couvert par une assurance, la prime correspondante est mise à la charge du programme.

4. Les sommes remboursées à l'Agence en application du paragraph I.3 sont portées au crédit du budget considéré.

IV

Dans les accords concernant la participation d'un Etat non membre à un programme du l'Agence, cette dernière insère une clause par laquelle ledit Etat déclarera expressément accepter les principes contenus dans la présente Résolution. En ce qui concerne les accords déjà conclus à la date de la présente Résolution, l'Agence fera le nécessaire pour qu'ils soient amendés en conséquence.

B I

1. Dans le cas où l'Agence, un Etat membre ou un Etat participant au programme considéré peut encourir une responsabilité internationale à l'occasion de l'exécution du lancement d'objets spatiaux et des services associés par un Etat qui n'est pas un Etat membre ou participant au programme considéré ou par un organisme relevant de la juridiction dudit Etat, l'Agence prend les mesures nécessaires afin que

l'accord ou le contrat de lancement contienne les principes suivants:

(a) Dans les cas où la demande en réparation est présentée audit Etat ou organisme, l'Agence sera autorisée à suivre la procédure ou à s'y joindre.

(b) Dans le cas où la demande serait présentée à l'Agence, cette dernière demande audit Etat ou organisme de se joindre à la procédure.

(c) La somme fixée pour la réparation sera répartie entre l'Agence, l'Etat ou l'organisme en question en fonction du degré de leur responsabilité respective dans le dommage, étant entendu que l'Agence ne supportera en aucun cas les dommages causés par la faute lourde, l'acte intentionnel ou l'omission délibérée dudit Etat ou organisme.

2. Le Conseil peut, dans certains cas, autoriser à l'unanimité l'Agence à conclure des accords ou contrats dérogeant aux principes ci-dessus.

II

1. Lorsqu'elle rend un service de lancement, l'Agence prend les mesures nécessaires afin que le bénéficiaire souscrive une police d'assurances concernant sa responsabilité et celle de l'Agence pour les dommages pouvant en résulter. Toutefois, l'Agence demeure responsable pour les dommages causés par une faute lourde, un acte intentionnel ou une omission délibérée de sa part ou de personnes à son service, sous réserve des dispositions du paragraphe B.I.2.

2. Pour les autres prestations, rendues par l'Agence, les dispositions applicabbles seront arrêtées ultérieurement par le Conseil.

Annexe 4A — Accord CSG

Article 13

1. L'Agence garantit le Gouvernement français contre toutes réclamations pour tout dommage, préjudice ou perte subi par un Etat membre de l'Agence ou par un Etat tiers ou par un de leurs ressortissants, du fait de l'exécution au CSG d'un programme de l'Agence ou d'autres activités que le Gouvernement français exécute pour le compte de l'Agence dans le cadre du présent Accord.

2. La garantie visée ci-dessus ne s'applique pas si le dommage, le préjudice ou la parte résulte d'une faute lourde, d'un acte ou d'une omission délibérés d'un fonctionnaire ou agent du Gouvernement français dans le cadre de l'exécution du présent Accord.

3. Le Gouvernement français informe l'Agence de toute réclamation dirigée contre lui au sujet d'un dommage, d'un préjudice ou d'une perte visé au paragraphe 1er et la consulte. L'Agence se joint à la procédure et se substitue au Gouvernement français, avec l'accord de celui-ci, si le droit applicable l'y autorise.

4. L'Agence avance, conformément aux dispositions arrêtées par le Conseil, les fonds nécessaires au règlement des réparations dues par le Gouvernement français, si celui-ci en fait la demande. Si le Gouvernement français a versé la réparation mise à sa charge, l'Agence la lui rembourse intégralement.

5. L'Agence ne garantit pas le Gouvernement français contre les réclamations relatives aux dommages, préjudices et pertes causés à un Etat membre, à un Etat tiers ou à un de leurs ressortissants, du fait de l'exécution au CSG d'activités et programmes autres que ceux de l'Agence.

6. La réparation des dommages, préjudices et pertes de toute nature subis par l'Agence du fait des activités du CNES, ou par le CNES du fait des activités de l'Agence, dans le cadre de l'exécution du présent Accord, estt réglée conformément au Protocole visé à l'Article 2.

Annexe 4B — Accord entre le Gouvernement français et l'Agence spatiale européenne relatif au Centre Spatial Guyanais (CSG) (1993-2000)

Article 5
(Utilisation des moyens et installations du CNES au CSG)

3. Lorsqu'une demande d'utilisation de ces installations et moyens du CNES au CSG est adressée par un Etat non membre, un ressortissant de cet Etat non membre ou une organisation internationale, au CNES ou au Gouvernement français, ces derniers en informent le Directeur Général de l'Agence. Le Directeur général de l'Agence transmet toute demande d'utilisation formulée par un Etat non membre, un ressortissant de cet Etat non membre ou une organisation internationale au Conseil qui émet un avis sur cette demande. L'Accord est ensuite conclu par le Gouvernement français qui informe l'Agence de la négociation et la consulte en particulier sur les aspects pouvant mettre en jeu ses intérêts. L'entité autorisée à utiliser lesdites installations s'engagera à ne former aucun recours vis-à-vis de l'Agence et de ses Etats membres pour tout dommage, préjudice ou perte qui seraient subis par elle-même, les personnes à son service, ses contractants ou sous-contractants ou par des tiers à l'occasion d'une telle utilisation, sauf faute lourde, acte intentionnel ou omission délibérée de l'Agence, de ses Etats membres ou des personnes à leur service. Le Gouvernement français est invité à négocier une clause par laquelle le Gouvernement dont relève l'entité devant utiliser lesdites installations devra garantir le Gouvernement français, l'Agence et ses Etats membres contre tout recours qui pourrait être intenté au titre de la Convention sur la responsabilité internationale pour les dommages causés par des objets spatiaux entrée en vigueur le 1er septembre 1972. En l'absence de cette clause le Gouvernement français assurera en tout état de cause la garantie de l'Agence et de ses Etats membres.

Article 11
(Responsabilité internationale)

1. Conformément aux dispositions de la Résolution ESA/C/XXII/Res. 3 adoptée par le Conseil de

l'Agence le 13 décembre 1977, l'Agence garantit le Gouvernement français contre toutes réclamations dirigées contre lui et relatives aux dommages au sens de la Résolution précitée, causés à elle-même, à un Etat membre, à un Etat tiers, à des ressortissants desdits Etats ou à toute autre personne, du fait de l'utilisation des moyens du CNES/CSG aux fins d'un programme de développement Ariane de l'Agence.

Cette garantie ne s'applique pas si les dommages résultent d'une faute lourde, d'un acte intentionnel ou d'une omission délibérée de la part du Gouvernement français ou de personnes agissant pour son compte.

2. L'Agence ne garantit pas le Gouvernement français contre les réclamations relatives aux dommages causés à elle-même, à un Etat membre, à un Etat tiers, à des ressortissants desdits Etats ou à toute autre personne, du fait de l'exécution au CSG d'activités et programmes autre que ceux de l'Agence.

Dans le cas particulier du l'utilisation des installations et moyens du CNES au CSG par un Etat non membre, un ressortissant dudit Etat ou par une organisation internationale, les dispositions pertinentes de l'Article 5.3 ci-dessus sont applicables.

3. Le Gouvernement français garantit l'Agence et ses Etats membres contre les réclamations causés à l'Agence, à un Etat membre, à un Etat tiers, à des ressortissants desdits Etats ou à toute autre personne du fait de l'exécution au CSG d'activités de lancement par la Société Arianespace ou par les personnes à son service. Cette garantie ne s'applique pas si les dommages résultent d'une faute lourde, d'un acte intentionnel ou d'une omission délibérée de l'Agence, de personnes employées par l'Agence ou des Etats membres de l'Agence (à l'exception de l'Etat français ou des organismes publics en relevant). Dans l'hypothèse où l'Agence est le client d'Arianespace, et ceci indépendamment de toute faute de l'Agence, la garantie sus-mentionnée ne s'applique pas lorsque le satellite de l'Agence s'avère être à l'origine du dommage; dans ce cas, les dépenses exposées au titre de la procédure et de la réparation des dommages sont supportées par l'Agence et réparties entre les Etats participants au programme de satellite concerné conformément aux dispositions de la Résolution précitée au 13 décembre 1977 dans son paragraphe A.III.3.

4. La réparation des autres dommages, préjudices et pertes de toute nature liés à l'exécution du présent Accord et qui seraient subis par l'Agence, ses biens et ses personnes du fait des activités du Gouvernement français et/ou du CNES du fait des activités de l'Agence au CSG, est réglée entre l'Agence et le CNES.

Annexe 5 — Accord ELA

Article 14

1. Lorsque la responsabilité internationale du Gouvernement français est engagée du fait de l'exécution sur la Base d'une activité ou d'un programme de l'Agence requérant la mise en oeuvre des installations, équipements et moyens humains et matériels du CSG, la réparation de tout dommage, préjudice ou perte résultant de ces activités ou programmes s'effectue conformément aux dispositions de l'Article 13 de l'Accord CSG.

2. Lorsque la responsabilité internationale de l'Agence est engagée du fait de l'exécution sur la Base des activités ou programmes de l'Agence ne requérant pas la mise en oeuvre des installations, équipements et moyens humains et matériels du CSG, l'Agence est responsable de tout dommage, préjudice ou perte découlant de ces activités ou programmes. Sous réserve des dispositions sur les privilèges et les immunités de l'Agence, cette responsabilité est régie par le droit français.

L'Agence dégage le Gouvernement français de toute obligation mise à sa charge, en particulier de toute indemnité, en cas de dommage, préjudice ou perte causé à des tiers par suite des activités ou programmes de l'Agence visés dans le présent paragraphe.

3. L'Agence, ou le CNES, selon le cas, supporte la réparation de tout dommage, préjudice ou perte subi par les personnes à son service, du fait des activités visées dans le présent Accord, même si la responsabilité incombe à l'autre Partie, ou aux personnes à son service, sauf toutefois si le dommage, le préjudice ou la perte résulte d'une faute lourde de la part de l'autre Partie ou des personnes à son service. Les dispositions précédentes s'appliquent, de la même manière, à tout dommage, préjudice ou perte que les personnes au service de l'Agence, ou du CNES, selon le cas, pourraient causer aux matériels, équipements et installations de l'autre Partie, ou des personnes au service de celle-ci.

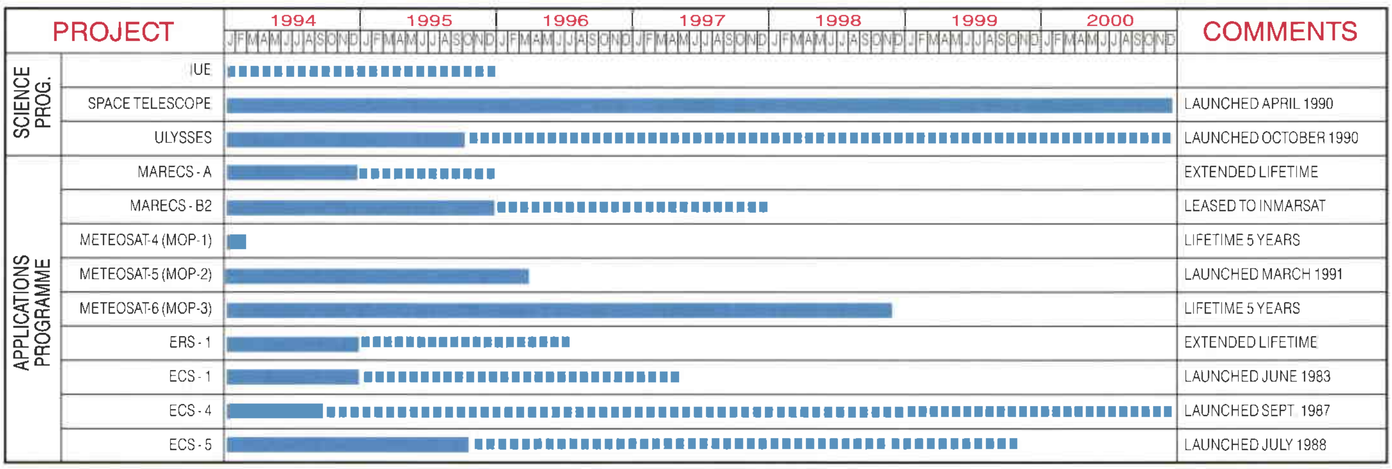
Annexe 6 — Déclaration de certains gouvernements européens relative à la phase de production des lanceurs Ariane

III.9 En cas de recours intenté par les victimes de dommages causés par les lancements Ariane, Arianespace sera tenue de rembourser, dans la limite d'un plafond de 400 millions de francs français par lancement, le gouvernement français appelé, au titre du paragraphe IV.1 à supporter la charge financière de la réparation de ces dommages.

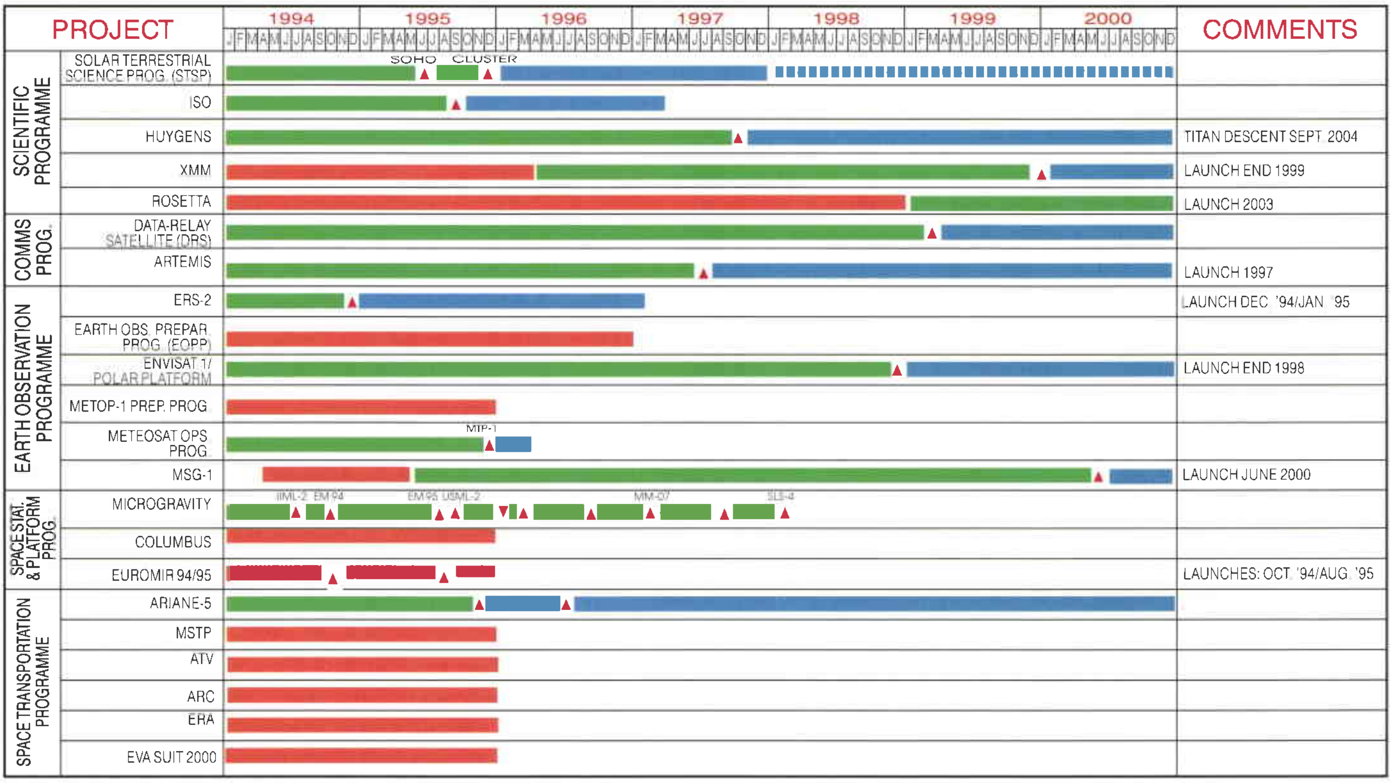
IV.1 En cas de recours intenté par les victimes de dommages causés par tout lancement Ariane conduit par Arianespace, le gouvernement français supportera la charge financière de la réparation de ces dommages.

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

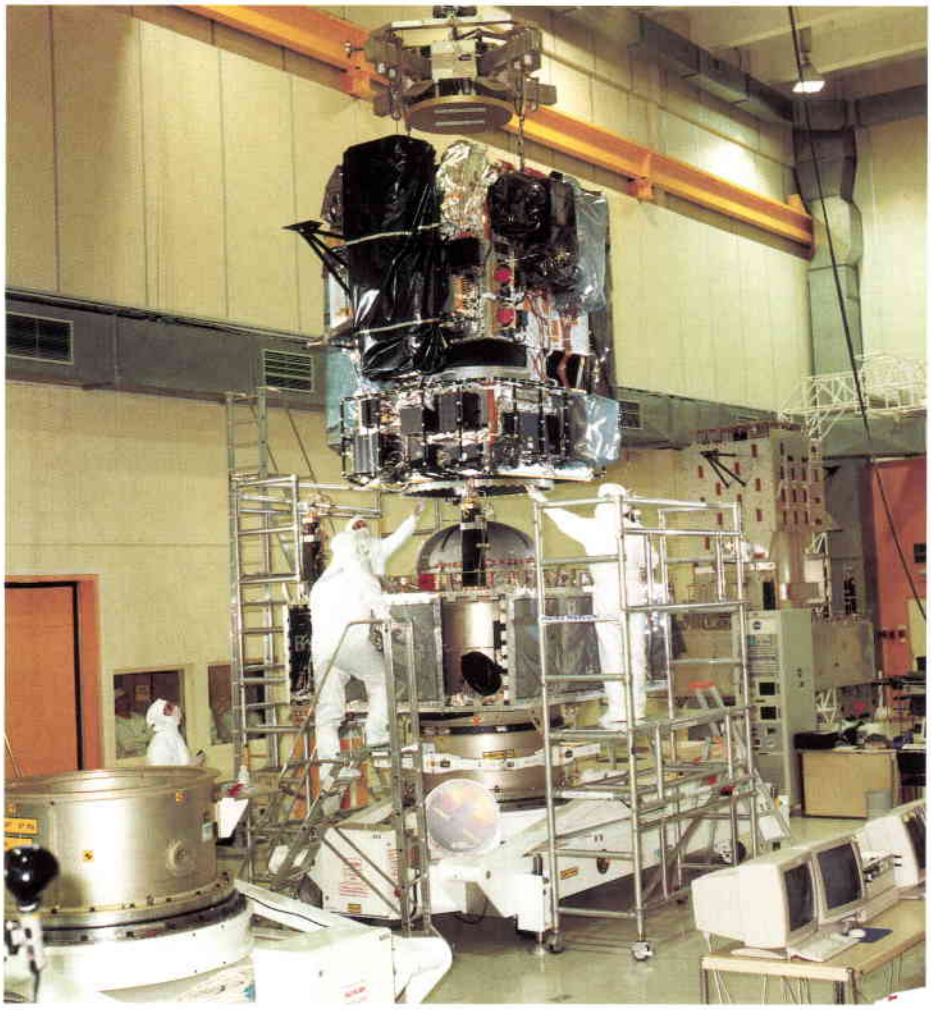
■ OPERATIONS ■■■ ADDITIONAL LIFE POSSIBLE ▼ RETRIEVAL

Ulysse

Le 13 septembre, Ulysse a franchi une étape importante de son voyage d'exploration au-dessus des pôles du Soleil. Ce jour-là, la sonde spatiale a atteint sa latitude maximale dans l'hémisphère sud, à 80,2° au sud de l'équateur du Soleil. Actuellement, Ulysse remonte lentement vers l'écliptique, en direction des régions du pôle nord, qu'il explorera à la mi-1995. La mission continue de se dérouler sans encombre.

Les opérations visant à limiter la nutation d'Ulysse ont débuté le 11 août. La sonde spatiale est suivie pratiquement en continu à partir du centre de Canberra en Australie faisant partie du réseau de l'espace lointain de la NASA (DSN), ou de la station de l'ESA à Kourou, Guyane française. Ces mesures ont été prises en prévision de la réapparition probable des perturbations de type nutation qui s'étaient produites au début de la mission Ulysse. Le mode de fonctionnement mis en oeuvre à cet effet consiste à créer un amortissement actif en utilisant le système Conscan embarqué, qui maintien le pointage de l'antenne à grand gain vers la Terre à l'intérieur d'une plage prédéterminée. Cette méthode exige une liaison montante en continu à partir du sol. Les limitations de la couverture géographique de la station de Canberra (seul centre DSN de l'hémisphère austral) a imposé d'inclure une station supplémentaire afin d'obtenir une couverture pratiquement continue. A l'heure où ces lignes sont écrites, aucun signe de réapparition de la perturbation n'a été mis en évidence.

L'ESTEC a également été le théâtre d'activités scientifiques intenses au cours de la semaine du 13 septembre, pendant laquelle a été organisé un atelier de 3 jours auquel ont participé plus de 80 spécialistes d'Ulysse. Le centre de conférence de l'ESTEC a été transformé en un 'laboratoire' scientifique très animé pendant toute la durée de l'atelier, chaque équipe de chercheurs travaillant sur les données les plus récentes. L'atelier a été suivi par une journée de la presse le 16 septembre.



Soho

Industrie

Les deux modules de vol de la sonde Soho ont été assemblés entre juin et août 1994 avant d'être acheminés à l'usine Matra Marconi de Toulouse.

L'intégration des expériences sur le modèle de vol du module charge utile (PLM) s'est achevée en juin, les problèmes apparus sur différentes expériences ayant été corrigés ou, à défaut, identifiés, en vu d'un examen ultérieur plus approfondi. Un essai fonctionnel au niveau système avec l'ensemble des expériences intégrées a eu lieu dans les locaux de Matra Marconi Space (G-B) à Portsmouth au cours de la deuxième quinzaine de juin. Le PLM a ensuite été expédié à Toulouse fin juillet.

Après l'achèvement de l'intégration et de l'essai du module de servitude (SVM) à Toulouse vers la fin du mois de juin, celui-ci a subi ses essais mécaniques, en avance sur le calendrier, au cours d'un bref séjour dans le centre d'essai voisin d'Intespace.

Les activités conduites chez Matra Marconi à Toulouse (F) sont maintenant programmées en double équipe afin de respecter la date de lancement fixée.

Le modèle de qualification et d'identification (EQM) de l'enregistreur européen à état solide a été intégré aux autres éléments de la sonde spatiale à la fin du mois d'août après avoir subi avec succès ses essais de qualification.

Coopération ESA-NASA

La Revue critique de conception du lanceur chargé de mettre Soho en orbite (Atlas II AS, vol AC-117) a eu lieu à San Diego les 22 et 23 juin et a donné, dans l'ensemble, des résultats positifs à l'exception de quelques points méritant un examen plus approfondi.

Les essais de compatibilité, au niveau du secteur sol, entre le système de contrôle de la NASA au centre spatial Goddard (GSFC) et le SVM à Toulouse ont eu lieu en juin. Des lignes de communications

Payload of the Soho spacecraft being removed from the Service Module at Matra, Toulouse (F).

Séparation de la charge utile du véhicule spatial Soho du module de service chez Matra à Toulouse (F).

Ulysses

On 13 September, Ulysses passed a major milestone in its journey of exploration over the poles of the Sun. On that day, the spacecraft reached its maximum latitude in the southern hemisphere, 80.2 degrees south of the Sun's equator. Ulysses is now slowly climbing back towards the ecliptic, en route to the north polar regions which it will explore in mid-1995. The mission continues to run smoothly.

Ulysses nutation-damping operations commenced on 11 August. The spacecaft is being tracked almost continuously from either NASA's Canberra Deep Space Network (DSN) complex in Australia or the ESA Kourou station in French Guiana. These measures were taken in anticipation of the predicted onset of the nutation-like motion that disturbed the spacecaft early in the mission. In this mode of operation, active damping is achieved through use of the onboard Conscan system, which maintains the high-gain antenna Earth-pointing within a preset deadband. This in turn requires a continuous uplink signal from the ground. Geographical coverage limitations at Canberra (the only DSN complex in the Southern Hemisphere) made it necessary to include an extra station to ensure almost continuous coverage. At the time of reporting, no evidence of the return of the disturbance has been found.

The mission's scientific activities also reached a peak in the week of 13 September, when a three-day Workshop attended by more than 80 Ulysses investigators was held in ESTEC (NL). The ESTEC Conference Centre was transformed into a lively scientific 'laboratory' for the duration of the Workshop, with each experiment team working on the latest data. The Workshop was followed up with a Press Day on 16 September.

Soho

Industry

Assembly of the two flight modules of the Soho spacecraft has been completed between June and August 1994 and they have come together at the Matra Marconi plant in Toulouse.

The flight-model Payload Module (PLM) has completed experiment integration in June, problems with several experiments having been corrected or at least identified for further attention later. A system functional test took place at Matra Marconi Space (MMS-UK) in Portsmouth (UK) in the second half of June, with all experiments integrated. The PLM was shipped to Toulouse at the end of July.

The Service Module (SVM) completed its integration and testing in Toulouse by the end of June and has undergone, ahead of schedule, its physical-properties test during a brief excursion to the nearby Intespace test complex.

Activities at Matra Maconi in Toulouse (MMS-F) are now planned on a double-shift basis to maintain the agreed launch date.

The EQM model of the European Solid-State Recorder joined the rest of the spacecraft at the end of August after successful completion of its qualification testing.

ESA-NASA cooperation

The Critical Design Review for the Soho launch vehicle (Atlas II AS flight AC-117) took place in San Diego on 22 – 23 June and the conclusions were generally positive, with a few items highlighted for further attention.

The Ground Segment Compatibility Test between the NASA control system at Goddard Space Flight Center (GSFC) and the SVM in Toulouse took place in June. Commercial communication lines were used to link the two sites for this first closed-loop test between the spacecraft and its future controllers. This test was also concluded positively and lessons learned will be used to improve and refine the ground segment.

Experiments

All experimenters have delivered flight-quality models, allowing full testing at system level to proceed. In a few cases, extra activities have been planned in the rest of the environmental test programme to modify or improve some elements of certain experiments (e.g. detectors, PROMS).

The UVCS and SUMER experimenters in particular will refurbish their flight models later in the programme with flight detectors and/or mechanisms that are being reworked. The cross delay line detectors (XDL) of both UVCS and SUMER are proceeding according to schedule, with a demonstration model and the first flight model already delivered to UVCS.

The preparatory work to set up the Experiment Operations Facility (EOF) at NASA-GSFC has progressed in terms of both physical setup (rooms, furniture, etc.) and testing of the interconnections between the experimenter-provided and -operated Electrical Ground Support Equipment (EGSE) and the main control facility.

Cluster

Both the protoflight model (PFM) ad F2 spacecraft have almost completed their environmental test programme at IABG Munich.

The F3 spacecraft is currently in its thermal test programme, following which it will be prepared for vibration testing in a stack configuration with F4.

The F4 spacecraft has completed all subsystem and payload integration and testing and is ready for shipment to IABG to commence environmental testing.

During the second week of October, all four fully integrated flight spacecraft will be together in the IABG clean room. This opportunity will be used to introduce the Cluster programme to the press.

After this press event, the PFM and F2 spacecraft will be returned to Dornier, where the scientific payload will be removed for refurbishment and fitting of final flight detectors to the sensors.

The F3 and F4 spacecraft will continue their environmental test programme at IABG.

The first two flight models of the Solid-State Recorders are due for delivery in mid-October, followed by the second pair before the end of 1994.

The groups responsible for the scientific payload are now preparing for the detector exchange and calibration phase *commerciales ont été utilisées pour relier les deux sites à l'occasion de ce premier essai en circuit fermé entre la sonde spatiale et ses futurs contrôleurs. Cet essai a également abouti à des résultats positifs et l'expérience acquise servira à améliorer et à affiner le secteur sol.*

Expériences

Tous les chercheurs ont fourni leurs expériences aux caractéristiques des modèles de vol, ce qui a permis de procéder à l'ensemble des essais au niveau système. Dans un petit nombre de cas, des activités supplémentaires ont été inscrites au programme d'essais d'ambiance afin de modifier ou d'améliorer les éléments de certaines expériences (par exemple détecteurs, PROMS).

En particulier, les responsables des expériences UVCS et SUMER amélioreront leurs modèles de vol lors d'une phase ultérieure du programme en les équipant de détecteurs de vol et/ou de mécanismes en cours de remaniement. La mise au point des détecteurs à lignes de retard croisées (XDL) pour les deux instruments UVCS et SUMER se poursuit conformément au calendrier, l'UVCS ayant déjà reçu un modèle de démonstration et le premier modèle de vol.

Les travaux préparatoires pour la mise sur pied du centre de commande des expériences (EOF) au GSFC de la NASA ont progressé tant en ce qui concerne l'installation matérielle (locaux, mobilier, etc.) que les essais d'interconnexion entre les équipements électriques de soutien sol (EGSE) fournis et exploités par l'expérimentateur et le centre de contrôle principal.

Cluster

Le programme d'essais d'ambiance du prototype de vol (PFM) et de l'unité de vol F2, qui se déroule à l'IABG, Munich, touche à son terme.

Le programme d'essais thermiques de l'unité de vol F3 est en cours. F3 sera ensuite préparé pour subir les essais en vibration en empilement avec F4.

Les activités d'intégration et d'essai de la charge utile et des sous-systèmes de l'unité F4 sont toutes terminées et F4 est prêt pour expédition à l'IABG en vue des essais d'ambiance.

Au cours de la deuxième semaine d'octobre, les quatre modèles de vol entièrement intégrés se trouveront réunis dans la salle blanche de l'IABG. C'est à cette occasion que le programme Cluster sera présenté aux journalistes.

A la suite de cet événement médiatique, les modèles PFM et F2 retourneront chez Dornier où la charge utile scientifique sera retirée pour remise en état et installation sur les instruments des détecteurs de vol définitifs. L'IABG poursuivra le programme d'essais d'ambiance des unités de vol F3 et F4.

Les deux premiers modèles de vol de l'enregistreur à mémoire à état solide doivent être livrés à la mi-octobre et les deux autres d'ici fin 1994.

Les groupes responsables de la charge utile scientifique préparent maintenant la phase de remplacement et d'étalonnage des détecteurs des instruments qui seront réintégrés début 1995, en préparation de la livraison. La plupart des détecteurs des unités PFM, F2 et F3 seront remplacés et il se pourrait que certains composants sensibles des détecteurs de F4 soient inclus dans le programme de remise en état. Ce programme garantira que seuls des détecteurs en excellent état seront embarqués pour la mission.

A l'ESOC, les travaux portant sur le secteur sol se déroulent conformément au calendrier; la majeure partie du matériel est maintenant livrée et la première version du logiciel est disponible pour les tâches opérationnelles. La revue de mise en oeuvre du secteur sol est fixée à la mi-novembre.

Les activités relatives au système d'accès aux données scientifiques se poursuivent elles aussi conformément au calendrier et la première version de l'interface utilisateurs a été livrée et installée avec succès dans tous les centres de données. Pour ce qui est du centre commun des activités scientifiques, le calendrier est respecté et la définition détaillée des interfaces avec l'ESOC, ce qui couvre la télécommande des charges utiles et la surveillance du bon fonctionnement et de la sécurité, est achevée,

Le programme Ariane-5 Apex n'a pas notifié de changement de la date de lancement, fixée au 1er décembre 1995. Confirmation est attendue d'ici fin 1994.

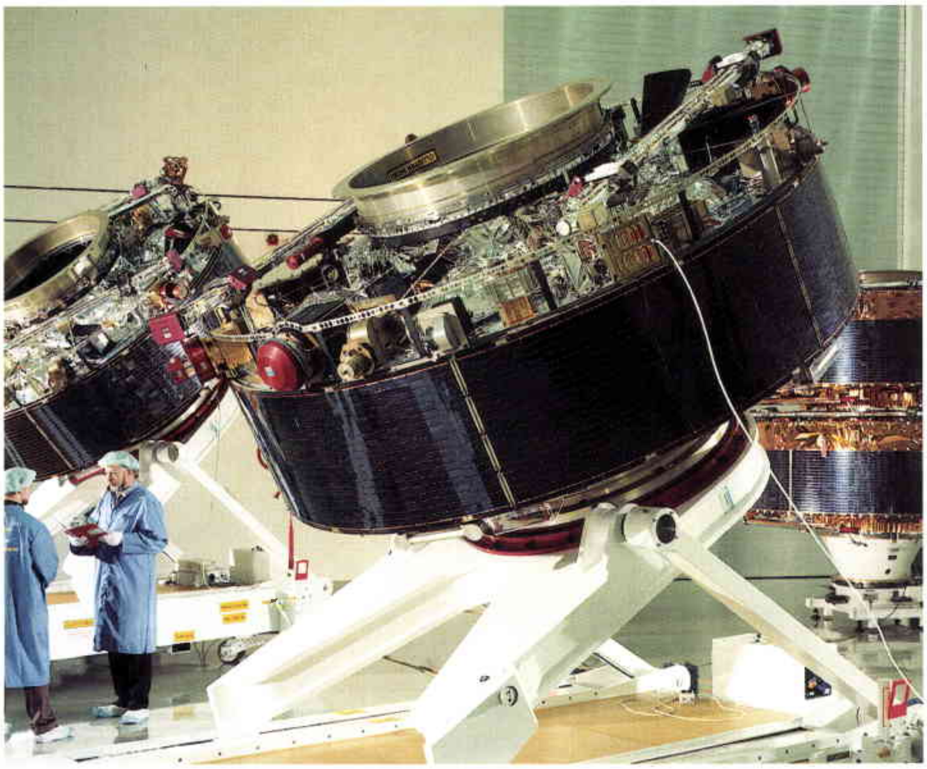
ISO

Le modèle de vol du module charge utile de l'observatoire spatial dans l'infrarouge a été livré à l'ESTEC (NL) en juin. Il a ensuite été intégré au modèle de vol du module de servitude. Depuis lors, le satellite et ses instruments scientifiques ont été soumis à d'importants essais électriques, de fonctionnement et de propreté électromagnétique, qui ont tous été menés à bien avec succès.

A l'issue de tous ces essais, un sujet de préoccupation subsiste à propos du couvercle cryogénique du module charge utile (éjecté en orbite), qui présente quelques points chauds localisés susceptibles de perturber les détecteurs les plus sensibles de l'une des expériences scientifiques. Des recherches sont en cours pour déterminer les causes possibles et trouver des solutions.

ISO flight-model satellite at ESTEC (NL), after mating of the Service and Payload Modules, in July 1994.

Intégration du modèle de vol du satellite ISO aux modules de servitude de charge utile à l'ESTEC en juillet 1994.



L'ensemble des quatre satellites Cluster chez IABG à Ottobrunn (Allemagne)

The four Cluster spacecraft, together at IABG, Ottobrunn (D)

on the instruments prior to them being reintegrated early in 1995 in preparation for delivery. Most sensors on PFM, F2 and F3 will be exchanged, whilst some sensitive components of the F4 sensors may also be included in the refurbishment programme. This programme ensures that only prime-quality detectors will be flown on the mission.

The ESOC ground-segment tasks are proceeding on schedule, with the majority of the hardware now delivered and first release of the software available for operations tasks. The ground-segment implementation review is scheduled for mid-November.

The Science Data System effort also continues on schedule, with the first issue of the User Interface delivered and successfully installed at all data centres. The Joint Science Operations Centre is on schedule, and detailed interface definition with ESOC covering payload commanding and health and safety monitoring is complete.

No change to the declared launch date of 1 December 1995 has been notified by the Ariane-5 Apex programme; a confirmation is expected before the end of 1994.

ISO

The flight-model Payload Module of the Infrared Space Observatory was delivered to ESTEC (NL) in June. It was subsequently mated with the flight-model Service Module. Since then, the satellite and its scientific instruments have been subjected to extensive electrical, functional and electromagnetic cleanliness tests, all of which were completed successfully.

One concern arising out of all the above tests is that the Payload Module's cryocover (ejected in orbit) has some local warm areas which disturb the most sensitive detectors of one particular scientific instrument. Investigations are underway to identify the possible causes and to find solutions.

The satellite will now be subjected to mechanical environment tests, both acoustic and vibration.

Work on the ground segment is also proceeding satisfactorily. A major step forward has been the successful completion of interface tests between spacecraft and science operations development software at the Agency's Villafranca ground station, near Madrid.

The project continues on schedule for the planned September 1995 launch date.

Huygens

Integration of the Structural/Thermal/Pyro Model (STPM) Probe was completed in DASA, Ottobrunn (D) during August, in line with the nominal project planning. This Probe model will be used for mechanical qualification testing and is therefore built with flight-standard structure, covers, mechanisms, heat shield, etc. Mechanically and thermally it is identical to the flight-model Probe.

The integration process flowed quite smoothly despite a number of minor problems being found which gave rise to the generation of Non-Conformance Reports (NCRs). Resolution of these NCRs was usually achieved by local repair, with appropriate feedback to the subsystem manufacturers to eliminate such problems on flight units. System-level testing of the STPM is underway with the final Physical Properties Test sequence already completed.

Integration of the engineering model (EM) Probe has been underway since mid-July with system-level testing planned to start in mid-October, following the Electrical Hardware Design Review. The EM Probe will be electrically representative of the flight model, but mechanically will be in the Entry Module configuration, i.e. without the deceleration/heat shield and back-cover structures, and without certain release mechanisms.

In general terms, the project is proceeding very well, with technical concerns progressively being eased. Schedule maintenance is still a key issue and is receiving constant management attention.

Working interfaces with JPL/NASA partners continue to be good, with NASA'S reaffirmation of Cassini project continuation with a baseline launch date of October 1997, providing a morale boost for all project participants.

Le satellite va maintenant faire l'objet d'essais de résistance mécanique sur les plans acoustique et vibratoire.

Les travaux sur le secteur sol se déroulent également de manière satisfaisante. Un grand pas en avant a été franchi avec la réussite des essais critiques d'interface entre le véhicule spatial et le logiciel de développement des opérations scientifiques, qui ont été conduits à la station sol de l'agence de Villafranca près de Madrid.

L'avancement du projet est conforme à la date de lancement prévue (septembre 1995).

Huygens

L'assemblage du modèle structurel/thermique/pyrotechnique (SPTM) de la sonde a été mené à bien dans les locaux de la DASA à Ottobrunn (D) au cours du mois d'août, conformément au calendrier nominal du projet. Comme ce modèle doit servir aux essais de qualification mécanique, il a été réalisé aux normes du modèle de vol en ce qui concerne la structure, les couvercles, les mécanismes, le bouclier thermique, etc. Sur les plans mécanique et thermique, ce modèle est identique au modèle de vol de la sonde. Le processus d'intégration s'est déroulé de manière tout à fait satisfaisante malgré la mise en évidence d'un certain nombre de problèmes mineurs, qui ont donné lieu à des rapports de non- conformité (NCR). La plupart des défauts ont été éliminés par des réparations sur place, les fabricants des sous-systèmes étant dûment informés afin que les problèmes ne se reproduisent pas sur les unités de vol. Les essais du STPM au niveau système sont en cours, la dernière séquence d'essais mécaniques ayant d'ores et déjà été menée à bien.

L'intégration du modèle d'identification (EM) de la sonde est en cours depuis la mi-juillet, les essais au niveau système devant démarrer à la mi-octobre à l'issue de la revue de conception des composants électriques. Le modèle d'identification sera représentatif du modèle de vol sur le plan électrique, mais se présentera dans la configuration du module de rentrée sur le plan mécanique, c'est-à-dire qu'il sera dépourvu du bouclier thermique, du couvercle arrière et de leurs mécanismes d'assemblage, ainsi que de certains mécanismes de séparation.

Assembly of the Huygens (STPM) Probe at DASA, Ottobrunn (D).

Assemblage du modèle STPM de la sonde Huygens chez DASA à Ottobrunn (Allemagne).

D'une façon générale, le projet avance de manière très satisfaisante, les incertitudes techniques étant progressivement levées. Le respect du calendrier est toujours un point crucial auquel les responsables du projet accordent une attention permanente.

L'Agence continue d'entretenir de bonnes relations avec ses partenaires au sein du JPL de la NASA, l'Agence américaine ayant confirmé la poursuite du projet Cassini, avec une date de lancement de référence en octobre 1997, ce qui est un encouragement pour tous les participants au projet.

Rosetta

Ces derniers temps, les activités ont été axées sur la définition de l'Orbiteur de Rosetta par une équipe de l'ESA afin de préparer les définitions d'interface avec la charge utile de l'Orbiteur et les deux ensembles d'expériences scientifiques de surface (SSP). Cette définition livrera les éléments d'information nécessaires pour la phase de définition détaillée qui doit commencer fin octobre et pendant laquelle l'industrie procédera, en étroite collaboration avec l'équipe de l'ESA, à des arbitrages entre options pour différents éléments critiques de la mission.

La phase de soutien industriel durera au minimum un an et sera conduite parallèlement par deux groupements industriels de manière à ce que toutes les options recensées soient étudiées sous différents angles.

Lors d'une récente réunion avec les fournisseurs de l'ensemble d'étude scientifique de surface (SSP), le concept de l'Orbiteur et les différents éléments du SSP ont été examinés de façon approfondie. De manière générale, les éléments du SSP actuellement étudiés par les deux groupements et pour lesquels l'ESA recevra des propositions officielles en novembre, sont compatibles avec les caractéristiques du concept de référence

Rosetta

Recent activities have concentrated on the definition of the Rosetta Orbiter by an ESA in-house team in preparation for interface definitions to the Orbiter Payload and the two Surface Science Packages. This definition will be used as the inputs to a detailed definition phase due to commence in late October in which Industry will work in close cooperation with the ESA team to trade off options for various mission-critical items.

The industrial support phase will last a minimum of one year and will be conducted by two parallel industrial groups to ensure that all identified options are studied from different angles.

At a recent meeting with the Surface Science Package (SSP) suppliers, concepts for the Orbiter and the individual SSPs were extensively discussed. In general, the SSPs being studied by the two groups, for which ESA will receive formal proposals in November, are both compatible with the current Orbiter baseline design features. Additionally, the meeting covered the flight operational requirements originating from the SSPs and their interaction with the baseline Orbiter mission.

Following receipt of the proposals in November, it is expected that the two SSP suppliers will prepare payload Announcements of Opportunity (AO) for simultaneous issue with the ESA Orbiter payload AO in March 1995.

The selection of the SSP payload is proposed to be done initially by the suppliers. This will be followed by a full proposal update to the Agency in time for the normal ESA payload selection process, which will be applied to the Orbiter payload proposals. This approach will ensure that the overall scientific return from the mission is fully co-ordinated.

DRTM

Artemis

Following the decision of the Ariane Programme Board to no longer consider Artemis as a candidate for an Apex launch, discussions were held at a special Joint Communications Board (JCB) on 6 July on how to proceed programmatically and financially. These will be continued in September in readiness for a decision at the October JCB.

Steady progress has been made on the preparation and issue of interface-requirements drawings for the engineering and structural models of the satellite. Equipment layout drawings for these models, as well as the PFM satellite, are virtually complete.

Engineering/qualification models (EQM's) of many equipment items are now entering their test programmes, and Baseline Design Reviews are being held at subsystem level.

Preliminary results of the coupled load analysis have been issued by the launch-vehicle authority and reviewed by the ALS system team. Initial results are positive in that the load-analysis values show that the quasi-static levels defined in the environmental specification are not exceeded.

Significant progress has been achieved in the finalisation of the test requirements and Assembly, Integration and Test (AIT) planning for the three satellite models (SM, EM and PFM). Definition of the requirements for the AIT campaigns using the ESTEC test facilities has also continued. A review has been made of the AIT activities with a view to improving the schedule.

Some improvements on the Hi-Rel parts delivery forecasts have been achieved and more manpower is now being devoted to procurement follow-up.

Silex system and Low Earth Orbit (LEO) terminal for Spot-4

The first results of the microvibration test performed on the structural/thermal model (STM) of the LEO terminal are very encouraging in so far as they show a lower than expected sensitivity of the pointing performance to microvibrations.

The acoustic vibration tests on the STM have been completed and the measured levels on the critical optical head have been found to be equal to or lower than the predicted ones. The STM terminal has also successfully completed the solar vacuum test campaign.

Integration of the EQM terminal is under way, but the schedule remains critical due to delays in some equipment deliveries.

An in-depth analysis of the critical paths has been performed with the Prime Contractor, leading to the identification of an alternative integration sequence which will minimise the effects of these delays.

DRS

The current DRS phase is almost complete. The Phase-B2 proposal received from industry to perform all the technical activities up to the start of Phase-C/D has been negotiated and agreed. Prime Contractor activities have been initiated under a Limit of Liability.

Since this phase will prepare the technical and programmatic material for the DRS Phase-C/D proposal, the ESA Request for Proposal for that phase is an essential input ensuring that the work is carried out on a secure basis. The Procurement Proposal for Phase-C/D was presented to ESA's Industrial Policy Committee (IPC) in May, but was withdrawn following a request by several Delegations that the JCB should first discuss the strategy to be followed.

The offers received for the S-Band Data Relay (SDR) receive and transmit active phase array have been evaluated and negotiated, and preferred suppliers have been identified. The development and manufacture of this payload is planned to be performed in two steps, in line with the DRS Phases 1 and 2. The EQM equipment will be developed and manufactured and high-rel parts will be procured in Phase 1, while the assembly, integration and test of the EQM payload and the manufacturing, assembly and test of the flight payloads will be performed in Phase 2. Because of the uncertainties in the DRTM Programme due to the need to finance the launch of Artemis, presentation of a Contract Proposal for the Phase 1 activities to the IPC has been delayed.

Additional procurements have been made of those items of equipment that are common to Artemis and DRS. They will first serve as integration spares for Artemis, and will subsequently be used for the DRS-1 satellite.

actuel de l'Orbiteur. Les participants à cette réunion ont en outre traité des impératifs de fonctionnement en vol découlant des éléments du SSP et de leur interaction avec la mission de référence de l'Orbiteur.

Après réception des propositions, en novembre, les deux fournisseurs des éléments du SSP devraient préparer des appels de propositions de charge utile qui seraient envoyés simultanément à l'appel de propositions lancé par l'ESA pour la charge utile de l'Orbiteur, c'est-à-dire en mars 1995.

Il est proposé que le choix initial de la charge utile SSP soit fait par les fournisseurs. Ce choix sera suivi par une actualisation de l'ensemble de la proposition adressée à l'Agence, en temps opportun pour le déroulement de la procédure de sélection des charges utiles habituelle à l'ESA, qui sera appliquée aux propositions de charge utile de l'Orbiteur. Cette façon de procéder garantira la pleine coordination du rendement scientifique global de la mission.

DRTM

Artemis

Le Conseil directeur du programme Ariane ayant décidé de ne plus considérer Artemis comme candidat à un vol Apex, le Conseil directeur commun des programmes de satellites de communications (JCB) a examiné lors d'une réunion spéciale le 6 juillet la façon dont ce projet serait poursuivi sur le plan programmatique et financier. Ces débats se poursuivront en septembre en vue d'une décision à prendre à la réunion d'octobre du JCB.

La préparation et la publication des dossiers d'impératifs en matière d'interfaces pour les modèles d'identification (EM) et de structure (SM) du satellite se sont poursuivies régulièrement. Les dossiers sur l'aménagement des équipements dans ces modèles et dans le prototype de vol (PFM) sont pratiquement terminés.

Les programmes d'essai des modèles d'identification/qualification (EQM) de nombreux éléments débutent maintenant et des revues de conception de référence sont menées au niveau sous-système.

Le responsable du lanceur a communiqué les résultats préliminaires de l'analyse couplée dynamique, qui ont été examinés par l'équipe système d'ALS. Les premiers résultats sont satisfaisants puisque les valeurs de l'analyse montrent que les niveaux quasi statiques figurant dans les spécifications ne sont pas dépassés.

La mise au point définitive des impératifs d'essais et du planning d'assemblage, d'intégration et d'essai (AIT) des trois modèles du satellite (SM, EM et PFM) a beaucoup progressé. La définition des impératifs s'est également poursuivie en vue des campagnes AIT qui feront appel aux installations d'essais de l'ESTEC. Une revue des activités AIT a été menée afin d'améliorer le calendrier.

Les prévisions de livraisons des pièces à haute fiabilité ont été améliorées et les effectifs affectés au suivi de l'approvisionnement ont été augmentés.

Expérience Silex et terminal en orbite terrestre basse (LEO) sur Spot-4

Les premiers résultats de l'essai en microvibration du modèle structurel et thermique (STM) du terminal LEO sont très encourageants car ils montrent que la capacité de pointage est moins sensible que prévu aux microvibrations.

Les essais en vibration acoustique du STM sont terminés et les valeurs mesurées au niveau de la tête optique critique sont égales ou inférieures aux valeurs prévues. La campagne d'essais du STM en caisson vide-soleil s'est également bien déroulée.

L'intégration de l'EQM du terminal est en cours mais le calendrier reste critique en raison de retards dans la livraison de certains équipements.

Une analyse approfondie des chemins critiques réalisée avec le maître d'oeuvre a permis de trouver une autre séquence d'intégration qui réduit les incidences de ces retards.

DRS

La phase actuelle de DRS est presque terminée. L'industrie a envoyé une proposition de phase B2 portant sur toutes les activités techniques jusqu'au démarrage de la phase C/D qui a été négociée et acceptée. Les activités du maître d'oeuvre ont été lancées mais avec une limitation d'engagement.

Dans la mesure où cette phase préparera la proposition de phase C/D sur le plan technique et programmatique, la demande d'offre de l'ESA est un facteur essentiel pour la conduite des travaux sur des bases solides. La proposition d'approvisionnement relative à la phase C/D a été présentée au Comité de la politique industrielle (IPC) en mai mais a été retirée à la demande de plusieurs délégations souhaitant que le JCB examine d'abord la stratégie à suivre.

Les offres reçues au sujet de la charge utile en bande S d'émission/transmission à réseau actif à commande de phase de relais des données (SDR) ont été évaluées et négociées, ce qui a permis de retenir les fournisseurs. Il est prévu de réaliser et de fabriquer cette charge utile en deux étapes, parallèlement aux phases 1 et 2 de DRS. La réalisation et la fabrication des équipements de l'EQM ainsi que l'approvisionnement des pièces à haute fiabilité se feront au cours de la phase 1, tandis que l'assemblage, l'intégration et les essais de l'EQM des charges utiles et la fabrication, l'assemblage et les essais des modèles de vol des charges utiles se feront lors de la phase 2. En raison des incertitudes qui planent sur le programme DRTM, liées à la nécessité de financer le lancement d'Artemis, la présentation à l'IPC d'une proposition de contrat portant sur les activités de phase 1 a été reportée.

L'approvisionnement d'autres équipements communs à Artemis et DRS a été réalisé. Ils serviront d'abord de rechanges pour l'intégration d'Artemis puis seront utilisés dans le satellite DRS-1.

Terminal experimental en bande S (ESBT)

Le répéteur est maintenant réparé et muni d'une nouvelle carte multicouche. L'ESBT devrait être livré au CNES en novembre.

Secteur sol

L'Agence a reçu une proposition relative au secteur sol de contrôle d'Artemis envoyée par un consortium récemment créé, ALTEL, regroupant des équipes d'Alenia Spazio et de Telespazio.

La proposition d'ALTEL a été examinée lors de la réunion spéciale du JCB du 6 juillet à l'ESOC et le sera de nouveau afin

Experimental S-Band Terminal (ESBT)

The transponder has now been repaired with a new multilayer board. ESBT delivery to CNES is expected to take place in November.

Ground segment

The Agency has received a proposal for the Artemis spacecraft-control ground segment from a newly-formed consortium ALTEL, consisting of groups from Alenia Spazio and Telespazio.

The ALTEL proposal was discussed at the special JCB held in ESOC on 6 July and further discussions are being held in readiness for the September IPC and October JCB.

Artemis ground-segment activities unaffected by the ALTEL offer continue as planned with, in particular, the delivery and test of the SILEX LEO Mission Control System to be installed at ESA's Redu (B) ground station.

Interface tests with the CNES Spot-4 control centre have started and will lead to system tests with the SPOT/PASTEL spacecraft engineering model next year.

Almost all In-Orbit Test Facility procurements are now underway.

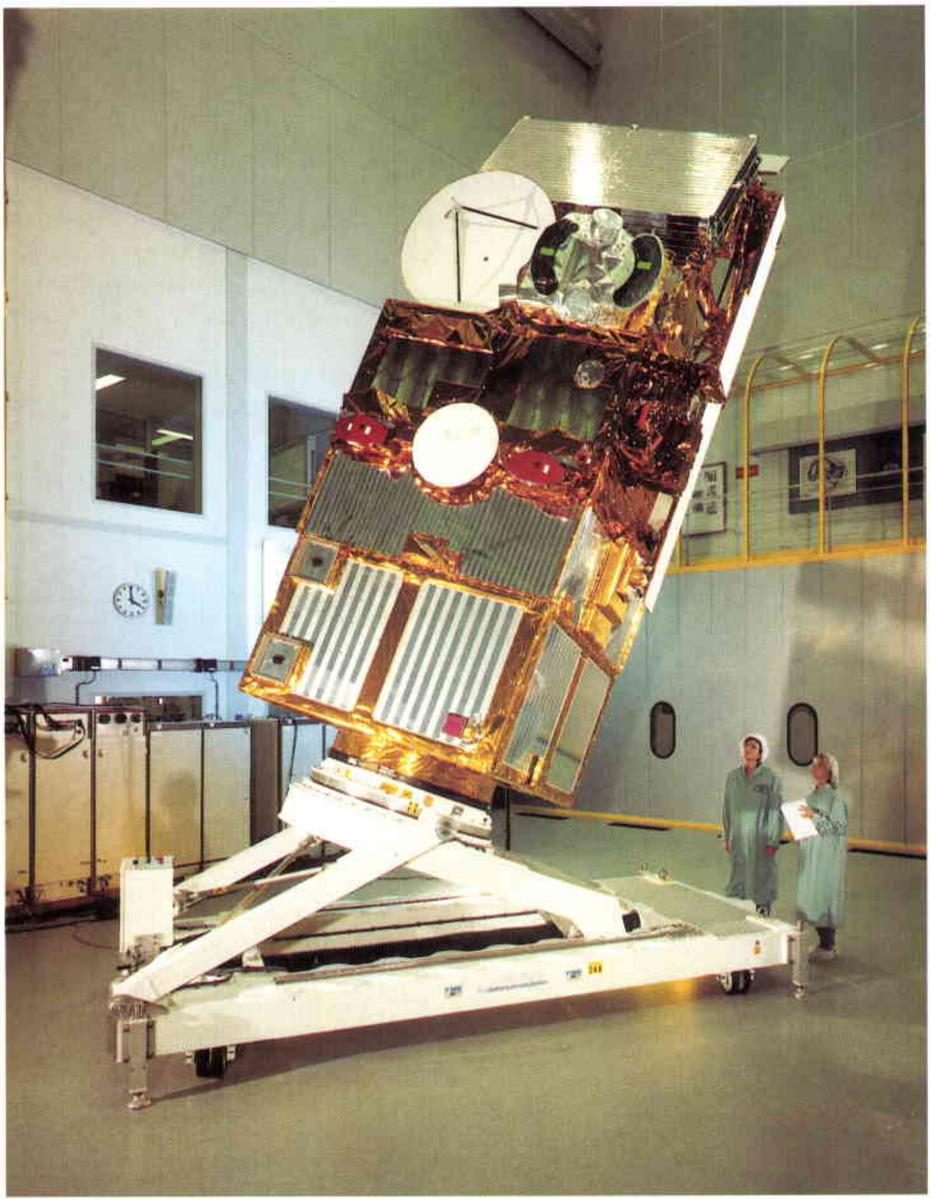
User interfaces

An Agency review of the interfaces between Artemis/DRS and Envisat has been held. This concluded that all major aspects of the inter-orbit link interfaces were properly defined and reflected in the plans and designs of both programmes.

Definition of the DRS user terminal that is planned to be carried on the Columbus Orbital Facility (COF) continues. It has now been agreed by NASA that such a terminal may be carried and used to transfer data from the COF directly to Europe.

The Atmosphere Re-entry Demonstrator programme has identified that it would be attractive for the vehicle to carry a data-relay link to maximise the information recovery during the flight, and discussions have been held to define a cheap, simple means of providing such a link.

The Memorandum of Understanding governing collaboration between ESA and NASDA, the Japanese Space Agency, for the OICETS/Artemis experiment was approved by the ESA Council in June.



Modèle de vol d'ERS-2 au centre d'essais de l'ESTEC à Noordwijk (Pays-Bas)

The ERS-2 flight model in the Test Facility at ESTEC, Noordwijk (NL)

ERS-1

The health of the satellite after three years of operation in orbit remains excellent, with all systems operating within specification and so far only one in-flight redundancy being used (instrument data transmission travelling wave tube). As ERS-1's design life was three years, some of its elements are approaching the end of their qualified life. However, since the available redundancy has not yet been used, considerable operating lifetime remains and ERS-1 should therefore be available as a standby for ERS-2 and to support tandem operation with ERS-2 during much of the latter's operational life.

ERS-2

The satellite integration and test activities have now been completed and preparations are underway for launch at the end of 1994/beginning 1995 from Kourou on an Ariane-4 launch vehicle.

The orbit into which ERS-2 will be injected is carefully phased with the very similar orbit of ERS-1 to ensure a constant offset between the two satellites. The same point on the ground will be revisited by the two satellites within a one or eight-day period.

de préparer les réunions de l'IPC en septembre et du JCB en octobre.

Les activités relatives au secteur sol d'Artemis qui ne sont pas couvertes par la proposition d'ALTEL se poursuivent comme prévu, notamment la livraison et les essais du système de contrôle de la mission pour le terminal LEO/SILEX sera installé à la station sol de l'ESA à Redu, en Belgique.

Les essais relatifs aux interfaces, menés avec le centre de contrôle de Spot-4 du CNES, ont démarré et déboucheront l'année prochaine sur les essais au niveau système faisant intervenir le modèle d'identification du satellite Spot/Pastel.

La quasi-totalité des approvisionnements relatifs à l'installation d'essai en orbite est en cours.

Interfaces utilisateurs

L'Agence a réalisé une revue des interfaces entre Artemis/DRS et Envisat et conclu que les principaux aspects des interfaces relatives à la liaison interorbitale étaient correctement définis et pris en compte dans les plans et les concepts des deux programmes.

La définition du terminal utilisateurs DRS qu'il est prévu d'embarquer sur l'élément orbital Columbus (COF) se poursuit. La NASA a maintenant accepté que ce terminal soit embarqué et utilisé pour transmettre les données du COF directement en Europe.

Les responsables du programme de démonstrateur de rentrée atmosphérique ayant fait savoir qu'il serait intéressant d'embarquer une liaison de relais de données à bord du véhicule afin d'optimiser la récupération des données lors du vol, on a examiné comment installer une liaison de ce type de façon simple et peu onéreuse.

Le Mémorandum d'accord qui régit la collaboration entre l'ESA et la NASDA (Agence spatiale japonaise) dans le cadre de l'expérience OICETS-Artemis a été approuvé par le Conseil de l'ESA en juin.

ERS-1

A l'issue de trois ans de travail en orbite, le satellite demeure en excellente forme, tous les systèmes fonctionnant dans les limites des spécifications, et seul un instrument de réserve a été utilisé jusqu'ici (tube à ondes progressives pour la transmission des données). ERS-1 ayant été conçu pour une durée de vie de trois ans, certains de ses éléments arrivent à la fin de leur résistance prévue. Cependant, les instruments de réserve n'ayant pas encore été utilisés, ERS-1 dispose toujours d'une capacité de fonctionnement considérable et devrait donc être disponible en renfort d'ERS-2 ainsi que pour procéder à un travail en tandem avec ERS-2 pendant une bonne partie de l'exploitation de ce dernier.

ERS-2

Les activités d'intégration et d'essai du satellite sont désormais terminées et les préparatifs sont en cours pour son lancement fin 1994/début 1995 à Kourou par un lanceur Ariane-4.

L'orbite sur laquelle ERS-2 sera injecté est calculée pour être en phase avec le l'orbite très similaire d'ERS-1 afin d'assurer un calage constant des deux satellites. Le même point au sol sera survolé deux fois par les deux satellites dans un laps de temps de 1 ou 8 jours.

Un avis d'offre de participation a été lancé pour l'étude et la caractérisation scientifique des nouveaux instruments GOME, canaux visibles de l'ATSR et PRARE à bord d'ERS-2 et a permis de choisir une large gamme de projets qui seront mis en oeuvre pendant la phase de recette en orbite du satellite, laquelle doit durer au total 6 mois.

EOPP

Solide terrestre

A la suite des délibérations du Conseil directeur d'observation de la Terre de juin, il a été mis fin à la possibilité d'une coopération ESA/Agence spatiale russe sur l'expérience EXTRAS (Mesure du temps et des distances et sondage atmosphérique). Priorité est désormais donnée à une mission consacrée à la mesure du champ gravitationnel terrestre. Ce sera une reprise du programme Aristoteles, dont le lancement avait été proposé initialement en 1997, mais qui n'avait pas reçu de soutien financier.

Métop-1

Les études de définition de phase A se sont poursuivies pendant la période couverte par le présent rapport. Des travaux visant à établir les impératifs de la phase B ont été engagés; il doivent être financés sur le programme préparatoire Métop.

Autres études

Des études sont en cours dans l'industrie afin d'évaluer le potentiel de petits satellites pour l'observation de la Terre. On continue également à travailler à la définition d'une série de nouveaux instruments pour de futures missions.

Campagnes

Les activités de la campagne EMAC qui avaient été approuvées se sont poursuivies avec de nouveaux vols. Sur ces entrefaites, une nouvelle campagne dénommée ELITE est en préparation en complément de l'expérience américaine LITE (Lidar en technologie spatiale), qui devrait être embarquée sur la Navette spatiale en septembre.

Météosat de deuxième génération (MSG)

En ce qui concerne les activités de définition aux niveaux système et sous-système de phase B, le premier point de passage obligé a été franchi sans encombre par l'industrie au cours de la revue préliminaire. Les ensembles d'appels d'offres pour les principaux sous-systèmes viennent d'être adressés à l'industrie afin de retenir les sous-traitants qui seront chargés des activités de conception et de définition détaillées de phase B. Les premières propositions ont déjà été reçues et sont en cours d'évaluation. Un consortium industriel, bénéficiant du soutien de l'un des chercheurs principaux, a fait connaître son intérêt pour la fabrication et l'essai de l'instrument GERB (Bilan radiatif de la Terre sur orbite géostationnaire). L'intégration de cet instrument dans le programme MSG est envisagée à titre d'ensemble AOP (Avis d'offre de participation).

Métop

Le programme préparatoire Métop est en bonne voie. L'industrie a engagé des travaux sur la conception et le montage-table d'éléments critiques des instruments

An Announcement of Opportunity for the scientific investigation and characterisation of the new instruments — GOME, ATSR-Visible Channels and PRARE — onboard ERS-2 has resulted in the selection of a wide range of projects which will start to be implemented during the commissioning phase of the satellite, which is expected to last a total of six months.

EOPP

Solid Earth
Following discussions in June with the Earth-Observation Programme Board, the possible ESA-Russian Space Agency cooperative experiment, Experiment on Time, Ranging and Atmospheric Sounding (ESTRAS), has been discontinued. Priority is now being given to a mission dedicated to measurement of the Earth's gravity field. This will be a follow-on to the Aristoteles Programme, which was originally proposed for launch in 1997, but was not financially supported.

Metop-1
The Phase-A definition studies have continued during the reporting period. Work has been initiated to establish the Phase-B requirements, which are to be funded from the Metop Preparatory Programme.

Other studies
Industrial studies are in progress to assess the potential value of small satellites for Earth observation. Work also continues on the definition of a range of new instruments for future missions.

Campaigns
The agreed EMAC campaign activities have continued with further flight activities. Meanwhile, a new campaign called ELITE is in preparation to underfly the US LITE experiment (Lidar in Space Technology Experiment), which should fly on the Space Shuttle in September.

Meteosat Second Generation (MSG)
The first checkpoint for the Phase-B system and subsystem design definition activities was passed successfully by Industry during the Preliminary Review.

Major subsystem 'Invitation to Tender' (ITT) packages have recently been issued to Industry, in an open competition to select subcontractors for detailed Phase-B engineering and design activities. The first proposals have already been received and are under evaluation.

Notification of interest from an Industrial Consortium, supported by a Prime Investigator, has been received for the manufacture and testing of a Geostationary Earth Radiation Budget (GERB) Instrument. This Instrument will be considered for integration within MSG as an Announcement of Opportunity Package (AOP).

Metop
The Metop Preparatory Programme is now well underway. Industrial work to design and breadboard critical elements of the MIMR (Multifrequency Imaging Microwave Radiometer) and ASCAT (Advanced Scatterometer) instruments has commenced. Building on the results of the Phase-A industrial study conducted within the framework of the Earth-Observation Preparation Programme (EOPP), a satellite-system Phase-B is being prepared.

The selection of the final Metop satellite configuration, particularly the payload definition, is now maturing following deliberations within and between ESA and Eumetsat.

Envisat-1/ Polar Platform

Systems
The Envisat Mission System Preliminary Design Review (EMS-PDR) has been completed with a Review Board meeting in the second half of July 1994. All elements of the Envisat-1 mission, including the Polar Platform, the payload instruments and the ground segment, have been reviewed together for the first time, showing good overall progress. Problems have been identified in some specific areas and the necessary remedial actions have been defined. The industrial consortia, led by BAe and Dornier, have been briefed on the main results of the Review.

Polar Platform
The Polar Platform activities are proceeding according to plan. Manufacture of the Service Module flight-model structure is well advanced and should be completed by end-1994. Integration of the flight model will start in early 1995. Availability of the Payload Module structural model has been delayed due to manufacturing difficulties. As part of the solar-array qualification programme, thermal-cycling testing of two qualification-model panels has taken place in the Large Solar Simulator at ESTEC (NL).

Following problems encountered during the life-testing of development models, redesign of the DRS Antenna Pointing Mechanism (APM) and Solar Array Drive Mechanism (SADM) is in progress and should be completed by the end of the year.

The Preliminary Launcher Coupled Dynamics Analysis of the Envisat-1 satellite with Ariane-5 has been completed. The separation shock test between the Polar Platform and Ariane-5 Launch Vehicle Adaptor will be carried out in September.

An Agency internal review of the PPF and Artemis programmes has confirmed the proper design of the PPF communications subsystem and the adequacy of the PPF link via the Data Relay Satellite.

Final negotiation of two major subcontracts has been completed, with Matra for the Service Module and Dornier for the Payload Equipment Bay. Final contract negotiations with BAe are now in progress. The contract with BAe for the complete PPF is expected to be signed by fall 1994.

Envisat-1
Instrument design and development activities are progressing well, with a number of bread-board activities nearing completion. Work on the engineering models of some instruments is already well advanced.

The commercial difficulties experienced with the MIPAS instrument have been settled with an industrial agreement on a different sharing of work and responsibilities. Attention is now focused on the MERIS instrument, where a number of difficult technical problems still exist. Different design solutions are being considered and traded-off.

On the ASAR instrument, the electrical design is progressing normally. Promising

MIMR (radiomètre hyperfréquences imageur multifréquences) et ASCAT (diffusiomètre de technologie avancée). Sur la base des résultats de l'étude de phase A conduite par l'industrie dans le cadre du programme EOPP, on prépare une phase B du satellite au niveau système.

Le choix de la configuration finale du satellite Métop, et en particulier la définition de sa charge utile, prennent forme à la suite des délibérations conduites au sein de l'Agence et entre celle-ci et Eumetsat.

Envisat-1/Plate-forme polaire

Systèmes

La revue de définition préliminaire au niveau système de la mission Envisat (EMS-PDR) s'est achevée dans la deuxième quinzaine de juillet 1994 par une réunion de la Commission de revue. Tous les éléments de la mission Envisat-1, plate-forme polaire, instruments de la charge utile et secteur sol, ont été pour la première fois passés en revue dans leur ensemble, et la Commission a noté une bonne progression générale. Elle a cerné des problèmes dans certains domaines spécifiques et défini les remèdes nécessaires. Les consortiums industriels, pilotés par BAe et Dornier, ont été informés des principaux résultats de la revue.

Plate-forme polaire

Les activités se poursuivent selon le plan. La fabrication de la structure du modèle de vol du module de servitude a bien progressé et devrait être terminée fin 1994. L'intégration du modèle de vol sera mise en route début 1995. La mise à disposition du modèle structurel du module de charge utile a été retardée pour des difficultés de fabrication. Dans le cadre du programme de qualification des réseaux solaires, deux panneaux du modèle de qualification ont été soumis à des essais de cyclage thermique dans le grand simulateur solaire de l'ESTEC (Pays-Bas).

A la suite des problèmes rencontrés lors des essais d'endurance des modèles de développement, la conception du mécanisme de pointage d'antenne (APM) et du mécanisme d'entraînement du réseau solaire (SADM) du DRS fait l'objet de nouvelles études qui devraient s'achever pour la fin de l'année.

L'analyse préliminaire de la dynamique couplée du satellite Envisat-1 et du lanceur Ariane-5 s'est achevée. Les essais de choc à la séparation de la plate-forme polaire et de l'adaptateur du lanceur Ariane-5 sont menés en septembre.

Une revue des programmes PPF et Artemis conduite en interne à l'Agence a confirmé le bien-fondé de la conception du sous-système de télécommunications de la PPF et l'adéquation de la liaison PPF via le satellite de relais de données.

Les négociations finales des deux principaux sous-contrats, avec Matra pour le module de servitude et avec Dornier pour la case à équipements de la charge utile, se sont achevées. Les négociations finales du contrat BAe progressent; le contrat portant sur l'ensemble de la PPF devrait être signé à l'automne 1994.

Envisat-1

Les activités de conception et de mise au point des instruments progressent normalement, un certain nombre de travaux sur montages-table étant proche de leur achèvement. Les travaux sur les modèles d'identification de certains instruments ont déjà bien progressé.

Les difficultés d'ordre commercial rencontrées avec l'instrument MIPAS ont été résolues par un accord industriel prévoyant un partage différent des travaux et des responsabilités. L'attention se porte désormais sur l'instrument MERIS qui présente encore un certain nombre de problèmes techniques difficiles. Différentes solutions de conception sont à l'étude et feront l'objet d'arbitrages.

Sur l'instrument ASAR, l'étude électrique progresse normalement. Des résultats prometteurs ont été obtenus avec la deuxième génération de modules d'antennes actives et la conception du radiateur est en voie d'achèvement. La conception structurelle de l'antenne et la définition détaillée de l'interface entre l'antenne et la plate-forme sont en revanche sources de préoccupations, dues principalement à une augmentation importante de la masse de l'antenne. Des tâches spécifiques ont été définies à la suite des recommandations de la Commission EMS-PDR. La conception détaillée de l'antenne devrait être définitivement fixée et gelée pour la fin décembre 1994.

Les négociations contractuelles avec un certain nombre de sociétés appartenant au consortium Envisat devraient être engagées dans un proche avenir.

Secteur sol

Les deux contrats parallèles concernant la phase de consolidation du secteur sol d'Envisat ont été préparés et sont prêts à la signature par les industriels.

Recherche en microgravité

La mission IML-2 du Spacelab s'est déroulée du 8 au 23 juillet de cette année. La Navette Columbia, emportant quatre matériels d'expérience de l'ESA pour des recherches en sciences de la vie, physique des fluides et croissance des protéines a été lancée du Centre spatial Kennedy à l'ouverture du créneau, le 8 juillet à 12h43, heure locale. Elle a atterri, toujours au KSC, le 23 juillet à 6h38. La plus longue des missions de la Navette lancée à ce jour, elle a permis de mener à bien un programme d'expériences très complet.

Les moyens fournis par l'ESA étaient les suivants: le Biorack, embarqué pour la troisième fois, avec 19 expériences de biologie; l'ensemble d'étude des gouttes, bulles et particules, lancé pour la première fois, avec 8 expériences d'études de phénomènes de physique des fluides; l'installation point critique, embarquée pour la deuxième fois, dont cinq expériences ont étudié le comportement de fluides autour de la température correspondant au point critique; et l'installation de cristallisation de protéines de technologie avancée (2 ensembles, l'un embarqué pour la première fois, le deuxième pour la seconde) comportant 18 expériences d'étude de la croissance des protéines dans des conditions très précises. Les installations d'expériences de l'ESA et la quasi-totalité des 50 expériences menées au cours de cette mission ont fourni des résultats extrêmement probants.

L'un des aspects importants de la mission IML-2 a été la télécommande de plusieurs results with the second generation of active antenna modules have been obtained and the radiator design is being finalised. The structural design of the antenna and the detailed definition of the interface between the antenna and the Polar Platform are, however, a cause of concern, due mainly to a significant increase in the antenna's mass. Specific actions have been defined following the recommendations of the EMS-PDR Board. The detailed antenna design is expected to be finalised and frozen by end of December 1994.

Contract negotiations with a number of companies in the Envisat Consortium are expected to start in the near future.

Ground Segment
The two parallel contracts with Industry concerning the Envisat Ground Segment Consolidation Phase have been prepared and are ready for signature.

Microgravity Programme

The IML-2 Spacelab mission took place from 8 to 23 July 1994. The Space Shuttle 'Columbia', carrying four ESA experiment facilities for investigations in life sciences, fluid physics and protein growth, was launched from Kennedy Space Center exactly on schedule, on 8 July 1994 at 12:43 a.m. local time. It landed again at KSC on 23 July 1994 at 06:38 a.m. This was the longest Shuttle mission flown so far and hence it allowed an extensive experimental programme to be undertaken.

The ESA experiment facilities were: the Biorack, flown for the third time, with 19 experiments in biology; the Bubble, Drop and Particle Unit, flown for the first time, with 8 experiments for investigating fluid-physics phenomena; the Critical Point Facility, flown for the second time, with 5 experiments studying the behaviour of fluids around the critical-point temperature; and the Advanced Protein Crystallisation Facility (two units, one flown for the first time, the other for the second time) with 18 experiments, investigating protein growth under very controlled conditions. The ESA experiment facilities and almost all of the 50 experiments carried out during this mission performed extremely well.

An important aspect of the IML-2 mission was the remote operation (i.e. operations from sites other than the Payload Operations Control Center at NASA-MSFC) of several European experiment payload facilities from ESA and other space agency sites for the first time on such a large scale. This activity, financed by the Columbus Utilisation Preparation Programme, was introduced rather late in the ground operations scheme for the mission, but turned out to be very useful.

The experiment hardware for the physiological and material-science experiments to be conducted on Euromir'94 was delivered and transported to the Mir Space Station by the 'Progress' vehicle on 25 August. A parabolic-flight campaign in support of these experiments had been performed in July. The remaining preparations for the Euromir'94 mission in October are well underway.

Columbus Programme

Columbus Orbital Facilities (COF)
Industry's primary efforts have been focused on continued technical definition of the COF 'design-to-cost' configuration option. Key configuration features of this option, which is aimed at achieving the lowest possible COF development costs, are:

- Reuse of the primary and secondary structure currently under development by ASI/Alenia for the Mini Pressurised Logistics Module (MPLM), together with maximum reuse of subsystems hardware. This approach results in a reduction in COF length from an 'APM5' to an 'APM4'.
- Return to the Space Shuttle as the primary launch vehicle for the COF, as the MPLM is presently only being qualified for this launch vehicle.
- Elimination of such features as accommodation of an Optical Window, 'hook and scars' for later accommodation of an internal/external robotics capability, or an External Platform.

At its meeting on 12 July, the Space Station Control Board (SSCB) approved changes to the ISS Assembly Sequence, as proposed by NASA. This was the first SSCB meeting in which RKA participated as a full member of the Board. Key changes introduced into the assembly sequence by this SSCB approval are:

- A two-year delay in the launch of the Russian Science Power Platform (SPP), which is now targeted for launch in Phase 3, rather than Phase 2 of Station assembly.
- Introduction of a US 'Power Tower' in Phase 2, to replace the Russian SSP until it is launched in Phase 3.
- Launch during Phase 2 (Nov. 1998) of the first Russian Research Module.
- Launch of the COF on Ariane-5 (Feb. 2001)

Work has continued with NASA and the other International Partners on the preparation of Volume 3 of the Concept of Operations and Utilisation (COU) document, which covers implementation aspects of the operations and utilisation principles previously agreed and base-lined at the ISS System Design Review in COU Volume 1. Important implementation aspects covered in Volume 3 are the role of Ariane-5/ATV for the launch of the COF and the subsequent role of Ariane-5/ATV in the logistics support of ISS, and implementation aspects of the distributed operations concept for the COF.

Complementary Columbus Orbital Facilities (CCOF)
Declarations for CCOF: Early Delivery to ISS and COF Enhancements were approved by Council at its meeting on 19 July. These proposals cover the complete development and early delivery to ISS of the Columbus Mission Database, and laboratory support equipment (glovebox, freezer, and hexapod), plus industrial tasks in 1994/1995 on the Columbus Ground Software Reference Facility (GSRF), and on the DRS terminal for the COF.

Council was also briefed on the successful outcome of the recent technical discussions with NASA and RKA-NPO Energia on ESA's Service Module proposal. A Resolution was unanimously approved by Council requiring ESA to submit Programme *installations expérimentales européennes, autrement dit leur mise en oeuvre à partir de laboratoires autres que le Centre de contrôle des charges utiles du NASA-MSFC, notamment de l'ESA et d'autres établissements spatiaux, et ce pour la première fois à une aussi grande échelle. Cette activité, financée par le programme de préparation de l'utilisation de Columbus, avait été décidée à une date relativement tardive du calendrier des activités au sol, mais s'est révélée extrêmement utile.*

Le matériel devant servir aux expériences de physiologie et de science des matériaux à mener à bord d'Euromir 94 a été acheminé jusqu'à la station spatiale Mir par le véhicule Progress le 25 août. Une campagne de vols paraboliques avait été exécutée en juillet en préparation de ces expériences. Les derniers préparatifs pour la mission Euromir 94 d'octobre de cette même année sont en très bonne voie.

Programme Columbus

Elément orbital Columbus (COF)

Les travaux de l'industrie ont porté essentiellement sur la poursuite de la définition technique de l'option 'configuration à faible coût' du COF. Les principales caractéristiques de cette option, qui vise à réduire au maximum les coûts de développement, sont les suivantes:

- *Réutilisation de la structure primaire et secondaire en cours de réalisation par ASI/Alenia pour le MPLM (mini-module logistique pressurisé), ainsi que toute la réutilisation possible de matériels pour les sous-systèmes. A la suite de ces travaux, la longueur du COF a été ramenée d'un format 'APM5' à un 'APM4'.*
- *Retour à la solution de la Navette spatiale comme lanceur principal du COF, le MPLM n'étant actuellement qualifié que pour ce véhicule.*
- *Suppression d'éléments comme la mise en place d'une fenêtre optique, 'des crochets et des points d'ancrages' pour l'installation ultérieure d'une capacité robotique interne/externe, ou d'une plate-forme extérieure.*

A sa réunion du 12 juillet, la Commission de contrôle de la Station spatiale (SSCB) a approuvé les modifications de la séquence d'assemblage de l'ISS proposées par la NASA. A cette réunion, la RKA était pour la première fois membre de plein droit de la Commission. Les principales modifications à apporter à la séquence d'assemblage à la suite de cette décision du SSCB sont les suivantes:

- *un report de deux ans du lancement de la plate-forme logistique scientifique (SPP) russe, fixé désormais à la phase 3 au lieu de la phase 2 de l'assemblage de la Station;*
- *introduction dans la phase 2 d'une 'Power Tower' américaine en remplacement de la SSP russe jusqu'à son lancement au cours de la phase 3;*
- *lancement au cours de la phase 2 (novembre 1998) du premier module de recherche russe;*
- *lancement du COF sur Ariane-5 (février 2001).*

La préparation du volume 3 du document 'Concept de l'exploitation et de l'utilisation' (COU) s'est poursuivie avec la NASA et les autres partenaires internationaux; ce document porte sur les aspects de mise en oeuvre des principes d'exploitation et d'utilisation arrêtés précédemment en commun et définis dans leurs grandes lignes à la revue de définition système de l'ISS dans le volume 1 du COU. Les aspects importants inscrits dans ce volume 3 sont le rôle d'Ariane-5/ATV pour le lancement du COF et le rôle ultérieur d'Ariane-5/ATV pour le soutien logistique de l'ISS, ainsi que les aspects de réalisation du concept d'exploitation réparti du COF.

Installation orbitales complémentaires Columbus (CCOF)

Décisions relatives au CCOF: la livraison à court terme à l'ISS des éléments complémentaires a été approuvée par le Conseil à sa session du 19 juillet. Il s'agit de la réalisation complète et de la livraison rapprochée à l'ISS de la base de données mission de Columbus et d'équipements de soutien de laboratoire (boîte à gants, congélateur et hexapode), ainsi que des tâches industrielles à mener en 1994-95 sur le banc de référence de développement au sol de logiciels (GSRF) et sur le terminal DRS du COF.

Le Conseil a également été informé de la bonne fin des discussions techniques récentes avec la NASA et avec RKA/NPO Energia sur la proposition de module de servitude de l'Agence. Il a approuvé à l'unanimité une résolution invitant l'Exécutif à soumettre au Conseil directeur des programmes spatiaux habités de septembre des propositions de programme relatives à la réalisation et à la livraison à court terme du DMSR destiné au module de servitude russe et à la réalisation et à la livraison à court terme du système de régulation d'ambiance et de soutien-vie (ECLSS) destiné au minimodule logistique pressurisé (MPLM) de l'ASI/Alenia.

Ariane-5

Système

Les derniers travaux sur la partie haute lanceur (Case, L9, SPELTRA, Coiffe) ont débuté par les essais de compatibilité électrique et se poursuivent jusqu'en février 1995 par des essais de tenue à l'ambiance acoustique et aux chocs pyrotechniques générés par la découpe des différentes structures.

La qualification de la coiffe est maintenant bien avancée puisque les essais acoustiques sont terminés et que le dernier essai de séparation des deux demi-coques est prévu en novembre. Par ailleurs les essais de qualification de la case sont en cours et se déroulent conformément au planning.

Etage L9

L'étage L9 de mise au point est intégré au banc de Lampoldshausen et les résultats des deux premiers essais, de courte durée, sont conformes aux prévisions ce qui permet d'entreprendre la campagne des deux essais de durée nominale (1130 secondes) en octobre.

Le premier des 4 moteurs Aestus de qualification est en cours d'intégration finale donc les essais commenceront fin octobre pour se terminer en janvier 95.

Les essais de qualification formelle devraient avoir lieu mi-1995.

Etage H155

La campagne d'essai du banc d'étage lourd H155 a commencé début septembre proposals to the Manned Space Programme Board in September for development and early delivery of DMSR for the Russian Service Module and for development and early delivery of the Environmental Control and Life Support System (ECLSS) for the ASI/Alenia Mini Pressurised Logistics Module (MPLM).

Flight	Date	Satellite	Customer
64	17.6.94	Intelsat 702 STRV 1A STRV 1B	Intelsat UK Ministry of Defence
65	8.7.94	PAS 2 BS – 3N	Pan American Satellite NHK
66	10.8.94	Brasilsat B1 Turksat 1B	Embratel Turkish Ministry of Telecommunications
67	9.9.94	Telstar 402	AT&T

Arianespace envisages a somewhat higher launch rate of 10 to 12 launches per year over the next two years.

Ariane-5

System

The latest work on the launcher's upper section (Vehicle Equipment Bay, L9 stage, Speltra and fairing) started with electrical compatibility tests and will continue until February 1995 with testing of resistance to the acoustic environment and the pyrotechnic shocks generated by the various structures' cutting systems.

Fairing qualification testing is now at an advanced stage, with the acoustic test now completed and the final separation test on both halves of the shell planned for November. VEB qualification testing is underway and proceeding on schedule.

L9 stage

The L9 development stage has been integrated on the teststand at Lampoldshausen and the results of the first two short-duration tests were as predicted. The first of two firing tests of nominal duration (1130 s) was performed in October.

The first of the four Aestus qualification engines is undergoing final integration. Testing will therefore start in late October and be completed in January 1995.

The formal qualification tests are to be carried out before mid-1995.

H155 stage

The campaign of tests on the H155 battleship stage test stand started in early September and is continuing in October with two long-duration tests. All ELA-3 fluid

Essai de mise à feu du propulseur M3 à Kourou en Guyane (20 juin 1994)

The M3 firing test on 20 June in Kourou, French Guiana

et se poursuit en octobre par deux essais de longue durée. L'ensemble des circuits fluides et électriques de l'ELA-3 est donc validés par cet exercice. La fabrication des éléments de l'étage pour le premier vol d'Ariane-5 se poursuit conformément au planning avec par exemple la livraison de la jupe avant et du bâti-moteur et la fin de soudage des réservoirs LOX et LH_2.

Quant au moteur Vulcain, la cadence d'essai a été plus faible que prévue à la suite d'un incident sur une cellule d'essai qui est aujourd'hui réparée. A fin septembre le moteur Vulcain en est à 191 essais cumulant plus de 48 400 s de fonctionnement. Il faut noter de plus que l'intégration du moteur du vol 501 est en cours.

Etage P230

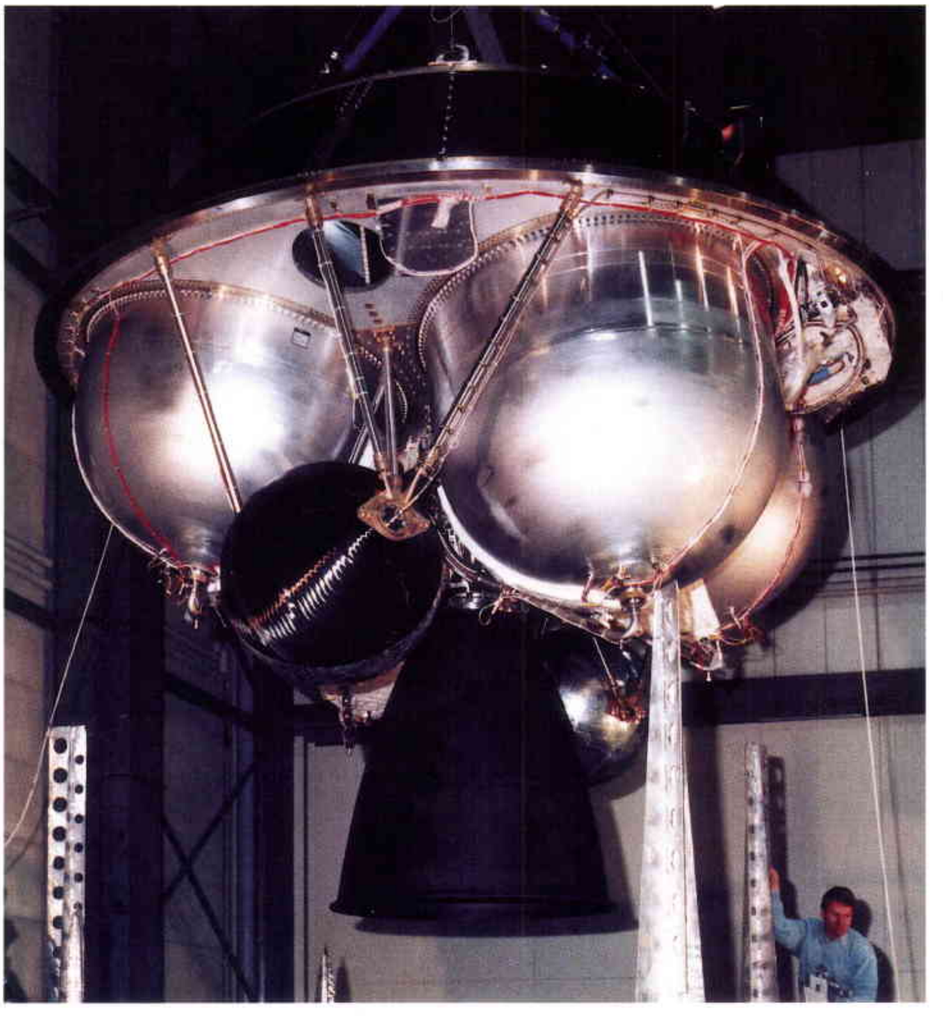
Le tir M3 a été effectué en Guyane le 20 juin. Il s'agit du troisième tir à l'échelle 1. Ce propulseur M3 était conforme à sa configuration de vol tant au niveau des structures, de la tuyère, du groupe d'activation que de ses performances propulsives.

Les prochains tirs M4 et M5 sont prévus respectivement en fin septembre et en décembre, ce qui permettra d'engager la qualification formelle de l'étage P230 dès le premier trimestre 95.

Lancements opérationnels Ariane

Après un arrêt de quatre mois consécutif à l'incident survenu lors du lancement V63, les lancements ont repris un rythme accéléré avec le lancement de V64 le 17 juin avec un lanceur en version 44LP (deux propulseurs d'appoint à ergols liquides et deux propulseurs à propergol solide). Ce lancement a été suivi le 8 juillet par V65 avec un lanceur en version 44L (quatre propulseurs d'appoint à ergols liquides), puis V66 le 10 août avec à nouveau un lanceur en version 44LP et enfin le 9 septembre V67, une version 42L du lanceur (deux propulseurs d'appoint à ergols liquides).

Au total, depuis la reprise des vols, six satellites de télécommunication et deux petits satellites scientifiques (environ 50 kg) ont été placés avec une très grande précision sur orbite de transfert géostationnaire.



The Ariane-5 L9 Stage.

L'étage L9 d'Ariane-5.

Vol	Date	Satellite	Client
64	17.06.94	INTELSAT 702 STRV 1A STRV 1B	Intelsat UK — Ministère de la Défense
65	08.07.94	PAS 2 BS — 3N	Pan American Satellite
66	10.08.94	BRASILSAT B1 TURKSAT 1B	Embratel TURQUIE — Ministère des P et T
67	09.09.94	TELSTAR 402	AT&T

La société Arianespace envisage de maintenir une cadence élevée de lancements (10 à 11 par an) pour les deux années à venir.

MSTP

Technologie

La préparation des activités technologiques, adaptée aux besoins des véhicules ATV et CTV s'est poursuivie et les travaux vont démarrer sous peu dans l'industrie. Dans le programme de technologie figure le démonstrateur de rentrée atmosphérique (ARD), dont la and electrical circuits are being validated in the process. Production of stage elements for the first Ariane-5 flight is proceeding on schedule; for example, the forward skirt and thrust frame have been delivered and LOX/LH_2 tank welding has been completed.

The scheduled testing of the Vulcain engine was slowed by an incident during which a test cell was damaged; it has now been repaired. By late September, the engine had undergone 191 tests involving a cumulative running time of over 48 400 s. Integration of the 501 flight engine is also underway.

P230 stage

The M3 firing was carried out in French Guiana on 20 June. This was the third full-scale firing. The M3 booster was in its flight configuration, in terms of structures, nozzle, actuator unit and also performance levels.

The next M4 and M5 firings are planned for late September and December, respectively, enabling formal P230 stage qualification testing to start in the first quarter of 1995.

Operational launches

After a four-month halt due to the Flight 63 incident, Ariane-4 launches resumed at an accelerated pace with Flight 64 on 17 June using an Ariane 44LP (the version with two liquid- and two solid-propellant boosters). This was followed by Flight 65 on 8 July using an Ariane 44L (four liquid-propellant boosters), Flight 66 on 10 August again used the 44LP version and most recently Flight 67 on 9 September was a 42L (two liquid-propellant boosters).

In all, six telecommunications satellites and two small (about 50 kg) science satellites have been placed into very precise geostationary transfer orbits since flights resumed in June.

Arianespace envisages a somewhat higher launch rate of 10–12 launches per year over the next two years.

MSTP

Technology

Preparation of the technology activities, adjusted to the needs of the ATV and CTV vehicles (see below) has progressed and industrial work will start shortly. The technology programme includes an Atmospheric Re-entry Demonstrator (ARD), the feasibility of which has now been sufficiently established. As this capsule has been conceived as an APEX passenger for Ariane flight V502, the planning constraints are critical.

System studies

System studies that are in progress address the operation and utilisation of the MSTP elements in the Space Station scenario, and the determination of environmental re-entry constraints.

In the context of merging the Columbus and MST Programmes, in-house activities are concentrated on the harmonisation of the respective ground segments. Sizeable cost savings will be derived from the common infrastructure and procedures.

Crew Transport Vehicle (CTV)

The Phase-0 industrial studies have been finalised. Both contractors proposed four system concepts, responding to four sets of system requirements, and redesigns for the associated vehicles. From the system concepts that best fit with the European development capability and could potentially respond to ISSA servicing and rescue needs, two were selected for Phase-A study: a simple capsule nominally landing in water, with a logistics carrier as growth potential, and a bi-conic vehicle nominally landing on the ground. An agreement with NASA is currently being prepared regarding CTV missions to the International Space Station.

Assured Crew Return Vehicle (ACRV)

The Phase-A extension studies have been completed. Apart from a joint evaluation with NASA, ACRV activities will be discontinued. Crew-return aspects are now being dealt with within the framework of the CTV studies.

Servicing elements
ERA and EVA

Following the redefinition of the Space Station assembly sequence, in particular the Russian Segment elements, ERA activities are being realigned to correspond to an early-delivery in-orbit date of February 1999. The ERA System Requirements Review has been successfully completed and the industrial proposal for full development and initial operations is in progress.

Following the achievement of an ESA/RSA/NASA agreement on European participation in space-suit development for the Space Station, the EVA Suit 2000 Programme Proposal has been submitted to the Manned Space Programme Board and to the ESA Council. Unfortunately, at the time of writing (early September) the Member States cannot fund completion of this joint ESA/RSA development, and preparations for project closeout have therefore been initiated.

Automated Rendezvous Predevelopment (ARP)

The previous Automated Rendezvous and Capture Programme (ARP) has been redefined following the non-availability of the NASA Shuttle flight planned in the ARC context. This redefinition led to the setting-up of the 'ATV Rendezvous Predevelopment (ARP) Programme' dedicated to technology activities linked directly to the ATV Space Station Rendezvous verification. Requests for proposals concerning GPS Receiver Procurement, Rendezvous Sensor Predevelopment and Rendezvous System Activities (including demonstration flights aboard the Space Shuttle) have been prepared and sent to Industry.

Automated Transfer Vehicle (ATV)

The ATV Phase-B contract was 'kicked-off' in July 1994, and will last until the end of 1995. Definition of the ARC servicing missions to the Space Station has been improved through discussions with NASA and with support from Russian industry, the ATV being now considered in the studies related to the Space Station operation and utilisation plans. The next milestone is the ATV System Concept and Programmatic Review (SCPR) due to take place in November 1994.

faisabilité est désormais suffisamment établie. Comme cette capsule a été conçue en tant que passager APEX du vol Ariane-5 V502, les contraintes de calendrier sont particulièrement sévères.

Etudes système

Les études système en cours portent sur le fonctionnement et l'utilisation des éléments MSTP dans le scénario de la Station spatiale et sur le calcul des contraintes liées à la rentrée atmosphérique. Du fait de la fusion des programmes Columbus et MST, les activités internes portent essentiellement sur l'harmonisation de leurs secteurs sol respectifs. Des économies non négligeables résulteront de l'infrastructure et des procédures opérationnelles communes.

CTV (véhicule de transport d'équipages)

Un point final a été mis aux études industrielles de phase 0. Les deux contractants ont proposé au niveau système quatre concepts répondant à quatre ensembles d'impératifs, dont la conception a été revue, compte tenu des véhicules associés. Parmi les concepts de système qui s'adaptent le mieux à la capacité de réalisation européenne et pourraient répondre théoriquement aux besoins de desserte et de sauvetage de l'ISSA, deux ont été retenus en vue d'une étude de phase A: une capsule de conception simple, devant normalement se poser sur l'eau, accompagnée d'un transporteur logistique en tant que potentiel de croissance, et un véhicule biconique devant normalement atterrir au sol.

On procède actuellement à la préparation d'un accord avec la NASA au sujet des missions CTV en direction de la Station spatiale internationale.

ACRV (Véhicule de secours pour le retour de l'équipage)

Les études complémentaires de phase A se sont achevées. Hormis une évaluation à mener en commun avec la NASA, les activités ACRV vont s'interrompre. Les questions de retour des équipages sont désormais traitées dans le cadre des études CTV.

Eléments de service ERA et EVA

A la suite de la redéfinition de la séquence d'assemblage de la Station spatiale, et en particulier des éléments russes, les activités ERA sont réétudiées en fonction d'une date de livraison en orbite de février 1999. La revue des impératifs système ERA a été menée à bonne fin et la proposition industrielle relative aux activités initiales et en régime opérationnel de croisière est en cours.

Suite à la signature de l'accord ESA/RKA/NASA sur la participation européenne à la mise au point d'une combinaison pour la Station spatiale, la proposition de programme EVA 2000 a été soumise au Conseil directeur des programmes spatiaux habités et au Conseil de l'Agence. Malheureusement, les Etats membres ne sont pas en mesure, au moment où nous écrivons (début septembre), de financer la bonne fin de ces travaux de développement communs ESA/RKA, et les préparatifs de l'arrêt progressif du projet ont été lancés.

ARP (Prédéveloppement du rendez-vous ATV)

Le précédent programme de rendez-vous et de capture automatiques (ARP) a été redéfini, le vol de la Navette prévu dans le contexte de l'ARC ne pouvant plus être accompli. Cette redéfinition a mené à la mise en place d'un 'programme de prédéveloppement du rendez-vous ATV (ARP)', portant sur les activités technologiques liées directement à la vérification du rendez-vous ATV/Station spatiale. Des demandes de propositions relatives à l'approvisionnement d'un récepteur GPS, aux travaux de prédéveloppement d'un détecteur de rendez-vous et aux activités système du rendez-vous proprement dit (y compris des vols de démonstration à bord de la Navette américaine) ont été préparées et envoyées à l'industrie.

ATV (Véhicule de transfert automatique)

Le contrat de phase B de l'ATV a reçu son feu vert en juillet 1994, son achèvement étant prévu fin 1995. La définition des missions ARC de desserte de la Station spatiale a été améliorée grâce aux négociation avec la NASA et au soutien de l'industrie russe, l'ATV étant désormais pris en compte dans les études sur les plans d'exploitation et d'utilisation de la Station spatiale. La prochaine étape sera la revue de concept et de programmation du système ATV (SCPR) qui doit se tenir en novembre 1994.

In Brief

ESA Returns to Farnborough Air Show

After a six-year break, ESA returned to Farnborough International 94, with an independent space pavilion. The show was held from 5 to 11 September.

The theme of the pavilion was 'Europe — Putting Space to Work'. The pavilion was jointly organised by ESA, the British National Space Centre (BNSC), and the United Kingdom Industrial Space Committee (UKISC). The objective was to enable professional visitors and the general public to learn more about ESA and the British space community, and the achievements that Europeans are making in space today.

The space pavilion turned out to be one of the most visited exhibits at the show. The principal attraction was ESA's virtual reality demonstration. By donning a pair of special goggles, visitors were able to 'visit' the International Space Station, 'enter' the Columbus Attached Laboratory and 'open' experiment containers.

Michael Heseltine, President of the UK's Board of Trade, tries out the virtual reality demonstration at the Farnborough air show

Space Exhibition in Munich

In July, ESA participated in another space exhibition, this time in the chancellery of the Bavarian Government in Munich. The exhibition was jointly organised by ESA, several Bavarian space-related companies, and the Bavarian chancellery. It attracted more than 10 000 visitors during its four weeks on display.

In Memoriam
Renzo Carrobio di Carrobio (1905-1994)

L'ambassadeur Renzo Carrobio di Carrobio vient de nous quitter récemment. L'Europe spatiale perd en lui un de ses plus fervents défenseurs.

Né à Rome le 19 mars 1905, Renzo di Carrobio était destiné très tôt à la carrière diplomatique qui l'a vu occuper divers postes consulaires à Moscou, Toulon, Berne, New Dehli, Trieste... Ministre plénitentiaire, ambassadeur d'Italie au San Dalvador (1952) puis en Afrique du Sud (1959), il fut l'un des principaux acteurs de l'Europe spatiale dans les années soixante en devenant le premier Secrétaire général du CECLES/ELDO (1962...) qu'il a marqué de son talent de diplomate et son action de pionnier.

Renzo di Carrobio était lieutenant de réserve et chevalier de la Grande Croix de l'Ordre du Mérite de la République.

Renzo Carrobio di Carrobio

Space Radiation Environment Monitored

Two models of ESA's Radiation Environment Monitor (REM) are now in orbit and are simultaneously studying the space radiation environment in two widely different and important orbits.

The REM counts electrons and protons that penetrate the REM's hemispherical shielding to reach the silicon detectors. The two REMs are identical instruments and are calibrated together.

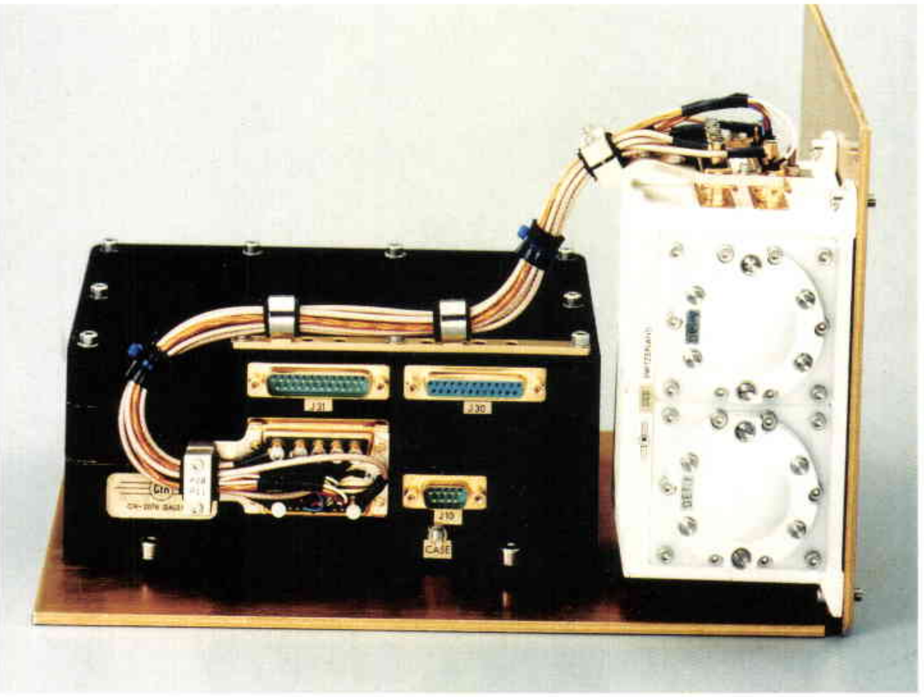
One of the REMs is part of the payload of the micro-satellite Space Technology Research Vehicle (STRV 1B) launched into geostationary transfer orbit by Ariane V64 on 17 June. STRV 1B is one of a pair of satellites built by DRA (UK). The geostationary transfer orbit is particularly interesting for radiation studies because it passes through the belts of trapped radiation (called the Van Allen belts) and is also exposed to solar energetic particles and cosmic rays. In early September, the STRV REM closely monitored an electron 'storm' that resulted from a geomagnetic disturbance.

The second REM was carried to Mir in a Soyuz vehicle in July and was installed on the outside of Mir during an EVA on 9 September. That REM is now being commissioned and initial tests have provided several hours of good data.

In addition to comparisons between the data collected by the two REMs, the data can be compared to that obtained by other radiation sensors on STRV and sensors on the Space Shuttle mission that will visit MIR in 1995.

The design life of STRV is one year, and the MIR contract calls for the delivery of data for one year, after which time the REM will become part of the EuroMir programme.

The REM was developed under ESA's CACH programme (with CIR and PSI of Switzerland) and the two instruments are now in orbit as part of ESA's Technology Demonstration Programme.



The Radiation Environment Monitor (REM) in the STRV configuration. The white box is mounted on the outside of the spacecraft with a clear view into space. The REM counts the electrons and protons that penetrate the shielding (two white domes, on right) and reach the silicon detectors

Surprising Results from Ulysses' South Polar Pass

On 13 September, ESA's Ulysses spaceprobe passed under the south pole of the Sun — a major milestone on its journey of exploration through the region of space far from the plane in which most planets and spacecraft orbit the Sun.

To mark that milestone, more than 80 scientists who have been participating in the joint ESA-NASA mission gathered at ESTEC in The Netherlands to discuss their latest results. They stressed the unique nature of Ulysses' highly inclined, out-of-ecliptic orbit, that offers a totally new vantage point from which to study the Sun and its environment at solar minimum.

The findings reported to date include:

— *Two distinct classes of solar wind*
Solar wind is the stream of electrically-charged particles that flows continuously away from the Sun. The solar wind in the polar region is faster and simpler than solar wind at the equator. Solar wind from the poles has a different chemical composition than the slower equatorial wind and has a lower-temperature source. Solar wind studies are not only of interest to space scientists: The solar wind influences our life on Earth, in particular our technological systems such as electricity distribution grids and telecommunication networks. Ulysses' measurements of the 'simple' solar wind over the pole will help us to understand this influence.

— *Unexpected features in the polar magnetic field*
The outwardly-directed magnetic field above the Sun's south pole is weaker than expected, with no evidence of a 'magnetic south pole'. In addition, the magnetic field is less smooth than expected, showing many types of fluctuations. Continuous, long-period waves discovered by Ulysses over the pole are particularly interesting. Many of these features are as yet unexplained, and scientists will have to re-think their ideas about how the Sun's magnetism is carried into the solar wind.

— *The 'cosmic ray funnel' over the poles is missing*
Measurements of cosmic rays during the south polar pass were awaited with great interest. It was hoped that these particles, created in the explosions of distant stars, would have easier access

John Simpson (left), one of the Ulysses principal investigators, from the University of Chicago; Edgar Page (centre), ESA Science Coordinator at JPL; and Roger Bonnet (right), ESA's Director of Science, recount the history of the Ulysses project

Members of the Ulysses science team discuss results in the 'international scientific laboratory' set up at ESTEC during the Ulysses workshop in September

to the heliosphere along the polar magnetic fields than in the ecliptic where the highly disturbed solar wind forms an effective barrier. In fact, the predicted influx of cosmic ray particles over the pole was not observed. Ulysses detected an increase of at most a factor of two in the flux of cosmic rays over the south pole with respect to the fluxes measured in the ecliptic, compared with a predicted increase of 10 times or more. The absence of a 'cosmic ray funnel' is puzzling, although the answer may be related to the waves in the magnetic field that Ulysses found over the south pole. It is quite possible that these fluctuations are able to scatter the incoming cosmic ray particles, making the 'funnel' less effective.

— *First evidence of large-scale, global 'heliospheric weather'*
While it was far below the ecliptic, at 55 degrees south of the Sun's equator, Ulysses detected energetic particles associated with a solar flare that occurred on the Sun more than 20 degrees north of the equator. This shows that the effects of particle radiation from solar outbursts, which can threaten Earth-orbiting technological systems, are felt over a wide range of latitudes. Information of this kind, which only Ulysses in its unique orbit can provide, will contribute to our ability to predict the short-term effects on Earth of given solar outbursts, thereby bringing the implementation of 'heliospheric weather forecasting' one step closer.

With its exploration above the Sun's south polar region completed, Ulysses is now heading back toward the ecliptic en route to the second polar pass, this time above the north pole. Between June and September 1995, scientists will have an opportunity to compare conditions in the north with those encountered in the southern hemisphere, leading undoubtedly to new discoveries and more puzzles. Looking even further ahead, there are now firm indications that NASA will follow ESA's lead and continue to support the mission for a second solar orbit, which will include polar passes in 2000 and 2001.

R. Marsden
Project Scientist

International Space University Holds 7th Summer Session

The International Space University (ISU) held its seventh summer session this past summer, in Barcelona, Spain. A total of 124 space professionals from 29 countries participated in the intensive 10-week programme. Each year, ESA sponsors a group of Europeans to attend ISU. This year, the group included three ESA staff members: Allessandro Donati from ESOC, and Philippe Gilson and Bengt Johlander from ESTEC.

The curriculum

The ISU curriculum begins with core courses that cover the major fields of space activity. Each student then follows advanced courses within a chosen area of specialisation. The students must also participate in a design project. Those design projects require multi-disciplinary skills and demonstrate well the multicultural aspects of international cooperation. The projects are also attracting growing interest from major space agencies. Last year's GEOWARN project, for example, has prompted NASA to launch a feasibility study.

The design projects

Two projects were undertaken this year: a Global Access Tele-health and Education System (GATES) and a Solar System Exploration Design project.

In the GATES project, the potential of applying existing satellite communications to render health and education services more accessible on a global scale was examined. A highly innovative, low-Earth-orbit satellite constellation that would provide global coverage with high cost-efficiency has been proposed. (There will be a full article on that project in the next issue of the ESA Bulletin.)

In the second project, the solar-system-oriented project, the current crisis in space exploration was examined. Feasibility studies on low-cost missions that would be feasible in keeping with the 'smaller, cheaper, faster' philosophy, were performed. The proposed missions that made the final selection include an asteroid tackle, lunar-polar prospecting, a Mars Cup race and novel approaches to life-science experiments.

Other activities

Other events outside the scheduled curriculum form an integral part of the ISU experience. Space professionals from all spacefaring countries teach the courses or give lectures. This year, the lecturers included managers of NASA's Clementine and DC-X projects, and high-level representatives of the European, Russian and Japanese space agencies. A number of astronauts were also present, including Buzz Aldrin, the second man to walk on the Moon; Jeff Hoffman, who participated in the Hubble Space Telescope Servicing Mission; Jim Newman, the first ISU graduate in space; and Oleg Atkov, a cosmonaut who has spent eight months in space.

Not all learning, however, happens in the classroom. The more daring students participated in a parabolic flight, allowing them to experience moments of low gravity, and the courageous were also able to try skydiving, to feel the full effect of gravity.

Next year

ISU has been offered a donation of a small communications satellite from CTA Inc., an American company. The aim is to allow students to actually perform in-orbit experiments. It is hoped that the so-called ISUSat will be operational in time for next year's summer session, to be held in Stockholm, Sweden.

Participants in this summer's ISU in Barcelona

Philippe Gilson, an ESA staff member and ISU student, meets Buzz Aldrin, the second man to walk on the Moon, at the ISU in Barcelona

Record Number of Ariane Launches in 1995

Arianespace recently released its launch manifest for Ariane for the next year. A record 12 launches are scheduled from Kourou, French Guiana, in 1995.

ESA's Infrared Space Observatory (ISO) will be granted priority for a launch within the satellite's September 1995 to January 1996 launch window.

In addition, ESA's Cluster series of satellites are to be launched on Ariane-5's first qualification launch, foreseen at the end of November 1995.

Ariane-4 launches planned for the remainder of 1994 and for 1995

Launch			Launcher	Satellites
Vol 70	1994	Nov	42P	PAS-3
Vol 71		Dec	44LP	BRASILSAT B2 & Hot Bird 1
Vol 72	1995	Jan	40	ERS-2
Vol 73		Feb	44LP	INTELSAT 706
Vol 74		Mar	42P or 40	DBS-3* or HELIOS 1A
Vol 75		Mar	40 or 42P	HELIOS 1A or DBS-3*
Vol 76		Apr	44P	N-STAR A*
Vol 77		May	44L	PAS-4 & AMOS
Vol 78		Jun	42L	ASTRA 1E
Vol 79		Aug	44L	TELECOM 2C & INSAT 2C
Vol 80		Sep	44P	N-STAR B*
Vol 81		Oct	44LP	INTELSAT 707*
Vol 82		Nov	44L	PALAPA C1 & MEASAT-1
Vol 83		Dec	42P	M-SAT*

* These satellites will be ready to launch in Kourou on an earlier slot, if the opportunity arises.

ESA and Russia to Continue Joint Activities

To mark each agency's commitment to working together, Jean-Marie Luton, the Director General of ESA, and Yuri Koptev, the Director General of the Russian Space Agency (RKA), have signed a Cooperation Agreement on joint activities in the area of crewed flights and associated space transportation systems. The agreement was signed in Moscow on 5 October.

The agreement supplements the existing legal framework for contracts placed with the Russian firm RKK-Energia for the execution of the EuroMir-94 and EuroMir-95 missions and the active continuation of joint work on future crewed space transportation systems.

It also demonstrates both agencies' resolve to maintain their drive for closer long-term cooperation on crewed space infrastructures, especially in the context of the future International Space Station. In addition, the agreement lays the foundation for specific cooperation between Russia and Western Europe on industrial development projects, allowing for the conclusion of further detailed agreements on the implementation of jointly-defined programmes.

J.-M. Luton (left), Director General of ESA, and Y. Koplev (right), Director General of the Russian Space Agency, sign a Cooperation Agreement on joint activities in the area of crewed spaceflights and associated space transportation systems

ESA Astronaut Spends Month in Space

The longest mission in European space history came to an end on 4 November when the Russian Soyuz Transfer Module (TM-20), carrying ESA astronaut Ulf Merbold, landed in Kazakhstan. Also on board were two Russian cosmonauts who had been on board the Mir Space Station since July. The crew brought back about 18 kg of samples and film.

The EuroMir-94 mission began on 3 October when the Soyuz TM-20 lifted off from the Baikonur cosmodrome in Kazakhstan, Russia, carrying Merbold and two other Russian cosmonauts. The Soyuz then docked with the orbiting Mir two days later. This brought the number of crew members on board Mir to six.

During his month-long stay in orbit, Merbold took numerous biological samples that will provide European on the human body of longer periods spent in the space environment. The research will benefit astronauts who may spend long durations on board the International Space Station. He also conducted technological experiments that will help ESA to develop new, more effective equipment for space missions. In addition, he took hundreds of photographs of the Earth's surface.

Five ESA materials-sciences experiments will probably be conducted by the cosmonauts at a later date because of the failure of a crucial experiment furnace. Extensive efforts to repair the furnace, which had been aboard the station for many years, had to be abandonded.

The two EuroMir crews wait in the quarantine area for the final assignment made by the State Commission a few hours before the mission began. The Commission included a representative from ESA's European Astronaut Centre. From left to right: ESA astronaut Ulf Merbold, Elena Kondakova and Aleksandr Viktorenko were confirmed as the prime crew, and Yuri Gidzenko, Sergeij Avdeev and ESA astronaut Pedro Duque were confirmed as the back-up crew

Ulf Merbold dons his space suit in the clean room a few hours before boarding the launcher

Ulf Merbold (foreground) and the two Russian cosmonauts wave good-bye before boarding the Soyuz rocket

The Soyuz rocket lifts off from the Baikonur cosmodrome on 4 October at 03:42 local time, carrying Ulf Merbold and two Russian cosmonauts

All photos: P. Aventurier for ESA

Spare parts needed to repair it will be shipped to the station on a Progress supply vehicle. The data from the experiments could then be returned to Earth on board a US Space Shuttle that is planned to dock with Mir next summer.

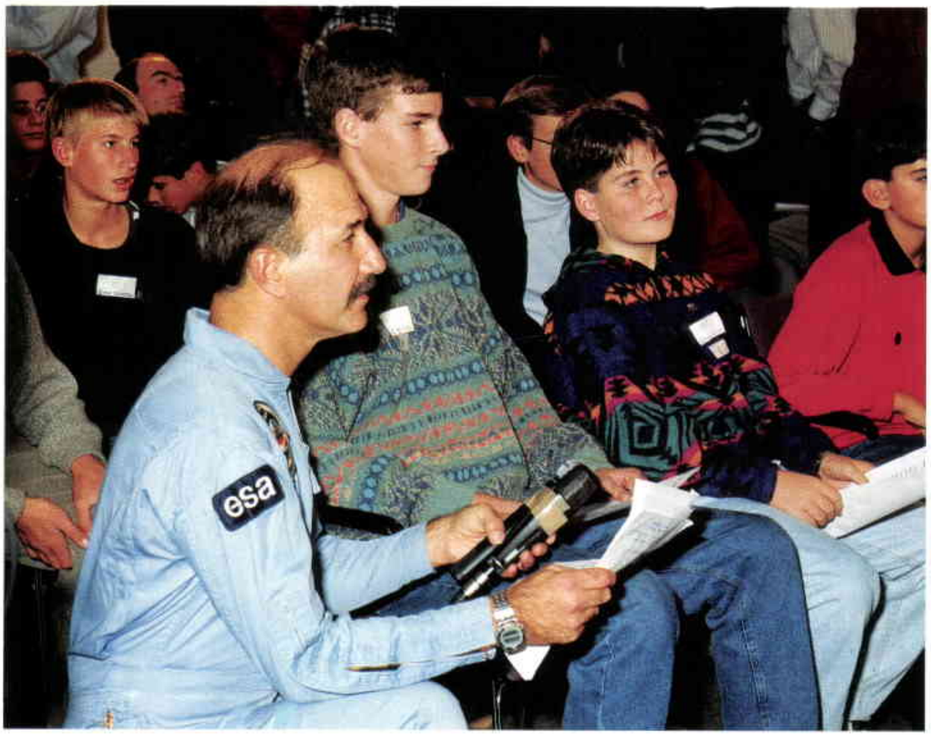
On 4 November, after one month in space, Merbold and two cosmonauts who were aboard Mir before his arrival, returned to the transfer module, undocked and began their hour-long descent through the atmosphere. They landed safely with the aid of parachutes.

Throughout the mission, scientists at centres in Europe monitored their on-board experiments and communicated with the space station, via the mission control centre near Moscow, using ESA's DICE satellite videoconferencing system (see full article in this issue of the Bulletin). The DICE system allows up to four sites to conduct a live videoconference simultaneously. ESA had approximately 20 minutes of video communication with Mir daily, in addition to audio communication and the transferring of experiment data. The DICE system was also used to allow Merbold to give press conferences from the space station, to speak with the German Chancellor Helmut Kohl, and to discuss living and working in space with a group of European school children. He also used the system on weekends to speak with his family. Such family contact is considered to be important on long-duration flights.

EuroMir-94 was the first of two ESA crewed missions with the Russians. The next one, scheduled for August 1995, will be even more ambitious. It will last 135 days and include the first spacewalk by an ESA astronaut. Two ESA astronauts, Christer Fuglesang and Thomas Reiter, are currently training for that flight.

Ulf Merbold (centre) and two cosmonauts on board Mir

Students discuss living and working in space with Ulf Merbold via a live videoconference. Wubbo Ockels (in ESA suit), another ESA astronaut, leads the discussion. Questions included 'How do you shower in space?', 'How does a rocket go so high?' and 'What planets can you see?'



Ulf Merbold just after landing, after having spent a month in space

Second ESA Astronaut Blasts Off

ESA astronaut Jean-François Clervoy and five NASA astronauts blasted off from Kennedy Space Center on 3 November on an 11-day atmospheric research mission, named Atlas-3.

The Space Shuttle Atlantis (STS-66) carried into orbit the Atlas laboratory: six instruments mounted in the orbiter's cargo bay on a Spacelab pallet, allowing the experiments to be exposed directly to the space environment.

The Atlas-3 mission is the third in a series of missions to take 'snapshots' of the atmosphere throughout an 11-year solar cycle. The experiments on board are sponsored by space organisations and institutes in various countries including Belgium, France, Germany and the USA.

Clervoy, of French nationality, is undertaking his first space flight. In addition to his main role as mission specialist, he has another important responsibility: he is operating the Shuttle's 15-metre-long robotic arm to deploy and later recover a German atmospheric research satellite. The CRISTA-SPAS will operate from an orbit 40 to 70 km behind the Shuttle for eight days, studying the middle atmosphere of the Earth. It will then be recovered using the robotic arm and placed in the payload bay for its return to Earth. The data gathered by the CRISTA-SPAS will complement that gathered by Atlantis' main payload.

Clervoy is testing a new approach technique that is expected to be used during the Shuttle docking with Mir next year. The approach is designed to minimise damage to Mir from the Shuttle's proximity operations.

The mission is expected to end on 14 November, with Atlantis returning to Kennedy Space Center.

ESA astronaut Jean-François Clervoy during final training at Johnson Space Center in Houston before the Atlas-3 mission launched on 3 November (NASA photo)

Plan for Use of Tethers in Space Proposed

Eighty scientists, engineers and other experts from European, American, Canadian and Russian research institutes, space agencies and industry gathered at ESTEC on 28 to 30 September for an International Round Table on Tethers in Space. They proposed a phased approach to begin the utilisation of the developed tether technologies. The meeting was organised upon the initiative of ESA, ASI and DARA.

A tether system provides new ways of carrying out conventional space missions, or new capabilities. A smaller satellite is deployed from a main satellite and remains attached to the main satellite by a thin cord or tether. The tether can be tens of kilometres long. A number of demonstration tether experiments have been undertaken and a fair understanding of the principles and behaviour of tethers in space has been achieved. Based on that experience and on theoretical work done over the past 20 years, tethers can now be operated in space in a controlled and safe manner.

The Round Table participants therefore proposed a stepped approach to begin to use tethers. An initial European demonstration or pre-operational phase would first be undertaken, in 1997 – 98, to verify the selected methods and technologies, and it would be combined with synergistic scientific measurements and opportunities. The utilisation phase would then follow.

The group agreed that the following areas of application have scientific, technical and operational (and therefore commercial) potential:

- Scientific research:
  - Atmospheric physics research, with potential evolution toward aerothermodynamic research
  - Electrodynamic research in the Earth's ionosphere, thermosphere and mesosphere
- Operational support of the space station, for example, frequent return of samples and waste disposal at a lower operational cost, with a potential evolution toward orbit reboost.

Each of these areas also offers great potential for international cooperation.

Since there are already several flight opportunities for tether electrodynamics, or plans for flights, the participants recommended that ESA concentrate on proposed tether missions that have not yet been carried out, such as tether-assisted re-entry or an atmospheric-research mission. For those missions, technology can be derived from elements existing in Europe and being developed by ESA up to the breadboard level. Potential platforms to support a demonstration mission include Russian spacecraft, the US space shuttle and expendable launcher upper stages.

Representatives from the national space agencies that sponsored the meeting expressed their willingness to continue to support tether activities in Europe.

Return to Sardinia: The 30th Anniversary of Sounding Rockets

Thirty years ago, in July 1964, ESRO, a forerunner of ESA, launched its first ever payload into space. It was a small sounding rocket, launched from the Salto di Quirra rocket range in the interior of Sardinia, Italy. The original launch tower still stands there — a tribute to the people who worked long and hard for the Sounding Rocket Programme.

It was to this launch tower that a group of about 30 technicians, engineers, scientists and others, who had been involved in the early Sounding Rocket Programme, came to commemorate the 30th anniversary. Men and women of 10 different nationalities travelled from as far away as Canada and Sweden in a nostalgic return to the scene of their earlier triumphs.

On 30 September, the day of the official reunion, the group travelled to Capo San Lorenzo, an Italian naval base on the east coast of Sardinia, for an official welcome. Upon arrival, everyone paused outside the auditorium to admire a Skylark rocket — the same type of rocket as had been used in that first launch.

After a welcoming speech by the Commandant of the naval base, several 'old timers' spoke. Rudi Meiner, a project scientist in earlier days, was the master of

The Skylark lifts off from the launch tower in Sardinia, marking ERSO's first launch of a sounding rocket

ceremonies. Steve Pooley, the oldest member of the group and one of the original campaign directors, gave one of his amusing anecdotal talks. Admiral Mondino, also one of the early campaign directors, gave another speech and David Beattie, an experimenter on the first payload, followed. Finally, Arne Pedersen, previously a scientific coordinator, talked about the scientific aspects of the programme.

At the close of the session, to the surprise of the participants, each person was presented with a certificate of service. The group then drove by coach along a steep and winding road to the naval base at Perdasdefogu. After lunch, they continued on to the original launch site. Once there, the moment of true sentimentality arrived as Pete Starling attempted to climb the rusting launcher. Others wandered around the base, picking up components that had been left lying for many years.

Although no one wanted to leave, the Navy hosts urged the group to return to the buses. The clouds descended as the party arrived at the Telemetry Station, which was by then shrouded in mist. The Italian hosts, nevertheless, welcomed the group with wine and cheese.

As darkness fell, the group sadly left Perdasdefogu to return to their hotel. The journey was long and winding. The silence in the coach was full of unspoken memories. Each participant had time to reflect on his own experience of what had been an exciting and interesting period of early space research.

Maggie Sanderson

Early members of ERSO's Sounding Rocket Programme team gather in front of the original sounding rocket launch tower to celebrate the 30th anniversary of the first launch

Bold Scientific Programme for Next Century

ESA has defined a space science programme that will follow on from its current long-term plan, Horizon 2000. The new programme, called Horizon 2000 Plus, is concerned with missions beyond 2006 and spans some ten years. It is designed as a 'rolling' programme to ensure continuity and coherence with the objectives of the existing plan. The objectives and financial projections of the new programme must now be incorporated into ESA's Long Term Plan, which will be presented to the next ESA Council meeting at ministerial level, in 1995.

Objectives of Horizon 2000 Plus

It is recommended that, depending on funding, ESA implement two or three 'Cornerstone' missions and four medium-sized missions, in addition to those currently being implemented through Horizon 2000. 'Cornerstone' missions are large missions in well-defined areas of space science and should be European or European-led undertakings.

Horizon 2000 was built around four Cornerstones: the Solar Terrestrial Science programme, an X-ray spectroscopy observatory, a rendezvous with a comet for in situ investigations, and a sub-millimetre observatory.

The Cornerstone missions recommended in Horizon 2000 Plus are:

- A mission to Mercury, the planet nearest to the Sun and which is still largely unexplored. Both planetary and magnetospheric aspects are to be addressed.
- An interferometric observatory. Such a mission, performing astrometric observations at a resolution reaching ten micro-arcseconds, would enable distances, motions and luminosities of tens of millions of stars in our galaxy to be obtained, and would allow their mass distribution to be studied. The mission would also allow the search for Jupiter-like planets and brown dwarf companions around the stars. In addition, it is recommended that studies using infrared interferometry be performed to detect Earth-like planets around other stars.
- A gravitational wave observatory, particularly one allowing observations at low frequencies. Such a mission would make it possible to explore the very early phases of the universe and to observe massive black holes and their coalescence, furthering the understanding of the nature of gravity and of general relativity.

The four medium-sized missions will be selected competitively, based on proposals submitted by the scientific community, as was done with the original Horizon 2000 programme. There are, however, some areas that are of great interest, namely the study of Mars and a solar physics mission. It was therefore recommended that ESA seek to participate in future international projects in those areas, as opportunities arise. It should also draw on opportunities provided by the International Space Station to prepare for potential future missions as well as for future small and medium-sized projects.

To ensure that the missions achieve their goals and that they are conducted efficiently, the programme will require the development of some very advanced technologies, particularly in the areas of spacecraft mass and power, pointing, data handling and communications.

Development of the plan

At its Ministerial Meeting in Granada in 1992, the ESA Council asked that a plan be drawn up establishing space science objectives for the period after the current plan, Horizon 2000, has been completed.

ESA received an overwhelming response to a call for mission concepts: the scientific community (more than 2500 scientists in Europe alone) proposed some 110 ideas that reflect future trends in space science and represent the community's main areas of interest. The Survey Committee, a committee of representatives from the European scientific community, was subsequently set up to review the proposals and draft a plan. It was assisted by 'topical teams' that surveyed the main science areas and by ESA working groups that studied the international space science environment. Following a series of discussions, the Survey Committee then met with the ESA Executive in Rome in late September to finalise the plan.

Focus

Vienna, Austria

Data acquisition: Fucino, Italy
Data processing: Italian PAF, ASI, Matera, Italy

Red:	Orbit 7696 – Frame 2637 – 4 Jan. 1993
Green:	Orbit 5692 – Frame 2637 – 17 Aug. 1992
Blue:	Orbit 4189 – Frame 2637 – 4 May 1992

In this ERS-1 SAR multitemporal image, the River Danube can be seen crossing from left to right as it flows through a fertile depression with distinctive field patterns. The bright, built-up area expanding southwards in the top right includes the city of Vienna. The hilly area to the left shows a different morphology due to the different lithological compositions: crystalline, limestone, and sandstone. It ends west of Vienna in the famous 'Vienna Woods'. To the lower right is the Neusiedler Lake, which exhibits surface roughness effects due to local light winds.

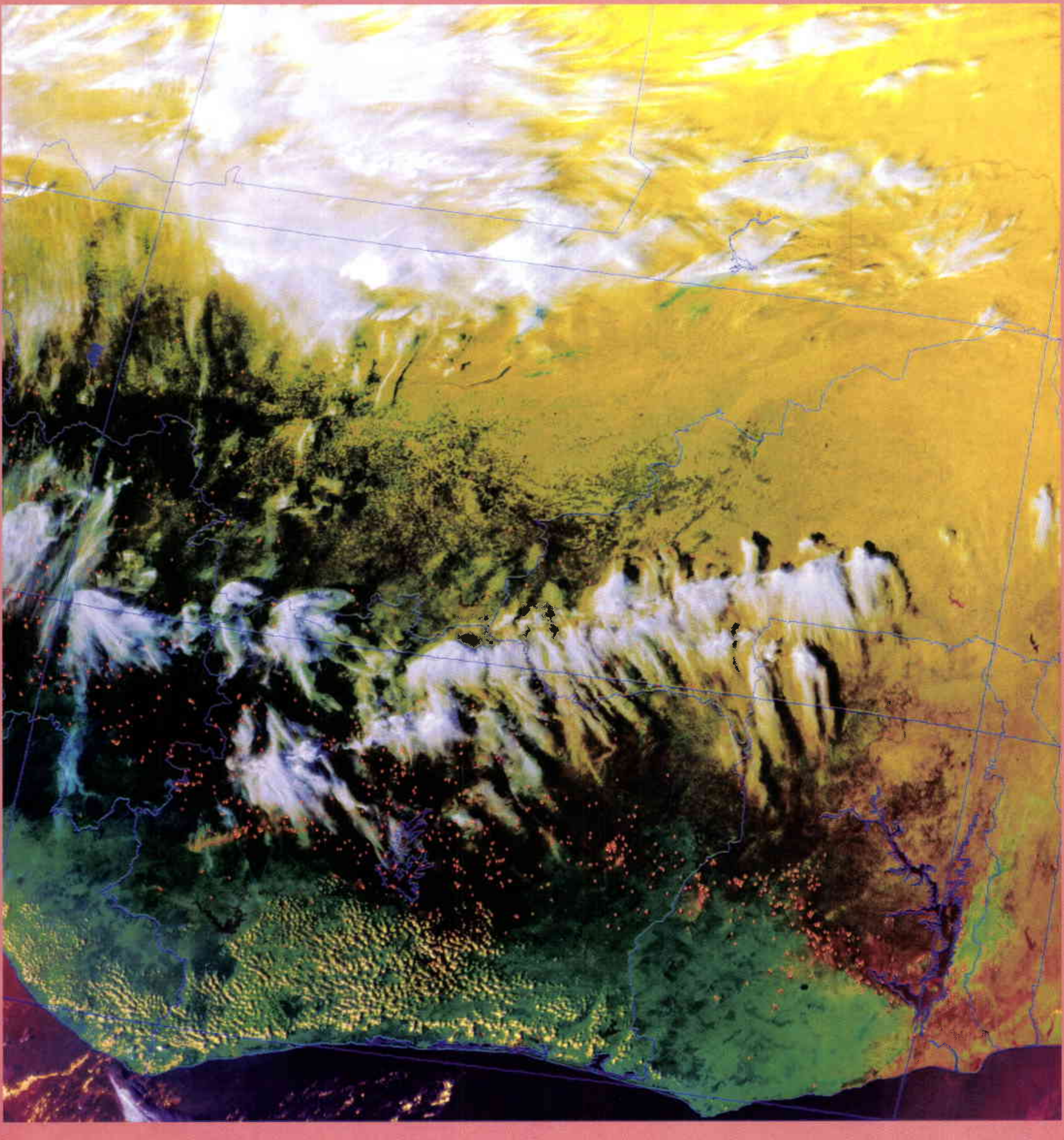
Earth

West Africa

Data acquisition: Niamey Ground Station, 28 January 1993
Data processing: ESA/ESRIN, Frascati, Italy

This three-band (1,2,4) NOAA-11 AVHRR colour composite is the result of the application of calibration, classification and enhancement techniques to the original data. The 'active fire' algorithm has marked the pixels in red whenever a fire has been detected. It has identified over 1700 'active fires', due mainly to human action and rural habits, over a wide geographical area that includes the following countries: Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, part of Benin, part of Niger, Burkina Faso, Mali, part of Senegal, and part of Mauritania.

O. Arino, J. Lichtenegger, & G. Calabresi
ESA/ESRIN, Frascati, Italy



Publications

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

ESA Journal

The following papers were published in ESA Journal Vol. 18, No. 3:

INTERMARSNET — AN INTERNATIONAL NETWORK OF STATIONS ON MARS FOR GLOBAL MARTIAN CHARACTERISATION
A. CHICARRO, G. SCOON & M. CORADINI

LISA — A LASER INTERFEROMETER SPACE ANTENNA FOR GRAVITATIONAL-WAVE MEASUREMENTS
Y.R. JAFRY, J. CORNELISSE & R. REINHARD

MERCURY ORBITER — AN INTERDISCIPLINARY MISSION
R. GRARD , G. SCOON & M. CORADINI

MORO — A EUROPEAN MOON-ORBITING OBSERVATORY FOR GLOBAL LUNAR CHARACTERISATION
A. CHICARRO, G. RACCA & M. CORADINI

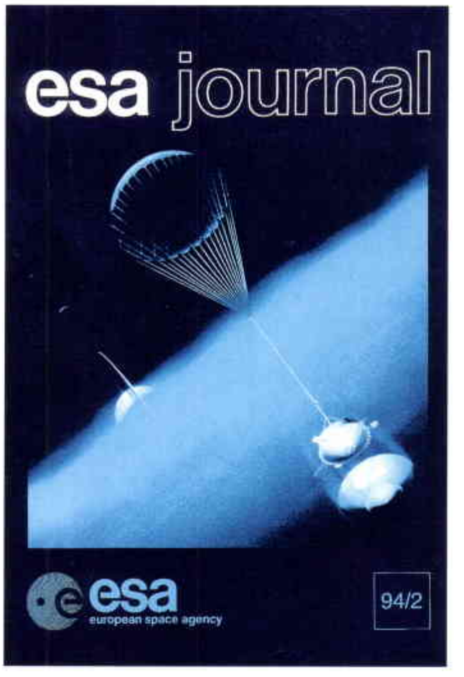
STARS — AN INVESTIGATION OF STELLAR STRUCTURE AND EVOLUTION
M. FRIDLUND ET AL.

STEP — A FUNDAMENTAL-PHYSICS LABORATORY IN SPACE
R. REINHARD, Y. JAFRY & R. LAURANCE

COBRAS/SAMBA — A MISSION DEDICATED TO THE MEASUREMENT OF COSMIC BACKGROUND ANISOTROPIES
L. TAUBER, O. PACE & S. VOLONTE

ESA Special Publications

ESA SP-364 // 70 DFL
PROCEEDINGS OF THE TECHNOLOGY TRANSFER WORKSHOP
25 – 27 May 1994, ESTEC, Noordwijk, The Netherlands
(ED. T.D. GUYENNE & J.J. HUNT)

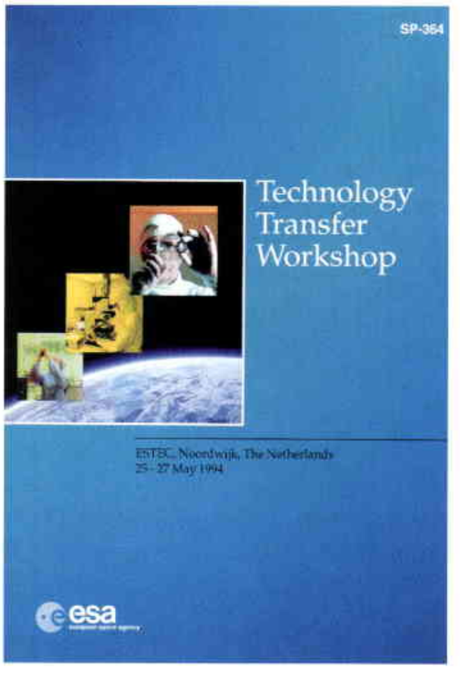


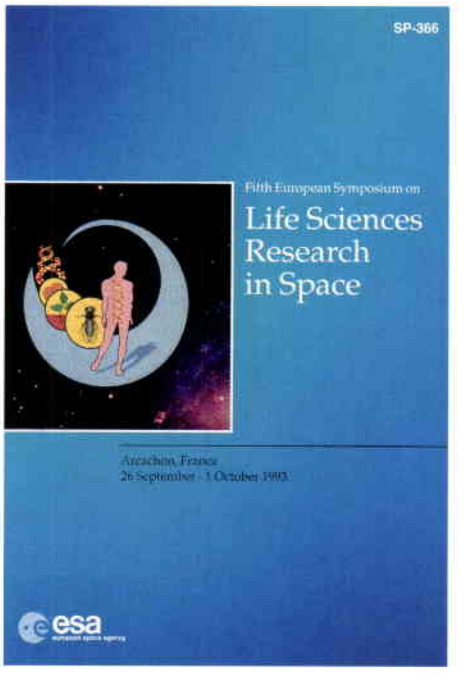
ESA SP-366 // 80 DFL
FIFTH EUROPEAN SYMPOSIUM ON LIFE SCIENCES RESEARCH IN SPACE
26 September – 1 October 1993, Arcachon, France
(ED. H. OSER & T.D. GUYENNE)

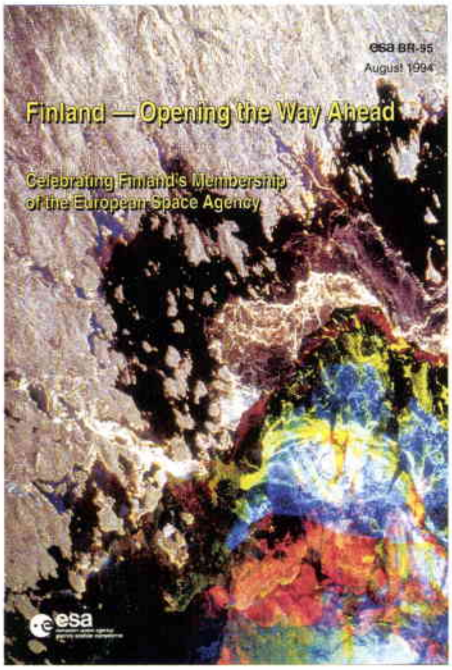
ESA SP-1131 (Revision 2) // 50 DFL
CATALOGUE OF ESA PATENTS
P.A. KALLENBACH
(ED. B. BATTRICK & W.R. BURKE)

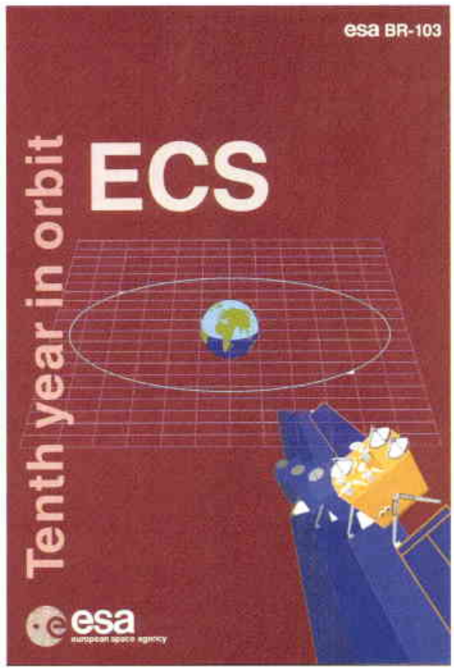
ESA Brochures

ESA BR-68 (FRENCH) // 50 DFL
COMMENT OBTENIR DES MARCHES AVEC L'ESA
(ED. B. KALDEICH)









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EUROMIR, MISSIONS TO SPACE WITH RUSSIA
ESA PUBLIC RELATIONS

ESA BR-108 // 35 DFL
ULYSSES — FIRST YEAR IN FLIGHT
N. ANGOLD ET AL.
(ED. W.R. BURKE)

ESA Newsletters

EARTH OBSERVATION QUARTERLY (FRENCH) —
No. 44, JUNE 1994 (NO CHARGE)
(ED. T.D. GUYENNE)

PREPARING FOR THE FUTURE
(Technology Programme Quarterly)
— VOL. 4, No. 3, SEPTEMBER 1994
(NO CHARGE)
(ED. M. PERRY)

REACHING FOR THE SKIES
(Quarterly Newsletter on ESA's Launchers) —
No. 12, SEPTEMBER 1994 (NO CHARGE)
(ED. T.D. GUYENNE)

ESA Procedures, Standards and Specifications

ESA PSS-01-411 // 50 DFL
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D. ROUAT ET AL.

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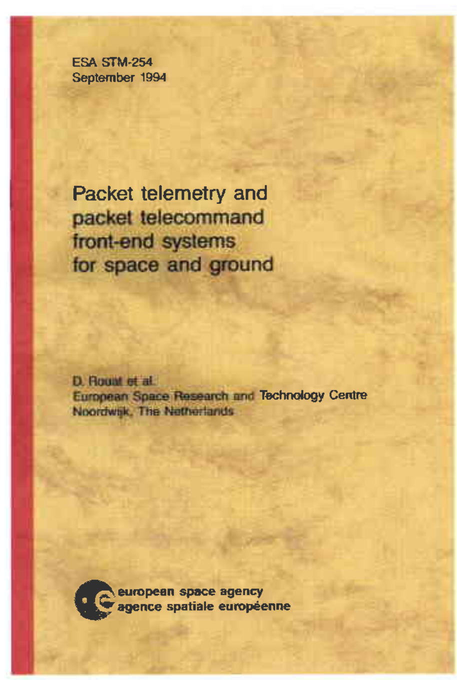
P.M.A. JOLLET



NINTH EUROPEAN SYMPOSIUM GRAVITY-DEPENDENT PHENOMENA IN PHYSICAL SCIENCES

Berlin Congress Centre, 2 - 5 May 1995
Berlin, Germany

The Ninth European Symposium will provide a forum for the presentation of scientific investigations on gravity-dependent phenomena in physics, fluid and materials sciences. Contributions on both, theoretical and experimental aspects are solicited. The topics to be addressed include:

- combustion
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- self-organization and pattern formation
- solidification processes
- thermophysical properties
- other topics in fundamental physics

Special attention will be paid to results of recent Space Shuttle and MIR missions. In addition, the presentation of experiments using re-entry satellites, sounding rockets, parabolic aircraft flights, drop tubes, and centrifuges is encouraged. Further ground-based investigations and the development of new diagnostic methods should contribute to a substantial programme. Presentations will be given in the form of invited papers and posters.
(*A more detailed scope of the Symposium will be outlined in the Second Announcement to be issued by the end of August 1994.*)

Interested authors are invited to submit an extended 2-page abstract of their proposed paper by **13 January 1995**. The abstracts and any requests for further information should be sent to:

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Gravity-Dependent Phenomena in Physical Sciences
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This Symposium is co-sponsored by Deutsche Agentur für Raumfahrtangelegenheiten GmbH (DARA), and the European Space Agency (ESA)

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Note

In the last three years we have left the price of our publications unchanged. Costs have risen in that time, particularly postal charges, and from 1 January 1994 new prices will be charged as shown above.

To compensate for this increase two discounts will be possible:

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