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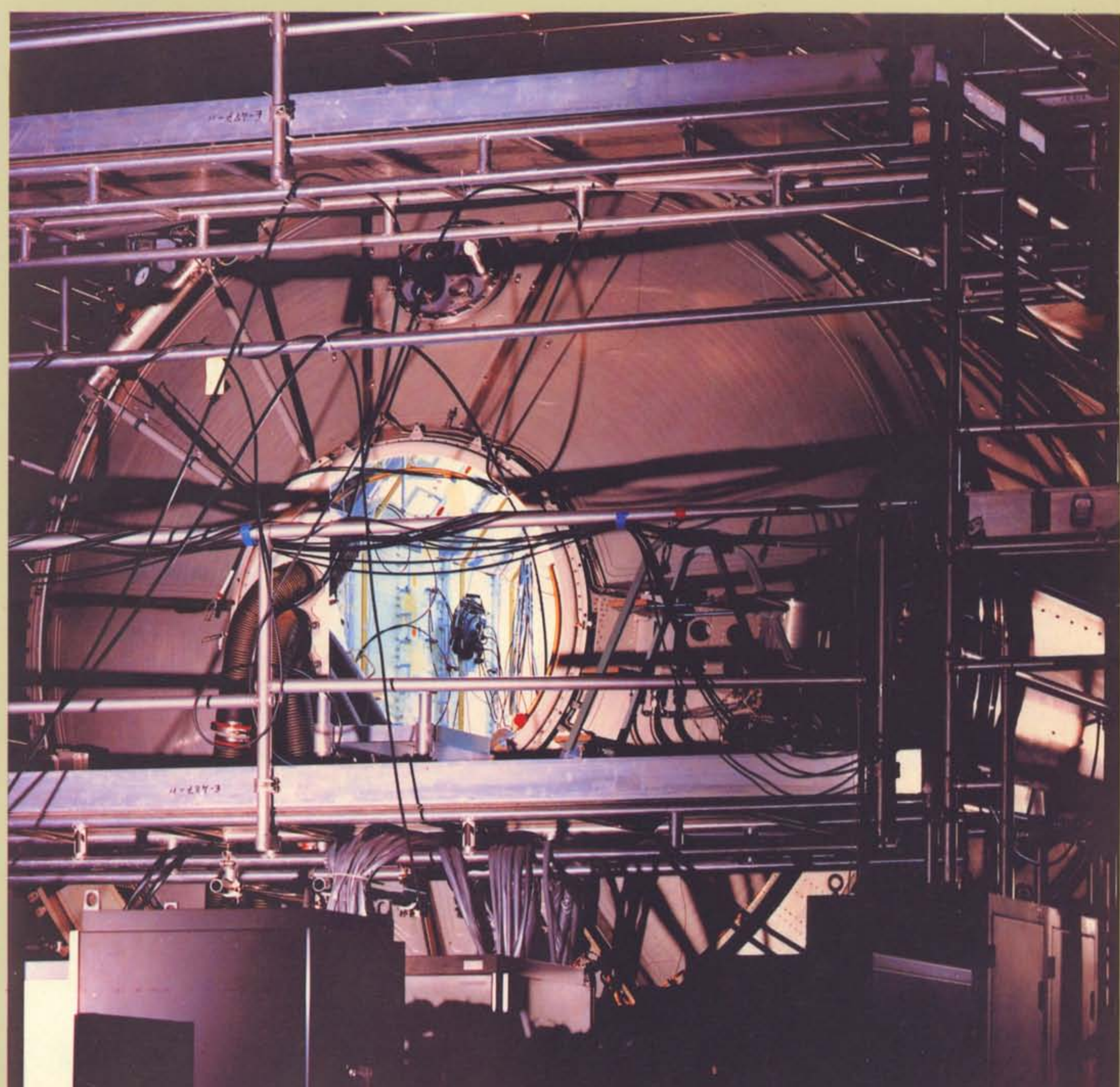

general planning activities

european space agency

The European Space Agency was formed out of, and took over the rights and obligations of, the two earlier European Space Organisations: the European Space Research Organisation (ESRO) and the European Organisation for the Development and Construction of Space Vehicle Launchers (ELDO). The Member States are Belgium, Denmark, France, Germany, Italy, Netherlands, Spain, Sweden, Switzerland and the United Kingdom. Ireland has signed the ESA Convention and will become a Member State upon its ratification. Austria, Canada and Norway have been granted Observer status.

In the words of the Convention: The purpose of the Agency shall be to provide for and to promote, for exclusively peaceful purposes, co-operation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems,

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

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

The Directorate of the Agency consists of the Director General; the Director of Planning and Future Programmes; the Director of Administration; the Director of Scientific Programmes; the Director of Applications Programmes; the Director of the Spacelab Programme; the Technical Director and the Director of ESOC.

The ESA HEADQUARTERS are in Paris.

The major establishments of ESA are:

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

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

ESRIN, Frascati, Italy.

Chairman of the Council: Mr. J. Stiernstedt (Sweden).

Director General: Mr. R. Gibson.

agence spatiale européenne

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

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

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

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

Le Directoire de l'Agence est composé du Directeur général, du Directeur des Programmes futurs et des Plans, du Directeur de l'Administration, du Directeur des Programmes scientifiques, du Directeur des Programmes d'Applications, du Directeur du Programme Spacelab, du Directeur technique et du Directeur de l'ESOC.

Le SIEGE de l'ESA est à Paris.

Les principaux Etablissements de l'ESA sont:

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

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

ESRIN, Frascati, Italie.

Président du Conseil: M.J. Stiernstedt (Suède).

Directeur général: M. R. Gibson.

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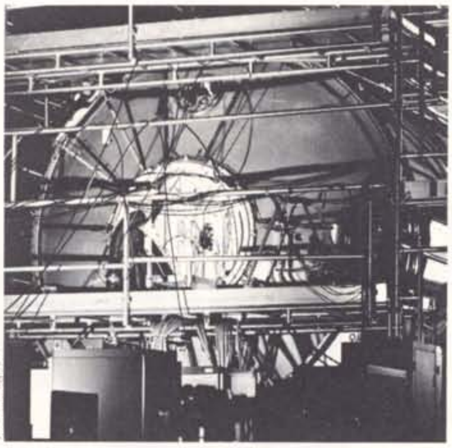

Spacelab Engineering Model (long module) under test in the Spacelab Integration Hall at ERNO, Bremen.

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Circulation Office
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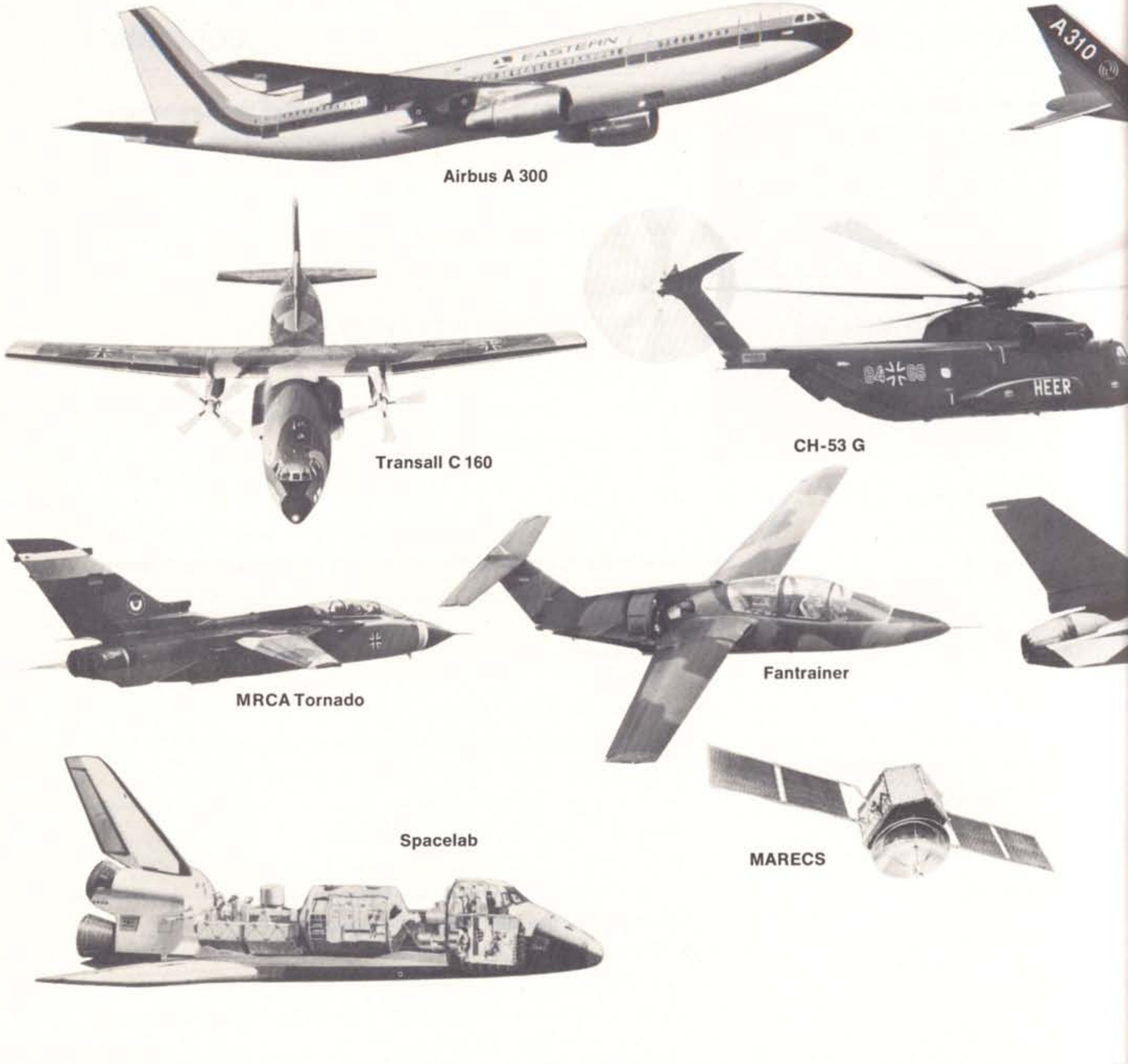
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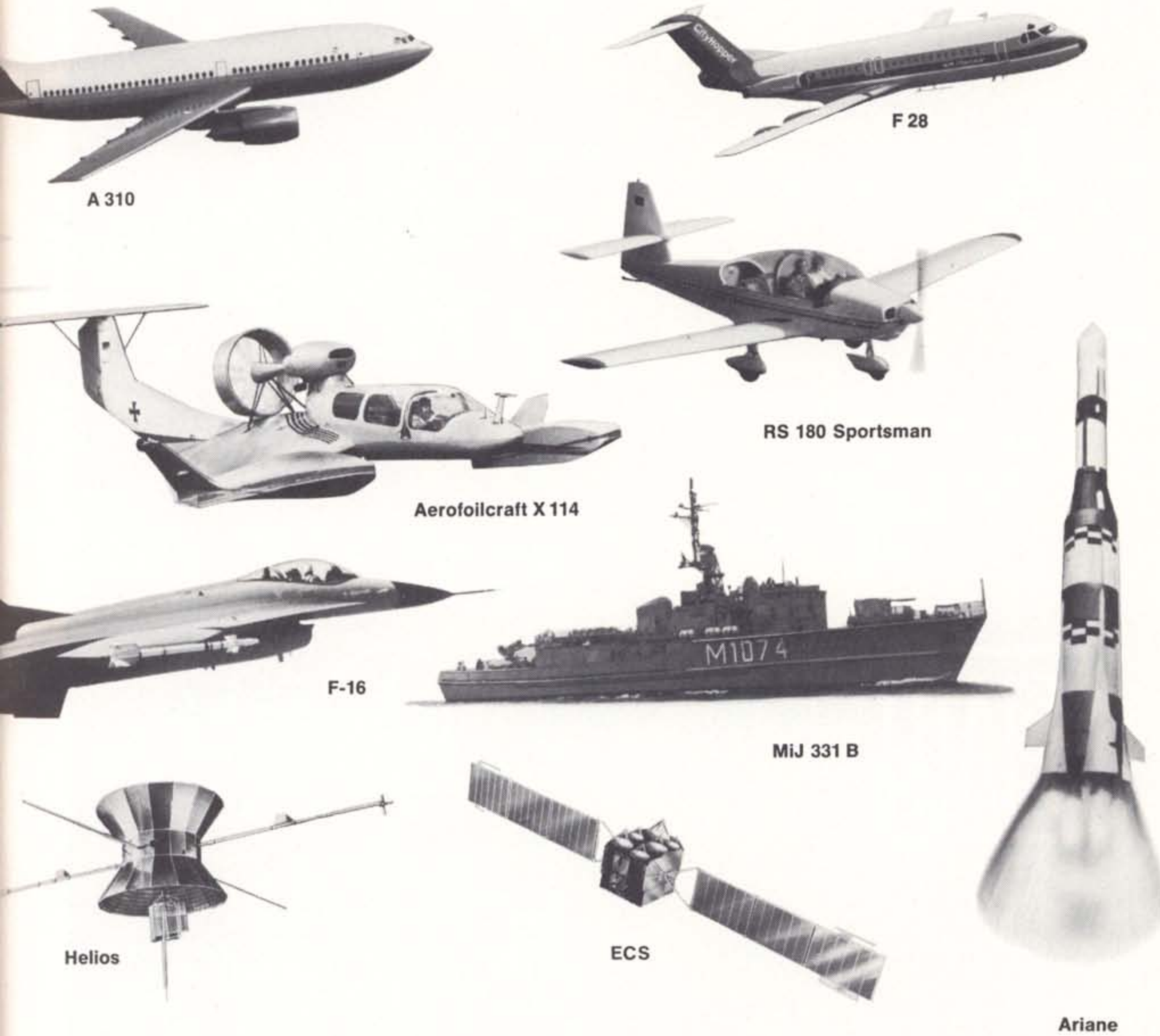

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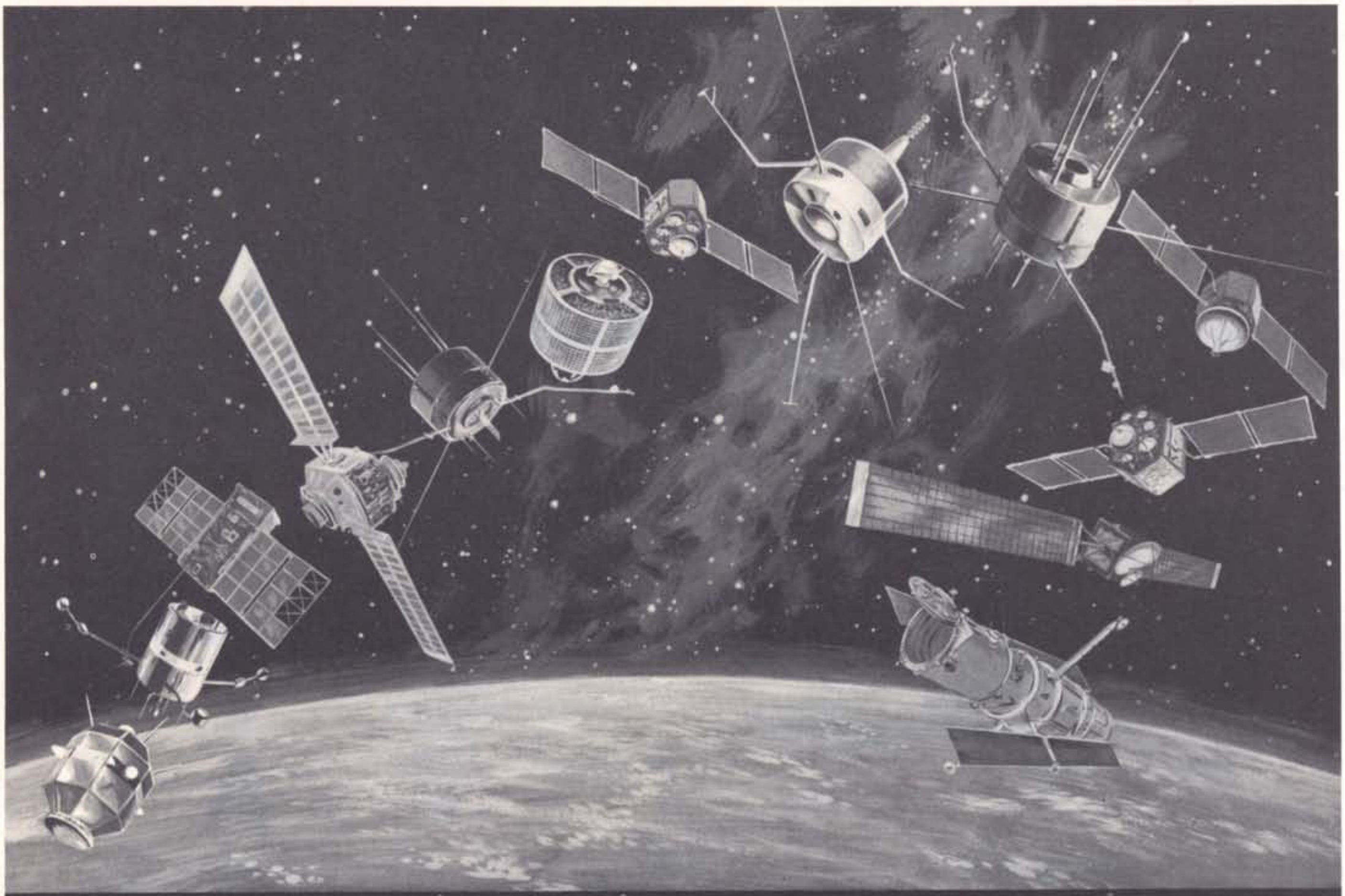

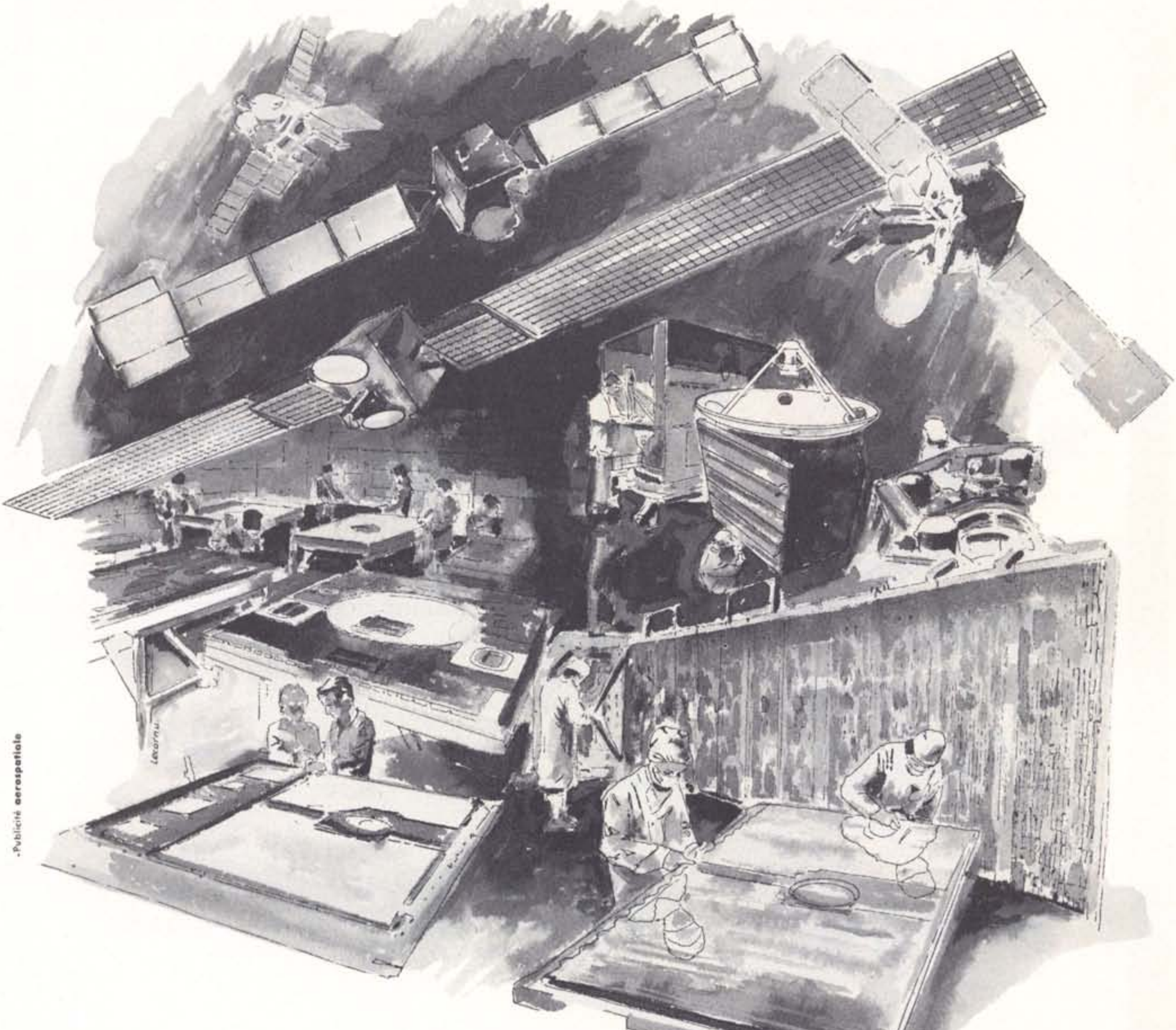
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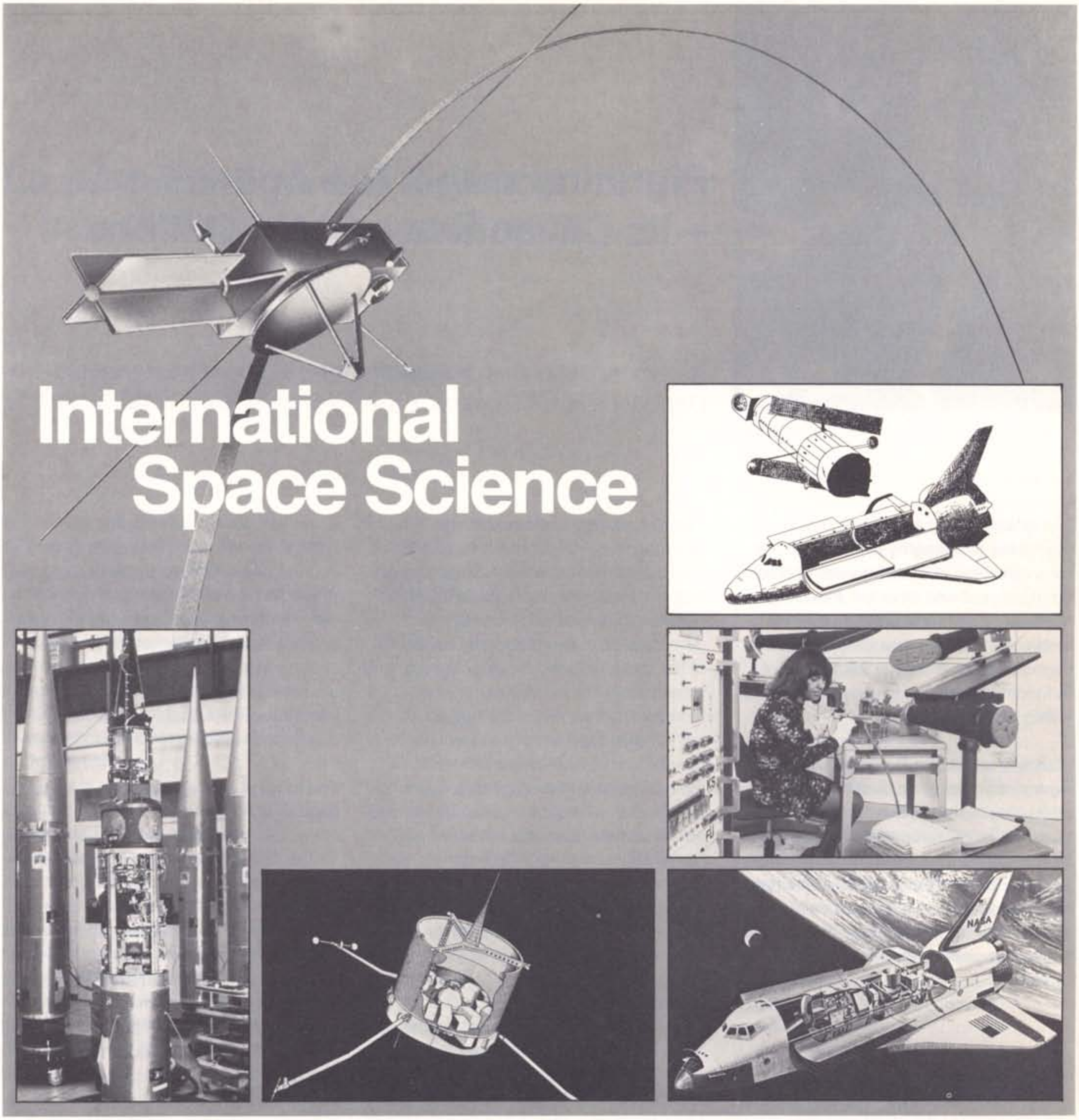
International
Space Science

Planning within the Agency – Its Difficulties and Limitations

A. Lebeau, Director of Planning and Future Programmes, Deputy Director General, ESA

The attainment of ambitious space objectives is a lengthy process calling for a definition of how the work should be organised and directed. Planning fulfils this need by projecting the technical, financial and chronological aspects of activities into the future; individual efforts fall properly into place within this framework.

Planning within the European Space Agency comes up against various difficulties; some of them are due to the very nature of space activities, others stem from the European nature of the establishment. The limitations to what can reasonably be achieved by planning are directly related to these difficulties, which it is worth identifying from the outset.

The uncertainties of forecasting
As regards the particular features of space activities, there are several factors that in practice militate against rigid planning. There is the uncertain development of users' requirements and of the technologies available. As far as the former is concerned, the uncertainty of forecasts lies in the fact that space technology offers either entirely new possibilities or, in the areas where it replaces existing means, a new quality of service. Conventionally, user requirements are influenced often in their extent and sometimes in their nature by the availability and quality of the means. This reaction between means and requirements, as we know, creates instability; it leads to frequent reappraisal of the importance and urgency of the objectives and to reoptimising of the balance of effort. But furthermore, the way in which the available technologies evolve is partly unforeseeable; first, because their evolution is dominated by the American effort, the scope, orientations and choices of which represent a basic datum for Europe, and secondly, and more intrinsically, because innovation leading to technological changes plays an important part in this evolution.

In addition, the execution of the programmes is inevitably subject to certain contingencies. At the present time we are far removed from the π factor quoted by Mr MacNamara as the usual relationship between forecasting and achievement in the area of advanced technology. Moreover, the European context shows no evidence in this connection of an identifiable handicap, either with respect to the accuracy in forecasting the costs of projects or in the intrinsic level of these costs. Nevertheless a margin of about 20% is considered a normal precaution, though this too may be exceeded. The interaction of these contingencies and the overall financial constraints is therefore a second factor leading to more or less frequent planning readjustments.

The implicit consensus at the European level
On a different plane, the European setting for the Agency's planning also engenders its own difficulties.

Planning expresses in terms of means and actions a space policy stated in terms of objectives. Europe's space policy is not the result of an explicit decision, as the policy of a government can be. It takes the form rather of a consensus that is mainly implicit and within which appear leanings by some Member States or even divergences on the part of others. Furthermore, the scope and limits of the Agency's role are the subject of considerably varying shades of opinion. These differences quite naturally show themselves in the attitudes adopted by various countries towards the overall conception, role and content of planning.

Planning – a help and a hindrance
In addition, the decision-making machinery that determines the new programmes in practice rules out any firm planning.

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La planification de l'Agence – ses difficultés et ses limites

A. Lebeau, Directeur des Programmes futurs & des Plans, Directeur général suppléant, ESA

L'ambition des objectifs spatiaux nécessite des délais pour les atteindre et impose donc qu'on définisse comment s'organise l'effort et comment il chemine. La planification répond à ce besoin. Il s'agit de formuler sous ses aspects techniques, financiers, chronologiques, une projection vers l'avenir des activités; à l'intérieur de ce cadre l'effort de chacun peut s'insérer harmonieusement.

La conduite des activités de planification au sein de l'Agence spatiale européenne se heurte à diverses difficultés; les unes relèvent de la nature même de l'activité spatiale, les autres découlent du caractère européen de l'établissement. Les limites de ce qu'on peut raisonnablement attendre d'un effort de planification ont un rapport direct avec ces difficultés; il est donc utile de bien les discerner.

Incertitude des prévisions

S'agissant des caractères propres à l'activité spatiale, plusieurs éléments interdisent en pratique une planification rigide: ce sont l'incertitude sur l'évolution des besoins des utilisateurs et des technologies disponibles. En ce qui concerne les premiers, l'incertitude des prévisions tient à ce que les techniques spatiales offrent soit des possibilités entièrement nouvelles, soit, dans les domaines où elles se substituent à des moyens existants, une qualité nouvelle du service. Selon un processus classique, le besoin, tel que l'expriment les utilisateurs, est influencé par la disponibilité et la qualité des moyens, souvent dans son ampleur, parfois dans sa nature. Cette réaction des moyens sur les besoins engendre, on le sait, une instabilité; elle oblige à réévaluer fréquemment l'importance et l'urgence des objectifs et à réoptimiser l'équilibre des efforts. Mais, en outre, les technologies disponibles évoluent de façon partiellement imprévisible. D'abord parce que leur évolution est dominée par l'effort américain dont l'ampleur, les orientations, les choix sont des données de fait pour l'Europe. D'autre part, de façon plus intrinsèque, parce que l'innovation, génératrice de mutations techniques, joue un rôle important dans cette évolution.

A cela s'ajoute que l'exécution des programmes comporte inévitablement une part d'aléas. Nous sommes loin aujourd'hui du facteur π cité par M. MacNamara comme le rapport habituel entre la prévision et la réalisation dans le domaine des techniques de pointe. D'ailleurs, le contexte européen n'apporte à cet égard aucun handicap identifiable, que ce soit dans la précision avec laquelle sont prévus les coûts des projets ou dans le niveau intrinsèque de ces coûts. Mais il reste qu'une marge de l'ordre de 20% est considérée comme une précaution normale et qu'il peut arriver qu'elle soit dépassée. L'effet du jeu contingent des aléas et des contraintes financières globales est donc un deuxième élément qui contraint à des réajustements plus ou moins fréquents de la planification.

Un consensus implicite au niveau européen

Sur un plan différent, le cadre européen dans lequel s'inscrit la planification de l'Agence engendre, lui aussi, ses difficultés propres.

La planification traduit en termes de moyens et d'actions une politique spatiale exprimée en termes d'objectifs. La politique spatiale de l'Europe n'est pas le résultat d'une décision explicite, comme peut l'être celle d'un gouvernement. Elle s'exprime plutôt comme un consensus largement implicite par rapport auquel se marquent, chez certains Etats membres, des tendances voire des divergences. En outre, l'étendue et les limites du rôle de l'Agence spatiale européenne sont l'objet de sérieuses nuances d'opinion. Ces différences se transposent tout naturellement dans les attitudes prises par les uns et les autres sur la conception d'ensemble, sur le rôle et sur le contenu de la planification.

Moteur et frein de la planification

En outre, les mécanismes de décision qui déterminent les programmes nouveaux interdisent en pratique une planification ferme.

On sait, en effet, que les programmes de l'Agence relèvent de deux grandes catégories: les programmes obligatoires auxquels tous les Etats membres participent en proportion de leur revenu

suite page 10

Planning within the Agency

It is well known that the Agency's programmes fall into two major categories; the mandatory programmes to which all the Member States contribute in proportion to their national income, and the optional programmes which allow each Member State the possibility of not participating and the participants of freely fixing the level of their participation.

In practice, the decision-making machinery for the mandatory activities, the scientific programme for example, determines by a simple majority vote the nature of the projects to which will be allocated an envelope that is known in advance. Such machinery lends itself readily to accurate medium-term planning, but unanimity is required to change the level of the envelope.

On the other hand, for the optional programmes the decision covers jointly the content of the project and the allocation of adequate resources. This mechanism provides an essential dynamic element since it enables the most determined Member States to spur on the others or, at worst, to go ahead without waiting for their adhesion. But there are drawbacks to this, especially as regards planning, because the optional nature of the project means that each Member State is free to commit itself or not, and it is precisely this freedom that engenders uncertainty and prevents firm medium-term planning of future projects.

As regards the actual techniques used, planning tasks, like all tasks involving the handling of large quantities of data, are transformed by the use of computers. Two points need to be made in this connection. First, the data-processing tools required for planning produce a synthesis and help towards decisions. They are intrinsically different and less cumbersome than the tools required for financial and contract management. Furthermore, the introduction of data-processing facilities should be done very gradually and give rise to careful experimentation. There is always the risk that an unwieldy tool may crush rather than serve those for whom it is intended.

Planning consists of a synthesis through which a vision of the future is expressed. As such, it lies at the crossroads of the Agency's financial and technical activities without really belonging to either. It must be built on a detailed knowledge of what exists – means, projects, personnel, budgets – and what has been decided. In particular, it depends on an accurate knowledge of the differences between forecasts and actual results. But it also requires a clear vision of the various objectives, of their interdependence, and of their place in an overall policy.

La planification de l'Agence

national, et les programmes optionnels qui laissent ouverte à chaque Etat membre la possibilité de s'abstenir et aux participants de fixer librement le niveau de leur participation.

En pratique, le mécanisme de décision des activités obligatoires – le programme scientifique par exemple – détermine par des votes à la majorité simple, la nature des projets auxquels sera affectée une enveloppe connue à l'avance. Ce mécanisme se prête bien à l'établissement d'une planification précise à moyen terme; mais l'unanimité est nécessaire pour modifier le niveau de l'enveloppe.

Au contraire, pour les programmes optionnels, la décision porte conjointement sur le contenu du projet et sur l'affectation de ressources adéquates. Ce mécanisme est un élément de dynamisme indispensable parce qu'il permet aux Etats membres les plus déterminés d'entraîner les autres ou, au pire, d'avancer sans attendre leur adhésion. Mais il comporte ses inconvénients, notamment dans l'etablissement de la planification. En effet, le caractère optionnel du projet traduit la liberté de chaque Etat membre de s'engager; c'est précisément l'exercice de cette liberté qui engendre une incertitude et qui interdit une planification ferme à moyen terme des projets futurs.

S'agissant des techniques propres dont elles font usage, les tâches de planification, comme toutes celles qui impliquent la manipulation de grandes quantités de données, sont transformées par l'usage de l'informatique. Deux remarques s'imposent à cet égard. Tout d'abord, les outils informatiques dont a besoin la planification sont des outils de synthèse et d'aide à la décision. Ils sont intrinsèquement différents et d'ailleurs moins lourds que les outils nécessaires à la gestion financière et contractuelle. Par ailleurs, l'introduction des moyens informatiques doit se faire de façon très progressive et donner lieu à une expérimentation prudente. Le risque existe qu'un outil surdimensionné écrase plus qu'il ne serve ceux auxquels il est destiné.

La planification étant une activité de synthèse par laquelle s'exprime une vision de l'avenir, elle se trouve par définition placée au point de jonction des activités financières et techniques de l'Agence sans qu'elle puisse appartenir en propre ni aux unes ni aux autres. Elle exige, comme fondement, une connaissance approfondie de ce qui existe, moyens, projets, personnel, budget et de ce qui est décidé. Elle repose en particulier sur une connaissance précise des écarts entre les prévisions et les réalisations. Mais elle demande également une vision claire des divers objectifs, de leur dépendance mutuelle et de leur place dans une politique d'ensemble.

Forward-Looking Financial Planning

K.-E. Reuter, Head of General Planning Department, Directorate of Planning and Future Programmes, ESA, Paris

Forward-looking financial planning is a basic requirement for any international organisation like ESA, which not only employs its own staff and maintains its own installations, but which also has to look after a series of large technological development programmes with considerable involvement on the part of some of Europe's most advanced industries. Financial planning is also necessary for the Member States, who have to prepare themselves for making the requisite financial resources available on time. However, the environment of an organisation structured like ESA, with its sometimes contradictory influences, renders the financial planning extremely complex, a fact not easily deduced from published results by the uninitiated external observer.

This article and those by H. Broberg, G. Coste, G. Niederau and L.A. Potter are intended to highlight some of the major problems and tasks inherent in the Agency's financial planning.

Analysing the past

The basis of all planning activities is a good knowledge of the past and an analysis of those events that are relevant for the future. As Member States are often not in a position to give clear guidelines as to where and to what level the Agency's programmes should evolve, past decisions can offer parameters for a future financial framework. The Agency's present programme is governed in the main by three major decisions taken by the Member States in 1971, 1973 and 1975.

The so-called First Package Deal of 1971 defined the Mandatory Programme, consisting of the Basic Activities and the Scientific Programme, and opened the way towards the inclusion of Applications Programmes such as Aerosat, Meteosat and Telecommunications into the Agency's activities.

The Second Package Deal in 1973 firstly created the Agency's Space Transportation Programmes, namely Spacelab as a cooperative venture with NASA's Space Shuttle Programme, and Ariane, the heavy European launcher, and secondly extended the Applications Programmes towards maritime telecommunications.

Finally, in 1975, the Member States voted to set up the European Space Agency per se, to take over the rights and obligations of ESRO and ELDO. At the same time, it was decided to include the maintenance and running of the Ariane launch base at Kourou, French Guiana, among the Agency's activities.

Keeping these decision dates in mind, it is interesting to look back at the financial effort that the European countries have put into their cooperative space programmes in the last decade. Figure 1 shows the annual expenditure – at *current prices* – of ESRO/ESA programmes from 1968 to 1978, to which the ELDO expenses have been added in the early years to complete the review. Figure 2 recapitulates these expenditure levels, but this time at common mid-1978 price levels and 1979 conversion rates. As a first rough impression, these historical figures would seem to indicate a tendency for the European countries to want to keep their financial commitments for space activities at a steady level (at constant prices). This impression is supported by an analysis of overall European space expenditure, including national programmes.

Figures 3 and 4, published previously in a document entitled 'Medium-Term Orientation of the Activities of the European Space Agency' [ESA/EXEC(76)1], present these total European expenditures for the period 1968–1975 both at current and at mid-1976 price levels. Here the tendency on the part of the Member States to maintain a constant annual space expenditure is even more apparent.

A further aspect can be analysed by looking at Member-State contributions broken down by country. Figure 5 shows the individual States' contributions to European programmes for the period 1963–1978 as a percentage of the total. Here too, continuity prevails over drastic change.

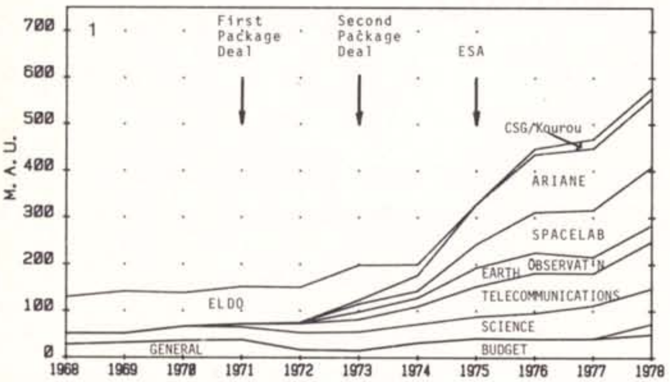
Figure 1 – Total ELDO/ESRO/ESA expenditure (current prices)

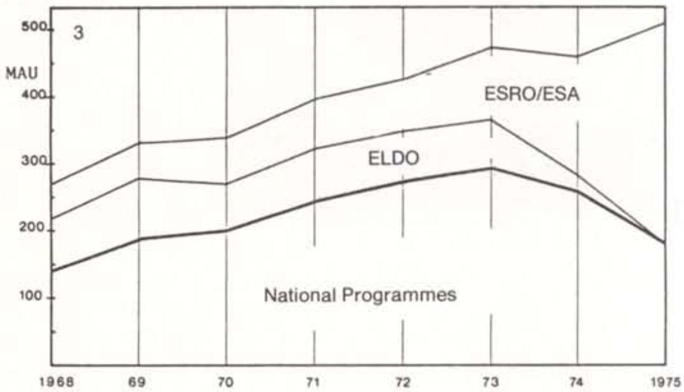
Figure 2 – Total ELDO/ESRO/ESA expenditure (common mid-1978 prices, 1979 conversion rates)

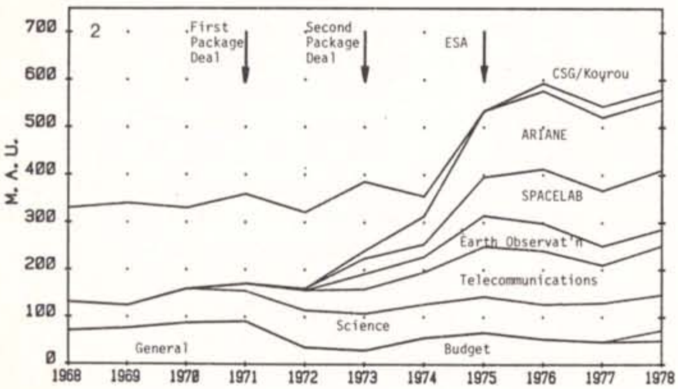
Figure 3 – Expenditure on overall European space activities (current prices)

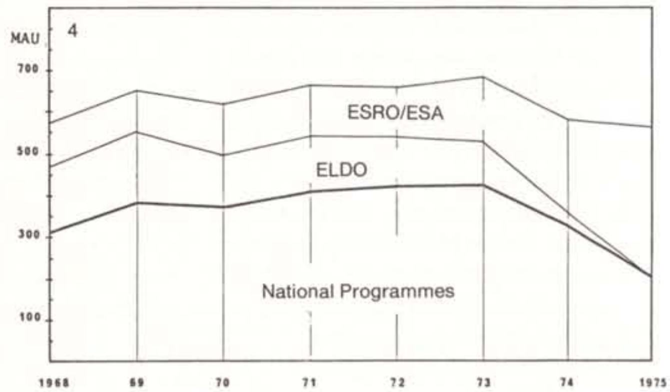
Figure 4 – Expenditure on overall European space activities (mid-1976 prices)

Figure 5 – ESA Member State contributions to ELDO, ESRO and ESA, 1962–1978: each Member State's contribution shown as a percentage of the total contributions for the same year.

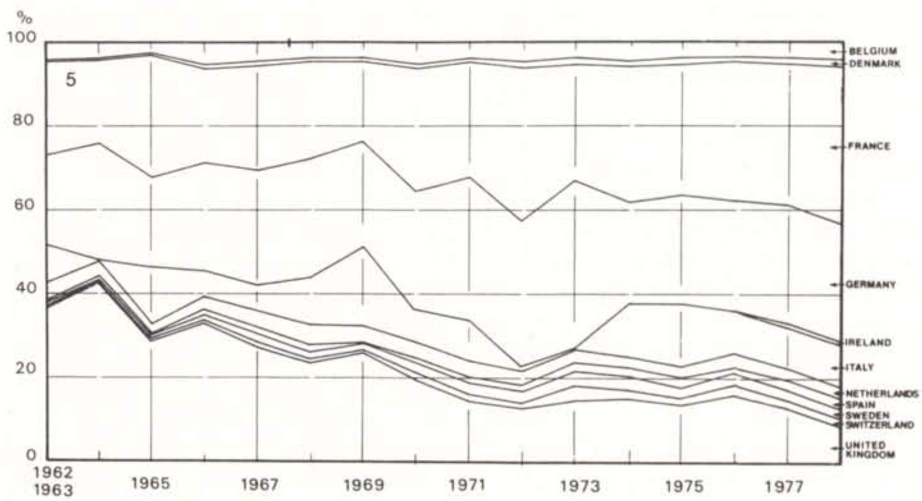








Having looked at the history of European space activities, it is informative to compare Europe's financial effort with that of other countries like the United States or Japan, which are comparable in economic importance. Such a comparison is made in Figure 6*, where the percentages of Gross Domestic Product devoted to civil space activities are indicated. Though there is a tremendous gap between the financial efforts of the USA and Europe, the European trend towards continuity is confirmed.



Follow-up of approved programmes

A second requirement when planning for the future is a detailed knowledge of the programmatic and financial requirements of the approved, on-going programmes.

As the programmatic aspects for ESA's on-going programmes are presented in detail later in this issue, the graphical summary presented in Figure 7 will suffice here.

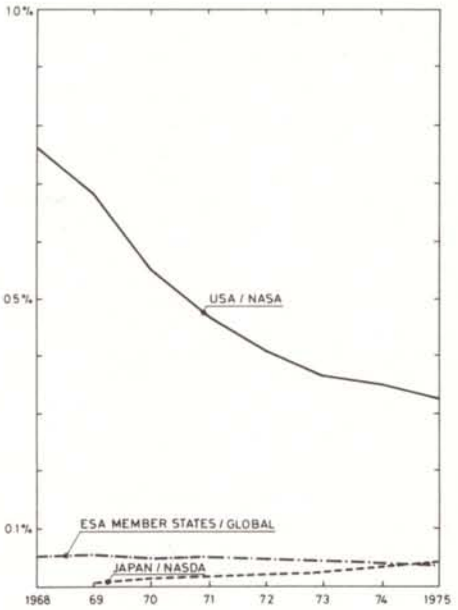
The financial aspects, however, deserve a closer look, as they to a large extent determine the limitations on the start of new programmes. Figure 8 summarises the funding requirements for all approved programmes for the period 1978–1984, as

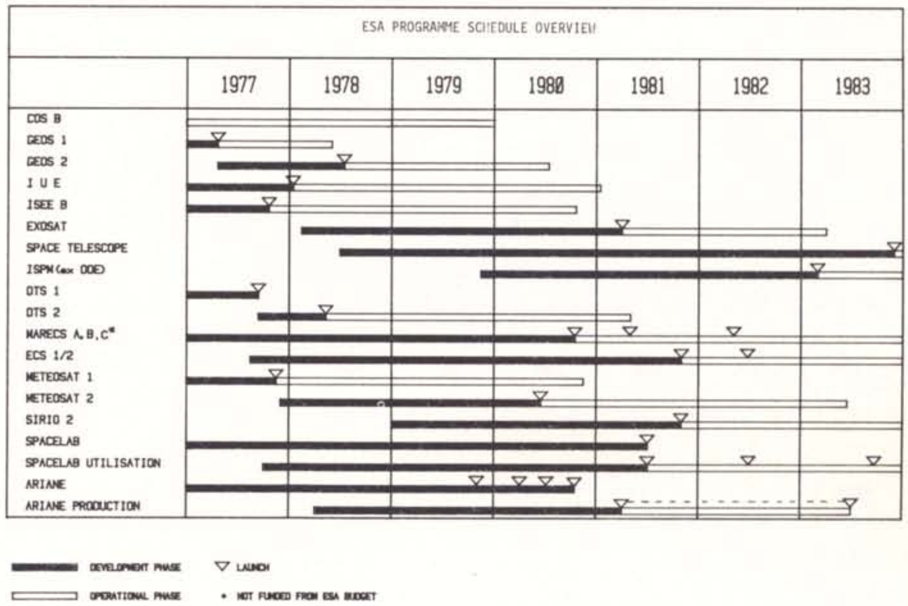
* Prepared for the ESA Science Advisory Committee's Recommendations on the Development of Space Science in the 1980s.

Figure 6 – Percentage of Gross Domestic Product devoted to space activities:
—— USA for NASA
–.–.– ESRO/ESA Member States for global space activities
– – – Japan for NASDA

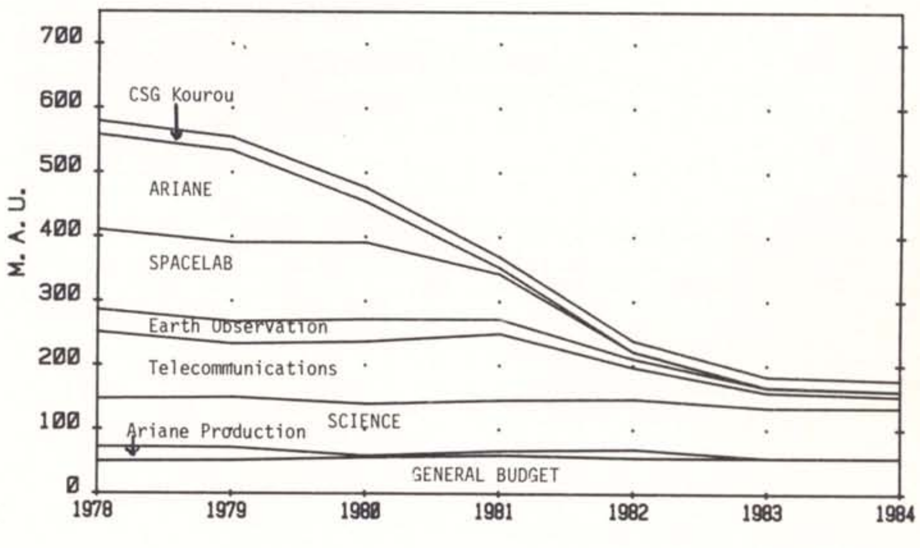
Figure 7 – ESA programme schedule overview

Figure 8 – Financial requirements of approved ESA programmes (mid-1978 prices, 1979 conversion rates)





currently estimated at constant mid-1978 price levels and 1979 conversion rates. The sharp decline in these estimates after 1980 demonstrates that from 1981 onwards continuity of the European space programmes is no longer assured. It is therefore a matter of urgency for the Agency and the Member States to prepare the ground for decisions on new programmes to avoid breaking the continuity that has prevailed for the last 15 years. The planning of future activities has to take account of this situation and must try to evaluate financing levels and programme proposals that are both mutually compatible and also comply with the needs of user organisations.



Assessment of the planning wedge for future programmes

Starting from the limit set by the financial resources absorbed by on-going programmes on the one hand and from extrapolated total-contribution expectations on the other, one can arrive at a wedge of financial resources that could be made available to new programmes. The depth of this wedge largely depends on the realistic assessment of the political will of Member States to maintain the continuity of space activities in Europe and to undertake cooperative programmes, a will that in our example must be translated into total financial commitments.

Whilst few firm intentions have been voiced, an important element of speculation still remains inherent in the overall forecasts. It is therefore presently a matter of looking at several options for total resources and of planning programmes towards both minimum and maximum annual values. The maximum of 480 MAU per annum that is considered would result in good continuity in European programmes; the minimum of 420 MAU would reduce space activities considerably and require capacity adjustments throughout Europe, because the Agency not only finances its own installations, but also those specialised facilities that have been built by Member States within the framework of their own national programmes. Table 1 and

Figure 9 – Financial framework for future programmes (mid-1978 prices, 1979 conversion rates)

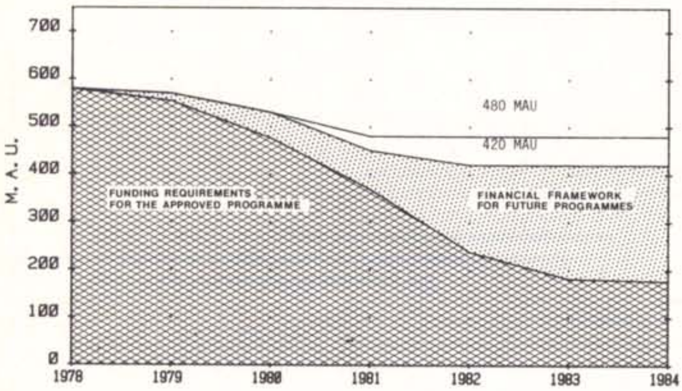


Figure 10 – Financial framework for future programmes (mid-1978 prices, 1979 conversion rates)

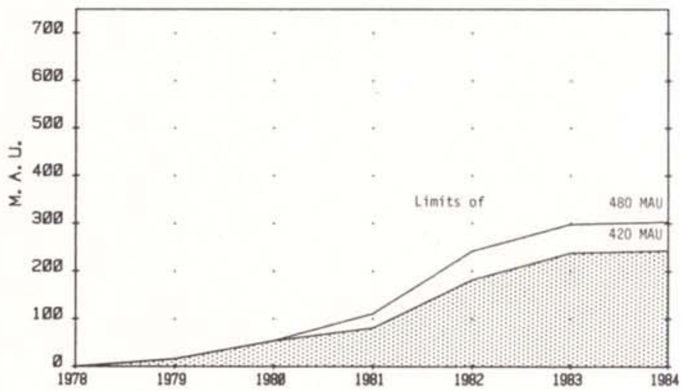
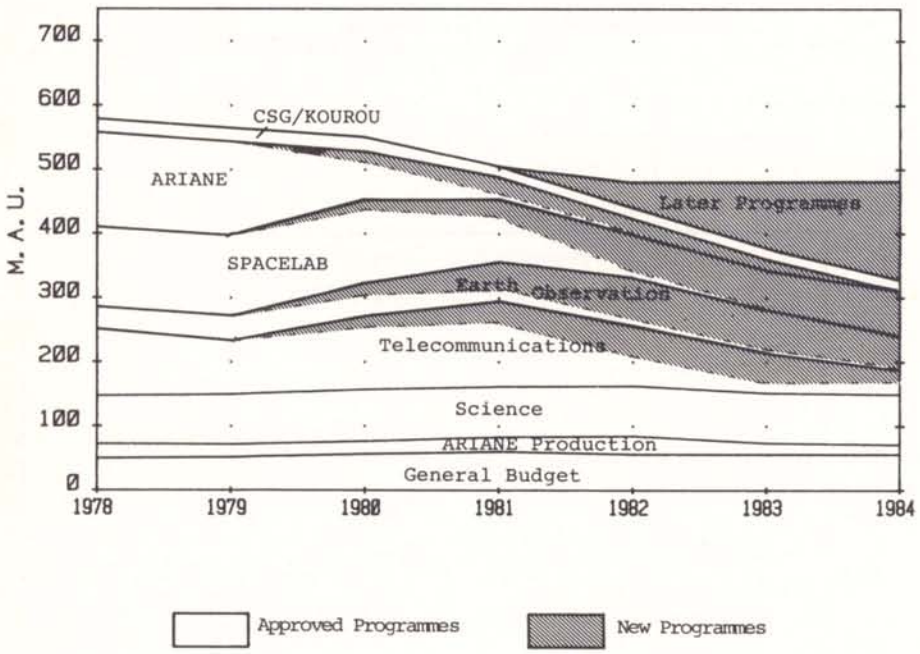


Figure 11 – Overall medium-term plan integrating approved and new programmes (mid-1978 prices, 1979 conversion rates)



Figures 9 and 10 illustrate one means of representing the evaluation of the financial framework for future programmes.

Optional planning for future programmes

New programmes have to be accommodated within the available financial resources in such a way that a good balance between the different programme sectors is assured. This requires a considerable simulation effort if the number of programme proposals is high. Purely for the sake of this article, we might consider just the set of programmes in Table 2 as an example.

Assuming, furthermore, that Earth-Observation Programme C and Space-Transport Programme A have to be started as an almost automatic continuation of other already approved programmes, the flexibility in planning is further reduced. Two options, one for each planning level, are shown in Tables 3 and 4 as examples of possible insertions of optional new programmes.

Assuming now that a planning option of the type shown in Table 4 could indeed be accepted in its entirety, we arrive at an overall plan that integrates both categories, approved and new programmes, as shown in Figure 11.

Once approved, such an overall plan, which the Agency aims for in its proposals

Table 1 – Financial framework for future programmes (mid-1978 prices, 1979 conversion rates)

	Financial framework (MAU)									
Programmes	1979	1980	1981		1982		1983		1984	
Approved programmes	554	476	369	369	238	238	182	182	177	177
Future programmes	16	54	81	111	182	242	238	298	243	303
Total	570	530	450	480	420	480	420	480	420	480

for total funding, would have two merits. First, the dialogue between the executing Agency and its supervising Member States would become more meaningful, as a common baseline for discussions and modifications would be available. Secondly, it would allow the Agency to plan its own internal resources well ahead in a way that would be fully consistent with the evolution of its programmes.

Planning of internal resources

A particular problem inherent in the Agency's planning activities lies in the economic allocation of the Agency's internal manpower and facility resources to specific programmes. The financial rules and the structure of presenting the Agency's expenditures require a full sharing out to programmes of the costs of the support potential of the Agency's establishments and of those facilities that are run by national organisations but financed in part or in total by the Agency.

This system of total-support sharing and support financing through programmes is unique in the World for a government organisation whose aim it is to promote research and to develop advanced technology. Normally, as in CNES, DFVLR, RAE or NASA, R & D organisations dispose of:

(a) an operational budget, out of which they can pay salaries to their staff and maintain their installations, and
(b) an investment budget, that finances projects and industrial development work.

The ESA system was created when optional projects with free contribution percentages for different countries were introduced, in order to distribute the financing of the Agency's own technical capability in a just manner related to the contributions to the different programmes. This system has worked efficiently as long as the expanding programme has consumed all of the Agency's capacities.

Recently, however, the system has been demonstrating its inherent contradictions,

Table 2 – A new programme proposal scenario (mid-1978 prices, 1979 conversion rates)

	Cost per year (MAU)					
Programme proposal	1979	1980	1981	1982	1983	1984
Telecom Programme A	6	27	38	34	18	
Telecom Programme B		18	30	45	38	20
Earth Observation A	7	12	18	16	8	
Earth Observation B	4	13	30	52	55	45
Earth Observation C		3	9	9	5	
Space Transport A	3	12	24	24	18	
Space Transport B		10	28	57	61	70

Table 3 – Low option for future programmes (mid-1978 prices, 1979 conversion rates)

	Cost per year (MAU)					
Programme	1979	1980	1981	1982	1983	1984
Fixed						
Earth Observation C	–	3	9	9	5	–
Space Transport A	3	12	24	24	18	–
Option 1						
Telecom Programme A	6	27	38	34	18	–
Earth Observation A	7	12	18	16	8	–
Total Option 1	16	54	89	83	49	–
Lower margin	16	54	81	182	238	243
Not allocated	–	–	–	99	189	243

Table 4 – High option for future programmes (mid-1978 prices, 1979 conversion rates)

	Cost per year (MAU)					
Programme	1979	1980	1981	1982	1983	1984
Fixed						
Earth Observation C	–	3	9	9	5	–
Space Transport A	3	12	24	24	18	–
Option 2						
Telecom Programme B	–	18	30	45	38	20
Earth Observation B	4	13	30	52	55	45
Space Transport B	–	10	28	57	61	70
Total Option 2	7	56	121	187	177	135
Higher margin	16	54	111	242	298	303
Not allocated	9	–	–	55	121	168

as the already approved programmes have been running their course and decisions on new ones have been rather slow in coming. In this situation, the support costs allocated to new programmes are still awaiting approval. The ESA system allows only one alternative, namely the allocation of arbitrarily higher charges to already approved programmes.

Here a further pitfall appears in that the approved optional programmes are governed by international legal arrangements that limit their total envelopes. They can therefore not absorb indefinitely those support costs that represent technical effort planned for new programmes that have not yet been approved. In the absence of a mechanism that would allow allocation of this unused technical capacity to a budgetary buffer, the approved programmes could conceivably be loaded with other programmes' unused support effort unless an interventionary management decision is taken to the contrary.

Economic and monetary aspects

One problem that has already had a negative effect on annual budget discussions and approvals in recent years also has an impact on forward planning, with unfortunate, unstabilising results. The Member States have experienced serious inflationary trends during the last six years, varying from country to country from 1% at best and 28% at worst, per annum, for the industrial sector involved in space activities. These escalations have produced cost increments of between 8% and 15% annually in the Agency's programmes over the same time period. During that same period, which followed the decision to abandon the Bretton/Woods system with fixed parities to the US-dollar and to introduce the system of freely floating currencies, the values of the national currencies of ESA's Member States have fluctuated in relation to the Accounting Unit by between +21% and −21%.

It is obvious from these facts alone that the accuracy of forecasting within the Agency has been considerably hampered by the hazards of European economic evolution, particularly in respect of estimating individual Member State's contributions. Here the two effects, inflationary trends and currency-value variations, redouble their impact; the currencies of countries with small price variations appreciate with respect to the Accounting Unit, while those of countries with high inflation rates depreciate with respect to the AU, thus increasing twofold the contributory effort that the latter countries have to support.

This insecurity in the forecasting of future expenditure is certainly one of the factors that has impeded a swift decision in the approval of new programmes in many cases, as the degree of confidence in the estimates presented has not been very highly valued.

Outlook

The above paragraphs have considered the Agency's planning activities in a somewhat idealised light, leaving aside the frequent modifications that arise in the course of programmes and the many iterations involved in arriving at an overall plan. Another aspect that has not been treated here are the political considerations underlying the planning. Suffice it to say that a prime objective of all programmatic and planning activities must be to contribute to a resuscitation of the political consensus required in defining a European Space Programme. To achieve this goal, planning has to be concentrated on the longer-term future, trying to propose programme scenarios that are no longer subject to the daily budget fluctuations. In this respect, the idealised portrayal of planning that has been presented might hopefully serve as a model for a refreshed approached to future activities.

Investment Planning in the Agency

H. Broberg, General Planning Department,
Directorate of Planning and Future Programmes, ESA, Paris

The financial term 'investment' is often understood to mean the placing of capital in particular assets that are likely to grow in value over a certain period of time. The concept of investment has a somewhat different meaning, however, when it comes to the provision of resources for an activity or programme. In this case assets, for example equipment, are bought ahead of needs in order to ensure availability of the facilities and other resources required for timely and cost-effective programme execution. This is certainly the case within the Agency, where the main task is to manage and execute the development of large scientific and technical space programmes on behalf of the eleven Member States.

Why invest?
Investment in facilities and resources is no incentive in itself as the items purchased will normally depreciate as time passes. Moreover, any facility needs to be maintained and provided with operators and software, and attracts costs even when not in use. There is therefore a rather strong incentive not to make such investments if the work can be carried out by using resources procured other than by capital investment.

Nevertheless, there are a number of cases in which investments are, in any event, necessary or desirable: for example (the items quoted in brackets here are taken from the recently published ESA Investment Plan):

1. A facility is needed that is not available elsewhere (e.g. refurbishing of the ESTEC Dynamic Test Chamber, as there is no other chamber large enough in Europe for the thermal testing of the largest Ariane-carried spacecraft).
2. Project requirements cannot be met safely by existing external facilities (e.g. additional ground support to Ariane double launches).
3. The anticipated utilisation of a facility is such that purchase is the most economic path (e.g. purchasing a computer in cases of prolonged operation if more economical than renting).
4. Logistics call for a secondary facility to be provided close to a major facility, even though the same secondary facility might already be available elsewhere (e.g. providing physical-measurement machines in the vicinity of a large space-simulation chamber).

An additional consideration is the importance of phasing out obsolete equipment, which often consumes more than it produces (i.e. rarely used but maintained), or is wasteful to use compared with modern equipment. It may be hard to accept economic loss in cases where the equipment looks 'as good as new', but this course must sometimes be accepted.

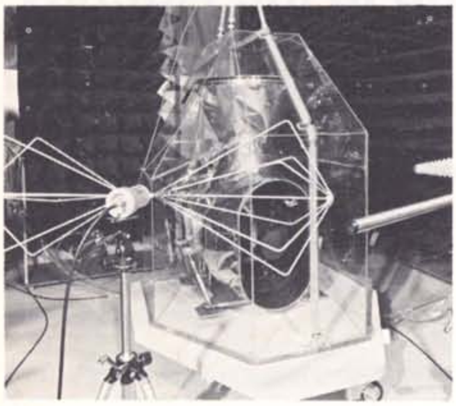
In short, the negative aspects of investment in facilities which depreciate and are expensive to own should always be balanced against the advantages of availability, safety, cost-effectiveness, etc.

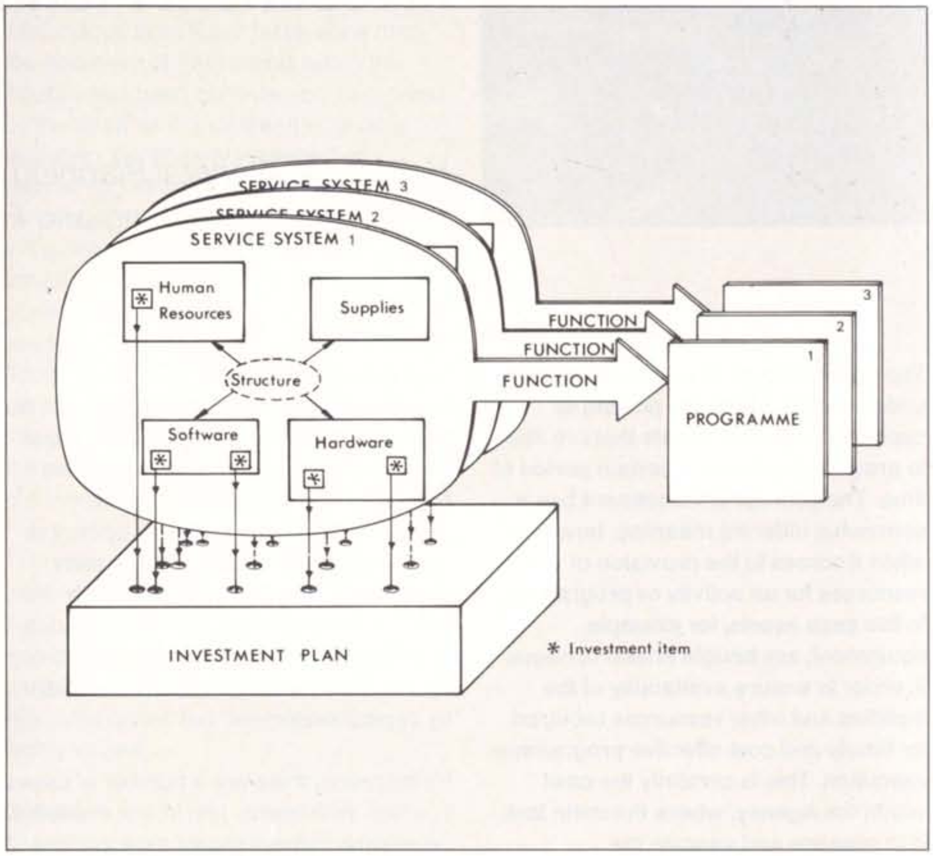
Taking a systems approach
The investments made by ESA are generally designed to secure elements of systems necessary to serve the needs of its programmes. Such service systems normally have the potential to serve several projects, either in parallel or consecutively. It does sometimes happen that a system can be devoted solely to one project, especially in the case of dedicated satellite ground-support equipment.

Before proceeding to discuss how best to specify such systems and their investments, it may be helpful to elucidate what we mean here by a 'system'.

For our purposes, we can consider a service system to be 'defined' by the following:

Figure 1 – The integrated investment plan





- *The main function*, which needs to be described (e.g. space simulation) together with the specific system parameters (e.g. temperature, pressures, etc.) and the constraints on these (variability, tolerances, etc.).
- *Hardware elements*, such as equipment, buildings and vehicles.
- *Software elements*, such as procedures, instructions and computer programs.
- *Supplies*, such as power, air conditioning, consumables and spare parts.
- *Human resources*, such as for management, operation and maintenance.
- *A structure*, be it geometric, temporal or hierarchical, in which the above elements are connected to provide the desired function.

The system so-defined forms a complete operational unit and can also be considered a complete *cost centre* in financial terms.

When defining a specific system it is important to use a top-down approach, starting from the function and branching down to the various elements, and only then attempting to optimise the structure in which these and other resources are used. Although investment plans often concentrate mainly on hardware and to a lesser extent on software elements, one must take care not to lose sight of the overall picture presented by the system model. After all, the total cost of procuring, maintaining and operating a system is made up of both investment and running costs, and the delineation between the two is often somewhat arbitrary. This is particularly true for software development, but also applies to staff training and modifications to equipment. These are areas in which it may be a matter of personal judgement whether or not a

Figure 2 – Investment projects for environmental testing

Investment projects	Estimated cost, MAU (mid-1978 prices)	Implementation period					
		1978	1979	1980	1981	1982	1983
1. Vibration							
Adaptation of ESTEC vibration facility to larger spacecraft*	0.752						
Replacement of vibrator power amplifier	0.215						
Vibration data handling	0.500						
2. Thermal							
Adaptation of DTC for thermal testing of larger spacecraft*	0.950						
Thermal data handling	0.300						
3. Electromagnetic compatibility							
Automation of EMC stations	0.200						
Adaptation of EMC facility to larger spacecraft*	0.500						
4. Miscellaneous							
Alignment equipment for larger spacecraft*	0.200						
Spin dynamic facility	0.170						
Physical measurement equipment	0.165						
Total of 1 to 4	3.952						
5. Minor replacements, all areas	0.23/year						

* Larger spacecraft: large satellites carried by Ariane/Spacelab payloads

certain element should be treated as an investment.

The major service systems employed by ESA are the following:

1. Overall checkout systems, ensuring communication with and interrogation of a spacecraft and providing access to all electrical parameters during the integration and test phases.
2. Environmental testing systems, providing simulated conditions for the control of spacecraft behaviour under launch and space conditions and for qualification and acceptance testing.
3. Ground-support systems for the control of satellite orbital operations as well as spacecraft data acquisition, telecommand and tracking.
4. Computer systems, supporting satellite operations in real time [as part of 3 above], as well as facilities for batch processing and interactive applications.

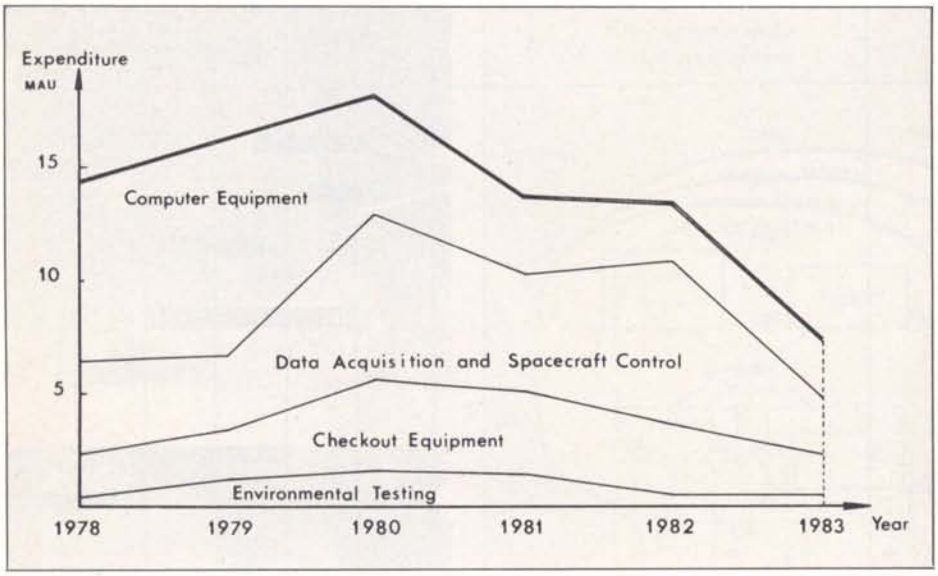
Only systems 1 to 3 can really be said to meet the system definition that we have given above, and the computer facilities are generally employed in support of other systems. However, because of their special characteristics, their high cost and the fact that they themselves embrace most system ingredients, the larger computer facilities are treated as separate items in ESA's investment planning.

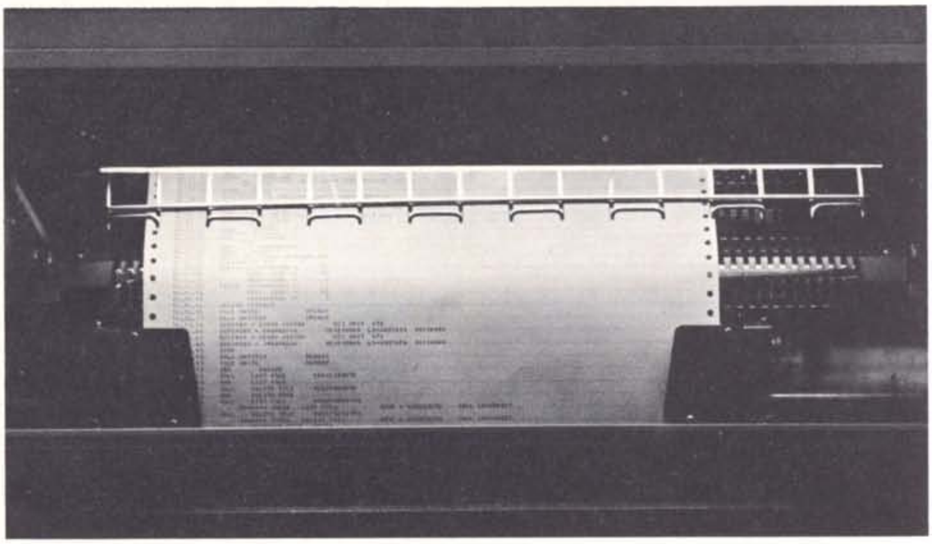
Why investment plans?

Having identified the service systems needed to conduct the Agency's programmes, the system requirements have to be transformed into adequate specifications. It is at this point that one must consider the best means of acquiring the necessary hardware and software elements, as well as supplies and human resources. Analysis will usually show that some system elements are best procured as investment items, while others can be acquired more efficiently in other ways, for example by exchange, lease or rent.

If all the system elements needed to conduct a programme are to be available in time, a systems acquisition plan must be devised to ensure that all the constituent elements are ready and in place when the time comes for the system to be made operational. An integrated investment plan is closely linked with such system acquisition plans in that it reflects all of the elements requiring investment. The incentive for ESA to prepare an integrated plan for its investments lies partly in the strong financial drive to keep expenditure under strict control, not only because of the initial outlay but even more so because of the induced follow-on costs, and partly in the interest in

Figure 3 — Anticipated levels of expenditure in the ESA Investment Plan for service systems





coordinating the investments as far as possible across different internal systems, and between ESA and other parties (national centres and industry).

How to establish an investment plan
Assuming that the service systems have been sufficiently well defined and that the investment requirements have been identified, the next step is to describe those investments in such a way that they can be submitted for a management decision. One suitable approach is to build up investment packages that are large enough to have meaningful roles in the programmes, though still falling within the basic function of a support system.

Each such investment package can be formulated as a small project in itself. The time schedules for these investment projects are linked to the first user (project) and thereby to the mission model developed by the Agency (see Figure 7, page 13).

The investment projects for environmental testing in the ESA Investment Plan can be taken as an example (Fig. 2) of this above approach to defining investment packages. It should perhaps be added that this area has been chosen as an example because of its simplicity, rather than any financial significance.

If, however, decisions on investments are to be facilitated, it is not sufficient just to define the investment packages of the service systems. These must also form part of the budgets and medium-term plans of the Agency establishments to which they belong (ESTEC, ESOC, ESRIN). The relation to medium-term plans is particularly important, since a rather modest investment in one year's budget can lead to considerable running costs in subsequent years.

Some aspects of the ESA Investment Plan
In December 1978, ESA submitted a complete and integrated plan to its Council covering investments required during the years 1978-1983 for the service systems described on the previous page, items 1 to 4.

The investment levels for the four areas treated are illustrated graphically in Figure 3, where both the overall level of investment and its main components can be seen.

The total annual expenditure averages out at some 15 MAU, although it is considerably lower towards the end of the period. In reality this reduction may not occur, as new programmes are likely to require investments that have not yet been taken into account. For example, the need to replace existing electronic equipment for data acquisition and spacecraft control, which may become obsolete during the period shown, will depend on decisions to be taken as regards the Agency's programmes in the years beyond 1984.

From Figure 2 it can be seen that a major part of the investments in environmental testing stems from the need to provide testing facilities for the larger spacecraft that will characterise the Ariane and Spacelab era.

Approximately 50% of the investment foreseen in the area of ground-support facilities for orbital operations is dedicated to a worldwide network of UHF stations. This network is intended for future projects (after 1983) and, following the abandonment of VHF, will be needed for the placing in orbit of geostationary satellites, and possibly also for supporting low-orbiting spacecraft.

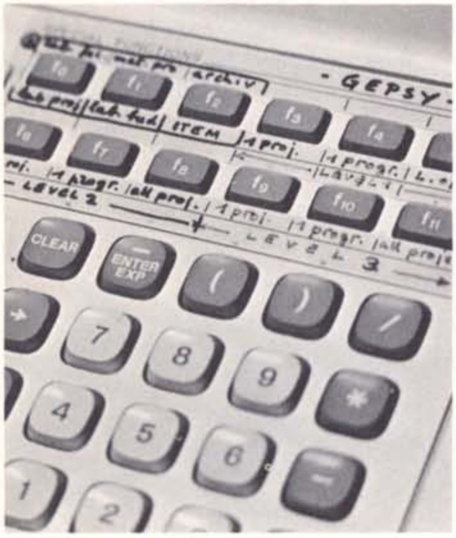
The Meteosat Ground Computer System (MGCS), consisting essentially of two ICL-2980 machines, is the largest single investment item among the computer systems, accounting for some 25% of the total. Thereafter, the largest items will be the renewals of the offline computer facilities at ESTEC and ESOC, each representing some 20% of the computer investment.

The major part of the investment in checkout is motivated by the age of existing general-purpose checkout stations and electronic ground test equipment. A gradual changeover is being made to modern equipment, characterised mainly by the use of microprocessors in place of the earlier types of small computers.

Investment planning on a European level

For many years, the Agency's programmes have been making use of environmental test facilities at national centres, mainly CNES in France and IABG in Germany, in addition to those installed at ESTEC. With the growth of space activities and with the trend towards larger spacecraft, this cooperation has been intensified, and a growing number of external facilities are being utilised in ESA's programmes. This evolution has brought a need for a coordinated approach towards investment in European test facilities for space development, and the ESA Council has now approved a policy [ESA/C(78)108] relating to a so-called 'coordinated set of European test facilities'. The major investment projects for modification or extension of existing or for new facilities will be subjected to this coordination and the nature and degree of ESA involvement in such investment projects will be determined on a case-by-case basis by Council.

The ownership outside ESA of facilities serving ESA programmes will certainly also be discussed in more general terms than above, and it would seem that the pooling of European (Member State) resources will be considered to an increasing degree in the optimisation of future investments.



GEPSY – Un système d'information au service de la planification et de l'élaboration des décisions

G. Coste, Département Programmation générale, Direction des Programmes futurs et des Plans, ESA

Une revue rapide de la littérature spécialisée fait rêver de systèmes de gestion intégrés qui recueillent des dizaines de milliers d'éléments d'informations à la base, pour en faire de brillantes synthèses au sommet, des tableaux de bord pour la Direction générale et donnent le dernier point de la situation sur l'exécution de la production. L'ensemble étant traité sur un ordinateur dernier cri, à la mémoire infaillible, sinon généreuse en octets.

En général hélas un système de cette complexité ne fonctionne pas à l'envers; il est capable d'enregistrer des situations, il ne l'est guère d'aider à les modifier. Faut-il alors revenir au vieux système d'autrefois, téléphoner aux chefs de projet, obtenir leurs suggestions, ébaucher 'à la main' une synthèse et achever par quelques coupes aveugles et indéterminées?

Une telle extrémité peut être évitée si l'on dispose d'un système de traitement qui manipule simplement un millier d'informations globales, et qui permet de conduire rapidement des simulations, d'introduire des hypothèses de travail, de comprendre la circulation de l'information et d'élaborer des recommandations comme celle-ci: 'Le projet Z devrait réduire de 2 MUC ses dépenses de soutien, car elles sont anormales comparativement à celles du projet X'. Le dialogue peut alors s'établir entre la planification et le chef de projet dans un cadre clair et se concentrer sur les anomalies identifiées. Si de plus, cette petite base de données est maintenue constamment cohérente avec les derniers chiffres du budget, du plan financier, des coûts-à-achèvement, du niveau des effectifs et enfin des niveaux de ressources et de financement, elle permet à tous les responsables de la planification de maintenir l'unité dans les décisions, c'est-à-dire de parler le même langage.

Peut-être même que ce système appelé GEPSY (GEneral Planning SYstem) permettra à tout le monde de comprendre comment les coûts directs des établissements, après être passés par la distillation de la 'charging policy' (politique d'imputation des coûts), se transmutent en coûts indirects dans les projets, sans laisser de 'résidus'.

Quelques éléments sur la structure de gestion de l'Agence

On peut tout d'abord avoir en tête l'idée générale que l'Agence spatiale européenne fonctionne comme le maître d'ouvrage des programmes spatiaux européens pour le compte des Etats membres (Fig. 1). C'est l'industrie européenne (en général) qui réalise les satellites, lanceurs, stations sol etc. Si l'on rapproche les ressources qui arrivent dans l'Agence (recettes des Etats membres) de celles dépensées dans l'industrie, la différence est ce que l'on pourrait appeler 'les frais de maîtrise d'ouvrage'. Ils représentent en moyenne 10 à 13% des ressources. (On peut faire un rapide calcul en faisant le rapport (personnel + fonctionnement)/dépenses totales).

Lorsqu'un projet est décidé par les Etats membres, il est défini notamment par un coût-à-achèvement (Fig. 2), c'est-à-dire une enveloppe financière globale qui est assortie d'un échéancier de paiements pluriannuels (voir article de L.A. Potter). L'exécution est confiée dans l'Agence à une équipe de projet dépendant d'un directeur de programme qui exerce la responsabilité de maîtrise d'ouvrage.

Toutes les dépenses effectuées sous son autorité sont appelées *dépenses directes*: on y trouve les dépenses de personnel de l'équipe et de son fonctionnement, quelques investissements; la majorité des

Figure 1 – Le rôle de l'ESA en tant que maître d'ouvrage

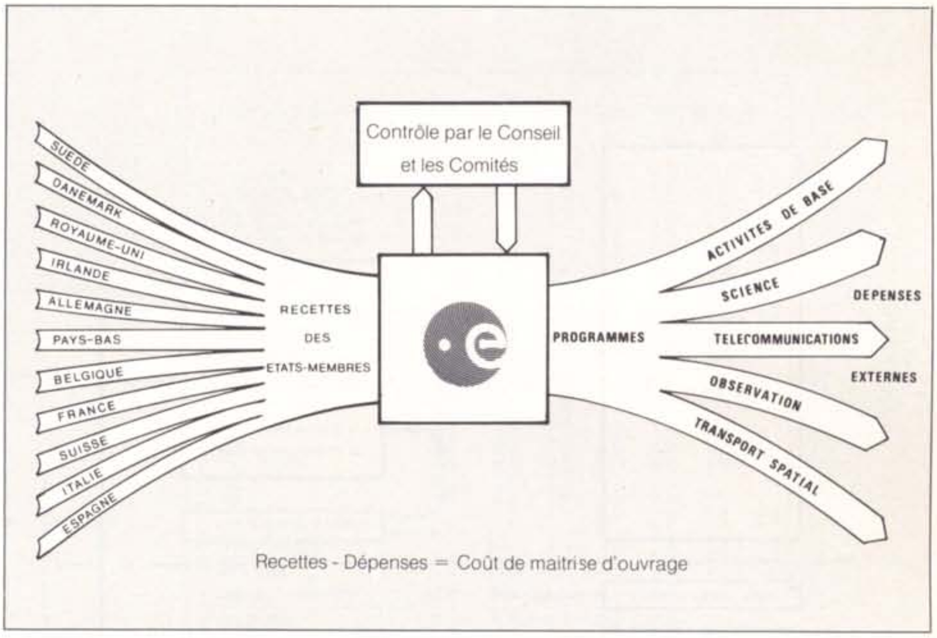
Figure 2 – Coût-à-achèvement du projet ECS

dépenses est concentrée dans le grand titre 'développement' regroupant le coût du contrat industriel et des moyens de lancement.

Les autres dépenses sont dites *indirectes*, et représentent 10 à 20% du coût total. Il s'agit:
- de dépenses effectuées, pour le compte du projet, mais sous-traitées aux deux Etablissements techniques ESTEC et ESOC (en général logiciels spécifiques, station de contrôle, essais spécifiques etc.);
- d'utilisation de moyens des deux Etablissements. Ces moyens mis en pool au service de tous les projets sont facturés en fonction de l'utilisation (en heure, homme × mois). Par exemple: moyens d'essais et de calcul, station du réseau de mise en orbite…
- de la répartition des frais administratifs, au prorata des coûts du personnel de l'équipe.

La Figure 2 montre la disposition classique du rapport de coût-à-achèvement sous la forme imprimée par GEPSY sur l'exemple du projet ECS.

Il faut bien remarquer que les équipes de projets ne sont pas sous la responsabilité des Etablissements techniques (même si elles y résident physiquement). Ces Etablissements ont donc des dépenses *directes* propres, dites de soutien, destinées à satisfaire les demandes des projets et aussi certaines dépenses de recherches etc. L'ensemble de ces dépenses pluriannuelles (sur six ans) constitue le Plan à Moyen Terme des Etablissements. Ces dépenses sont ensuite facturées, *réimputées* sur les projets suivant certains critères d'utilisation. La procédure d'imputation, la détermination des coûts de facturation, constituent la politique d'imputation des coûts. La Figure 3 en donne une représentation très simplifiée. (Une autre représentation plus imagée, mais plus réaliste, de la 'charging policy' est donnée par la Figure 4). Notons au passage une



WBS	CC	TT	U			1977	1978	1979	1980	1981	1982	1983	CTC
110	00	01	0	*	manpower HQ (mx)	-	3.00	3.00	3.00	3.00	1.00	-	13.00
110	00	01	1		manpower HQ	-	0.11	0.12	0.11	0.11	0.04	-	0.49
110	00	02	0	*	manpower ESTEC (mx)	-	27.00	30.00	25.00	20.00	10.00	3.00	115.00
110	00	02	1		manpower ESTEC	-	1.00	1.10	1.00	0.81	0.39	0.12	4.50
110	00	03	0	*	supernumerary	-	1.00	1.00	1.00	1.00	-	-	4.00
110	00	03	1		supernumerary	-	0.01	0.02	0.02	0.02	-	-	0.07
11					ESA STAFF	-	1.12	1.32	1.13	0.94	0.43	0.12	5.06
120	00	01	1		temp/PT/experts	-	0.02	0.03	0.02	-	-	-	0.07
12					NON-ESA STAFF	-	0.02	0.03	0.02	-		-	0.07
1					STAFF EXPENDITURE	-	1.14	1.35	1.15	0.94	0.43	0.12	5.13
230	00	01	1		missions HQ+ESTEC/meetings	-	0.23	0.34	0.30	0.35	0.11	0.03	1.36
23					MISSIONS EXPENSES / ESA STAFF	-	0.23	0.34	0.30	0.35	0.11	0.03	1.36
2					RUNNING EXPENDITURE	-	0.23	0.34	0.30	0.35	0.11	0.03	1.36
330	00	01	1		techn assistance	-	0.01	0.10	0.14	0.05	0.03	-	0.33
33					TEST FACILITIES	-	0.01	0.10	0.14	0.05	0.03	-	0.33
3					FACILITIES	-	0.01	0.10	0.14	0.05	0.03	-	0.33
430	00	01	1		Comm syst test equipment	-	-	0.31	0.31	0.40	0.02	-	1.04
430	00	02	1		c/s. TM/TC station	-	0.08	0.42	-	-	-	-	0.50
43					TEST FACILITIES	-	0.08	0.73	0.31	0.40	0.02		1.54
450	00	01	1		payload monitor + s/w	-	-	0.21	2.17	1.96	-	-	4.34
45					TRACKING, TELEMETRY & RANGES	-	-	0.21	2.17	1.96		-	4.34
4					INVESTMENT	-	0.08	0.94	2.48	2.36	0.02	-	5.88
510	00	01	1		Comm syst devl studies	-	-	0.22	0.29	0.57	-	-	1.08
51					STUDIES	-	-	0.22	0.29	0.57	-	-	1.08
520	00	01	1		Main development	3.49	15.19	16.59	16.90	14.33	7.36		73.86
520	00	02	1		MSSK	-	-	-	1.44	0.08	-	-	1.52
52					DEVELOPMENT OF SPACECRAFT	3.49	15.19	16.59	18.34	14.41	7.36	-	75.38
540	00	01	1		ARIANE ECS1	-	-	7.09	9.89	9.64	-	-	26.62
540	00	02	1		insurance ECS 1	-	-	-	-	3.81		-	3.81
54					LAUNCH COSTS	-	-	7.09	9.89	13.45	-	-	30.43
5					DEVELOPMENT	3.49	15.19	23.98	28.52	28.43	7.36		106.89
600	00	01	1		Administrative support	-	0.26	0.38	0.33	0.27	0.12	0.03	1.39
60					ALLOCATED ADMIN.SUPPORT	-	0.26	0.38	0.33	0.27	0.12	0.03	1.39
6					ALLOCATED ADMIN.SUPPORT	-	0.26	0.38	0.33	0.27	0.12	0.03	1.39
750	40	01	1		outside test fac & TA	-	-	0.21	1.19	0.60	0.40	-	2.40
75					ESTEC SUPPORT	-	-	0.21	1.19	0.60	0.40	-	2.40
760	00	01	1		antenna REDU	-	0.02	0.09	-	-	-	-	0.11
760	00	02	1		TTC facilities	-	-	-	1.34	1.15	-	-	2.49
760	00	03	1		reconfiguration REDU	-	-	0.06	0.12	0.11		-	0.29
760	00	04	1		s/w support	-	-	0.01	0.06	0.05	-	-	0.12
760	00	05	1		extern comput ESTEC	-	-	0.03	-	-	-	-	0.03
76					ESOC SUPPORT	-	0.02	0.19	1.52	1.31	-	-	3.04
7					SPECIAL TO PROJECT EXPENDITURE	-	0.02	0.40	2.71	1.91	0.40	-	5.44
850	01	01	0	*	manpower (mxy)	-	13.00	19.50	18.75	14.00	5.00	-	71.05
850	01	01	1		manpower (mau)	-	0.06	1.42	1.36	1.02	0.30	-	5.04
850	09	01	1		facilities	-	0.24	0.59	0.34	0.29	0.16	-	1.62
850	01	01	1		site services	-	0.36	0.42	0.34	0.27	0.14	0.04	1.57
85					ESTEC SUPPORT	-	1.46	2.43	2.04	1.58	0.68	0.04	8.23
860	01	01	0	*	manpower (mxy)	-	0.75	3.75	4.25	7.50	1.50	-	17.75
860	01	01	1		manpower (mau)	-	0.07	0.35	0.41	0.71	0.14	-	1.68
860	09	01	1		facilities	-	0.04	0.08	0.10	4.27	1.46	-	6.03
860	09	02	1		batch computer	-	0.13	0.34	0.44	0.50	0.50	-	1.91
86					ESOC SUPPORT	-	0.24	0.77	1.02	5.40	2.10	-	7.62
870	09	01	1		investment allowance	-	0.10	0.41	0.23	0.19	0.00	-	1.09
870	09	02	1		res CNES/IABG	-		0.30	0.15	0.15	0.11	-	0.71
870	09	03	1		difference on line	-	-	0.46	-0.15	-0.15	-0.16	-	0.00
87					ESTEC INFRASTRUCTURE	-	0.10	1.17	0.23	0.19	0.03		1.00
880	09	01	1		investment allowance	-	-	-	0.04	0.58	0.23	-	0.85
88					ESOC INFRASTRUCTURE	-	-	-	0.04	0.58	0.23	-	0.85
8					SUPPORT ACCORDING TO USAGE	-	1.88	4.37	3.24	7.83	3.04	0.04	20.50
					GRAND TOTAL FOR THIS PROJECT	3.49	18.01	31.70	38.77	42.14	11.51	0.22	146.92

DEPENSES DIRECTES

SALAIRES ET CHARGES SOCIALES

FRAIS DE MISSIONS

FONCTIONNEMENT OU ACHAT D'EQUIPEMENTS SPECIFIQUES AU PROJET

REALISATION PAR L'INDUSTRIE DU SEGMENT SPATIAL
ACHAT DU LANCEUR ET LANCEMENT

DEPENSES INDIRECTES

CHARGES ADMINISTRATIVES

REALISATION ET ACHAT D'EQUIPEMENTS SPECIFIQUES PAR ESTEC ET ESOC

UTILISATION DES MOYENS D'ESTEC ET ESOC OU DE PERSONNEL SPECIALISE

AMORTISSEMENT DU MATERIEL

ECHEANCIER PREVISIONNEL DU COUT A ACHEVEMENT

Figure 3 – Les relations entre les coûts directs des emplois 'Supports' et les coûts rechargés aux projets en tant que coûts indirects constituent la 'politique d'imputation des coûts'.

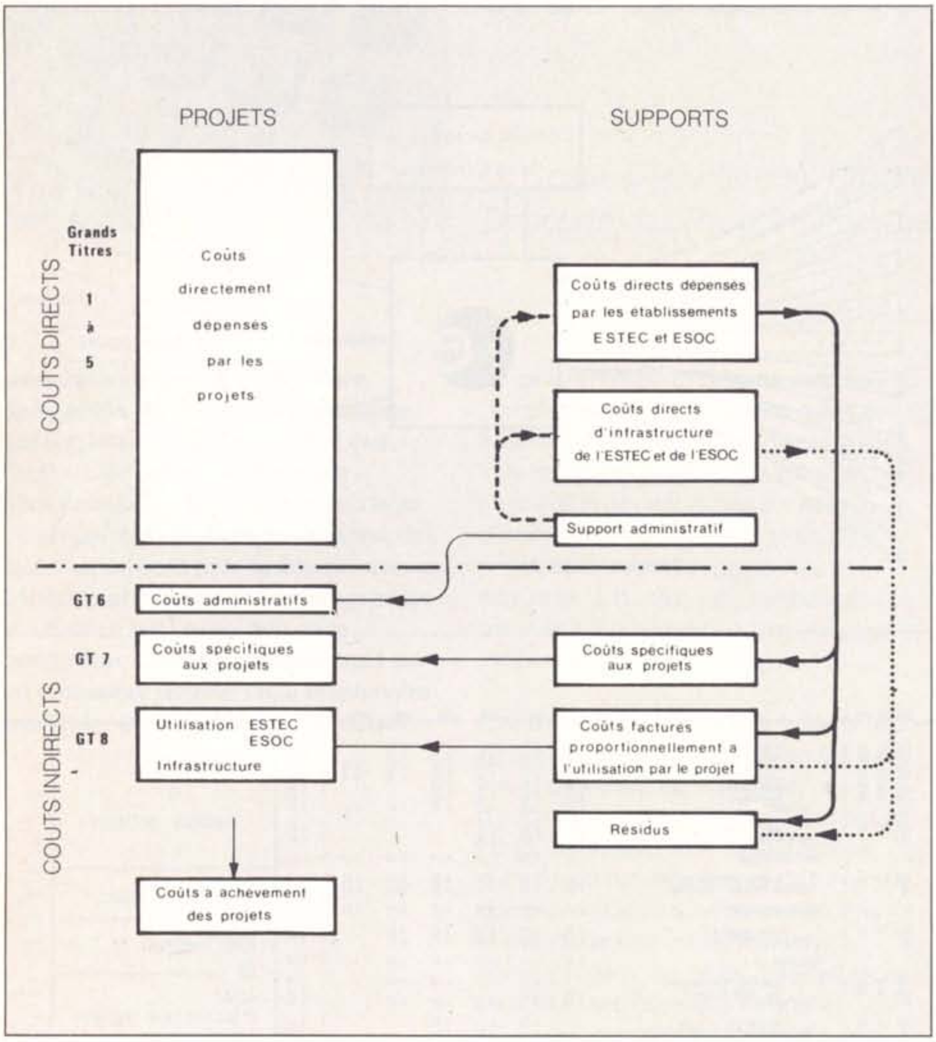
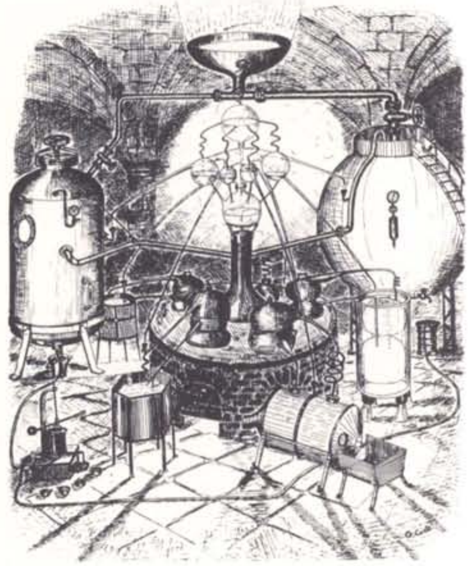


Figure 4 – Une interprétation libre de la 'charging policy'



contrainte majeure de l'Agence que chaque exercice annuel doit respecter:

> Somme des coûts directs des projets + somme des coûts directs des Etablissements = somme des coûts-à-achèvement des projets.

Les différences qui pourraient apparaître constituent les 'résidus'. (On assimile au premier ordre les activités de base à un projet).

Enfin intervient le concept de centres de coût introduit à partir de 1979: il est possible de regrouper les dépenses des Etablissements par unités de même nature technique (moyens d'essais, de calcul, réseau etc.). Cette notion nouvelle permettra de relier plus clairement les dépenses des Etablissements aux projets (voir article de H. Broberg).

Les principales fonctions du système GEPSY

GEPSY, c'est tout d'abord une banque de données. L'élément de base est ce qu'on appelera un *'item'*. Il est constitué:

- d'un titre indiquant la nature de l''item'
- d'un échéancier de paiements
- d'un code qui permet de 'l'étiqueter' et d'y avoir accès au moyen d'une table. On trouve dans les Figures 2 et 5 de nombreux exemples d'item.

On voit donc qu'un item peut représenter une grosse somme: 73 MUC par exemple sur le contrat de développement ECS de la Figure 2. Cela correspond au fait que la responsabilité se trouve concentrée dans les mains du chef de projet, qui est capable de donner plus de détails sur simple demande, au cours de la négociation de l'échéancier de l'item. Par contre, certains coûts sont séparés s'ils sont de nature différente (personnel, investissement), ou dépensés dans des centres différents (ESTEC ou ESOC).

La banque de données comprend environ 1500 items qui sont inscrits sur une 'diskette' souple. L'interrogation de ce fichier, sa mise à jour et la production d'éditions sont assurés par un mini-ordinateur de 16 kmots de mémoire (Fig. 6). On peut par exemple lui demander de produire:

1. Le coût-à-achèvement d'un projet: ECS par exemple (Fig. 2). La machine recherche tous les items portant le code projet d'ECS (34), les classe suivant le code budget et en fait l'édition. Les grands titres 1 à 5 sont les coûts directs, le titre 6 les imputations administratives, les titres 7 et 8 les imputations des Etablissements techniques.

suite page 71

Figure 5 – Extraits de listings sur les dépenses de soutien de l'ESTEC, le niveau de ressources de l'ESA et les dépenses de personnel

NIVEAU DE RESSOURCES

prix mi-1978 taux de change 1979		) 1977	1978	1979	1980	1981	1982	1983
60	GENERAL STUDIES	-	6.93	7.30	6.13	6.13	6.13	6.13
61	TECHNOLOGICAL RESEARCH	-	12.63	14.20	15.44	15.03	14.05	13.82
62	INFORMATION RETRIEVAL SYSTEMS	-	4.51	4.28	3.64	3.64	3.64	3.64
63	EDUCATION	-	0.52	0.57	0.53	0.53	0.53	0.53
64	OTHER ACTIVITY (FRASCATI)	-	0.12	0.11	0.10	0.10	0.10	0.10
79	EXOSAT (gen budg contrib)	-	-	-	4.30	3.30	-	-
80	ESTEC SUPPORT	-	-1.53	-1.11	-2.86	-2.20	-0.20	0.81
85	ESOC SUPPORT	-	3.08	-0.55	2.52	-0.09	-0.41	3.72
90	FIXED COMMON COST	-	8.72	8.87	7.68	7.68	7.68	7.68
91	ADMIN SUPPORT NON-FIXED	-	-0.03	-0.05	0.42	1.12	1.04	0.90
94	ADMIN. SUPPORT FIXED	-	-	-	-0.20	-0.20	-0.20	-0.20
95	CSG KOUROU	-	20.72	20.94	20.64	15.09	15.09	15.09
96	HQ BUILDING	-	1.70	1.91	1.70	1.01	0.86	0.85
97	OUTSIDE CUSTOMERS	-	1.06	-	-	-	-	-
98	ESTEC INFRASTRUCTURE	-	6.99	7.58	10.37	8.50	6.13	6.34
99	ESOC INFRASTRUCTURE	-	4.08	7.57	6.97	5.51	4.25	4.11
1	PROGRAMME BUDGET GENERAL	-	71.10	70.83	77.30	65.15	59.48	64.31
6	COS B	67.05	2.57	2.25	-	-	-	-
7	GEOS	98.31	4.37	0.58	-	-	-	-
10	I.U.E.	12.87	3.66	2.03	2.70	0.33	-	-
11	ISEE	32.35	1.70	0.37	0.34	-	-	-
13	EXOSAT	13.86	28.95	32.50	38.54	20.03	4.49	0.32
14	SPACE TELESCOPE	1.93	10.52	18.22	16.13	13.63	4.53	6.14
15	LIDAR PHASE B	-	0.48	0.05	-	-	-	-
16	SLED	0.16	1.26	1.11	0.45	-	-	-
17	GEOS 2	7.64	11.90	7.30	2.72	4.67	-	-
18	ISPM(ODE)	-	1.72	5.50	16.21	21.63	21.77	6.16
21	NEXT SCIENTIFIC PROJECT	-	-	-	-	13.52	39.40	57.57
26	EXOSAT EXTRA-FINANCE	-	-	-	-4.72	-3.62	-	-
27	SCIENCE CONTINGENCY	-	-	0.50	1.00	1.00	1.00	1.00
28	SCIENCE MANAGEMENT	0.39	0.45	0.56	0.54	0.54	0.54	0.54
29	SPACE SCIENCE	5.46	5.80	6.01	6.04	6.04	6.04	6.04
2	PROGRAMME SCIENTIFIQUE	240.02	73.38	77.70	79.95	77.77	77.77	77.77
30	TELECOM PHASE 2	189.91	41.89	14.37	11.34	4.00	-	-
31	AEROSAT	15.28	0.96	0.14	-	-	-	-
33	MARECS A	91.39	30.14	17.04	6.90	5.87	3.64	-
34	EUROPEAN COMM. SATELLITE (ECS)	3.49	18.81	31.70	38.97	42.14	11.51	0.22
35	TELECOM PHASE 3 bis	-	-	-	14.66	22.50	34.65	25.12
38	MARECS B	-	-	10.75	24.36	27.43	0.53	-
40	HEAVY SATELLITE / realisation	-	-	5.10	24.00	35.50	30.00	35.40
41	ADVANCED SYS&TECH PROG (ASTP)	-	1.90	3.38	4.38	4.78	-	-
42	H-SAT phase B	-	6.50	-	-	-	-	-
3	PROGRAMME DE COMMUNICATIONS	300.07	100.20	82.56	125.41	142.22	88.33	60.74
32	METEOSAT SPACECRAFT	155.04	22.66	11.53	6.06	1.20	0.93	0.03
36	METEOSAT EXPLOITATION	0.34	5.43	8.16	6.84	-	-	-
37	METEOSAT 2 (L03)	-	[illegible]	[illegible]	[illegible]		-	-
								-
								-
								7.10
								7.21
								34.99
								-
								-
								-
								34.99
								212.10
								212.10
								457.12

GH 1 STAFF EXPENDITURE

PROJET	1979	1980	1981	1982	1983
06 COS B	-	-	-	-	-
07 GEOS	-	-	-	-	-
10 I.U.E.	0.19	0.20	0.06	-	-
11 ISEE	-	-	-	-	-
13 EXOSAT	1.13	1.17	0.67	-	-
14 SPACE TELESCOPE	0.98	1.00	1.04	1.19	1.30
15 LIDAR PHASE B	-	-	-	-	-
16 SLED	0.08	-	-	-	-
17 GEOS 2	-	-	-	-	-
18 ISPM(ODE)	0.86	0.95	1.09	0.98	0.45
21 NEXT SCIENTIFIC PROJECT	-	-	0.38	0.95	1.60
28 SCIENCE MANAGEMENT	0.36	0.35	0.35	0.35	0.35
29 SPACE SCIENCE	1.87	1.88	1.88	1.88	1.88
30 TELECOM PHASE 2	0.24	0.24	0.20	-	-
31 AEROSAT	0.06	-	-	-	-
32 METEOSAT SPACECRAFT	0.34	0.17	0.12	0.12	0.02
33 MARECS A	1.38	0.49	-	-	-
34 EUROPEAN COMM. SATELLITE (ECS)	1.35	1.15	0.94		
35 TELECOM PHASE 3 bis	-	-	-		
36 METEOSAT EXPLOITATION	1.52	1.24	-		
37 METEOSAT 2 (L03)	0.42	0.24	-		
38 MARECS B	-	0.66	0.66		
40 HEAVY SATELLITE / realisation	0.22	1.10	1.10		
41 ADVANCED SYS&TECH PROG (ASTP)	0.25	0.25	0.25		
42 H-SAT phase B	-	-	-		
48 SIRIO-2	0.31	0.32	0.32		
49 SLUP-DM1.DM2.D1.D4	0.55	0.80	1.45		
52 SLUP-FSLP	1.22	1.15	0.35		
54 SPACELAB	3.85	3.79	2.30		
56 ARIANE	0.41	0.42	0.08		
60 GENERAL STUDIES	1.80	1.53	1.53		
61 TECHNOLOGICAL RESEARCH	1.97	1.95	1.95		
62 INFORMATION RETRIEVAL SYSTEMS	1.29	1.27	1.27		
63 EDUCATION	0.02	0.02	0.02		
64 OTHER ACTIVITY (FRASCATI)	0.11	0.10	0.10		
65 EARTHNET	0.25	0.25	0.17		
70 ARIANE USER SUPPORT	0.36	-	-		
74 METEO EXPLOIT. EXTENSION	-	0.28	1.52		
75 NON IDENTIFIED PROGRAMMES	0.60	1.20	3.00		
80 ESTEC SUPPORT	11.86	11.17	11.17		
85 ESOC SUPPORT	6.09	4.91	4.91		
90 FIXED COMMON COST	4.66	2.46	2.46		
91 ADMIN SUPPORT NON-FIXED	8.75	7.77	7.77		
94 ADMIN. SUPPORT FIXED	0.85	2.03	2.03		
97 OUTSIDE CUSTOMERS	-	-	-		
98 ESTEC INFRASTRUCTURE	2.06	1.96	1.96		
99 ESOC INFRASTRUCTURE	1.13	0.96	0.74		
STAFF EXPENDITURE	59.39	55.43	53.86		

80 ESTEC SUPPORT

BUD	CC	IT	U		1977	1978	1979	1980	1981	1982	1983
7				SPECIAL TO PROJECT EXPENDITURE	-	-3.72	-3.71	-6.20	-4.99	-4.19	-3.45
850	00	10	1	iue	-	-0.01	-	-	-	-	-
850	00	13	1	exosat	-	-1.77	-2.95	-2.48	-0.65	-	-
850	00	14	1	space telescope	-	-1.24	-1.01	-1.70	-1.24	-0.70	-0.60
850	00	15	1	lidar	-	-0.07	-0.05	-	-	-	-
850	00	16	1	sled	-	-0.32	-0.15	-	-	-	-
850	00	17	1	geos 2	-	-0.80	-	-	-	-	-
850	00	18	1	ISPM(ODE)	-	-0.66	-0.90	-1.94	-2.41	-1.05	-0.37
850	00	21	1	new scientific pr.	-	-	-	-0.22	-1.52	-3.48	-5.13
850	00	28	1	science management	-	-0.05	-0.05	-0.04	-0.04	-0.04	-0.04
850	00	29	1	space science	-	-1.58	-1.51	-1.63	-1.63	-1.63	-1.63
850	00	30	1	telecom phase 2	-	-1.69	-0.21	-	-	-	-
850	00	31	1	aerosat	-	-0.07	-0.02	-	-	-	-
850	00	32	1	meteosat 1	-	-0.87	-0.53	-0.10	-0.01	-	-
850	00	33	1	marots a & b	-	-1.29	-1.37	-1.60	-0.75	-	-
850	00	34	1	ecs 1 & 2	-	-1.46	-2.43	-2.04	-1.58	-0.60	-0.04
850	00	35	1	telecom phase 3 bis	-	-	-	-	-	-0.08	-0.08
850	00	36	1	meteosat exploitation	-	-	-	-	-	-	-
850	00	37	1	meteosat 2/L03	-	-0.07	-0.21	-0.04	-	-	-
850	00	38	1	marots B	-	-	-	-0.75	-1.05	-	-
850	00	39	1	marots c & d	-	-	-	-0.02	-0.07	-0.95	-0.08
850	00	40	1	heavy satellite	-	-0.43	-1.28	-1.54	-1.23	-0.17	-
850	00	41	1	astp	-	-0.34	-0.35	-0.46	-0.44	-	-
850	00	42	1	new telecom pr.	-	-	-	-	-1.83	-2.79	-4.26
850	00	45	1	remote sensing	-	-	-	-1.01	-1.10	-2.01	-2.05
850	00	48	1	sirio 2	-	-	-	-	-	-	-
850	00	49	1	spacelab DM1	-	-	-0.42	-	-	-	-
850	00	51	1	spacelab fod	-	-	-	-1.00	-1.25	-1.25	-
850	00	52	1	spacelab utilisation	-	-0.60	-0.73	-1.70	-1.56	-1.59	-1.59
850	00	54	1	spacelab	-	-4.06	-2.00	-1.92	-0.87	-	-
850	00	55	1	ariane fod	-	-	-	-	-0.04	-0.04	-
850	00	56	1	ariane dev.	-	-0.09	-0.11	-0.12	-	-	-
850	00	57	1	ariane prod.	-	-	-	-0.12	-0.12	-0.12	-0.12
850	00	58	1	spacelab feo	-	-	-	-0.46	-0.52	-0.45	-0.45
850	00	59	1	apex	-	-	-	-0.05	-	-	-
850	00	60	1	general studies	-	-1.40	-1.42	-1.37	-1.37	-1.37	-1.37
850	00	61	1	technological research	-	-2.33	-2.17	-2.13	-2.08	-2.07	-2.01
850	00	65	1	earthnet	-	-	-0.11	-	-	-	-
850	00	70	1	ARIANE user sup.	-	-	-0.05	-	-	-	-
850	00	79	1	new programmes	-	-	-1.56	-	-	-	-
850	00	90	1	fixed common cost	-	-0.09	-0.10	-0.10	-0.10	-0.10	-0.10
850	00	93	1	infrastructure	-	-1.47	-2.11	-2.01	-1.90	-2.02	-2.02
850	00	94	1	admin.sup.fixed	-	-0.08	-	-	-	-	-
850	00	97	1	outside customers	-	-1.01	-0.15	-0.54	-0.02	-0.02	-0.02
85				ESTEC SUPPORT	-	-23.85	-25.63	-27.24	-26.34	-23.49	-22.04
891	00	01	1	SUPPORT RESERVE	-	-1.30	-1.60	-1.77	-1.59	-1.54	-1.47
89				SUPPORT BALANCE	-	-1.30	-1.60	-1.77	-1.59	-1.54	-1.47
8				SUPPORT ACCORDING TO USAGE	-	-25.23	-27.23	-29.01	-27.93	-25.03	-23.51
				GRAND TOTAL FOR THIS PROJECT	-	-1.53	-1.11	-2.86	-2.20	-0.20	0.01

ESA's Computerised Medium/Long-Term Planning System

G. Niederau, General Planning Department, Directorate of Planning and Future Programmes, ESA, Paris

P. Brunt, General Technology Systems Ltd., London

ESA's planning activities are mainly directed at elaborating elements for future programmes, assessing different programme options financially, and evaluating clear-cut budgetary figures for these different options. These activities are complicated and time consuming, but they have far-reaching effects, especially where such matters as Member States' contributions are concerned. The concept thus arose of relying for parts of these tasks on the help of a computer, to allow more detailed and precise information to be made available more quickly and to extend ESA's capabilities in the areas of historical data analysis, longer-term financial projections, and the assessment of potential returns and benefits.

System objectives and constraints
The aim has been to develop a computerised system that can provide assistance in ESA's management, planning and assessment activities. The primary functions of the system are listed in Table 1.

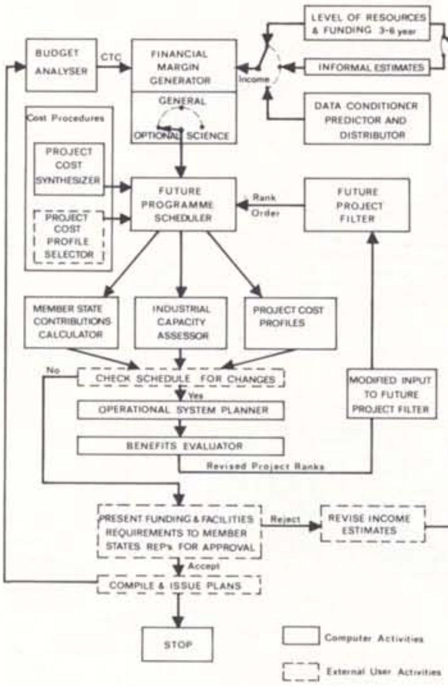
The computer program designed to perform the tasks shown must operate under a number of important constraints:

- the program is installed on a computer in one of ESA's establishments (ESTEC), but is operated principally from ESA Headquarters in Paris. Owing to the limited capacity of the communication lines, interactive conversational operation is not possible, thereby imposing limitations on mode of operation and program structure where decision points are necessary;
- efficient programming is desirable to minimise core and disk storage requirements;
- the program should be in a sufficiently basic form of Fortran-IV to permit transfer to a future ESA machine with minimum difficulty;
- data files must be organised in such a way that they can accept estimates as well as factual data, to permit the program to be used, for example, whilst awaiting the results of off-line studies on specific aspects of data formulation;
- it is desirable to run only those parts of the program that are necessary in the execution of a particular function; this aim needs to be balanced against the advantages of the overall program system, the subprograms of which are ideally run in sequence with minimal interruption;
- it is essential to be able to update the data stored in the program in a regular, planned and formalised manner to coincide with key events in the ESA financial year.

Overall logic and operation
In generating the overall software, recognition has been given to the two broad subdivisions of activities to be considered, namely:
- *Accounting, Planning and Forecasting*, comprising budgetary analysis, forecasting, cost modelling, calculation of financial margins, and scheduling of future programmes.
- *Benefits and Returns*, comprising market-capture analysis, benefit evaluation, and assessment of potential financial returns.

Figure 1 illustrates the key elements of the system. The Budget Analyser yields project Cost-to-Completion (CTC) estimates drawn from Financial-Plan data. Income estimates obtained from either Level of Resources and Funding Requirements documents, informal estimates or targets, or analysis of national econometric parameters, are combined with CTCs to generate a Margin for future projects (income minus planned expenditure). Selecting one main programme area for attention, estimates of candidate project costs and expenditure profiles are combined with a priority list from the Future-Project Filter, and an optimised (within the available

Figure 1 – Overall system logic



margin) set of projects and time scales is scheduled, taking account of a number of parameters and formulated objectives. Calculations of Member States' contributions, manpower requirements and expenditure distributions give a complete picture of the proposed combination of projects. One or more of these can then be evaluated in greater detail to assess market prospects, benefit potential and/or financial-return potential. This may modify the view held of the desirability of a specific project, which can lead to a further iteration through the Future-Programme Scheduler.

Firm proposals, backed by extensive analysis, can then be offered to the appropriate Delegate Bodies for approval. If approved, the projects are adopted; if rejected, the grounds for rejection (e.g. reduced income) can be used to modify the assumptions and the iteration can be recommenced.

Program structure
The planning system is programmed into eight independent, but linked, subprograms, written in Fortran-IV and installed on the ESA ICL System 4 at ESTEC. Operation is possible both from Noordwijk and from ESA Headquarters in Paris. The subprograms are linked through data files containing extensive, topical data. Data input is via card reader, and output is returned through line-printers or, for checking purposes, directly via the user's terminal.

The eight subprograms can be run independently, once linked to the necessary data files, to perform the following tasks:

Subprogram 1:
Input of ESA budgets (accounts and financial plan) at very detailed level for all approved and agreed ESA programmes and updating of this information at mid-year change of price level.

Subprogram 2:
Analysis of ESA budgets in various ways,

Table 1 – System functions

1. Provide for allocation of expenditure codes.
2. Compare internal/external expenditure.
3. Compare direct/indirect expenditure.
4. Generate project-expenditure profiles.
5. Compute national % contribution scales to projects (past + present).
6. Store annual accounts and perform analyses of accounting details.
7. Store Financial-Plan data for the running year and evaluate expenditures by project.
8. Evaluate cumulative expenditure by project.
9. Store price-level conversion indices, financial envelopes of projects, Arrangement price levels and evaluate cumulative expenditure by project.
10. Store and provide Cost-to-Completion profile by project.
11. Estimate future ESA income from
    (i) Levels of Resources and Funding Requirements
    (ii) Informed estimates
    (iii) Extrapolation of national space expenditure/econometric relationships from stored econometric data.
12. Generate (financial) Margins for future projects.
13. Generate industrial-capacity estimates.
14. Determine costs of candidate future projects.
15. Select expenditure profiles for candidate future projects.
16. Perform scheduling of projects within available financial margin.
17. Evaluate industrial-capacity utilisation.
18. Calculate % contribution scales for future-project schedules.
19. Calculate detailed financial breakdown of future-project schedules.
20. Determine operational system procurement schedules, running costs/phasing and pay-back period.
21. Calculate market capture and revenue statistics.
22. Record Member States' objectives, and evaluate contributions of candidate projects thereto.
23. Rank candidate projects via objectives and relevance tree.

Table 2 — List of raw-data files

1.	ESA expenditure past/current
2.	ESA expenditure future
3.	Project codes
4.	Contribution scales
5.	Allocation of scales
6.	Scale subroutines – future
7.	Provisional scales – future
8.	National Income (NI) figures
9.	Gross Domestic Product (GDP) figures
10.	NI expressed as % of GDP
11.	Population figures
12.	Number of telephones in use
13.	Electricity production
14.	Consumer price indices
15.	Conversion rates
16.	National space expenditure
17.	National space spend distribution
18.	Backdating price indices
19.	Overall ESA price index
20.	Detailed ESA price indices
21.	Financial envelopes
22.	Past project cost summary
23.	Candidate project cost estimates
24.	Programmes and project codes
25.	Projects not yet approved
26.	Levels of resources and funding requirements
27.	National contribution constraints
28.	Standard cost profiles of projects
29.	Standard internal cost distribution.
30.	Space industry and employment figures
31.	Space industry charging rates
32.	Candidate projects
33.	Candidate projects criteria & weighting factors
34.	Candidate projects scores & probabilities

particularly with respect to internal/external and direct/indirect expenditure, and generally by project, year, ESA totals, etc.

Subprogram 3:
Synthesis of costs for new projects through a structured cost tree.

Subprogram 4:
Forecasting (prediction) of ESA funds for future years on the basis of international econometric data. Optimised scheduling of future programmes within calculated available margins, and distribution of planned expenditure.

Subprogram 5:
Analysis of Member States' contributions for the various programmes. Comparison of industrial resource requirements for future programmes with anticipated European industrial capacity.

Subprogram 6:
Input of description and characteristics for ESA space products and competing services for several missions. Comparison of 'mission-capture' likelihood between ESA and competing organisations. Evaluation of returns and development costs for alternative ESA space products.

Subprogram 7:
Evaluation of programme benefits via a relevance tree for different ESA activities.

Subprogram 8:
Comparison of income and expenditure profiles for potentially marketable ESA products, including both 'one-shot' (e.g. launchers) and 'continuous service' products (e.g. communications satellites). Net-present-value calculations are used to evaluate intervals from initial investment to final break-even return on capital.

The structure and interconnection of the first five subprograms is illustrated in

Figure 2 – Accounting planning and forecasting program elements 1-5

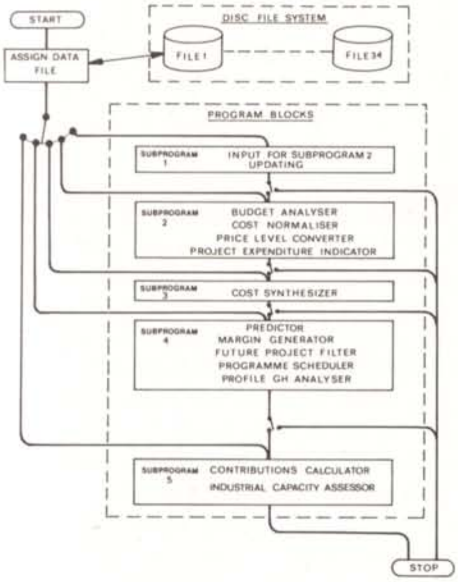


Figure 3 – Return/benefit program elements 6-8

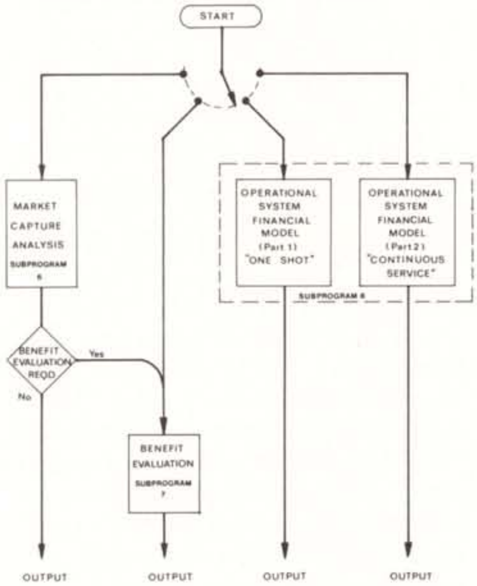


Figure 2, and of the final three in Figure 3.

The existing 34 raw data files are grouped into 15 data files within subprograms 1-5 for reasons of efficient and logical handling. The remaining three subprograms utilise card inputs for each run.

Data compilation and updating

The successful operation of such a planning system depends on the compilation and maintenance of a comprehensive data base consisting of a comparatively large number of nonoverlapping raw data files containing a wide range of statistics, estimates and forecasts. Any such base must be related to a point in time so that all data in all files are consistent – both internally and with respect to each other. Data have to be stored uniquely to avoid discrepancies and incomplete updating. Some 34 data files have been compiled for the Accounting, Planning and Forecasting elements, and these are listed in Table 2. Although regular, formalised updating of the data files is essential, ad hoc or continuous updating is neither necessary nor desirable. A regular programme of updating is followed, based on six categories of event, the frequency and timing of these updates being on the following lines:

- improved economic statistics become available, probably once or twice a year;
- mid-year change of price levels prior to elaboration of the next year's budget – annually June/July;
- publication of next year's Financial Plan – annually August/September with periodic revisions;
- publication of Annual Accounts – annually not later than 30 April;
- new project approved by Council – at any time;
- new Member accedes to ESA Convention – at any time.

In addition, better data may become available at any time and these may be incorporated in conjunction with other updates – or indeed, alone if required, so long as the extent of the impact of the change is recognised and new runs carried out.

The nature of the Returns and Benefits subdivision is such that data are compiled according to the needs of the particular analysis being carried out and are not stored and updated in the same way.

Conclusion

The system described above represents a comprehensive and powerful tool both when elaborating future-programme proposals and when evaluating the different programme possibilities. It has been built up so that as many parameters as necessary can be taken into account in each case, including those of a more emotional nature, such as national preferences for certain programmes and, as a consequence, the probabilities as to whether or not Council will accept these programmes. By taking over the routine work, the system allows the user to devote more time to the more conceptual aspects of the planning process.

Comparison of Programme Costs with Envelopes of Legal Arrangements

L.A. Potter, General Planning Department, Directorate of Planning and Future Programmes, ESA, Paris

In the early days of ESRO there was a single budget funded by the Member States in accordance with a contribution scale based on Gross National Product. This relatively blissful and simple financial environment came to an end in 1971 with the advent of 'à la carte' or programme budgets. Since then, the Member States have had the possibility to contribute to new applications programmes in accordance with their particular desires and/or capabilities.

The result of this is that Member States now contribute not only to the Basic Activities of the Agency and the Scientific Programme according to the original scheme of Gross National Product, but also to a series of special programmes, each according to their agreed wishes at the commencement of the programme.

The conditions of membership of these programmes are set out in a series of legal arrangements and one of the most important elements of these is, of course, the estimated ceiling of total costs or the 'Financial Envelope'.

Introduction

The legal arrangements for a particular Agency programme, state, in essence, that the signatories agree to participate in that programme with an agreed division of contributions up to a total ceiling price of *X* Million Accounting Units (MAU), expressed under defined economic conditions. In drawing up these 'Arrangements', however, one has to consider the procedure to be followed in the event that this ceiling is reached during programme execution. The typical approach is that the possibility of overrun is recognised in the Arrangement by the introduction of a 20% margin above the ceiling. The Member States are then kept informed of the progress of the programme, and in the event that the estimated Cost-to-Completion exceeds the agreed ceiling, the additional expenditure must be decided by a two-thirds majority of the participating members. In the event that the estimated Cost-to-Completion exceeds the ceiling plus the 20% margin, participants who so wish may withdraw from the programme.

Under these circumstances of legal arrangements and fixed financial ceilings, it is absolutely imperative that both the Agency and the participating Member States be kept informed of the progress of their programmes, and in particular of how the financial evolution stands with respect to the ceilings in the Arrangements. In the early days of stable economic conditions and short programmes, one could follow the execution of a programme reasonably well from the so-called 'Cost-to-Completion' table, expressed in terms of past accounts and future estimates, but the violent fluctuations in inflation and currency-conversion rates of recent years have rendered this simple approach unusable. It is interesting to note that since 1973 the range of annual inflation indices among member nations has ranged from +1.1% to +27.9%, and the conversion rates between national currencies and the Accounting Unit from −21% to +21%.

Clearly some procedure is required which can remove the effects of inflation and changing conversion rates from the evolving Cost-to-Completion estimates, in order that they can be compared directly with the original ceiling, i.e. in the same economic terms. Such a procedure is referred to within the Agency as a 'back-dating' procedure.

The basic technique can be summarised by two simple equations that show how the accounted figures and later estimated figures are corrected by back-dating indices to an original economic condition, i.e. Year 0:

If the total of 'actual payments'

$$C_A = C_1 + C_2 + C_3 + C_4 \quad \text{then}$$

Total at back-dated prices of Year 0

$$C_B = \frac{C_1}{I_1} + \frac{C_2}{I_1 \times I_2} + \frac{C_3}{I_1 \times I_2 \times I_3} + \frac{C_4}{I_1 \times I_2 \times I_3 \times I_4}$$

where I_n is the inflation index between years n and $n-1$, and C_n is the annual expenditure.

The calculation itself appears to be simple enough; on the other hand, establishing the data for the calculation can be far from simple, depending upon the objective of the back-dating.

Difficulties in establishing a back-dating procedure

The path towards the development of such a procedure is littered with difficulties and obstacles, some of which verge on the imponderable. These problems have three sources:

(i) Expenditure data
(ii) Indices
(iii) ESA's Financial Rules.

Each of these will be examined in turn.

Problems of expenditure data

One of the principal ingredients of the back-dating procedure is the knowledge for each element of the programme of what amount of work was done, when it was done, and where it was done. To know this accurately for work already done calls for a work-package accounting system. Such a system is clearly the basis of normal 'cost plus' and so-called 'fixed price with price revision' development contracts; on the other hand, for fixed-price contracts, purchase items, etc., this information is either not required or is not available. For work to be done in the future, one has to assume when and where each package will be executed, a detail of planning not always available. However, even if all of these data were available in usable form, the sheer volume to be processed would preclude their use for the purposes of back-dating.

The next level of data indicative of the work content, its location and its timing, is the payments. Unfortunately, the payments lag behind the real incidence of work by some period due to the normal delays of processing through the subcontractors, main contractors and Agency financial offices. Furthermore, even though one knows the currency in which payments are made, these are not always an indication of where the work was actually performed.

Problems of indices

The other principal ingredients of a back-dating procedure are the factors used to represent the effects of inflation and currency conversion rates.

Taking the inflation first, the contracts placed by the Agency frequently contain price revision clauses, following current practice, allowing the contractors to be compensated for the effects of inflation on their costs during the execution of the contract. This compensation, or price revision, is based upon inflationary effects actually experienced. It follows, therefore, that to conduct a precise back-dating one would need the actual indices experienced by each contract and work package in each period, which brings us back to the problems cited above, namely those of volume and availability. On the other hand, there are general indices available covering a whole country for each industry, service, etc*. These general indices are, of course, the mean values of the inputs received from the various statistical reporting centres and there may be significant deviation between the mean value for the specific industry and the local value experienced and applied by a single company on a particular Agency contract.

As regards the variations in conversion rates, there is no shortage of indices as the movements of rates are readily available. The problem here lies in the above-mentioned lag in payments. The amount to be paid for a particular task in national currency is calculated under the conditions applicable at the time of execution. On the other hand, the amount to be accounted by the Agency in Accounting Units is dependent on the conversion rates pertaining on the day of payment, some months later. Furthermore, the currency of payment is not always the currency applicable at the location where the work was executed, there being some situations where prime or main contractors assume responsibility for payment of subcontractors, including currency conversion.

Problems of ESA's Financial Rules

The Agency's Financial Rules contain some features pertaining to price levels and exchange rates which have been designed to provide a common approach acceptable to the financial planning and treasury procedures of all the Member States.

In respect of price levels, these rules require that budgets be prepared and executed for a particular year in the price levels applicable for the previous year. Except for salaries and certain special situations, compensation for differences in price levels between budget allocations and the appropriate bills is not made during the year of execution.

The net result of this is that the consequent shortfall is either converted into a reduction of budget, or the payment is delayed until later years. It is clear that the former cannot apply in the case of firm commitments such as a major external development programme, and in this case the only solution is to delay the end-of-year payments until the following year *and* to add the compensation for differences in price levels in the year of execution to a later year. Unfortunately, documents on medium-term funding requirements and budgets for the following year are required to be published before the appropriate statistics, and hence indices, are available for the difference between the last year and the current year. Thus the compensation pointed out above cannot be made until two years after the time of execution. The effect is that budgeted payment appropriations for external development lag behind the normally planned schedule, further aggravating the difference in price level

* These indices are compiled for the Agency by the Federal Statistical Office, Wiesbaden, Germany.

between time of work execution and the time of settlement.

The other aspect of the Financial Rules that has an impact on the back-dating is the adoption of fixed conversion rates for a particular year's financial operations based upon the average daily conversion rate for the month of June in the preceding year. The use of these fixed conversion rates introduces an error into the back-dating calculation, due to the difference between the conversion rate applying to the payment and that accounted in Accounting Units when one uses the latter in the calculation. This error, however, could be agreed as compensating to some extent for the errors caused by delay in payment as the rates used are, on average, twelve months out of date.

From the foregoing it can be seen that a precision back-dating is, to all intents and purposes, practically impossible, requiring resources and data out of all proportion to the task. This again raises the question of the objective of the calculation.

The participating Member States need to know what they are getting (or will get) for what they have agreed to pay. This is a question of value, not of accounting. One can draw a parallel: if one buys caviar, for example, having accepted the price per kilo one does not insist that it is weighed out with an accuracy of 10^{-2}g (=0.02 FF); this is a matter of value. On the other hand, when paying one would expect the change to be precise to the last centime; this is a matter of accounting. The back-dating calculation is therefore a matter of value, not of accounting. It enables the Member States to make the essential management decision 'Are we getting what we ordered?'.

What is needed therefore as a decision basis is a procedure that produces an acceptable result with a reasonable level of effort. A corollary to such a procedure, however, is that it must be sufficiently transparent for the Member State Delegations to be able to monitor the calculations.

The procedure proposed by the Agency was designed with these requirements in view. It was first proposed and adopted by the delegate bodies in 1975, and has been used since then in the routine annual comparison of all programmes with their Arrangements.

General description of the ESA procedure
The basic assumptions or simplifications that we have made in the procedure are as follows:

(i) Geographical distribution of 'External Development' effort is assumed to be constant throughout the execution of the contract, modified only by the influence of national inflation and currency exchange rates. This will introduce a random error.
(ii) Payment is assumed to be in step with the work. The time delay introduces a negative error, i.e. the back-dated figure will be overcompensated for the effects of inflation.
(iii) The Agency-adopted currency conversion rates are assumed to represent real life. This tends to introduce a positive error, i.e. the back-dated figure will be undercompensated as the rates used really represent the situation one year earlier.
(iv) It is assumed that the average national inflation statistics apply in each company of that country This produces a random error.
(v) It is assumed that 'Internal & Support' expenditures are sufficiently similar and sufficiently small fractions of the whole (<30%) for these to be grouped together and back-dated by a single weighted composite index.

The above assumptions lead to a procedure whereby the total expenditures of a project, both accounts for the past and estimates for the future, are divided into the two categories 'Internal & Support', and 'External Development'. The payments falling into each year for these categories are back-dated by the appropriate compound index derived from the official statistics of the Agency and the officially adopted conversion rates.

In effect, the basic procedure illustrated on the first page of this article is applied separately to the two types of expenditure and the results added.

Details of the procedure
Before going into the detailed elements of the 'calculations', it may be useful to recapitulate the price-level and exchange-rate conventions used in the Agency.

The Financial Rules require that our Budgets, Financial Plans and Levels of Resources for a particular year are prepared in price levels ruling at the time of preparation, i.e. the middle of the previous year. Similarly, forecasts of Cost to Completion are presented in the price level pertaining one year before the date of the Arrangement.

During the course of a project, the estimates are up-dated annually according to the indices of inflation obtained by an expert body. This procedure works as follows:
Take a project in respect of which the initial schedule of payments is established during the Year 0 in terms of Accounting Units at the price levels ruling on 30/6/0 (30 June of Year 0).

Let $x_1, x_2, ..., x_n$

denote the amounts foreseen for the years 1, 2, ..., n

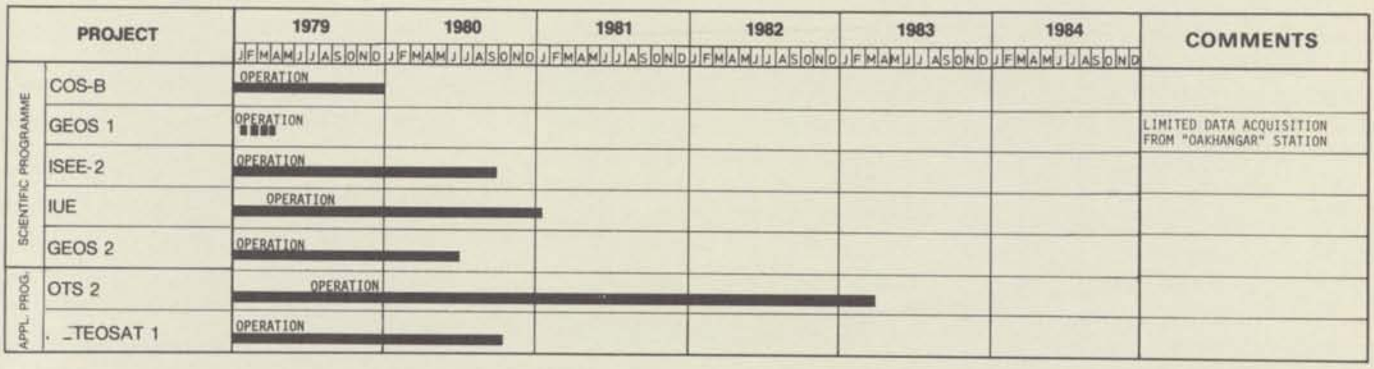
and let $\tau_1, \tau, ..., \tau_n$

denote the price-level variations observed for the periods 1/7/0 to 30/6/1, 1/7/1 to 30/6/2, ..., 1/7/$n-1$ to 30/6/n.

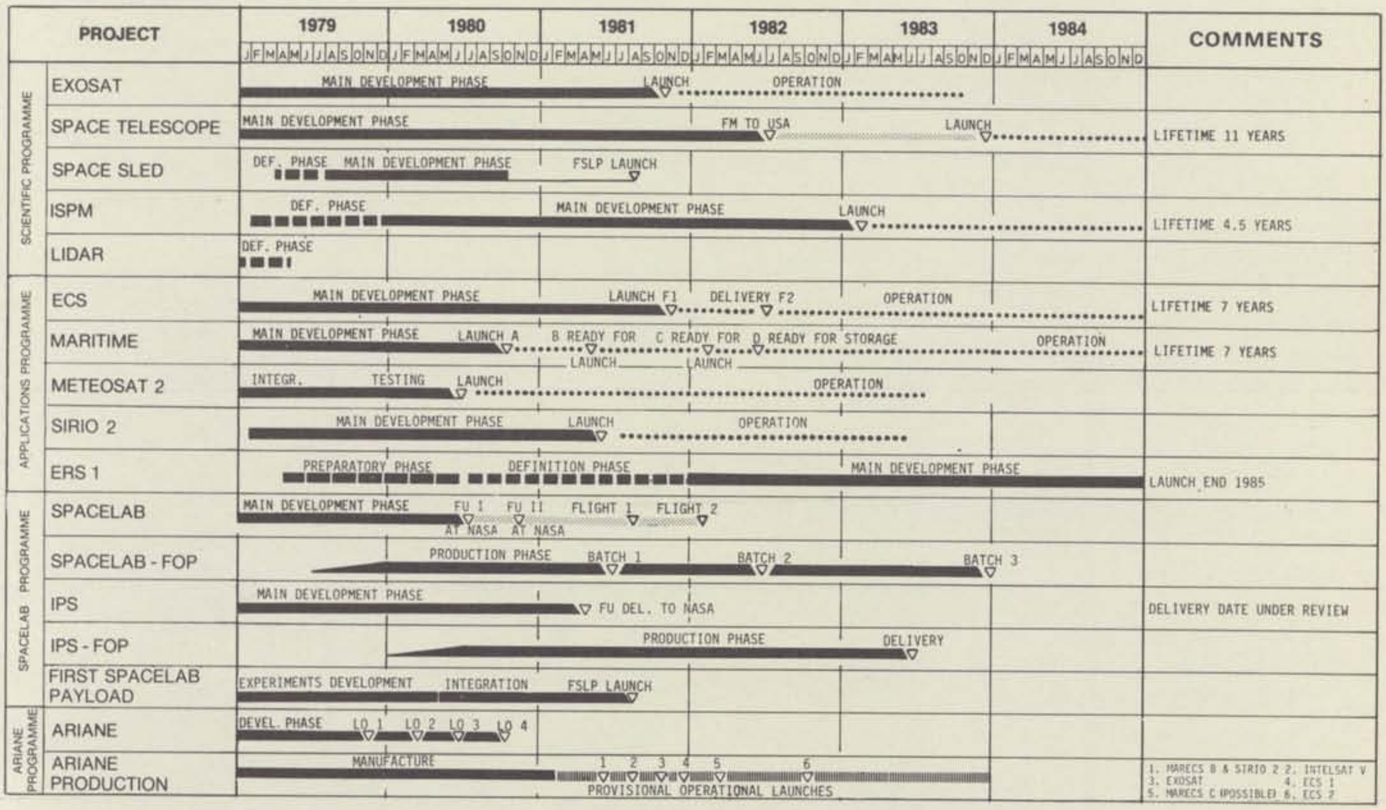
continued on page 45

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

In Orbit / *En orbite*



Under Development / *En cours de réalisation*



* Reporting status as per end February 1979/Bar chart valid per end March 1979

Bien que le planning ci-dessus soit valide jusqu à fin mars 1979, la situation des projects décrits dans les pages qui suivent s'arrête à la fin de février 1979.

Cos-B

Depuis la publication du dernier rapport, Cos-B a terminé une série d'observations de régions du ciel qui avaient été choisies pour permettre l'étude de la galaxie de Seyfert, 3C 390.3, de la région du disque galactique dans laquelle se situe le Cygne (troisième observation) et de la galaxie M31. Le pointage a ensuite été modifié de façon à comprendre dans le champ de visée l'amas de galaxies de Persée (y compris NGC 1275) et le radiopulsar PSR 0355+54. Il n'y a rien eu à signaler au sujet du fonctionnement de l'expérience ou des sous-systèmes du satellite au cours de cette période.

En ce qui concerne l'analyse des données, un grand pas en avant a été fait avec la détermination des facteurs correctifs (principalement pour tenir compte du fonctionnement irrégulier de la chambre à étincelles pendant la première année d'opérations en orbite), facteurs qui sont nécessaires pour obtenir des distributions à grande échelle de l'intensité du rayonnement gamma à partir d'observations multiples. Des cartes du rayonnement gamma dans la région du ciel comprise à l'intérieur d'un angle de 15° de part et d'autre de l'équateur galactique ont été présentées au 9ème Symposium sur l'Astrophysique Relativiste (Texas); c'était la première fois que des cartes de ce type étaient établies pour trois intervalles distincts d'énergie photonique à partir des données d'une seule expérience. Les résultats font apparaître une certaine corrélation avec d'autres indicateurs de structure de la galaxie mais également des divergences importantes dont certaines ont été imputées à des sources de rayons gamma localisées. Les profils d'intensité en fonction de la latitude révèlent l'existence de deux composantes dans l'émission. La composante étroite n'est observée qu'à des longitudes comprises dans un angle d'environ 60° par rapport à la direction du Centre galactique, sa largeur permettant de situer son origine à quelque 5 kpc du Centre. La composante large, observée à des intensités différentes à toutes les longitudes, semble avoir pour origine une région située à environ 1 kpc du Soleil.

Geos-1 & 2

Geos-1 qui avait été mis en hibernation en juin 1978 – quelques semaines avant le lancement de Geos-2 – a été remis en opération en octobre et a depuis lors fourni, à raison de trois heures par jour, des données de bonne qualité par l'intermédiaire de la station en bande S située au Royaume-Uni.

Geos-2 continue lui aussi à transmettre des données de bonne qualité, 24 heures sur 24, à la station en bande S qui lui est consacrée non loin de l'ESOC. De gros efforts ont été déployés aussi bien par l'ESOC que par les expérimentateurs pour produire le logiciel afin de surmonter les difficultés rencontrées par trois expériences, difficultés dues à une anomalie survenue au réseau solaire (court-circuit dans un câble reliant les cellules). Le traitement des données et la production des relevés journaliers à l'ESOC se poursuivent sans encombre. On s'efforce de procéder à la coordination et à la corrélation des mesures de Geos-1 & 2 avec celles d'autres satellites de la campagne IMS (ISEE, SCATHA).

Le fait de disposer de données provenant simultanément des deux Geos permettra d'effectuer des études de corrélation intéressantes et offre une occasion unique pour l'étalonnage réciproque des instruments. Geos-2 est actuellement utilisé en soutien à une campagne de fusées-sondes qui sera lancée à partir de Kiruna. Les données en temps réel de ce satellite sont effectivement disponibles au Centre de contrôle de Kiruna et servent à évaluer les conditions de lancement.

ISEE

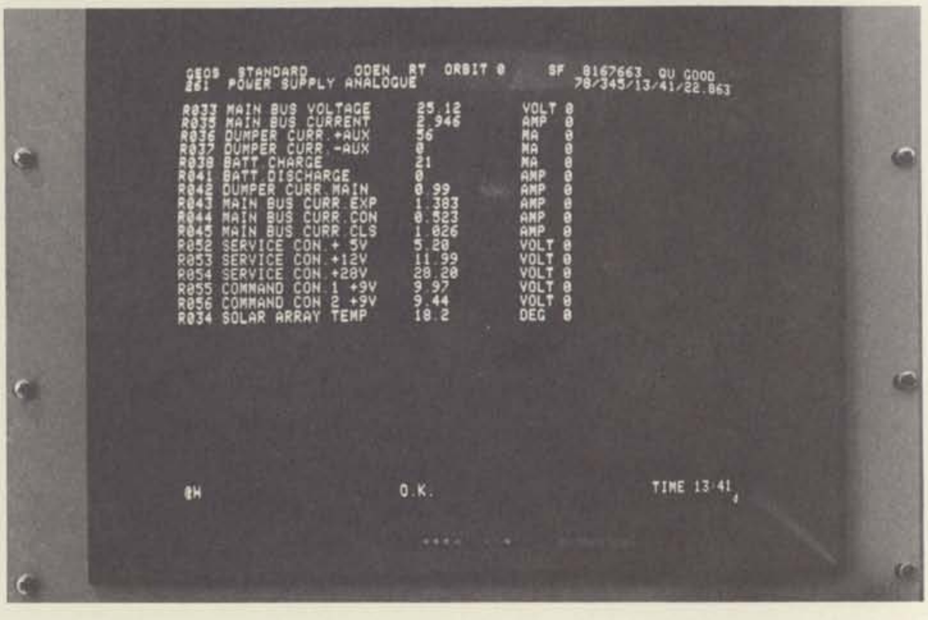
ISEE-1 and 2 ont continué à fonctionner de façon satisfaisante, exception faite pour un détecteur état solide sur une expérience américaine embarquée sur ISEE-2 dont le fonctionnement bruyant a brouillé les mesures d'électrons de faible énergie. Sur le plan scientifique la perte occasionnée est heureusement minime. Le taux de récupération des données de ces deux véhicules spatiaux est tombé début décembre à un niveau critique pour la mission, cette diminution correspondant à une augmentation de la distance séparant les deux satellites. Des mesures sont actuellement prises pour y remédier.

ISEE-3 continue à fonctionner comme prévu, avec un taux de récupération des données dépassant 89%.

OTS

A 10°E de longitude au-dessus de l'équateur sur son orbite géosynchrone, OTS-2 continue de bien fonctionner. Depuis son lancement, une série complète d'essais qui font partie du Programme d'essais orbitaux (OTP) ont permis de vérifier le fonctionnement de tout les matériels du véhicule spatial, y compris les matériels redondants.

Le bon fonctionnement en orbite des systèmes et des équipements utilisés sur OTS-2 a prouvé que leur application



Exemple de visualisation des données de maintenance de Geos

A typical Geos 'housekeeping' display

Cos-B

Since the last report was written, Cos-B has completed observations of regions of the sky chosen to permit studies of the Seyfert galaxy, 3C390.3, the Cygnus region of the Galactic disc (third observation) and the galaxy M31. The pointing direction was subsequently modified to include in the field of view the Perseus cluster of galaxies (with NGC 1275) and the radio pulsar PSR 0355 –54. No change in the performance of the experiment or spacecraft subsystems has been detected in this time.

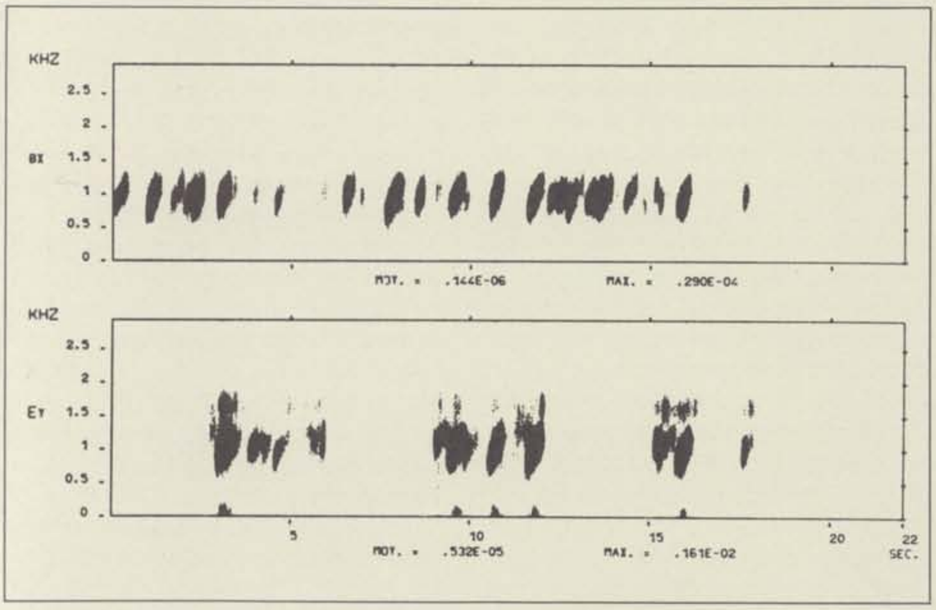
A major step forward in the analysis of the data has been achieved with the determination of the correction factors (mainly for the variable performance of the spark chamber during the first year in orbit) needed to obtain large-scale distributions of gamma-ray intensity from the results of multiple observations. Maps of the gamma-ray sky within about 15° on either side of the galactic equator were presented at the Ninth Texas Symposium on Relativistic Astrophysics, the first time that such maps have been derived for three separate intervals of photon energy from the results of a single experiment. The results show some correlation with other tracers of galactic structure, but also significant departures, some of which have been ascribed to localised gamma-ray sources. Latitude profiles of the intensity indicate the existence of two components in the emission. The narrow component is seen only at longitudes within about 60° of the direction of the Galactic Centre and has a width consistent with an origin at about 5 kpc from the Centre. The wider component, seen with varying intensity at all longitudes, appears to originate within about 1 kpc of the Sun.

Geos-1 & 2

Geos-1 which had been switched off in June 1978 – a few weeks before the launch of Geos-2 – was reactivated last October and good-quality data are being received by an S-band station in the UK for three hours per day.

Geos-2 continues to generate good-quality data on a twenty-four hour per day basis, which are acquired by the Geos-dedicated S-band station near ESOC. Considerable efforts have been made by both ESOC and the experimenters to generate software to overcome difficulties with three experiments caused by a solar-array anomaly (short circuit of one string). Data-processing and summary production at ESOC is continuing without difficulty. Efforts are proceeding to coordinate and correlate measurements with other IMS spacecraft (ISEE, SCATHA).

The availability of simultaneous data from Geos-1 and 2 will lead to interesting correlative studies and offers a unique opportunity for the cross-calibration of instruments. Geos-2 is presently also supporting a sounding-rocket campaign being carried out from Kiruna. Real-time data from Geos-2 are being used at the Kiruna control centre in the assessment of suitable launch conditions.



Magnetospheric 'chorus' (electron cyclotron waves) observed on Geos-2 at ~0600 UT on 16 January 1979

'Choeur' magnétosphérique (ondes cyclotron électroniques) observé par Geos-2 le 16 janvier 1979 ~0600 TU.

ISEE

ISEE-1 and 2 have continued to operate well, with the exception of a solid-state detector in a US experiment carried by ISEE-2 which has become noisy and has obscured low-energy electron measurements. The scientific loss here is fortunately minimal. Data recovery from the two spacecraft fell to a mission critical level in early December, correlating with increased spacecraft separation. Steps are being taken to correct this.
ISEE-3 continues to operate nominally, with data recovery of more than 89%.

OTS

OTS-2 continues to operate satisfactorily in its geosynchronous orbit, positioned at 10°E longitude over the equator. Since its launch, a comprehensive series of OTP (Orbital Test Programme) tests has checked the performances of all primary and redundant spacecraft hardware.

The concepts and equipment used on OTS-2 have demonstrated, through satisfactory in-orbit performance, that they are directly applicable for use on the future operational ECS satellites. The few anomalies that have been encountered have had no significant impact on the mission of OTS-2, and have provided valuable information on design improvements which can be incorporated into the future satellites.

In January 1979, an agreement for cooperating in the use of and further in-orbit testing of OTS was signed by ESA and Interim Eutelsat. This agreement constitutes a major stepping stone for future cooperation between the two organisations for the operational European Communications Satellite System.

Exosat

Satellite
The development of the engineering-model subsystem is nearing its peak as

directe sur les futurs satellites opérationnels ECS était possible. Les quelques anomalies de fonctionnement qui ont été observées n'ont eu aucune incidence importante sur la mission d'OTS-2 et ont au contraire fourni des informations précieuses sur les améliorations conceptuelles qui pourront être apportées à ces futurs satellites.

En janvier, un accord de coopération pour l'utilisation d'OTS et pour de nouveaux essais orbitaux de ce satellite a été signé entre l'Agence et EUTELSAT Intérimaire. Cet accord constitue une étape importante de la future coopération entre les deux Organisations pour le système opérationnel de satellites européens de télécommunications.

Exosat

Satellite

Le développement des sous-systèmes du modèle d'identification approche de son aboutissement: la plupart des unités – à l'exception de celles du sous-système de commande d'orientation et de contrôle d'orbite – subissent actuellement des essais fonctionnels et d'ambiance avant d'être livrées au contractant (MBB, Allemagne) pour assemblage, intégration et essais au niveau satellite. Certaines unités du sous-système d'alimentation en énergie et de gestion des données ont mal résisté aux essais de vibration et les travaux de modification ou de réparation nécessaires ont entraîné un nouveau glissement du calendrier, qui s'est répercuté à son tour sur le programme d'assemblage, d'intégration et d'essais du modèle d'identification.

Devant les retards des sous-systèmes, ainsi qu'un nouveau glissement dans la fabrication de la structure du modèle d'identification, le contractant a décidé de remettre en état le modèle de configuration utilisé jusqu'ici pour la modélisation et la production du câblage, en vue de permettre l'assemblage et l'intégration préliminaires des sous-systèmes en attendant la livraison de la structure du modèle d'identification qui devrait maintenant avoir lieu à la mi-juillet.

L'utilisation de cette structure auxiliaire, pour mener des activités préliminaires d'assemblage, d'intégration et d'essais jusqu'au stade où il conviendra de transférer les sous-systèmes de bord à la structure du modèle d'identification, présente les avantages suivants:

1. *Contrôle des procédures d'intégration et d'essai projetées et mise au point définitive du logiciel de vérification;*
2. *Emploi de la structure du modèle d'identification pour les essais de réponse dynamique, dont la nécessité est impérative compte tenu du sérieux retard du programme relatif au modèle mécanique et de l'incertitude actuelle concernant les niveaux applicables pour les essais de qualification des unités.*

Un plan d'essais a été établi; une fois approuvé par le contractant, sa mise en oeuvre devrait permettre de mieux cerner les possibilités et le comportement dynamique de la structure et faciliter l'acquisition des données d'ambiance réalistes nécessaires pour toutes les unités de bord, et en particulier pour les équipements sensibles aux vibrations tels que le suiveur stellaire (tube dissecteur d'images) et les expériences.

Charge utile

Le développement de la charge utile du modèle d'identification progresse dans l'ensemble de façon satisfaisante. Le remaniement de la conception et la modification de certaines unités sont devenus nécessaires au vu des résultats des essais au niveau unité et d'une analyse dynamique de certaines interfaces entre le véhicule spatial et les expériences (moyenne énergie, banc propre), sans toutefois remettre en cause une livraison conforme au calendrier d'ensemble actuellement applicable.

Ariane

On a procédé pour la configuration satellite/lanceur à une analyse de la réponse dynamique d'où il ressort qu'il y a incompatibilité avec les possibilités de charge de la structure pour certaines conditions de vol, plus particulièrement en fin de combustion du deuxième étage. Ceci nécessite l'étude du renforcement de la structure principale. Ce problème est étroitement lié au fait que l'on n'a pas encore pu vérifier les prévisions relatives au comportement du lanceur Ariane en vol. Les vols de qualification qui auront lieu en 1979-1980 permettront peut-être d'assouplir les niveaux d'entrée actuellement définis pour les événements critiques de la phase de vol, mais ceci ne peut malheureusement aider à prendre la décision nécessaire à ce stade précis du programme.

Prenant en compte les nouveaux impératifs de sécurité du pas de tir fixés par le CNES, l'ESOC a procédé au calcul des créneaux de lancement possibles, qui se situent de la mi-mai à la fin août 1981 et de début novembre 1981 à début février 1982.

ESOC

En ce qui concerne les activités d'approvisionnement prévues pour la station sol de Villafranca, les spécifications de la plupart des matériels ont été mises au point et bon nombre d'invitations à soumissionner ont été lancées pour les principaux sous-systèmes et unités. En outre, les offres industrielles déjà reçues pour l'équipement de bande de base et l'équipement calcul de télémesure (surveillance et contrôle) sont en cours d'évaluation.

L'élaboration des spécifications du logiciel de gestion et de traitement des données, de planning de la mission et de contrôle du satellite approche de sa fin, à peu de choses près.

L'ensemble de la conception du système sol sera à nouveau passé en revue au deuxième trimestre de cette année.

Télescope spatial

Réseau solaire

Le feu vert complet ayant été donné au contractant pour la phase C/D, ce dernier a augmenté l'effectif de ses équipes de projet en prévision de la phase de définition détaillée.

Un effort particulier a été consacré à la solution des problèmes d'interface entre le Télescope spatial et le réseau solaire. A cette fin, un groupe de travail 'Interfaces' s'est réuni en janvier/février aux Etats-Unis. Il a adopté un document de contrôle portant sur le détail d'environ 80– des interfaces, y compris ceux qui sont critiques au stade actuel du programme.

Deux problèmes techniques font actuellement l'objet d'études poussées: il s'agit d'éviter l'ombre portée par le télescope sur le réseau solaire et de concevoir un type de réseau qui se prête à des remplacements en orbite.

Module de la chambre

Le contractant a présenté fin décembre une estimation de coût de la phase C/D most units, except those of the attitude and orbit control subsystem, are presently undergoing functional and environmental testing prior to delivery to the contractor (MBB, Germany) for assembly, integration and testing at satellite level. Some units of the power supply and data handling subsystem have failed during vibration testing and the modification/repair work needed has caused a further slip in schedule, in turn affecting the engineering-model assembly, integration and test programme.

As a result of the subsystem delays and a further slip in manufacture of the engineering-model structure, the contractor has decided to refurbish the configuration model used so far for harness modelling and production to facilitate the preliminary assembly and integration of subsystems prior to delivery of the engineering-model structure proper, which is now expected in mid-July.

Proceeding with this auxiliary structure for preliminary assembly, integration and test activities up to a suitable point for transfer of on-board subsystems to the engineering-model structure offers the following advantages:

1. Verification of draft integration and test procedures and finalisation of checkout software development.
2. Use of engineering-model structure for dynamic response tests badly needed in the light of the drastic delay in the mechanical-model programme and the prevailing uncertainty with respect to unit test levels applicable for qualification testing.

A test plan has been set up and once agreed with the contractors its implementation should lead to a better 'feel' for the structure's capabilities and dynamic behaviour. It will also be of help in acquiring the realistic environmental data needed for all on-board units, particularly for vibration-sensitive items like the star tracker (image dissector tube) and experiments.

Payload
Engineering-model payload development is proceeding satisfactorily in the main. Redesign and modification of some units has become necessary in the light of unit-level testing results and following dynamic analysis of certain spacecraft/experiment-unit interfaces (medium energy, clean bench), but is not jeopardising a delivery consistent with the overall schedule which is presently still valid.

Ariane
A dynamic-response analysis for the satellite/launcher configuration has been performed and the data acquired indicate an incompatibility with the structure's load capability for certain flight conditions; it is most pronounced during the end of the second-stage burn. Reinforcement of the primary structure therefore needs to be studied. The problem is closely connected with a lack of verification of predictions concerning the Ariane launcher's in-flight behaviour. Qualification flights during 1979/80 may allow a relaxation of presently defined input levels for critical flight events, but this unfortunately is of no help in the decision making needed at this point in the programme.

Based on new launch range safety constraints issued by CNES, calculations have been completed by ESOC which offer launch windows in the period mid-May to end-August 1981 and beginning November 1981 to beginning February 1982.

ESOC
The procurement process for the Exosat ground station at Villafranca has reached the point where most of the hardware specifications have been completed and a number of 'invitations to tender' have been issued for major subsystems/units. In addition, offers already received from industry for the telemetry (monitor and control), computer and baseband equipment are currently being evaluated.

Software specifications for data handling/processing, mission planning and spacecraft control are, with minor exceptions, nearing completion.

The Space Telescope/*Le Télescope spatial*

A second review of the design of the overall ground system is scheduled for the second quarter of this year.

Space Telescope

Solar array
Following the full go-ahead for Phase C/D, the contractor has increased his project teams for the design detailing phase.

Major emphasis has been on the resolution of interfaces between the Space Telescope and the solar array. To this end, an Interface Working Group meeting was held in January/February in the USA. This resulted in an agreed Interface Control Document specifying approximately 80% of the interfaces, including all those critical for the present stage of the programme.

Two technical problems are under intensive investigation, namely protection of the solar array against shadowing and designing of the array such that it can be replaced in orbit.

Camera module
At the end of December the contractor submitted a Phase C/D cost estimate containing a significant increase. The contractor has also submitted a rationale, in the form of change notices, for that increase. These changes will be negotiated during March with the contractor. At the same time, a final negotiation of the technical specifications will take place.

Design of the technical interfaces with the Space Telescope leads to a number of difficulties associated mainly with the module-to-Telescope mounting and the thermal interfaces. The present technical and scientific baseline for the Faint Object Camera (FOC) was presented to NASA, which has subsequently formally accepted the introduction of the hot bi-alkali photocathode, and the spectroscopic mode in the f/48 optical relay.

qui est en augmentation sensible. Il a également présenté sa justification de cette augmentation en se fondant sur des modifications qui seront négociées courant mars. Au même moment aura lieu la négociation finale des spécifications techniques.

La conception des interfaces techniques avec le Télescope spatial s'accompagne d'un certain nombre de difficultés portant principalement sur les détails de montage et les interfaces thermiques du module de la chambre pour objets à faible luminosité (FOC) et du Télescope. La conception de référence technique et scientifique de la FOC a été présentée dans sa forme actuelle à la NASA, qui a accepté officiellement l'introduction de la photocathode chaude bi-alcaline et d'un dispositif spectroscopique dans le relais optique de f/48.

Détecteur de photons
L'adoption de la photocathode chaude bi-alcaline vient d'être confirmée après que les tubes intensificateurs échantillons aient été construits et assayés avec succès. L'étude détaillée de la conception s'est poursuivie, et les travaux ont également débuté sur le modèle structure/thermique. En prenant forme, les conceptions ont occasionné un certain nombre de difficultés, la modification de la dimension des boîtiers ayant entraîné certains retards dans l'aménagement de la plate-forme.

Par ailleurs, le contractant s'est attelé à la préparation d'une proposition de prix forfaitaire pour la phase finale de ce contrat, laquelle doit être remise en mars.

Rapports avec la NASA
La réunion trimestrielle sur l'avancement des travaux s'est tenue début février aux Etats-Unis, à la suite d'une présentation de la situation actuelle de la FOC au personnel du Centre Goddard et du Siège de la NASA. Cette dernière a officiellement approuvé les modifications apportées à la FOC dans la forme présentée. Elle a par ailleurs signalé l'apparition d'un certain nombre de problèmes techniques aux Etats-Unis, l'un des plus graves étant l'insuffisance des marges de masse et d'énergie qui pourrait avoir des répercussions sur la partie européenne du Télescope.

Traîneau spatial

A la suite de la décision prise en novembre 1978 d'arrêter les travaux dans l'industrie, une équipe renforcée a été créée au sein de l'Agence pour définir une nouvelle conception simplifiée du Traîneau spatial correspondant aux impératifs scientifiques récemment assouplis. Cette conception a été officiellement examinée en décembre par l'Agence et l'équipe scientifique 'Traîneau' qui l'ont jugée satisfaisante.

L'Agence a préparé une proposition dont l'un des éléments essentiels était que tous les travaux d'ingénierie au niveau système seraient effectués par elle de façon à mener le projet à bien dans les délais désormais beaucoup plus courts restant disponibles pour la FSLP. Lors de sa réunion de janvier, le Comité du programme scientifique n'a pas pu approuver les fonds supplémentaires nécessaires à la réalisation de ce projet et a décidé de suspendre sa décision jusqu'à ce que la communauté des utilisateurs scientifiques ait déterminé si, dans la limite des crédits budgétaires disponibles, une expérience de remplacement dans le domaine des sciences de la vie pourrait prendre place dans la première charge utile du Spacelab ou dans une mission ultérieure.

Il ressort des récentes délibérations de la communauté scientifique que la nouvelle conception du Traîneau constitue le minimum acceptable pour obtenir des résultats scientifiques valables. Ce projet est actuellement en attente; le Comité du programme scientifique examinera fin mars s'il peut approuver le programme proposé.

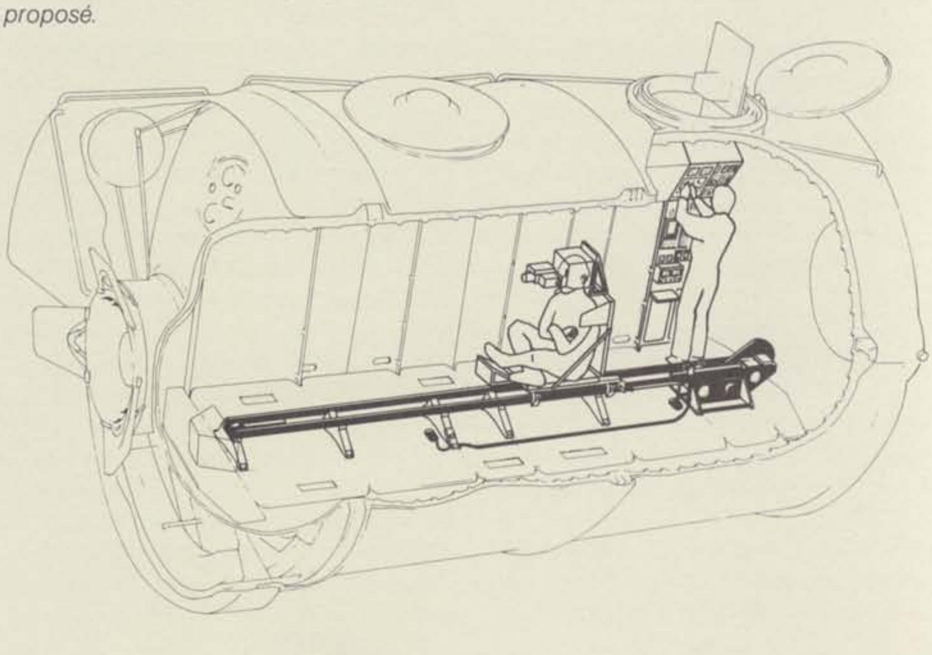
ISPM

Le projet ISPM a franchi une étape importante avec l'approbation, par le Comité de la Politique industrielle, de la recommandation de l'Exécutif visant à confier des contrats concurrentiels de conception du système (phase B) à MBB, chef de file du Groupe COSMOS, et à Dornier System, chef de file du Groupe STAR; les travaux progressent de façon satisfaisante dans les deux firmes.

Sur le plan scientifique, les travaux se poursuivent sur la mise au point définitive de la charge utile, et la solution du problème d'incompatibilité (mentionné précédemment) entre le magnétomètre vectoriel à hélium et l'expérience de bobine exploratrice a considérablement progressé.

La fourniture du générateur radio-isotopique à thermocouple (RTG) par l'intermédiaire de la NASA pose encore des problèmes de développement qui ont contraint à abandonner une technologie nouvelle pour le convertisseur de faisceau et à revenir à une méthode plus ancienne et moins efficace sous l'angle du poids. Si cette méthode donne une certaine assurance de livraison dans les délais, elle a en revanche entraîné une augmentation du poids qui, à son tour, diminue légèrement la durée de la mission à une latitude solaire élevée.

Des efforts sont en cours pour limiter au minimum les effets de cette situation, l'ESA et la NASA ont bon espoir que les objectifs de la mission seront pleinement atteints.



Le Traîneau spatial / The Space Sled

Photon Detector Assembly
The introduction of the hot bi-alkali photocathode was confirmed after sample intensifier tubes had been successfully manufactured and tested. Design detailing has continued, with work commencing also on the structural thermal model. The maturing designs have caused some difficulties with changing box sizes, leading to some delay in the platform layout work.

The contractor has also been preparing a fixed-price quotation for the final phase of this contract, which will be submitted in March.

Interfaces with NASA
The Quarterly Progress Meeting was held at the beginning of February in the USA, and was preceded by a presentation on the status of the Faint-Object Camera to NASA Goddard and NASA HQ staff. NASA has formally accepted the changes to the FOC as presented, and has also indicated that a number of technical problems are emerging in the USA, not least of which are insufficient mass and power margins; both of these could affect the European element of the Telescope.

Sled

Following the decision to stop the work in industry in November 1978, a strengthened team was formed within the Agency to define a simplified alternative concept for the Sled which would satisfy the recently relaxed scientific requirements. This concept was formally reviewed by ESA and the Sled Science Team in December and found to be satisfactory.

An essential element of the new Sled concept is that the system-level engineering work would be performed by the Agency itself in order to realise the project in the now much shorter time available for meeting the First Spacelab Payload (FSLP). The Science Programme Committee could not approve the additional funds needed for the project at its meeting in January 1979, but elected to defer its decision until after the Scientist User Community had determined whether an alternative life-science activity could be implemented for FSLP or a later mission with the funds still available in the budget.

Recent deliberations by the scientist community led to the conclusion that the newly proposed Sled concept is the minimum acceptable solution for a worthwhile scientific return. The Sled project is now in a hold phase until the end of March 1979, when the Science Programme Committee will consider its approval.

ISPM

The ISPM Project has taken a significant step forward in that the Industrial Policy Committee has approved the Executive's recommendation to place competitive system design (Phase B) contracts with MBB and Dornier System, leading to COSMOS and STAR consortia, respectively, and satisfactory progress is being made with both companies.

On the scientific side, work is continuing on finalisation of the payload and considerable progress has been made in resolving the previously discovered incompatability between the vector helium magnetometer and the search-coil experiment.

One continuing problem is the supply of the radio-isotope thermal generator (RTG) which is provided via NASA. Due to development problems, it has been necessary to abandon a new technology for the heat converter and to revert to an older, and less-weight-effective approach. This, although providing some certainty of delivery to the required schedule, has led to a weight increase which, in turn, slightly reduces the mission time at high solar latitude.

Efforts are being made to reduce this impact to a minimum and both ESA and NASA are confident that the overall mission objectives will be achieved.

ECS

The contract for the provision by British Aerospace to ESA of two ECS spacecraft and for the launch of the first one in November 1981 was signed early this year. The initial spacecraft development programme is proceeding normally, except with regard to the battery and the solar panels, with which technical problems have been encountered, but these are being solved. Although the Critical Design Review has not yet taken place, it has been necessary to begin the manufacture of the flight units for the Marecs spacecraft. This Review of ECS is currently scheduled for the middle of the year. The decisions taken by the ESA Council at its December 1978 meeting raise good hopes that an agreement with Interim Eutelsat on the operational use of the ECS spacecraft will be signed in the very near future.

Maritime Satellites

Marecs-A and B
The contract with British Aerospace for the Marecs-A and B satellites was signed on 22 January. The qualification of the communications payload's most critical item, the L-band transistor power amplifier, is nearing completion. Integration of the development model payload incorporating the change of frequencies (11/14 GHz to 4/6 GHz) has started. Manufacture of most of the platform flight units is in progress. Marecs-A is scheduled for launch on Ariane L04 in October 1980, and Marecs- B in April 1981.

Joint Venture for a Global Maritime System
Discussions are still going on between the Agency and the Joint Venture for the provision of an extension of the Marecs-A and B programme to establish a Global Maritime System. The configuration presently retained relies on both Marecs and Intelsat-V satellites with maritime payloads.

Heavy European TV-Broadcast Satellite

The H-Sat Preliminary Phase-B contract with the Eurosatellite consortium is now practically completed, the remaining industrial work being limited to some specific payload hardware tasks which are scheduled for completion later in the year. A Final Report summarising the Preliminary Phase-B results has been issued.

A further internal programme of work was approved by the December Council and started in January. The main objectives were to investigate the potential for further improvements in the existing platform design and to pursue the general domain of broadcast by satellite. This work is now being expanded. The Council, at its end

ECS

Le contrat prévoyant la livraison par British Aerospace à l'Agence de deux satellites ECS et le lancement du premier en novembre 1981 a été signé au début de l'année. Le développement du satellite se déroule suivant le programme initial sauf en ce qui concerne la batterie et les panneaux solaires pour lesquels des problèmes techniques sont apparus mais sont en cours de solution. Bien que l'examen de la conception critique n'ait pas encore eu lieu, il a été nécessaire de commencer la fabrication d'unités de vol utilisées pour le satellite Marecs. Cet examen d'ECS est actuellement prévu pour le milieu de l'année. Les décisions prises par le Conseil de l'Agence au cours de sa réunion de décembre laissent augurer une signature très prochaine de l'accord avec EUTELSAT Intérimaire pour l'utilisation opérationnelle du satellite ECS.

Satellites maritimes

Marecs-A et B

Le contrat couvrant les satellites Marecs-A et B a été signé avec British Aerospace le 22 janvier. La qualification de l'élément le plus critique de la charge utile de communications – l'amplificateur de puissance à transistor en bande L – est presque achevée. L'intégration de la charge utile du modèle de développement, incorporant la modification de fréquences (passage de la bande des 11/14 GHz à celle des 4/6 GHz), a commencé. La fabrication de la plupart des éléments destinés à l'unité de vol de la plate-forme se poursuit. Le lancement de Marecs-A sur Ariane L04 est prévu pour octobre 1980 et celui de Marecs-B pour avril 1981.

Association d'intérêts pour un système maritime global

Les discussions se poursuivent entre l'Agence et l'Association d'intérêts pour qu'une extension du programme Marecs-A et B permettre d'aboutir à un système maritime global. La configuration actuellement retenue est basée à la fois sur des satellites Marecs et Intelsat-V dotés de charges utiles maritimes.

Satellite lourd de télédiffusion européen

Le contrat préliminaire de phase B du satellite H-Sat confié au consortium EUROSATELLITE est maintenant pratiquement terminé, seules restent à exécuter quelques tâches spécifiques relatives aux matériels de la charge utile et qui doivent être achevées plus tard dans l'année. Un rapport définitif récapitulant les résultats de cette phase B a été établi.

Le Conseil de décembre a approuvé un nouveau programme interne de travaux qui ont commencé en janvier et dont l'objectif principal était d'étudier la possibilité d'apporter de nouvelles améliorations à la conception actuelle de la plate-forme et de poursuivre les études dans le domaine de la radiodiffusion par satellite. Le champ de ces travaux est maintenant élargi; c'est ainsi qu'à sa session de fin février, le Conseil a approuvé un nouveau budget consacré à la 'poursuite des études du futur programme européen de satellites de télécommunications' qui durera jusqu'à fin juillet 1979. L'objectif de ces études est la mise au point de propositions de missions futures et l'évaluation du marché possible pour une plate-forme lourde. L'optimisation d'une plate-forme lourde européenne qui ne soit pas exclusivement liée au concept initial de satellite de radiodiffusion visuelle et sonore et à l'ancienne mission H-Sat sera entreprise en étroite collaboration avec les utilisateurs éventuels et les délégations intéressées.

Météosat

Véhicule spatial F1

Météosat-1 continue à très bien fonctionner. Toutes les unités embarquées, y compris les unités de secours, sont en bon état. Il semble que la contamination de l'optique refroidie du radiomètre persiste mais les images fournies aux utilisateurs n'en ont pas été affectées. Une nouvelle décontamination sera effectuée en avril. La mise au point définitive du logiciel d'application début février s'est traduite par une amélioration spectaculaire de la disponibilité du système de calcul au sol de Météosat (MGCS).

Véhicule spatial F2/L03

Le modèle structurel de Météosat a été endommagé lors de l'essai en vibrations du composite Météosat/APPLE/CAT qui s'est déroulé en décembre. Ce modèle avait été renforcé avant cet essai pour pouvoir supporter les niveaux de vibration de L03 (qui sont nettement supérieurs à ceux pour lesquels Météosat avait été conçu à l'origine) mais ce renforcement s'est révélé insuffisant. De nouvelles modifications sont maintenant prévues.

Projet GOES-1

Depuis le démarrage de la première expérience mondiale du GARP (FGGE), le 1er décembre 1978, la capacité de prise d'images de GOES-1 a été exploitée intensivement. Toutes les données d'images sont décomprimées à Villafranca avant d'être diffusées via le véhicule spatial, puis archivées. Le traitement des données est effectué par l'Université du Wisconsin, la Deutsche Forschungs- und Versuchsanstalt für Luft-und Raumfahrt (DFVLR) en Allemagne et le Laboratoire de Météorologie dynamique (LMD) en France.

Sirio-2

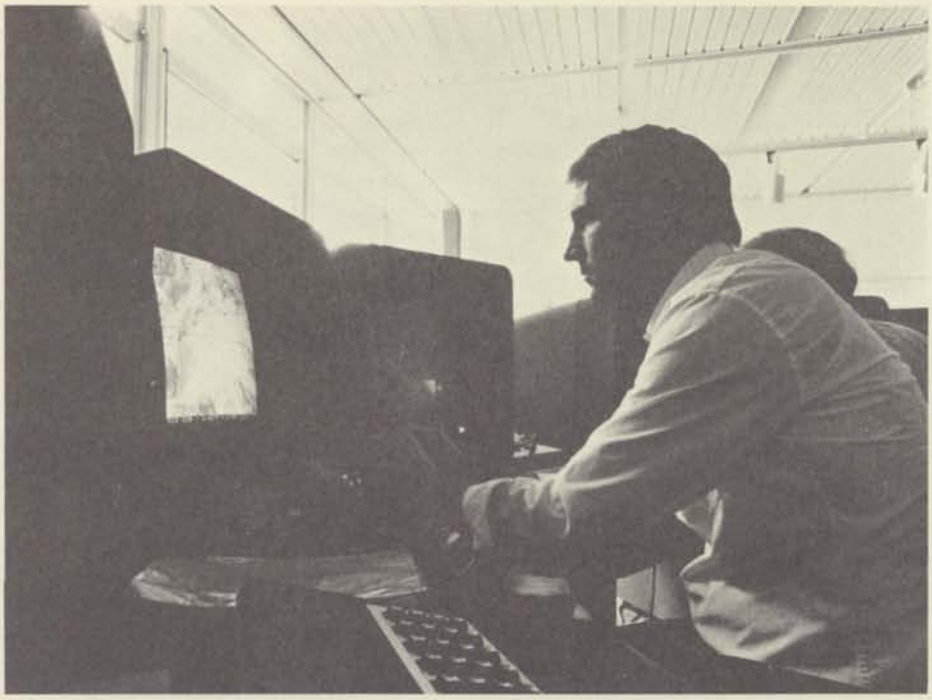
Le Conseil ayant décidé, à sa session du 7 novembre, d'inclure le programme Sirio-2 dans les programmes de l'Agence, et le Comité de la Politique industrielle ayant approuvé, le 14 décembre, la passation du contrat de réalisation du satellite avec la 'Compagnia Nazionale Aerospaziale' (CNA), la phase de réalisation (C/D) du programme a démarré.

Le coup d'envoi a été donné au cours d'une réunion tenue à Rome les 24 et 25 janvier à laquelle participaient les co-contractants et les sous-traitants. Le point de départ officiel de la période de 27 mois prévue pour les activités de développement, d'approvisionnement et d'intégration a été également fixé. Le satellite devra donc être livré à la base de lancement de Kourou avant le 24 avril 1981 et son lancement par Ariane-SYLDA est prévu pour juin 1981.

En février, le Conseil directeur du programme de satellite météorologique et le Conseil de l'Agence ont approuvé le budget 1979 et le règlement d'exécution du programme.

Télédétection

Le développement des deux expériences de télédétection qui seront embarquées sur le premier Spacelab (expérience



The Meteosat Control Room at ESOC. The display is of a computer-processed and referenced partial image.

La Salle de Contrôle Météosat à l'ESOC. On voit sur l'écran une image traitée par ordinateur.

of February meeting, approved a further budget devoted to 'Continued Studies of the Future European Telecommunications Satellite Programme', which will last until the end of July. The study has as its objectives the generation of future-mission proposals and assessment of the corresponding market for a large platform. The optimisation of a Large European Platform not linked exclusively to the original TVBS concepts and the former H-Sat mission will be undertaken in close collaboration with potential users and interested delegations.

Meteosat

F1 spacecraft

Meteosat-1 continues to function very well. All on-board prime and back-up units are in good order. The radiometer cold optics have shown signs of continued contamination although the images provided to users have not been affected. A new decontamination cycle will be performed in April. The freezing of the applications software in early February has resulted in a drastic improvement in the availability of the Meteosat Ground Computer System (MGCS).

F2/L03 spacecraft

The Meteosat structural model was damaged during the Meteosat/Apple/CAT composite vibration test in December. Prior to the test, it had been strengthened to withstand the L03 levels (which are appreciably higher than those for which Meteosat was originally designed), but this strengthening proved to be insufficient. Further modifications are now planned.

GOES-1 project

Since the start of the First GARP Global Experiment (FGGE) on 1 December 1978, GOES-1 has been operated intensively for image taking. All image data are stretched in Villafranca before being disseminated through the spacecraft and archived. These data are processed by the University of Wisconsin (USA), the Deutsche Forschungs- und Versuchanstalt für Luft- und Raumfahrt (DFVLR) in Germany, and the Laboratoire de Météorologie Dynamique (LMD) in France.

Sirio-2

Following the Council's resolution of 7 November to include Sirio-2 among the Agency's programmes and the Industrial Policy Committee's (IPC) approval on 14 December to award the satellite development contract to Compagnia Nazionale Aerospaziale (CNA), the main development phase (C/D) of the programme has started.

The kick-off meeting was held in Rome on 24/25 January, with both the co- and subcontractors present, and the formal starting point for the 27-month development, procurement and integration programme was established. The satellite is to be delivered to the Kourou Launch Site before 24 April 1981, and an Ariane/Sylda launch is foreseen for June of that year.

In February, the 1979 budget and the implementing rules were approved both by the Programme Board concerned (PB-MET) and by Council.

Remote Sensing

The development of the two remote-sensing experiments that will be flown on the first Spacelab (microwave experiment and metric camera) is progressing according to schedule. The Design Reviews took place in February and the proposals for experiment use are under evaluation.

The two satellite Phase-A studies (Land Applications and Coastal Ocean Monitoring missions) initiated last autumn are nearing completion with very promising results. In parallel, and as a complement to these Phase-A studies, a remote-sensing preparatory programme is expected to start in mid-March with the final approval of the Remote Sensing Programme Board. This preparatory programme, which Council approved last December for inclusion in the Agency's programmes, will primarily cover the pre-development of critical items in preparation for a Phase-B for the first European Remote Sensing Satellite (ERS-1), expected to be launched in the mid-1980s.

hyperfréquences et chambre photogrammétrique) se poursuit conformément aux plans. Les examens de conception se sont déroulés en février et les propositions d'utilisation des expériences sont en cours d'évaluation.

Les études de phase A des deux satellites – mission d'applications terrestres et mission de surveillance des océans dans les zones côtières – commencées à l'automne dernier, sont presque achevées et leurs résultats sont très prometteurs. Parallèlement, et pour compléter ces études de phase A, un programme préparatoire de télédétection doit en principe démarrer à la mi-mars avec l'approbation définitive du Conseil directeur du programme de télédétection. Ce programme préparatoire, dont le Conseil a approuvé en décembre dernier l'inclusion dans les programmes de l'Agence, couvrira essentiellement le pré-développement d'éléments critiques pour préparer la phase B du premier satellite européen de télédétection (ERS-1) qui devrait être lancé au milieu de la prochaine décennie.

Spacelab

Le premier porte-instruments du Spacelab a été livré comme prévu à la NASA (Kennedy Space Center) en décembre 1978, avec plusieurs éléments de l'équipement mécanique de soutien au sol. Un deuxième porte-instruments sera expédié en avril. Ils seront tous les deux utilisés par la NASA au cours des vols d'essai de l'Orbiteur de la Navette spatiale qui commenceront en novembre et se poursuivront tout au long de 1980.

Des difficultés techniques rencontrées au cours de la phase d'intégration et d'essai du modèle d'identification ont imposé un ajustement du calendrier. La firme industrielle à laquelle a été confié le contrat principal de développement a proposé les dates de livraison suivantes:

Modèle d'identification	*avril 1980*
Unité de vol no. 1	*juillet 1980*
Unité de vol no. 2	*novembre 1980*

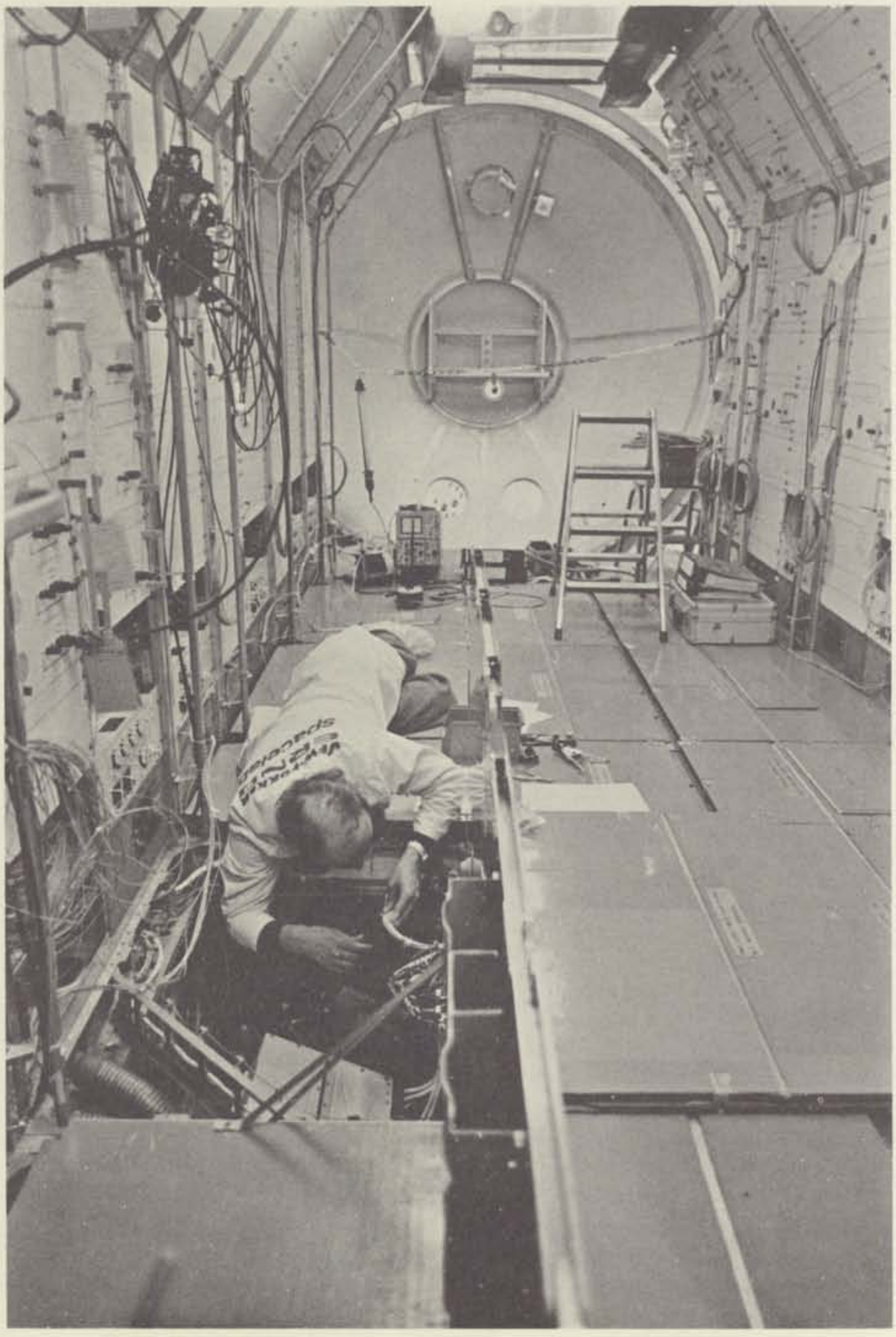
Ces dates sont compatibles avec les plus récents plans de la NASA pour les deux premiers vols du Spacelab.

La NASA a officiellement annoncé que la date de lancement de la première mission du Spacelab, qui emportera une charge utile commune NASA/ESA, était désormais fixée au 17 août 1981. C'est sur cette date que sont maintenant basés tous les plans relatifs à la première charge utile du Spacelab (FSLP). La NASA a également annoncé que toutes ses tâches d'intégration, y compris les activités de niveau IV relatives à la première mission, seraient effectuées au Kennedy Space Center. L'incidence de cette décision sur le projet FSLP est en cours d'examen.

Une Commission médicale, composée de huit experts nommés par les Etats membres de l'Agence, a été mise en place pour superviser toutes les expériences de la FSLP au cours desquelles des spécialistes 'charge utile' doivent servir de sujets. Cette Commission veillera à la protection des droits et de la santé des spécialistes 'charge utile' et au respect des règlements et procédures adoptés par les diverses instances internationales.

Modèle technologique du module long de Spacelab, avec les sous-systèmes et les baies d'expériences intégrés, au cours des essais chez ERNO, à Brême

Spacelab's Long Module (engineering model), with integrated subsystem and experiment racks, under test at ERNO, Bremen.



Spacelab

The first Spacelab pallet and several items belonging to the mechanical ground-support equipment were delivered to NASA (Kennedy Space Center) in December 1978 as scheduled. Shipment of a second pallet will take place in April. The two pallets are intended for use by NASA during the Orbiter Test Flights of the Space Shuttle, which will begin next November and continue throughout 1980.

Because of technical difficulties encountered during the integration and testing of the engineering model, a schedule adjustment has become necessary. The main industrial contractor has proposed the following delivery dates:

Engineering model	April 1980
Flight unit I	July 1980
Flight unit II	November 1980

These dates are compatible with the latest NASA planning for the first two Spacelab flights.

NASA has officially announced a new launch date of 17 August 1981 for the first Spacelab mission, which carries a joint NASA/ESA payload. This date is now the basis for all planning activities for the First Spacelab Payload (FSLP) project. NASA has also announced that all NASA Spacelab integration activities will be executed at Kennedy Space Center, including the level-IV integration work for the first Spacelab mission. The impact of this decision on the FSLP project is currently under consideration.

A Medical Board composed of eight experts nominated by ESA Member States, has been established to oversee all FSLP-related experiments that involve Payload Specialists as test subjects. This Board will ensure that the rights and welfare of the Payload Specialists are fully protected and in keeping with the regulations and procedures adopted by various international bodies.

Ariane

Ariane erected for the first time on the launch table

Early in December, a particularly important phase in the development of Ariane began at the Launch Site in Guiana – the propellant mockup tests. Their purpose is to qualify the equipment and procedures for filling the launcher, using a dedicated mockup to represent the flight model in terms of filling, pressurisation, sealing and thermal protection. Real propellants and fluids are used.

This exercise comprises three phases:

(i) A preliminary phase, intended to qualify the operations for handling the various launcher elements and transporting them from the Launcher Integration Site at Les Mureaux to the Ariane Launch Site at Kourou. It involves transport by barge from Les Mureaux to Le Havre, by ship from Le Havre to Cayenne, and by road from Cayenne to the Launch Site. This qualification took place satisfactorily in June 1978.

(ii) A launcher-erection phase and bending-mode tests. These operations took place between 4 December 1978 and 4 February 1979, and allowed verification of: the interface between the first stage and the launch table; the procedures for connecting up the umbilical cables and plaques; and the operations for handling and assembling the payload and fairing.

(iii) A launcher-filling phase. The main objectives of this phase are to qualify the procedures, software and ground and on-board hardware needed for the filling, draining, pressurisation and flushing operations, using the real launch countdown and a simulated wait on the launch pad, and to measure the launcher's movements when exposed to the wind and the evolution of the propellant temperatures.

A further objective of this phase is to assess the Launch Site's ability to carry out two complete fills of the launcher and five complete fill sequences for the third stage (LOX, LH_2 and helium).

For these latter two phases, a sequence of operations was adopted that allowed all the objectives to be covered in a series of steps, and the operations planned for real launches to be carried at the appropriate moments.

Since less experience is available with cryogenic phenomena, the filling tests on the third stage (H8) will be carried out first, and those on L140 and L33 will follow only when the procedures for H8 have been perfected.

It was originally planned to conduct this test campaign between August and November 1978, but it was delayed by:

- the fact that it took longer than scheduled to set up the facilities, which are rendered complex by the very nature of the fluids used: liquid hydrogen, liquid oxygen, nitrogen tetroxide, and unsymmetrical dimethyl-hydrazine.
- the introduction of modifications resulting from the development of the stages.

To prevent these delays from compromising the overall time schedule for Ariane, the Launch-Site test philosophy has been changed: the phase comprising the validation of the checkout system and the operational electrical checking procedures will be carried out before and not after the propellant mockup operation as originally planned.

The Kourou Launch Centre.
Centre de lancement de Kourou

Ariane

Première érection d'Ariane sur la table de lancement

Début décembre a commencé en Guyane, sur l'Ensemble de Lancement, une phase particulièrement importante dans le cadre du développement d'Ariane, les essais Maquette Ergols. Le but de ces essais est de qualifier les matériels et les opérations de remplissage du lanceur, à l'aide d'une maquette spécifique représentative du modèle de vol en ce qui concerne les remplissages et lapressurisation, l'étanchéité au ruissellement et les protections thermiques, en utilisant les ergols et les fluides réels.

Cet exercice se déroule en trois phases:

(i) Une phase préliminaire permettant de qualifier les opérations de manutention et de transport des différents composants du lanceur entre le Site d'Intégration Lanceur aux Mureaux et l'Ensemble de Lancement Ariane à Kourou. Cette phase, essentiellement effectuée par voie fluviale entre Les Mureaux et Le Havre, par voie maritime entre Le Havre et Cayenne, et par voie routière entre Cayenne et l'Ensemble de Lancement, s'est déroulée de façon satisfaisante au mois de juin 1978.

(ii) Une phase d'érection du lanceur et essais de lâcher – Ces opérations qui se sont déroulées du 4 décembre 1978 au 4 février 1979 ont permis de vérifier l'interface entre le 1er étage et la table de lancement, les procédures de raccordement des ombilicaux et prises culots, les opérations de manutention et d'assemblage de la charge utile et de la coiffe.

(iii) Une phase de remplissage du lanceur – Les objectifs de cette phase sont notamment de qualifier les procédures, le logiciel et les matériels sol et bord nécessaires aux opérations de remplissage, vidange, pressurisation et assainissement, compte tenu de la chronologie de lancement réelle, et de simulation d'attente sur rampe, de mesurer les mouvements du lanceur exposé au vent et l'évolution des températures des ergols.

Un autre objectif de cette phase est l'évaluation de l'aptitude de l'ensemble de lancement à effectuer deux pleins complets du lanceur et cinq séquences complètes de remplissage du troisième étage (LOX, LH_2 et hélium).

Pour effectuer ces deux dernières phases, un enchaînement des opérations a été défini de façon à avancer pas à pas pour couvrir tous les objectifs et pour réaliser aux moments opportuns les opérations telles qu'elles sont prévues pour la mise en oeuvre des lanceurs réels.

Compte tenu de la moins bonne connaissance des phénomènes cryogéniques, les premiers essais de remplissage seront effectués sur le troisième étage (H8), ceux du L140 et du L33 n'intervenant qu'après la mise au point des procédures H8.

Ariane erigé sur table de lancement
Ariane erected on the launch table at Kourou

Initialement prévue pour la période d'août à novembre 1978, cette campagne d'essais a été retardée:

– par une mise au point plus longue que prévue d'installations rendues complexes par la nature même des fluides utilisés (hydrogène et oxygène liquides, peroxyde d'azote, diméthylhydrazine);

– par l'introduction des modifications résultant de la mise au point des étages.

Afin que ces retards ne compromettent pas le calendrier général Ariane, la procédure des essais mise en oeuvre sur l'ensemble de lancement a été modifiée de façon à effectuer d'abord la phase de validation du banc de contrôle et des procédures de contrôle électrique opérationnelles, initialement planifiées à l'issue de l'opération Maquette Ergols.

continued from page 32

Let it be assumed that, from the technical standpoint, the execution of the project is in conformity with the forecasts on which the initial schedule was based. The real needs of the project, in terms of current Accounting Units, can then be expressed as follows:

Year 1 $x_1(1+\tau_1)$
Year 2 $x_2(1+\tau_1)(1+\tau_2)$
.
.
.
Year n $x_n(1+\tau_1)\dots(1+\tau_n)$

However, the budget for Year 1 remains in the price level of Year 0, and during Year 1 the estimates of Year 2 and later are updated to the price levels of Year 1, as follows:

Year 1 x_1
Year 2 $x_2(1+\tau_1)$
Year 3 $x_3(1+\tau_1)$
.
.
.
Year n $x_n(1+\tau_1)$

A year later (during Year 2), the up-dating process is repeated:

Year 1 x_1
Year 2 $x_2(1+\tau_1)$
Year 3 $x_3(1+\tau_1)(1+\tau_2)$
.
.
.
Year n $x_n(1+\tau_1)(1+\tau_2)$

From this it can be seen that each year a programme running as planned is missing that part of its resources corresponding to the inflation from the previous year. Compensation for this effect is normally made in the second year after the budget execution in question, as follows for Year 1:

Year 1 x_1
Year 2 $x_2(1+\tau_1)$
Year 3 $x_3(1+\tau_1)(1+\tau_2) + \underline{\underline{x_1\tau_1}}$

When back-dating the Costs-to-Completion estimate of a project, however, it is the price level ruling at the time of execution that must be used and not the price level upon which the particular budget was prepared. That it to say, past payments and budgets in execution must be back-dated according to their real purchasing power. Thus the back-dating calculation for the above project during Year 3 (i.e. while Year 3 and later is still expressed in Year 2 prices) will be made as follows when $E_1, E_2 \dots E_n$ are actual or planned expenditures:

$$E_0 = \frac{E_1}{1+\tau_1} + \frac{E_2}{(1+\tau_1)(1+\tau_2)} + \frac{E_3}{(1+\tau_1)(1+\tau_2)} \dots + \frac{E_n}{(1+\tau_1)(1+\tau_2)}$$

where E_0 can be compared directly with the ceiling agreed in the Arrangement.

As noted earlier, this procedure is applied independently to the two principal groups of expenditure, namely 'Internal & Support' and 'External Development'.

Preparation of the weighted-average index for Internal & Support costs

In order to obtain an average index, several weighting calculations have to be carried out. The basic price variation indices provided annually by the Federal Statistical Office in Wiesbaden, are weighted according to the proportions of the expenditure categories and according to the geographical distribution of work. A further weighting concerns the currency conversion rates, which modify the overall weighted index in accordance with the geographical distribution of work.

For the past years, the distribution of expenditure is taken from the accounts and for the year in execution from the Financial Plan.

Table 1 shows an example of this calculation for a hypothetical project.

Table 1 — Weighted average index for price variations and exchange rates, Internal and Support costs, for 1977 to 1978, for a hypothetical project

Heading	Expenditure pattern 1978 (MAU)	Expenditure pattern (%)	Price variations 1977-1978	Exchange variations 1977-1978	Weighted combined variation
Personnel (NL)	0.40	22.2	1.037	1.073	24.70
Running (NL)	0.10	5.6	1.038	1.073	6.24
Facilities	–	–			
Investment	–	–			
Administrative support (NL)	0.10	5.6	1.061	1.073	6.38
Special-to-project expenditure	0.10	5.6	1.069	0.988*	5.92
Support usage:					
Personnel (NL)	0.40	22.2	1.053	1.073	25.08
Personnel (D)	0.20	11.1	1.053	1.064	12.44
Other	0.50	27.7	1.053	0.988*	28.82
Total	1.80	100.0	–	–	109.58 Index = 1.096

* A weighted average for the General Budget

It should be noted that in the last stage of back-dating, i.e. to the price level ruling in the Arrangement, the column for conversion-rate variation would not be used.

Preparation of the weighted-average index for External Development
In this group there is a single expenditure category dominated by the main spacecraft and/or payload-development contract(s). The elements of the calculation of a single back-dating index are therefore the geographical distribution of the work, the individual national indices for price variation and the individual currency variations.

As I have already said, it must be assumed that the geographical distribution of work as planned remains constant throughout the execution of the project and is only modified by the successive effects of national price and currency variations.

A typical calculation of annual indices for a hypothetical development project is shown in Table 2. In this example the geographical distributions are imaginary, but the price variations and currency variations are real. It should be noted that between successive stages of the calculation each new distribution is normalised to 100.

As noted above, the first stage (last years) of the back-dating corrects the last conversion-rate variation only, whereas the last stage of the calculation back to the Arrangement economic conditions does not correct the conversion-rate variation.

The final back-dating calculation
Having calculated the weighted-average indices for the two main groups of expenditure, these are applied in a cumulative manner, as shown in Table 3 for the same hypothetical project.

The final stage of the work is to present the Cost-to-Completion in so-called 'current' price levels, together with the indices used and the back-dated annual amounts with the back-dated total for comparison with the estimate presented at the time of the original Arrangement, for use in the Agency reports. This takes the form shown in Table 4.

A simple division of back-dated total by original estimate reveals any under or overrun as a percentage of the Arrangement.

Table 2 — Calculation of back-dating indices for hypothetical development.

	B	DK	F	D	I	NL	E	S	CH	GB	USA
Mid-1976 to Mid-1977											
Geog distribution	2.412	3.304	18.985	28.383	13.492	1.090	3.763	4.011	3.840	9.898	10.822*
Price variation	1.073	1.069	1.113	1.049	1.248	1.061	1.173	1.089	1.018	1.100	1.071
Conv rate variation	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000**
New distribution	2.588	3.532	21.130	29.774	16.838	1.156	4.414	4.368	3.909	10.888	11.591
									Overall Index 1.102		
Mid-1977 to Mid-1978											
Geog distribution	2.349	3.205	19.177	27.021	15.281	1.050	4.006	3.964	3.548	9.881	10.519
Price variation	1.058	1.087	1.121	1.043	1.128	1.047	1.226	1.110	1.017	1.100	1.085
Conv rate variation	1.069	0.986	0.933	1.064	0.933	1.073	0.951	0.979	0.965	0.948	0.973
New distribution	2.656	3.436	20.057	29.987	16.082	1.179	4.671	4.308	3.482	10.304	11.105
									Overall Index 1.073		
Mid-1978 to mid-1979											
Geog distribution	2.477	3.203	18.698	27.955	14.993	1.099	4.354	4.016	3.246	9.606	10.353
Price variation	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000***
Conv rate variation	1.010	0.980	0.987	1.034	0.942	1.015	0.800	0.877	1.209	0.977	0.915
New distribution	2.501	3.139	18.455	28.906	14.123	1.116	3.483	3.522	3.924	9.385	9.473
									Overall Index 0.980		

* Geographical distribution of development contracts

** Exchange rate omitted from this stage

***Price variation omitted from this stage

Table 3 — Cost-to-completion back-dating for a hypothetical project

	1977	1978	1979 and later years	Total back-dated
Internal and Support costs	$\frac{0.44}{1.079}$	$\frac{1.70}{1.079 \times 1.096}$	$\frac{20.62}{1.079 \times 1.096 \times 1.040}$	18.61
Development	$\frac{0.50}{1.102}$	$\frac{8.50}{1.102 \times 1.073}$	$\frac{50.20}{1.102 \times 1.073 \times 0.980}$	50.96
Total project cost back-dated to Arrangement price level				69.57
Arrangement ceiling (at mid-1976 price level)				70.00
Deviation				0.6%

Table 4

PRICE BASIS
NIVEAU DES PRIX Mid-1978

EXCHANGE RATES 1979
TAUX DE CONVERSION

COST-TO-COMPLETION (CTC) PAYMENTS IN MAU — HYPOTHETICAL — *COUT A ACHEVEMENT (CTC) PAIEMENTS EN MUC*

	1977	1978	1979	1980	1981	1982	1983	1984	1985	*CTC*	
DIRECT INTERNAL COSTS											*DEPENSE DIRECTES INTERNES*
Personnel (net)	0.10	0.40	0.50	0.50	0.50	0.40	–	–	–	2.40	*Personnel (net)*
Running	0.02	0.10	0.12	0.12	0.12	0.20	–	–	–	0.68	*Fonctionnement*
Facilities											*Installations*
Investment											*Immobilisations*
TOTAL	0.12	0.50	0.62	0.62	0.62	0.60	–	–	–	3.08	*TOTAL*
DIRECT EXTERNAL COSTS											*DEPENSES DIRECTES EXTERNES*
Studies	0.50	1.00	0.20	–	–	–	–	–	–	1.70	Etudes
Spacecraft Development	–	5.00	8.00	9.00	4.50	2.00	1.00	–	–	29.50	Développement du véhicule
Payload Development	–	2.50	4.00	4.50	2.50	0.50	–	–	–	14.00	Développement de la charge utile
Launch Costs	–	–	–	4.00	5.00	5.00	–	–	–	14.00	Frais de lancement
TOTAL	0.50	8.50	12.20	17.50	12.00	7.50	1.00	–	–	59.20	*TOTAL*
CONTINGENCY											*MARGE D'ALEAS*
EXCHANGE LOSSES											*PERTES DE CHANGE*
INDIRECT COSTS											*DEPENSES INDIRECTES*
Administrative Support	0.02	0.10	0.12	0.12	0.12	0.10	–	–	–	0.58	*Soutien administratif*
Special to Project Expenditure	0.05	0.10	0.20	0.50	1.00	0.50	–	–	–	2.35	*Dép. spéc. aux projets*
Support according to Usage	0.25	1.10	2.00	2.50	3.00	3.50	1.75	1.75	1.00	16.85	*Soutien en fonction utilisation*
TOTAL	0.32	1.20	2.32	3.12	4.12	4.10	1.75	1.75	1.00	19.78	*TOTAL*
GRAND TOTAL (NET)	0.94	10.30	15.14	21.24	16.74	12.20	2.75	1.75	1.00	82.06	*TOTAL GENERAL (net)*
RESERVE FOR PRICE VARIATIONS											*RESERVE POUR VARIATIONS DE PRIX*
INCREASE IN INTERNAL AND INDIRECT COSTS %	7.9	9.6	4.0								*AUGMENTATION DES DEP. INTERNES ET INDIRECTES %*
INCREASE IN EXTERNAL COSTS %	10.2	7.3	2.0								*AUGM. DES DEPENSES EXTERNES %*
BACKDATING TO THE ARRANGEMENT	0.86	8.63	12.92	18.14	14.21	10.23	2.29	1.42	0.81	69.57	*RETROACTUALISATION AU NIVEAU DES PRIX DE L'ACCORD*
COST ESTIMATES OF THE ARRANGEMENT										70.00	*COUT ESTIMATIF DE L'ACCORD*
REMARKS						*OBSERVATIONS*					

Conclusion
The procedure described above provides a result of adequate accuracy for the management decisions for which it is intended with reasonable levels of expended effort. In addition, it has the great merit that it can easily be followed and that the data are traceable.

Economic Benefits of ESA Contracts

G. Niederau, General Planning Department, Directorate of Planning and Future Programmes, ESA, Paris

One of the most direct results of the joint European space effort has been the development of technology that on the one hand has increased scientific knowledge and on the other can be directly applied in, for example, communications satellites. The results achieved have allowed the European countries to gradually catch up with the 'big space powers' in terms of both science and applications.

However, ESA's activities also have a number of indirect effects on the overall economic activities in its Member States, as a result of the cooperation between the Agency and the many European firms that work actively in the space programmes. These induced (secondary) effects have been analysed through a study carried out for ESA by the Theoretical and Applied Economics Department of the Louis Pasteur University in Strasbourg. The first phase of this study was completed last summer.

In order to carry out its programmes, ESA demands of industry products of a high technological standard to precise specifications. To be able to deliver these products and to meet the specifications, the European companies have set up a complex industrial organisation with the aim of fostering the best conditions for mutual cooperation.

Participation in Europe's space programmes calls for advanced technological knowhow together with mastery of the problems of project management within an international organisation. These characteristics have a wide range of major economic consequences that can be identified and, to a certain extent, measured in the firms concerned.

One of ESA's roles is to improve the competitiveness of European industry. Although the quantitative aspects of the analysis presented here may not bring out this point in its entirety, they might nevertheless serve to provide an indication of the degree of success that is being achieved in that area. The fact that a complete quantitative knowledge of the overall secondary value of ESA contracts can never really be achieved calls for care in expounding the results. What is important, however, is to consider qualitatively the development of secondary effects engendered by ESA contracts in European industry.

In the Strasbourg study, the induced economic effects of the contracts placed by the Agency have been measured by making an overall estimate of the way in which the firms have made use of their experience in the space field to increase the level of their activities or to improve their methods of production or management.

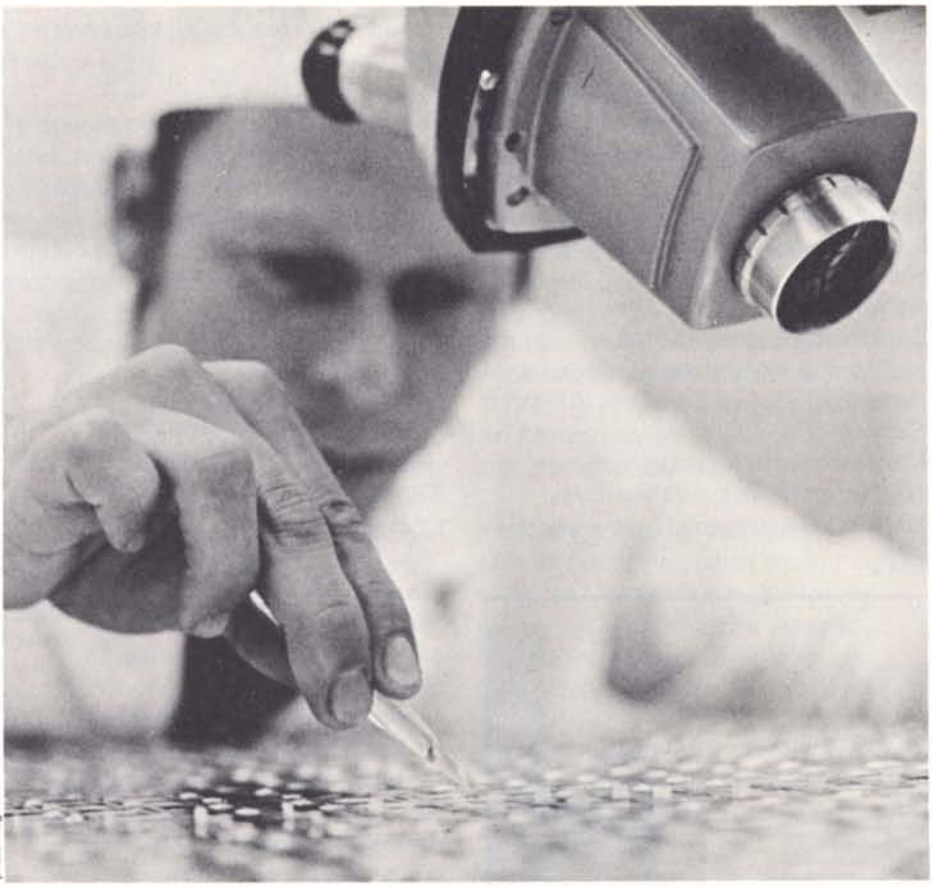
One hundred and seventy one cases of benefit were quantified in respect of the 77 contractors visited by the investigating team between March 1977 and March 1978. In addition, the contractors quoted some 80 other types of benefit which it was impossible to quantify, many relating to increased expertise of personnel through exchanges of information with other contractors, and to the marketing effect of their association with ESA.

To explain the method used for quantification, it is convenient here to cite two examples encountered when visiting firms, examples that are not exhaustive in themselves but nevertheless provide concrete illustrations of the mechanisms of generating secondary benefits.

Example 1

This case of benefit is one of a new product developed for space requirements and reused in a new technological field, namely that of new energy sources.

The contractor in question has developed a technology that allows excessive heating of the electronic equipment on board a spacecraft to be avoided by dumping heat outside the craft. This process has promising applications in a wide variety of fields, such as solar energy, water heating, desalination of salt water, refrigerating processors, etc. Having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mastered the process, the contractor has established a leading position in the area of new energy sources. A market for this technology already existed in 1977, and it is expected to grow exponentially.

The secondary benefit in this case can be quantified in terms of the amount of added value relating to sales of this technology in areas other than space, weighted, for each year in which a cost-estimate is possible, by the effect of ESA contracts on this innovation.

Example 2
Space requirements have demanded qualitative improvements in a large number of products. Reliability, lightness, and greater resistance to shock and vibration are but a few of the essential qualities required in a space environment. Clearly the rapid transfer of such improvements to the industrial field and a fortiori to off-the-shelf products is a difficult matter. In the short term, account must be taken of the price constraints imposed by compliance with such requirements, but with the prospect of long-term improvements to the existing product any progress made in the quality of the product plays a very important role for most contractors.

A number of cases of transfer of qualitative improvements to industrial products have already been noted. In the production of nickel-cadmium batteries, for example, one firm has been able to improve the quality of its products by complying with the requirements of a space contract partly funded by ESA.

The type of battery studied, although slightly more expensive than that produced by competitors, has met with particular success in the launcher and missile markets, partly as a result of the good guarantee that can be given as a result of qualitative improvements incorporated through the space work.

The secondary benefit here can be quantified as follows:
- the influence of ESA over a one year period is measured in terms of the proportion of ESA contracts involved in all contracts carried out by the firm for space applications.
- the influence of the quality is reflected by a certain percentage of sales due to the high reliability of the product. This percentage differs according to the type of market.

The two examples noted show that the economic benefits accruing from ESA contracts appear as very varied forms of advantage for the contracting firms, and in conducting the survey among the firms engaged on ESA programmes four main categories of benefits could be identified:

Category 1 – Technological benefits
Category 2 – Commercial benefits
Category 3 – Organisation and methods benefits
Category 4 – Work-factor benefits.

The analysis of the quantified results which we will go on to discuss is based on this classification and on a grouping of activities in six principal sectors, on the basis of the INSEE (Institut National de Statistique et d'Etudes Economiques) nomenclature of economic activity.

Sector 1
Electronic and electrical ground equipment, comprised of ground telecommunications systems, radio links, electronic ground testing and measuring instruments, radar systems, etc.

Sector 2
Electronic and electrical on-board equipment, comprised of on-board servo systems, precision instruments, optical systems, measuring instruments, batteries, etc.

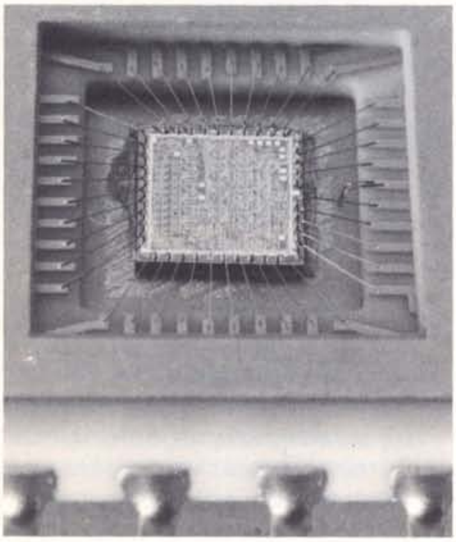
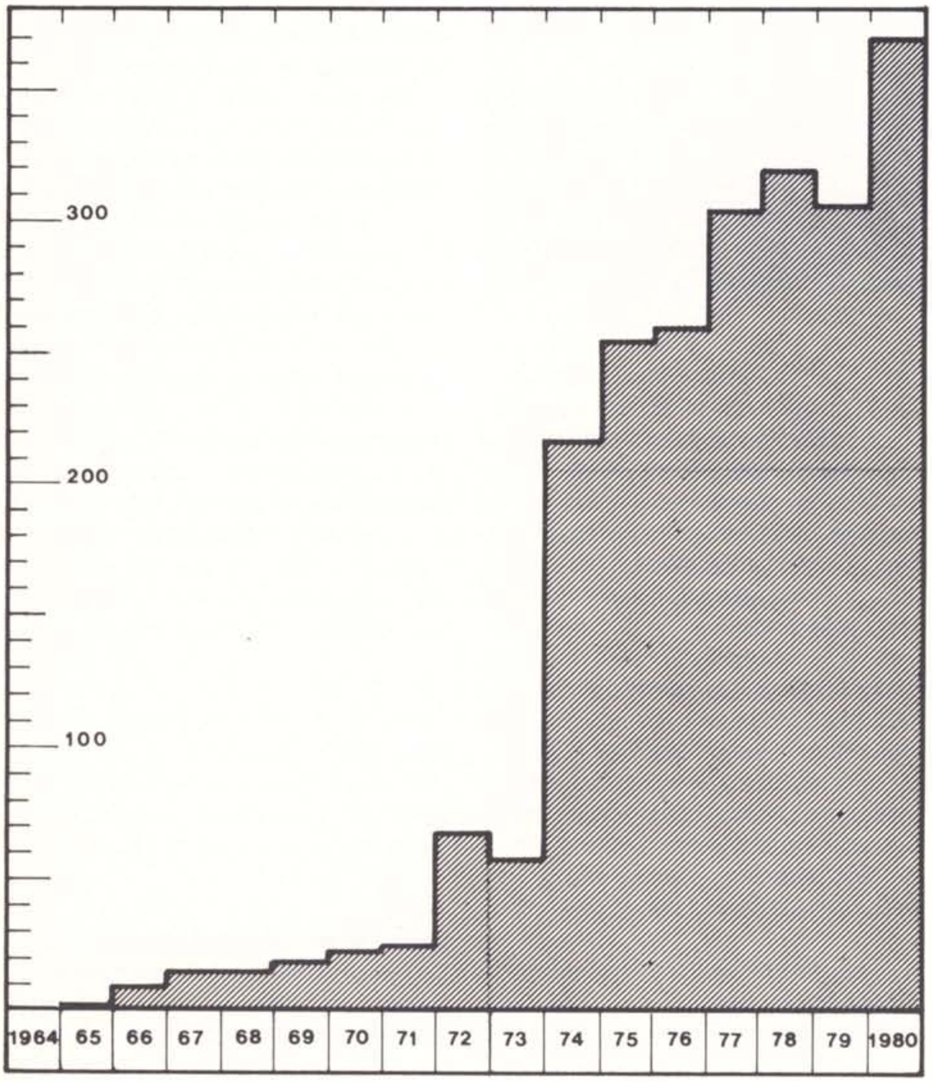


Figure 1 — Total annual benefit (in MAU, value 31 December 1977)



Sector 3
Aerospace industry, comprised of prime contractorship in respect of rockets, structures, integration, apogee boost motors, propulsion units, etc.
Sector 4
Electronic data handling and processing systems, comprised of hardware and software.
Sector 5
Engineering, comprised of launch-site engineering, systems design, transport systems.
Sector 6
Miscellaneous industrial equipment and new technologies, comprised of new forms of energy, thermal control, control of industrial processes, pumps, vibration tests, etc.

Sectors 5 and 6 include miscellaneous activities whose importance is low in terms of ESA contracts, but they complement space activities and benefit, as will be shown later, from the process of diversification of benefit originating in the other sectors.

Quantitative results
The quantitative results relate to the 77 contractors in the sample, which represents about 81.5% of ESA's expenditure in its Member States between 1964 and 1975.

In each of the 171 cases of quantified benefit, the ESA contractors have assessed their gains (or losses, if any) over a period extending up to 1980. To appreciate the specific benefit to the contractors themselves, the amounts indicated in terms of turnover have always been converted into terms of added value. When the observed benefits were shown to generate economic effects with these contractors' suppliers, an assessment of the amount of corresponding benefit for the suppliers is given by the value of intermediate consumption.

The total net benefits resulting from ESA contracts can be summarised as follows (all further figures expressed in Accounting Units as at 31 December 1977):

Total benefit for the sample of which	= 2260 MAU
Net total benefit for ESA contractors	= 1803 MAU
Estimated net total benefit for the contractors' suppliers	= 457 MAU

The total amount of contracts in terms of payments received by the contractors in the sample was 850 MAU. The overall ratio of the total amount of benefit to the total value of contracts received by the contractors in the sample is therefore

2260/850 = 2.7 (the estimated standard deviation is 0.6).

This ratio is a *synthetic indicator* of the overall results. It means that an expenditure of 100 units by ESA has resulted in an average of 270 units of benefit for ESA's contractors and their suppliers.

This ratio should not, however, be interpreted as a financial return on investment, since a number of economic agents (contractors' competitors, contractors' customers, etc.) have not yet been taken into account in this first phase of the study. To allow conclusions to be reached relating to all economic agents in the Member States, a second-phase study is presently under way.

The total benefit extrapolated for the whole of industry in the Member States is 2772 MAU, while the total expenditure of the Agency between 1964 and 1975 amounts to 1855 MAU.

If account is taken of that total expenditure by the Agency (contracts within the Member States, contracts outside the Member States, Agency running expenditure, etc.) the benefit/expenditure ratio is of the order of 1.5.

Annual evolution of the net total benefit
As Figure 1 shows, generally speaking the annual total benefit has grown sharply, especially after 1974, and will reach a maximum of 374 MAU in 1980. The slight reduction observable in this strong trend in 1979 occurs because the total benefit results from several types of benefit, some of which develop very differently over the period in question:

- Up to 1977 a large part of the total benefit identified by the contractors consists of new contracts funded by bodies other than ESA but obtained wholly or partly thanks to ESA. After that date, the contribution of this type of benefit decreases rapidly because forecasting regarding new contracts becomes very difficult from 1977 onwards.
- On the other hand, the amount of benefit corresponding to increased sales due to new products or technological improvements generally develops exponentially.

The reaction times corresponding to the 171 cases of quantified benefit are shown in Table 1. The reaction time is defined

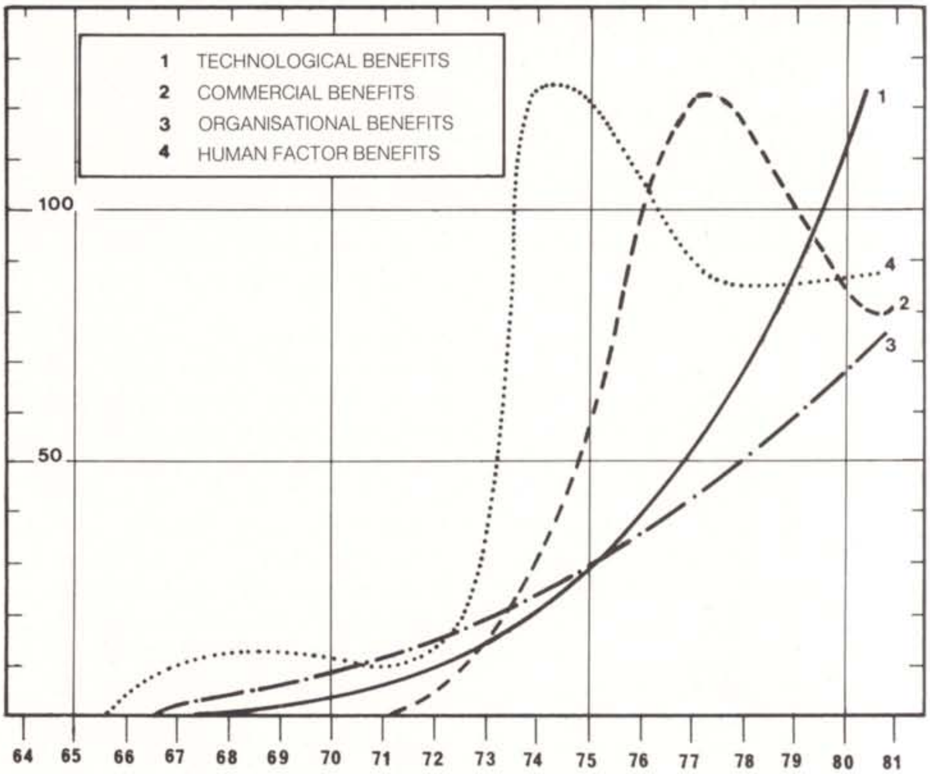
Table 1 — Reaction time for the emergence of benefit

Reaction time	Amount of benefit (kAU, 31 12 77)	Percentage of total benefit
1 year and less	389 017	17.2
2 years	407 621	18.0
3 years	295 790	13.1
4 years	292 135	12.9
5 years	326 580	14.5
6 years and more	548 855	24.3
Total	2 259 998	100.0

Table 2 — Benefit distribution among the benefit categories

Category	Total amount	
1 Technological benefits	505 924 kAU	(22.4% of the total benefit)
2 Commercial benefits	590 055 kAU	(26.1% of the total benefit) This category of benefit comprises all types of benefit corresponding to various cases of sales increases by the contractor without any determining technological innovation. Here ESA's influence is due either to space qualification or to the new opportunities of sales open to the contractor after completion of work for ESA. In particular, the aspect of *international collaboration* is recognised as a remarkably positive one by all contractors. Many European firms that have worked jointly on an ESA contract have thus been able to serve their apprenticeship for international collaboration. Some of them have set up particularly strong links with each other, enabling them to perform very many mutual services (use of equipment, exchange of engineers, marketing network).
3 Organisation and methods benefits	380 998 kAU	(16.9% of the total benefit) This type of benefit leads to improved productivity in the firms, through improvements to general organisation of production.
4 Work-factor benefits	783 022 kAU	(34.6% of the total benefit) According to a large number of the contractors interviewed, a major part of the benefits induced by ESA contracts is due to the effect on manpower. A company's space department is a promotion sector as regards both knowhow and individual talents. Benefits in this category can be divided into two parts that are quantifiable in terms of added value in relation to a hypothetical situation: increase in personnel knowhow, and maintenance of a highly skilled production team.

Figure 2 — Annual evolution of categories of benefit (in MAU, value 31 December 1977)



here as the time that elapses between the placing of the ESA contract(s) generating the benefit, and the beginning of the period during which the first secondary effects are recorded by the contractors. Note that the mean reaction time for the emergence of a benefit is at least three years.

Overall losses

Losses, which were also estimated during the interviews, have resulted essentially from cost overruns on contracts, and from the cost of preparing tenders that did not lead to contracts. The overall losses accumulated in this way as a result of ESA contracts were estimated to be 43 MAU over the seventeen-year period.

Annual development of the benefit categories

Figure 2 shows the adjusted curves for development in respect of each category of benefit. Generally speaking, this figure provides a synthesis of a very significant part of the information collected during the Strasbourg investigation and analysis of the four curves presented there leads to a number of interesting conclusions:

Analysis of the evolution of benefits in terms of work factor

This curve correlates closely with the evolution of ESA contracts. The reaction time between ESA contract placement and this type of benefit is very short and this curve therefore shows the 'immediate' effects of ESA contracts on the contractors.

One of the immediate benefits of space programmes is the creation within certain contracting firms of a 'critical nucleus' of highly qualified engineers. This nucleus ensures that these particular contractors can maintain a high R & D activity, allowing them to tender competitively and credibly for complex contracts and to envisage future diversification. This category of benefit is related to the magnitude of the space programmes and it has therefore evolved with particular speed between 1972 and 1975. After 1975 the prospects for space programmes became less certain, and ESA contractors took this uncertainty into account in quantifying this category of benefit.

Analysis of the evolution of commercial benefits

This curve follows the evolution of ESA contracts with a time lag of two to three years, the commercial benefits induced by ESA contracts generally being felt by the contractors after that sort of time lapse.

Two phenomena should be taken into account in interpreting this data. Firstly, for the years prior to the commencement of the investigation (1977), there is a 'forgetfulness effect' at work; that is to say information on this type of benefit gradually disperses with time, all the more so since some of those responsible for the first ESA projects have since left the space sector. Secondly, for the years following the investigation (1977), an 'uncertainty effect', reflecting growing uncertainty in the future of space programmes in general, has tended to reduce the quantified amount of commercial benefit. This is particularly evident in the case of 'new contracts' foreseen by contractors.

Analysis of the evolution of technological benefits

Unlike the two previous curves, the evolution of technological benefit shows a regular exponential growth. The reason for this is that diversification and the production of new products require a structural change in a firm's capital equipment and result from a longer-term industrial strategy than the previous cases. On the basis of the information collected, this curve could be extrapolated beyond 1980, but to do so strictly correctly it will be necessary to take into account factors other than those induced by ESA, whose influence can be just as decisive after that date.

Analysis of the evolution of benefits in organisation and methods

The curve corresponding to organisational benefit grows regularly like the commercial-benefits curve, but less

Table 3a — Distribution of benefit from each sector according to benefit category

Sector	Technological benefit	Commercial benefit	Organisational benefit	Work-factor benefit	Total
1 Ground electronics	62 937	50 886	13 686	19 203	146 712
2 On-board electronics	302 761	168 300	62 491	89 890	623 442
3 Aeronautics	100 009	313 208	266 689	585 269	1 265 174
4 Data handling	36 992	57 661	11 277	70 494	176 423
5 Engineering	0	0	23 424	2 602	26 026
6 Industrial equipment	3 226	0	3 431	15 564	22 220
Total	505 924	590 055	380 998	783 022	2 259 998

Table 3b — Percentage distribution of benefit from each sector according to benefit category

Sector	Technological benefit	Commercial benefit	Organisational benefit	Work-factor benefit	Total
1 Ground electronics	42.9	34.7	9.3	13.1	100
2 On-board electronics	48.6	27.0	10.0	14.4	100
3 Aeronautics	7.9	24.8	21.1	46.3	100
4 Data handling	21.0	32.7	6.4	40.0	100
5 Engineering	0	0	90.0	10.0	100
6 Industrial equipment	14.5	0	15.4	70.0	100

steeply. This curve shows the regular improvement of the contractors' productivity, from the organisation and methods points of view.

In conclusion, the first two categories of benefit – commercial and work-factor – are correlated with the evolution of ESA expenditure, with a variable time lag. The technological and organisational benefits, on the other hand, lead to an evolution in the contractors' structure and internal organisation.

Benefit distribution among the activity sectors

An analysis from the point of view of benefit/contract ratio brings to light the following principal characteristics:

- The three main sectors concerned with space activities – on-board electronics, aeronautics and data handling – which have accounted for *about 93% of total contracts*, show a benefit/contract ratio of a comparable order of magnitude.
- The other sectors, which show lower amounts of contracts obtained, have a benefit/contract ratio appreciably higher than average in the case of ground electronics and lower than average in the case of industrial equipment, where supplies are generally fairly standardised.

Significant differences between sectors show up clearly, however, when the distribution of the amount of benefit in each sector is treated according to category of benefit (Tables 3a,b).

These distribution tables highlight two distinct groups of sectors that show appreciable benefits. Group 1, comprising ground electronics, on-board electronics and data handling, is characterised by outstanding benefits in the *technological and commercial* areas. Group 2, comprising aeronautics, engineering and industrial equipment, is characterised by greater relative benefits in the areas of *organisation and work factor*.

Export benefits

'Export benefits' are those that give rise to sales or other benefits obtained outside ESA's Member States.

As the total amount of export benefit has been assessed as 622 488 kAU, i.e. 27.5% of the total benefit, contractors in the Member States have clearly been able to significantly increase their sales in countries that are difficult to penetrate commercially, such as the United States, or to gain a leading position in some markets in developing countries. A large number of contractors enjoying these benefits consider them particularly positive, since it is probable that without the ESA reference and space qualification many foreign markets would remain closed. It is thus partly thanks to the space qualification awarded by ESA that some European contractors have been able to take part in American space programmes funded by NASA, Comsat, Intelsat, etc.

Benefits outside space activities
In respect of each contractor interviewed, the quantified benefits have been divided into two separate groups, depending on whether the benefits concern exclusively the space sector of the firm or its other activities:

- Amount of benefit induced in purely space activities:
  715 MAU (31.6% of the total benefit)
- Amount of benefit induced in the contractor's other activities:
  1545 MAU (68.4% of the total benefit).

This strong penetration of the advantages obtained into activities other than the space field calls for an explanation.

A first possible reason lies in the place of the space sector in the firms canvassed. Generally speaking, the space sector constitutes only about 3% of the total activity of the contractors in the sample. This contribution, which is relatively small in terms of turnover, is nevertheless considered by a large number of contractors to be an essential one for the development of their business. For instance, this sector is often regarded as a kind of 'training school' in which personnel of all levels and responsibilities (engineers, executives, etc.) are versed before being posted to other sectors of activity, so ensuring that all the experience and knowhow accumulated in this 'leading' sector can be transferred to the contractor's other activities. The fact that an important part of the quantified return corresponds to 'work-factor benefits', which are easily transferrable from one sector to another, makes it easier to spread the benefits gained in the space sector to all the other activities.

Benefits by countries
The ratios between benefits and contracts by country do not reveal major differences between the Agency's various Member States. France, the United Kingdom and Italy have coefficients close to the general average (2.7); the estimate for Germany is slightly higher (3.2) than for the countries as a whole, while that for the 'other countries' (Belgium, Denmark, Spain, The Netherlands, Sweden and Switzerland) is slightly lower (2.2).

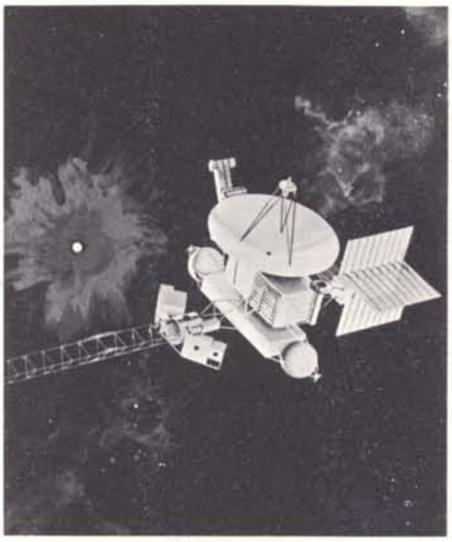
More significant differences emerge when pursuing the type of benefit obtained. If one examines the export benefit (outside the Member States), obtained by countries, the amount obtained by the category 'other countries' is relatively high (58.9% of their total benefit), whereas Italy's benefit (9.1% of its total benefit) is relatively small.

Other criteria also reveal differences between countries. France, for example, transfers most of its benefit outside the space sector (more than 80% of its benefit), whereas the United Kingdom disseminates most of its benefit within the space sector itself (60% of its benefit).

Collaboration of contractors
Some 130 visits to firms were needed to obtain a complete quantification from the 77 contractors in the sample. In most cases, additional visits had to be made to one and the same contractor either because several departments in the one firm were concerned with space work, or because the complexity of certain cases called for a more detailed interview.

The collaboration of the contractors in the investigation has proved remarkable in every respect. The investigating team has assessed that industry's overall contribution to the study could be as high as 250 man-days, one firm alone devoting more than 19 man-days to the members of the investigating team. Clearly, European industry has taken a strong interest in the investigation.

Outlook
The results of the second-phase study which is currently under way will be presented within the framework of a joint ESA/University of Strasbourg International Colloquium on 'The Economic Effects of Space and Other Advanced Technologies', to be held in the Spring of 1980 in Strasbourg, under the patronage of the Council of Europe.



Planning for the Next Scientific Projects

M. Delahais & D. Dale
Directorate of Scientific Programmes, ESA

ESA's Scientific Programme is directed towards providing European scientists with opportunities for the scientific exploration of space. The financial resources available for the Programme from the Agency's Member States are finite and careful planning is required if full exploitation of the resources is to be achieved. In addition, the Science Programme endeavours to cater for a variety of scientific disciplines, which usually involve advanced techniques and progressive thinking. For these reasons great attention has to be paid to the planning of potential scientific missions and a planning function has to be maintained on a continuous basis. This article attempts to highlight the mechanisms and responsibilities involved in the various steps leading up to the approval of a new scientific project within the Agency, and also outlines the projects that will be candidates at the next selection.

The current activities of ESA pursue many different avenues of space, including applications, manned flight and scientific exploration. The latter activity was the main objective of the founding organisation (ESRO) and still accounts for a significant part of the Agency's on-going programmes. In the formulation of the 1971 'Package Deal' by which the ESRO activities were expanded, a set amount of funding was to be allocated each year for a mandatory scientific programme: the funding limit was essentially set at 1971 levels, and was to be adjusted each year for inflation. The mandatory Scientific Programme is currently credited with 77.78 MAU (1 AU = 1.235 US $) for 1979.

Although, generally speaking, the scientific projects of the Agency are to be funded from this mandatory budget, there always remains the possibility of optional projects which receive special financial support from those Member States that wish to participate, and from time to time such projects are studied by the Agency with such a funding policy in mind.

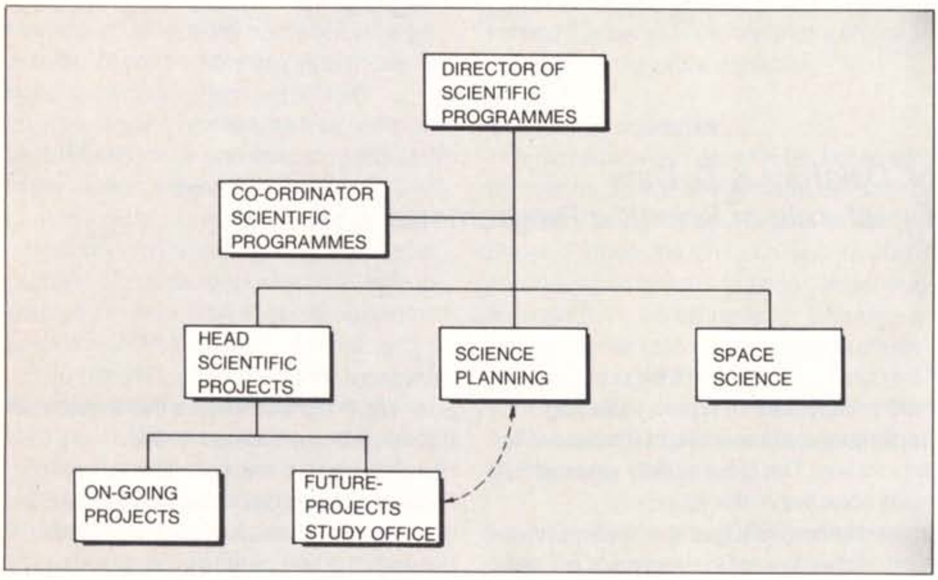
For the purpose of illustrating the planning and approval processes, however, the main emphasis of this article is placed on missions that are candidates for funding from the mandatory programme budget.

Organisation and planning sequence
Within the structure of the Agency, the responsibility for the planning and execution of scientific projects falls within the Directorate of Scientific Programmes (Fig. 1). The main participants in the planning activity, under the Director of Scientific Programmes, are the Science Planning Group located at ESA Headquarters in Paris and the Future Projects Studies Office located at ESTEC in Noordwijk. There is a strong interaction between the two groups in all planning phases, but broadly speaking the Headquarters-based Science Planning Group assumes responsibility for preliminary assessment in the initial selection of a number of proposed missions, while the Future Projects Studies Office assumes responsibility for the subsequent detailed feasibility studies leading to a technical definition and costs and schedule planning.

Periodically, as and when budget availability permits, the possibility of a new project arises. Projects funded from the mandatory-programme budget are selected by the Science Programme Committee (SPC), and it is the task of the Agency's planning groups to establish a reasonable 'menu' from which the SPC can make its selection. Before any approval decision can be made, however, considerable work has to be undertaken with a view to demonstrating to the SPC not only that the intended project is feasible both scientifically and technically, but also that the necessary funding can be found within the scientific budget. This pre-decision activity (illustrated in Fig. 2) – termed a 'planning cycle' – typically lasts about two years, and can be subdivided into three stages:

– *The Proposal Stage* (Stage-I) consists of a preliminary scientific definition of the proposed mission, which is submitted to

Figure 1 — ESA's Directorate of Scientific Programmes.



the Agency by members of the scientific community. Proposals may be submitted in response to a 'Call for Proposals' made by ESA in anticipation of a new project start, or may equally well be unsolicited and submitted by a proposer for inclusion by the Agency in its next convenient planning cycle.

Screening of the proposals for passage to the next stage is performed by the appropriate ESA committees, namely, the Scientific Advisory Working Groups and the Science Advisory Committee (SAC).

– *The Assessment Stage* (Stage-II) is primarily intended as a general assessment of the proposed project in terms of scientific value (and potential competition), technical feasibility, potential cost and schedule. The assessment team consists largely of external scientific consultants (including the project's proposer) and members of the relevant ESA Working Group, with some support from the Directorate of Scientific Programmes and the technical planning groups.

On completion of the proposed project assessments, the Working Groups and the Agency's Science Advisory Committee are requested to issue a recommendation concerning those projects that appear attractive and which should proceed to the next planning stage: the SPC is informed of the assessment results and is also asked for its comments at this stage. Bearing in mind the SAC's recommendations and the SPC's comments, the Executive then decides which proposals are to be progressed to the subsequent planning stage, and which are to be mothballed pending supplementary studies or perhaps advancements in technology.

– *The Study Stage* (Stage-III) is directed towards establishing the definition of the project with an adequate level of detail, such that it may be presented to Working Groups, the SAC and the SPC as a candidate for approval. Aspects covered in this stage include:

- model-payload interface definition
- spacecraft subsystems description, with particular emphasis on critical areas
- complete mission analysis
- development schedule and accurate cost estimates
- in the case of cooperative projects, the terms of cooperation with the partner or partners.

Stage-III studies may be performed either within the Agency or contracted to industry, but in either case the engineers are supported by a team of scientific experts.

On completion of Stage-III, the results are studied by the appropriate ESA Working Group and the SAC, who recommend to the Executive either rejection, mothballing or approval. Subsequently the Director General requests a formal decision from the SPC on inclusion of the mission in the Agency's programme and its funding from the mandatory scientific budget. If the SPC gives its approval, the project then becomes part of the Agency's Scientific Programme for the development phase. The remaining contribution of the planning groups is to assist in the selection of the actual scientific instruments to be flown, the planning activities up to this transition point having relied on a model payload. Instrument selection normally takes place after project approval, following receipt of replies to a 'Call for Experiment Proposals'.

The project choice for 1980/81

Having briefly explained the mechanics of the Agency's planning procedure, it remains to outline the options that exist for the next scientific project.

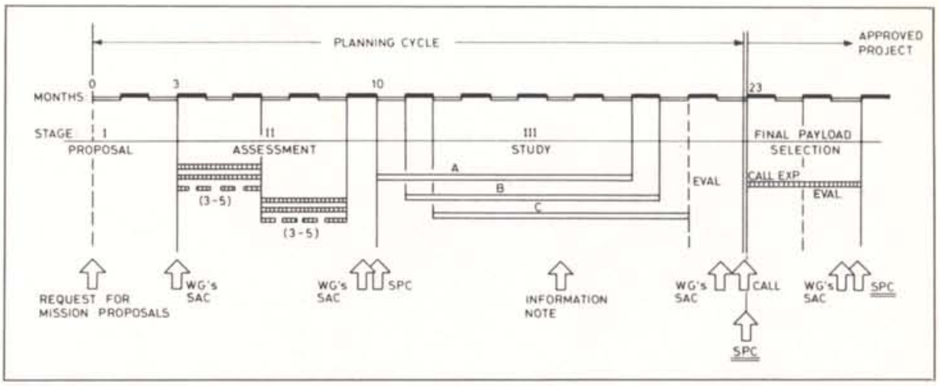
Funding projections indicate the possibility of two new project selections in both early 1980 and 1981. In terms of planning, this means that Stage-III studies should be performed during 1979 for the 1980 selection, together with several (about six) assessment studies in preparation for the 1981 selection.

ESA has already issued a Call for Proposals for the 1981 selection, but replies are not expected until the end of March 1979. The summaries presented here therefore relate only to the on-going studies in support of the 1980 selection.

There are four principal candidate projects currently under study for which Stage-III is scheduled to be completed in

Figure 2 – Structure of a planning cycle.

Figure 3 – Geos-3.



August/September this year. Two of these four, Geos-3 and the Halley's Comet probe, fall in the solar-system discipline, and the other two, the Astrometry and EXUV projects, in the astrophysics domain.

Geos-3 (Fig. 3)
The Agency's Geos-1 and 2 spacecraft, designed for magnetospheric research, were launched in April 1977 and July 1978, respectively.

In late 1978 the Agency began considering the possibility of a third Geos mission, conceived as a low-cost spacecraft (hence the Geos-1/2 design derivative) to be launched as a passenger on one of the early Ariane flights.

During the last few months of 1978, two possible scientific objectives for the mission evolved: lunar research and/or exploration of the Earth's distant magnetotail. The lunar-research option would be principally directed at the imaging and detection of water at the lunar poles, and would thereby require that the spacecraft be injected into polar lunar orbit. The magnetotail-research option, relying largely on instruments that have already been flown on Geos-1 and 2, would expand the field of magnetospheric research from near-Earth studies to the determination of the behaviour and characteristics of the magnetosphere in deep space. Few interplanetary spacecraft have previously crossed the magnetotail in this region, en route to planetary goals, and data from such distances are therefore very sparse indeed. Such sophisticated orbits can be achieved either by making use of the Moon's gravitational pull, or by injecting the spacecraft towards the anti-Sun libration point, a point in space behind the Earth from the Sun, on an extension of the Sun–Earth line, at which the gravitational attractions of the two planets and centrifugal force balance.

The technical studies have shown that the main modification needed to the Geos design would be replacement of the existing solid-chemical apogee boost motor by a liquid bi-propellant motor system. The reason for this is that trajectories studied to date – studies are still continuing with a view to determining whether orbit options exist using the solid motor – require that velocity manoeuvres be made at several points during the mission, which means that the motor must be periodically started up and shut down. A solid-chemical motor cannot provide such a capability, since once fired it continues to run until it exhausts its fuel.

Various other modifications of a minor nature are also needed to provide the Geos spacecraft with the necessary resources for a relatively deep-space mission, but all the indications are that the mission proposed could offer a relatively inexpensive means of performing some quite unique research.

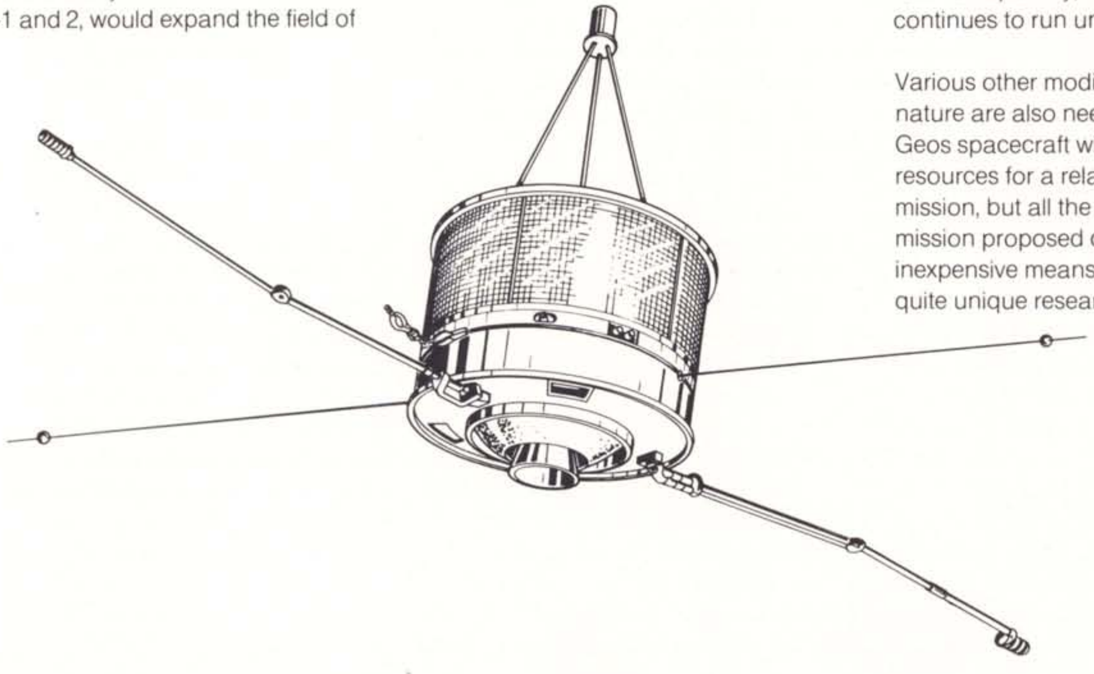


Figure 4 — The Halley's Comet probe.

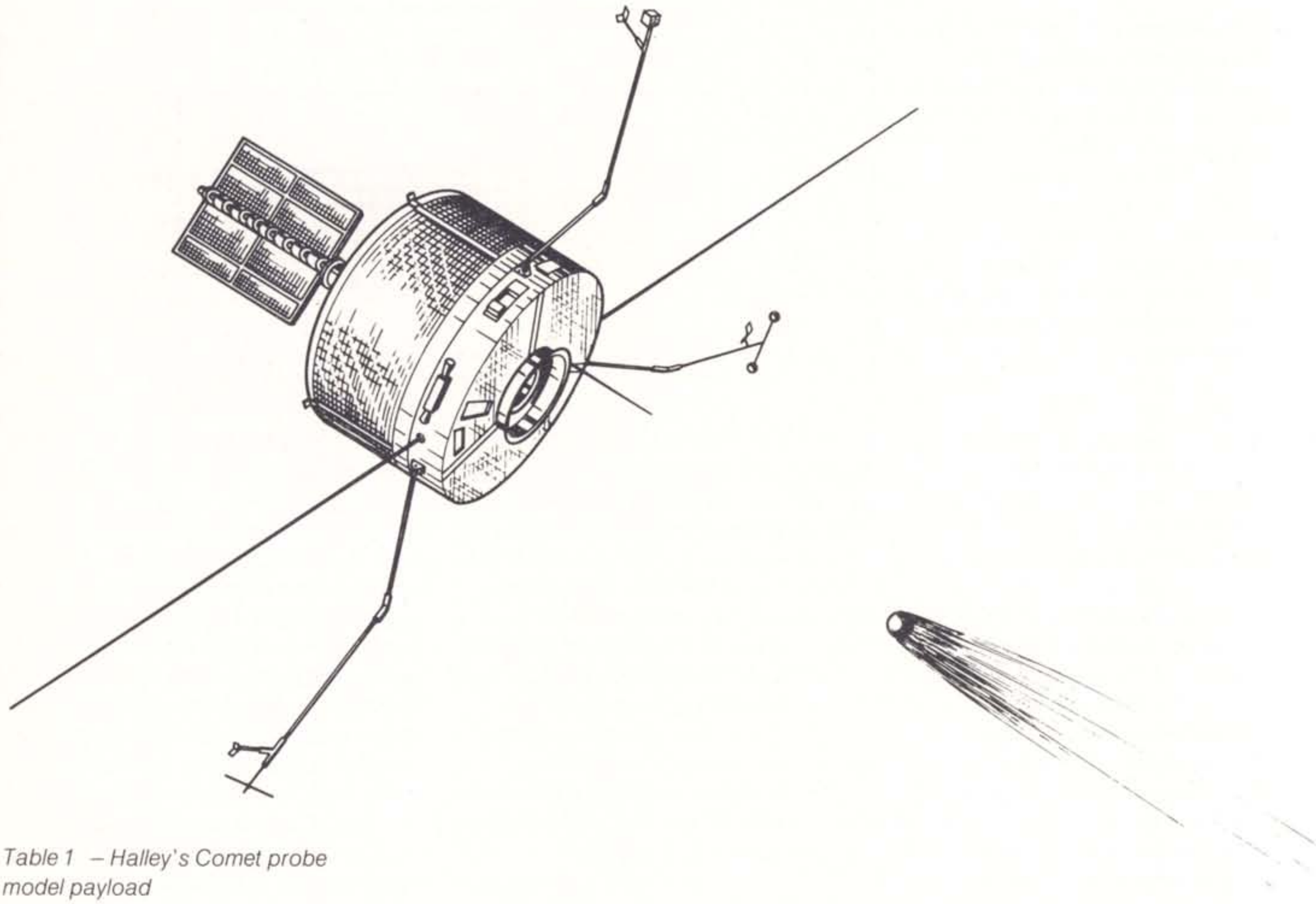


Table 1 – Halley's Comet probe model payload

Instrument	Mass (kg)	Power (W)	Telemetry (kbit/s)
A1 Neutral mass spectrometer	8	8	2.0
A2 Ion mass spectrometer	8	5	1.6
A3 Dust impact spectrometer	8	10	3.0
A4 Magnetometer	3.6	3.5	1.0
A5 Medium-energy ion/electron analyser	5	5	1.0
Sub-total A	32.6	31.5	8.6
B1 Probe camera system	6	8	2.5
B2 Dust impact detector	1.1	1.5	0.1
Sub-total B	7.1	9.5	2.6
Total A+B	39.7	41.0	11.2
C1 Dust number-density analyser	0.6	2	0.01
C2 Plasma wave system (passive analyser)	4.6	4.7	0.85
C3 Plasma wave system (active sounder)	–	–	–
C4 Solar absorption dust measurement	–	–	0.02
C5 Thermal electron probe	2.3	3	0.25
C6 Energetic ion/electron analyser	5	5.4	0.9

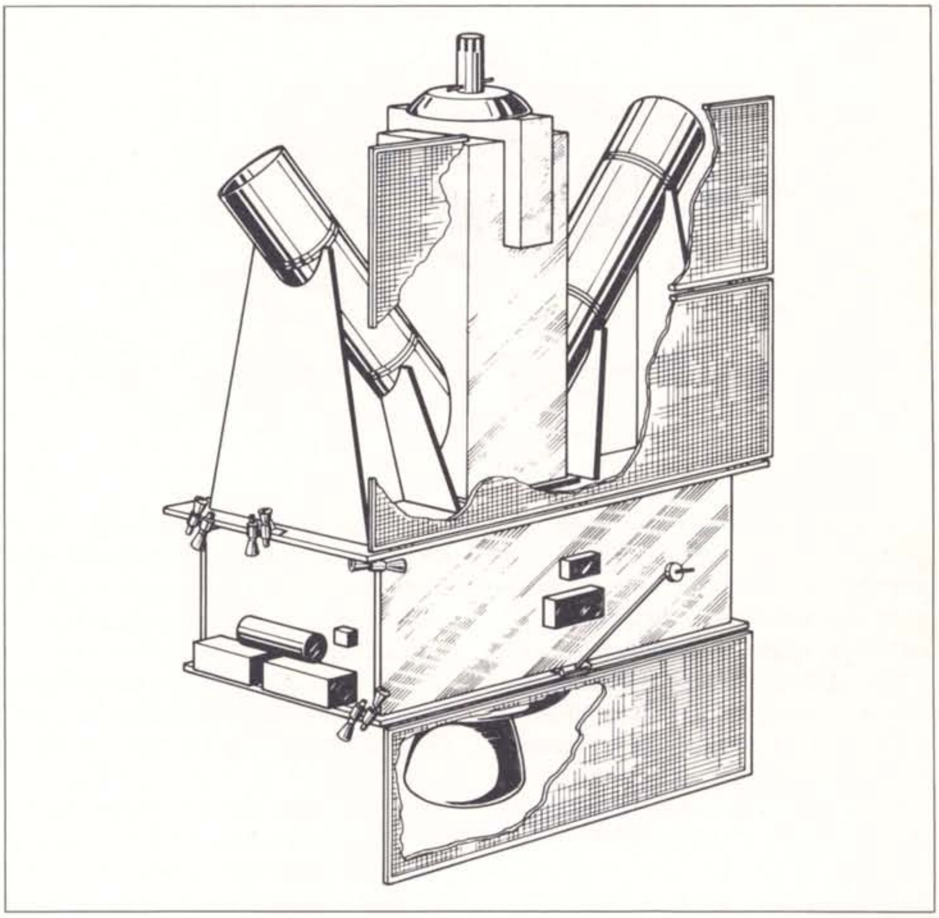
Note:

Category A: on the assumption that adequate instrumentation can be designed in these areas, these instruments should be included in the model payload and accommodated if at all possible.

Category B: these instruments were judged to be the most valuable from a scientific point of view to add to the payload, if probe resources permit.

Category C: these instruments were also considered to be potential valuable components of a probe payload.

Figure 5 – The Astrometry Satellite (Hipparcos).



Halley's Comet probe (Fig. 4)
The last observation of Halley's Comet was in 1910 and the next is expected in 1985/86. Natural laws dictate this 76 year observation cycle and there is hence very strong and worldwide interest in conducting research during the next sighting. Today's tools provide much greater scope than ever before for research into the structure and nature of the Comet, since it is now possible to pay a visit to Halley and perform in-situ measurements.

With such goals in mind, ESA and NASA have been collaborating on studies aimed at definition of a joint cometary mission. The outline planning for the mission calls for a large spacecraft (NASA-provided) weighing about 3000 kg, driven by an advanced solar electric propulsion (SEP) unit. A small probe (ESA-provided) weighing about 200 kg is attached to the NASA mother spacecraft. The trajectory of the combined spacecraft is controlled by the SEP thrusters to intercept Halley's orbit, 105 days after launch (28 December 1985), when the Comet is approaching its closest point to the Sun (about 0.6 astronomical units), and where the Comet's chemical activity is greatest. The ESA probe is to be released to pass close to the Comet's nucleus – within less than 2000 km – and to perform in-situ environmental monitoring on the way in. At the same time, the thrusters on the NASA spacecraft are to be fired to move the larger spacecraft outside the hazard envelope of the Comet. It must be remembered that the approach speed of Halley is 57 km/s and that the nucleus is surrounded by micrometeor-type particles travelling at the same speed, which could result in severe physical damage to the spacecraft.

Following the encounter with Halley, the NASA spacecraft's trajectory is again to be adjusted by its thrusters, and it will travel through space for another three years before making a rendezvous with a second comet known as Temple-2.

The design of the ESA probe is already being studied and, with a view to minimising cost, it has been based on the Agency's earlier ISEE-B satellite. Main design changes for the probe include provision of a protection shield, to prevent impact damage when in the micrometeoroid environment of the Comet, and an uprated communications system for telemetry of the data over the large interplanetary distances involved (about 100 million kilometres to Earth). The model payload for the probe is summarised in Table 1.

In view of the relatively short duration of the cometary encounter, which lasts about 10 h, and since the ESA probe is to remain attached to the main spacecraft until about two weeks before Halley interception, it has been possible to make some compensatory simplifications to the original ISEE-B design by, for example, removing the attitude-control system and command receivers. It is therefore envisaged that an exciting exploratory-type mission can be achieved at low cost.

Astrometry Satellite (Hipparcos) (Fig. 5)
Astrometry, the science of positions and motions of heavenly bodies, is the oldest branch of astronomy. In spite of its long history and the progress that has been made over the years, it is the only discipline that has not yet experienced the kind of scientific explosion that has so drastically changed research in other fields over the past thirty years. Nevertheless, astrometric data are at the foundation of most astrophysical theories and of our concept of the Universe in terms of distances, masses, brightnesses and motions of stars.

Figure 6 — The EXUV satellite.

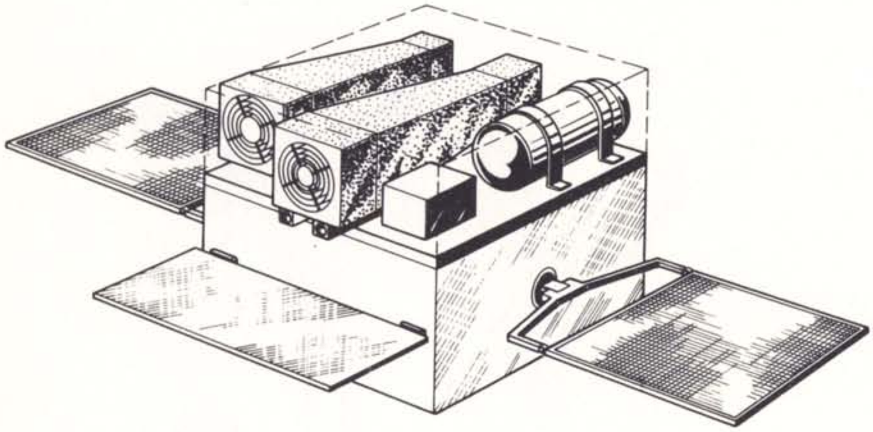


Table 2 — The EXUV satellite's telescopes

	XUV	EUV
Type	nested Wolter	nested Wolter
Aperture	60/70 cm	80 cm
Focal length	1.3/1.75 m	1 m
Mass	160 kg	130 kg
Field of view	2° (full angle)	3° (full angle)

The Astrometry Satellite, also called 'Hipparcos' after the famous Greek astronomer (190–120 BC), is the only tool so far conceived that is capable of producing advances in astrometry through space research. The satellite will provide improvements of factor 10 or more in the accuracy of present ground-based measurements, and will allow observation of one hundred times more celestial objects of various kinds.

Specific scientific objectives include the accurate measurement of five astrometric parameters of celestial bodies; position, proper motion, and trigonometric parallaxes. As an example of the sort of precision to be achieved, it is anticipated that star positions could be measured to within 0.0015 arcsec.

The principle used for determining the astrometric parameters relies on a high-precision measurement of the angular distance between stars, which are separated by about 70°. A differential position comparison is made of the two stars when their images are superimposed in the focal plane of a single telescope, the stars themselves having been imaged separately from two different fields of view with a separation angle of 70°. The images are superimposed onto the common focal plane by means of a complex mirror in the single telescope.

Hipparcos would be launched by Ariane into geostationary orbit (period 24 h) in a plane close to the Earth's equator, thereby providing continuous satellite visibility from a European ground station. The attitude of the satellite would be controlled in such a way that the telescope fields of view scan the complete celestial sphere.

The nature of the precision requirements demands the application of advanced technological techniques in which tolerable mechanical and thermal instabilities are very small. Consequently, the designing of this satellite has not been found simple in that various computer models are needed to establish the design parameters and to ensure that the desired accuracies can be achieved.

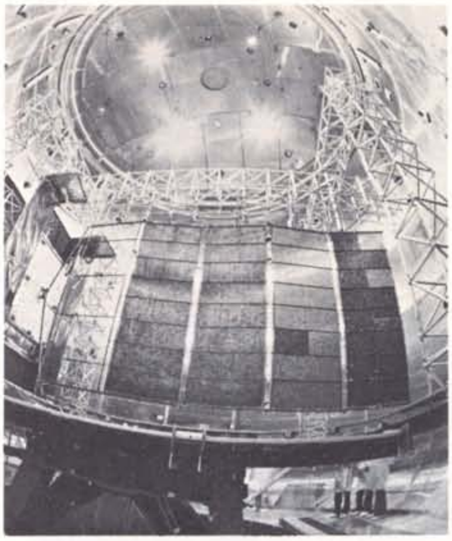
EXUV (Extreme UV X-ray survey satellite) (Fig. 6)
This all-sky survey satellite is intended to map brightness distribution in the wavelength region 15–1000 Å of the electromagnetic spectrum, with an unprecedented level of sensitivity and an angular resolution of a few arcminutes. The objectives include a search for point sources in the EUV region of 100–1000 Å together with a high-resolution map in the ultra-soft X-ray region of 15–250 Å.

The scientific instrumentation consists of two independent grazing-incidence telescopes, the characteristics of which are outlined in Table 2.

The spacecraft, launched by Ariane into a highly eccentric orbit (apogee 120 000 km), would have an orbit inclined by about 70° to the equator. The orbit is engineered such that the apogee remains over the northern hemisphere, which results in maximum visibility from a European ground station. The 650 kg spacecraft is spin-stabilised, with the spin axis always directed at the Sun. The two telescopes are mounted perpendicular to the spin axis, so that the natural motion of the Earth around the Sun results in a full-sky survey being achieved within six months. The second part of the mission, leading to a total satellite lifetime of approximately two years, would be devoted to the observation of point sources identified in the earlier survey phase.

Conclusion
The planning of new scientific missions is not a one-shot staccato-like business, but is rather a continuous and developing exercise in which the Agency endeavours to respond to the wishes and hopes of the scientific community on a fairly frequent basis. It is true that funding limitations do not permit the total satisfaction of all, and as always compromises have to be made.

The planning sequence that is in use nevertheless permits proposals to be made and examined in any scientific space discipline, and the Agency's Scientific Programme thereby provides the opportunity, albeit with somewhat restricted funding at the present time, for Europe to play a prominent role in space-science exploration.



Environmental Testing of Future Large European Spacecraft

K. Beckel & E. Classen,
Test Services Division, ESTEC, Noordwijk, The Netherlands

In the past all ESRO and ESA satellites have been of the Scout or Thor-Delta launcher class and most have been the subject of a conservative test, model and design approach. Testing in the existing European environmental test facilities caused no special problems, although the limits of some key environmental test facilities have been reached with the recent, larger Delta-class satellites. The future, however, is characterised by Ariane-launched, and possibly some Shuttle-launched, satellites and by Spacelab payloads. In addition, new Spacelabs or parts of Space Stations might possibly form ESA's contribution to some future joint NASA/ESA programme. The fact that these new larger items of space hardware involve many areas of uncertainty, particularly as far as testing is concerned, led to the setting up early in 1977 of a 'Design, Model and Test Working Group'. The Group was charged with presenting a test philosophy, consistent with an appropriate design and model philosophy, for this new generation of larger space hardware and with proposing a test-facility investment plan for ESA for the years up to 1990.

The main work was carried out by a group of engineers at ESTEC, supported by specialists from the three main national test centres in France (CNES), Germany (IABG) and the United Kingdom (RAE). Seven smaller studies in specialist areas were subcontracted to industry.

Background
The investigations were based on a mission model constructed using information available mainly from ESA documents. The model included a balanced space programme of telecommunications, earth observation, science, Spacelab payloads, and space transportation systems and orbital space stations. The hardware involved could be classified into five distinct groups:
Class A: Scout-type satellites (maximum diameter 1 m, less than 200 kg)
Class B: Delta-type or half Ariane-capability satellites (maximum diameter 2.2 m, maximum 900 kg)
Class C: Ariane-class satellites (maximum diameter 3 m, maximum 1800 kg)
Class D: Large pallet-borne Spacelab payloads (diameter 4 m × 8 m, maximum 5000 kg)
Class E: New Spacelab, Space Station elements, etc.

The Working Group's investigations concentrated mainly on Classes C, D and E. Some effort was also devoted to reviewing earlier projects, including their cost statistics.

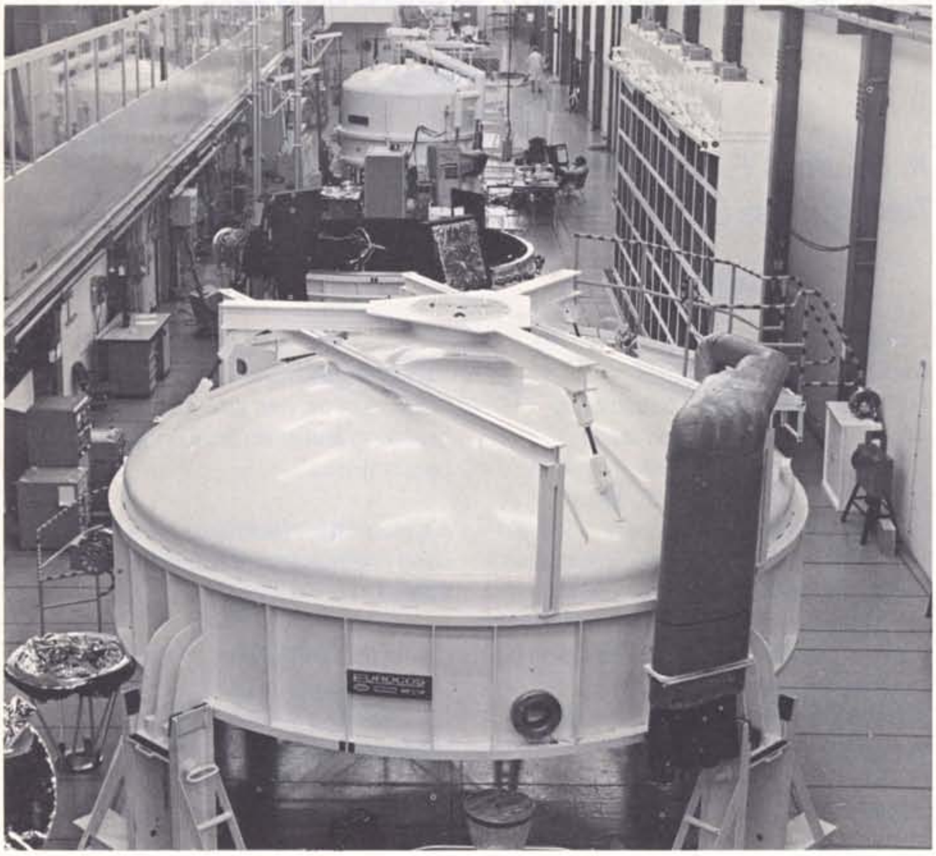
A typical cost breakdown for a medium-sized communications satellite is shown in Table 1.

Owing to the high cost of thermal testing (70%), the future requirements for this particular test discipline had to be investigated very carefully. Figure 1 shows the capital investment and running costs for solar-simulation and thermal-vacuum facilities as a function of useful test volume, as an example.

The most important findings that emerged from the cost comparison were:
- the investment costs for a solar-simulation facility are significantly higher than for all other facilities, including thermal-vacuum, for the same payload class;

Table 1 — Typical cost breakdown for environmental testing of a medium-sized communications satellite (percentages)

	System and subsystem tests, %	Unit tests, %	Total
Thermal tests	44	26	70
Vibration tests	6	5	11
Acoustic tests	6	–	6
Electromagnetic compatibility (EMC) tests	1	5	6
Other tests	5	2	7
	62	38	100



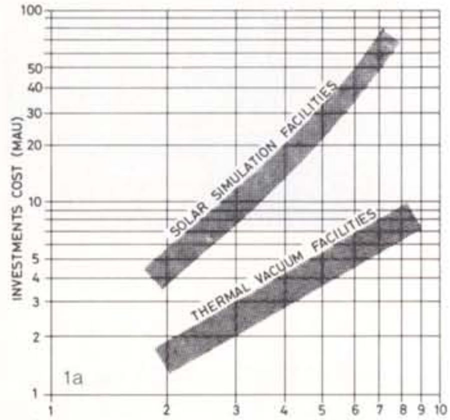


Figure 1a – Typical total investment costs for solar-simulation and thermal-vacuum facilities, including building costs (1977 prices)

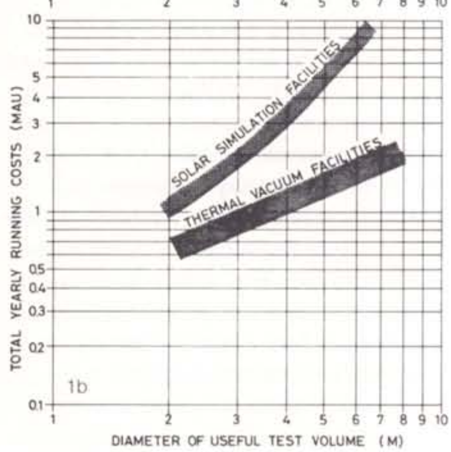


Figure 1b – Typical total annual running costs (fixed and variable) for solar-simulation and thermal-vacuum facilities, based on 2000 test hours per year (1977 prices)

- the same trend applies, though less severely, to the running costs of solar-simulation facilities.

Because of its considerable impact on costs, the *model philosophy* was also carefully examined. Clearly, an important cost saving could be realised by reducing the number of spacecraft models used in development, thereby reducing the total amount of hardware involved in a programme. On the other hand, the risk of unexpected programme delays, as well as of additional costs and failures in orbit, would be increased. A trade-off has thence to be made between cost and risk.

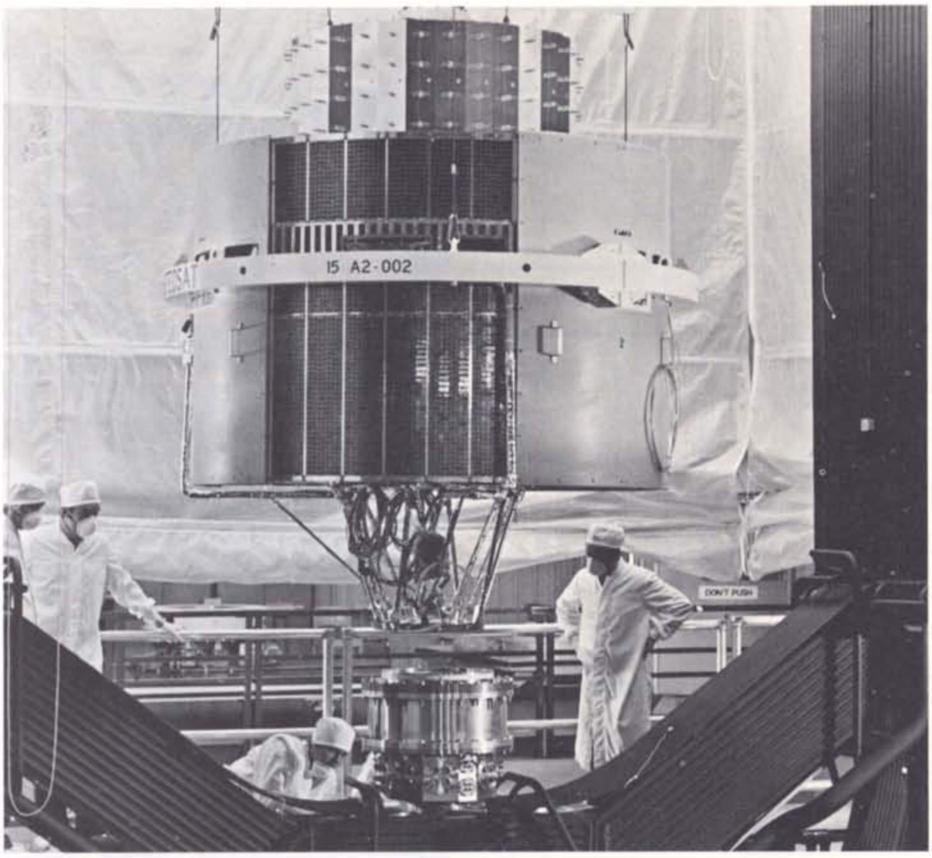
It is considerations such as these that have shaped the proposal of a design, model and test philosophy for the future generation of large space hardware.

The design, model and test philosophy
A *system-level* test (on a flight model or a specially built test model such as a full-sized structural or thermal model) will still be required for Ariane payloads (Class C). This test must cover the three principal environments – mechanical, thermal and electrical – for two reasons:
- the analytical tools available today, and in the forseeable future, are not able to fully model environmental conditions with sufficient accuracy and reliability for confirmation by test to be dispensed with ('design-verification test');
- the quality-assurance screens, without a system-level test, give insufficient confidence in the correct in-orbit functioning of the spacecraft because many potential failures can only be identified through such a test ('quality-assurance test').

The same is true, with some relaxation in test requirements, for Spacelab payloads (Class D) also, because a test approach without a system-level test would drastically increase the mission risk, an unacceptable step bearing in mind the high overall mission cost.

To allow testing at a *modular level*, new Shuttle payloads such as the elements for a Space Station (Class E), have to be designed modularly with clearly defined interfaces. With few exceptions, the system and module-level tests foreseen for the programmes up to 1990 can be performed in the existing European test facilities with limited modifications, provided that the limitations of the available facilities are observed in designing future space hardware. It is therefore necessary to develop appropriate design criteria and test programmes early in the study phase of future projects.

As far as the *model philosophy* is concerned, the experience of the Agency



and the spacecraft contractors to date indicates that some of the conservatism of the past can be relaxed. A protoflight approach, combining the qualification and the first flight models can be applied in most projects without undue risk, although it is generally considered necessary to retain the structural/thermal model for design verification early in the project. Nevertheless, the deletion of the qualification model represents an important cost saving compared to the 'classical' model approach.

Design-verification and quality-assurance testing

Structural testing

For Class-C and D payloads at system level and Class-E payloads at module level, a static-load test, a modal-survey test, a sine-vibration test, a random-vibration test and an acoustic test are still considered appropriate. The static-load and modal-survey tests have to be performed on a structural model early in the programme as a means of verifying the structural mathematical model. The sinusoidal-vibration (up to 100 Hz), random-vibration (up to 200 Hz) and acoustic tests are needed for qualification and acceptance testing of the space hardware.

The sine-vibration test has always been an area of particular concern because of the danger of overtesting, and with the larger structures that will have to be tested in the future, this problem will become increasingly important. As a result, structural test specialists in Europe and the United States have been looking for alternatives. The limited frequency range of this particular test and the fact that only a multidegree-of-freedom platform allows the real interface motion at the spacecraft support points to be simulated, thereby providing satisfactory test realism, make hydraulically driven vibrators an attractive solution. The sinusoidal-vibration test could then be replaced by one simulating the real spacecraft motions caused by launcher-engine ignition, stage separation, etc. The same facility could also be used for the random vibration test. A further reason for pursuing this solution is that many Class-D payloads, and even some Class-C payloads, cannot be tested adequately on the existing large shaker installations because they deliver insufficient shaker force.

Thermal testing

Again for the Class-C and D payloads at system level and Class-E payloads at module level, a thermal-balance and a thermal-vacuum test are considered adequate.

The thermal-balance test, a tool for verifying and updating the thermal mathematical model and for qualifying the thermal design, has to be performed on a thermal model early in the programme. It is advisable to repeat the test on the protoflight model, especially after any design modifications.

The thermal-vacuum test is intended to confirm satisfactory spacecraft operation under thermal conditions more severe than predicted in orbit, and it also provides a highly effective quality-assurance screen, to detect failures in design, manufacture, integration, etc.

The classical method of performing a heat-balance test is to illuminate the spacecraft with artificial sunlight and simulate the cold background of space by cooling a shroud surrounding the spacecraft to approximately −180°C. This so-called 'solar-simulation' test has been standard practice for past ESRO/ESA projects.

This test is, however, only meaningful so long as the artificial Sun can illuminate the spacecraft more or less entirely in its orbital configuration. Difficulties occur with many pallet-borne Spacelab payloads because the cargo bay

Table 2 — Typical total investment and running costs for thermal environmental test facilities (including building costs, 1977 prices)

Facility type	Payload class	Investment costs (MAU)	Total annual running costs* (MAU)
Solar simulation	B (Delta)	9.6	2.0
	C (Ariane)	22.0	4.0
	D (Spacelab payload)	62.0	11.0
Thermal vacuum	B (Delta)	2.6	0.9
	C (Ariane)	4.1	1.3
	D (Spacelab payload)	6.6	1.8

* Fixed and variable costs, based on 2000 test hours/year

introduces 'solar reflection' and thermal radiation effects. The latter are difficult to simulate in ground testing unless a facility producing a solar beam of sufficient diameter to illuminate the complete Shuttle bay is available, and this is out of the question for economic reasons (Fig. 1). The largest existing solar-simulation facility in Europe is the SIMLES at CNES in Toulouse, which produces a solar beam diameter of 3 m.

Other constraints on solar-simulation facilities are introduced when the item under test has to be held in a certain position, for example in a horizontal orientation when heat pipes are present.

Fortunately, the existing thermal-analysis tools permit the thermal input to the spacecraft to be predicted in many cases with sufficient accuracy when the test specimen is rather simple in shape and has well-known optical surface properties, which is true of a great number of spacecraft. In such a case the thermal-balance test can be considerably simplified, by heating the spacecraft with special heaters such as infrared lamps (Fig. 2). Such a test can be performed in a facility for which the investment and running costs are considerably lower than for a comparable solar-simulation facility of adequate size (see Table 2 and Fig. 1). It should perhaps be noted here that the total costs for a test are not only determined by the running costs of the facility; preparation time, software availability, need for adaptors, etc., have also to be taken into account.

All in all, the infrared test approach can be considered to provide an attractive alternative to solar simulation, and as a result a larger solar-simulation facility will not be needed in Europe before 1990.

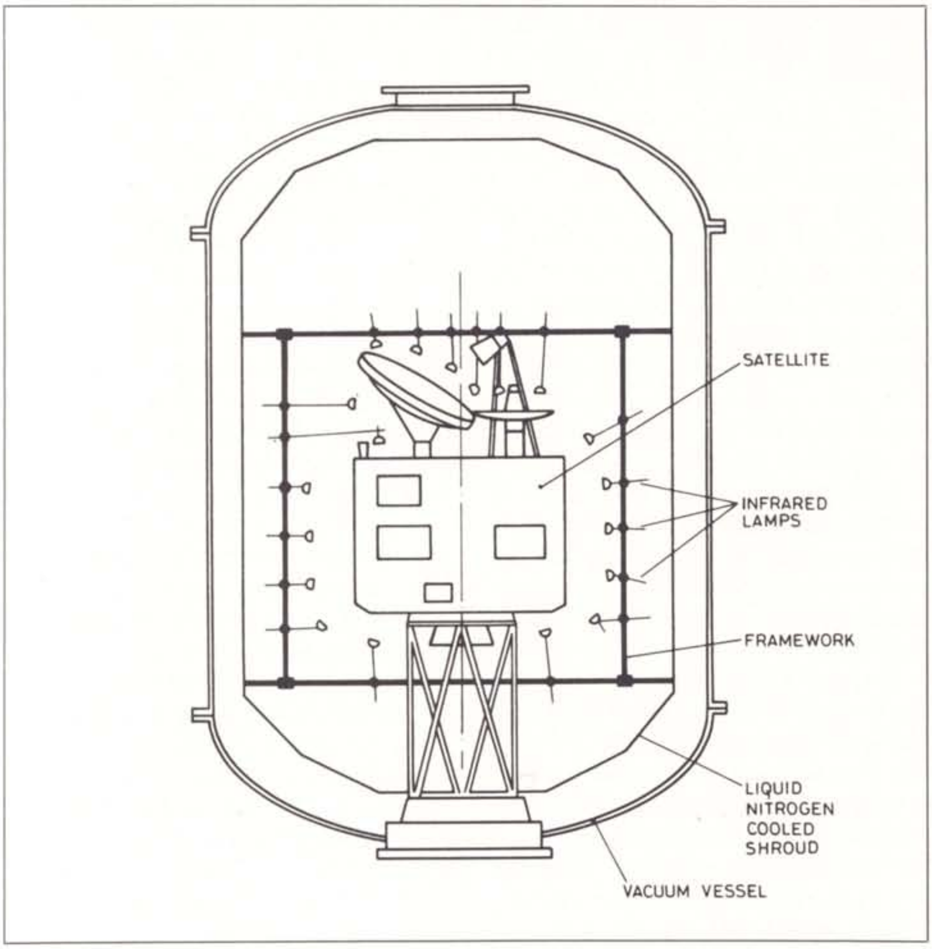
Because there has been little experience in Europe of using these infrared techniques for testing, some effort will, however, still be needed to make this test approach a useful tool for thermal design verification.

Electrical testing
The Design, Model and Test Working Group concentrated mainly on the needs of electromagnetic-compatibility (EMC) and magnetic testing. Recently, electrical charging of spacecraft in geostationary orbits has also become increasingly important. No major problems could be identified for the years up to 1990, except a possible limitation in the size of facilities for EMC tests on future large telecommunications satellites.

Facility requirements
In the light of the investigations made and the principles of the design, model and test philosophy outlined above, four recommendations could be made regarding future investment in environmental test facilities on a European scale:

(a) A facility capable of performing thermal-balance and thermal-vacuum tests using simple infrared heating devices instead of true solar simulation is needed for the very large Spacelab payloads and some large satellites. This facility would also bring increased flexibility by providing an alternative to the SIMLES solar simulator in Toulouse. In this context,

Figure 2 – A thermal-balance test using infrared lamps installed in a thermal-vacuum chamber



the feasibility of providing the existing Dynamic Test Chamber (DTC) at ESTEC with the additional equipment needed to perform infrared tests is being studied.

(b) A solution has also to be found for the vibration testing of payloads weighing more than about two tons. A hydraulic, multidegree-of-freedom vibration facility would be the ideal answer because of the high degree of test realism that it would give. More detailed investigation of the feasibility of such a facility is under way. Should this test approach prove to be impracticable, the alternative would be a facility using several conventional electrodynamic vibrators in parallel. This, however, would only allow single-axis vibration, which is the approach that has been used in the past for the Agency's smaller spacecraft.

(c) A need for a large EMC chamber could be identified, but the provision of such a facility would not have a significant impact on investment plans. Any further activity in this direction is being held over until the Agency's future programmes are better defined.

(d) Although unfavourable logistics can result in increased costs and delays when testing at different test centres, duplication of test facilities for this reason alone is clearly not justified, except in the case of comparatively inexpensive items such as physical measurement facilities.

Conclusion

The design, model and test philosophy that has been outlined would seem both to meet the development and verification requirements of ESA's projects for the next decade and to be compatible with an overall low-cost approach. Only two additional facilities, thermal and vibration, are needed to cope with the Agency's testing needs until 1990.

Additional studies of the philosophy are continuing at ESTEC and it is expected that in the course of this year final decisions can be made regarding investment and implementation schedules. Whatever the result of these further investigatons, it is already clear that the necessary investments will only be in the order of a few MAU, provided the principles of the philosophy that has been outlined are taken into account for all the Agency's future programmes that involve large items of space hardware.

In Brief

ESA Delegation Visits China

'The united European space effort can balance the space activities of the two superpowers; China, therefore, wishes to increase contacts and to cooperate with the European Space Agency', said Vice-Premier Wang Chen, receiving an ESA delegation in the Peking Palace of Congress on Sunday, 18 February.

The ESA eleven-man delegation, led by the Director General, consisted of five delegates and six members of the Executive. They stayed in China on a fact-finding visit from 12 through 19 February. A report on the mission to China has been made available to Delegations of ESA's Member States for further distribution within those States.

Invited by the Chinese Electronics Society, the delegation was given the opportunity to have lengthy discussions with the Chinese Astronautics Society and the Chinese Academy of Sciences and to visit space-related institutes, factories and establishments in Peking, Shanghai and Nanking.

The delegation was welcomed everywhere with the greatest warmth and openness. Chinese hosts showed their installations, the technology of some of which was very advanced, and expressed the hope for close cooperation with ESA, aiming at improvement in some of their less advanced technological areas.

Discussions were sufficiently frank and specific to enable the delegation to identify possible areas of reciprocally interesting cooperation. These are now under study and proposals will be presented to the ESA Council in due course.

Without prejudice to subsequent cooperative agreements, the Director General agreed to receive visits from Chinese specialists in a number of fields of mutual interest and to provide further information on ESA activities and on the European technical and industrial capabilities.

A fragmentation of responsibilities has taken place in the space field in China during the last years, and Chinese space activities require coordination of a large number of units. The report on the mission attempts to describe the present situation, which is bound to evolve towards a more centralised and definite distribution of tasks between the various organisations involved.

Mr. Roy Gibson, ESA's Director General, being welcomed by the Chinese Vice Premier, Mr. Wang Chen, at the Palace of Congress, Peking, on 18 February.

Le Directeur Général de l'Agence, M. Roy Gibson, reçu par le Vice Premier Ministre chinois, M. Wang Chen, au Palais des Congrès à Pékin le 18 février.

The report also contains brief descriptions of the facilities visited by the delegation which include: the Institute of Control Engineering and that of Environmental Engineering, representing the main Chinese facilities for the testing, assembly, integration and telemetry and telecommand of satellites; the Peking meteorological centre and the Nanking Purple Mountain Observatory; the Nanking and Shanghai ground stations, where Chinese communications ground equipment is being tested – at Shanghai by utilising the French-German Symphonie satellite; the Shanghai Institute of Applied Physics, concentrating on infrared studies and the development of scanners and radiometers for space as well as medical and other applications.

Some time will be necessary to digest the above information, to finally decide on the areas of cooperation and to finalise and implement agreements.

In the meantime, the Director General has expressed the hope that the flow of information generated by the visit in both directions will be a valid contribution to the establishment of increasing cooperation in the space field, at all levels, between China, the Agency and ESA Member States.

Visite d'une délégation de l'ESA en Chine

En unissant ses efforts dans le domaine spatial, l'Europe est en mesure de concurrencer sur ce plan les deux super-grands; la Chine est de ce fait désireuse de renforcer ses relations avec l'Agence spatiale européenne et de coopérer avec elle. C'est ce qu'a déclaré le Vice-Premier Ministre Wang Chen en recevant au Palais des Congrès de Pékin, le dimanche 18 février, une délégation de l'ESA venue en Chine, du 12 au 19 février, pour une visite d'information.

Cette délégation, conduite par le Directeur général, se composait de onze personnes: des représentants de cinq des Etats membres et six hauts fonctionnaires de l'Agence. Un rapport sur la mission en Chine a été remis aux Délégations des Etats membres de l'Agence pour qu'elles puissent en faire la diffusion qu'elles jugeront utile au plan national.

Invitée par la Société chinoise d'Electronique, la délégation a pu avoir des échanges de vues approfondis avec des membres de la Société chinoise pour l'Astronautique et de l'Académie des Sciences de Chine et elle a pu visiter des instituts, usines et établissements travaillant pour l'espace, à Pékin, Shanghai et Nankin.

La délégation a partout reçu un accueil extrêmement chaleureux et ouvert. Ses hôtes chinois lui ont montré leurs installations – dont la technologie est, pour certaines d'entre elles, très avancée – et ils ont exprimé l'espoir qu'une étroite coopération s'instaurera avec l'Agence et que cette coopération leur permettra d'améliorer leur technologie dans certains secteurs où ils sont moins avancés.

Les discussions se sont déroulées dans un climat de franchise et ont été suffisamment détaillées pour permettre à la délégation d'identifier des secteurs possibles de coopération mutuellement intéressants. Ces possibilités sont actuellement à l'étude et des propositions seront présentées en temps voulu au Conseil de l'Agence.

Sans préjuger d'éventuels accords de coopération ultérieurs, le Directeur général a accepté de recevoir des experts chinois spécialistes de plusieurs domaines présentant un intérêt commun et de fournir d'autres informations sur les activités de l'Agence et sur les capacités techniques et industrielles de l'Europe.

Au cours de ces dernières années, il s'est produit en Chine une fragmentation des responsabilités dans le domaine spatial et les activités chinoises en la matière nécessitent la coordination d'un grand nombre d'éléments. Le compte rendu de la mission s'efforce de décrire la situation actuelle qui toutefois ne peut manquer d'évoluer vers une répartition plus centralisée et plus précise des tâches entre les divers organismes intéressés.

Le rapport donne également une description succincte des installations visitées par la délégation: l'Institut des Techniques de la Régulation et l'Institut des Techniques de l'Environnement, qui sont les principales installations chinoises pour les essais, le montage et l'intégration ainsi que pour la télémesure et la télécommande des satellites; le Centre météorologique de Pékin et l'Observatoire de la Montagne Pourpre de Nankin; les stations-sol de Nankin et de Shanghai, où sont testés les équipements-sol de télécommunications chinois (à Shanghai les Chinois utilisent pour ces essais le satellite franco-allemand Symphonie); l'Institut de Physique appliquée de Shanghai, qui se spécialise dans l'étude de l'infrarouge et dans le développement de 'scanners' et de radiomètres tant pour les applications spatiales que pour des applications médicales et autres.

Il faudra un certain temps pour exploiter les informations ainsi recueillies avant de décider finalement des secteurs de coopération à retenir et d'élaborer et de mettre en oeuvre les accords correspondants.

D'ici là, le Directeur général a exprimé l'espoir que le courant d'informations qui, grâce à cette visite, s'est établi de part et d'autre, se révélera précieux pour l'instauration d'une coopération croissante, à tous les niveaux, dans le domaine spatial entre la Chine, l'Agence et ses Etats membres.

Delegation's visit to the Chinese Academy of Space Technology

Visite de la délégation à l'Académie chinoise de Technologie spatiale.

Intelsat-V Launch-Services Contract Signed

The contract that formalises the order for the launching by Ariane of satellites of the Intelsat-V programme, reported in the last Bulletin, was signed at the Agency's Paris Headquarters on 15 February by Mr Santiago Astrain, Director General of INTELSAT, and Mr Georges van Reeth, ESA's Director of Administration, representing the Director General. Under the terms of this contract the Agency undertakes to provide one Ariane launch with effect from April 1981, and grants an option for a second Ariane launch. The financial conditions laid down in the contract embrace a firm fixed price of US $25.29 million for the first launch, and US $27.46 million for the optional second launch.

Signing of the Intelsat contract by Mr. Georges van Reeth (left) and Mr. Santiago Astrain of INTELSAT.

The INTELSAT programme provides for the development and launch of seven satellites, the first four of which are due to be launched by Atlas-Centaur between mid-1979 and end-1980. The last three units are expected to be launched in April 1981, July 1981 (tentatively planned as the Ariane launch), and July 1982.

photo aérospatiale

Artist's view of the launch of an Intelsat-V by Ariane at the moment of jettisoning the protective fairing during the flight of the second stage of the vehicle.

Italian Visitors to ESTEC

The accompanying photograph shows Prof. E. Amaldi (right) and Dr. S. Valente (left) Italy's new delegates to ESA's Science Programme Committee, in the course of a visit to ESTEC's test facilities on 1 March, accompanied by Prof.

M. Trella (centre), ESA's Technical Director, Mr. E. Classen (second from left) of ESTEC, and Dr. V. Manno (second from right) of ESA Headquarters.

New Director for ESOC

The Agency's Council, at its meeting in Paris on 3 April, on a proposal by the Director General, appointed Dr. Reinhold Steiner as Director of the European Space Operations Centre (ESOC), Darmstadt, Germany. He succeeds Prof. Gianni Formica and will take up his duties before mid-July.

Dr. Steiner (51) is Swiss. He has a degree in Chemical Engineering from the Swiss Federal Institute of Technology (ETH) in Zurich, a Diploma from Imperial College London, and a PhD in solid-state physics from the University of London. After some years in industry, he was appointed Scientific and Technical Counsellor at the Swiss Embassies in Washington and Ottawa and later Counsellor for Space and Telecommunications Affairs at the Embassy in Washington. During that same period, he was a full member of the Board of Governors of INTELSAT. In 1973, he founded INTECO Ltd., a firm of consultants based in Washington dealing with various projects in the space field.

In addition to being responsible for the direction of ESOC, as a member of the ESA Directorate Dr. Steiner will take part in the collective consideration of the major management problems related to the Agency's activities.

Exhibition 'In en uit de Ruimte' in The Netherlands

The largest space and astronomy exhibition ever held in The Netherlands was staged in Twente, in the east of the country, between 11 January and 18 February. The exhibition, housed in one of the buildings of Twente's Technical High School, was supported by:

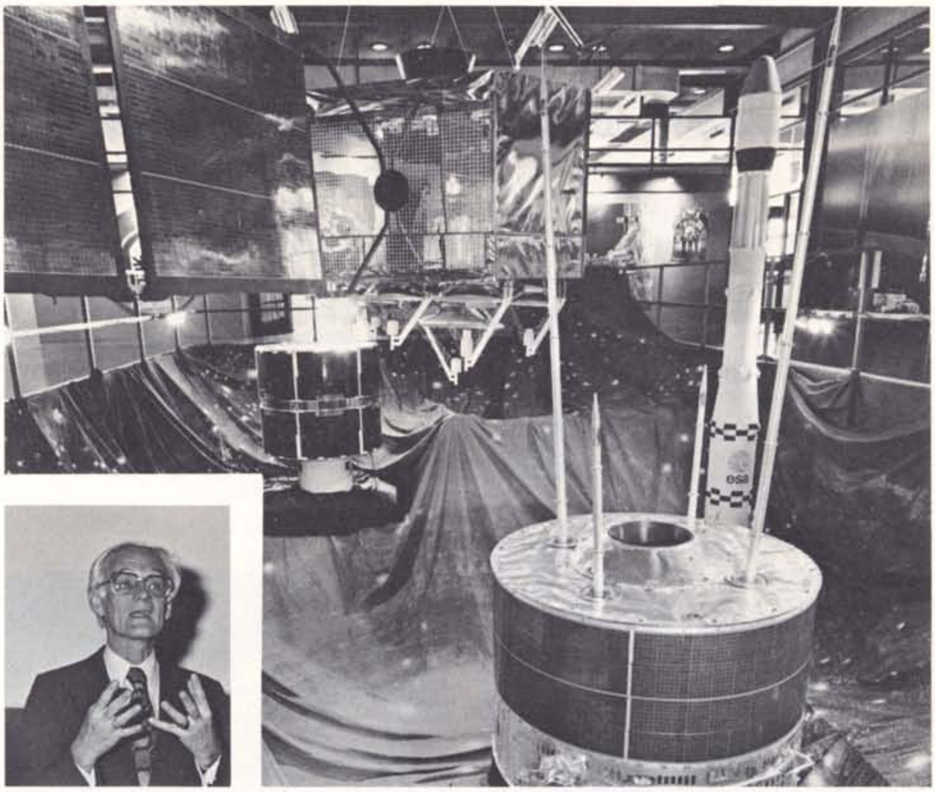
- ESA/ESTEC
- The Royal Dutch Meteorological Institute, De Bilt
- The International Institute for Aerial Survey and Earth Sciences (ITC), Enschede
- Holland Signaal Apparaten (Philips), Hengelo
- The Dutch Aerospace Laboratory, Amsterdam
- The Aerospace Museum Twente, Hengelo
- The Technical High School, Twente
- Radio Astronomical Observatory, Dwingelo
- Radio Astronomical Observatory, Westerbork
- Astronomical Society of TH Twente
- The Dutch Society for Meteorology and Astronomy, Boekelo
- The Astronomical Observatory, Enschede.

The comprehensive range of exhibits

provided by ESA included full-sized models of OTS, Geos, Cos-B, ESRO-II, ESRO-IV and Heos-A2, and scale models of Ariane, Spacelab, Meteosat, IUE and the Space Shuttle.

Centre of attraction for many of the 70 000 visitors to the exhibition was a working Meteosat Secondary Data User Station (SDUS).

The exhibition was opened by Prof E van Spiegel, Director General of the Dutch Ministry of Science, and Prof C de Jager, one of the pioneers of scientific space research, delivered an opening address.



The ESA/ESTEC display in the entrance to the exhibition at Twente Technical High School.
Prof C de Jager, of the Utrecht University's Space Research Laboratory, delivering the exhibition's opening address. (inset).

Space Astronomy and Astrophysics Summer School

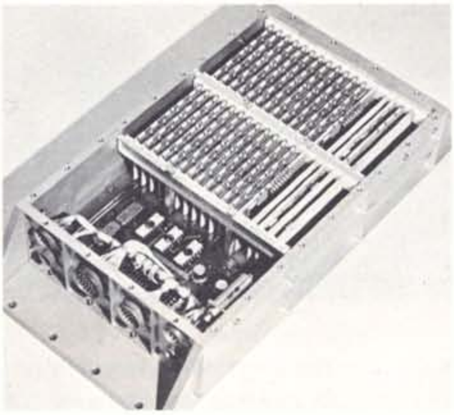
A summer school with the title 'Space Astronomy and Astrophysics' is to be held at Alpbach, Austria from 18-27 July 1979. The school is being organised under the auspices of the Austrian Solar and Space Agency (ASSA), with ESA and other Agencies as co-sponsors.

The course will consist of morning lectures and workshops in the afternoons, and some specialised seminars will also be given in the evenings. The lectures will concentrate on the various aspects of the formation and evolution of stars: interstellar medium, molecular clouds, compact HII regions, protostars, stellar atmospheres, planetary nebulae, supernovae, white dwarfs, neutron stars, and black holes.

Instruments used in space astronomy and astrophysics will be discussed in three Working Group sessions.

Further information can be obtained from:

The Austrian Solar and Space Agency
Attention: Dr E Mondre
Garnisongasse 7
1090 Wien, Austria



The processing electronics for the electric-field experiment supplied by ESA's Space Science Department for flight on the Magik spacecraft.

Cooperative Electric-Field Experiment on the Intercosmos 'Magik' Satellite

The Space Plasma Physics Division of ESA's Space Science Department has been involved in developing and building an electric-field experiment for Magik (Magnetospheric Inter Kosmos) in cooperation with Dr I Zhulin of the Izmiran Institute in Moscow, which forms part of the USSR Academy of Sciences. This cooperative effort was started in April 1976, and the development work was based on the Division's experience with electric-field probes and electronics for the Agency's own Geos satellite.

Magik (Interkosmos 18) was launched on 24 October 1978, into a near-polar orbit with an apogee of 775 km, a perigee of 409 km, an inclination of 83° and an orbital period of 96.3 min. It is a three-axis stabilised spacecraft carrying a payload of electric and magnetic-field experiments, and also experiments to investigate energetic particles, both ions and electrons.

The electric-field experiment supplied by ESA consists of three mutually orthogonal dipole antennas, circuitry to measure triaxial DC fields, and two hybrid correlators to investigate 0.5 kHz AC fields. The correlator data will be analysed by SSD.

The electric-field data from Magik and Geos together provide a unique contribution towards the understanding of the energy flow that takes place between the Earth's magnetosphere and ionosphere.

Application of Space Techniques to Earthquake Prediction

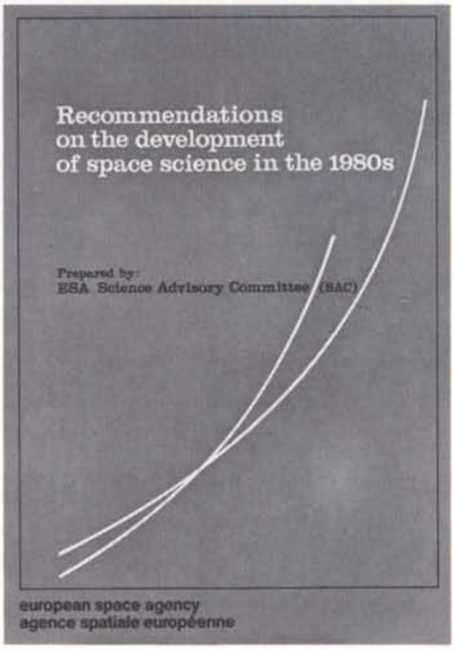
Some forty specialists from ten European countries attended a seminar on earthquake prediction, held recently in Strasbourg (5-7 March 1979) under the joint auspices of the European Space Agency and the Parliamentary Assembly of the Council of Europe. At the end of this meeting, a concerted European research programme on earthquake prediction was drawn up which will

combine data supplied by ground-based instruments with those obtained from space systems. If the operational phase is to commence around 1990, the programme's preparatory phase should start now. The research programme would concentrate on the Alpine-Mediterranean seismic belt, which runs from the Near East through the East Mediterranean, the Aegean, the Balkans, the Apennine Peninsula, the Sicilian-Calabrian Arc, and the Iberian Peninsula to the Azores. Seismotectonic evaluation of this area will allow a new seismic map of Europe to be drawn.

The Proceedings of the seminar have just been published by the Agency as ESA SP-149 (price 50 FF).

Recommendations on the Development of Space Science in the 1980s

The considerations and recommendations presented in this report, prepared by the ESA Science Advisory Committee (SAC), are the outcome of an exercise that has been under way in ESA since 1975, aimed at elaborating the first Long-Term Policy Programme for the Agency's scientific activities.



The report does not address itself to the selection of the next scientific projects, but concentrates rather on analysing the role of space science research in Europe in the coming decade, taking into account the needs of the scientific community and the broad prospect that can be assessed today for the development of space activities in general.

After a critical review of the past role and effectiveness of ESA in science, the SAC expresses its views on the development of space science in the 1980s and proposes ways of implementing its recommendations, as well as the directions in which the present and future technical resources of the Agency should be oriented.

The SAC's report is now available as ESA Special Publication No. 1015 (ESA SP-1015).

The Achievements of ESA's Scientific Satellites 1968–1978

With the launch of Geos-2 in July 1978, the European Space Agency began its twelfth consecutive success story. Technically, all the spacecraft put into orbit have performed sufficiently well to enable the intended missions to be accomplished, and no experiment on which a mission was critically dependent has suffered catastrophic failure. Indeed the technical performance of the scientific

packages developed in national institutes has been extremely good and has at least equalled the performance of the spacecraft subsystems developed in industry.

The reports contained in this book aim to describe what was hoped for when each of the first nine satellites was planned, to list the experiments carried and to summarise some of the most important scientific achievements.

The book is available as ESA Special Publication No. 1013 (ESA SP-1013, price 75 FF).

FOR AVAILABILITY AND ORDER FORM FOR THESE THREE PUBLICATIONS, SEE INSIDE BACK COVER AND PAGE 81, RESPECTIVELY.

GEPSY – Un système d'information au service de la planification et de l'élaboration des décisions

suite de la page 25

2. Le même type de rapport peut être demandé pour un emploi soutien par exemple 80 = ESTEC (Fig. 5). Dans ce cas, les grand titres et 8 donnent, en négatif, les facturations ('charges') sur les programmes. On vérifie par exemple qu'il y a coincidence pour le code projet 34 ECS (Figs. 2 et 5).

3. On peut avoir à s'assurer que les dépenses totales d'un programme suivent un certain niveau: par exemple, le programme scientifique qui, on le sait, 'ne doit pas être inférieur à un certain niveau de dépense'... ni supérieur du reste en pratique.

4. L'exercice peut être demandé pour tout le niveau de dépenses des programmes: on obtient alors le niveau de financement total de l'Agence (Sur la Figure 5, on remarque la cohérence pour ECS et ESTEC).

5. On peut aussi se demander quelles sont les dépenses de l'ESTEC rechargées sur les projets, ou le niveau des dépenses de personnel dans les projets etc. (Fig. 5).

Si l'analyse des éditions de synthèse conduit à relever des écarts de programmation, il est possible, en éditant les niveaux de détail, d'identifier les principales causes de déviations, et ainsi d'entamer le dialogue avec le responsable technique qui a produit l'information et qui possède les détails nécessaires. Cette procédure est rendue possible par le faible nombre d'informations traitées en même temps (un coût-à-achèvement de projet ne comporte pas plus de 20 ou 30 items en moyenne).

GEPSY est donc un réel *instrument de dialogue* entre les niveaux d'élaboration des synthèses sur lesquels s'appuie la Direction générale et le niveau d'exécution des projets.

Faiblesses actuelles du système et évolution future

Dans son état de développement actuel, GEPSY a déjà démontré l'utilité d'un système simple au 'carrefour' d'autres systèmes plus complexes d'information, indispensables à d'autres aspects des activités d'information et de gestion; il ne peut cependant fournir pour l'instant une simulation complète pour deux raisons majeures:

1. Tout d'abord, il n'existe pas de lien informatique entre les coûts indirects portés dans les projets (items des grands titres 6, 7, 8) et les imputations des emplois 'soutien'. La liaison est faite 'à la main', ce qui peut donner lieu à des erreurs de transcription – et en tout cas gaspille du temps. GEPSY sera transformé sous peu dans ce sens, ce qui ne présente pas de difficultés majeures.

2. Plus grave, la liaison informatique entre les coûts directs des Etablissements et les coûts imputés (aux projets) n'existe pas non plus. La raison réside dans la conception actuelle de la 'charging policy'. Sa mise en oeuvre implique la connaissance d'un détail très fin des dépenses directes des Etablissements (principalement emplois 80, 85 et 93) pour en séparer les imputations sur les projets. L'information traitée par GEPSY étant à un niveau trop global, il apparaît une incompatibilité. Le résultat en est qu'une modification dans ces coûts directs n'est pas automatiquement traduite par une variation dans les imputations.
Cette difficulté ne peut être levée que par deux biais:

- introduire dans le système un calcul d'imputation 'à peu près', fondé sur des pourcentages fixes; cette simplification aura l'avantage d'introduire plus de clarté.
- demander périodiquement aux Etablissements d'effectuer sur un ordinateur plus important le calcul réel, de façon à recaler la base de donnée GEPSY.

Ces améliorations sont en cours d'implantation. On pourrait aussi songer à une simplification radicale de la politique d'imputation elle-même!

Lorsque ces faiblesses auront été surmontées, GEPSY sera devenu un instrument de simulation et de modélisation des dépenses actuelles et futures de l'Agence et permettra de faire comprendre rapidement le lien entre les prévisions budgétaires et les dépenses de programme. De ce fait il donnera à la Direction générale un outil capable de mieux éclairer ses décisions.

Figure 6 – Le système GEPSY en opération.

Publications

The documents listed have been issued since the last publications announcement in the Bulletin. Requests for copies should be made in accordance with the Table inside the back cover and using the Order Form on Page 81.

ESA Journal

The following papers were published in Vol. 3, No. 1:

ORBIT DESIGN FOR A GEOMAGNETIC-TAIL MISSION
CORNELISSE, J.W./SCHNIEWIND, J.F./KNOTT, K.

ATTITUDE CONTROL BY SOLAR SAILING — A PROMISING EXPERIMENT WITH OTS-2
RENNER, U.

EFFECTS OF ELECTRON IRRADIATION ON LARGE INSULATING SURFACES USED FOR EUROPEAN COMMUNICATIONS SATELLITES
REDDY, J./SERENE, B.E.

THE QUALIFICATION OF A LARGE ELECTRON-IRRADIATION FACILITY FOR TELECOMMUNICATIONS-SATELLITE DIFFERENTIAL-CHARGING SIMULATION
SERENE, B.E./REDDY, J.

OUTLOOK FOR SATELLITE COMMUNICATIONS AT 20/30 GHZ
BERRETTA, G.

Special Publications

ESA SP-141 *SPACECRAFT ON BOARD DATA-MANAGEMENT. PROCEEDINGS OF AN INTERNATIONAL ESA-EUROSPACE CONFERENCE, NICE 24-27 OCTOBER 1978. (DEC. 1978)*
GUYENNE T.D. (ED)
PRICE CODE C2

ESA SP-1010 *APPLICATIONS OF EARTH RESOURCES SATELLITE DATA TO DEVELOPMENT AID PROGRAMMES. (FEB 1979) — TEXT IN ENGLISH AND IN FRENCH.*
ESA REMOTE-SENSING WORKING GROUP
PRICE CODE C1

Scientific and Technical Reports

ESA STR-202 *THE PROTOTYPE LOW-ENERGY TELESCOPE SYSTEM FOR THE INTERNATIONAL SOLAR POLAR COSPIN EXPERIMENT. (JAN 1979)*
MARSDEN, R.G./HENRION, J.
PRICE CODE C1

Scientific and Technical Memoranda

ESA STM-206 *MATERIALS DATA RETRIEVAL AT ESTEC. (NOV 1978)*
DAUPHIN, J./JOLLET, P.
PRICE CODE C1

Procedures, Standards and Specifications

ESA PSS-49 (TST-01) *HEAT-PIPE QUALIFICATION REQUIREMENTS — ISSUE-1 (JAN 1979) STRUCTURE AND THERMAL CONTROL DIVISION, ESTEC.*
PRICE CODE C1

Technical Translations

ESA TT-471 *ELECTROPHORESIS EXPERIMENT MA-014 IN THE APOLLO SOYUZ TEST PROJECT. PART 1: SCIENTIFIC RESULTS*
HANNIG K., WIRTH, H/LEIHENER, D./ LOESER, R. /DERSCH, W., BUNDESMIN. FUER FORSCH. U. TECHNOL., GERMANY

ESA TT-472 *ELECTROPHORESIS EXPERIMENT MA-014 IN THE APOLLO SOYUZ TEST PROJECT. PART 2: TECHNICAL ASPECTS*
SCHOEN, E./DORL, G./LEMKE, H., BUNDESMIN. FUER FORSCH. U. TECHNOL., GERMANY

ESA TT-473 *ELECTROPHORESIS EXPERIMENT MA-014 IN THE APOLLO SOYUZ TEST PROJECT. PART 3: FUTURE APPLICATIONS*
SCHOEN, E./DORL, G./LEMKE, H., BUNDESMIN. FUER FORSCH. U. TECHNOL., GERMANY

ESA TT-479 *INVESTIGATIONS OF A HIGHLY LOADED COMPRESSOR CASCADE WITH CONTROL OF THE BLADE BOUNDARY LAYER. PART 5: EXPERIMENTAL INVESTIGATIONS OF THE CASCADE WITH SLOTTED BLADES*
KIOCK, R., DFVLR, GERMANY

ESA TT-481 *SYNTHETIC APERTURE RADAR (SAR) SYSTEM LIMITATIONS DUE TO PHASE ERRORS*
BOESSWETTER, C. DFVLR, GERMANY

ESA TT-487 *COVERAGE FIELD OF EARTH OBSERVATION SATELLITES AT THE EARTH'S SURFACE. DESCRIPTION OF THE COMPUTER PROGRAM COFI*
JOCHIM, E./PAWLIK, W., DFVLR, GERMANY

ESA TT-489 *MEASUREMENT OF SMALL CONCENTRATIONS OF POLLUTANTS IN GASES BY AN OPTICAL AC WAVELENGTH SCANNING METHOD*
KELM, S./EBERIUS, H., DFVLR, GERMANY

ESA TT-491 *LA RECHERCHE AEROSPATIALE — BIMONTHLY BULLETIN, 1978-1*
ONERA, FRANCE

ESA TT-492 *STUDY OF HYDRAULIC GENERATORS FOR VIBRATION TESTING OF LARGE SPACE MODULES*
MERLET/LEMONDE, SOPEMEA, FRANCE

ESA TT-493 *CALCULATION OF THE INTERFERENCE EFFECTS BETWEEN THE ENGINE WING AND THE BASE WING OF A CIVIL AND MILITARY TRANSPORT AIRCRAFT BY THE VORTEX LATTICE METHOD*
SCHROEDER, W., DFVLR, GERMANY

ESA TT-494 *COVERAGE BEHAVIOUR OF ERDSAT FOR SOME SELECTED REGIONS OF THE WORLD*
JOCHIM, E., DFVLR, GERMANY

ESA TT-495 *FEASIBILITY STUDY OF A SPACELAB EXPERIMENTAL PLATFORM (SEAP).*
MANSKI, D./NATENBRUK, P., BUNDESMIN. FUER FORSCH. U. TECHNOL., GERMANY

ESA TT-496 *LA RECHERCHE AEROSPATIALE — BIMONTHLY BULLETIN, 1978-2*
ONERA, FRANCE

ESA TT-499 *SOME IMPORTANT RESULTS OBTAINED DURING THE ANALYSIS OF NEAR MISSES AND MIDAIR COLLISIONS*
WEBER, O., DFVLR, GERMANY

ESA TT-501 *LINK INVARIANT LINE PROGRAMS IN COMMUNICATION SYSTEMS*
BUCHBERGER, F., DFVLR, GERMANY

ESA TT-502 *HOT GAS SIDE HEAT TRANSFER COEFFICIENTS IN HIGH ENERGY ROCKET ENGINES WITH THRUST VARIATION*
STERNFELD, H., DFVLR, GERMANY

ESA TT-503 *INVESTIGATIONS ON UNSTEADY PRESSURE DISTRIBUTION MEASUREMENTS IN ROTATING SYSTEMS*
KIENAPPEL, K., DFVLR, GERMANY

ESA TT-504 *THE DETERMINATION OF THE LAVAL NOZZLE EXIT CONDITIONS AT A TOO HIGH COUNTER-PRESSURE, ESPECIALLY FOR A PROPANE OXYGEN GAS GENERATOR*
RIESTER, E., DFVLR, GERMANY

ESA TT-505 *THE USE OF RAM ROCKETS FOR HIGH ALTITUDE MISSILES*
RIESTER, E., DFVLR, GERMANY

ESA TT-506 *BETTER PERFORMANCE FOR AIRCRAFT TRACKING AND HOLDING UNDER GUST AND SHEAR WIND INFLUENCE BY USE OF DIRECT DIGITAL CONTROL*
SCHLUETER, H./BENDER, K., DFVLR, GERMANY

ESA TT-507 *INFLUENCE OF THERMOMECHANICAL TREATMENT ON MICROSTRUCTURE AND MECHANICAL PROPERTIES OF HIGH STRENGTH ALUMINUM ALLOYS*
WEL-PAMM, K./LUETJERING, G./BUNK, W.

ESA TT-508 *MOLECULAR TWO-DIMENSIONAL FLOW OF MIXTURES OF LIGHT AND HEAVY GASES WITH DIFFUSE AND SPECULAR REFLECTION*
WUEST, W., DFVLR, GERMANY

ESA TT-509 *NEW APPROXIMATE EQUATIONS FOR THE SATURATION PRESSURE OF WATER VAPOUR AND FOR HUMIDITY PARAMETERS USED IN METEOROLOGY*
BOEGEL, W., DFVLR, GERMANY

ESA TT-510 *PRESSURE PROFILE IN AN OPEN CAVITY WITH LINEARLY INCREASING OUTSIDE PRESSURE*
HAMACHER, H., DFLVR, GERMANY

ESA TT-511 *STABILIZATION OF FLAME IN A RAMJET COMBUSTOR BY MEANS OF A PILOT GAS GENERATOR*
RIESTER, E., DFLVR, GERMANY

ESA TT-512 *CONTROL SYSTEM DESIGN USING VECTOR-VALUED PERFORMANCE CRITERIA WITH APPLICATION TO THE CONTROL RATE REDUCTION IN PARAMETER INSENSITIVE CONTROL SYSTEMS*
KREISSELMEIER, G., DFVLR, GERMANY

ESA TT-513 *INVESTIGATION OF PHASE EQUILIBRIA OF TAC-FIBER REINFORCED COBALT-ALLOYS HAVING DIRECTIONALLY SOLIDIFIED EUTECTIC STRUCTURE AIMED AT MATRIX HARDENING*
DONNER, A., DFVLR, GERMANY

ESA TT-514 *DEFINITION AND REALIZATION OF A SPINNING MODE SIMULATOR*
VILLE, J.-M., ONERA, FRANCE

ESA TT-526 *BENEFIT COST STUDY MINIMETSAT: AN EXAMPLE OF THE ADAPTION AND EVALUATION PROCESS*
MAJUS, J., DFVLR, GERMANY

Contractor Reports

ESA CR(P)-923 *DEVELOPMENT STUDY FOR A HIGH ACCURACY STAR SENSOR — VOLUME 3: EVALUATION OF CRITICAL PROPERTIES OF CCD AND CID IMAGE SENSORS. (APR 1978)*
SIRA, UK

ESA CR(P)-1019 *LES SERVICES NOUVEAUX DE TELEVISION ENVISAGEABLES EN EUROPE A L'AGE DU SATELLITE DE TELEVISION DIRECTE. VOL. 3: ANNEXES. (UNDATED)*
EUROSPACE, FRANCE

ESA CR(X)-1030 *ION-PLATED LEAD AS A FILM LUBRICANT FOR BEARINGS IN VACUUM. (OCT 1977)*
ESTL, UK

ESA CR(X)-1038 *DEVELOPMENT OF A MILLIMETRE-WAVE PARAMETRIC DOWN CONVERTER — FINAL REPORT. (JUL 1977)*
FERRANTI, UK

ESA (CR(P)-1045 *MOLYBDENUM DISULPHIDE LUBRICATION — A CONTINUATION SURVEY 1975-76. (UNDATED)*
SWANSEA TRIBOLOGY CENTRE, UK

ESA CR(X)-1049 *PATTERN PREDICTION FOR L-BAND ANTENNAS ON AIRCRAFT — FINAL REPORT. (NOV 1977)*
TICRA APS, DENMARK

ESA CR(X)-1061 *COMPLEMENTARY WORK ON POWER AMPLIFIER FOR MULTIBEAM ARRAY MODEL — FINAL REPORT (NOV 1977)*
MULLARD, UK

ESA CR(P)-1077 *IRRADIATIONS PAR PROTONS ET IRRADIATIONS PAR ELECTRONS DE REVETEMENTS DE CONTROLE THERMIQUE ET DE FILMS POLYMERIQUES — RAPPORT FINAL. TOME 1: PARTIE EXPERIMENTALE. TOME 2: PARTIE THEORIQUE. (SEP 1977/FEB 1978)*
ONERA/DERTS, FRANCE

ESA CR(X)-1079 *SIMPLE TIME DIVISION MULTIPLE ACCESS (TDMA) SYSTEM STUDY — FINAL REPORT. (MAR 1978)*
DIGITAL COMMUNICATIONS CORP., USA

ESA CR(P)-1089 *ASTROMETRY SATELLITE PHASE — A STUDY — FINAL REPORT. VOLUME 1: TECHNICAL STUDY, VOLUME 2: APPENDICES. (MAR 1978)*
AERITALIA, ITALY

ESA CR(P)-1090 *SOUNDING ROCKET ACTIVITY IN EUROPE IN THE 1980'S — FINAL REPORT. (APR 1978)*
SWEDISH SPACE CORPORATION, SWEDEN

ESA CR(P)-1091 *STUDY OF THE SITUATION AND THE NEEDS IN AFRICA RELATING TO METEOROLOGICAL TELECOMMUNICATIONS. (MAR 1978)*
SOFREAVIA, FRANCE

ESA CR(P)-1092 *EVALUATION OF CRACK DETECTION METHODS — PHASE II REPORT. (FEB 1978)*
AERITALIA, ITALY

ESA CR(P)-1093 *STUDY OF THE USE OF SPACELAB-DERIVED ELEMENTS WITHIN DIFFERENT POSSIBLE STEPS TOWARDS A SPACE PLATFORM — FINAL REPORT. (APR 1978)*
ERNO, GERMANY

ESA CR(P)-1094 *POLARISATION PROPERTIES OF EDGE-LOADED HIGH-GAIN REFLECTOR ANTENNAS — FINAL REPORT, VOLUME 1: REPORT, VOLUME 2: MANUAL FOR GTDLAC PROGRAMS. (MAY 1978)*
IST. UNIV. NAVALE, NAPOLI, ITALY

ESA CR(P)-1095 *ETUDE D'UN SYSTEME DE CONTROLE D'ATTITUDE INCLUANT UN ESTIMATEUR DE LA DERIVE DES GYROMETRES ET UTILISANT LE CALCULATEUR EMBARQUE DE L'ESA — RAPPORT FINAL VOLUMES I ET II. (MAI 1978)*
AEROSPATIALE, FRANCE

ESA CR(P)-1096 *AN AEROMARITIME SATELLITE SYSTEM PAYLOAD DEFINITION. (MAR 1978)*
LM ERICSSON, SWEDEN

ESA CR(P)-1097 *FURTHER WORK TO MODIFY AN EMI 2-STAGE IMAGE INTENSIFIER TO BE SUITABLE FOR A SPACEBORNE ASTRONOMICAL INSTRUMENT ON S.T. (APR 1978)*
EMI, UK

ESA CR(P)-1098 *SECA PHASE 3 — RAPPORT FINAL. (FEV 1978)*
CROUZET, FRANCE

ESA CR(P)-1099 *ETUDE DE LA PHYSIQUE DES DEFAILLANCES ET DE LA FIABILITE DES TRANSISTORS HYPERFREQUENCE. VOLUME 1: RAPPORT FINAL, VOLUME 2: RESUME DU RAPPORT FINAL ET RECOMMANDATIONS D'EMPLOI. (OCT 1977)*
CNET, FRANCE

ESA CR(P)-1100 *AN INVESTIGATION INTO THE HYDROTHERMAL DEGRADATION OF CARBON FIBRE COMPOSITES. (MAY 1978)*
BRITISH AEROSPACE, UK

ESA CR(P)-1101 *FAILURE CRITERIA OF CFRP COMPOSITES AT CRYOGENIC TEMPERATURES. (MAY 1978)*
BRITISH AEROSPACE, UK

ESA CR(P)-1102 *DEVELOPMENT OF A COLD CATHODE ELECTRON EMITTER FOR IMAGE TUBES. (NO DATE)*
UNIV. AUTONOMA, MADRID, SPAIN

ESA CR(P)-1103 *EXTENSION DU 'PROGRAMME D'EVALUATION DE DIODES IMPATT A HAUT RENDEMENT' AUX DIODES A JONCTION P/N — RAPPORT FINAL. (AVR 1978)*
LAB. D'ELECTRONIQUE ET DE PHYSIQUE APPL., FRANCE

ESA CR(P)-1104 *DETAILED DESIGN OF A PRECISION TWO-AXIS IR HORIZON SENSOR — FINAL REPORT — APPENDIX. (SEP 1977)*
OFFICINE GALILEO, ITALY

ESA CR(P)-1105 *IMPLEMENTATION STUDY OF AN ATTITUDE AND ORBIT CONTROL SUBSYSTEM USING AN ADAPTIVE CONTROL ELECTRONICS – FINAL REPORT VOLUME A: DESIGN OF A MACS, VOLUME B: MACS HANDBOOK, VOLUME C: MACS APPLICATION TO OTS, ECS, EXOSAT, VOLUME D: MACS – DETAILED APPLICATION TO SPOT, VOLUME E: ANNEXES 4,5. (MAY 1978)*
MATRA, FRANCE

ESA CR(P)-1106 *SERVICES NOUVEAUX DE TELEVISION DIRECTE SUSCEPTIBLES D'ETRE EXPERIMENTES EN EUROPE AVEC UN SATELLITE H-SAT. (SANS DATE)*
EUROSPACE, FRANCE

ESA CR(P)-1107 *SURFACE TENSION TANK – STUDY OF DESIGN IMPROVEMENT AND FUNCTIONAL DEMONSTRATION – FINAL REPORT. (NO DATE)*
SEP, FRANCE

ESA CR(P)-1108 *DEVELOPMENT OF A MATHEMATICAL MODEL OF THE THERMAL DECOMPOSITION OF HYDRAZINE IN AN ENGINE. (MAR 1978)*
INTA, SPAIN

ESA CR(P)-1109 *COMPLEMENTARY PREDEFINITION STUDY OF A METEOROLOGICAL DATA DISTRIBUTION AND LASSO MISSION USING A SIRIO BUS – PHASE 'A' EXTENSION AND PRELIMINARY PHASE 'B' FINAL SUMMARY REPORT. (JUL 1978)*
COMP. NAZ. AEROSPAZIALE S.P.A., ITALY

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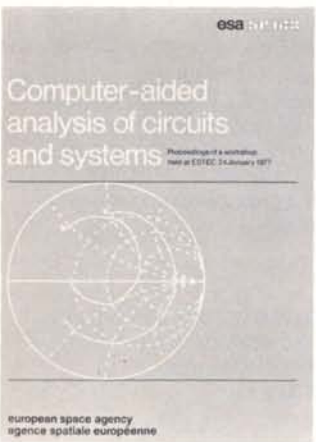

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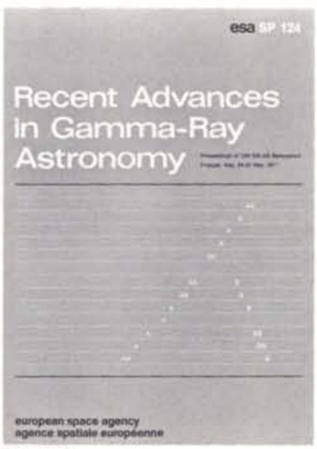

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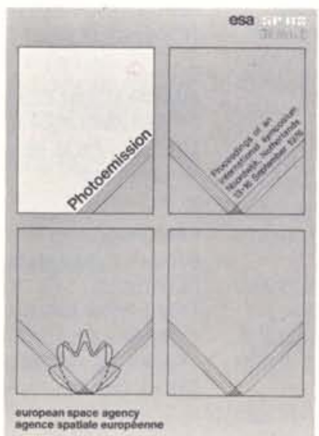

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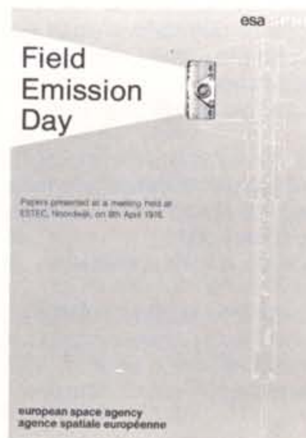

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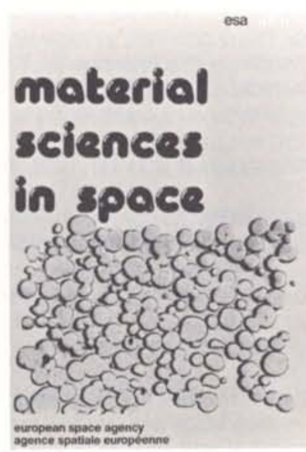

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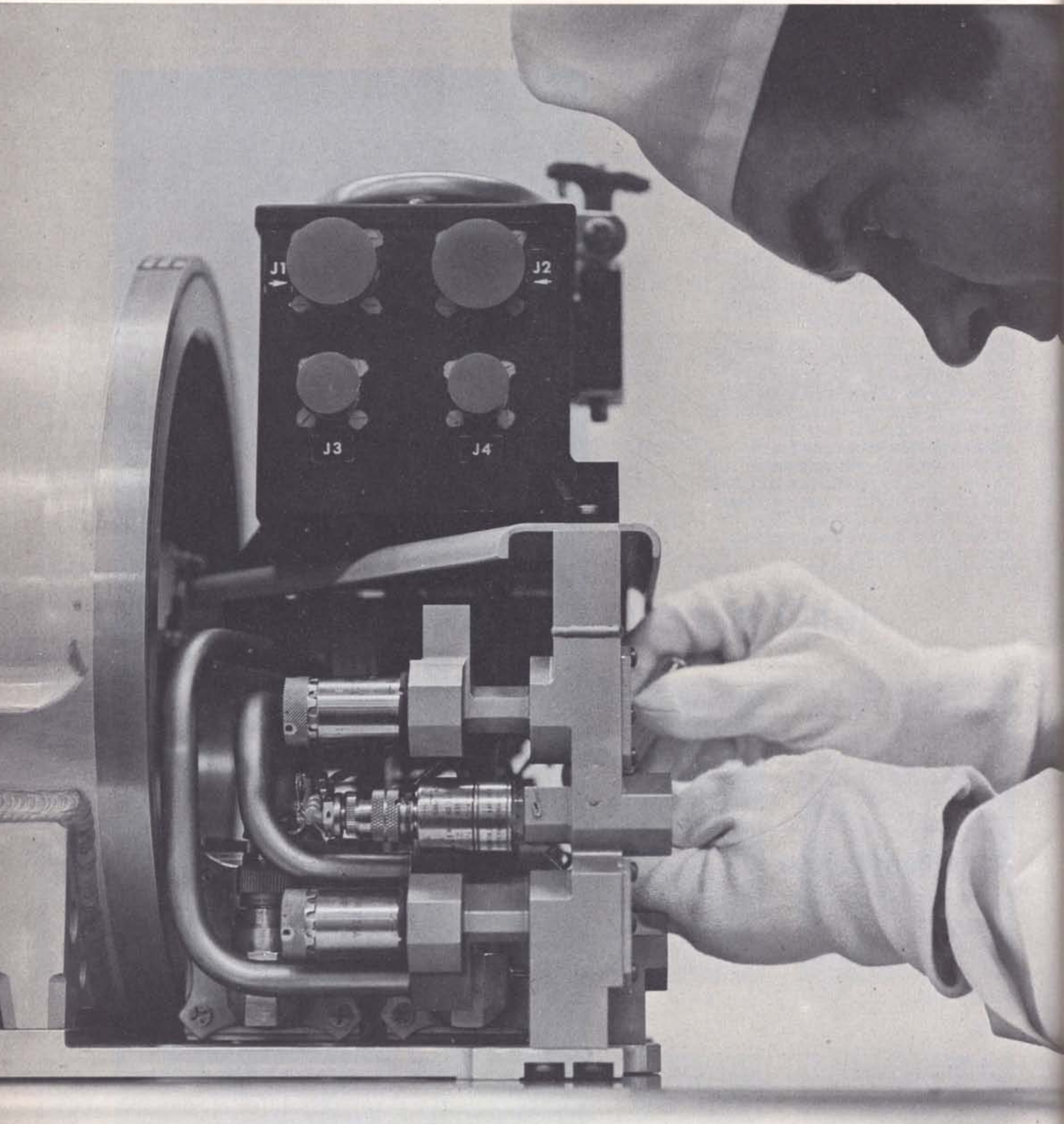
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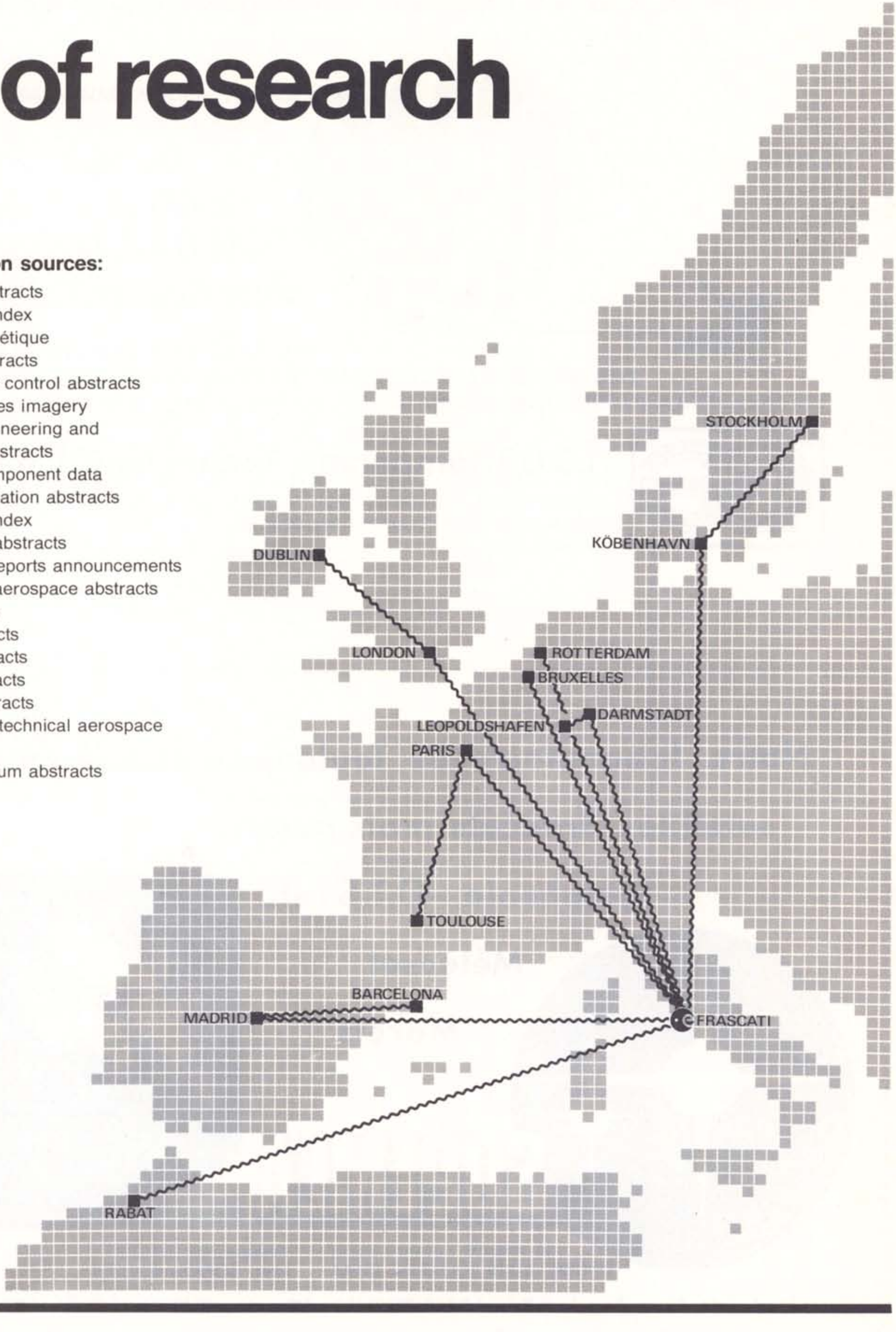

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