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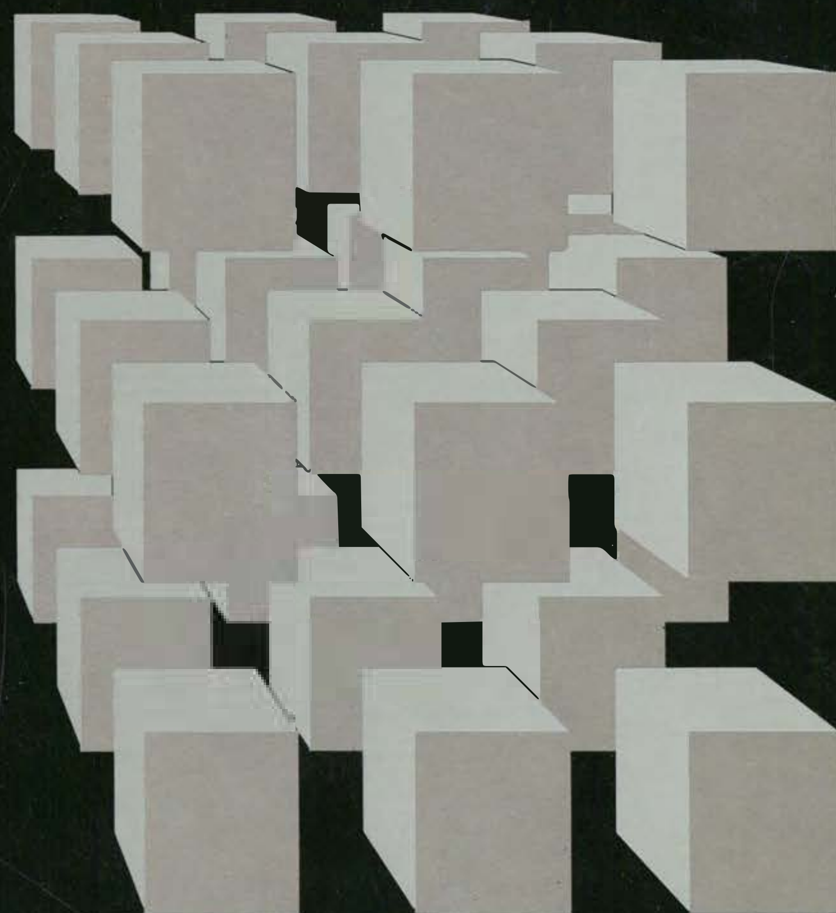
europe two decades in space



1964 1984

Recollections by some of the principal pioneers

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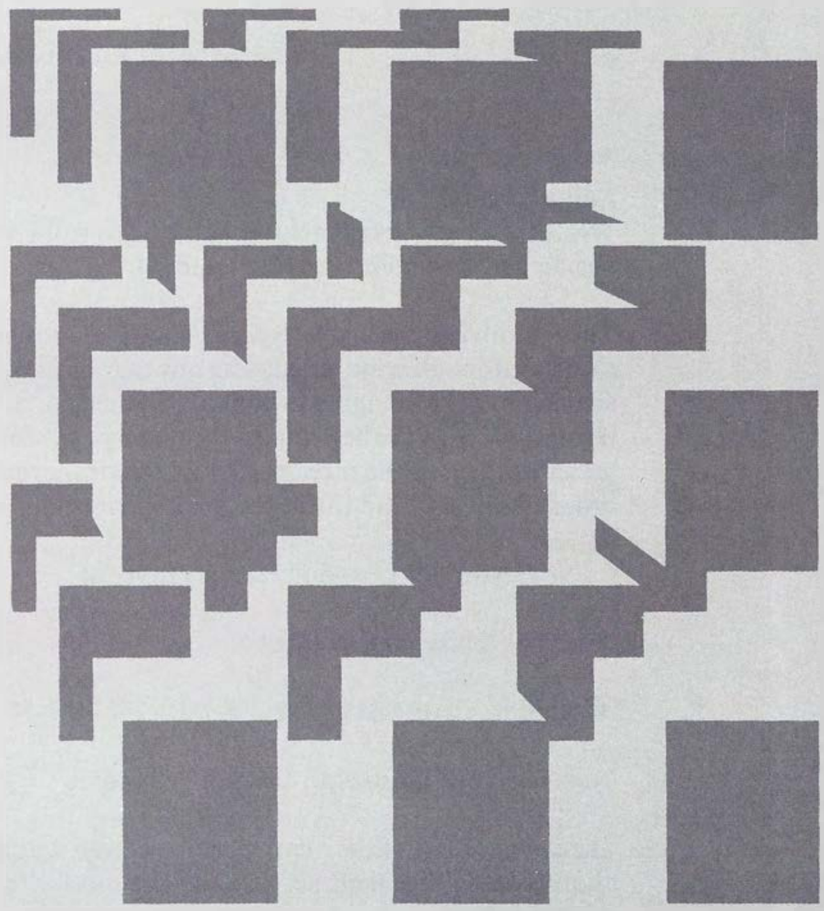

1964 1984

Recollections by some of the principal pioneers

Editorial Note
While it has been extremely stimulating to work with the authors of this book, it was difficult to decide how best to present the material.

The first division was relatively easy: 1. The Pioneers; 2. Some of our Friends; 3. Industrial Contributors. Beyond that it was not easy to find any chronological, or subject order as so many articles are wide-ranging in content. In the end, having set Professor Amaldi's famous article in its rightful place at the beginning – both of space research in Europe, and this book – we could do no better than place the pioneers in alphabetical order of *author*, the friends in English alphabetical order of *country*, and the industrial contributions in alphabetical order of *firms*.

Editors: Norman Longdon & Duc Guyenne

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The cooperation of the many persons – both within and outside ESA – who have loaned photographs from their personal collections for the illustration of this book is gratefully acknowledged.

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Foreword

ESA and the peaceful uses of outer space

Ambassador Peter Jankowitsch

Chairman, United Nations Committee on the Peaceful Uses of Outer Space

I wish to send sincere congratulations to ESA and its Member States on the occasion of the anniversary of twenty years of European space cooperation. Originally there were two European space bodies, the European Space Research Organisation (ESRO), and the European Space Vehicle Launcher Development Organisation (ELDO), which in 1975 were combined to create the European Space Agency (ESA). If we trace the European effort in outer space back even further, we find that we are also celebrating the 24th anniversary of the intergovernmental conference in Meyrin, Switzerland in 1960, when ideas were beginning to be shaped into reality. We can recognise the foresight shown by the European countries, involving their decision at that conference, based as it was on a sound economic, scientific and political insight, as we witness the fully-fledged ESA of today. We should not forget that that collective decision was reached only three years after the opening of the 'space age' by the two superpowers. It enabled European countries to pool efforts and resources and to carry out a joint space programme which now gives Europe a reasonable degree of independence and competitiveness in space activities. Europe was given a head start in the new era of tremendous scientific and technical development and discovery, at a time when the participating nations did not necessarily have accord in other areas. Such prevision secured Europe's position as the third space power today.

A comprehensive space capability

Reflecting Europe's decision to acquire a comprehensive space capability, ESA's and its individual Member States' contributions to man's effort in the development and applications of space technology and in space exploration are impressively wide-ranging. ESA has developed a reliable independent launch capability for many types of missions with the successful qualification of the Ariane launcher. The future models being projected will enhance and expand its capacity to meet the requirements of many users: a look at the manifest shows how confident are users both within and outside Europe. With Spacelab, ESA has shown its ability to make a major contribution to manned space missions. And although at the time of writing a full analysis of the first flight is not complete, NASA and the many diverse scientific communities which took part have expressed great satisfaction and confidence in Spacelab.

It is in the realm of scientific research that ESA and its Member States have the longest record of proven success. The return in the form of data has been continuous and exciting. From the early days of ESRO II, through the ever increasing sophistication of its satellites until we reach Exosat, opening up new vistas of the Universe, science has been the basis on which European co-operation has been built. Nor does it stop there: we all look forward to that almost science-fiction rendezvous between Comet Halley and Giotto, and the first look at the solar polar regions with ISPM. Other satellites will follow.

In the space applications field, with its potential for commercial success, there has understandably not always been the same degree of common endeavour, but Europe can proudly point to its Meteosat system, already used by many countries and familiar to millions on television, and shortly to gain 'operational' status. Even more convincing has been the breaking down of national barriers with the success of the experimental telecommunications satellite, OTS, and the start of the operational series with ECS. Olympus – or L-Sat as it is still more familiarly known – will take us a further step down the road. Now we look forward to the first cooperative venture in European earth resources satellites with ERS-1.

Although not an ESA satellite, I would like to mention Sarsat, a major humanitarian search-and-rescue project, which has been greatly assisted by an ESA member.

To be sure, these impressive achievements were born out of the high degree of cooperation among the members of ESA in pooling financial, technical and human resources, the organisational competence of ESA and the manner in which ESA and national agencies shared responsibility. ESA's success is itself living testimony to the potential that can be achieved through an intrinsic regional cooperation among countries of different sizes and at different stages of development.

A focal point for international cooperation
No less striking may be the emphasis ESA has placed and continues to place on international cooperation in space activities. Since its inception, ESA and its members have been cooperating with other countries, developed and developing countries alike. Numerous cooperative agreements have been signed with international organisations. One may cite cooperation with the United States on scientific programmes, with Inmarsat and Intelsat, with India (in particular through the agreement to launch 'APPLE'). There have been regular exchanges of information with the USSR and Japan, and even closer ties will be forged during the encounter with Comet Halley. A dialogue now exists with China, Indonesia and Morocco, and Brazil has agreed to the use of tracking and telemetry facilities in support of launches from French Guiana.

The strong belief that ESA and its members have in international cooperation naturally led ESA members to pursue an active role in the United Nations Committee on the Peaceful Uses of Outer Space which has been designated by the United Nations General Assembly as the focal point of its effort in international cooperation in the peaceful uses of outer space.

ESA and its members have been among the best represented since the inception of the Committee on the Peaceful Uses of Outer Space, whose involvement in outer space goes back almost to the opening of the space age, and they have made unique and significant contributions to its activities.

As a prominent non-super space power which has successfully conducted complex undertakings in international cooperation in such a sensitive area as outer space activities, ESA has always

commanded a high degree of respect among the membership of the Committee. The diplomatic efforts of ESA and its Member States have made a lasting impact on all aspects of the work tackled by the Committee. In an area where the possession or non-possession of hardware capability inevitably influences to a great degree the weight of one's say and consequently the result of negotiations, the existence of ESA as the third space power itself has had a most moderating influence. ESA should be proud of its invaluable contribution to the United Nations' effort which worked out all five international treaties which exist to date on what many describe as the last frontier of mankind.

One of the most important tasks before the Committee on the Peaceful Uses of Outer Space since its creation has been to help ensure that outer space should be used only for the betterment of mankind and to the benefit of States irrespective of the stage of their economic or scientific development. In fact the major theme of the First and the Second United Nations Conferences on the Exploration and Peaceful Uses of Outer Space (UNISPACE) was how to ensure that the full potential benefits of outer space activities are achieved by and for all peoples of the world. The paper submitted to the Second Outer Space Conference by ESA clearly reveals ESA's high consciousness of this important matter, and ESA's international cooperative programmes clearly demonstrate its genuine efforts in this area.

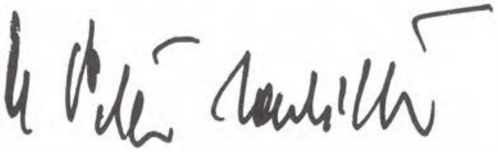
Another major task before the Committee has been the avoidance of the extension of national rivalries into outer space. As the agency whose activities are devoted solely to the peaceful uses of outer space, ESA has always been the leading advocate of limiting the use of outer space to peaceful purposes only. While their efforts are already enshrined in the five treaties which have been mentioned, recent developments demand that ESA members renew their efforts to prevent the extension of an arms race in outer space.

The two-pillar policy

In conclusion, the successful contribution to the peaceful uses of outer space made by ESA and its Member States consists of two pillars: their achievements in the development of space-related hardware and their diplomatic effort within and outside the Committee on the Peaceful Uses of Outer Space to help achieve its lofty tasks. As one who has closely followed the evolution of ESA's activities, I am confident that ESA will confirm, on this auspicious occasion, its goals and orientation as well as the validity of its two-pillar policy on outer space, and that it will strengthen its resolution to contribute further to the peaceful uses of outer space in the years to come.

UNISPACE '82 Conference in Vienna, Austria, August 1982.

As you read the articles which follow written in many cases by men of great academic and political distinction, or by those industrialists who were not afraid to face the challenge of the new technology, I am sure you will share with me the impression that all of them have the driving enthusiasm which space seems to engender in so many of us. These are the leaders who have never lost that youthfulness of heart, that imagination, and that belief in something beyond an earth-bound fate which has always led mankind to reach for the stars.



Introduction

Erik Quistgaard

Director General ESA (1980–84)

It is useful on occasion for an organisation to be reviewed by eyes unclouded by long associations and a mind unblemished by the struggle to give it birth and to sustain its early years.

Reading through the fascinating articles by some of the pioneers, it is abundantly clear that ESA exists today, like so many worthwhile ventures, because a few men with vision, and determination to see their dreams become reality, steadfastly refused to knuckle under to the forces that would have denied them. Others joined them until they had enough strength to face apathy and nationalism, and to inch their way forward towards a European concept.

These men were strong in their beliefs, and outspoken: a trait still evident in their writings. Any attempt to achieve a unity of such diverse cultures as are found in Europe cannot hope for a smooth passage, and the story as it unfolds in the pages of this book is a textbook example of internationalism constantly buffeted by national interests. For the scientist and the technologist, national boundaries have so often been a nuisance when they have been on the trail of new, exciting knowledge. To them, 'communities' are the gathering of peers without thought of colour, race or creed.

If this suggests that it is the politician who plays the role of villain, it would be a distortion of the complex truth. Many government representatives at political and civil service level are faced with conflicting demands upon the resources they control, and the policies they must expound. That so much has been achieved is itself an admission that there was a political will, even though at times its light burned exceedingly small.

A book of this nature should also be judged by what it does not include, as well as what it says. Unfortunately it seems that the pain of ELDO's demise was too great for those directly concerned, and who had striven so hard to make it a success, to write. This is understandable, but it is also a pity, for ELDO was a child of non-technical parentage, of a blindness to technical reality, which apparently Europe needed to bear. ESRO was luckier, that it was the internationally-minded space scientists who shaped its way of working. Those who gave everything to make ELDO work need not be ashamed, for from the fires rose a phoenix called Ariane of which we all can be proud.

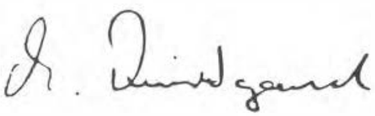
It has fallen to my lot to be in the Director General's chair as we pass the twenty-year mark. More importantly, the celebrations come at a time when ESA rides a wave of success. The last few years have seen the qualification of Ariane, and its use as a commercial launcher, the Marecs and ECS successes and their handing-over to INMARSAT and EUTELSAT for operational use. Exosat has opened exciting new glimpses of the universe, and we are still coming to terms with the amazing success of Spacelab, with all it can mean for the future.

And although this is a book of reminiscences, it would not honour the work of the pioneers if I ended this introduction without looking to the future.

The fundamental problem of national interests versus European concepts is still with us; it still governs any chance we may have of contributing to Europe's world standing in both technology and science. The 'haves' still wonder why they should share with the 'have nots', thinking more of the short term gains than the longer term benefits.

Perhaps, though, we have today one item which was denied the pioneers: a growing public awareness. The public knows not only what ESA has done, but that in space research, and space utilisation, one must think as a European, or become a bystander while the rest of the world achieves the really big successes that beckon us.

The pioneers who set us on the way, and whose book this is, need not fear that their successors lack in determination to carry on their work. The new generations take heart from their example, and prepare for the next two decades in their name.



The Pioneers

'In the Beginning...'

The Scientific and Technical Working Group considers that the main purpose of ESRO is to provide for and promote collaboration among European States in space research and technology.

For this purpose it is necessary to establish a scientific forum. This forum should also make recommendations for and keep under review a scientific programme. In order to carry out this task, ESRO should provide for:

1. the immediate development of rocket payload, satellite and space probe technology to enable an agree ... space science to be undertaken;
2. applied research in a n ... technology in order to offer better facilities for a more a ... science;
3. applied research of a ... looking assessments of space missic ... space

(from the Introduction to the 'Blue Book')

CONFERENCE OF PLENIPOTENTIARIES
for the establishment of a
European Space Research Organisation
Paris 14/15 June 1962

RESOLUTION No. 11

The Conference,

having heard the report of the Chairman of the European Preparatory Commission for Space Research,

considering it necessary to give a new impulse to the work of the Preparatory Commission,

considering the advantages to be expected from continuity between the activities of the Preparatory Commission and those of the European Organisation for Space Research after the coming into force of the Convention,

requests the Preparatory Commission to propose to Professor Pierre Auger that he devote his full-time activity to the executive secretariat of the Commission,

invites the Council of the European Organisation for Space Research to appoint Professor Pierre Auger as the first Director General of the Organisation

invites the Council of the European Organisation for Space Research to confirm as far as possible in their present or corresponding positions the senior staff members of the Secretariat of the Preparatory Commission.

Requests the Preparatory Commission to inform the interested staff members concerned of this unanimous desire.

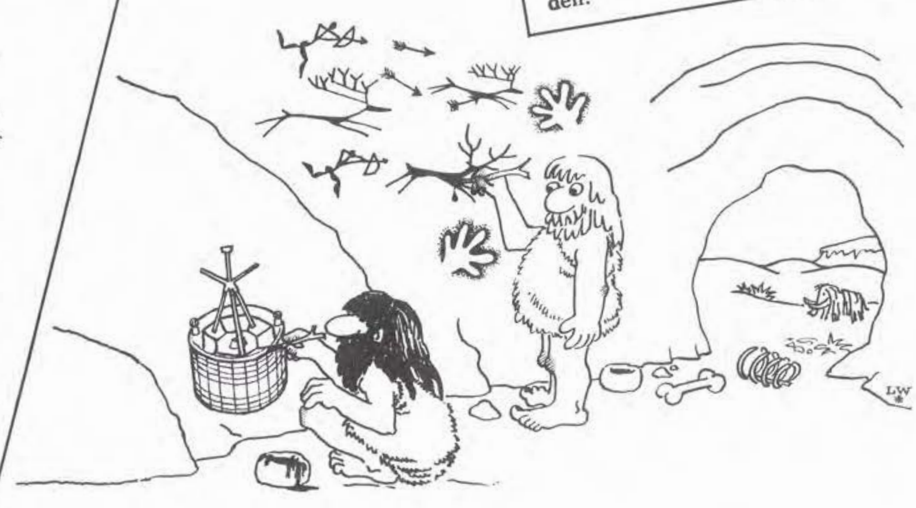
Europees ruimte-onderzoek gestart

(Van onze correspondent)

Parijs — Een commissie van voorbereiding heeft op een persconferentie in Parijs bekendgemaakt, dat de Europese organisatie voor ruimte-onderzoek nu officieel geboren is. Negen landen, waaronder Engeland, Spanje, Zweden, Zwitserland en ook Nederland, maken al deel uit van de organisatie. Verwacht wordt dat Italië binnenkort het cijfer tien rond zal maken.

De organisatie, waarvan de hoofdzetel in Parijs is gevestigd, omvat twee centra, een laboratorium in Italië en een „startbaan", die in Zweden in aanbouw is. Het belangrijke centrum voor ruimtetechnologie, waar de instrumentaria voor de raketten en de satellieten vervaardigd zullen worden, komt, zoals men weet, in Delft 800 mensen, van wie de helft ingenieurs en wetenschappelijke helpers, zullen aan dit centrum in Delft verbonden worden.

(from a Dutch newspaper, April 1964)



. . . as early as 1959 . . .

Why we need a European Organisation for space research

Prof. Edoardo Amaldi
Institute of Physics, University of Rome, Italy

Professor Amaldi, Director of the 'Guglielmo Marconi' Physics Institute in Rome, a member of the Scientific and Technical Committee of EURATOM and one of the 'fathers' of the European Nuclear Research Centre in Geneva (where he chaired the Committee on Scientific Directives), put forward, as early as 1959, *the idea of establishing a European organisation for space research. Here is the text of his proposal, which appeared in* 'Expansion Scientifique' *in December* 1959.

1. During the second half of the twentieth century, space research has become an essential element of our civilisation. This fact is disputed by no one, either in the scientific world or in political circles.

On the occasion of its 792nd plenary session, on 13 December 1958, the General Assembly of the United Nations set up an ad hoc committee charged with ensuring that the benefits of the scientific results of space research are available to every country in the world.

In the course of the year 1958, the International Council of Scientific Unions (ICSU) set up two committees. One, known as the Ad-hoc Committee on the Contamination of Extraterrestrial Space by Exploration (CETEX), was charged with determining the conditions under which space research should be carried out in order to avoid biological and radioactive contamination of extraterrestrial bodies such as the moon and the various planets, and, also to avoid any modification of their present environments. CETEX made a number of important recommendations, after which its activities were concluded; they were then taken up again by a new permanent committee set up by the ICSU. This committee, known as the Committee for Space Research (COSPAR), is responsible for coordinating and encouraging the development of the space research undertaken by the world scientific community.

2. It is as well to remember that extraterrestrial space research using rockets and artificial satellites received its initial impetus from an organisation set up on the occasion of the International Geophysical Year, and known as the Special International Geophysical Year Committee (CSAGI). A recommendation by the General Assembly of CSAGI (Rome, September 1954) forms the basis for all present and future space research, although the subsequent development of this research has undoubtedly been equally influenced by military considerations.

The first scientific results obtained by the use of rockets and artificial satellites during this preliminary stage of space research are of the utmost importance, and cover the widest range of scientific fields. The research in question is as follows:

A. Observations from rockets

a. Structure of the earth's atmosphere at altitudes up to 200 kilometres: pressure, density, temperature, chemical composition, winds;
b. the ionosphere: ionic composition, ion density, disturbance;
c. auroral particles and weak auroral radiation;
d. solar radiation, with particular emphasis on the X-ray and ultraviolet emissions in solar light;
e. the earth's magnetic field and the ionospheric currents;
f. cosmic rays; effect of latitude at an altitude of 90 to 150 km.

B. Observations from artificial satellites

a. Discovery of the existence of a double belt of radiation, known as the Van Allen belt;

b. studies of air density at altitudes in excess of 400 km;
c. measurements of the density of micrometeorites;
d. determining the effectiveness of temperature controls within an artificial satellite.

Some of these results, such as the discovery of a double belt of radiation, are of the utmost importance in that they open the doors of an entirely new field where one may encounter vast and hitherto unexplored phenomena relating to the properties of the earth, the sun and cosmic radiation. Yet these first results are no more than a modest first step in a field of research so vast and so important that it far transcends anything we can imagine at present.

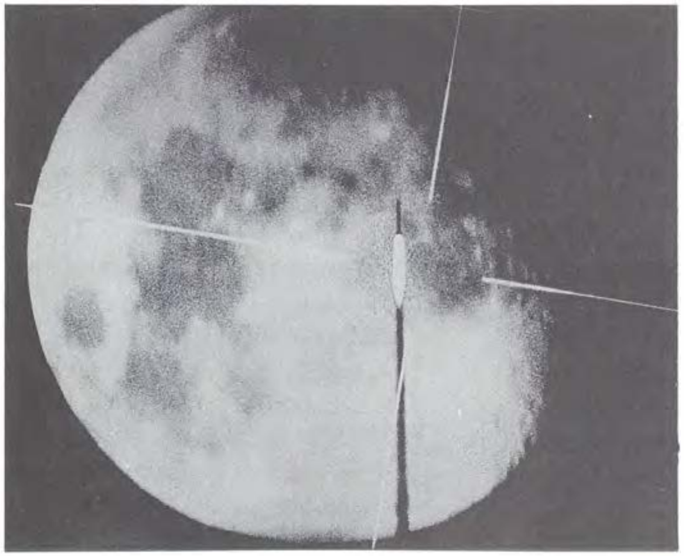
3. Hitherto, the Soviet Union and the United States have been the only countries in a position to mobilise the human and financial resources necessary for a high level of research activity in space. Other countries, less well endowed with financial means, industrial potential and organisation, will certainly find it a very difficult task to make their mark in this field, even though some of them can look back on very fine scientific traditions. It appears, then, that research of this type is destined to remain a monopoly of the United States and the Soviet Union, and that all the European countries, in particular, will be mere onlookers as the great undertakings get under way to East and West.

Yet an international organisation bringing together, for example, the resources of ten European countries would enable European scientists to make a worthy contribution to the exploration and study of extraterrestrial space.

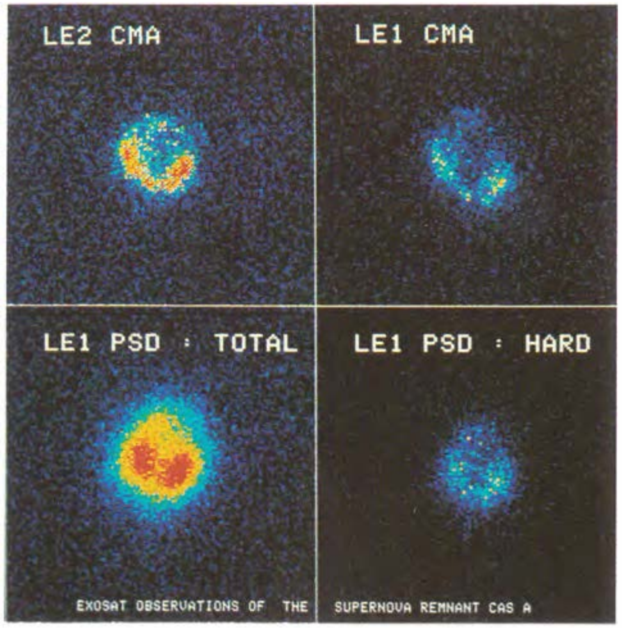
An insuperable gulf?

4. The setting-up of a European Organisation is an essential and urgent matter if we are not to find ourselves, twenty years hence, confronted by an unbridgeable gulf – scientifically, technically and industrially – separating those countries which can launch spacecraft into interplanetary space from those which cannot. Quite apart from the scientific results already referred to, the launching of artificial satellites requires and stimulates a tremendous industrial surge forward in the field of propulsion systems, metallurgy, electronics, etc., a surge which in turn influences the whole industry of the country.

5. The financial and human resources necessary to set up an organisation are not beyond the means of the European countries. Given a budget twice or perhaps three times that of the European Nuclear Research Centre (CERN), in other words given funds of



Skylark sounding rocket (launched from Salto di Quirra, Italy) with the Moon in the background.



Images of the supernova remnant CAS-A as observed by Exosat satellite.

some 130 to 180 million Swiss francs a year, a European Organisation for space research could obtain impressive results in four or five years. Finding the men will be difficult, but not impossible. There will be a need for technicians, engineers, chemists, metallurgists, electronics experts, physicists, etc. Many Europeans highly qualified in these fields are currently working abroad, and they would certainly be attracted by an organisation of this kind.

6. The European Space Research Organisation should have no other objective but research and would thus have to be independent of any military organisation and unrestricted by any law relating to official secrets. In other words, its very structure should reflect the international scientific nature of space research, in accordance with the principles formulated in the resolutions passed by the General Assembly of the United Nations and the International Council of Scientific Associations.

A purely scientific organisation would not only enjoy enormous moral authority but would certainly be the only type of organisation currently possible in Europe, given that its constitution would have to be ratified by the Parliaments of the Member States.

7. The European Space Research Organisation should at first concentrate on studying a very precisely defined programme. It could, for example, begin by studying just two questions. One might be a current problem of the same type as those already resolved by the Soviet Union and United States, selected as being capable of resolution in a relatively short space of time, say three or four years. This solution would have the advantage of leaving time free for the development of various auxilary techniques, personnel training, the solving of a large number of manufacturing problems, etc.

The second research problem could match the major undertakings simultaneously launched by the United States and the Soviet Union, which would obviously require a much more wide-ranging effort for a longer period, for example six or seven years.

There is no time to lose

8. The European Space Research Organisation would be empowered to set up laboratories and launching ramps. These two fields of activity, like the purely scientific institutions, should not be subject to any restrictions.

On the other hand, the study of many problems could be entrusted to national research organisations and industrial concerns, on the basis of a suitable plan which would be drawn up in advance. When the European Organisation begins to launch satellites into space, even on a reduced scale, the information transmitted back to earth could be picked up and interpreted by a large number of stations scattered among the universities and research institutes of the Member States, thus giving many scientists the chance to participate in space research.

9. To establish an organisation of this kind rapidly, the following procedure might be used: A number of European countries, for example Belgium, France, Germany, Italy and Holland, could appoint national commissions responsible for studying the problems posed by space research. Each commission would be made up, in more or less equal proportions, of experts on the construction, launching and ground control of artificial satellites and experts on the scientific questions raised by extraterrestrial space (physicists, geophysicists, astrophysicists). These commissions should undertake a preliminary study, examining the various resources available to each country within this field and similarly evaluating the overall extent of the human and financial resources necessary to make an effective contribution to space research. The various commissions could then hold a joint conference at which they would compare the results of their investigations and draw up a detailed programme to be submitted to the governments of the states concerned.

The preparatory phase should take no more than a year, so that the European Organisation – or at least a preliminary, provisional organisation – would be able to commence operations before the end of 1960. This would mean that Europe could hope to gather useful information by about 1964, and to bridge, by 1970, the gulf separating it from the Soviet Union and the United States.

If one of the European Research Organisations currently in existence were to assume responsibility for coordinating the contributions made by various countries to the establishment of the new organisation, this process would be considerably speeded up as a result.

The prehistory of ESRO – a personal memoir

Professor Pierre Auger

Director General ESRO (1964–67)
Member of the Institute of France, Paris

By the end of the Second World War, scientific research seemed ripe for reconstruction, and it is a fact that the next half-century, the second half of the 20th century, has seen something of a scientific explosion. This explosion has taken place not so much in the theoretical field, where such brilliant strides had been made during the previous fifty years – from the quantum theory and Bohr's work on the atom to the wave mechanics and quantum mechanics of the 20's and 30's – as in the hardware and methods of experimental research. And it was this field that saw the birth of 'big science' – big not only in terms of the size of the equipment and financial outlays involved, but also in terms of the numbers of teams, research groups and technicians whose work was indispensable to produce all this hardware and put it to work.

From elementary particles to extraterrestrial space

However, it became increasingly difficult for individual countries – apart from very large countries such as the United States and the Soviet Union – to keep up with this process of change. In any case, the universal, supranational nature of science was highly propitious for the setting up of laboratories and research bodies on an international basis, a fact which was expressed in a United Nations Resolution of 1946. In 1950, a more realistic approach to the problem was made by UNESCO, in the form of a project for a regional scientific research body in the European area: this was the genesis of CERN, whose successes in the science of elementary particles are common knowledge. Having been appointed by UNESCO to implement the Florence resolution of 1950, I was able, during the years 1950 to 1954, to get to know the various essential stages involved in setting up a body of this kind. It was in this latter year, 1954, that the statutes of CERN were ratified by the Member States, and the organisation was officially born.

One of the very earliest of these stages, but a vital one, is selecting the subject or at least the field in which the proposed organisation is to operate. The choice automatically falls on one of the great problems of modern science which then included, and still includes, the structure of matter, fundamental and molecular biology, and, finally, extraterrestrial space.

From the Nice Congress to the Meyrin Conference

To illustrate the interest already aroused by space research in those days, we need only recall the launching in 1957 of the first artificial satellite, the Russians' Sputnik. It was a matter of course, then, that the problems of space should engage the attention of scientists concerned with Europe's possible role in major modern research undertakings. If we were to look for the first stirrings of the movement that led to the creation of space-age Europe, we need perhaps look no further than a letter on the subject written by Eduardo Amaldi to a number of his colleagues – to which I may perhaps be forgiven for adding a conversation that took place between Amaldi and myself in the Luxembourg Gardens, Paris, in April 1959. We considered various possibilities, notably affiliation to the EEC, though I myself preferred a constitution on the same lines as that of CERN, whose success was a source of great encouragement. So far as the purely scientific paternity of the new organisation was concerned, there could be no better guarantee than the blessing, if I may so call it, given on behalf of the ICSU (International Council of Scientific Unions) by its special committee concerned with astrophysics, COSPAR. It was at the Committee's first session, in January 1960 at Nice, that the first clear idea of a European Space Research Organisation was born.

This meeting, attended by scientists from eight Western European countries, was followed a month later by another, at my Paris flat,

Some of the delegates who took part in the Conference of Nations at Meyrin – 1960.

involving nine scientists – I must put a marble plaque on the wall one of these days to mark the occasion! However, the representative of British science thought that our next meeting should be held against a more impressive background. And so it was that our little group was solemnly dedicated at a meeting at the premises of the Royal Society in London on 29 April 1960, where the representatives of the scientists of ten European countries agreed on the broad outlines of a programme of action. Even at this stage it was clear that the new organisation should concentrate on producing and launching spacecraft, rockets and satellites, to enable the experimental equipment designed and built by the scientific communities in the Member States to be operated in space.

Following this very important meeting, during which I was appointed Executive Secretary by my scientific colleagues, I set about the diplomatic tasks necessary to set up any inter-governmental organisation. This was a role I had already played during the launching of CERN, although then I had been working under the auspices of a powerful organisation, UNESCO, able to call on the services of a big international secretariat. This time my only available resources were my status as President of the French Space Committee and secretary of an unofficial committee. My colleagues requested me to call an inaugural meeting of a preparatory committee (which would be official) and my first task was to find a basis on which to convene this meeting. There were, I knew, two possibilities in this case: an international organisation or a government. It was natural for me to choose the second alternative, as I was at that time responsible at national level for setting up the French National Centre for Space Studies. So it was that on 23 and 24 June 1960, at the Ministry of Foreign Affairs in Paris, there took place those meetings at which the first official embryo – what embryologists would call a *morula* – came into being. This was the GEERS, the European Study Group on Space Research. Its administrative headquarters was set up under the chairmanship of Sir Harrie Massey, and I was appointed Executive Secretary. The meeting resolved to reconvene at Geneva in November of the same year with a view to debating, and if possible signing, an agreement establishing a preparatory commission – the second embryonic stage, the *gastrula*, complete with metabolism (in this case, financial resources).

Various meetings of experts took place in the interim – Paris in September, London in October, and finally the preliminary session of the Conference of Nations at Meyrin from 28 November to 1 December 1960, convened by the Swiss government and held in a hall provided by CERN, for luck. By terms of agreement drawn up there it was resolved to hold the first working meeting of the Commission in Paris, and to entrust me with convening it.

From COPERS to ESRO/ELDO
The Meyrin Agreement took effect from 27 February 1961, and the meeting was held on 13 and 14 March. At this point the GEERS was dissolved, and the administrative headquarters of the COPERS (European Preparatory Commission of Space Research) was set up under the chairmanship of Sir Harrie, and including Messrs Broglio, van de Hulst and Golay. I retained the post of Executive Secretary, and it was decided that my office would be based in Paris, remaining at the same address. There would be nothing for me to do but to have the heading of my notepaper changes from GEERS to COPERS.

So began the life of the new preparatory commission, with its committees and working parties. One of the latter was concerned with projects involving spacecraft, technology, informatics and the scientific programme. This met in Stockholm, London, Paris, etc.

The other working group, the AWG (Administration Working Group) went to work in Paris in May 1961, and then held many meetings with a view to preparing the legal, administrative and financial constitution of the future European Space Research Organisation, ESRO. Subsequent milestones were the dates on which it was decided to draw up the so-called 'Blue Book' project, the report made to COPERS by the Scientific and Technical Working Group. The second edition, prepared after the Munich meeting in October 1961, is dated December that year. So, exactly two years after the European Organisation was proposed at that first, purely friendly meeting in Nice, it took a more or less definitive form. One might have been forgiven for thinking then that the preliminary stages were over, and that the Convention establishing ESRO would be signed and ratified in quick time, enabling constructive work to start. In fact we had to wait until 20 March 1964 for that Convention to come into force, while everything that was achieved during those two and a quarter years was done in the name of the COPERS. This involved nothing less than deciding on the establishment of the Organisation's various institutions, determining where they would be set up, selecting some of their staff, calculating their budgets and allocating the technical and scientific programmes presented in the Blue Book.

The meeting for the purpose of signing the Convention was finally held in Paris on 14 June 1962, and this alone was sufficient to establish the COPERS on a solid international basis.

At the same time, in the spring of 1962, six European States signed

First home of the European Space Research and Technology Centre, (ESTEC), Delft, The Netherlands. - Photograph taken in 1964.

a Convention setting up ELDO, an organisation concerned with the construction and launching of big rockets to carry European satellites. This Convention was ratified in 1964. It might seem that this organisation was complementary and parallel to ESRO, but in fact there were profound structural differences; each ELDO Member State reserving the right to place its own contracts for implementing that part of the whole entrusted to it. The result was a widespread lack of integration, the effects of which are familiar, but within ESRO, with its international budget, technical management and financial administration were always based on collective decisions.

From the lakes of Kebnekaise to the dunes of Noordwijk
I should just like to conclude this brief description of what one might call the prehistory of ESRO with a few reminiscences –

The wild goose carrying the dwarf Nils Holgersson...

anecdotal rather than detailed – regarding the choice of sites for the main agencies of early space-age Europe. A letter sent out in July 1961 asked the Member States for their views on this subject. The Kiruna launching site posed no problems, and I still remember the picture I had of it as, with a few colleagues, I flew in a tiny aircraft over the extraordinary landscape of the lakes and hills of northern Sweden. I was fortunate enough to see the Kebnekaise, and couldn't help remembering the wild goose carrying the dwarf Nils Holgersson...

Choosing a site for the technical agency responsible for spacecraft design, and for the experiments which the national laboratories wanted to be conducted on board, was more difficult. The town of Delft was selected because of the intellectual and technical background it would provide for the planned establishment, and Dr. Lines occupied premises at the Technical University to draw up the plans and start the technical work. But visiting the site in 1962, I became certain that the polder (that is, land reclaimed from the sea) where we were proposing to build would have led us into serious difficulties. Piles would have had to be sunk to a depth of 30 metres to find a sandbank which would – or might – be able to support the building. After a memorable lunch, during which I became aware that the presence of ESTEC at Delft was not particularly welcome, I asked the government of the Netherlands to be kind enough to suggest a more suitable site. This they promptly did, and the result was the construction of ESTEC at Noordwijk, still on sand, but this time sand solidly packed by age-old dunes. The Computing Centre presented no problems; after visiting a number of sites proposed by Italy for the ESLAB laboratory (today ESRIN) we opted for the magnificent Frascati site, rather than for a former airfield which was subject to flooding from time to time.

There, I think, I should call a halt to these few personal reminiscences of the prehistory – or embryogeny, if you like – of ESRO, and wish long life and success to its present-day successor, the European Space Agency.

The site selected for the permanent home of ESTEC – in the dunes, Noordwijk, The Netherlands.


MINISTERE
RELATIONS EXTERIEURES
34

Spain and Space

General Luis de Azcarraga

Delegate of Spain to ESA Council

I have had the privilege of representing Spain in European cooperation for outer space research and utilisation almost since my country joined it. This has enabled me to be at present the senior member of the Council while watching and participating in the overall evolution of this important European activity, from a first row seat. I state this with satisfaction although without boasting: my only merit is to have reached the age of seniority with acceptably good health.

Changing for the best

I could comment on many aspects of the past, some of them perhaps amusing, but I do not think it of interest to remember them except to the extent that they prepare the future. During these years the Organisation has undergone institutional as well as structural and programme changes, from the early ESRO, essentially scientific and with moderate budgets to the present ESA, far more ambitious in every sense. And it is hoped that we may continue changing for the best.

A crucial event was the Conference of Ministers ten years ago, which assigned an essential medium term goal by consolidating Ariane, Spacelab and Telecommunication projects. A big step was thus taken, from a scientific organisation to the present European Space Agency without forgetting the origin, keeping what had already been done. New projects of practical application were added, satellite weight and performance were greatly increased, setting the basis for commercial utilisation. Lastly the range of purpose and internal structure of the organisation was completely modified. All that without prejudice to the initial concept of cooperation which constitutes the basic idea to be safeguarded.

Such a step if accomplished more gradually, less quickly, would have maintained parallelism among Member States; it would have prevented that distortions of capacity – particularly technological – might increase for the different national adaptations. This is a serious consequence that weighs more on some Member States and it should be corrected quickly; however, if we look upon it in a global way, ESA's result can be considered as reasonably good when judged by some of its outstanding achievements.

Perhaps a lack of symmetry of those functions makes it difficult to realise the depth of the change and the expectations it affords. Each one of the representatives at the Council, as well as leading members of the Executive, are no doubt conscious of both. However, the 'collective' expression seems sometimes enclosed in small horizons of parochial interests. And I personally question whether we have had the ability to do everything necessary to enable our governments to have a clear vision of what they can, and what is convenient for them to do 'collectively' as an expression of Europe; to avoid conflicting interests and look for, instead, an identity of vocations, so that really European programmes can be defined which provide *all* Members with the adequate technological progress, improvement of services and participation in the scientific community and industry, to justify the economic effort which becomes larger as years go by.

The grandeur of Europe

This is not always easy. The complexity of old Europe is a bond which other geographical areas lack. It is an inevitable starting point, but it is also the measure of its greatness. The utilisation of outer space needs each time bigger resources and concurrence of vocations; and, in the long run, the conquest of space might lead to a lot of juridical problems, if we fail to arouse an interest in most of the world. This can be the grandeur of Europe, to offer a scheme of

...only merit is to have reached the age of seniority with acceptable good health...

Villafranca ground station: 'Changing for the best'.

regional cooperation which may give origin to more extensive ones, something not always easy to do but which has been solved so far in ESA with relative success. As foreseen in the intergovernmental agreement which forms the basis of the European Space Agency, resulting from ESRO's long experience, it has established as essential concepts a cooperation accompanied by mutual concessions, a search for collective objectives, an eagerness to obtain – through transfers – a similar level of national technology, aiming in short at the creation of a competitive European industry.

It is well known that ESA has in its lap two groups of Members. One, less numerous, consists of those who have greater capacity, economic as well as industrial and scientific, able to sponsor some special projects, each of them different according to the Member's own competence. Another group with those more modest Members who might imagine major projects but who lack the capacity to carry them out, although the total of their political, social and economic contributions is necessary to finalise all the purposes. The participation of the second group can be in the long run more objective, less conditioned by particular interests, more convinced about the necessity of a real cooperation. What we need is that our basic agreement is not degraded but, on the contrary, that it be improved with everybody's assistance.

There is nothing new in these comments. But the opportunity to bring them back to mind is indeed new and bright. The twentieth anniversary is a typical date. And, in our case, it coincides with effective achievements which give ESA world prestige. The consolidation of Ariane launcher, as a valid offer to the world market. The unquestionable success of Spacelab which opens wide doors to research to experimenting in conditions of microgravity, to the future manufacturing of materials hardly imagined nowadays. The improvement of services such as telecommunications, meteorology, observation of earth resources etc...
Throughout these twenty years, during which ESA has offered the scientific community an excellent panel of experiences, we have also given evidence of having created a magnificent structure, whereby the Executive and concerted industry of its Members are able to go a long way ahead and deserve in the near future wide participation in projects originated in other geographical areas.

This is an opportunity which cannot be lost and it compels us to meditate whether the results so far achieved – just because they are brilliant – meet the imperatives of the intergovernmental Convention. Particularly if they tend to diminish the gap among Members and groups of Members or they widen it. The occasion seems ripe for us to continue the search for long term programmes which arouse an analogous interest in all Members and justify the economic and political support which they will undoubtedly require.

It is natural that Members differ about goals and expectations on which to spend funds available. But the Executive knows its job and has shown sufficient imagination to enable us to look forward to a certain balance in its proposals. Among major projects which ought to be included under the present push and in favour of the development of industries which may serve as 'locomotive engines' are other more modest or moderate projects – such as larger budgetary allocation of funds for technological developments and projects of medium type in the scientific field. This is what decisively stimulates the basic intergovernmental Convention of the Agency.

Cohesion and friendship

The Agency has proved that it can accomplish what seemed most difficult: to attain an international prestige which is good for all, although it has more repercussion in those more directly involved. What now should be attempted is something apparently easier: to promote that all delegations could present their governments clear evidence that each country has individually progressed.

The industries and scientific and technological development agencies of each Member should formulate ideas taking advantage of their own experience. Thus, the delegations would suggest collective performances which the Executive should integrate and give shape to in collective plans and programmes. The Council and its associated departments would discuss them for a final decision.

Since cooperation feeds on mutual concessions, hope is justified. Year 1984 must be a singular point in the historical trajectory of ESA. The Agency has what is essential: a technical basis, as evidenced by the Executive and the industry of Member States; an organic basis relevant to the Convention which has given good proof of the possibilities of its internal structure. In short, a favourable disposition of its Members, evidenced by the delegations' common purpose for cohesion and friendly relationship,

Original cover of ESRO Convention.

shown whenever the inevitable arguments and friction of all human endeavours have arisen.

I am for a continuation of our efforts towards satisfying legitimate individual aspirations within the framework of more general ones, so that the omen of success for the Agency brought by the twentieth anniversary of European space cooperation may materialise.

ESRO in 1967–68

Sir Hermann Bondi

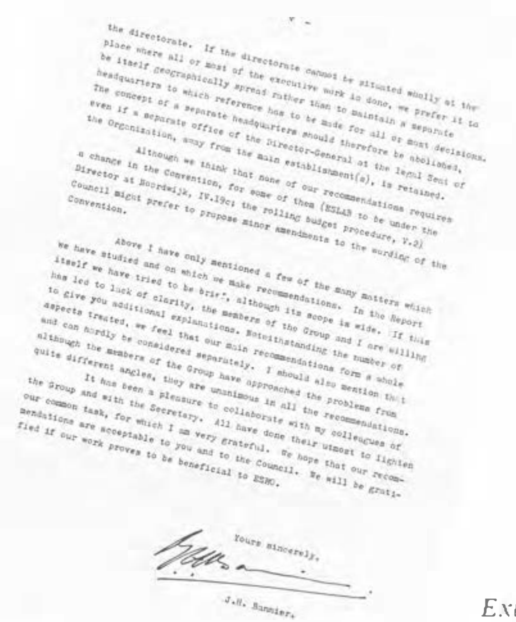
Fellow of the Royal Society
Director General ESRO (1967–71)

On 10 October 1967 I joined ESRO and became Director General one month later. At that time, a mere three years after its formal beginning, the foundations of the organisation had been well and truly laid. Pierre Auger, with his tremendous scientific standing, who had done so much to create the very concept of ESRO and to get ten countries to negotiate, sign, and ratify the treaty, had been my predecessor. With Freddy Lines as Technical Director, with Reimar Lüst (happily soon to be Director General of ESA) and Bert Bolin as successive Scientific Directors, a tremendous amount had been achieved in a remarkably short time. Excellent staff had been recruited, establishments were functioning in Paris, Noordwijk, Darmstadt, Kiruna and Frascati, and three satellites were in an advanced state of development. Indeed one of them had been completed in the previous spring, but a failure of the well-tried Scout launcher had robbed the organisation of its deserved triumph.

The blessing of the Bannier Report

Yet at the same time there were also shadows over my inheritance. Achieving so much so rapidly had inevitably led to much roughness in relations with Member States. Their dissatisfaction with the workings of ESRO's set-up had led them to create the Bannier Group. But this turned out to be a blessing, for the splendid Bannier Report was accepted by the Member States and gave me organisational arrangements and procedures which were of great value to ESRO; gave me also a marvellous set of Directors, and immeasurably eased my task in numerous ways. Yet the most dangerous clouds over ESRO's future were undue expectations of what European industry could achieve under ESRO's guidance within the financial limits set and within a relatively few years. Neither the size of the management task nor the cost factors were understood. The fact that, at that time, European salaries were far lower than American salaries led to the thought that the cost of complete European space systems should be correspondingly lower than that of similar American systems (the infamous 'transatlantic factor') which made no allowance for the more than counterbalancing effects of generally higher productivity in USA and especially their expensively acquired great expertise in space engineering. Thus not only had contracts been awarded for a pair

ESRO Council in session, November 1969.



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the directorate. If the directorate cannot be situated wholly at the place where all or most of the executive work is done, we prefer it to be itself geographically spread rather than to maintain a separate headquarters to which reference has to be made for all or most decisions. The concept of a separate headquarters should therefore be abolished, even if a separate office of the Director-General at the legal Seat of the Organisation, away from the main establishment(s), is retained.

Although we think that none of our recommendations requires a change in the Convention, for some of them (ESLAB to be under the Director at Noordwijk, IV.19c; the rolling budget procedure, V.2) Council might prefer to propose minor amendments to the wording of the Convention.

Above I have only mentioned a few of the many matters which we have studied and on which we make recommendations. In the Report itself we have tried to be brief, although its scope is wide. If this has led to lack of clarity, the members of the Group and I are willing to give you additional explanations. Notwithstanding the number of aspects treated, we feel that our main recommendations form a whole and can hardly be considered separately. I should also mention that although the members of the Group have approached the problems from quite different angles, they are unanimous in all the recommendations.

It has been a pleasure to collaborate with my colleagues of the Group and with the Secretary. All have done their utmost to lighten our common task, for which I am very grateful. We hope that our recommendations are acceptable to you and to the Council. We will be gratified if our work proves to be beneficial to ESRO.

Yours sincerely,

J.H. Bannier.

Extract from the Bannier Report.

A bleak future

What brought these interlinked problems to a head early in 1968 was the knowledge then acquired that TD1/2 would be far more expensive than anticipated. This glaring failure to estimate correctly brought to a head all the doubts of Member States about ESRO, about its ability to foresee costs, about its ability to distribute industrial contracts fairly among the differing countries, about its status in the widely differing concepts held about Europe's future in space.

In spring 1968 the future of ESRO looked bleak indeed, yet by the end of the year it was well established and could face the future full of confidence. How did this great reversal of fortune occur?

Status and confidence

The firm foundation was what our predecessors had got going. Three satellites were nearing completion and were indeed successfully put in orbit in May, October and December of 1968 respectively, where they functioned very well indeed. So what had only been a hope and expectation in spring 1968 became a solid and sound achievement a few months later. The ingenuity and patient negotiating ability of our team led to a special arrangement in relation to the ill-begun satellite pair TD1/2, that led to the

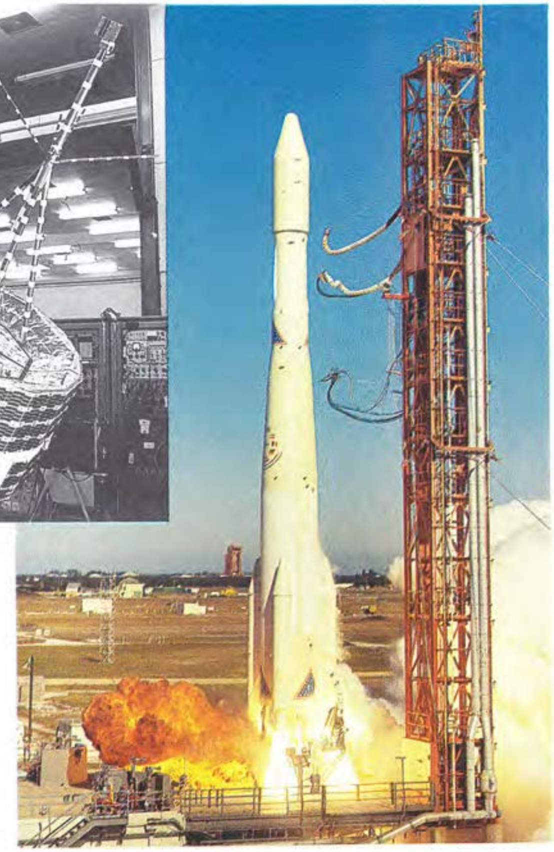
of highly complex satellites (TD1 and TD2) only one of which was ever developed, at almost three times the then expected cost of the pair, but this pair was only viewed as a modest precursor of truly major projects which were being planned. The most notable of these was the Large Astronomical Satellite, a concept so advanced that 15 years later a US effort of this kind is not without its problems. Perhaps the most difficult task ESRO achieved in my first year as Director General was to come to terms with reality, to help scientists, politicians and administrators in Europe to come to terms with what size and complexity of task could reasonably be performed by European industry within the limits of money and time set.

Less permanent, but more imminently threatening the very existence of ESRO, was the fact that it was then existing outside the terms of the Convention; for a year earlier unease about Europe's general space policy had led to a failure of the Member States to agree unanimously (as the Convention demanded) to a level of resources for the three-year period 1967-69. Thus we lived from hand to mouth, and 'extra-legally'.

'Thus we lived .... extra-legally.'

HEOS-1 satellite.

Launch of HEOS-1 on 5 December 1968 from the Eastern Test Range, California, USA.



financing of TD1 (with a revised design called TD1A) by only nine Member States in its development phase, but with all ten contributing to its eventual operation. The scientifically not quite so promising TD2 was cancelled. (Eventually, and in spite of awkward incidents in early operation, TD1A became Europe's first major space triumph, with a remarkable scientific output from a satellite of immense complexity.)

These successes led to the European space ministers giving ESRO their confidence and backing. By the end of 1968 we had returned to legality, with an agreed (and adequate) level of resources for 1969, 1970 and 1971, with a status and confidence that allowed new satellites to be planned and begun, with an industrial policy that was wholly acceptable to all Member States.

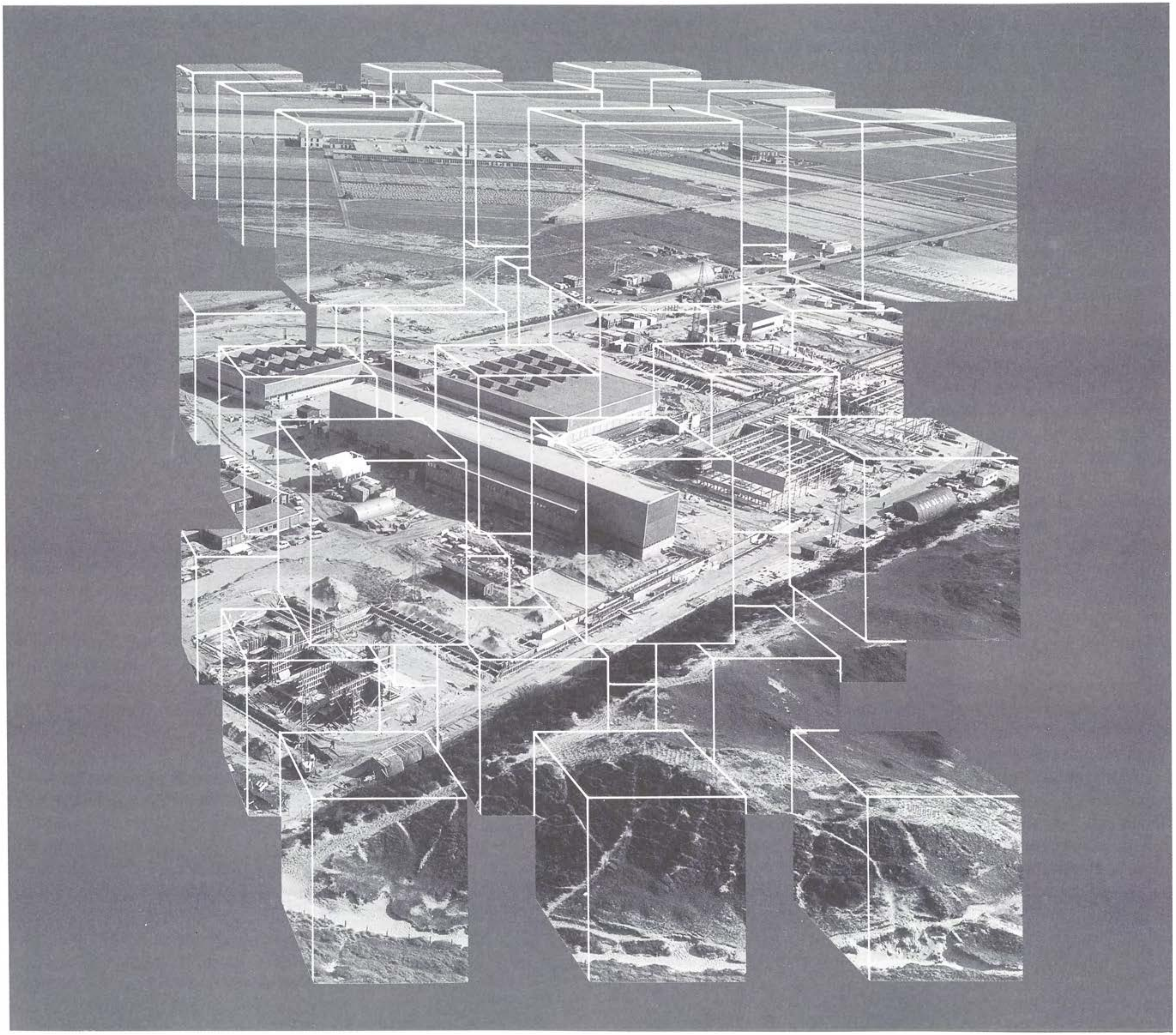
Thus the settlement of late 1968 led to a calm atmosphere in which the technical excellence of ESRO's teams could supply the necessary input to European industry, and work towards Europe's future in space.

Yet it was already clear that other problems were going to come to the fore, and that their resolution would be yet more difficult. That ESRO had to be able to handle applications as well as scientific satellites was beginning to be realised in 1968, but there was far less assurance about the size of the scientific effort in such a combined enterprise and whether it would be adequate to hold together a European community of scientists using space platforms; whether it would be a programme that would overshadow national efforts or be overshadowed by them. Also the relation of the European satellite effort to the European launcher effort remained wholly unclear.

These huge questions were in the background during my period as Director General which ended in February 1971, but were not burning until the question of the level of resources for 1972–74 became urgent in mid-1971, and were then resolved adequately after long and difficult negotiations.

Yet if Europe had not remained together in space in 1968, none of the later compromises and successes could have been achieved.

Hermann Bondi



A second-generation viewpoint

Professor Roger Bonnet

Director of Scientific Programmes, ESA

My first contact with space and my first real look at it was, as for many others of the second generation, coincidental with the launch on 4 October 1957 of Sputnik-I, the first man-made object to have orbited the Earth. Of course, the fact that the Soviet Union had made this possible was as strong a cause of astonishment as the intrinsic value of the event itself. With no exceptions whatsoever, the front pages of the newspapers had titles several centimetres high and all celebrated the technical challenge. Without any information on how the event had been made possible, the most imaginative and exotic designs of the hypothetical launcher made up of many fancy shaped boosters and stages, were offered to our incredulous eyes and left the best comics of that time far behind. My own imagination was struck, but I did not realise how profound the consequences of the event would be on the orientation of my studies and on my own later life.

At that time, I was a 20-year-old student at the University of Paris where I was studying physics with the intention of later teaching this subject myself. I was, as many others in the same situation, trying to find my way through the equations without any particularly well focused motivation. The 4 October event opened up a path which I enthusiastically decided to follow and which I am still following today (still enthusiastically). It was with completely new eyes that I looked at the skies, not only in an attempt to observe some of those sodium vapour clouds that a few probes were ejecting in those early days during their journey into space, but also because some of the brightest objects above suddenly appeared to be within reach. The seemingly far-fetched dream of landing on other planets that filled the pages of many children's and fiction books and which I had read with great delight a few years earlier, was on its way to becoming commonplace. From then on, life for me became both very easy and also extremely difficult.

Condemned to do the impossible

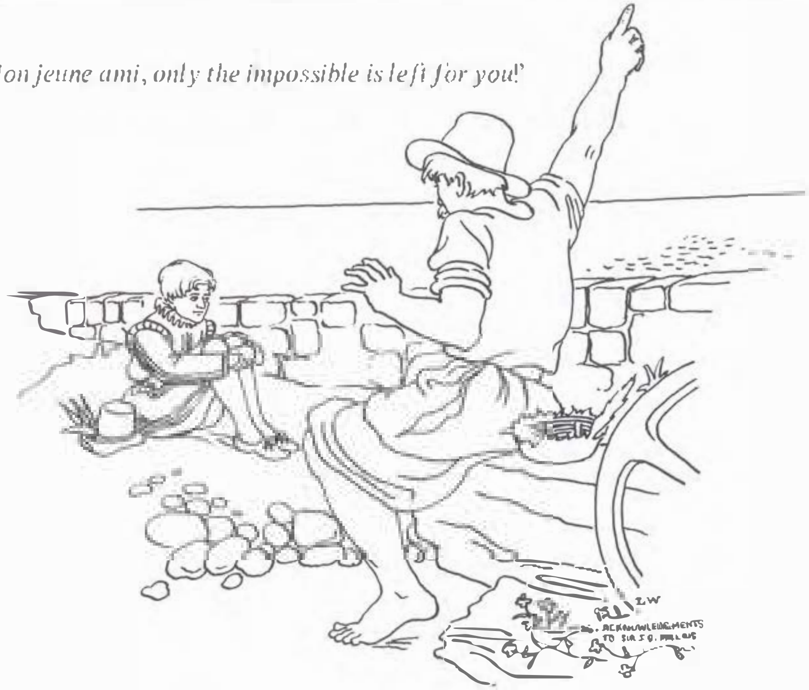
Because my decision was taken that I should become a space scientist, it was without any hesitation that I followed a course in astrophysics, the only one at that time to have some connection with space, and on a sunny afternoon in September 1960, I was on my way to Meudon Observatory where, on the kind and enlightening advice of Prof. Evry Schatzman, an appointment had been arranged for me with Prof. Jean-Claude Pecker. I will remember the details of that afternoon for a long time.

With an unforgettable smile and great kindness, Pecker welcomed me and said: 'Mon jeune ami, there are not so many young people interested in space: this is the reason why we are very happy that you are one of them because we have to start a national space programme', and he added: 'Of course, the Soviets and the Americans have already done everything (!) so it is only the impossible which is left for us to do and this is what we need you for ...'. I started to realise the difficulties ...

The first difficulty undoubtedly occurred a few days later when, after being given an appointment, I tried to keep pace with Prof. J. Blamont who, taking 1.5 m strides, was 'inspecting' the grounds on which his future Institute was to be installed.

Part of the 'impossible' was at that time (and still is to a certain extent) the investigation of the relations between the Earth and the Sun ... Blamont, who was my research tutor and thesis director until 1968, offered me the opportunity to carry out two rocket experiments to study the Sun's ultraviolet spectrum the energy of

'Mon jeune ami, only the impossible is left for you!'



which is absorbed by the atoms in the upper layers of the Earth's atmosphere and thereby controls its thermal and chemical balance. These experiments were part of the first French Space Programme that was established, upon a request from Prof. A. Danjon during the days following the launch of Sputnik 1, by Pecker and Blamont in the autumnal walks of the Parc du Chateau de Versailles.

In conducting this programme, the difficulties (both technical and human) were real but not insurmountable. It would be too far from the scope of this paper to describe them here, although an account of my first steps in space science may be far from boring...

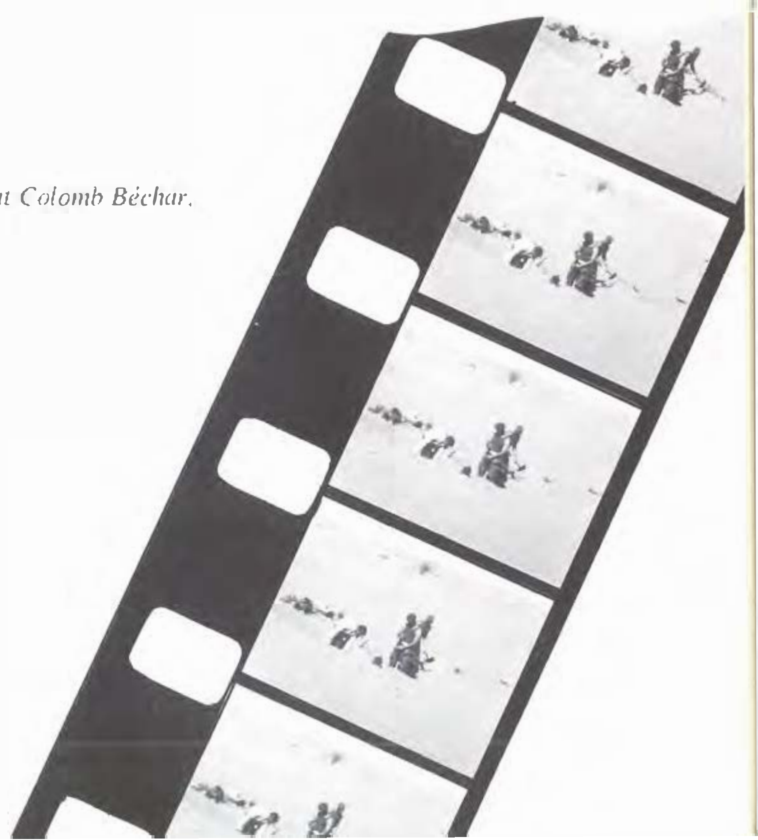
It is interesting to note that there were only a few people in the first generation of space scientists, for the most part physicists or astrophysicists brought up in the atmosphere of physical laboratories. The great majority of astronomers, for example, although coexisting very often with space scientists or space laboratories, unfortunately played very little part in space activities. This tendency had been going on for quite some time, but is, hopefully, no longer valid today. The benefits brought to astronomy and to our knowledge of the Universe by opening up the observable range of wavelengths to include a very wide range of infrared, ultraviolet, X and gamma ray radiations which do not reach the Earth's surface and need orbiting or spaceborne instruments to be detected, is today an indisputable fact.

Another feature of space activities and the most relevant one here has always been their international character. My first glance at this was at the launch range. 'En mission' at Colomb Béchar, we regularly met with scientists from several European countries: Sweden, Holland, Germany, etc. I remember very well the group of German scientists installed in a tent on the Bacchus Base at Hammaguir where they were preparing their baryum containers for the next rocket launch. They were headed by someone whose name was already famous: Prof. R. Lüst.

A source of deep motivation

A few years later, in 1963 to be precise, Prof. J.C. Pecker, who was chairing the Astronomy ad hoc Group of ESRO, invited me to help him as Secretary of the Group. My early contacts with European scientists made that period one of the richest in my scientific life, and European cooperation, which in fact constitutes the basis of my work today, has always been a source of deep motivation, although, surprisingly, I have never conducted any experiment either within ESRO or within ESA. This is probably one reason why I find myself in the privileged situation of being able to judge independently to what extent the European endeavour has been successful.

'En mission' at Colomb Béchar.



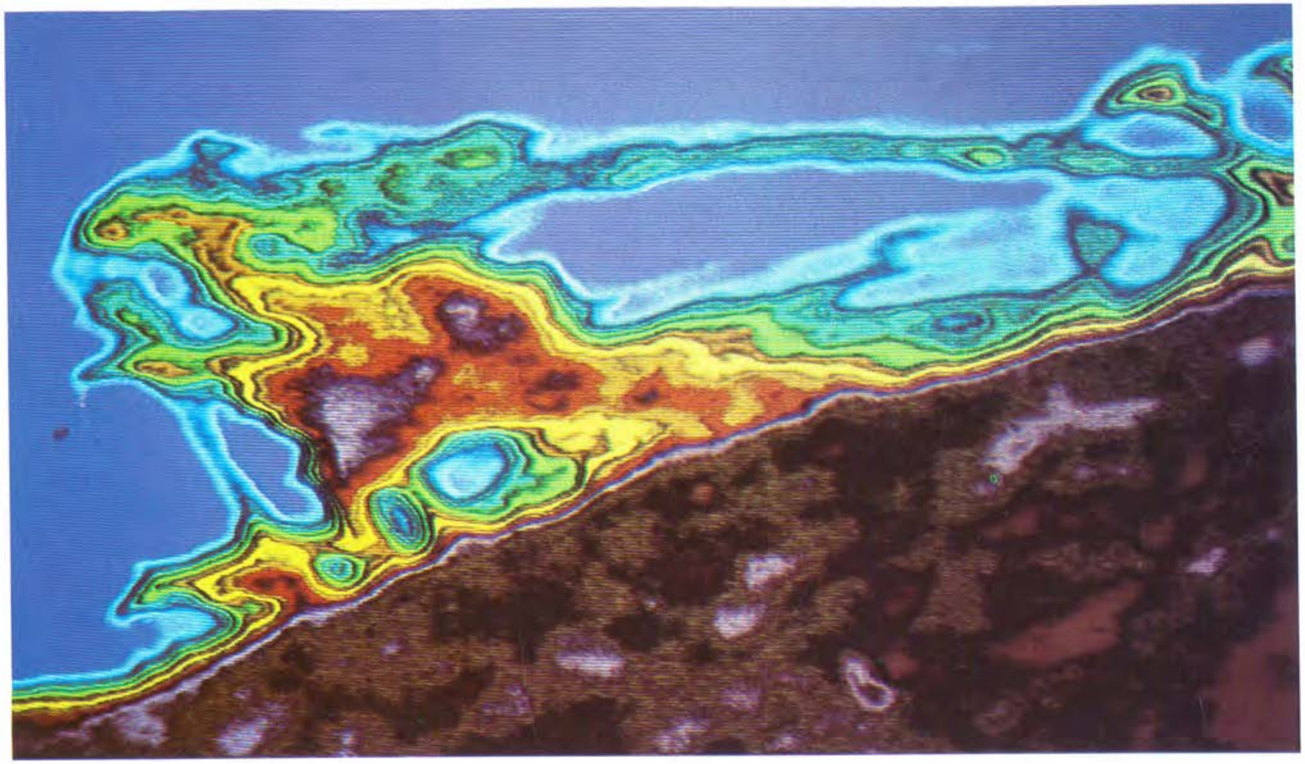


Image of the Sun in the Lyman α line as taken by a French-built telescope on board a NASA sounding rocket.

An unquestionable success has certainly been that, by extending the application of the basic principle of competition and peer reviews on a European scale to the realisation of space missions and experiments, European space science has been established at the highest level.

From the early rocket experiments and satellites of ESRO to the more sophisticated International Sun-Earth Explorer of ESA and NASA, continuous progress has been made in our knowledge and understanding of the near Earth environment, the structure of the magnetic field, and the magnetosphere of our planet and how it is affected by the solar wind and by the solar magnetic field itself. What took pages to describe even in a very schematic way, 20 years ago, can today be summarised in a single drawing. Thanks to the data from Meteosat (and to a tremendous effort of computer modelisation on the ground). I can dress myself every day according to the weather conditions as forecast on a daily basis. It will probably take some more time before we understand the more direct influence of solar variations on our weather and our climate and here the level of international involvement certainly encompasses the worldwide community.

But it is in the past 13 years that the evolution of the role of the European endeavour in space science has been the most dramatic. In spite of a budget equal to only one seventh of that of NASA, Europe has taken the lead in gamma ray astronomy (Cos-B), and will soon be the pioneer in the exploration of the solar system outside the plane of the ecliptic in which all planets are orbiting, by launching its ISPM mission in cooperation with NASA. In 1986, the Giotto spacecraft will encounter Comet Halley leading the way to a more extensive participation by Europe in the exploration of the solar system. In 1988, ESA will launch the first Astrometric Space Observatory, Hipparcos, and in 1992 its Infrared Space Observatory, ISO. Partly due to its participation in the International Ultraviolet Explorer (together with NASA and the UK) and in the Space Telescope with NASA, ESA has succeeded in convincing European astronomers that space astronomy is as vital for them as ground based astronomy. Did not a European astronomer recently claim that all future ESA projects should be observatories? We can hereby easily measure the distance accomplished . . .

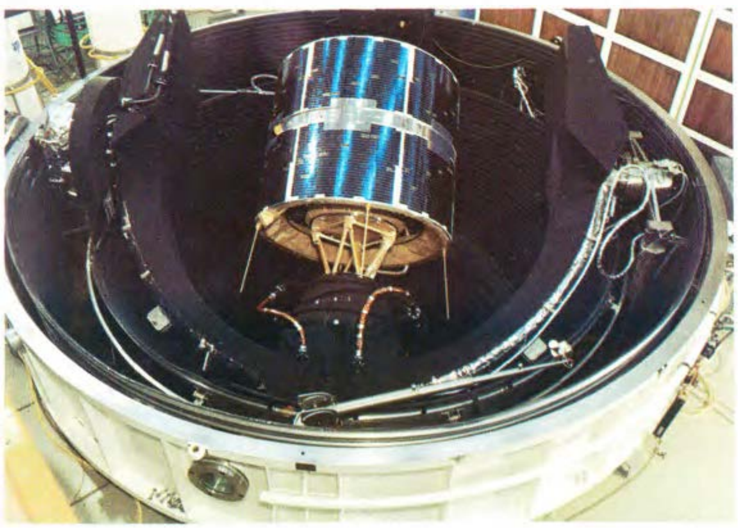
To reach the limits of the impossible

Indeed, things have changed since the launch of the first rocket experiments, but we should not conceal the fact that there is a danger in the marked trend of European space science towards this increased sophistication. Space experiments are thus becoming more and more expensive and cost far more than the limited budget the space agencies can afford. Consequently, they become scarcer and the number of inventive and experienced scientific groups is regularly declining. A space science programme will never be operational by definition; it relies on the continuous injection of both new ideas and the progress of new techniques, as well as on the expertise of highly specialised technicians. Will space science therefore gradually disappear through a continuous growth towards gigantism or because it has exhausted its capabilities? Have we already reached the limits of the 'impossible'?

Fortunately, the past 20 years have just opened new avenues for science whose perspectives are converging far away in time and probably in space. I cannot resist the temptation of comparing the success of the European space venture with that of another European one in science which materialises every day at CERN. The most recent discovery of the $W^{\pm}$ and the Z^0 bosons at CERN is a major milestone in our comprehension of the interactions which hold matter together at both the scale of the atom and that of the Universe. The theory predicts that at very high energies such as those which characterise the very first fractions of seconds of the early Universe, all these forces are indistinguishable.

The observation of phenomena associated with the gravitational forces exerted by neutron stars and black holes, which is possible in the X-ray spectrum, as well as the recent discovery in gamma rays of massive objects like 'Geminga' in the vicinity of our solar system, brings new insight to our understanding of both the formation and evolution of the Universe and of fundamental physics. Science is indeed entering a fantastic era and cosmology may well be the cement of physics and astrophysics.

It should be noted, however, that if it took less than three years to set up the experiment which led to the detection of the W and the Z^0 particles, the characteristic time which elapses between the moment the first idea for a space mission is emitted and that of its flight is much longer. In the early 1960s, scientists on both sides of the Atlantic were already discussing the measurement of the solar constant from space, but it is only since 1978 that such measurements have been made possible. The European X-ray astronomy



Cos-B in ESTEC HBF-3.

Infrared Space Observatory (ISO).

satellite, Exosat, was proposed in 1969 and launched in 1983 ... For more than ten years, Europe has been preparing itself for an infrared astronomy satellite: hopefully the Infrared Space Observatory which has just been selected by ESA will be launched in 1992. Discussions are under way to fly a mission to Saturn and its satellite Titan; if approved, the project will be launched some time in the 1993–1994 timescale, just in time to be ready for a flyby of Titan at the turn of the century.

On a sunny day in 2004
Looking back, the European space venture might easily have been recognised as the most obvious manifestation of the 'impossible' ... However, it can be admitted that, based on the experience of the past 20 years, this is not the case. European scientific cooperation in space, as well as in nuclear physics, today offers good evidence that projects larger in size and at a higher scientific level can be undertaken.

Because it has overcome the difficulties inevitably attached to cooperative ventures, it becomes clearer every day that Europe can serve in many instances as the central point of even broader interests and ventures – ventures such as the one which characterises the exploration of Comet Halley in 1986 through an interagency effort between NASA, the Soviet Union, Japan and ESA. Putting large astronomical telescopes and interferometers in space, exploring the solar system, understanding the Sun-Earth system for better control of our daily environment and of the evolution of our planet, are challenges which can be within the reach of the scientific community, provided it is realised how crucial the role of international cooperation will be. This may be the only way to avoid the fatal eventuality raised by my former question.

Provided this willingness exists to place efforts and resources together and at a sufficient level, we may look forward to reading 20 years from now the most exciting report on the first 40 years of international cooperation in space. Provided other generations of space scientists exist to write the report ... 'On a sunny afternoon of September 19XX, they were on their way to ...'.

Ariane – The road to independence

Dr. Peter Creola

Delegate of Switzerland to ESA Council
Chairman of Ariane Programme Board (1978 – 81)

The maze

In 1971, the European space partners were lost in a maze of frustrating negotiations, technical failures and far-reaching differences of interest:

- the negotiations on the final INTELSAT agreements ended in a compromise which did not take full account of certain factors that were essential to Europe. The fact that the European countries lagged behind the United States in technology had weakened their negotiating position.
- The first launch attempt of the Europa II rocket which was being developed with the intention of placing satellites in a geostationary orbit ended in spectacular failure. ELDO then went into liquidation, and the investigating commission concluded that Europa II, at the stage of development it had then reached, was not flightworthy.
- Denmark and France had withdrawn from the ESRO Convention, and the organisation looked likely to collapse, torn apart by the diversity of opinions among its Member States.
- European hopes for advanced technological participation in the Space Shuttle or in plans for developing the Space Tug as an essential component of the American space transport system collapsed.

The thread of Ariane

In 1972, the maze began to open up:

- by December 1971, a basis had been found for reforming ESRO in what was known as the 'First Package Deal', according to which the organisation would begin to develop meteorological and telecommunications satellites, in addition to scientific satellites. This prepared the way for an independent European application satellite capacity with some chance of commercial success.
- The official United States policy regarding the provision of satellite launch services was announced: the United States reserved its right to attach conditions to the launch of European payloads, a decision which encouraged those favouring development of an independent European launch capability, despite the failure of ELDO.
- After long negotiations, the European Space Conference took a number of basic decisions of principle in Brussels in December 1972. These decisions provided for all European space activities to be united within a single organisation, the European Space Agency (ESA). The nub of these agreements, which later came to be known as the 'Second Package Deal', was for the development of a manned space laboratory as a way of cooperating with the United States, and the development of a European launch vehicle for heavy payloads as the essential step towards independence in space.

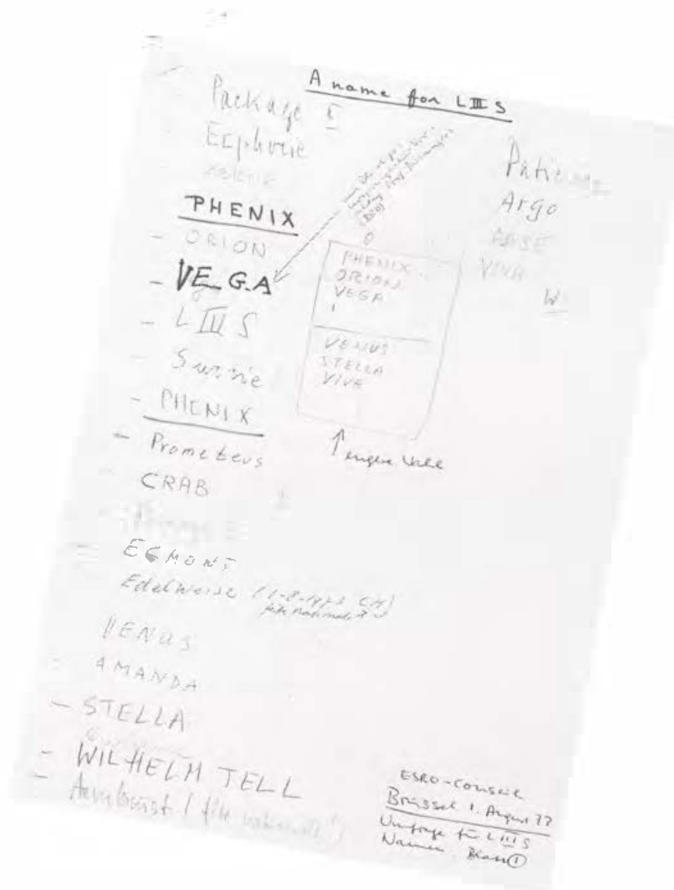
However, it took almost another year for the legal basis of these two major projects to be clarified, and for funding by the Member States of ESRO/ESA to be pledged.

The name

The new European launcher was known as L3S. How many people now remember that this meant: 'Lanceur trois étages de Substitution' (Replacement Three-Stage Launch Vehicle)?
It would take a whole page merely to explain the name of this project. At the time, no one seemed worried by it. Only one sentimental Swiss delegate urged that the new baby should be given a name. Apart from humorous suggestions such as 'Edelweiss' or 'William Tell' (the meeting took place on 1 August – the Swiss national holiday) there were high-sounding proposals

Europa II ready for launch at the Guiana Space Centre

The search for a name . . .



such as Prometheus, and more thoughtful ones such as Patience. Only one name got three votes: Vega. However, when, in September, the blank spaces in the agreement left for the name of the launch vehicle had to be filled, the French delegation raised a last minute objection. Minister Charbonnel had in the meantime let it be known that he could not accept Vega, since there was already a beer with the same name. France, as one of the main participants in the programme, would consider only three names: Phoenix, Penelope or Ariane. The quarrel between the protagonists of mythology burned bright: the German delegate rejected Phoenix: the ashes of ELDO were still too warm. Penelope was rejected, since the first flight was due in six years and not after twenty years of waiting. Only Ariane remained. It was Ariane's thread which enabled Theseus to find the way out of the maze. Skeptics of both sexes, who found that the explicitly male form of the European rocket did not suit this female name, gave way and, very rapidly, the name of Ariane became familiar. From 1977 onwards, they even knew how to pronounce it across the Atlantic . . .

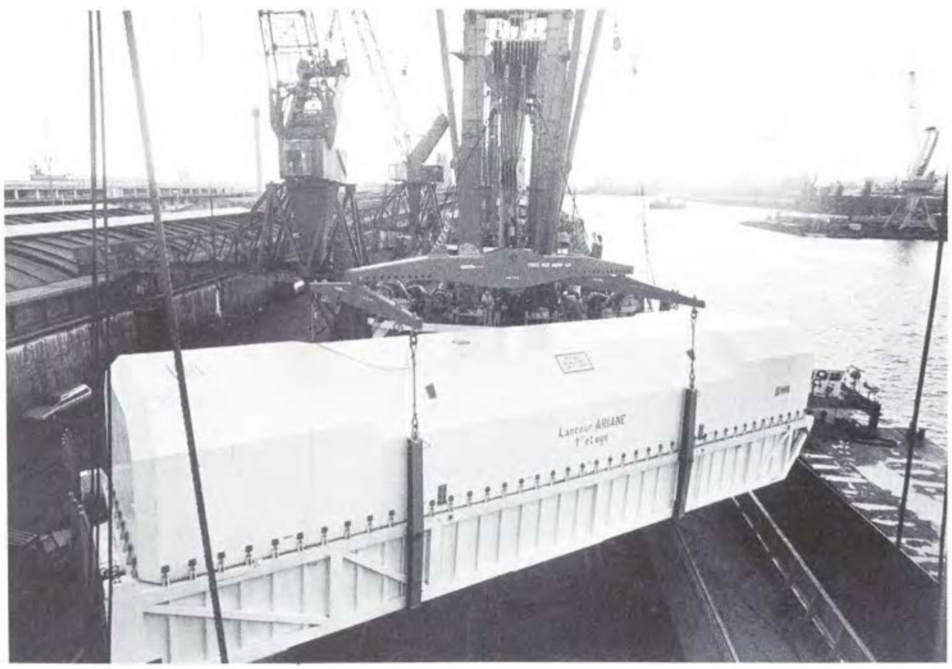
The development period

The Ariane agreement forming the legal basis of the programme, came into force on 28 December, 1973. In February, 1974, the Ariane Programme Board decided, unanimously, formally to begin the development phase and set the date for the first flight: 15 March, 1979. In October 1974, it was decided to abandon plans for building a Delta launch pad at Kourou. This parallel development could not have been justified either technically or financially. As the Ariane programme made rapid progress, confidence soon grew in the European launch vehicle's technical performance and its potential to be commercially competitive. The capacity in geostationary transfer orbit, originally set at 1500 kg, was raised to 1700 kg. Thus, Ariane offered twice the load of the most advanced Delta vehicle, and so began to be taken seriously, even outside Europe.

With hindsight, the difficulties encountered during the development phase were modest, even though all the technological problems had to be resolved entirely in Europe. From the outset of the programme, the United States authorities had refused permission for a technical assistance contract between Martin Marietta and SNIAS/Aérospatiale, and had also refused an export licence for the technology involved in the separation systems to the Swiss consortium charged with the task of developing the payload fairing. In the middle of December 1977, the initial ground test was carried out on a complete first stage in flight configurations. The cladding material on the throat of the nozzles of the Viking engines had subsequently to be modified due to its inadequate performance at high temperature. Development of the first stage was successfully completed in December 1978. Ground tests with the second stage had started in January 1978 with no particular technical problems, and the second stage was qualified in February 1979.

The path towards qualification of the third stage turned out to be rather stony. This was the first application in Europe of liquid oxygen/liquid hydrogen technology. It is interesting to note, however, that such was the technical competence of European firms in this new field that NASA obtained from Europe a licence for the use of the combustion chamber manufacturing method of the Ariane third-stage in the Space Shuttle main engines. During ground tests in November on the complete third stage of Ariane, an explosion took place. This was caused by a malfunction in the ground equipment, and neither the design nor the construction of the third-stage engine was responsible. Nevertheless, the interruption in the series of tests resulted in the date of the first flight being postponed to November 1979.

In December 1978, the modifications to the former Europa II launch base at the Kourou centre were completed, and in February 1979, a full-scale Ariane stood for the first time on the launch pad. In fact, this was the 'Propellant Model', designed not to fly, but



Shipment of Ariane 'propellant mock-up' on the Seine, on its way to Le Havre en route to Guiana essentially for the qualification and acceptance of the propellant feed systems. But, in the eyes of the programme managers, the delegates from the ESA Member States and the press, Ariane had become a reality, and proudly raised its head 47 metres into the skies of French Guiana.

INTELSAT

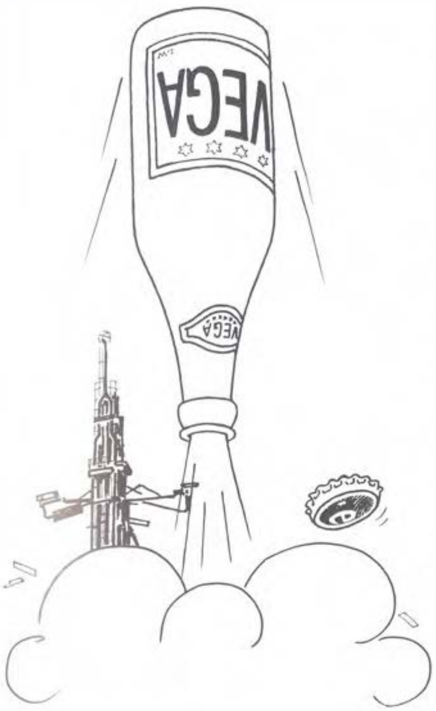
The INTELSAT agreements required the organisation to stimulate international competition whenever comparable bids were made for products or services. For this reason, INTELSAT has, since 1976, considered Ariane as one of the launch systems for the Intelsat V generation of satellites. In the Autumn of 1977, ESA submitted a bid for Ariane launches. For the first time, the European launching system was being compared on a commercial basis with the Space Shuttle. In terms of costs, Ariane was slightly ahead, but it was no easy matter to praise the advantages of this launch vehicle two years before its first flight, particularly as this was also Europe's first step in heavy launcher technology. In addition, no decision had yet been taken in Europe about a production series.

On 7 April, 1978, the ESA Council unanimously decided 'immediate production of five Ariane launch vehicles'.

Some 21.10 MAU were made available to finance initial production. The decision was formulated in a masterly manner. It left the Member States of ESA an adequate margin for manoeuvre until the time the final financial agreement was concluded, while giving potential clients outside Europe a degree of confidence in the commercial future of the European rocket. On 7 December, the board of governors of INTELSAT decided '... to order from ESA an Ariane launch vehicle, with the automatic option for another, to be ready for use by July 1981'.

What a breakthrough! A year before its first flight, Ariane had thus been recognised on the international market as a technically and financially viable alternative to the American launch vehicles and the Space Shuttle.

Full-scale Ariane 'propellant mock-up' erected for the first time on Kourou launch pad



The Christmas present

The campaign for preparing Ariane for its first flight began at Kourou on 1 October, 1979, the launch itself being planned for 15 December. After a trouble-free countdown, the first stage engines ignited . . . and went out again, without Ariane leaving the launch pad. By the time the project managers and the guests brought from Europe and elsewhere had got over the first shock, the cause of the failure was determined: the ground computer, receiving a wrong pressure indication in the combustion chamber of one of the engines, refused to release the retaining arms, and triggered the automatic shutdown sequence. Investigation showed that only one pressure probe had been damaged at the moment of ignition, and that the four engines had in fact developed normal power.

The flexibility and the energies of the launch team were sorely tested. The procedures for 'launch abort', drawn up just before the launch, were taken out again, and the team was strengthened by a number of specialists from Europe. Another launch attempt was made on 23 December, but a number of small technical problems and bad weather resulted in postponement to 24 December. At 2:14 p.m. local time, Ariane L01, weighing 210 tonnes, left the ESA launch pad. The launch could be followed visually from the roof of the control centre. Seen from a distance, Ariane, as slim as a pencil, poised on its column of fire like a glass rod, rose noiselessly, travelling faster and faster into the blue sky. It was not until later than an all-enveloping thunder and the distant roar along the flight path could be heard as the rocket, its path gradually curving over more and more, until, it was travelling almost horizontally, disappeared from view. Two flashes: separation of the first stage after burnout, and ignition of the second stage at an altitude of 51 km.

The cinetheodolite picture in the control centre showed two tiny bright dots separate from Ariane, which was now flying at an altitude of 110 km at more than 12000 km/h – the payload fairing had separated. Forty seconds later came, in rapid succession, the indications 'End of propulsion second stage', 'Separation 2/3' and 'Third stage ignition'. Even the most blasé were excited. Some people had wondered whether the highly complex third stage

The first success . . .

would ignite correctly in the first of the four flight tests planned. After nine minutes, the indication 'End of propulsion 3': the engine of the third stage had burned out at the final speed of 35129 km/h. The planned orbit was reached, and the payload (1.4 tonnes of ballast and the 200 kg test satellite) was released. Excitement, hugs and tears – looking back, this now seems oversentimental, but at the time it was certainly the most moving and historic moment in twenty years of European space cooperation. After all the mistakes and all the crises, Europe, joined together in ESA, now had its own launch vehicle, and hence the essential means to conduct its own space policy. Moreover, for the first time in the conquest of space, a large three-stage launcher had flown successfully at the first attempt, without the different stages having been tested previously in flight, either individually or as part of another rocket.

A setback

On 23 May, 1980, came the launch of Ariane L02. For this second test flight, the test satellite was accompanied by the German scientific satellite Firewheel and the radio-amateur satellite Oscar 9. Some 108 seconds after ignition, it was Ariane itself which turned into a wheel of fire: unstable combustion in one of the first-stage Viking engines led to erosion of the combustion chamber. The chamber wall was burnt through, the transverse thrust tore the engine from its mountings; fuel lines came free and the propulsion bay caught fire. Having lost its thrust, Ariane turned over and broke up. The self-destruct system tore open the tanks and the rocket exploded.

The tragedy was not visible from the ground: immediately after liftoff, L02 disappeared into thick low cloud. In an incredible silence, everybody watched the display panel where, after 'lift-off', nothing else appeared. The ends of the two trajectory plotters fell back to zero. Was the rocket continuing on its way with only telemetry and radar failing to do their job? A picture appears on the cinetheodolite screens: a twisted piece of steel falling towards the sea, turning over and over, like a dead leaf...

Further successes

Investigations, numerous ground tests of Viking engines and the necessary modifications caused a delay of one year in the Ariane programme. It was only on 19 June, 1981 that it was possible to launch L03 with three payloads: a test satellite, an Indian telecommunications satellite APPLE, and Meteosat 2 of ESA. The launch was successful and, in December 1981, it was the turn of L04; this was also launched successfully with Marecs A as payload. This marked the end of the test phase. Three successful launches out of four was not a bad result, even though the loss of L02 was regrettable. After all, the qualification rules laid down before the first test flight had foreseen as many as two failures out of the four flight tests.

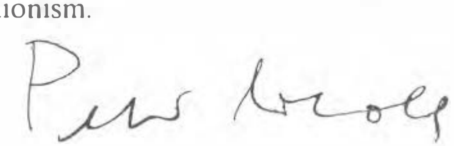
Even before the last test launch, Arianespace, the Ariane space production and marketing company, had signed the first contract to place an American satellite in orbit.

The four test launches had failed to detect one weak point: the turbine-driven pump in the third-stage engine. A combination of defective test procedures and a poor quality drive mechanism caused the loss of the fifth Ariane, which, during the first operational launch on 13 September 1982, failed to reach orbit. There followed nine months of intensive investigations and tests until the successful launch of L6 on 16 June, 1983, with ECS 1 as payload. Shortly afterwards, it was L7; with Intelsat V-F7. The European launch vehicle had launched, for the first time, a commercial non-European satellite, thus following up the 1977 decision taken by the Council of the INTELSAT governors. For the first time, a satellite belonging to the world's largest satellite organisation had been launched by a non-American vehicle. Ariane's competitive capability was thus demonstrated yet again. On 5 March 1984, the eighth launch of Ariane, this time with Intelsat-V-F8 as payload, was also a success.

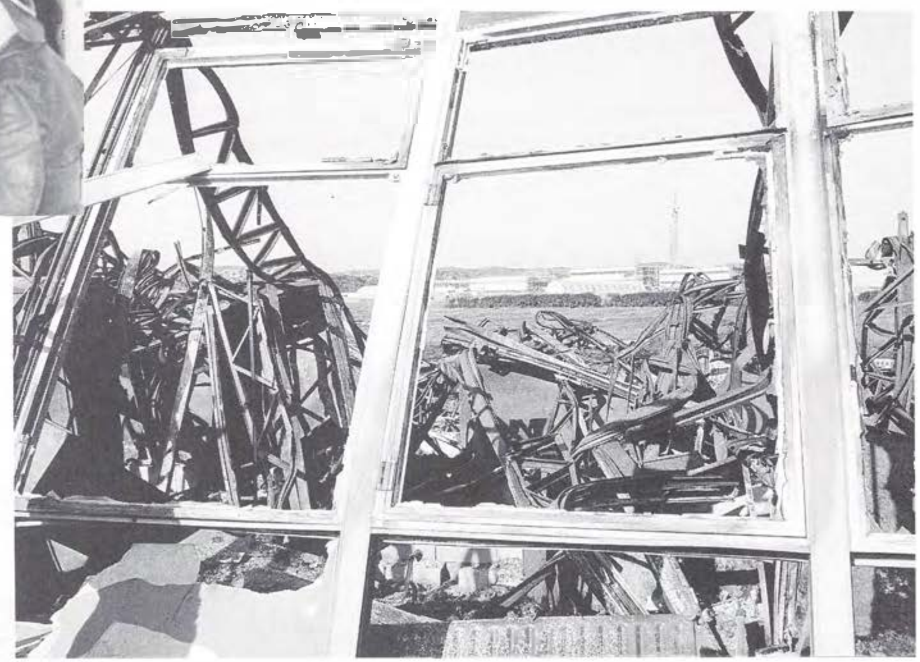
Outlook

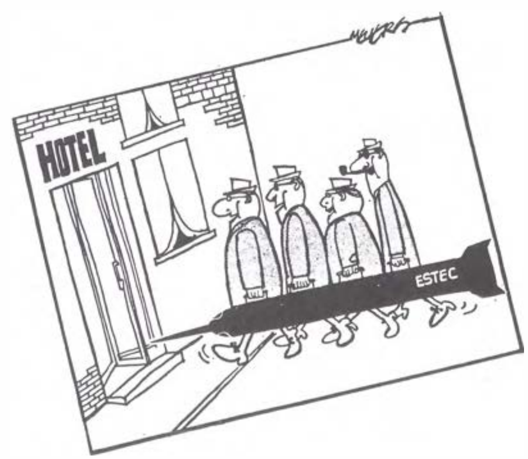
The success of the current versions of Ariane is assured. All the programme objectives have been achieved or exceeded. With the first successful flight of Spacelab, Europe has taken the first step towards manned flights. We can be proud of this success.

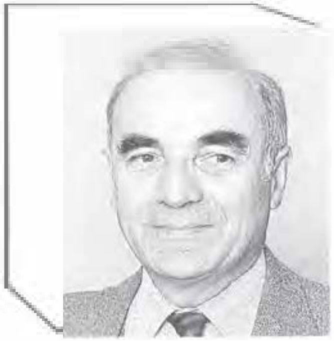
During the next two years, there will be complex negotiations on what European space policy should be up to the end of the century. New and important decisions will have to be taken. I hope that this time, we shall be spared the test of the maze. I hope that a new and broad consensus will develop which will enable the independent launch vehicle capacity and the technology of manned flight to be combined into a single coherent programme, depending as little as possible on decisions taken outside Europe, without falling into the trap of isolationism.



One 'hot' day at ESTEC in 1966...







To build Europe's place in space: keep both feet on the ground

Prof. Hubert Curien

Chairman of ESA Council (1981–84)

In a volume published to mark a twentieth anniversary, it is difficult to eschew the old campaigner's style, punctuated with 'I was there' for successes and 'had they only listened to me' for setbacks. It is also tempting to go in for the ratiocinations of a tactician or the vaticinations of a strategist. I am not sure I shall manage to avoid such pitfalls or resist such temptations.

Many opportunities are granted to me to talk about Europe, essentially the Europe of research and technology, and I am careful on such occasions not to draw up a black list of failures or a grey list of semi-successes. Rather do I try to analyse the reasons behind the unqualified successes, which are not as few and far between as some would have us believe. Foremost amongst these stands the European Space Agency and with it, of course, the European Organisation for Nuclear Research (CERN) and the European Science Foundation, which exemplifies, in a very different manner, a political determination for multilateral action. The incentives and stimuli of the European Community should also be included. If other brilliant ventures, such as the European nuclear fusion laboratory (JET) and the European Southern Observatory (ESO) are omitted from this compilation, it is not through an oversight or from any doubt but rather through plain caution: I prefer to discuss only those topics with which I am familiar.

Specificity and complementarity

All these corporate efforts, all these transnational organisations have one essential feature in common: their *specificity*, whether it be their field of activity (space, particles, ...) or their mode of operation (incentives, interagency relations, ...). In Europe, whosoever wishes to use the most powerful and most modern particle-splitting facilities unhesitatingly heads for Geneva. European space buffs, without exception, find themselves in the ambit of ESA. This does not, and should not, lead to a phasing out or a weakening of national or bilateral activities. Multilateral efforts will flourish only if they are an essential complement to the efforts of thriving national institutions.

As it happens, this notion of *complementarity* is not all that easy to define. It varies from place to place and may also alter with time. The balance between national and multilateral commitments cannot systematically be the same for every country when the population and ipso facto the size of their scientific communities may vary by a factor of ten. I use the term 'systematically' advisedly, lest the reader should conclude from my statement that the portion of its overall activities a country conducts in the European framework is invariably in inverse proportion to its bulk. And if some States were inclined to lecture their fellows on their European commitment, which God forbid, the distinction between lecturer and lectured would not necessarily be one of size.

The European space tetralogy

A complementarity which also varies with time: a project which ten years ago would without demur have been dealt with in a multilateral framework can have undergone a change of nature or of scale. Could this simply be an effect of the technological progress we are striving for? Take space communications for instance. The operation of a satellite system for telephony, data or information transmission is now within the compass of a number of European nations. The development of such systems is no longer a focus for broad multilateral cooperation. This in no way implies that telecommunications should henceforth be barred from joint European ventures. However, it does mean that in this area a second wind and, more specifically still, a new inspiration has to be found.

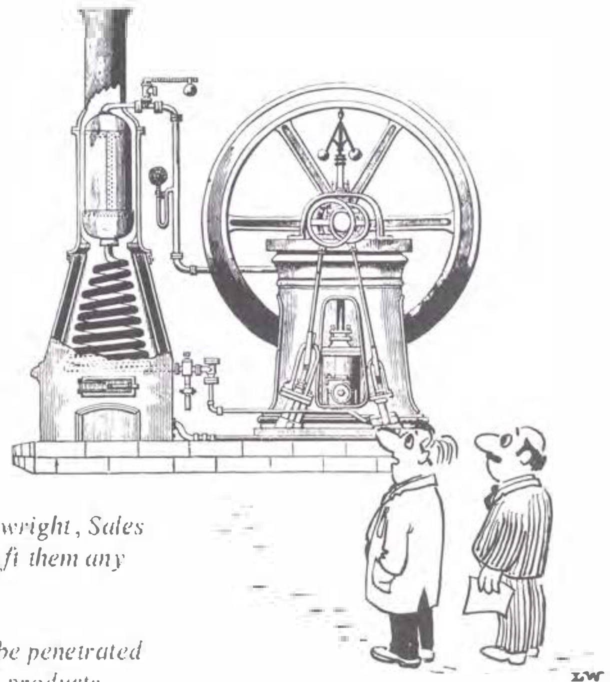
Along with Spacelab and Ariane, space communications have been one of the basic features of the European space trilogy. Tetralogy even, rather than trilogy, for besides applications programmes, the scientific programme is a fundamental component of ESA's activities. For ten years this has been our four-edged mainstay. Contracts have been fulfilled. ECS and Marecs were built and launched and they are serving us well. Spacelab was handed over to NASA and has flown to every user's satisfaction. Ariane has become a commercial launch vehicle. As for our scientific satellites, they have earned Europe a well-deserved reputation. Thus we are now faced with the need to define a *new programme package*. To generate this, we must make the best possible use of previous experience without lulling ourselves with illusions of facility.

Certain facts are clear. The Europe of tomorrow is inconceivable without a launch capability tailored to essential market requirements. After Ariane I, II, III and IV, we will need an Ariane V whose definition is becoming a matter of urgency. Europe must also define its stance as regards its presence in the exploitation of space: man or robots, permanent or intermittent. She has yet to decide what effort she is willing to devote to those increasingly important areas, such as Earth observation, on the borderline between research and exploitation. Lastly, she must determine what her stake will be in the race for knowledge of the Universe.

The choices facing us are many and varied. To my mind, the danger lies not in any shortage of the good minds and the goodwill which are required to buttress each case and make headway. Rather does it lie in a wish – legitimate in some respects – to button everthing up together. If we were to postpone taking any decision until all of them were quite ready, we might well miss the boat.

Spacelab (module and tunnel) on board Columbia Shuttle during STS-9 flight.

Erection of Ariane L5.



'It's no good Mr. Arkwright, Sales say they just can't shift them any more!'

... New markets can be penetrated only by new or better products.

Over the past twenty years, the European space *industry* has given ample proof of its capacity for achievement and innovation. European programmes, whether they be multilateral, bilateral or national, have been sufficiently novel to generate a capacity for invention and development which we must take care to foster. It is possibly in this area that greater vigilance is especially called for. The fact that the classical uses of space have become commonplace should not deceive us: the greater the number of customers, the more demanding they become. Invariably, the baseline for their requirements is the performance of those systems with the greatest reliability. New markets can be penetrated only by new or better products. So there is an overriding and urgent need to define an R&D policy which, in order to be genuinely stimulating, must be intellectually ambitious.

'Mr. 15%' or 'Mr. 50%'?

And whilst on the subject of intellectual ambition, it is natural that we should also assess our material capacity. All measurements are relative: in space, the two yardsticks are, of course, the Soviet Union and the United States. I do not propose to draw comparisons between the two superpowers but to compare us with one of them. For simplicity's sake, let us take the United States: its space spending is, for the time being, ten times that of Europe as a whole. And recent statements by leading authorities in the US do not portend any slackening of their efforts in this area. This is nothing new and it raises a fundamental query as regards both the definition of our programmes and that of modes of cooperation between Europe and the United States. While we are competitors in a ruthless commercial context, where the power of possible monopolies is a stark reality, we are also, of course, partners in quite a few 'ententes cordiales'. Should we cast ourselves in the role of Mr. 15% for a host of joint programmes or in the seemingly more comfortable role of Mr. 50% for a smaller number of ventures? The question may well be put thus for cases limited in scope. It is undoubtedly put in other terms for very big programmes in which Europe cannot expect to be offered, and probably could not accept, anything but a minority share. The future US space station is the most topical instance of this. Personally, I do not doubt that a satisfactory solution will easily be worked out, which will enable us to participate in this great new programme, without having to surrender our own identity.

I will have had the honour to chair the Council of the European Space Agency for a span of three years. At the close of some protracted, and possibly unproductive, session of that body, I may well have caught myself regretting that Europe, from the heritage of its very long history, should not yet be quite ready to take to heart only the object lessons of its great creative thrusts. But our vicissitudes on the whole have been few and always incidental: they have never really upset me. I am one of those for whom the shadows on a painting are but a foil for its highlights.

And now, were it not for some qualms that it should be thought bombastic, I might be tempted to close with a paradox: he travels furthest, even in space, who always keeps both feet firmly on the ground.

'Waiting for Kourou' – 15 April 1975

Dr. Wolfgang Finke

Chairman of ESA Council (1975–78)

It was after lunch by the time the summons from the Chancellery finally put an end to the delegation's hours of waiting. They had had to eat in a side room, separate from the others, but eventually the telephone message did enable everyone to be together again for coffee. The news was good – the conference was saved, and the establishment of the European Space Organisation was no longer in doubt.

This episode, which could easily have turned into a drama, took place during the last ministerial-level European Space Conference, on Tuesday 15 April 1975, in the Palais d'Egmont in Brussels. The ministers responsible for space affairs in most Western European countries, or at least their representatives, were meeting under the chairmanship of the Belgian Minister of State Geens to put the finishing touches to the work of unification which would lead to a European presence in space. Only a few questions remained open – it had proved possible to deal with most of them at the previous Brussels conferences on 20 December 1972 and 12 July 1973.

In particular, agreement in principle had been reached at these earlier conferences regarding two major groups of questions, namely:

- first, that ESRO and ELDO should be combined to form a new, more comprehensive European space organisation, ESA; and
- secondly, that the new organisation should allow for optional programmes for the Member States alongside the programme which would be obligatory for all of them.

Wearisome and tough negotiations

It was also agreed that the scientific programme should continue, and should form part of the obligatory section. Finally, the 1973 Brussels conference succeeded in reaching agreement on the desirability of starting with three substantial optional programmes, each of which would be run by one of the major Member States. Thus:

- France would be responsible for a new European launcher programme, which at that stage was still known by the name L3S rather than its more attractive later name of Ariane;
- Germany would take charge of a European involvement in the American post-Apollo programme, which in 1972 was still known by the working title of 'Sortie lab', though this was changed to Spacelab as early as 1973, and
- Britain would be in charge of a European Maritime radio satellite programme, which, during its first phase, was to be known by the contraction Marots by analogy with OTS, the Orbital Test Satellite programme for terrestrial communications satellites which was already running.

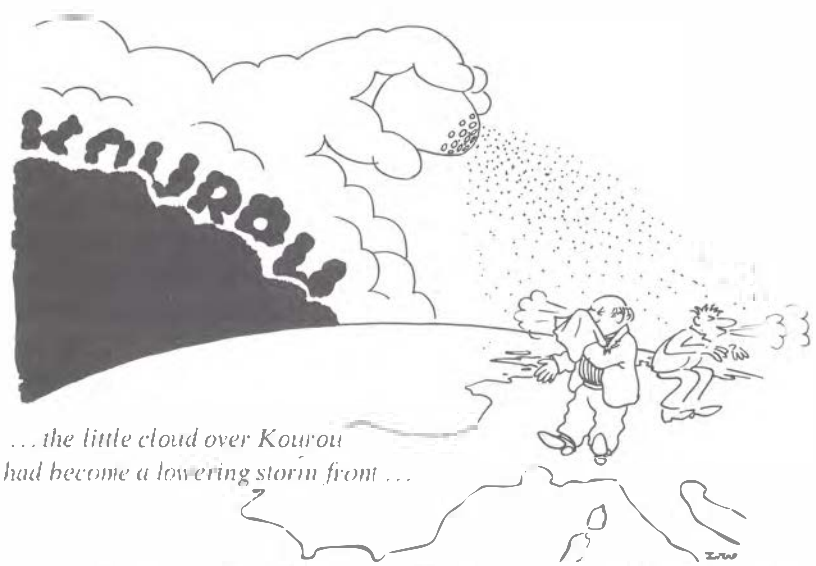
Further progress had been made in the 21 months which had elapsed since the last Brussels conference. Most of the questions which had been left unanswered by the ministers in July 1973, and reservations concerning the individual elements of the programmes, were cleared up. The so-called representatives and their assistants had, in the course of wearisome and tough detailed negotiations, completed the text of the Convention to which there was no longer any serious opposition – the result partly of conviction, partly of exhaustion. Finally, during the last few weeks before the Brussels conference of April 1975, it had also proved possible to reach agreement on the appointment of personnel to fill the most important posts within the new organisation.

Cloud over Kourou

By Easter 1975, which fell on 30 March, it really did look therefore as if the conference arranged for a fortnight later would be able to limit itself to the formal sanctioning of what had already won universal acceptance in a material sense. There may still have been one or two little clouds in the sky – one over Redu, one over Kourou, and a very little one over Paris – but by and large the European space climate seemed full of the promise of spring.

But, contrary to all expectations, the cloud over Kourou did not disappear. Instead it suddenly assumed threatening dimensions, darkened and cast a heavy shadow first over Bonn, then over Paris and finally over Brussels. The launching site for the French Diamant rockets, near Cayenne and close to the equator, had been designated as the successor to Woomera in Australia, a site which had brought so little joy to European rocket builders. What had unfortunately been forgotten was that the cost of this should have been included in the L3S/Ariane negotiations from the beginning, so that the necessary finance for the launching site opposite Devil's Island was now lacking.

The sums involved were relatively small. The initial French estimate for the first five years was just under 80 MAU. France was prepared to pay 50 MAU of this amount, and the other countries were to provide the remainder. This meant, in particular, the Germans. But the Germans hesitated and the effect was that the



... the little cloud over Kourou had become a lowering storm front ...

... European enthusiasm for the land where the pepper comes from had its limits ...

Main entry to the Guiana Space Centre.

others, instead of making a greater effort, withheld their contributions. On the evening of 14 April all the Germans could say was that the Federal Cabinet would be reviewing the matter again the following day. They were not radiating optimism. The little cloud over Kourou had become a lowering storm front.

The conference on 15 April began just after 11 o'clock. The first material item on the agenda, after the report from Mr. Stenmans, Chairman of the Representatives Committee, was:

> ESA participation in the running costs of the Guiana space centre at Kourou.

Germany's request that the matter be dealt with later did not receive majority support. The French minister d'Ornano stressed the importance of this particular item for the progress of the conference as a whole; the German minister, Matthöfer, indicated that this was precisely the area in which he had absolutely no freedom to negotiate. The proceedings rapidly ground to a halt, and there was nothing the chairman could do but suspend the sitting for a premature and lengthy midday break. While some made phone calls or merely waited, others eventually sat down to eat. The atmosphere was muted.

Aerial view of ELA-1 (with ELA-2 in the background).

By the time that Federal Chancellor Schmidt in Bonn eventually decided against his finance minister and in favour of Kourou, it was early afternoon. At the conference in Brussels, coffee was served to the accompaniment of more cheerful expressions all round.

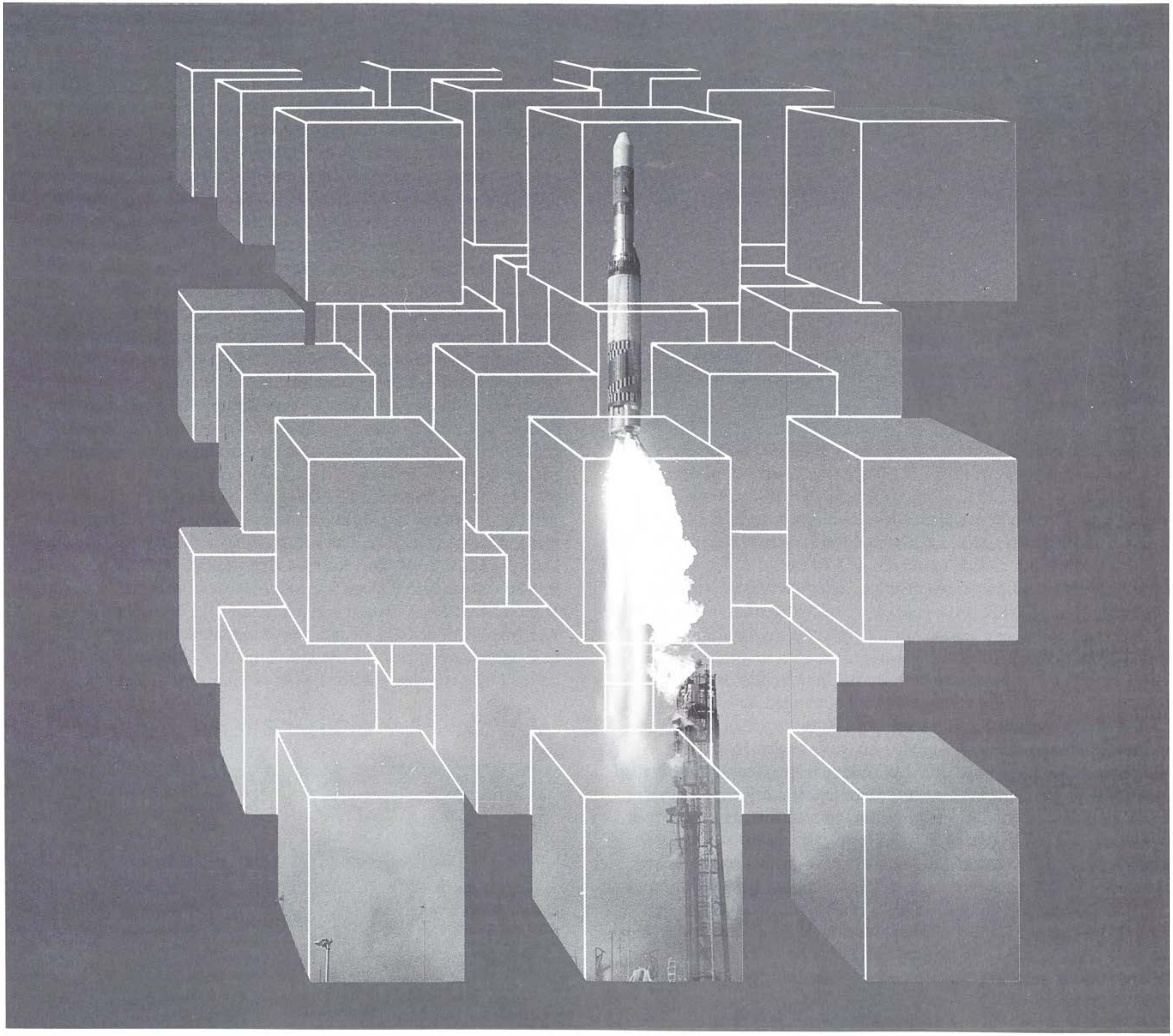
Still 10 MAU short

The German contribution to the Guiana launch base was to be a total of DM 50 million, and to remain unchanged over the entire period of the project. There were to be no contingency plans for inflation, nor any claims for profits made on foreign exchange. At the prevailing exchange rate, the German contribution was worth 10.65 MAU. This, together with the French share of 50.03 MAU and the total of approximately 8.5 MAU put forward by the other countries, still fell 10 MAU short of the likely running costs for the launch site to the end of 1980. The European enthusiasm for the land where the pepper comes from had its limits.

The eloquence of Minister d'Ornano finally caused the sum to be raised to 69.435 MAU. He undertook to try to make further savings and to stop any remaining gap with additional French aid.

The breakdown of the conference had been averted. The infectious air of relief proved uncommonly successful at speeding up discussion of the remaining items on the agenda. The passage of time produced a similar effect. A further point was that the enforced suspension of negotiations due to the Kourou question had enabled preliminary decisions to be reached on a number of subjects, which were subsequently given final approval by the ministers. These included confirmation of the text of the ESA Convention, approval of the text of the resolution for the closing statement of the Conference of Representatives on the establishment of the European Space Agency, and the appointment of Mr. Gibson as Director General of ESA, together with eight other directors. A brief exchange of ideas on the long-term prospects of the new organisation then followed. Before darkness had fallen Minister of State Geens was receiving the delegations' appreciation for the skilful way in which he had presided over the negotiations and their congratulations on the success of the conference.

The signing of the new Convention took place on 30 May 1975 in Paris. Almost seven years had elapsed since the formation of a joint European Space Organisation had first been proposed, at the ministerial-level European Space Conference at Bad Godesberg in September 1968. A month and a half later the European Space Agency, ESA began its de facto existence. Another five and a half years were to pass before it also existed de jure, with the depositing of the last instrument of ratification on 30 October 1980.

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The birth of the European Space Agency

Minister Gaston Geens

President of the Flemish Executive
President of the European Space Conference (1974 – 75)

When, in April 1974, I was given responsibility for scientific policy within the Belgian Government, one of the first files I studied was the one relating to European space affairs.

For several years, at the request of his European colleagues, the Belgian Minister of Scientific Policy had been trying, by his own actions as well as by approaches to and meetings with other people, to win over all the members of ESRO and ELDO to a space policy which would be more comprehensive in its aims and better structured in its execution.

The situation in 1974, if not satisfactory, was at least perfectly clear. We had covered two important stretches of the road which was to lead us towards an authentically European space policy. On 20 December 1972, at the Palais d'Egmont in Brussels, the European Space Conference chaired by the late lamented Minister of State Théo Lefèvre had decided to set up a European Agency and had laid down its initial programme: the building of a heavy rocket under French supervision, the building under the responsibility of ESRO of the laboratory for the American post-Apollo programme, and the rational continuation of national programmes by the new Agency. On 31 July 1973, still at the Palais d'Egmont in Brussels, the same European Space Conference, now chaired by Minister Charles Hanin, was able to summarise in more specific, practical terms those decisions on matters of principal taken at Christmas 1972: an L3S heavy launcher would be built, costing so much and involving such and such contributions; the same would apply to Spacelab and to a Marots maritime navigation satellite, presented by the United Kingdom; a unified Agency would come into being on the 1 April 1974.

By the time I took up my responsibilities it was the end of April in that same year of 1974, and the decisions taken in 1972 and 1973, clear-cut though they were, were being slow to take effect.

1974: New actors on the stage
It should be pointed out that at that period the countries of Europe, having had their fingers badly burned by the failure of the Europa II rocket, were all the more reluctant to confirm their building plans as a result of changes in administration then taking place in several of those countries. In the middle of May 1974, in Bonn, Mr. H. Schmidt replaced Mr. W. Brandt at the Chancellery, while the B.M.F.T. became the responsibility of Mr. Hans Matthoefer, reputed to be a capitalist Social Democrat of hard-line trade union attitudes, with little enthusiasm for such long-term programmes. A few days later, Mr. Valéry Giscard d'Estaing was elected President of the French Republic and Count d'Ornano, an industrialist and Independent Republican, took over from Mr. Charbonnel as Minister of Industry and Scientific Affairs in the Chirac cabinet.

Everything depended very heavily on the attitude which the new French Government would take concerning Europe's involvement in space, and particularly on their attitude to the launcher, that spearhead of the previous French Government. Everything depended a great deal, too, on the attitude of the German Government, which was more interested in the post-Apollo programmes than in the launcher programme, but was in close touch with Paris on all matters of joint interest.

A few days before the election of Mr. Giscard d'Estaing, a senior French official, at a meeting with Mr. Alain Stenmans, Secretary General of my department, had indicated what France's attitude was likely to be if Mr. Giscard d'Estaing won the elections. The

French Government would not sacrifice the space programme as a matter of principle, but neither would it continue to support it unless the results achieved were sufficiently in proportion to the cost incurred. This involved the assumption that the partners would agree on strict control of the programme, and in particular of the 'launcher' programme, which had been allocated to France. Looked at from this point of view, it appeared to be worth deferring the setting-up of the Agency for a while. Mr. Stenmans, after consulting me, had informed his contact that a further delay would make sense only if the necessary checks were carried out quickly and ESRO and CNES were to take no irrevocable decisions in the meantime.

Soon after the French delegation officially announced that it wished to take time to reconsider, and it was not until 16 October 1974 that it confirmed France's intention to replace the Europa III launcher programme with an Ariane programme.

Striking while the iron is hot

Once this stance had been adopted, I formed the opinion that in my capacity as Chairman of the European Space Conference I should strike while the iron was hot. On 21 October, together with Mr. Stenmans and Mr. van Eesbeek, I took advantage of a visit to Paris to arrange a meeting with Count d'Ornano. At our interview, which took place in the evening, in the rue de Grenelle, I was able to judge that the new French Government really did intend to carry through the Ariane programme, that it was ready to negotiate acceptable terms on certain outstanding questions (risk margins, the financial cost of the Kourou base, and industrial policy), and also that the government was prepared – a sine qua non for the other major partners – to participate in the remainder of the programme, and in particular in the Spacelab project, the matter of particular concern to the Germans.

Armed with these encouraging facts, I arrived in Bonn a few weeks later, on 9 December, again with Mr. Stenmans and Mr. van Eesbeek, for a meeting with Minister Matthoefer, Secretary of State Haunschild, who had conducted all the Spacelab negotiations with the Americans, and a number of their colleagues. For me, attending this working meeting was rather like taking a cold shower. The people I spoke to certainly gave us a cordial welcome, but they were totally rigid in their attitudes: from their point of view, France's good intentions were an excellent thing, but a great deal of work had yet to be done before there could be any sort of

ESRO's first launch facilities at Woomera range, Australia, showing Europa-1 launcher on the pad.

convening the European Space Conference at ministerial level; work would have to go ahead on drafting the texts relating to the new Agency, and all the delicate problems involving Ariane and Spacelab would have to be settled. I realised that Germany was not going to give her partners something for nothing, whoever those partners might be, and that everything would have to be prepared in such a way that the European Space Conference would, as it were, be left with nothing to do but to ratify the agreements.

I am bound to say that at that time my predecessors Lefèvre and Hanin very frequently came up against an idea which I still encounter today and which is common to several countries – namely that it is no good relying on a ministerial meeting to sort out those problems on which the deputies (i.e. the civil servants and the ministers' staffs) have been unable to reach agreements. My predecessors and I have always been of the opinion that there are times – to be selected with care, and not too frequently – when a meeting at ministerial level can unblock a few bottlenecks and open the way to a speedier settlement. My experience with the European Community has strengthened this conviction.

Be that as it may, on the occasion in question opinion in Bonn was that a ministerial conference would do nothing to expedite matters. The conclusion was inevitable: the ministers' deputies would have to redouble their efforts, with no further directives from the European Space Conference, to finish clearing the way and, with an adequate consensus on the part of all those involved, to prepare the technical machinery of the future agreement.

At this point Mr. Stenmans was invited by the deputies to chair their deliberations, in succession to Mr. Plate, a senior Dutch official who had just retired.

In Paris, on 16 and 17 January 1975 and then throughout the weekend of 8 – 10 February 1975, the Committee of Deputies held long, arduous meetings to finalise the Statute of the new Agency and settle all the associated problems. On the Belgian bench, Mr. van Eesbeek was unstinting in his efforts to help the chair to reconcile delegates' views on questions still in dispute.

As the preparatory work was going ahead well, my Secretary General and I paid a visit on 3 March 1975 to my Dutch colleague, Mr. Trip, at The Hague. On Monday 10 March, I received Mr. Gibson, who had been sounded out by the countries with a view to directing the new Agency, to exchange information about how work was progressing.

The European Space Conference in session at Palais d'Egmont, Brussels, 15 April 1975.

Signing of the ESA Convention in Paris in May 1975.

On 11 and 12 March the Committee of Deputies completed a draft Convention setting up the Agency, which was due to be submitted to the ministers on 15 April.

And so it was that on 15 April 1975 I had the great pleasure of seeing the European Space Conference, meeting once more at the Palais d'Egmont in Brussels, finally adopt the Convention setting up the European Space Agency. This Convention was officially signed in Paris on 30 May that year.

Thus, in 1972, 1973 and 1975, three Belgian Ministers of Scientific Policy had had the satisfaction, in their capacity as Chairman of a European Space Conference with no formally recognised existence, to preside over the three essential milestones along the road to the setting up of a Space Agency and the establishment of its initial programme – that same programme which is now coming to its end with a record of positive achievement. But that road had taken twelve years to travel, starting from the intentions declared in 1963 and the difficult beginnings of ESRO and especially ELDO. Why had the process taken so long and what was the political significance of its happy ending?

Delays and hesitations

In my opinion, three main factors played a part.

- In the first place, the founders of ELDO and ESRO were notably Atlantic-minded in their attitude to rockets (use of American rockets) and scientific-minded as regards satellites (reluctant to become involved in applications satellites).
- In the second place, the Member States, large and small, had been slow to accept two key ideas: leaving the Agency to handle the essential work of Europe's space efforts; and pursuing a genuine industrial policy in this respect, i.e. encouraging industries within the Member States to specialise and work for one another, thus gradually creating a genuine European industrial fabric for space purposes.
- In the third place, it was difficult to persuade some of the European countries involved, large and small, to accept a priority as regards the space programme which was not always in line with their national priorities. At that time, for example, Great Britain believed that it was impossible for her to undertake a major commitment both to space and to informatics (her top priority at the time), and intended to take an interest chiefly in the purely scientific aspects of space research. The Netherlands were vigorously attacking the problem of the quality of the environment, and allocated a lower priority to space, except as regards its purely scientific aspects. Germany's preference was to have the Agency concentrate only on pure research and basic technology, not applications. France stuck to the idea of the launcher for reasons of general policy, but otherwise she too would have been content to see the Agency concerned with purely scientific activities.

Various factors gradually silenced all these dissenting voices, and produced general acceptance of the need for a coherent European space policy. The first was the clearly expressed intention of the United States not to supply Europe with launchers for commercial applications; then came the economic crisis; and, on another level again, in the face of innumerable difficulties, the broadening and deepening of European solidarity, as evidenced by the British referendum on 5 June 1975 which brought that country into the European Community.

However, now that the new Agency existed it was necessary to make it work. Almost another two years passed before the Agency Council met for the first time at ministerial level. When it did, on 14 and 15 February 1977 the Agency Council was officially inaugurated and the winding-up of the European Space Conference was officially proclaimed. Mr. Pedini was elected Chairman of this first council at ministerial level. We made but little progress in

Delays and hesitations . . .

determining the outlines of Agency policy. It was the beginning of a new, fascinating but difficult chapter in European space history. There was little I could do in connection with it, as on 3 June I became Minister of Finance in the new Government of my country, and handed over my portfolio for scientific policy to Minister R. Vandekerckhove.

Choosing the right specialities

My contribution to this 20th anniversary of Europe in Space would be incomplete if I were not to admit that we Belgians, too, have had our moments of doubt and have overcome then.

In this context, I remember one ministerial council during which a number of my colleagues wondered whether Europe would ever get around to launching its rocket and penetrate the market of practical applications, and wondering too whether it was justifiable for a country such as ours to go on making such a substantial contribution (about 5%) to the European space enterprise. After mature consideration of the pros and cons, the then Prime Minister, Mr. Tindemans, gave me his support: he successfully put across the idea that, in a field of such guaranteed future value, it is more prudent and in the long run more practicable to keep going than to back down; provided one is careful to choose the right speciality and persistent in developing one's skills in them.

Today, I am glad to see that Mr. Tindemans was right, and that I too had not miscalculated. European space policy, for all its inadequacies, is today a fact; and its record of achievement is a fact, too, despite delays and occasional failures. Space-age Europe – no more than an idea and a hope for the future 20 years ago – is now demonstrating its existence and vitality, to the real profit of its members and of those other countries with which it works.

By the way . . .

Roy Gibson

Director General ESA (1975–80)

It will be interesting to see how the various authors record their impressions of the past twenty years of European space cooperation. Delegates, scientists and former officials have all, no doubt, differing views not only as to the value of the cooperation, but also as to how it all transpired; rather like the famous Japanese film which shows three different versions of the same events as experienced by the three main protagonists. It will surprise no-one that this near-extinct executive volcano will recount it as seen from inside the house.

Aiming for the stars

I do not believe that the occasion of an anniversary should be used as an excuse to present a bland and jocular account of past events; it must be clear even to the most casual observer that the way has been hard, and there is no sense in pretending otherwise. Basically difficulties arise – as they always do for international ventures – from the conflict between national and international interests. Some small comfort can perhaps be gained from realising that this conflict is clearly not limited to ESA – nor even to Europe as a whole – for I was recently struck by the sentiments of the Foreign Minister of the Philippines, Carlos P. Romulo, in his last major speech to the United Nations, where he said:

> '*The world has changed, but we have not changed enough. Human perspective is still transfixed on the precious but inadequate loyalties of home and country, when it needs, at a time when men aim for the stars, to encompass at least the human family on a tiny planet circling a minor sun.*'

And this from someone who, so far as I am aware, had never attended either a meeting of the ESA Council or a European Space Conference!

Praise be, then, to those who worked so hard twenty odd years ago to persuade, cajole and bludgeon their governments into supporting the ESRO cooperative venture. We owe much to their foresight and to their idealistic approach. They really believed that to succeed in space it was necessary for European countries to cooperate – and cooperate fully. The intervening years have tended to prove that the smaller the country, the more it strives to maintain a pro-European policy. 'Of course', a delegate from a not-so-small European country once explained to me, 'they realise that they must cooperate with others; their industry is too small to compete alone in world markets'. The explanation was simultaneously offered as a justification for the larger countries being excused from putting a high value on European cooperation. But, in fact the countries in Europe are all too small to be able separately to give economic battle to the giants – both those now fully grown and those, like China, who are still developing. The concept of European cooperation was born of realised economic necessity rather than sentiment, but it needs constant fostering in all fields – and space is no exception.

The 'ideal' delegate

All this is not to say that ESA never received support from its Member States. There have been periods where – for a multiplicity of reasons – sufficient support has been forthcoming to allow a new important programme to be funded; the fruits of those ventures are there for all to see. Often the positive decisions have been due to the personal dedication of individual delegates who consistently interpreted their instructions in as favourable a light for ESA as was humanly possible. Without betraying their national masters, they voted whenever possible for the European solution. It is indeed interesting to reflect how much of ESA's successes have been due to the tenacity of a handful of delegates over the years.

The formula for the ideal delegate will no doubt emerge from current work on genetic engineering (that for the ideal Director General will probably take longer), but it is hard to find many common traits among those who have given such meritorious service to ESA. Looking back, it seems that – inevitably – they were all back home sufficiently well-placed or respected (or, occasionally, both) to be able to influence their governments; sufficiently independently-minded not to yield to the temptation of gaining petty victories at the expense of the other delegates, and above all they enthusiastically enjoyed helping to build something considerably harder than a national venture. Those who have been associated with the ESRO-ELDO-ESA saga, will be able to recall the names of this band of European space pioneers.

Competence and dedication

But ESA's successes and failures cannot all be laid at the door of the delegates – important though they are; the quality of the staff is of course an equally vital factor. My own experience is that there has been a consistently high level of competence and dedication among staff. Here and there were a few time-servers, who had little interest in the aims of the organisation, and who used the office for their personal ends. (One finds such people in the most respectable organisations – national as well as international.) But they

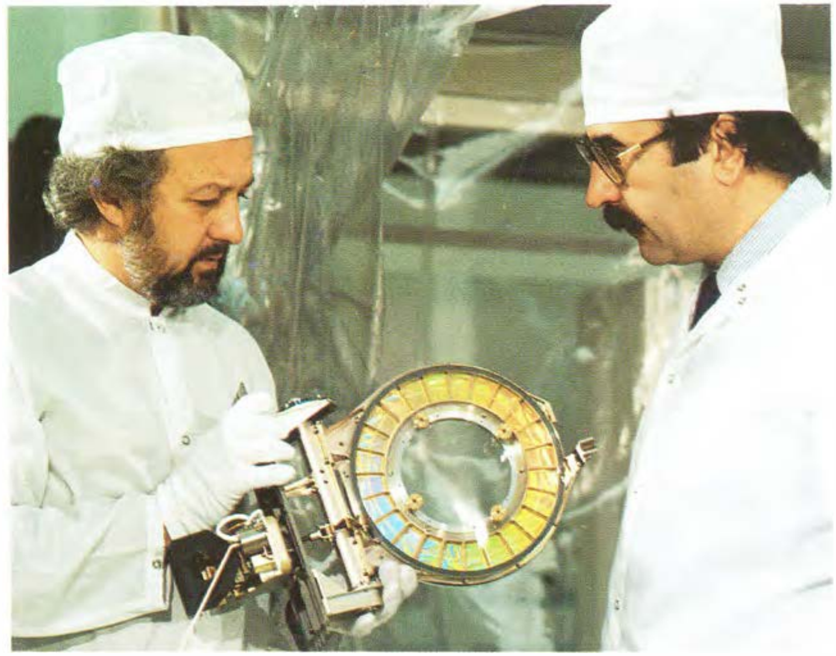
'... the formula for the ideal Director General will probably take longer ...'

represented – and still do, to the best of my knowledge – an extremely small percentage. Whether one looks back to the early days in Delft, the first buildings in Darmstadt, the early – almost ecclesiastical – lodgings in Frascati or the camping in Villafranca, the staff, right from the most modestly graded, were to 95% space enthusiasts and eager to build something for Europe. Neither should one forget their competence; ESA managed to acquire

An early sounding-rocket campaign

The early days in Delft ... (1964)

... there has been a consistently high level of competence and dedication among staff



specialists in many fields who could rival anything available outside. Overpaid? Nonsense! In many cases ESA had difficulty in matching the salaries such people could command at home – not to mention the U.S.A. (from whence, incidentally, we not only recuperated a contingent of expatriated Europeans, but also a small group of Americans, who embraced the European goals – as heartily as any). If this anniversary is to be the time for any award of bouquets, let one be given to the ESA staff. In doing so, it may unjustly honour a very small number who do not deserve it, but it will help to show the others – the overwhelming majority – that their efforts are appreciated. Let us not forget that even the weaker members of staff recruited by ESA are no worse than some of the diplomatic passengers some delegations in the past tried to off-load onto the organisation.

This twentieth anniversary year is likely, coincidentally, to be a particularly important year for European space cooperation. The programme decisions to be taken, the funds which will need to be raised, will this year determine the shape of European space cooperation for at least the next ten years, and probably more. There will be many temptations for Member States to exploit an opportunity to go it alone – or to seek out a preferred partner. They may well thereby win material benefit in the short-term, but if this is done at the expense of European cooperation, they will be betraying the whole intention behind these twenty years of hard work, and will seriously hinder the advent of the united Europe most thinking citizens hope one day to see. It will need all the competence, patience and dedication which delegates and staff can bring together. On this anniversary I sincerely hope that contemplation of the solid achievements which European space cooperation can demonstrate will produce a resurgence of the promising spirit we have often seen in the past twenty years. May the next twenty years be as successful as the past twenty.

R Gibson

More than we dared hope for

Prof. Marcel Golay

Director of the Geneva Observatory and Professor at Geneva University
Vice President of ESRO Council (1964–66)

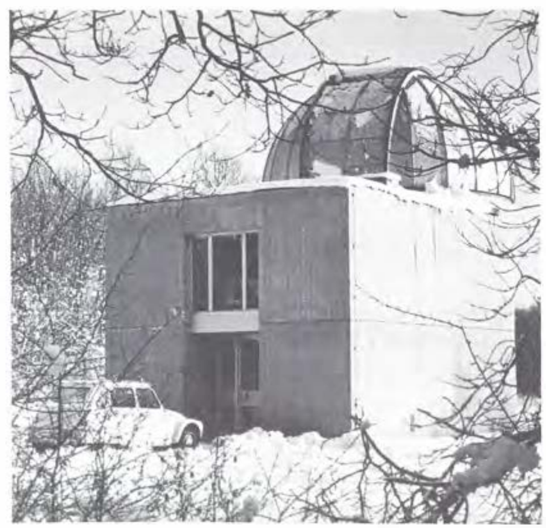
When an anniversary comes along, we may make it an excuse to talk or write about past events; events we have lived through and buried deep in our memories. This involves us in diving into piles of forgotten documents. At our observatory, documents relating to administrative and political matters are relegated to the most obscure corners of the archives. Not only that, but we have never seen a lot of point in keeping them properly organised, secure in the knowledge that all these documents are duplicated in the orderly files of government departments. My intrepid efforts to rescue first one document, then another, gradually revived my memories of what things were like in those days, and of the events which led to the establishment of ESRO.

Between October 1957 (when the first Sputnik was launched) and September 1962 (when the Swiss Federal Parliament accepted the agreements which established ESRO), I exchanged an enormous volume of correspondence with the federal, cantonal and university authorities, international organisations and national scientific and industrial organisations. Looking through it now, I am reminded both of the enthusiasm of the 30-year-old Observatory Director which I then was, and also of the tremendous resistance I had to overcome within my own country. I think the situation was more or less the same in most small countries. The fact of the matter was that we small nations saw space research as a typical 'big-power' venture (big in the military as well as the economic sense). The consensus of opinion then was that our industries and our laboratories would have to pull strings to obtain a few orders or a few small spaces in the satellites. There was no need to think in terms of setting up in business on our own account, even on a European scale – in fact it was impossible to consider it.

Anxiety among scientists

Space research – and remember, I am still talking only in terms of small countries – was the cause of anxiety, because the press insisted on talking about what they called the 'conquest' of space. By this they meant the presence of man in space, something which most European countries could neither imagine nor accept. It amuses me now to think that Europeans – including one Swiss, a former student at Geneva Observatory – are today preparing not to conquer space but just to work there.

My correspondence from 1957 to January 1960 reveals how isolated I was in what I was doing; and illustrates the growing fear in university and administrative circles that they might be called upon to finance a new science. The multi-disciplinary nature of space research was causing anxiety, where it should have been



Geneva Observatory.

arousing excitement and interest. Since then, the fact that a science involves a number of disciplines has become less of a cause for alarm, and has sometimes even helped to carry the day, although, after almost thirty years of university experience, this is an argument I feel should be applied with caution.

That isolation came to an end one evening in January 1960, during the first international symposium organised by Cospar in Nice. There I met various European scientists, including Professors Amaldi and Auger, all of us anxious about the ground that would be lost by science in Europe unless we were to try to set up a European space organisation. Others will do a better job than I of studying the individual archives and trying to describe how a multi-national organisation as important as ESA is born. But there is no doubt that, after January 1960, each of us was able to convey to his own national authorities the anxiety felt by European scientists, and to express it with arguments which were better structured as a result of our meeting in Nice. This joint effort, delicately coordinated by means of numerous telephone conversations and much correspondence, resulted in the meeting of representatives from various countries in London in April 1960, at the invitation of the Royal Society.

The example of CERN

What emerged from this meeting was an organisation with a brief to prepare and plan future action. Other meetings followed – Paris in June 1960, London again in October 1960. It was then that my colleagues entrusted to me the task of persuading the Swiss Government to take the initiative by calling a meeting at Geneva, under the auspices of CERN, of the representatives of governments interested in taking part in the setting-up of a European space research organisation. This inter-government conference was declared open at CERN in Meyrin on 28 November 1960 by Max Petitpierre, President of the Swiss Confederation.

There was a symbolic point behind the choice of CERN as the meeting place for this first intergovernment conference. CERN was the first cooperative European scientific organisation set up after the war. In scientific terms it had a specific purpose – making available to all the Member States equipment which none of them was capable of producing for itself. The success of the CERN experiment carried considerable weight with all the governments concerned. Not only that, but CERN's cooperation in promoting the discussions leading to the establishment of a space research organisation also served to confirm the importance of this research

Some participants of the Meyrin Conference (left to right: Messrs. Petitpierre, Auger, De Rose and Campiche).

to the progress of pure science. Suddenly the 'conquest of space' began to fade from the political consciousness, to be replaced by the idea of science in space. However, imitating the CERN experience in the space sector proved not to be easy. CERN, in those days, was an accelerator destined to become more and more powerful. Space research, even today, involves not only the development of rockets, application satellites and scientific satellites, and planetary exploration, but also men in space and, unfortunately, direct military applications. A fine sense of unity rapidly grew up between the scientists and their governments regarding the urgency of setting up a European organisation; but it promptly faded away when it came to agreeing on a programme and priorities.

The first options

I expect that everyone involved in the events of that period – a period extending from the Meyrin agreements to the signature by nine countries, on 14 June 1962, of the agreements establishing ESRO – has his own personal memories and his own version of the intensive discussions, occasional arguments and numerous official, not to say officious, meetings which marked it. For my own part, I do remember that the scientists present were agreed that ESRO should be primarily a scientific organisation. On the other hand, however, some government representatives made frequent attempts to impose upon us a launcher development programme. This is another story altogether, and a very long and meandering one too, which I shall not go into here. So far as the scientific programme was concerned, there seemed to me (and it is no good trying to be objective in talking about the history we live through) to be three options:

- The first principally combined the scientists whose disciplines related to the Earth's atmosphere, relationships between Earth and Sun, geophysics, meteorology, and cosmic rays. This body of opinion was in favour of a programme of probe rockets and large numbers of small and medium-size satellites.
- The second option was represented by the stellar and solar astronomers who wanted to produce one or two highly stabilised high-performance satellites.
- The third, by way of compromise, favoured a mixture of the two preceding options and was of particular interest to people attached to the governments of the major countries, who hoped to see the future organisation working on projects which would complement those envisaged within their own national programmes.

The programmes of the first option (rapidly supported by those people in favour of the third) had the advantage of meeting the needs of numerous European groups, but the disadvantage of dispersing and fragmenting the activities (and hence the effectiveness) of the future organisation.

There was, then, a considerable risk that we would become an international organisation responsible solely for carrying out those projects which it proved impossible to accommodate within national programmes.

The passive astronomers

The advantage of the programme of the second option was that it followed the CERN model, establishing a principle of cooperation with a view to carrying out a project which was indispensable to the scientists of each country but which none of them had the technological means or the scientific potential to complete alone. A project of this type could only have been imposed as a result of an exceptionally insistent demand from European astronomers – a demand as strong as that raised by the high-energy physicists in 1949, which led to the establishment of CERN in 1952. The paradox was that European astronomical circles displayed astonishing passivity. They welcomed our project in polite terms – and that was all. A number of factors make it easier – now – for us to understand this attitude. In most European countries, astronomy had developed much more slowly than other scientific disciplines. It was financed by only a tiny proportion of the national research budget; and the astronomers, few in number, were hard put to it to make their voices heard on national councils responsible for establishing relative priorities for scientific projects. To give some idea of the generally limited resources available to European astronomy in 1960, one need only recall that the Haute-Provence telescope, which was less than two metres in diameter and had been in service for only two years, was still one of the largest telescopes available at the time to those countries which were to become members of the organisation. The budget envisaged for a major European space astronomy project was probably at least as large as the total annual European expenditure on the entire field of astronomy. Afflicted by parsimonious budgets, outdated equipment and a shortage of technical staff, most European astronomers may have felt that they were inadequately

'. . . . European astronomical circles displayed astonishing passivity'.

prepared to commit themselves to – and dissipate their forces on – a space programme.

Not only that, but astronomers in every country rightly feared the development of competition between budgets intended for space astronomy and those earmarked for astronomy on the ground. The result of this passive attitude was that, when it came to the final choice, the day was carried by the scientific programme calculated to give satisfaction rapidly to the greatest number. Fortunately, astronomical projects were not abandoned; today, the IUE satellite is fulfilling our ambitions of twenty years ago.

It is interesting to recall here the unfailingly polite but extremely positive clashes between European astronomers when it came to defining what a telescope in space should do and why. A particular bone of contention was to decide which method of analysis of celestial phenomena should be given priority – because there were two, complementary and equally necessary. The choice to be made in 1960 was between high-dispersion spectrographic analysis of a very small number of stars on the one hand, and low-dispersion spectrophotometric analysis of a very large number of stars on the other. This choice once made, the astronomical community had yet another reason to split into two groups, one considering that satellite time should be used only to analyse stellar spectra for wavelengths shorter than 2500 Å, whilst the other believed this analysis should be extended to the lower limit of radiation accessible to the ground. Here again, between 1962 and 1983, ESRO – followed by ESA – provided each group with the space resources needed for its researches.

The hope of the 'little countries'

If in 1960 astronomers feared that investments on the ground would be cut back in favour of contributions to international space cooperation, those fears have proved groundless. In fact, both the preparation of space astronomy programmes and the analysis of data provided by space observatories have made it possible to justify substantial capital expenditure on the ground.

Today, the activities of ESA extend far beyond anything that its promoters visualised in 1960. We may well feel that the proportion of the Agency budget allocated to the scientific programme is rather too small, but the scientific spin-off resulting from the application programme are softening the blow to some extent. Thanks to the success of ESA, space research has been and remains possible in the smaller countries. It is now accepted in economic,

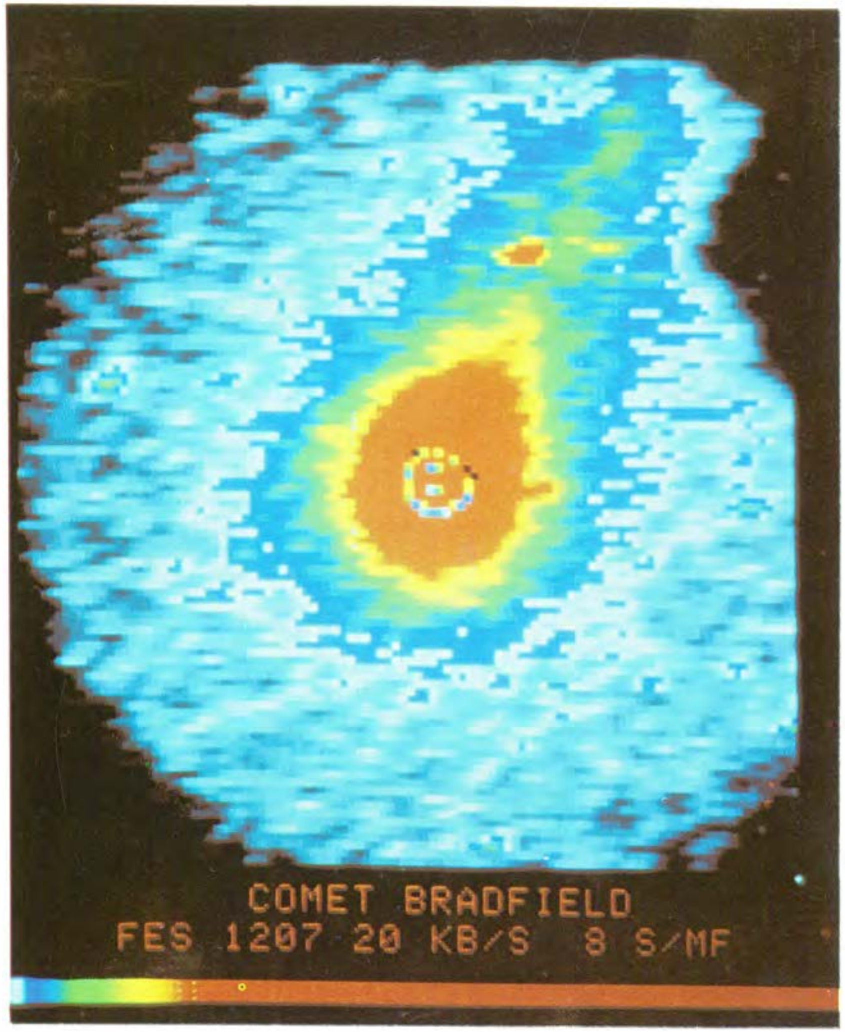
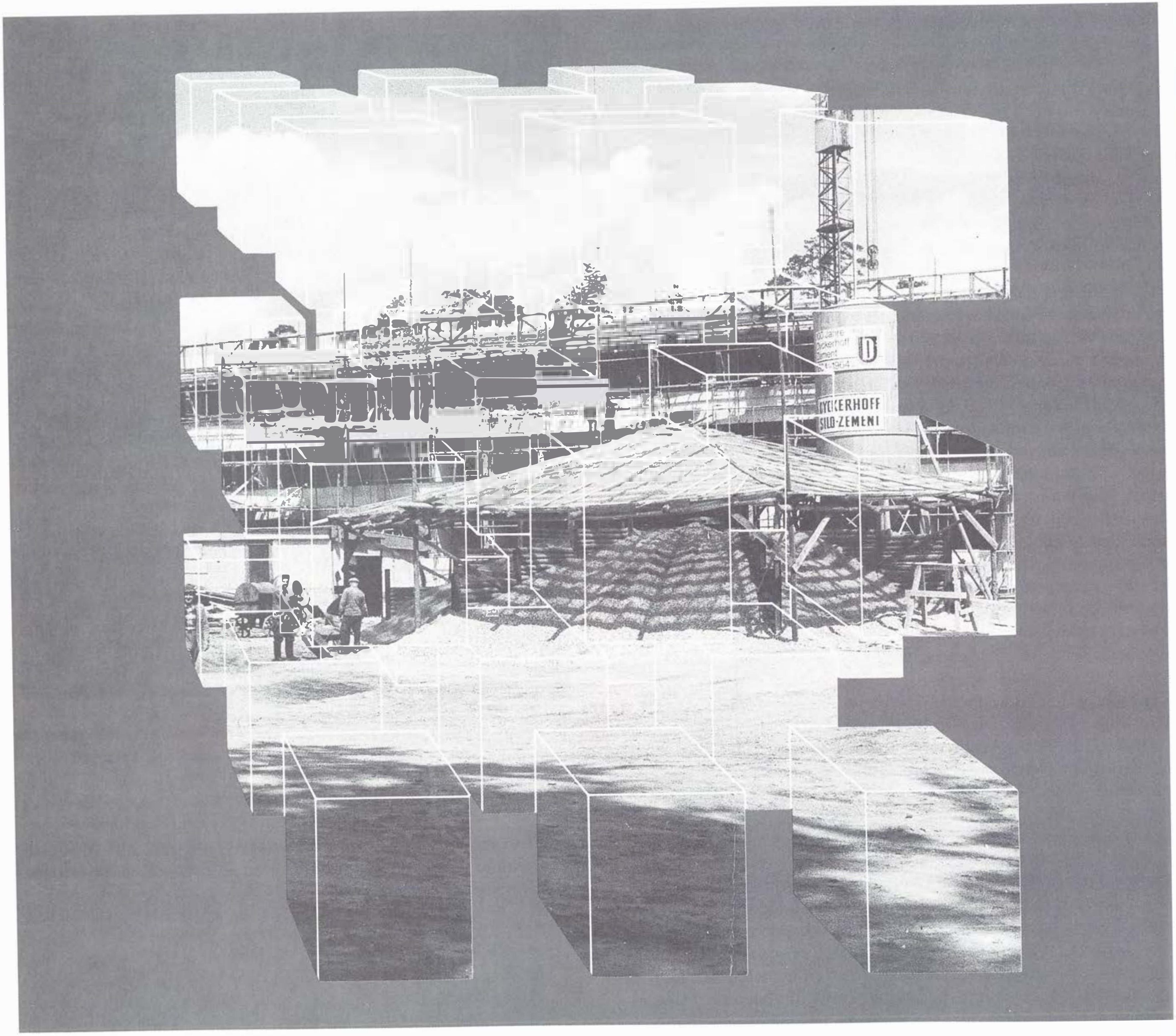


Image of Comet Bradfield taken by IUE telescope (January 1980).

political and university circles. We can only hope that expansion of its scientific programme will bring about an even greater increase in its impact on national research.

M Golay


SILO-ZEMENT

The rescue

Dr. Alexander Hocker

Director General ESRO (1971–73)

The test of any organisation, particularly a new and so far untried organisation, comes not when everything is running smoothly, but when the unexpected happens. Then the ability of the system to flex itself and to respond; and even more, the staff's adroitness and imagination when faced with an unforeseen challenge are put to the test.

ESRO's first such event came less than three months after the launch of TD-1A. The satellite had had a traumatic enough life up to launch. The enthusiastic plans for two satellites of the same class, using a standard platform had not included a realistic enough budget provision. Out of the resultant political chaos had come the first 'optional' project, with Italy declining to take part.

It was, therefore, with a sigh of relief that we watched on 12 March 1972, Europe's largest and most complex scientific satellite successfully launched from the Western Test Range in California. During its early orbits, the Estrack ground stations at Redu, in Belgium, Spitzbergen, Fairbanks in Alaska, and the Falkland Islands, the Norwegian station at Tromsø, and CNES stations on the Canary Islands and at Kourou (Guiana), were receiving the signals 'loud and clear'. Obviously there were periods when the satellite was out of range from any station, and yet picking up important information. Two magnetic tape recorders were on board to capture these data, and dump them while passing over the stations. All seven scientific experiments devoted to astrophysical studies, as shown in the table, were functioning well: then, by the end of May 1972, both tape recorders had broken down. What was most galling, as the satellite came within range of the stations, was that it was clear that the experiments were all in first class order. The only trouble was that 85% of the signals with the precious information were lost in space!

The immediate action I could take was to call on CNES and NASA for help. This was willingly given, and CNES stations at Ouagadougou (Upper Volta, West Africa), Pretoria (South Africa) and Brazzaville (the Congo), and NASA stations at Rosman (N. Carolina), Quito (Ecuador), Santiago (Chile) and Ororal (Australia) joined the network. Even then we were only recovering between 20 and 25% of the data.

Carte-blanche
I took the situation before the Scientific and Technical Committee in June 1972, explaining what we had achieved, and what we would like to do. The STC, urged on by the scientists who were crying for more data, gave us a carte-blanche to use our ingenuity to recover as much information as possible.

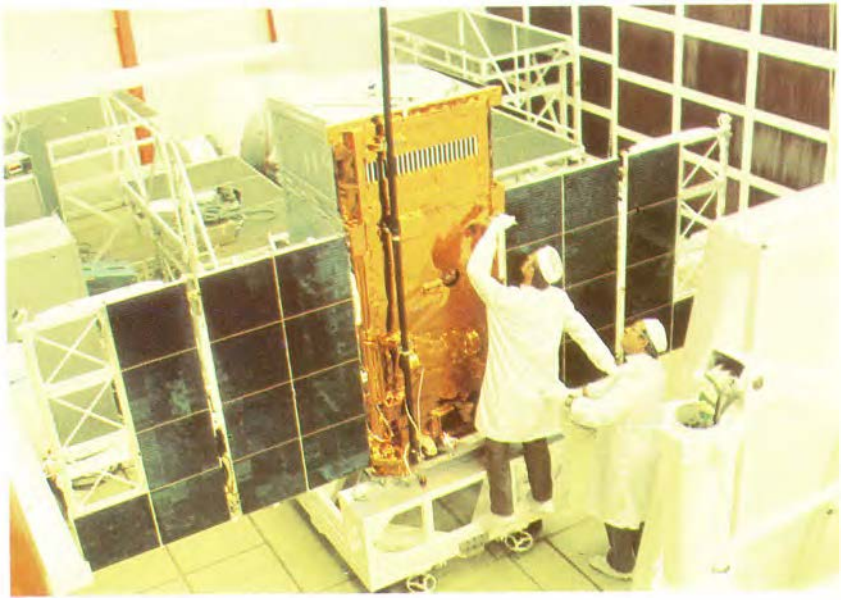
The staff responded magnificently. Working night and day they had an operational plan ready within four days. Urgent representations to NASA had resulted in six more stations plus a US naval ship being added to the network; then the Japanese, Italians and Germans offered a station each.

Still the scientists were not satisfied. Could we increase coverage between latitudes $-10°$ and $-70°$ in the direction of the galactic centre, while maintaining maximum coverage between latitudes $-10°$ and $+70°$ for coverage of the constellations Orion, Taurus, and Perseus?

The first 'fire brigade' action was based on seven additional ground stations. These were to be assembled from readily available electronic equipment, installed in air-transportable prefabricated, and conditioned shelters, located within reasonable distance of a commercial airfield.

Now we were up against an almost impossible deadline – every station must be 'on the air' by 1 August 1972 – seven weeks from conception of the plan to execution.

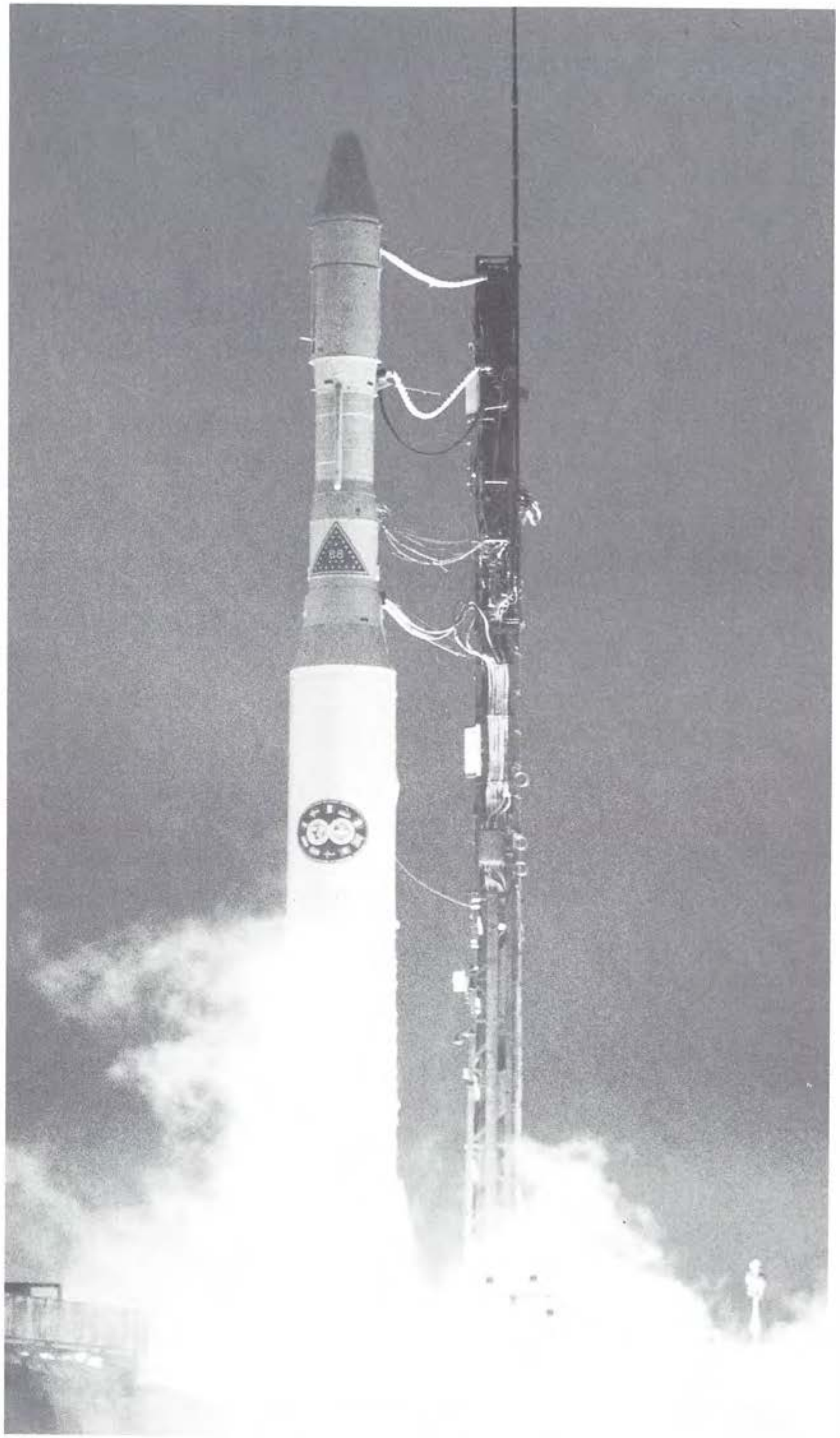
Industry was approached for equipment – four to five weeks! Impossible! But firms not previously considered came into the picture with entrepreneurial enterprise, and ESTEC found equipment from in-house sources with no questions asked! ESOC was organising, cajoling, and if necessary bullying all and sundry to get the bits and pieces together. As each station equipment was completed, we waited for the next pass over Darmstadt – prayers were said – and it worked! No time for congratulations – strip it down, pack it and get on with the next one.



TD-1A spacecraft during assembly and test.

TD-IA EXPERIMENTS

Experiment No.	*Scientific Group*	*Title*	*Measurement Technique*
S2/68	Institut d'Astrophysique, Liège; Royal Observatory, Edinburgh; Astrophysics Research Unit, Culham	Multicolour celestial scanning in ultraviolet (1350-3000 Å)	Off-axis paraboloidal telescope and spectrometer with 4 photomultiplier detectors (1 photometric and 3 spectrophotometric channels)
S59	Space Research Laboratory, Utrecht	UV stellar spectrometry (2000-3000 Å)	Gimballed telescope-spectrometer with star tracking and spectrum scanning
S67	Centre d'Etudes Nucléaires, Saclay	Spectrometry of primary charged particles	Two solid-state detectors coupled to a Cerenkov counter surrounded by plastic scintillator
S77	Centre d'Etudes Nucléaires, Saclay	Spectrometry of celestial X-rays (2-30 keV)	Double proportional counter with beryllium-plate window and collimator (parallel plates giving 1.45 × 11° field of view)
S88	University of Milan	Solar gamma rays (50-500 MeV)	Combination of tungsten-sheet converter, directional Cerenkov radiator, energy analyser and anticoincidence scintillator
S100	Space Research Laboratory, Utrecht	Solar X-rays (24-900 keV)	Caesium-iodide scintillation crystal with photomultiplier and solid-state background detector
S133	Centre d'Etudes Nucléaires, Saclay; University of Milan; Max-Planck-Institute for Extraterrestrial Physics, Garching	Celestial gamma rays (30-300 MeV)	Optical spark chamber with stereoscopic view and vidicon camera, in combination with two particle counters, Cerenkov counter and anticoincidence dome



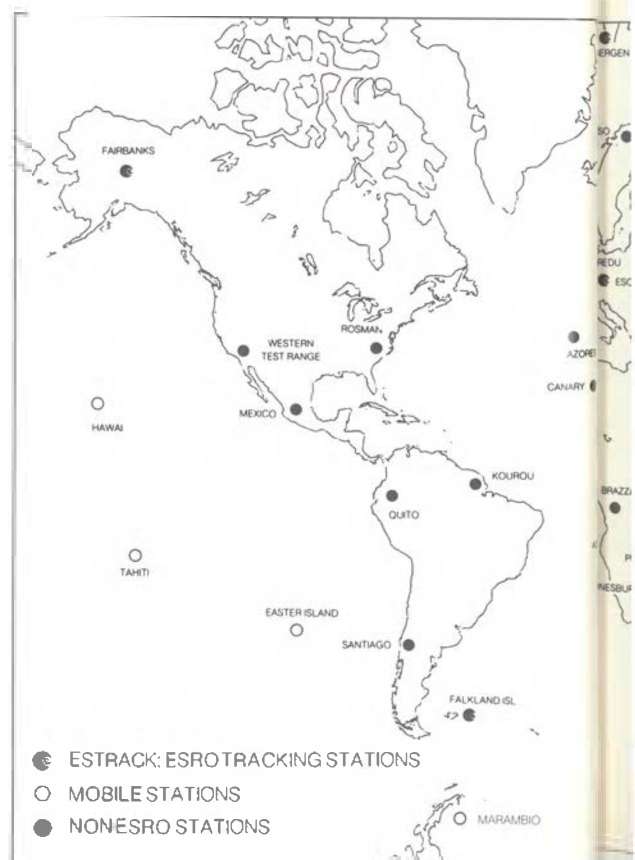
Launch of TD-1A from the Vandenberg Base, California, USA, 12 March 1972.

You cannot just 'arrive' in various parts of the world with a receiving station, no matter how peaceful your intentions. So urgently, diplomatic action was organised to clear permission for sites in Singapore, Fiji, Kauai, Easter Island, Papeete and Marambio in Argentine Antarctica. In addition arrangements were being made to hire a Dutch banana boat, the 'Candide', lying in Curaçao, install a station on it and sail it to 45°S, 100°W to cover an area devoid of land stations.

Teams had to be chosen, and given rapid training, not forgetting vaccination against smallpox, yellow fever, cholera, and typhoid. Visas were needed, residence permits, additional medical insurance, pay and subsistence. In some areas linguistic requirements had to be taken into account. Six team leaders were ESRO staff, the seventh a contractor, and most of the other team members – normally there were three in each team, including the team leader – were contract staff.

And supporting all this were the staff quietly arranging transportation and documentation for teams which would, in many cases, be far from regular or reliable means of communication.

Following the failure of TD-1A's tape recorders, the setting up of additional ground stations in 1973 was an extensive and successful exercise which enabled ESRO's most complex and challenging spacecraft to fulfil its mission.



Trials and tribulations
It is worth recalling both the success and some of the trials and tribulations of these teams in action:

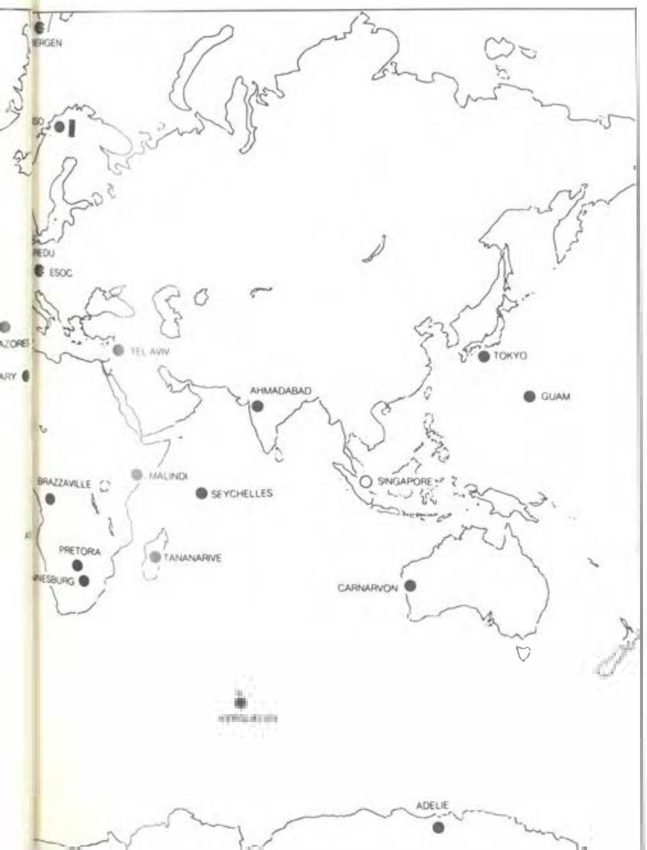
Singapore – arrived 25 July – equipment arrived 1 August – first pass taken 2 August – a total of 320 passes between 2 August and 24 October. Considerable maintenance problems due to hot, humid climate.

Suva (Fiji) – arrived 22 July – equipment 23 July – first pass within 48 hours – 320 passes in all. Then the antenna had to be lowered, and the station lashed down as it was in the path of the devastating hurricane BEBE. The nonchalant report of the station leader tells us 'Unfortunately, hurricane BEBE which had been fooling about in the area decided to pay us a visit… wind and rain of alarming ferocity. We, like the sea captains of old struck our top hamper, the antenna, in the course of which we were very nearly airborne. The station was secured with 400 ft of strong rope and after a struggle we felt reasonably happy that it would survive the blow. The aftermath of BEBE left 16 dead, thousands of homes demolished, large floods and damage that will take scores of years to repair.'

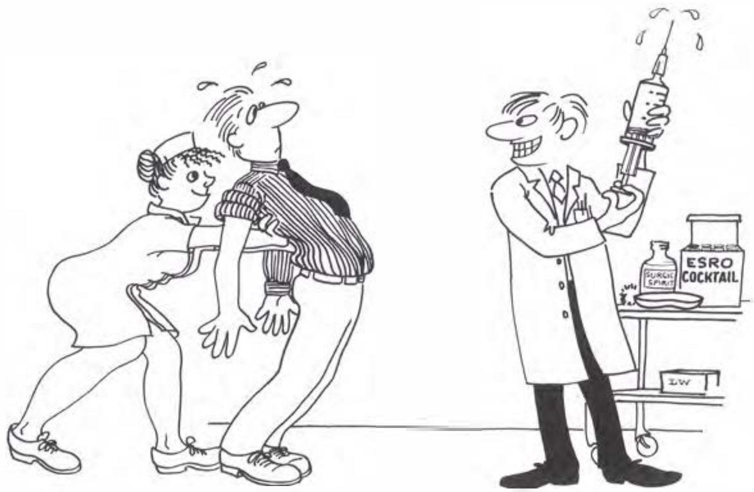
Papeete on Tahiti – a total of 226 passes from 1st August to 25 October, and *Kauai in the Hawaii Group* – 320 passes despite equipment troubles.

Easter Island – A total of 288 passes were taken in this very isolated station – one flight a week to the mainland, no local newspaper, and one telephone on the island. The station leader reported 'The first impression is disastrous. The people seem wild and unkempt. There is too much rain in winter, and too much dust in summer… the drinking water is salty, so everything made with water is salty… but after some time one realises that behind the heavy features of the inhabitants, their missing teeth, behind the grim expressions there is a gentle and kind people…'

Marambio in the Antartic – was at the other end of the weather spectrum, and despite special arctic-weather clothing, the staff had many difficulties with poor heating and inadequate living accommodation and sanitary arrangements. The Argentine scientists did all they could to help, even to the point of offering to sleep in tents to make room for the station equipment. 306 passes were taken, but the quality was not good.



An example of the transportable stations used in the rescue. This station was on Easter Island – its isolated position is clearly seen!



Smallpox, yellow fever, cholera, and *typhoid wasn't it?*

M.S. Candide – Join ESRO and go to sea in a 500-ton banana boat! A situation far too bizarre even for fiction: yet it happened. After many difficulties M.S. Candide was stationed in the 'roaring forties' where throughout the mission the wind averaged force 7, and at times reached force 11. Part of the antenna was carried away, and the ship was continually rolling and pitching, making both operations and maintenance extremely difficult. The cramped accommodation, vibration and limited food and water added to the rigours of the voyage. With much good will and help from the crew, 290 passes were taken. Unfortunately the tapes were of poor quality: an unfair reward for considerable devotion to duty.

Finally, the international cooperative spirit of scientists was well demonstrated when the New Zealand telemetry station at Lauder, in the extreme southern part of the country heard informally of ESRO's problems, and promptly offered support, taking 89 passes which gave excellent data.

Enthusiasm and inventiveness

So ESRO was put to the test, and although this story has never been given its deserved place in the annals of space history, possibly because the staff took it all in its stride, it illustrated the enthusiasm and inventiveness which played so important a role in the early European space efforts.

Instead of 15%, the scientists had 60% and more of the data they wanted so badly. After all, they had spent more than two years in their institutes working on these instruments.

While TD-1A was in eclipse and put into hibernation, plans were made for a second round of the rescue once the satellite was re-activated. From the lessons learned during the first rescue act an even more comprehensive coverage was possible, and in the end the recorded data recovery level had risen to 70%.

I am delighted that this commemorative book has given me the opportunity to pay tribute to those who took part in the rescue operations. Unsung they may have been, but the spirit and willingness they showed had much to do with the growth of European Space to its present eminent position.

The impact of space research on the astronomical sciences

Prof. Henk van de Hulst

Chairman of ESRO Council (1968 – 70)
Leiden Observatory, The Netherlands

The theme
The theme for this paper is set by the following quotation from the Annual Report for 1980 of the Dutch National Space Science Committee (GROC).

Results obtained from space research have become an integral part of modern astronomical knowledge. This fact is reflected at the Dutch universities in most astronomy courses, elementary or advanced, and on subjects ranging from the Sun and stars to interstellar matter and galaxies. Probably this would also have happened without the active engagement of Dutch groups in space science. But the mutual inspiration of space research groups and astronomy research teams working on related topics has certainly been beneficial. Until 1980, *inclusive, over 25 doctor's degrees were awarded at Dutch universities on the basis of theses dealing predominantly with space research . . .*

This statement refers to the situation in one country but it claims to reflect a general fact. Can this claim be substantiated? Can we differentiate between areas of strong and weak impact? And, if so, can this analysis guide in some manner our future decisions?[1] Inspired answers to these questions have been given even before the actual start of space research. Eulogies can be found in the 'motivation' part of any space project proposal. With over 20 years experience at hand we can now try to assess the impact objectively.

The assessment evidently must be based on the world-wide situation. Science does not recognise national boundaries. It is only in the financial and political arrangements that such details enter[2]. In most of this paper I shall not particularly stress ESA's role. If nevertheless I choose examples from ESA projects or from projects in which Dutch groups have actively participated, it is because I am more familiar with them.

Crosswords
Space science is not a science, nor a branch of science. Instead it is a multifarious collection of techniques, all of which are made possible by rocket propulsion into space. Arranging research topics by the techniques used is in a sense orthogonal to arranging them by the object studied. This situation has long been familiar to us astronomers and may have its parallels in other sciences.

It is hard to draw up a logical course outline in any astronomical subject. Our knowledge simply is too spotty. We may systematically draw a matrix in which one coordinate corresponds to the technique used and the other coordinate to the object studied. We may then fill in the boxes which contain significant knowledge, find that others must remain blank and that in a good many other boxes no firm knowledge is available yet. This description is reminiscent of a crossword puzzle and the analogy becomes even more pronounced when we realise that horizontal and vertical 'words' exist. Some actively worked research topics (like space science) hang together by the observational technique by which they are addressed. Other, equally exciting topics are coherent because different techniques applied to the same object form the basis of our understanding.

(1) The planning process will not further be mentioned in this paper, because I treated it extensively elsewhere: (Topics in Plasma-, Astro- and Space Physics, G. Haerendel and B. Battrick, eds., Max-Planck Inst. für Extraterr. Physik, Garching, Germany).

(2) Just one telling example. A recent ESA document, ESA/AF(83)61, add.1, has the title: 'Further legal considerations on the issue of the majority for adopting a 'moderation coefficient' for the retroactive adjustment of contributions due to conversion rate variations.'

Occasional matrices of this type are found in the published literature. They are rarely suitable as a teaching device. In fact, the majority of the students dislike being confronted with this situation, spoiled as students are by mathematics and physics courses which develop the subject more smoothly from one point of view. Some of the better ones enjoy being put in the midst of a chaotic research situation.

Interstellar matter

A specific example may help. The commissions of the International Astronomical Union certainly comprise the most competent research scientists in their field. They regularly summarise and review the progress made in the previous three years. The last such review was made for the General Assembly held in Patras, Greece, in 1982 ('*Reports on Astronomy*' Vol. 18). Here is what Commission 34 (on Interstellar Matter) found at that stage a pragmatic subdivision of their field. I cite only the section headings.

... Space Science ... is reminiscent of a crossword puzzle ...

1. Introduction
2. Physical state and dynamic processes
3. Neutral atomic hydrogen
4. Interstellar molecules
5. Interstellar grains
6. Star formation
7. HII regions
8. Planetary nebulae
9. Supernova remnants
10. Interstellar lines

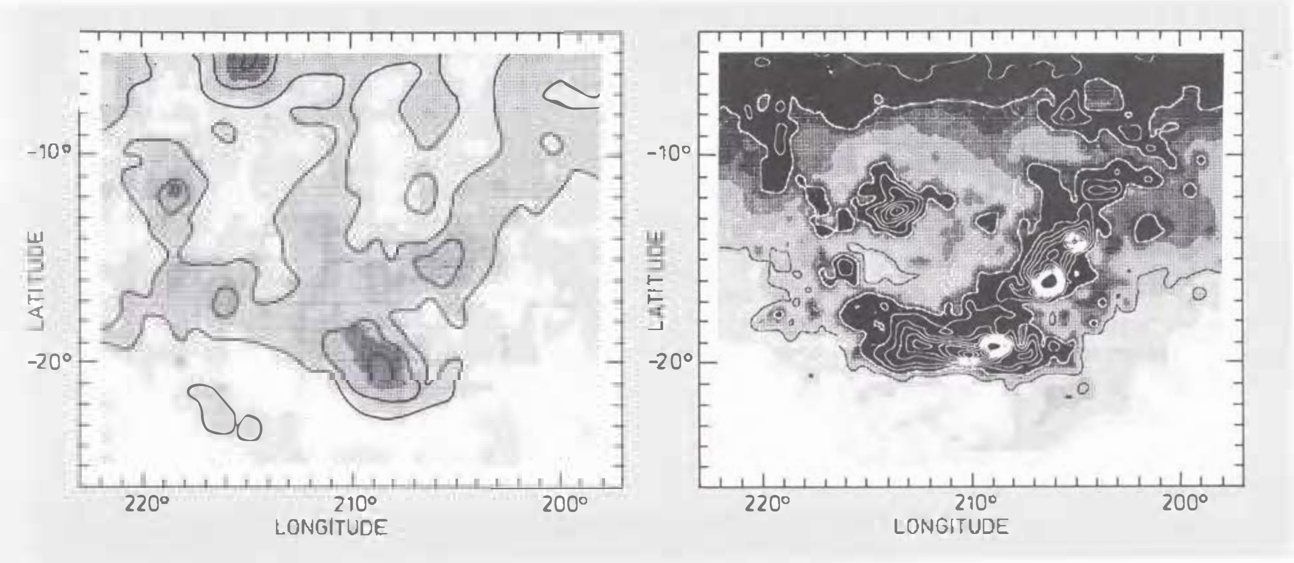
Clearly, this division is not logical but reflects an incompletely filled matrix of at least three dimensions. Sections 7-9 refer to characteristic objects in space, sections 3-5 to certain population groups present in those objects, and the further sections to techniques, observational (10) or theoretical (2, 6), by which the understanding of those objects can be improved. No wonder that certain topics recur several times in such a write-up. One such topic, the molecular clouds, is discussed below.

Molecular clouds

Space techniques have lately contributed in a rather surprising manner to our knowledge of molecular clouds.

It was known at least 20 years ago from the spallation products found in the cosmic rays that the cosmic rays must have travelled through an average column of gas of some 3 g/cm^2 before reaching our neighbourhood. It was also understood that gamma rays should be formed as a byproduct. At that time only the regions of interstellar space in which hydrogen is ionised and those in which it is atomic were open to observational study. Since 1969 radio astronomy techniques have made the millimeter CO lines observable and thus confirmed previous speculations that there must be important regions in which the gas, including its major constituent hydrogen, is molecular. Theoretical calculations showed that the CO/H_2 ratio must be of the order of 10^{-5} but its precise value remained unknown.

Gamma ray production by cosmic rays does not discriminate between ionised, atomic, or molecular hydrogen as targets because only interaction with the nuclei counts. When ESA's Cos-B, the first gamma-ray satellite to have both a good directional and energy resolution was planned, getting to know more about the results of this interaction seemed a safe bet. However, its results



Cosmic gamma rays produced by cosmic ray particles impinging on gas concentrations in the constellation Orion. Left: contours of gamma-ray intensity > 100 MeV as observed by Cos-B. Right: radio 21-cm line intensities, representative of atomic hydrogen (upper part of frame) and mm CO intensities, representative of molecular hydrogen (lower part)

gave a big surprise: over a dozen discrete sources appeared, most of which are still unexplained.

This exciting discovery diverted attention from the interaction process, but fortunately several workers pursued this 'classical' line of research. By now, with results of over $6\frac{1}{2}$ years operation in hand, local correlation studies, notably in Orion, make a rough separation of the contributions of atomic and molecular hydrogen possible. This, in turn permits an absolute determination of the H_2 column density and thus the first independent determination of the CO/H_2 ratio in molecular clouds.

Was this a surprise? Yes, it was a surprise that might have been expected if we had been brave enough to believe that Cos-B would give so many data of such excellent quality. This is not all there is to relate but it must suffice in the context of this article.

A quick survey

Just for fun, and skipping significant details lightheartedly, let us now run along all objects to which astronomy addresses itself and see how space techniques have contributed to our present knowledge.

The Solar System. Instruments have landed on the Moon, Venus and Mars, and man has walked on the Moon. Moreover, close-up photographs and other measurements have been taken of Mercury, Jupiter and Saturn and their major satellites and rings. The foreseen happened: the previous knowledge obtained by other methods has dwindled into a very minor part of our present knowledge. It is fair to say that these bodies have become close to 100% objects of space science. The same is true for the interplanetary gas, or solar wind and, slightly less, for the interplanetary dust, or zodiacal light. Halley's comet will be added to these trophies if ESA's Giotto mission in 1986 is successful. Asteroids are an obvious next choice. Yet it deserves emphasis that the visits until now have only had the nature of spot checks. If finances did not set a severe limit, ten times more frequent visits could easily be defended on scientific grounds.

The Sun. The Sun itself has not been approached closer than 0.3 astronomical unit. Its hot outer envelope, the corona, 30 years ago still required eclipse expeditions for a close study. It has now, through radio astronomy and X-ray astronomy, become an object for daily study. Fifty percent of our knowledge can be attributed to space techniques. Knowledge of the deeper layers, including the photosphere, depends less on space, although even there very significant additions have come from the space ultraviolet spectra. The next step in studying the solar oscillations must also come from space (e.g. project DISCO). It is curious to note that the one astronomical constant of life importance, the solar constant, in spite of stubborn efforts in specialised ground-based observatories for over a century, is not yet known to the precision (of 0.1%) which is necessary in climatological studies. Again, experts agree that only space measurements will yield the answer.

The stars. Stars form an intermediate stage, in which certain masses of cosmic gas temporarily come to relative rest, adopt an equilibrium form and generate energy by nuclear fusion. Their study formed for about a century the major fraction of research in astronomy. This fraction may now have dropped to about one third. Refinements of our knowledge of the quiet stars have come notably from space ultraviolet and infrared studies. However, the major impact of space observations has been on the beginning and end phases of stars. The sudden loss of mass in a supernova explosion was readily accessible for study by classical techniques. But virtually all we know now about the equally important gradual loss by stellar winds comes from space ultraviolet spectra. The exchange of mass between components of double stars has through X-ray astronomy been transformed within a decade from an abstruse subject in the theory of stellar evolution into a thriving and highly complex subject in observational astronomy.

Even wilder phenomena mark the birth of stars, or of 'nests' of stars, from interstellar clouds. Circumstantial evidence that this must still happen was abundant, but very little was known about the embryonic stages. Space research has from two sides been helping to close the gap left for speculation. On one side, far ultraviolet spectra, which contain the lines of the major elements and of the hydrogen molecule, have greatly improved our understanding both of the interstellar gas and of the solid dust grains. This adds up to a more realistic understanding of the environment in which the conditions for star formation must be met. On the other side, space infrared studies have made it possible to observe the stars in a younger, colder stage, when they are still enveloped in heavy dust clouds. After decades of speculative attempts, we now start to get a grip on star formation.

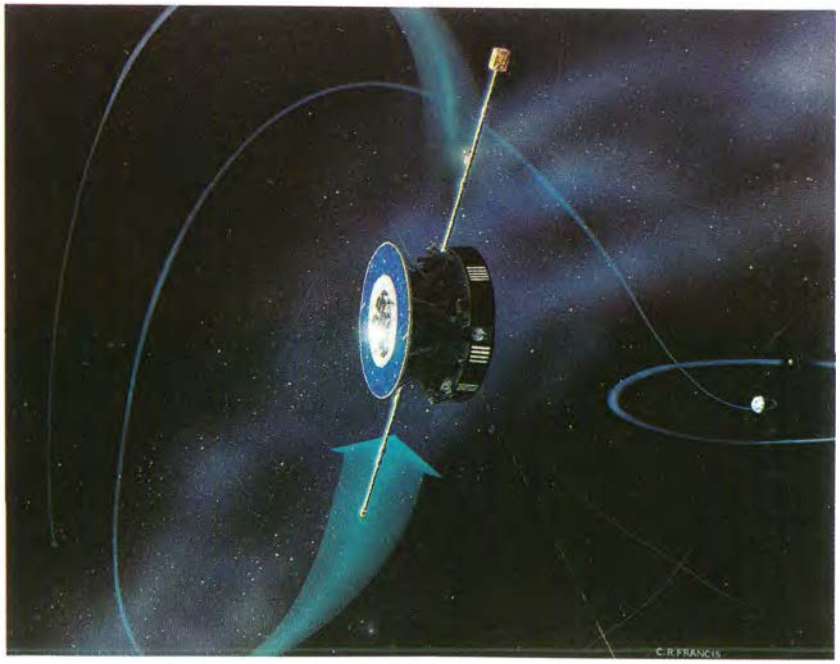
The Universe. From stars via spiral arms, galaxies, clusters of galaxies, and quasars to the universe is a far journey, to which I cannot do justice in a brief summary. I shall skip these subjects. Space science had added significantly to the knowledge in all these areas but the major data still come from ground-based observations. This will change in the coming years, notably when the Space Telescope becomes operational.

The yet to come

Let me very loosely introduce a quantitative measure by defining the fraction f of all astronomical research topics that is fully or partly dependent on space techniques. The question asked in the preceding section was: how large is f? In the present section we ask: how large is df/dt?

The present value of f is near 1/2. This impression from the preceding sketches was confirmed by a check of the titles in the last 5 years of '*Annual Reviews of Astronomy and Astrophysics*', a publication of high standing not biased to space. In roughly 80 titles I counted nearly 20 on the solar system, i.e. mostly space. Among the remaining 60 about 10 were based largely on space observations, 20 had a mixed character and 30 dealt only with ground-based observations or theory.

There are good reasons for believing that f still rises sharply with time. The successes of the past decades have shown that space astronomy is growing up in full health, but it has not reached maturity, let alone saturation. I have already made this point of the solar system. It is equally true for the rest of astronomy. Much of



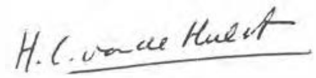
Artist's impression of DISCO spacecraft what is within technical reach has not even been tried yet. This includes X-ray spectroscopy missions and really high-resolution missions in optical astronomy. A few personal observations on missions now being prepared may illustrate this point.

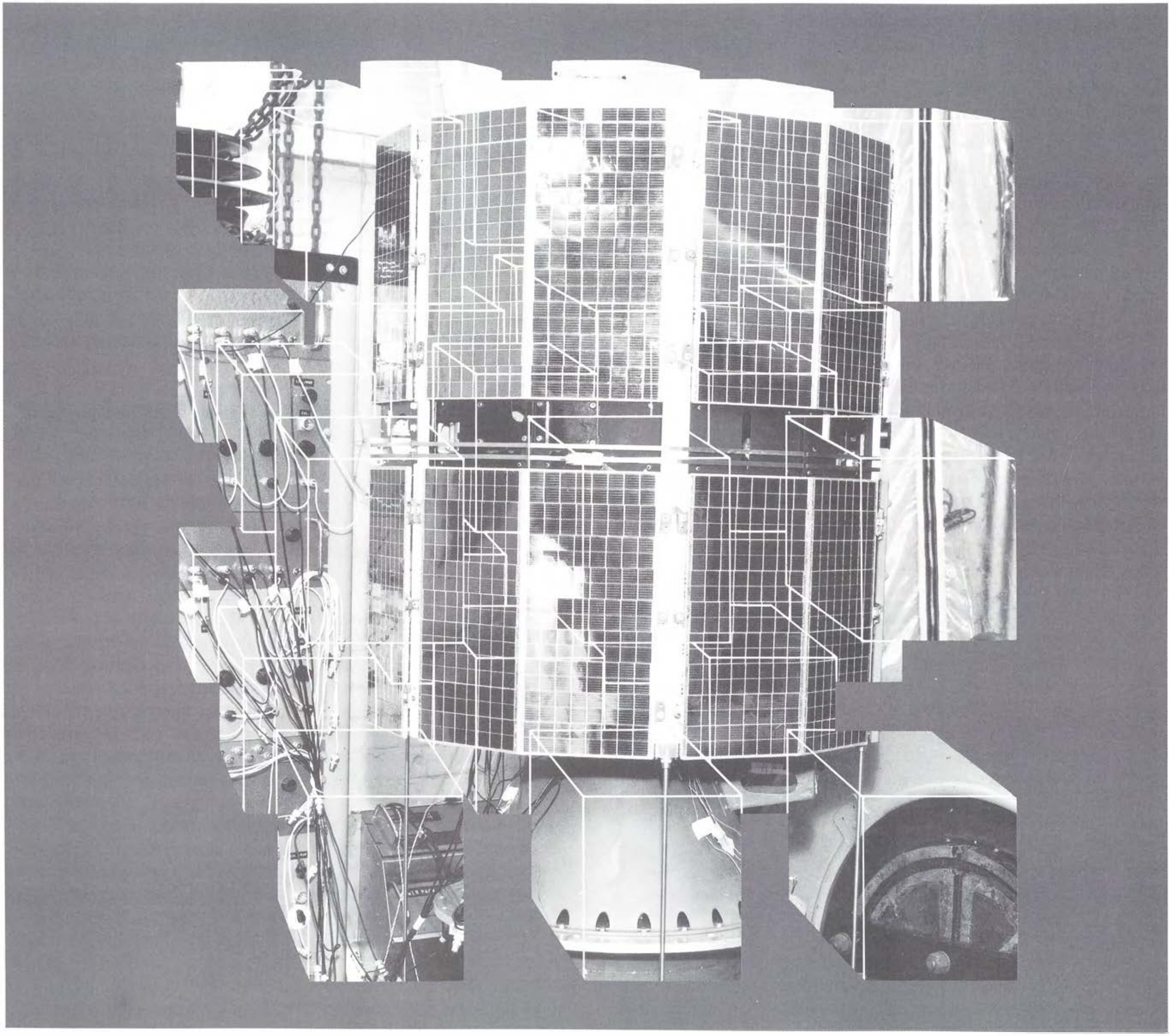
Optical astronomy from space still has not made its first big step. From the very beginning of space science a Large Astronomical Satellite (LAS, Europe) or Large Space Telescope (LST, US) figured prominently on the list of wishes. ESA's precursor COPERS even invited detailed proposals, received three, chose one to be built, and only then found that the plan had to be dropped altogether for lack of finances. This all happened in the spring and summer of 1964. An offspring of the winning idea later became IUE. NASA dropped the L of LST at the right moment and, in 1976 after finding ESA willing to take a 15 per cent share in the cost and manpower, obtained permission to go ahead with ST. This gigantic project will be first launched in 1986. The 'first' is significant because of the possibility of bringing it back by shuttle. Several years before launch, the ST Science Institute set up at Baltimore, also with an ESA share in manpower, has already become a bubbling astronomy centre. In addition ESA and ESO have set up at Garching a facility for added coordination and aid to the European users of ST.

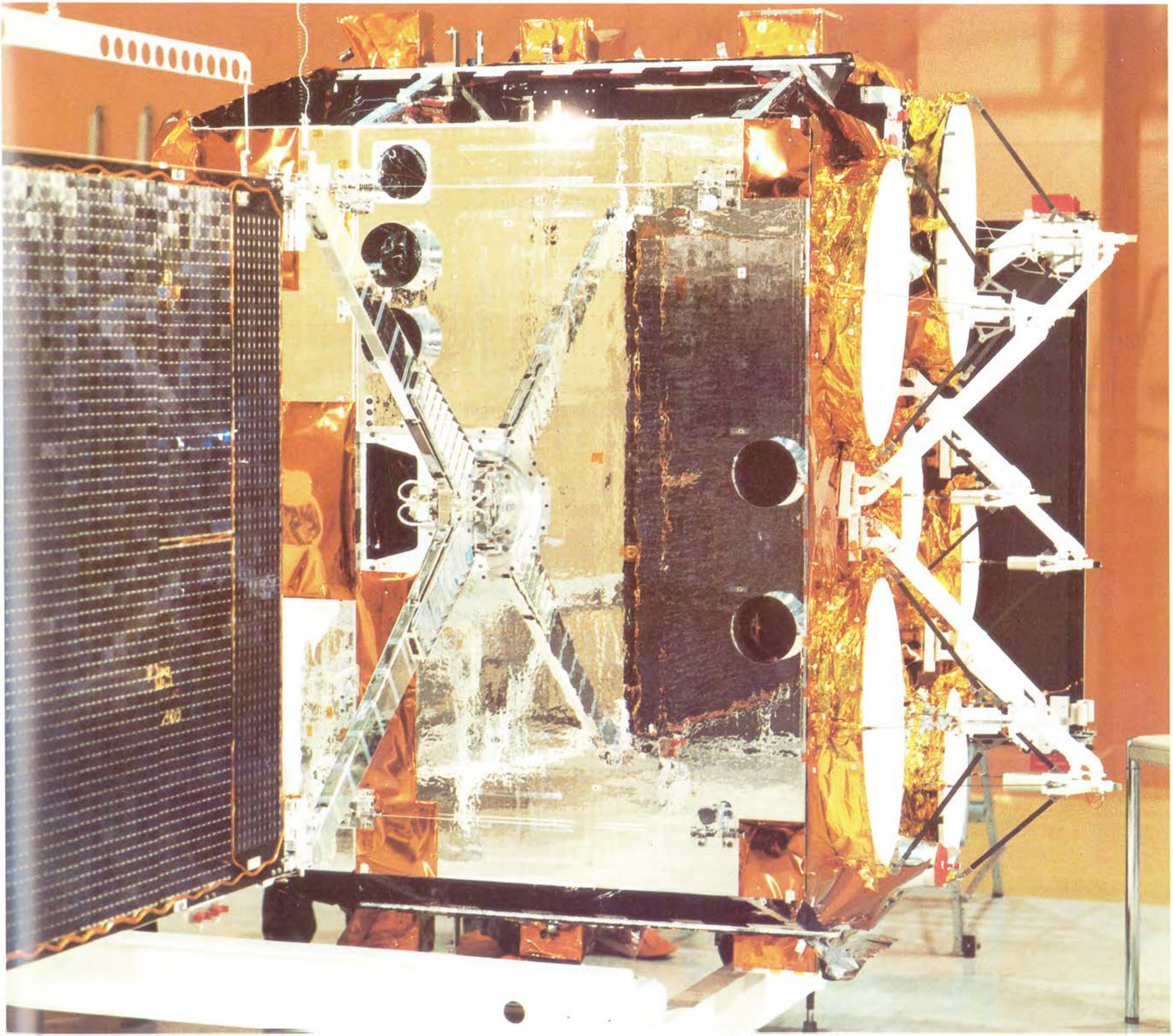
Again, if finances would not set the limit, a good scientific point could be made for launching simultaneously with ST a few smaller optical instruments, continuing the good tradition of TD 1A, Copernicus, ANS, and IUE, only with modern, faster detectors. Curiously, in 1962, when unrealistic estimates about a 'transatlantic factor' in the costs had not yet come home to us, COPERS asked a committee chaired by Paul Swings what the 'second large project' (after LAS) should be. The committee duly considered the possibilities and replied: another LAS. This, of course, was before the advent of X-ray astronomy.

Another yet-to-come is Hipparcos. The study of motions and positions in astronomy with the highest precision possible relied for a long time almost entirely on meridian telescopes. Every major observatory had to possess one. That part will be taken over by Hipparcos if the mission, to be launched in 1989, or later is successful. Together with the precise positions of moon, planets and other solar-system bodies, which already derive mostly from space science, this forms fundamental astronomy. The net effect will be that the part of astronomy that until now did not feel much of the impact of space techniques, will also be thoroughly pervaded by them.

The 'ifs' in the preceding account caution us that there may be bad luck. A satellite should not be praised before it is launched. On the other hand experience has taught us that good luck also exists: there may be surprisingly good quality or surprise discoveries. Astronomy, including space astronomy, remains a science of exploration.







Solar and stellar space research in Europe

Prof. Cornelis de Jager

Chairman of ESA Science Programme Committee (1981 – 84)
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Some personal reminiscences
My first involvement in the progression COPERS-ESRO-ESA was on 17 and 18 May 1961, when COPERS (Commission Préparatoire Européenne de Recherches Spatiales) held its second meeting, in Scheveningen, the Netherlands. It was a great experience to participate in the sessions where, full of enthusiasm, the first building blocks were laid for the European Space Agency. At the end of that meeting the chairman, Dr. Hocker, invited me to become chairman of a newly established Working Group, Nr. III, dealing with data systems and data analysis. It is remarkable, in retrospect, to notice how European space involvement was built up on enthusiasm rather than experience. This was surely the case with me. I had had some experience with data handling, since only two years before the Utrecht University had installed its 'large' computer, the ZEBRA. (Zeer Eenvoudige Binaire Reken Automaat), which filled a whole room, although it had only the capacity of a cheap present-day table computer. I knew how to programme this system and was thus considered an expert in data analysis! With members of the Working Group, including people like Blassel and Pecker we visited the data systems at Goddard and were astonished at the capacity of this 'huge' piece of instrumentation. The work of my Group finished about one year later, when we submitted our recommendations to COPERS.

About the same time scientific groups were set up to deal with the various flight proposals that had in the meantime been received from the European Community. In that framework I became chairman of the Working Group SUN, which worked in parallel with some six other groups with names such as STAR, PLA etc. 'Not hindered by too much experience' as Dr. Bannier once described the situation, we tried to find our way in building up a programme for European space science activities, based on the launching of sounding rockets, satellites, and space probes. Balloons and aeroplanes were excluded from the onset – a wise move.

A few years later I became a member of the Launching Programme Advisory Committee (LPAC). From this period, when I cooperated closely with eminent people, Lüst, Boyd and Blamont, I have the best memories. The LPAC had an important and often decisive role in the growing organisation. Gradually learning what could be done and – more importantly – what could not be done with the limited amount of money, we were not too afraid to take drastic decisions like the one not to involve ESRO in planetary research. I still consider that a wise decision. Needless to say that with such dynamic personalities on our committee as those mentioned, our meetings were not always quiet and without ripples. Generally, chairman Lüst succeeded in keeping the group in good working order but sometimes members found it necessary to stand up during the discussions better to look their opponents in the eye. At such opportunities Boyd used to call Blamont 'Sir' and Blamont reciprocated with 'Monsieur' and when the waves really went high, he started talking French which outplayed Boyd. But the meetings ended always in good harmony, based on our common conviction that we were working for a very good cause: the building up of European space science.

I cannot detach these experiences from the fact that during the same period I was building up one of the Dutch space research laboratories, the one at Utrecht. I was convinced that such a laboratory could and should play a fundamental role, not only nationally but for a major part also in the development of European space research and for that reason I tried to base its programme primarily on that of the European organisation. We

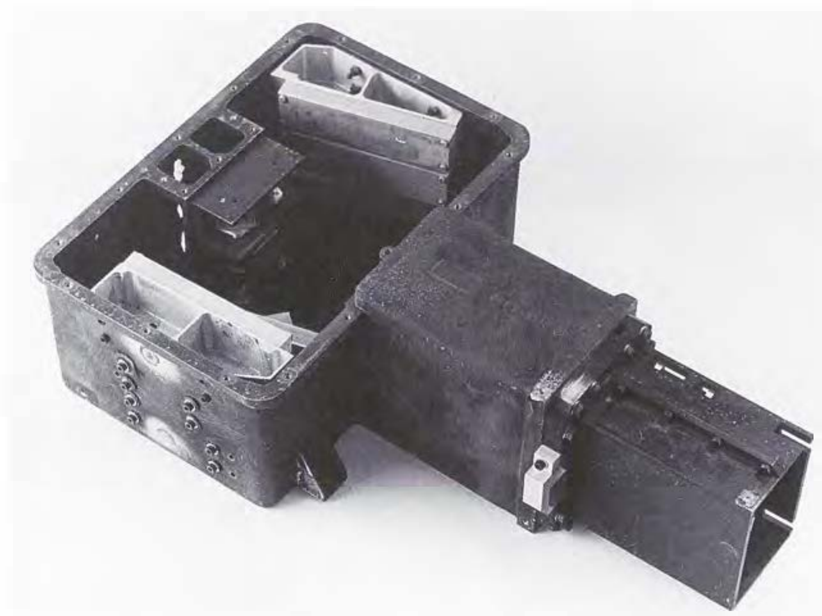
thus joined in ESRO's successes but also in its inevitable failures. Life is not easy for those who start from scratch but it is fascinating.

Initial overoptimism

The charter of COPERS-ESRO mentioned its programme: the launch of a large number of sounding rockets, of a fair number of satellites, and in addition two larger enterprises, which we chose to be a lunar probe and a large astronomical satellite. And all that for the sum of 1500 million French francs. Clearly, a franc had more value at that time than nowadays, but it cannot be denied there was some optimism in our programme. When more prudent persons referred to the fact that NASA needed more money for comparable programmes, the answer sometimes referred to the 'Atlantic factor' meaning that on this side of the Atlantic we could work cheaper than in America. Indeed, salaries were much lower in Europe than in the US at that time, but we soon learned that for high-level technological research similar costs apply, here *and* there. But, gaining that knowledge took a few years.

The most bitter experience in that period was without doubt the initial TD failure. The ESRO starting programme, as established around 1964–1965 contained the launch of four small satellites (ESRO I to IV) and two larger ones, the TD 1A and TD 1B. The TD series – called after the launcher: Thor Delta – was thought to become our streetcar and it was hoped that a long series of missions with this kind of versatile instrument could be realised.

However, approximately one year after the start of the C/D phase, it became clear that money-wise this programme was beyond our capacities and the decision had to be taken to cancel the full TD programme. For me personally this was a very grievous decision, not only for Europe's sake but also because my laboratory was involved in the conception of no less than four scientific instruments for this series. Later, the TD programme was partly rescued, by introducing it again in the programme of the Organisation as a 'special project', but only for TD 1A. For my laboratory at Utrecht this meant that we could continue with two of the four instruments; the other two were placed in our little museum so that visitors as well as our younger co-workers could learn from them.



Instrument R 126 designed for TD-1B (which had never flown) to observe the Sun's corona.

Large stellar and solar instruments: LAS and HELOISE

One of the big spacecraft to be initiated by the agency would be the Large Astronomical Satellite, LAS. The Announcement of Opportunity for LAS was reacted upon by three consortia, one Belgian-French-Swiss, another German-Dutch, and another British. So I got involved in the project Gernelas (German-Netherlands Large Astronomical Satellite). In the final evaluation of the three projects the highest score was given to the British proposal but neither that nor any of the other proposals came to fruition because in the meantime we had learned our lesson and knew better than before what could not be done for the money available. Nevertheless, LAS was a wonderful and ambitious project. The instrument would be capable of getting stellar spectral and photometric observations of high quality, due to its rather faint stellar brightness limits, and had Europe at that time possessed the financial means to develop the project it would have given our continent a mighty push in the development of stellar and extragalactic research at a very early epoch.

A similar project of comparable scope was HELOISE: High Energy Large Orbital Instrumentation for Solar Experiments. It was conceived during a study week early 1966 in Nice, France, and the beautiful acronym is due to Jean Rösch. This instrument would have done much more than has been so far achieved: solar spectroscopy in many energy bands from the visible to the X-ray range, solar imaging in various spectral ranges. The project did not come to fruition but the mere fact of thinking deeply of what would be necessary for highly advanced solar research was stimulating and surely does not mean lost time. The effect was visible later in European contributions to American spacecraft: OSO (Orbiting Solar Observatory) and SMM: the Solar Maximum Mission. But any project of that size was in the late-sixties (and even now!) undoubtedly beyond the financial possibilities of the European agency.

Model of the Large Astronomical Satellite (LAS).

Towards a realistic programme

All the experiences described above were necessary to learn how to do space research in a realistic way. The launch of ESRO II was initially a failure not because the satellite did not function, but the fourth stage of the launching rocket failed. With ESRO II, an instrument built by my laboratory for that first satellite to be launched for ESRO, is lying on the bottom of the Pacific. But thanks to the fact that in those days a flight prototype had to be built for any spacecraft, it was possible to launch another version of ESRO II within one year. And thus Europe eventually started a diverse programme of research by means of a number of small, explorer-type satellites. The launch of TD 1A in 1972 was certainly a highlight and an important next step, particularly so because it enabled European scientists to start with stellar and solar research: I refer to the Liège-London-Edinburgh UV stellar photometer, the Utrecht UV stellar spectrograph, and the Utrecht hard X-ray photometer. It was a bad day, when a few months after the launch the taperecorder aboard the satellite broke down, but in a heroic enterprise a few dozen ground receivers were set up all over the Earth, with unequalled success, because more then 60% of the data were saved during two years of operation of the spacecraft.

A tremendous success a few years later was the Cos-B satellite, through which Europe entered the field of astronomical gamma-ray research, by producing a spacecraft that is still unique and of which the results have not yet been reproduced by any other agency.

From LAS to IUE – the highly efficient workhorse

The experience gained in the LAS enterprise was not lost. It was the perseverance of Robert Wilson, being convinced of the usefulness and the necessity of an ultraviolet satellite for stellar spectroscopy, which lead to a new concept in which many of the ideas of LAS could be refound. The concept for an ultraviolet

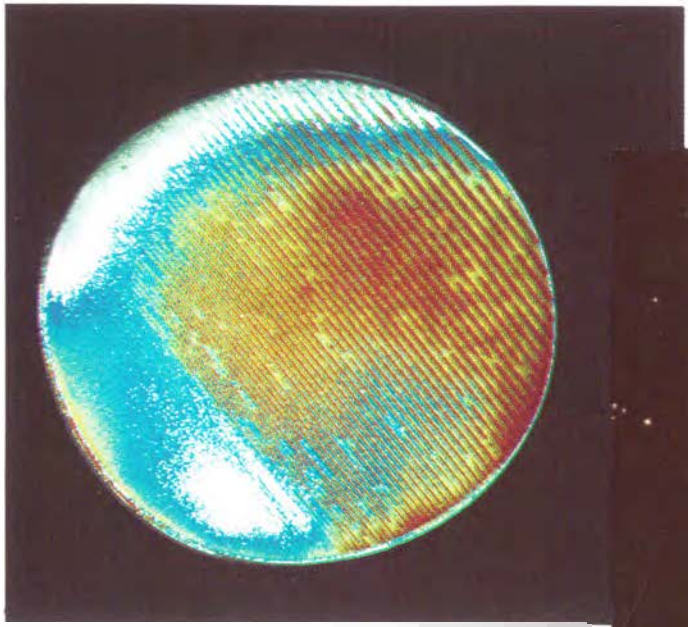
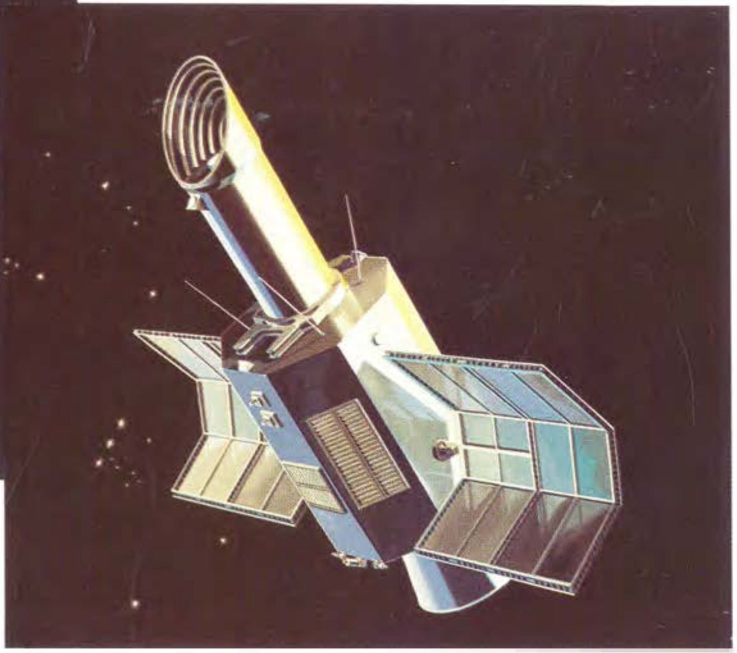


Image transmitted by IUE to Villafranca ground station, showing the high-dispersion short wavelength spectrum of a hot star.



IUE satellite.

spectrographic satellite was initially submitted to ESRO but was apparently beyond our possibilities. It was thereafter presented to NASA and this agency, immediately convinced of the importance of the concept, took it over. Eventually it became a three-Agency mission in which NASA, SERC and ESA cooperated. The International Ultraviolet Explorer is undoubtedly the most efficient workhorse for astronomical space research produced so far. Launched in 1978 it is already in its sixth year and at the time of writing this paper the observational programme for the seventh year is being conceived. Hundreds of scientists all over the world have been using the results of this instrument and it is hard to judge what the state of stellar scientific research would be nowadays should IUE not have existed. It is to be hoped that this spacecraft can still continue for a few more years and that its follows-up: the space telescope, and the project Columbus – if it will ever come to life – can be as useful to the community as IUE was.

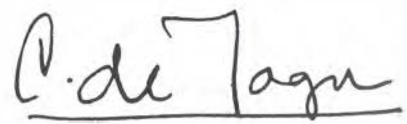
How about HELOISE?

The intellectual efforts in conceiving the HELOISE spacecraft were also not lost, as said before. The spacecraft that still resembles HELOISE best is the NASA Solar Maximum Mission, in which a good few European scientists are involved. The recent Japanese Hinotori satellite has certain elements that were already considered for HELOISE in the early days of 1966. It is also for that reason to be regretted that the European Space Agency has never had the possibility of embarking on a good programme for solar research, and this in spite of the long and rich tradition of European science in this field. Recent breakthroughs in observations of solar oscillations are primarily European: groups in France and in the UK played a dominant role in revealing the major elements of solar seismology. But the project DISCO, meant to keep the European lead in this field by adding to the ground-based observations those made in so much better conditions in space, was not selected for the next ESA round, because the choice went to another extremely ambitious project, ISO which, after the recent successes of IRAS, may give Europe a leading role in the field of infrared observation of stars and extended objects. With the ISO project European scientists have again embarked on a very important line of research which will bring this branch of research to the forefront.

The difficulty, however, met by the ESA selection bodies, is that out of a good number of very timely and highly interesting mission proposals, only three or four can be selected each *decade* because of the low budget ESA allocates to scientific research – an embarrassing and truly humiliating situation.

The present status of European space research

This brings me to my concluding statement. Europe has enormous intellectual capabilities. The countries cooperating in ESA are fully comparable with the US as far as manpower, gross national products and intellectual tradition. Yet the European scientific space programme has a budget only one fourth to one sixth of that of NASA. In spite of that we have succeeded in building up a strong and important space programme that is able to compete with what comes along in other parts of the world. But the question may really be asked whether it is not becoming time for Europe to realise the importance of its intellectual heritage, its high intellectual tradition, and the obligation to ourselves and later generations to maintain and further develop that high level of cultural activity, and thus to realise that a programme of scientific space research satisfying traditional European demands should at least be based on a budget comparable to that of the NASA science programme. This statement is the more pressing because future activities will be more and more based on cooperative concepts. In such large international cooperative programmes ESA should be more than just a shield-bearer for other agencies.



ESA and Norway

Bjørn Landmark

Head Space Activity Division, Royal Norwegian Council for Scientific and Industrial Research

During the latter part of the fifties several research groups in Norway were actively studying the polar ionosphere and the aurora. This work represented a continuation of a long tradition of science in Norway in a field where contributions from distinguished scientists such as Birkeland, Størmer and Vegard had been of great importance.

In our studies we made use of different types of ground-based techniques. We based our studies both upon active soundings of the layers with radio waves and upon making deductions from passive recordings of electromagnetic radiation in different wavelengths, including optical studies of the aurora.

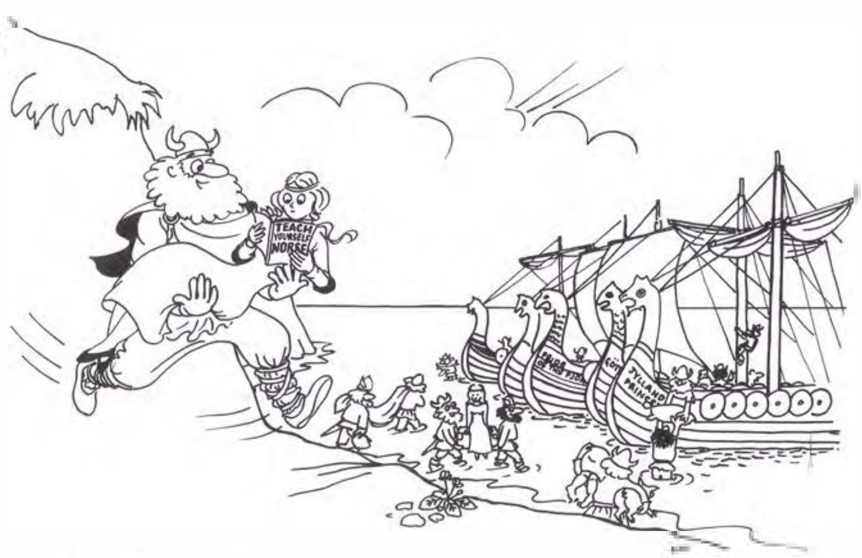
Similar studies were in progress in many research groups around the world. Some of these groups had started to include measurements by means of sounding rockets in their studies, and we followed this work with growing interest. It became more and more clear to us that we also needed to use sounding rocket measurements in our studies in order to be able to keep up the quality of our work.

Fruitful cooperation

A small sounding rocket programme was started in 1960. We established a very modest rocket range on the island Andøya in northern Norway in cooperation with, and with the help of, NASA, including provision of a mobile telemetry station which we used during the early years. We launched our first rockets in 1962 in a cooperative programme with the Technical University of Denmark. Subsequent rockets also included instruments provided by scientists from the United States and from Sweden.

In these years a fruitful cooperation between groups in the Scandinavian countries developed. As Austrian scientists (Dr. Ortner, and later Dr. Riedler) worked in Kiruna and took part in our research programme, it was natural that they continued to do so also having established their own activity in Austria.

During this period the work of COPERS also started. I was fortunate to be selected as one of those who took part in this work on behalf of my country. I look back to the days of COPERS with great pleasure. We felt that we were doing important work and I still remember many of the meetings when we worked on the text for parts of the 'Blue Book' describing the science programmes of ESRO.



. . . a fruitful cooperation between groups in the Scandinavian countries developed . . .

My colleagues and I were, of course, very disappointed when our authorities decided that Norway should not become a Member State of ESRO. In spite of this unfortunate decision, however, and thanks to the generous attitude of the delegates from the Member States, we continued to have good relations with the organisation. Norwegian scientists continued to serve on Ad Hoc Working Groups, where the scientific programme of ESRO was discussed, and there were a number of cases when I worked as a consultant for the organisation. In this respect I have many good memories of Dr. Trendelenburg's laboratory, Eslab in Noordwijkerhout, and also from late evenings in his home by the beach in Noordwijk. I also remember with great pleasure the solar eclipse campaign in Greece in 1966 where I served as the project scientist for one of the projects.

Esrange Special Project

There have been a number of cases of cooperation between Norway and ESRO (and later ESA). Some of the most important of these are described below.

In the field of *sounding rockets*, the cooperation has been of particular importance for us. There were a number of cases when ESRO used our range for its campaigns. In the first ESRO also made important investments at the range in order to make our facilities compatible with its requirements.

In 1971 ESRO decided to stop its sounding rocket programme because this activity could better be taken care of as part of the national programmes. The Esrange facility in Kiruna was taken over by the Swedish authorities. As there was a continuing need both for the services of that range and of the Andøya range, discussions were started which led to the creation of the Esrange Special Project (ESP).

Simultaneous launch of two Nike-Tomahawk sounding rockets from Andøya into an auroral display

A Fulmar sounding rocket ready for launch at the Andøya Rocket Range

In this project, which has been in operation since 1 July 1972, a number of ESA's Member States cooperate in order to maintain a sounding rocket launch facility in northern Europe consisting of both Esrange and the Andøya range.

The ESP has been a successful project, and it is still very much alive. Up to now (1 February 1984) 341 rockets have been launched within the project. 100 of these rockets have been launched during the winter season 1983/84, and 42 more are planned before this season is over.

The ESP, through its Programme Advisory Committee (PAC) has also played an important role in the continued planning of the European sounding rocket programme. PAC has arranged six symposia in Member States, and the seventh is planned to be held in Norway during the spring of 1985. A number of cooperative projects have been initiated and discussed at the symposia. Such a cooperation is of particular importance for a small country like Norway. The ongoing cooperative programmes, especially those with German scientists are of very great value for our scientists.

Also in the field of *scientific satellites* Norwegian scientists have been able to take part in some projects through cooperative arrangements with research groups in Member States. Thus, Norwegian scientists took part in the instrumentation of the two ESRO-1 satellites, and also in one of the experiments in Spacelab-1.

Obviously it has been important for our scientists to take part in the satellite projects from a purely scientific point of view. The activity related to the building of instruments both for satellites and sounding rockets and to the integration of the rocket payloads has also a technological value. I believe that the building up of technological competence resulting from this activity will be one of the fundaments on which we shall base our hopefully increasing industrial participation in space programmes.

In the field of *satellite telemetry reception* there was also cooperation between ESRO and Norway in the early days. In that period most of the organisation's satellites were in near polar orbits and thus there was a requirement for a read-out station at a very high latitude. For this reason ESRO established one of its satellite tracking stations in Ny-Ålesund on Spitzbergen. This station was operated for the organisation by NTNF (the Royal Norwegian Council for Scientific and Industrial Research) from 1967 to 1974.

For the ESRO-1 satellite there was a requirement for a high data rate channel that could not be taken care of by the onboard tape recorder. NTNF decided to establish the station in Tromsø, as there it could meet the needs for data in the European auroral region. Our station in Tromsø was used for data recovery from the satellites ESRO-1, ESRO-2, TD-1A and ESRO-4.

In 1973, in the period when ESRO was transformed into ESA, the Norwegian situation was again studied. The importance of the new applications programmes was recognised, and it was realised that the planned Marots programme would be of great importance to us. Unfortunately our authorities decided that we should not apply for a full membership of the Agency but it was fortunate that we at least were able to take part in the Marots project.

Signing of the Association Agreement of Norway with ESA (Paris, 2 April 1981)

The importance of our participation in the Marots/Marecs activities is illustrated by the fact that Norway through our Telecommunications Administration became a significant member of INMARSAT (8%) where the Marecs spacecraft form part of the operational system.

Our participation in the Marots/Marecs activities has also been of considerable importance for our industrial activity. This is not only because of the industrial return we have obtained, but even more because of its effects upon our industrial involvement in the production and marketing of ship terminals for use with the INMARSAT system.

As the ESA convention came into force in 1980, Norway's relations to ESA were again studied, and from 1 November 1981 we became an Associated State of the Agency. The agreement makes it quite clear that this status can not be permanent and that it should lead to a full membership within a five-year period.

Industrial interests

Although I would have preferred that we had chosen to apply for full membership at once, I can understand the arguments and reasoning behind the chosen solution. These are mainly based on the need for our industry to build up the necessary competence in order to be able to contribute to and make use of the possibilities offered by the industrial activities of the Agency.

The industrial interests are perhaps the most important reason why Norway now has decided to improve her relations with ESA. Norway also recognises the need to develop further her high technology industry, and the importance of space related activities in this respect is more and more widely recognised.

Our *user interests* are also very important. With our offshore activity, our large merchant fleet and maritime regions, the ERS-1 programme is of course of special importance.

Finally, the *more political aspects* have also been one of the factors behind our wish to improve relations with the Agency. This is to me the most important reason why I so much look forward to the day when we become a 'proper member of the family', and when our delegation to the Council shall not have to leave 'Salle A' when the important matters are being discussed.

Some recollections of the period 1970–75

Prof. Maurice Lévy

Chairman of the ESRO Council (1973–75)

As a specialist in theoretical nuclear physics and high-energy physics, I had no direct contact with space questions until 1968, when I set off for Washington to establish a scientific mission at the French Embassy. My team included a CNES representative, and I soon formed fairly close relations with NASA. I was also involved in the negotiations for the new INTELSAT Convention. At that time, there was a great deal of discussion between Europe and the United States on what space policy should be adopted.

On my return to France in January 1971, I was appointed a Director of a department in the Ministry for Industry and Research: the 'SEPOR'. This department was responsible for major research organisations: CNES, CNEXO and the research side of CEA. The Minister, Mr. Ortoli, asked me to be a member of the French delegation to ESRO and ELDO.

The crisis of 1971

As I arrived, ESRO was in a state of crisis! France had strongly criticised the Convention, supported by all the other member countries, and had announced that she would withdraw from the Organisation unless a number of reforms were implemented during 1971.

France took the view that ESRO had become too exclusively scientific. It is true that this was its original purpose, but in the meantime, the applications satellites – for telecommunications and meteorology, for example – had put in an appearance. The 'Group of Three' (Belgium, France and the Federal Republic of Germany) were of the opinion that ESRO should redirect its satellite policy accordingly. Since the Organisation's current budget was limited to 35 million accounting units (MAU), given over entirely to satellites, the question was being asked whether the scientific budget should not be cut. It should be noted that, at that time, most of the delegations, with the exception of that of France, were dominated by scientists who feared the establishment of an applications programme which, it was well known, would be very costly. For my part, without underestimating the value of scientific research in space, I was surprised to see how my European colleagues turned away from the applications satellites. Indeed, at the time, many scientists and high officials considered that satellites could be bought from the United States.

As far as France was concerned, applications were not the only source of incentive: we were also beginning to come out in favour of launch vehicles. We wanted Europe to break free of the INTELSAT monopoly which forbade point-to-point telecommunications between two countries. The United States had announced that it would refuse to launch any operational telecommunications satellites outside this structure; when we were forced to have Symphonie launched by a Thor-Delta, the Americans demanded a written commitment that the satellite was experimental in nature. In fact, there were ministers in the French government who believed it useless to spend so much money on space research if it did not contribute to the policy of independence, and if it was not orientated to applications.

I spent the first six months of the year in various consultations, working on the basis of proposals drawn up by Professor Puppi; the negotiations culminated on 14 July 1971. The meeting was held at ESTEC, rather than at the offices of ESRO, because of the French public holiday. We had previously held small meetings in various places, in attempts to resolve the situation. The first glimmer of light came with one of our draft resolutions: this was supposed to be as comprehensive as possible, embodying applications and launch vehicles, as well as the scientific programme, which we nevertheless wanted considerably reduced and limited to 10 MAU in real terms. At the request of Belgium and Germany, we agreed to go up to 12 MAU, and we stuck with this figure until the 14 July agreement.

I should point out that, to our mind, the ESRO budget covered the scientific programme, the operating overheads and the applications programmes. Unfortunately, every one of the applications programmes encountered problems. For example, the United Kingdom was opposed to telecommunications on the grounds that decisions in this field were a matter for the Post Office. The same applied to meteorology, where France had already begun its Meteosat programme. And, as regards air navigation, nothing could be done without the cooperation of the United States.

At that stage, it was not possible to go beyond decisions of principle regarding the implementation of any applications programme. Moreover, nobody was going to enter into blind commitments: our draft resolution proposed a ceiling of 60 MAU for applications and a limit of 10 MAU on the general budget, plus 12 MAU for the scientific programme, giving a total budget of the order of 82 MAU. This was already a considerable increase, but, more important, it represented a complete change in the distribution of expenditure.

In May 1971, another political factor gave a considerable fillip to the negotiations: this was the agreement between President Pompidou and Prime Minister Edward Heath over the entry of the United Kingdom into the Common Market. I went to London the following month in an attempt to resolve the space situation. Our partners outside the Group of Three tended to follow the United Kingdom. It is remarkable that throughout the European negotiations on space, it was never possible to turn an impasse into a positive outcome unless there was agreement between the United Kingdom and France. This is not to say that the other countries

The ESRO Council in session at ESTEC (13-14 *July* 1971).

played no part; indeed, we had far-reaching agreement with Belgium and Germany, except that we ourselves were ready to accept situations of conflict. Nevertheless, the key problems always ended in a confrontation between France and the United Kingdom. In this way, the June 1971 meeting with our British opposite numbers was very fruitful.

Negotiations between the different delegations therefore began informally at ESTEC on 13 July, and went on until 2 a.m. I must say that the closing hour of the negotiations was dramatic. I remember that Roy Gibson, at that time Director of Administration of ESRO, and who played an important part in the negotiations in that role, was in particularly good form. At the end of the meeting, he produced bottles of Frascati wine (ESRO-grown), and we drank a few toasts.

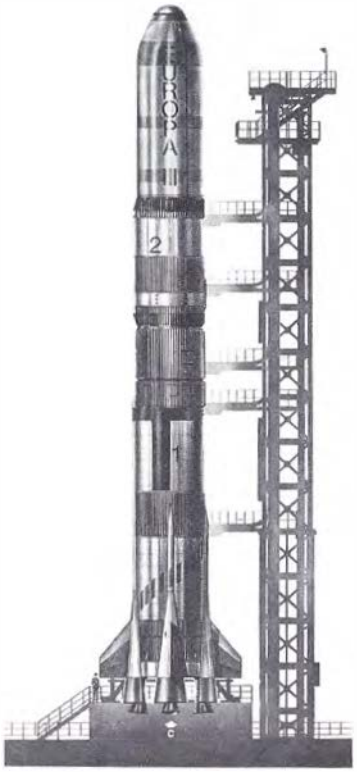
Despite this agreement in principle, not everything was settled. As far as the British were concerned, the problem of telecommunications satellites remained. In the meantime, however, the British delegation had been modified, and now included not only the Science Research Council, but also the Ministry for Industry. This ministry was particularly interested in applications, but the Post Office was still not represented. Another serious problem, raised this time by Italy, was that of a 'fair return'.

The next step was a meeting at the Quai d'Orsay with the main delegations. We proposed a new system for telecommunications. The initial telecommunications satellite of the Agency (OTS) would do no more than pave the way for the future operational satellites. In this way, there would be a preoperational phase, followed by an operational phase proper. To progress from the first to the second phase would require a two-thirds majority of the Council. This proposal could be financed by the British Ministry for Industry, without involving the Post Office, who were interested only in utilisation. (Ironically, a few years later, when the time came to enter the operational phase, it was the British who were the most enthusiastic!). My British opposite numbers were so astonished that they asked whether my proposal did, in fact, represent the point of view of my government. Once my minister had assured them on this point, the question was settled, but Italy caused some suspense at the last minute. It was already December, and very close to the date on which the Convention would terminate. Rome finally gave its agreement on the telephone at the very last minute ... When the Italians announced their agreement during an ESRO meeting in Paris, all the delegations applauded. There was great rejoicing in the room, and, catching the Chairman's eye, I could not resist the temptation to quote the Gospel: 'There shall be more joy in heaven over one sinner that repenteth, than over ninety-and-nine righteous persons who do not need to repent.'!

'... there shall be more joy in heaven ...'

Launch vehicle problems

The year 1971 also saw a number of crucial problems in this field, for various versions of Europa-II were being launched, and negotiations were in hand for the Europa-III programme, for which there was only a predevelopment phase. On 5 December 1971 came the failure of the Europa-II rocket, which led to a complete review of the ESRO programme. In the draft resolution of the Organisation, we had proposed a chapter on launch vehicles, in which we said that ESRO should use European launch vehicles subject to certain cost ceilings. On 1 January 1972, General Aubinière, until that time Director General of CNES, was appointed Secretary General of ELDO. Initially, his policy consisted of stopping the Europa-II programme for the benefit of Europa-III. This policy was obstructed by the Germans, who



Artist's view of Europa-III.

wanted nothing further to do with the Europa-III and called for a less costly programme. Europa-III was a highly ambitious programme, since it included a second stage, driven by a high-pressure cryogenic motor of 20 tonnes thrust, involving a technology we knew little about. The Germans were more interested in this technology than in the launch vehicle itself, and, in any event, the minister at that time was opposed to the continuation of the project. In Munich, we decided with our German partners to stop this programme. The only alternative remaining was to develop Europa-II, a technically mediocre programme, which it was finally decided to terminate at the beginning of 1973. From then on, ELDO, lacking a programme, had no longer any reason to continue in being.

Meteosat

France had begun a Meteosat satellite programme in Toulouse, but, in June 1971, it became clear that the French research budget would not enable this programme to enter the operational phase. Some people in CNES wanted us to withdraw from ESRO precisely to leave enough funds to continue Meteosat. However, an agreement had been concluded with ESRO, and more funds had to be set aside for the European organisation. France therefore took the decision to request that Meteosat should be Europeanised. This was a real difficulty, because the French government saw the new structure of ESRO as satisfactory only if the Meteosat problem could be settled at the same time. When France criticised the Convention, the broadening of the Meteosat programme to a European scale had not been a condition since, at that time, Meteosat – as far as CNES was concerned – remained a national programme. I was therefore placed in an embarrassing situation: Meteosat had to become European, but since this condition had not been introduced during the negotiations, it was difficult for us to introduce it thereafter. In any case, certain countries would have regarded this as unacceptable blackmail. I had therefore taken some degree of personal risk by giving my agreement to the resolution settling the problems of ESRO without providing any solution to the problem of Meteosat.

Meteosat-1 on top of Delta launcher.

We therefore began, in January 1972, to talk of Meteosat during meetings between ESRO and CNES. We tried to divide the satellite development programme into two parts, one to be carried out at ESTEC, and the other at Toulouse, so that, even if Meteosat became European, the Toulouse Space Centre would continue to play an important part, and the earlier French development work would not have been in vain. The Director General of ESRO (Dr. Hocker) and the Programme Director (Mr. Dinkespiler) were in favour of this. However, there remained the basic objection of the British, who considered that it was a dangerous precedent to develop ESRO satellites in other than European centres. So, off I went to London again to negotiate with the Science Research Council, whose Director, Brian Flowers, was one of my old friends. Without too much difficulty, we managed to produce a joint text on the Europeanisation of Meteosat; this text was presented to the ESRO Council, which finally accepted it in March 1972. Thus, it is thanks to the British that my career was not ruined!

Establishment of the European Space Agency
It all began in the summer of 1972. The two launch vehicle programmes Europa-II and III were, by then, virtually shut down. It remained to be seen whether ELDO was to be dissolved. In the meantime, the British had a new Minister for Industry, Mr. Heseltine (the present Minister of Defense). In France, Mr. Charbonnel had succeeded Mr. Ortoli. The new idea floated by Mr. Heseltine was that the time had come to combine launch vehicles and satellites within one and the same organisation. In other words, Europe ought to have *its own* agency, after the fashion of NASA.

In the summer of 1972, there was a new development: France had begun to prepare a new 'replacement three-stage launch vehicle' (LIIIS), which later would become Ariane. This was a different design from Europa-III: the intention was to limit the technological risks by utilising the engines of Diamant and the cryogenic motor of 7-tonne thrust already developed in France, but with the objective of placing satellites in geostationary orbit.

Concerning the creation of a European Space Agency, France, although not enthusiastic, was not against the idea, since this appeared an elegant way to settle the problem of ELDO. The objections came rather from ESRO, where they had the impression that their former rival was being 'bought up', even though it no longer had any programme. The negotiations then dragged on.

The first meeting of the European Space Conference took place in Brussels at the end of 1972, where the principles of unification were formulated, but no further progress was made. Having become Chairman of the ESRO Council at that time, I was actively involved with this problem from January 1973 until the end of my term in June 1975 (in other words, just after the creation of the Agency). Events had progressed very slowly because France had put the Ariane programme on the negotiating table (the Swiss would have preferred to call it Vega, but this could have led to confusion with a brand of beer).

These were, perhaps, the most difficult negotiations the French have even undertaken on questions of space, because everything was against us: first of all, it was an expensive programme; then, we were still suffering the effects of the failure of Europa; finally, there was the basic opposition of the United Kingdom. In addition, certain European countries were unwilling to bear the costs of Europeanising the ambitious space centre France had set up in Guiana. In July 1973, these negotiations led to the second European Space Conference, with an agreement under which France took on a substantial share of the cost of building Ariane. This was also a period of extreme complexity, because there were parallel negotiations with the United States on the post-Apollo programme, which was finally to lead to Spacelab.

The Brussels Space Conference therefore ended with a triple compromise:

1. France would devote the greater part of its effort to Ariane;
2. Germany would account for the greater part of Spacelab;
3. The United Kingdom would devote considerable resources to the maritime satellite Marots.

In my opinion, this represented a major step backwards for the European space cause: this was 'à la carte' participation, where each of the large countries selected the programme or programmes in which it was particularly interested, leaving the crumbs to the others. The British – once again – were unwilling to participate in Ariane, which they considered to be a dangerous project. So I took my pilgrim's staff once again, and went off to find some kind of compromise: the United Kingdom agreed to put a little money into Ariane, on condition that a British computer was carried on board. In exchange, we were to do the same for Marots. Participation by the other countries was equally symbolic: as far as Ariane was concerned, this meant that, even in the case of cost overruns, it would be up to France to find the difference, which caused us some disquiet.

The first few months of 1974 were taken up by consultations aimed at finding a Director General for the new Agency. An event of major importance then took place in France: the death of President Pompidou. He was replaced by Mr. Giscard d'Estaing, whose Minister for Industry and Research was Mr. Michel d'Ornano.

The new President of the Republic, who had long been Finance Minister for Mr. Pompidou, had been very hostile to the Ariane programme, judging that the expenditure was motivated solely by national independence. He thought it would be more economic for Europe to buy its launch vehicles from the United States, as well as its telecommunications satellites. (This did not stop him, some years later, from claiming to be the father of the Ariane programme.) In fact, the programme had begun in July 1973, after the agreement reached at the European Space Conference in Brussels. Substantial funding had already been committed for preliminary contracts. At the request of Mr. d'Ornano, I had to freeze for a period of three months all the final contracts I had had to sign as President of CNES, operating agent for the ESRO programme. A difficult situation, if ever there was one.

In France, the Ministry of Defense and the Ministry of Foreign Affairs were in favour of the continuation of the Ariane programme, under the agreement already signed. According to detailed economic studies, the potential market for Ariane was at least 40 launches (we now envisage more than 100). The French government finally came out in favour of continuing the programme, but on two conditions:

1. The ESA Convention should be renegotiated, to give terms more favourable to France;
2. The national programme, and hence the CNES budget, should be substantially cut, in order to avoid paying too high a cost.

It was the second condition which, two years later, led to my departure from CNES.

In fact, few items remained to be negotiated in the ESA Convention. As far as France was concerned, it was rather a matter of principle: only a few symbolic changes were required. As regards candidates for the office of Director General of ESA, our partners soon made it clear that we had no chance, apart from General Aubinière. The final decisive stage was reached when the Germans supported the candidature of Roy Gibson, who had already been acting in the role since the beginning of 1974. On 15 May 1975, in Neuilly, the ministers ratified the ESA Convention, with Roy Gibson as its first Director General.

My job as Chairman of ESRO Council was finished. On 1 July 1975, I handed over to my first-class German colleague, Dr. Finke. I remained as head of the French delegation and Chairman of the Agency's Science Programme Committee. On 1 July 1976, having left the chairmanship of CNES for purely national reasons, I gave up my functions in the Agency to turn to something completely different. This was the end of my 'space adventure'.

(Excerpts from an interview with Prof. Lévy by T.D. Guyenne in Paris, La Villette, on 5 February, 1984).

The preparation for the European collaboration in space science

Prof. Reimar Lüst

President of the Max-Planck-Gesellschaft, Germany

In 1984, ESA will celebrate twenty years of official European cooperation in space science: the European Space Research Organisation (ESRO) legally came into being on 20 March 1964 and the European Launcher Development Organisation legally existed from 1 March 1964. However, in 1984 it would be quite appropriate to celebrate the twenty fifth anniversary of active collaboration in space science as it actually started as early as 1959.

The 'club of Five'

As always in history, events and successes are very closely connected with individuals. I want to pay tribute to five men who played important roles in creating and developing a European organisation for space research, although many more have contributed a great deal too. These men are: Edoardo Amaldi, Pierre Auger, Henk van de Hulst, Freddie Lines and Sir Harrie Massey.

It was Edoardo Amaldi who, in 1959, wrote a stimulating article challenging Europe to catch up in space with both the USA and the USSR within five years (see for instance H. v.d. Hulst 'Planning Space Science').

Pierre Auger, with his experience from the foundation of CERN, took up Amaldi's initiative and called for a first, highly informal discussion during the first COSPAR Symposium in Nice, in January 1960. At that time, Henk van de Hulst served as the first president of COSPAR. Due to an initiative of Sir Harrie Massey, the Royal Society invited scientists from European countries to a meeting on 29 April 1960 for a first discussion of a European programme and the setting up of an organisation for space science. The meeting lasted two days and closed with a visit to the Royal Aircraft Establishment in Farnborough. One important member there was Freddie Lines who later was one of the architects in the planning of ESRO and who was to become one of the first key ESRO executives as Technical Director and Director of ESTEC. Sir Harrie Massey as Chairman of the Council of the Preparatory Committee (COPERS) and later of the Council of ESRO, and Pierre Auger as Secretary General of COPERS and later the first Director General of ESRO, were the two driving forces towards a European collaboration in space science. Henk van de Hulst too, was deeply involved as Vice-Chairman and later as Chairman of the Council, while, in the beginning, Edoardo Amaldi helped more behind the scene but fortunately was to become very actively involved first as Chairman of ESA's Science Programme Committee and later as Chairman of the Space Science Advisory Committee. I was called in to work for the European collaboration in space science by Henk van de Hulst when, at a Council meeting of COPERS in Paris in March 1961, he had to spell out my unknown name to the German delegation, and I was appointed as Scientific Coordinating Secretary for the Interim Scientific and Technical Working Groups (ISTWG). From that time until 1971, I was closely involved in the preparation of ESRO and in the first years of its active life. From Amaldi's first initiative to the legal existence of ESRO it took five years. Three decisive steps taken during this preparatory phase should be mentioned in particular:

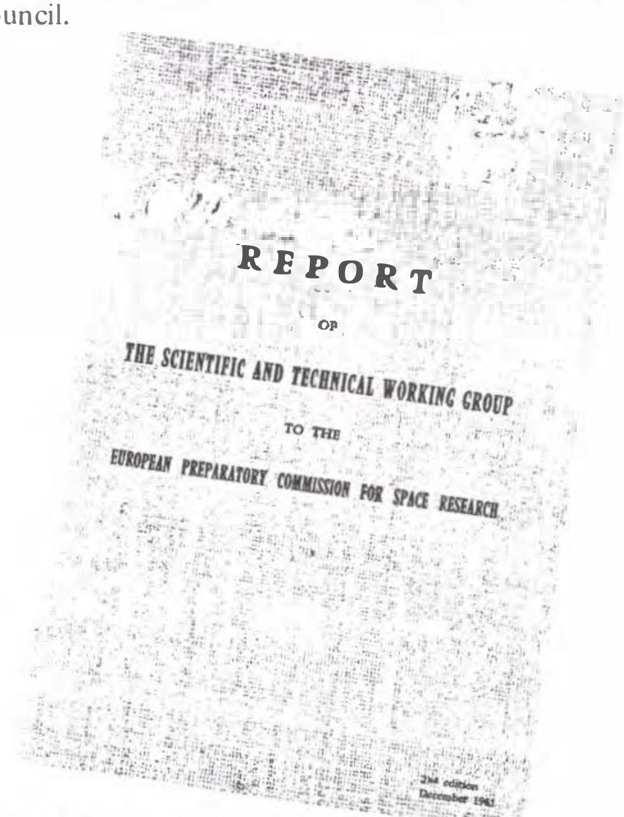
(i) the drafting of the organisational structure;
(ii) the preparation of the scientific programme;
(iii) the start of space projects.

The 'Blue Book'

The first concept of the structure and general scientific programme for ESRO could be developed very rapidly. Freddie Lines and I wrote down the ideas, brought together a meeting of the ISTWG in London under the chairmanship of Lamek Hulthen and these ideas were finally contained in the so called 'Blue Book', prepared with Pierre Blassel's assistance.

Also of great importance was the work of the Administrative Working Group under the chairmanship of Alexander Hocker. ESRO and ESA owe a lot to his very experienced guidance and understanding how scientists work.

The organisational concept as developed in the year 1961, still holds today at ESA, with a headquarters, a technical centre (ESTEC) and a data centre (ESOC), including a network of tracking and data receiving stations. At that time, a research institution, namely ESRIN, was not yet planned but the concept contained a range for launching sounding rockets (Esrange). Unlike the conceptional planning for the establishments, the decision on their location was not so easy. But a committee of the Council, under the chairmanship of Dr. Dahl, visited the various proposed sites and cleared the way rather well for the decisions of the Council.


REPORT

OF

THE SCIENTIFIC AND TECHNICAL WORKING GROUP

TO THE

EUROPEAN PREPARATORY COMMISSION FOR SPACE RESEARCH

2nd edition
December 1961

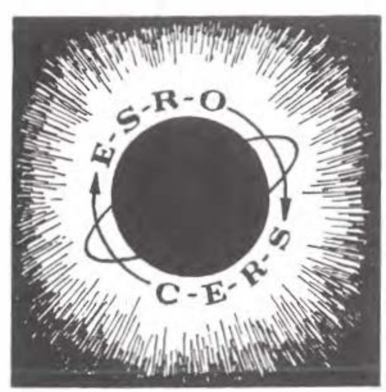
Cover of the 'Blue Book' (December 1961)

The general concept for the scientific programme laid down in the 'Blue Book' contained plans for a sounding rocket programme, for small and medium sized satellites and for two large projects, for instance a large astronomical satellite and a cometary mission. With the exception of these two large projects, the outlined programme could be realised in substance but not by the foreseen numbers of launchings. The very successful sounding rocket programme was terminated finally as an ESRO programme in 1971 due to financial limitations. However, the two large projects – so intensively discussed in the early sixties and then cancelled – have now become practically reality, namely as the Giotto project and in a certain way as the Hipparcos and ISO projects in the ESA programme.

The first experiments

But, during the period of COPERS, the actual planning was carried even further by calling for and collecting proposals for experiments for sounding rockets, satellites and space probes. At the beginning of 1963, 78 proposals for experiments on sounding rockets and 71 proposals for experiments on satellites were available, and they were discussed and analysed in the different working groups. As early as 1963, it was not an easy task to select from them the experiments for the payloads of the first satellites ESRO 2 (launched in 1968), ESRO I (1968 and 1969), HEOS-I (1968) and TD-I (1972). More than ninety percent of the experiments launched up till the end of 1972 had already been submitted by the scientific groups before 1964.

But even before ESRO was established legally, the scientists in Europe wanted to go ahead and to build hardware. This meant that the scientists asked and urged the Council of COPERS to commit and to spend money not only for planning purposes, but for hardware. In particular, there was one project which could not wait because it was aimed at a fixed date.



Artist view of the solar eclipse over Europe in May 1966

Solar eclipse campaign in Greece (May 1966)

This was the solar eclipse over Europe in May 1966. During this event a sounding rocket campaign should take place in Euboea (Greece). Finally, we were able to convince the Council of COPERS to develop and to build payloads for such a campaign. So this solar eclipse campaign became one of the first scientific projects of ESRO.

But in addition, it was already possible to start two satellite projects before the beginning of ESRO's legal existence. These were two collaborative projects with the United States. From the beginning of the planning we worked very closely together with NASA. Already at an early stage it was possible to get an agreement on the composition of the payloads of the first two ESRO satellites containing only experiments from European groups.

The rapid building and the success of ESRO was made possible by

1. The enthusiasm and devotion of many scientists in the European countries.
2. The skill and hard labour of very competent people within ESRO. I want to mention especially the active scientific group within Eslab.
3. The cooperation of scientists in Europe. Although the creation of ESRO was mainly a political decision and although in the Council political arguments had considerable weight, the decisive factor for the selection of scientific experiments and missions was quality and scientific merit.

I hope that the spirit of the very first years will enable us to go ahead in a similar manner for the planning and execution of the programme in the next decade of ESA.

Ireland's involvement in space-related activity – A personal account

Michael C. Manahan

Directorate for Scientific and Technical Affairs, Dublin, Ireland

Running through Paris
For drama and excitement, nothing that has happened in our involvement in space has exceeded the occasion of Ireland's accession to the Convention of the European Space Agency. It was a cold dark evening in Paris on the last day of December in 1975. A 'window' had been left open to that very day for countries like Ireland, who had not been members of ESRO, to join the Agency. The government, at its first meeting after the Christmas holidays, had decided that morning that Ireland should join. It then became a matter of lodging the Instrument of Accession in time. Late in the afternoon, a harassed senior Irish diplomat made a frantic dash across Paris. Meanwhile, at the Quai d'Orsay, French officials, who must have felt that they had better things to do during the Christmas holidays, waited impatiently. Finally, at the eleventh – one might even say the twelfth hour – or more precisely at five o'clock on the stroke, the Irish diplomat dashed in. The Instrument of Accession was lodged. Ireland had just beaten the deadline. Ireland was now a member of the European Space Agency.

This dramatic denouement followed a more deliberate consideration of the case for Ireland's becoming involved in space.

It had been felt that a case did exist but only partially, on various particular grounds, for example, scientific, applications, development of high-technology industry, or benefiting from information facilities which would become available. The champions of the cause did, however, feel, and did argue, that a strong composite case could be made on the basis of the benefits which could emerge under all of these headings taken in the aggregate.

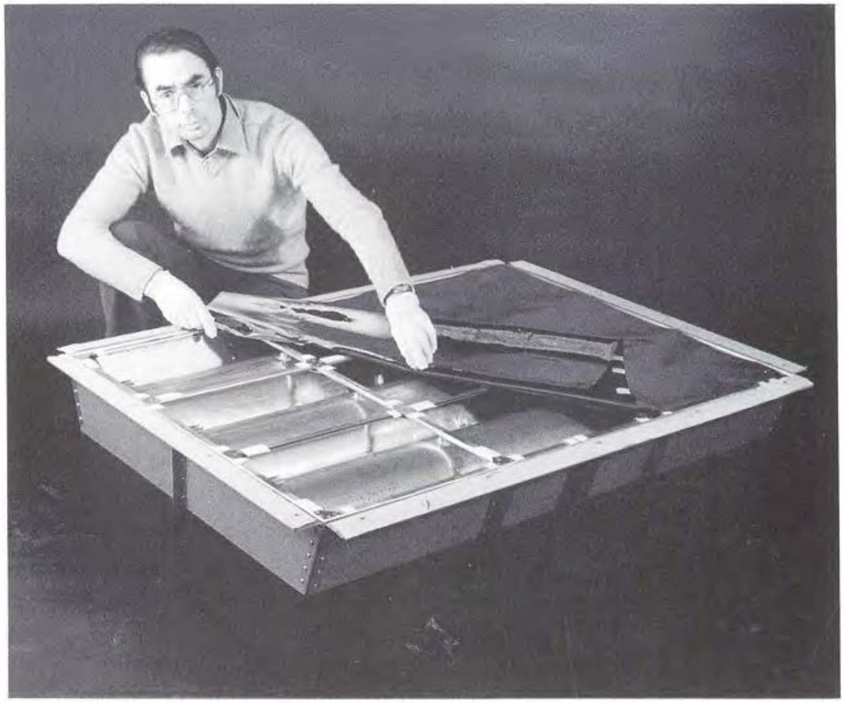
In this regard, Ireland suffered from the handicap of not having a space activity as such. The case was, however, argued that by starting off in this way and based particularly on the benefits which would accrue in support of the development of high-technology industry, a space activity could eventually develop, starting from what could be described as an 'inverted' approach.

Criticisms and witticisms
There remained the task of persuading the decision-makers. The gauntlet had to be run of criticisms and, indeed, witticisms. The criticisms were based on the inevitable arguments regarding opportunity cost and the possible spending of the resources involved on projects with a greater prospect of favourable cost-benefit. The witticisms arose from the inevitable and sceptical sense of humour of the Irish, which is, to say the least, keen, and to say the most, over-developed.

In the end, criticisms and witticisms notwithstanding, the Irish government could see the sense of the contribution that would arise in favour of development of high-technology industry and also of the possible emergence in due course, based on these benefits, of a real space activity.

This was not entirely, of course, an act of blind faith. On the one hand, ESA is the largest technological organisation in Europe. It is also the most successful. Ireland, in contrast, is the smallest, newest and youngest member of the Agency. Ireland is small in terms of area and population and had a late start in progressing up the scale of economic development.

Ireland does however, have a very considerable base in advanced technology. Indeed, the difficult task for Ireland, as indeed for a



The Long-Duration Exposure Facility (LDEF) – including an Irish experiment – to study life science and material science in space

It can be seen, therefore, why the main objective of Ireland's involvement in the Agency should initially have been the stimulation of the development of high-technology industry as well as the encouragement of space science and space applications. Space activities were seen in the long-term as an important element in Ireland's future technological industry development strategy.

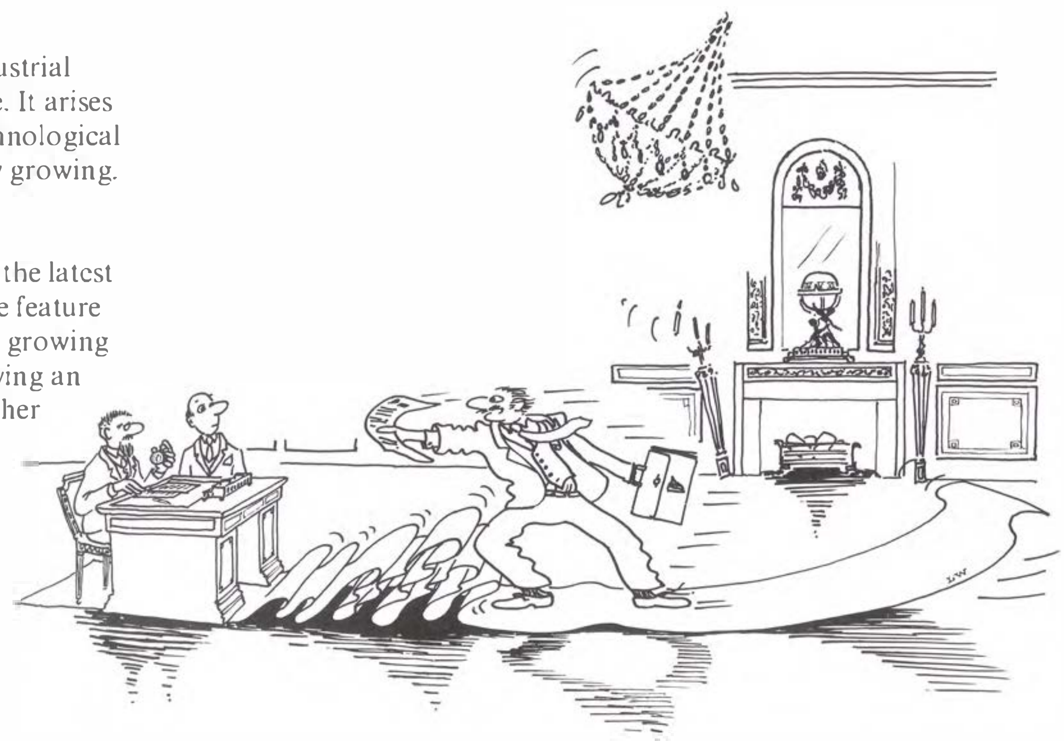
A happy involvement

Following Ireland's accession to the Convention of ESA, its involvement with space, apart from one difficulty, has been a happy one. The one difficulty arose, strangely enough, from the time which it took for the Convention of the Agency to come into full operation, so inhibiting the commencement of Ireland's participation as a full member. Once this initial stage was passed, Ireland's participation has been developing satisfactorily, notwithstanding the general resource problems which have affected most member countries during the current world-wide economic recession.

Meaningful participation by Irish research institutions and Irish industry in the activities of ESA has developed at a pace which has exceeded even our optimistic assumptions. The catalytic effect of

number of countries at the moment, in enhancing its industrial development, is not due to any lack of technological base. It arises rather from the fact that Ireland's capacity to exploit technological development and to find appropriate markets is still only growing.

This situation can be illustrated by reference to current development in Brussels where Ireland's participation in the latest industrial technology programmes is characterised by the feature that, instead of benefiting from technology inflow into its growing industrial sector, Ireland is in danger of losing out by having an outward flow of technology to benefit the industries of other member countries of the community.



... at five o'clock on the stroke, the Irish diplomat dashed in!

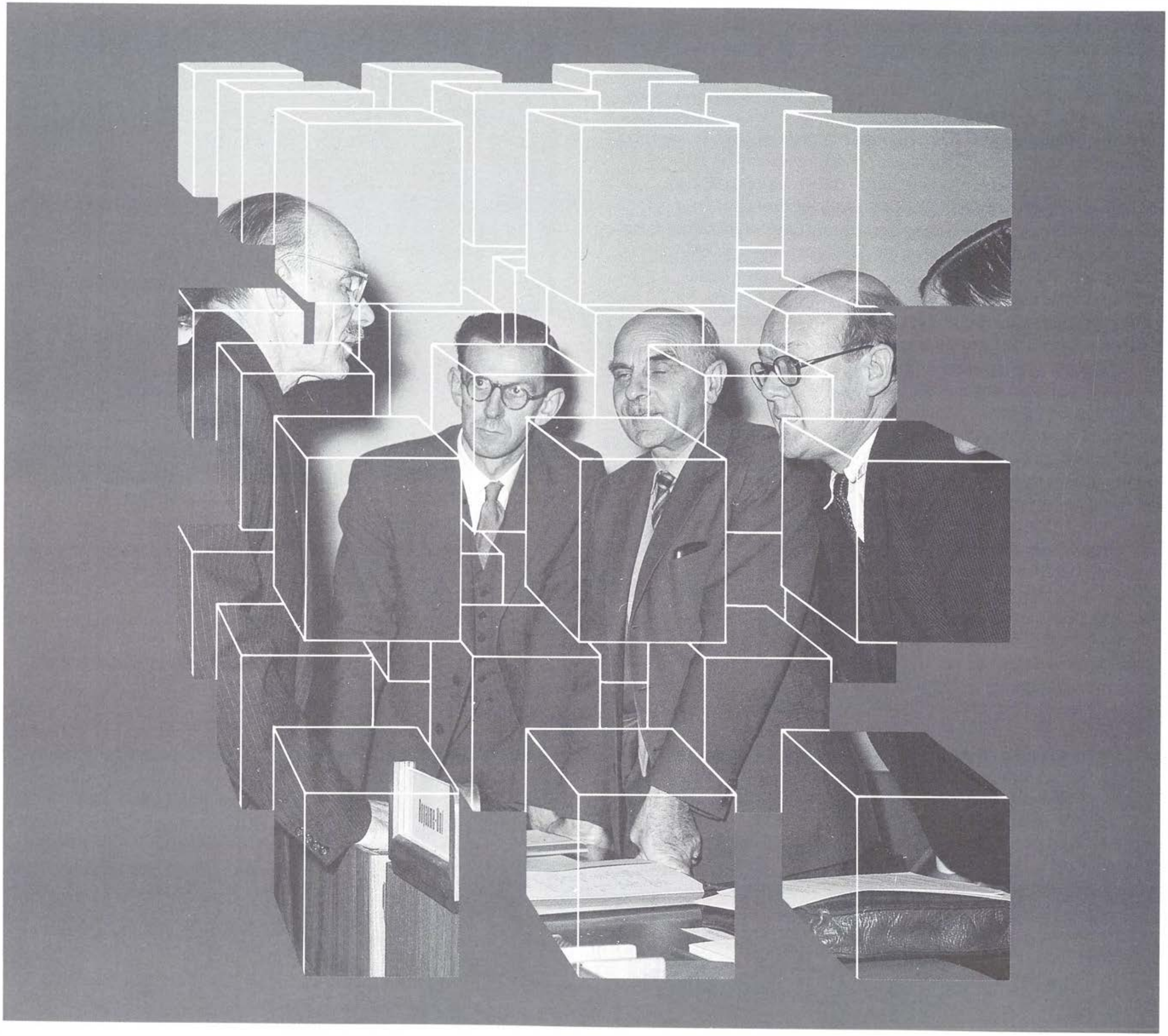
Ireland's participation is also beginning to emerge. During this stage of development the Agency has given every possible assistance particularly in the vital area of developing quality control.

There have been spin-offs from the involvement of Irish researchers in industrial situations. For industry there has been the value of interfacing with other European industrialists, of establishing credibility and of creating a track record which, of course, is absolutely vital. A further recent favourable development has been the actual setting up of companies to deal with space work.

For those of us who made the original case for Ireland's involvement in space, all this is satisfactory. However, even more satisfying is the latest development. As had been hoped at the outset, Ireland is now poised for a major step forward in space activity generally. Serious consideration is now being given to the launching of Ireland's own satellites. A government decision in principle has already been taken for the launching of a satellite for direct broadcasting, with an added facility for telecommunications, which will be put into operation when required. Ireland will thus at last begin to enter the space scene in a major way and the ambitions of those of us who originally made a case for Ireland's involvement in space activity, and in particular membership of the European Space Agency, will have begun to be realised.

It will be Ireland's intention to continue along the path on which it has set out in the realm of space. In this regard, we look to the assistance and advice of the Agency at the same level which we have so happily experienced hitherto. To this end, and also in a true European spirit, Ireland will assist in every possible way in the further development of the Agency's activities and programmes into the long-term future.

Floreat ESA!




esa
PRESIDENT

Belgium and space

Baron Paternotte de la Vaillée

Belgian Ambassador to France

Once the United States and the Soviet Union had conquered space in the late 1950's, Europe faced the task of establishing a presence in what was clearly a very important field.

The European Space Vehicle Launcher Development Organisation (ELDO) and the European Space Research Organisation (ESRO) were set up in 1964.

In 1963, a European Conference on Satellite Telecommunications (CETS) was convened, representing the first concrete application of the space programme. Belgium was involved from the start in the negotiations which led to the setting up of the two space organisations, and also played an important political role in the course of the European Space Conference (CSE), which resulted on 31 May 1975 in the setting up of the European Space Agency (ESA) which took over from ELDO and ESRO.

Belgium: a staunch defender of Europe in space
Between 1968 and 1972, Ministers Lefèvre and Hanin conducted an energetic campaign, in their capacity as presidents of the CSE, to draw up a European space programme and to solve the various problems confronting them during that period. Then and ever since, come what may, Belgium has vigorously defended the need for a coherent space programme on a sufficiently large scale to guarantee the independence of Europe in a field rich in subsidiary benefits. In fact, Belgium has realised that space technology would serve as a driving force for technological progress, and as a stimulus to industrial diversification. Almost one third of public spending on research has been allocated to space and to nuclear research.

Belgium's objectives remain the same: to bring scientists together to work for the progress of space sciences, to develop high technology in industry, and to exploit new techniques for practical applications.

In this context, Belgium is cooperating on a multilateral and bilateral level in a set of disciplines relating both to the strategic aspects of space research and to its applications in the fields of space transportation, Earth observation and telecommunications.

Belgium's scientific universities have unrestricted access to the results of this government action. The country's main effort is made within the framework of ESA, where Belgium is responsible for from 4 to 4.5% of the total contributions made to all the Agency's programmes.

Thus, for example, in 1983 Belgium contributed about 1400 million Belgian francs to ESA. Belgium's participation in ESA's scientific satellite programme is of major importance to our scientific community, which is involved in preparing various missions and in collecting and using the results. In addition, many Belgians work for the Agency.

When considering this important field of space science, it should not be forgotten that Belgian scientists have sponsored six experiments which were included in Spacelab's first payload.

So far as observation of the Earth is concerned, Belgium is involved in the Meteosat programme, data from which are used daily by the Royal Meteorological Institute. Belgium also takes part in the Earthnet programme, which, as part of the European remote sensing programme, is intended to collect data originating from US remote sensing satellites. These data are used by a number of

The European Space Conference in Brussels, (20 December 1972). From left to right: Dr. A. Hocker, Director General ESRO; Mr. Th. Lefèvre, chairman of the ESC; and Mr. A. Stenmans, Secretary General of the Science Policy Planning Department, Belgium.

university teams. Belgium is also contributing to the development of the first European remote sensing satellite, ERS-1, the function of which is the exploitation of the oceans and coastal zones and monitoring of the ice-caps. Belgian industry took part in the development of the orbital test satellite (OTS) designed by the Agency, and with the European satellite telecommunications system (ECS) which has been made available to Eutelsat.

A staunch defender of Europe in space.

Still in the field of telecommunications, the Belgian government and Belgian industrialists are involved in the Agency's programme concerned with maritime satellites (Marecs) and with the L-Sat satellite, the platform of which can carry various telecommunications and, in particular, direct television payloads.

In the development of space transportation systems, Belgium's share of the Spacelab programme is as high as 5.1%, or a financial contribution of 1300 million Belgian francs. Belgium is also contributing 2100 million francs to the development of Ariane.

It should also be mentioned that Belgium is a member of the world satellite telecommunications organisations, Intelsat and Inmarsat, and of the European organisations Eutelsat and Eumetsat.

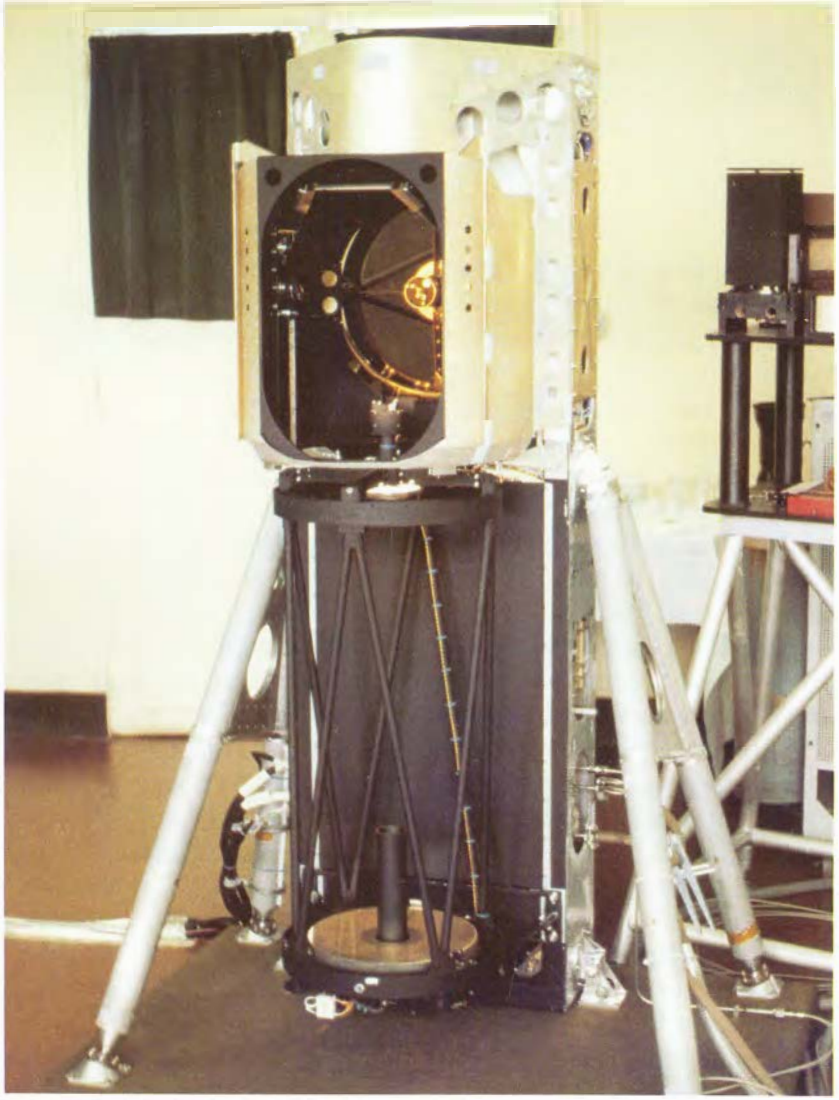
Finally, Belgium is involved in a series of Franco-German projects. For example, she is making a financial and industrial contribution to the SPOT Earth observation project, and has a 4% shareholding in the commercial company SPOT-Images.

The role of Belgian industry

Belgium is also working together with the Federal Republic of Germany on an experimental programme for the very high frequencies 20/30 GHz. Via Eurosatellite, Belgian industry is involved in the Franco-German direct television satellite project TV-Sat/TDF-1.

A Belgian firm is also participating in the French Telecom-1 programme, and in the GPS-Navstar international navigation and positioning system.

Now that the commercial opportunities are taking concrete shape, one of the three main objectives of European space policy is to integrate industry into the structures which are exploiting these markets. With this view in mind, not only will Belgium retain her presence in those ESA programmes which are of sufficient industrial interest, but she will also participate in foreign and multinational programmes whenever it is possible and suitable for her to



The joint Belgian-French grille spectrometer experiment flown on the First Spacelab Payload (FSLP) to study atmospheric parameters by analysing the light from the Sun at sunrise and sunset.

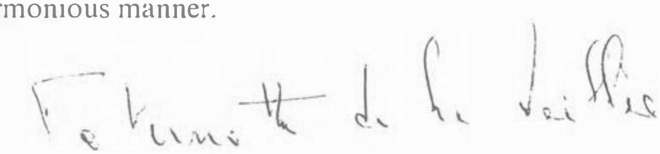
do so. Even if there are no Belgian companies capable of acting as prime contractors for the construction of a complete satellite, nevertheless Belgian industry must be represented among those firms capable of doing the necessary work for a satellite subsystem, and also among those supplying electronic or mechanical equipment.

There are clear signs of diversification in the Belgian space industry. What in fact is happening is that companies have each elected to align themselves with a specific project. They have made their mark by responding successfully to the demands made on them by their partners.

If we were to draw up a balance sheet of Belgian space policy, we would find a credit balance. National participation in the ESA scientific programme has, in effect, offered to university scientists and to research institutes the opportunity to use high-performance equipment and very sophisticated methods for research and experimental purposes. In addition, the study and processing of scientific data have facilitated high-level international contacts, and Belgium's contribution in the fields of astronomy, astrophysics and cosmic radiation is duly appreciated.

As for the Belgian economy, it is the beneficiary of all the disciplines which make use of space technology. This is important because it is and will be increasingly necessary for industry to resort to telecommunications, remote sensing and satellite meteorology, as well as to medical research and the processing of materials under zero gravity.

Thanks to the part played by Belgium in the space sector, special relationships have grown up between Belgian companies and various European firms. These working ties have had a beneficial effect on the general technological level of the firms concerned, and on their ability to make a success, in an international context, of programmes which are complex and extremely demanding in terms of reliability. It is clear that the resolute policy pursued by Belgium both at a multi-national and at a bilateral level in the field of space operations has had a positive effect on both the university and industrial sectors, the two complementing each other in a harmonious manner.



ESRO and ESA from the national point of view

J. Stiernstedt

Chairman of ESA Council (July 1978–June 1981)

The life and activities of any international organisation are to a very high extent guided by its members. Or – to be more precise – by the common denominator which the members may arrive at, based on their own national interests. At the same time the work of an international organisation tends to influence the national activities in the area concerned. For this reason it may be of some value to describe the Swedish attitude towards ESRO/ESA during the past twenty years and how it has changed with different political assessments of its national space activities.

Three crucial years

There are three crucial years – one for each decade – in the history of relations between Sweden and ESRO/ESA.

- 1962 when Sweden decided to join ESRO followed by a decision in 1964 to do this without creating a specific national space programme.
- 1972 when Sweden confirmed its participation in the 1971 ESRO package deal by establishing a programme aiming at supplementing the ESRO/ESA programme on the national level.
- 1979 when Sweden embarked on a national programme to some extent independent of the ESA programme.

On all occasions it was the Swedish membership in ESRO/ESA which served as a kind of steering-gear for the different decisions and attitudes.

The 1962 decision could be characterised as one of preserving the option.

(i) Space research was given a rather low priority within Swedish science policy. It was, however, felt that the small number of Swedish space scientists should not be denied the opportunity of participating in European projects. Nationally they had to compete with other sciences for grants and no specific space funds were earmarked.

(i) From an industrial point of view it was felt that Swedish industry should not be excluded from the opportunity of following the development of space technology: but on a minimum level of participation – a Swedish membership in ELDO, for instance, was out of the question.

(iii) During the same period Sweden decided not to join the European Communities. Politically there was a need to show European solidarity in more neutral areas, such as science and technology.

(iv) Finally – ESRO was interested in establishing its sounding rocket facility – Esrange – in a part of northern Sweden where labour supply is scarce and where all opportunities of creating new jobs must be taken care of.

Dramatic AFC meetings

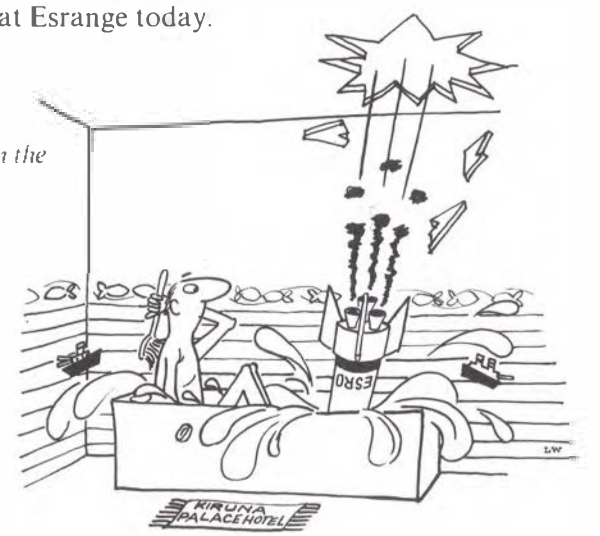
One of the practical consequences of the decision to participate in ESRO was that a number of Swedes – scientists and representatives of the ministries concerned, started their monthly, sometimes weekly, travels to Paris for different kinds of ESRO meetings at the international centre at Avenue Kleber or in the old headquarters in the Hotel Majestic. The meetings were long and exhausting. The AFC agendas were especially difficult. At times it was almost a rule that only about half of the agenda was dealt with at one meeting while the other half was left to the next meeting – a not very efficient way of running things: except in a few rare cases where the problems managed to solve themselves in the meantime.

One of the reasons why the first ESRO years were not very smooth was the competition for industrial return. Sweden was unsuccessful. I had often the feeling that Swedish industry was looked upon as too inexperienced to be given contracts of any significance. The situation was close to desperate when at a very dramatic AFC-meeting, in 1967 I believe, Saab-Scania was awarded the contract for the telemetry, tracking and command system for the TD 1A satellite. That was a turning-point. If this contract also had been lost – and it was very close to it – I am personally convinced that Sweden after the first eight-year period would have left ESRO.

Snow storm over Lapland

Another consequence of our ESRO membership was a series of seemingly endless negotiations between the Swedish Government and the Lapp population which was affected by the building of Esrange. The Lapps wanted compensation for the interference with the reindeer-breeding which the launching activities were believed to create. That the effects of a launch were overdramatised during these negotiations is a clear understatement – sometimes when listening to the Lapp arguments you had the feeling that the entire Lapland – together with northern Norway and northern Finland – would be launched into space together with the rockets. But everything has an end and in September 1966 the solemn inauguration of Esrange took place. It was very close to being cancelled. The charter plane from Stockholm with members of the Government, Parliament, the ESRO Council etc arrived at Kiruna airport in the middle of a very bad snow storm. In ordinary circumstances the plane would have returned to Stockholm but this was a special day, the plane just had to land and so it did, with the hearts of the passengers in their mouths. But all went well and soon the launch campaigns started. With them came new anxieties. The rockets had a tendency to land almost everywhere except in the carefully and, with all scientific means, calculated security areas where they were supposed to land. Northern Norway and northern Finland were particularly favourite targets. Once the railway between Kiruna and Narvik was close to being hit; another time parts of a rocket landed on exactly the same latitude as the town of Kiruna, fortunately enough some kilometers east of the town. In the end I had the not very pleasant task of telling the Director General of ESRO, who then was Hermann Bondi, that the Swedish Government had to forbid the launching of a certain type of rocket until it could be proved that its security had been improved. Bondi took it graciously and rather soon the decision could be reversed since the technical performance of the rocket was improved. I am still surprised that we managed to keep all this out of the reach of the press. Now it is history and can be told.
I do not need to add that similar events do not take place at Esrange today.

A Nike Black-Brant sounding rocket ready for launch at Esrange.

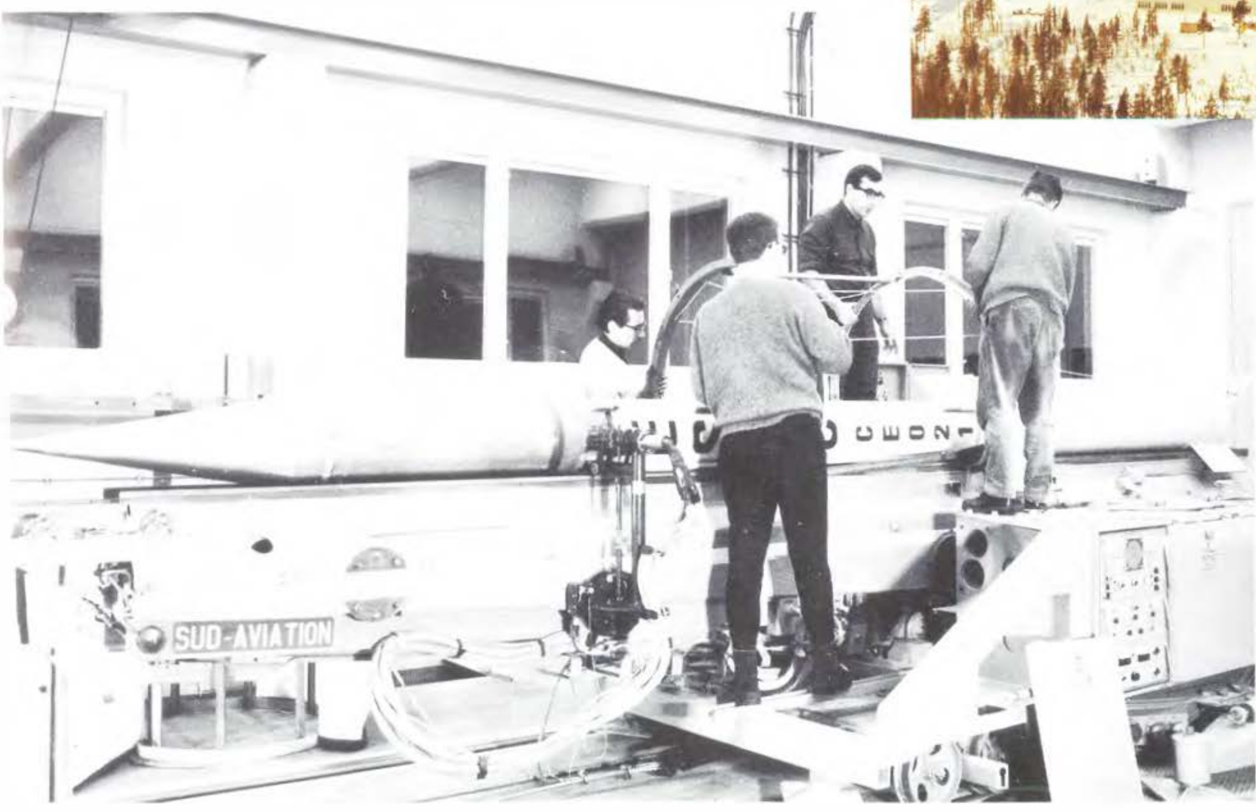


They land almost everywhere except in the carefully calculated security areas . . .

The transfer of Esrange

The second phase of the Swedish space history was the direct result of the 1971 ESRO package deal. During the negotiation of this deal Sweden was very close to leaving ESRO. The scientific return from our membership had certainly been good, but space science had still a low priority and the future for sounding rocket activities within the framework of the Agency which played an important part for Sweden looked dull. The industrial return was bad and if it had not been for the TD contract it would have been impossible to persuade the Government that Sweden should remain in the Agency. The decision to join the deal was finally taken on very much the same grounds as in 1962 – to keep the option open. But with one very important difference. The government and parliament took the consequences of the decision also on the national level. A new organisational framework for Swedish space policy was created. The grants to the national programme were slightly increased in order to create a better balance between national and international activities, and the transfer of Esrange from ESRO to Sweden was accepted even if it created some difficult problems. The establishment was far too big to be carried by the Swedish national programme and support from outside was a necessity. Out of European solidarity a number of ESRO members volunteered, and so the Esrange Special Project was created. And on the night of June 30 and July 1 1972 the midnight sun of Lapland, together with members of ESRO's Council and its AFC, could witness the solemn handing over of Esrange to the Swedish Government.

Aerial view of Esrange launch base

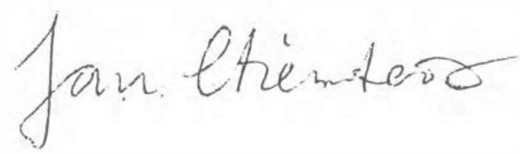


Preparation of Centaure rocket for the first launch campaign of Esrange (end 1966).

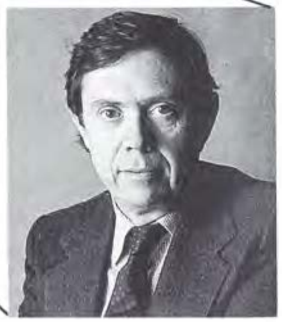
New crossroads

Our next and, so far last crucial decision was taken in 1979. The transition of ESRO to ESA and the priority given to applications opened the door for industry. The Swedish industrial return though still too low was improved and broadened. The industrial niche for Sweden could be defined. But soon we arrived at new crossroads. After a few years time it was absolutely clear to all concerned that ESA membership alone would not be enough if you wanted to develop a self-supporting industry. In 1979 the Swedish Parliament decided to increase the space activities funding by a factor of two. The purpose of the decision was to create a national programme in order to establish an independent capability which could participate in the production of future space systems needed by Sweden, mainly telecommunication systems. The philosophy behind this decision was that Swedish industry should prove its capability to cooperate with industries of other countries to sell space related products to third parties. In return there would be a Swedish 'home-market'.

We are still in the process of implementing the 1979 decision. In one year's time the first Swedish satellite will be launched. Swedish industry has for the first time had responsibility at systems level. For our ESA participation the new situation has meant two things. First of all a closer and more direct cooperation between Swedish industry and other European industries than earlier and to some extent also more freedom in the choice of industrial partners. Secondly it has meant applying harder criteria in the selection of ESA projects. Every increase of funds earmarked for ESA means a corresponding decrease of funds for the national programme. In the long run this must imply a harder demand for stronger harmonisation between the ESA programmes and the national programme. This could create difficulties with regard to conflicting interests of Member States. But it could also be a good basis for a European harmonisation in the real sense of the word. Let us hope that this will be the case during the years to come.



Some Friends



Canada – A partner across the water

Donald J. Johnston

Minister of State for Science & Technology and for Economic & Regional Development, Canada

I am pleased to be able to contribute to the commemorative book being published by the European Space Agency in celebration of Twenty Years of European Cooperation in Space. I am especially happy to do so because I had, recently, the opportunity to visit ESTEC to sign the second five-year framework agreement covering cooperation between Canada and ESA and to see something of the capability of the Centre. I wish to congratulate ESA on its many successes in the scientific field and in the application of space technology, where developments such as Ariane, Marecs and ECS are now in operational use.

It is opportune for me to assist in the twentieth anniversary celebrations because, two years ago, we celebrated the twentieth anniversary of the launching of our first satellite – Alouette I. This spacecraft was developed for ionospheric research purposes and, like each of the satellites in the Alouette–ISIS series, provided data to scientists around the world for over ten years.

A vital role

From the earliest days of the space age, the Canadian government has recognised the vital role it must play in fostering the use of space technology for the economic and social benefit of the country. As a result of this understanding and commitment, Canadians are one of the largest users of space technology in the world (on the basis of satellite capacity per capita), enjoy an efficient communications infrastructure, are able to utilise satellites for resource management, weather forecasting and navigation, and have developed an indigenous space industry capable of meeting many of our domestic needs. In the process, we have developed an international reputation for technical and operational excellence. The Canadarm, used so dramatically on board the Shuttle, has shown our capacity in remote manipulation in space and we are now looking forward to sending the first Canadian into space on a Shuttle flight in 1984.

From the beginning of Canada's space programme we have been committed to international collaboration. This aim has found expression in our support for the endeavours of the United Nations in its legal and technical bodies and in our participation in international operational systems, such as INTELSAT and INMARSAT, in both of which Canada was a founding member. But it is to our very successful international cooperation in space R&D that I wish to refer specifically.

It is not surprising that, outside the international organisations, Canadian cooperation in space R&D has been principally with the United States, and particularly with NASA. This close cooperation is a reflection of the fact that the USA is Canada's nearest neighbour and major trading partner and had early pre-eminence in space programmes, and that contacts between Canadian and American scientists and engineers are frequent and easy. But from the early years of the Canadian space programme we have tried to broaden the base of our collaboration in space R&D and it is in this context that we have sought cooperation with individual European countries and with ESA and its predecessor organisations. From 1967 we enjoyed observer status in the European Space Conference, and the Council of ESA at its first meeting in June 1975 confirmed Canada's status as an observer, expressing the hope that this was only the first step towards closer cooperation.

Even before the formation of ESA we were cooperating in programmes with ESRO and with individual European countries. One of these programmes might be mentioned. In 1971, the

Department of Communications (DOC) and NASA agreed on the joint Communications Technology Satellite (CTS) programme to develop a satellite communications system to operate at higher frequencies than existing systems. DOC undertook to design and build the spacecraft and to operate it in a geostationary orbit. NASA agreed to develop a high-power high-efficiency transmitting tube for the spacecraft and to provide a launch vehicle. In 1972, DOC accepted an ESRO proposal that the CTS spacecraft flight test several European designed payload components and solar cells mounted on a flexible material. The programme was carried out as agreed, with the satellite, christened Hermes when in orbit, operating successfully for nearly twice the planned two-year life. We were very appreciative of this opportunity to cooperate with Europe in a programme which has been of great benefit to the development of communication satellites on both sides of the Atlantic.

Upgrading Canada's relationship

While these cooperative programmes were under way, officials discussed ways of upgrading Canada's relationship with ESA. By February 1977, their discussions had progressed to the point that the Minister of Communications, Madame Jeanne Sauve, who later became Speaker of the House of Commons and is to be our next Governor-General, attended the ESA Council of Ministers meeting and indicated our interest in upgrading our relationship with the European Space Agency. This desire for closer cooperation with ESA was an outgrowth of Canada's foreign policy which called for the strengthening of commercial and economic ties with Europe.

Our first cooperative agreement was signed in December 1978, by Mme. Sauve and Mr. Roy Gibson, then Director General of ESA. Under the terms of this five-year agreement, which came into force on 1 January 1979, Canada has contributed to the general budget and has participated in the general studies concerning future projects and two optional programmes. The new agreement, which Mr. Erik Quistgaard and I signed on my visit to ESTEC in January, increases Canada's contribution to the general budget in keeping with our increased participation in ESA's programmes and continues most of the provisions of the old agreement. It is to remain in force until 31 December 1988.

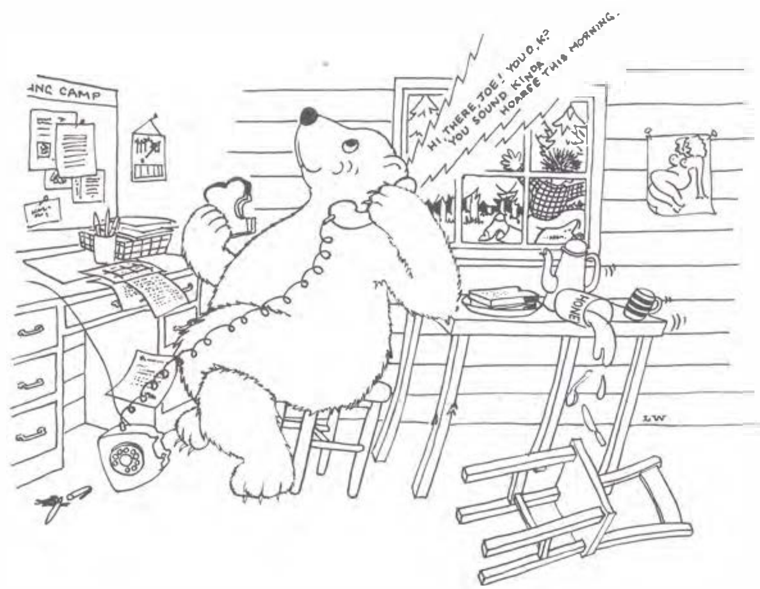
It is not surprising that given Canada's vast land mass and widely distributed population, we have concentrated on two areas of space activities – remote sensing and telecommunications – both at home and in our cooperation with ESA. We have contributed to the definition of the Olympus programme and now have an 11% share in the development and implementation phases. Canadian industry (Spar Aerospace of Toronto and Montreal and COM DEV of Cambridge, Ontario) will be supplying the large solar arrays and certain payload components and will be supporting British Aerospace in the integration and testing of Olympus in Canada. On the successful completion of the programme Spar will have access to a proven large satellite bus and will be a major sub-

Canadian Communications Technology Satellite (CTS) undergoing solar array deployment tests contractor to British Aerospace in its world-wide sales. The partners will have benefited from the use of the first-class facilities of the David Florida Laboratory and from the solar array expertise originally demonstrated in the Hermes programme.

Closer ties

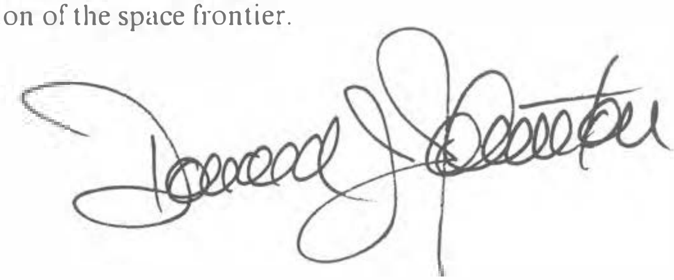
Between 1977 and 1980 we carried out a programme to explore the possibilities of an operational satellite system to meet our needs for surveillance data, particularly for Arctic data. The study showed the technical feasibility of the system and indicated that digital techniques, in which a Canadian company, MDA of Vancouver has a proven capability, were superior to optical techniques in data processing. It was, therefore, very opportune for us to take part in ESA's Remote Sensing Preparatory Programme which provided the chance of participating in the planning of a remote sensing system and, in doing so, to influence the eventual sensor complement of the satellite. This participation and our expected cooperation in the development and exploitation phases of the programme ensure not only that our data requirements, especially those for ice classification and monitoring, will be met but that our industrial participation will be in areas of Canadian expertise, such as microwave components and real-time processing of Synthetic Aperture Radar data, and in areas of interest to follow-on radar satellite programmes, exemplified by our Radarsat programme. We hope and expect that both the Olympus and ERS-1 programmes will lead to closer ties between the European and Canadian industries to allow them to work together in meeting the challenges of the future.

In concluding this article, I would like to stress the special nature of our agreements, both for ESA and for Canada. For ESA they represent the only arrangements for close cooperation concluded with a non-European State. For Canada they expand our opportunities for international cooperation beyond our historical links to the United States. Clearly, the agreements express an on-going commitment on both sides to the definition and development of space programmes of mutual benefit and interest.



It is not surprising that given Canada's widely distributed population, we have concentrated on . . . telecommunications

Space exploration gives us a glimpse of the limitless possibilities of the future. We must cherish this potential by dedicating ourselves to the peaceful exploration and use of space. I congratulate ESA on its contribution to this ideal and wish ESA many more years of success. Canada's domestic space programme and our international space commitments have reinforced the principle that space should be used for peaceful purposes. We Canadians are honoured to participate with our European neighbours in the exploration of the space frontier.



A satellite telecommunications system in Europe: a wild dream in 1967, a fact in 1984

Andrea Caruso

Secretary General of EUTELSAT, Paris

In the orbit of the geostationary satellites, 36 000 km directly above Gabon, a European satellite has for some months been supplying television transmissions between various Western European countries. The Eutelsat I-F1 satellite (known previously as ECS-1), launched by Ariane rocket on 16 June 1983, is the first of a set which are to represent the space sector of a European regional satellite telecommunications system. The establishment of this space sector will be completed by the launch of a second satellite in the spring of this year, and the third could also be in orbit by 1985. And so Europe will soon have available a satellite telecommunications system, serving the European region, and entirely designed, manufactured and set up by Europe itself. Then we shall be able to forget the long years of hesitation, patience and passionate commitment which it will have taken to get this far.

In fact, the idea dates back to 1967. At that time, just five years after Telstar provided the first satellite links between Europe and America, satellite telecommunications already seemed to be the privileged area of application of space technology. Europe had been present from the start of the adventure, with two of the world's very first ground telecommunications stations, and had played a critical role in the establishment of INTELSAT, the International Telecommunications Satellite Consortium, four years earlier. In 1967, already conscious of what was at stake, Europe was seeking the means to put her industry in the position to handle this new technological adventure. A European conference on space telecommunications (CETS) was held that year, and launched the idea of a telecommunications satellite for Europe. The CEPT, combining the Western European postal and telecommunications administrations, was then invited to carry out a profitability study of a system of this kind. However, the conclusions of this study were not encouraging; and hence this project never aroused much enthusiasm among those responsible for telecommunications, who considered that satellite links within Europe would never be economical in comparison with the ground network, which was already at an advanced stage of development. The size of the European continent, and the relations between the countries in its western part, meant that a satellite system would only be able to involve links carrying low-density traffic. The distribution of television programmes seemed more promising, but the EBU in its turn regarded the project as far too expensive, and rejected it. In 1967, then, it was still madness to talk in terms of a satellite system within Europe. Unlike INTELSAT, which was meeting a real need in improving communications between continents, a telecommunications satellite for Europe seemed on the evidence available to be a 'luxury' which Europe did not need and the telecommunications administrations could not afford.

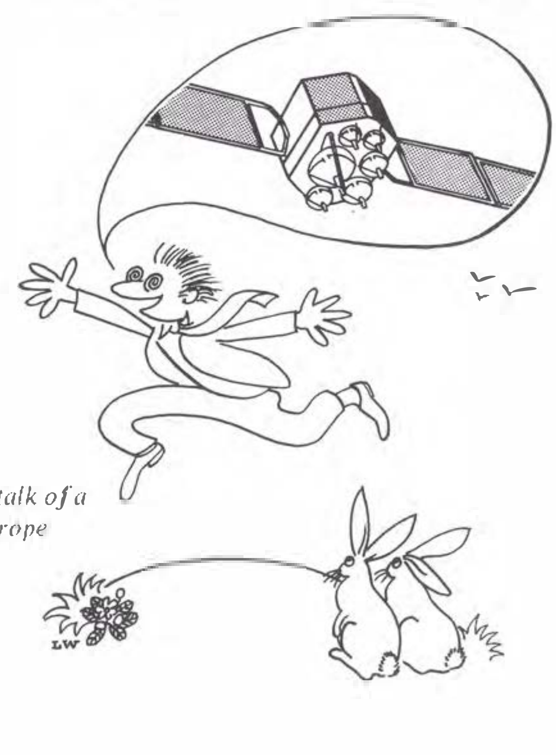
Political impulse

In the event, it was politics that provided the necessary impulse, with the convening of the European Space Conference (ESC). A decision was taken to the effect that, after all, studies relating to an applications satellite for telephone and television should be encouraged, and in 1969 the Committee of Senior Officials from the ESC set up a working party with a brief to define a European telecommunications satellite programme.

One year later, the CEPT, through its Coordinating Committee for Satellite Telecommunications (CCTS), expressed its desire to be closely associated with the work being carried out under the aegis of the ESC. The CCTS then set up the 'European Telecommunications Satellite' working party (SET), itself coupled with a permanent body (the 'Permanent Nucleus'), based in Paris. Then, for several years, studies were continued on the telecommunications side and, in close collaboration with ESRO, as regards the satellite sector. A study published in 1971 – in which, incidentally, there were already references to an organisation called EUTELSAT – presented some encouraging technical conclusions, while the financial conclusions called for a decision at the political level.

It was, in fact, politics which called the tune in 1973: nine European countries decided to inaugurate a telecommunications satellite programme involving a technological and experimental phase – this would be the OTS satellite – followed by an operational phase – which would be the ECS satellites, intended to be utilised by an international organisation. The postal and telecommunications administrations then ratified the decision and set to work to prepare the ground sector which would be associated with the OTS satellite. They also decided to propose a maritime satellite, Marots, as an alternative to the American Marisat satellites and to the INTELSAT projects in the field of space telecommunications for shipping purposes.

There remains the question of the launcher. Although Europe had given proof of its maturity with its Symphonie and Sirio satellite programmes, it was showing itself incapable of effectively coordinating the Europa launcher programmes. This failure left Europe dependent on American or Soviet launchers. One essential step was taken with the setting up of the European Space Agency (ESA) which revived, among others, the telecommunications satellite programmes and took over responsibility for the Ariane programme.



...it was still madness to talk of a satellite system within Europe

The close collaboration between the new organisation and the telecommunications administration was to become intensified, this time enabling all the projects to be completed.

However, unanimity was not yet the invariable rule within CEPT itself, and it was necessary to wait for the stimulus provided by various governments, including those of France, Italy and Switzerland, before the question of an international organisation to control the future satellite system was studied, by a conference which met in Paris in 1977.

On 30 June that year, seventeen governments signed the agreement setting up EUTELSAT on a temporary basis; they would later be joined by a further three members. Originally, though, the temporary EUTELSAT was to undertake the control of all the satellite systems set up by Europe, that is to say including not only ECS (for the fixed service) but also Marots (for shipping). However, when the international organisation INMARSAT was set up, it took over responsibility for the Marots space sector, which had in the meantime been modified and re-christened Marecs.

EUTELSAT breakthrough

It was on 1 September 1978, when the first Secretary General of the temporary EUTELSAT, Mr. Francois Job, and his first colleagues moved into the organisation's offices in the Maine-Montparnasse tower in Paris, that the existence of EUTELSAT really began. In effect, it provided the postal and telecommunications administrations with the essential tool they needed to ensure the success of the project. With this in mind, the organisation concluded several agreements, including a 1979 arrangement with the European Space Agency relating to the supply and maintenance of the space sector of the ECS system (an agreement which fully complied with the postal and telecommunications administrations' concern not to be solely responsible for financing the setting up of the system). Then, in 1982, a contract was signed with the European Broadcasting Union (EBU) whereby two repeaters of an ECS satellite were leased to the EBU for a period of 10 years. Finally, an agreement on Telecom-1 in the same year provided EUTELSAT with an additional space capacity to meet the requirements of its multiservice satellite system.

ECS mounted on SYLDA (containing AMSAT) prior to launch, with Ariane fairing in the background

But it was on 12 October 1983, above all, that EUTELSAT made its mark in the field of space telecommunications, when the first ECS satellite, launched on 16 June 1983 (and now re-christened Eutelsat I-F1) became operational. The next step was to be the inauguration of the second satellite, due to be used for Eurovision, telephone link-ups and business telecommunications.

In the meantime, the emergence of EUTELSAT among the space telecommunications systems had already produced reactions from partners such as INTELSAT, who believed that the European regional system was taking away some of its potential market. But it was necessary to accept that, on the evidence available, EUTELSAT was only the first in a group of regional systems soon due to develop in addition to world or national systems, and that sooner or later competition or overlaps would become more intense.

Patience pays off

On an institutional level, the constitution of EUTELSAT is approaching completion. More than twenty countries have already signed the Convention agreements and the Exploitation Agreement relating to the setting up of the final EUTELSAT organisation, adopted by the Inter-Government-Conference held in Paris in the spring of 1982. Today, it only remains for these agreements to be ratified by the parliaments of the signatory countries for them to come into force.

So, when we look back to see the road we have travelled since 1967, the disbelief we have had to overcome, the conflicting interests we have had to reconcile, and the slowness of the political and administrative machinery, we may feel astonished that a project of this kind has ever been able to become reality. Since it has, we have reason to be proud of all those who have struggled so hard to defend the idea that satellite systems for Europe was not just plain insanity. We should also pay tribute to all those who have allowed themselves to be persuaded, and have since made active contributions to the success of the project. We should be proud, too, of European industry, and its successes both with the Ariane launcher and with the application satellites. It has shown such patience and commitment in continuing its efforts while having to wait on the major political decisions. At the end of the day there is no doubt whatsoever that the setting up of the European Space Agency has played a major part in the success of the EUTELSAT project, to the extent that those responsible for it have always been able to provide the essential impetus and to maintain the atmosphere of frank cooperation between the various parties concerned.

With the EUTELSAT system, the Europeans showed that they were capable of making a success of a project which was considered impossible 15 years ago. European industry, for its part, is today able to harvest the fruits of this project and to export its knowhow. Now it is up to the postal and telecommunications administrations to show that the gain was worth the gamble, by making effective use of this modern tool and by improving it with the aid of future technologies.

Some reflections on ISRO- ESA cooperation

Prof. Satish Dhawan

Chairman of the Indian Space Research Organisation, Bangalore, India

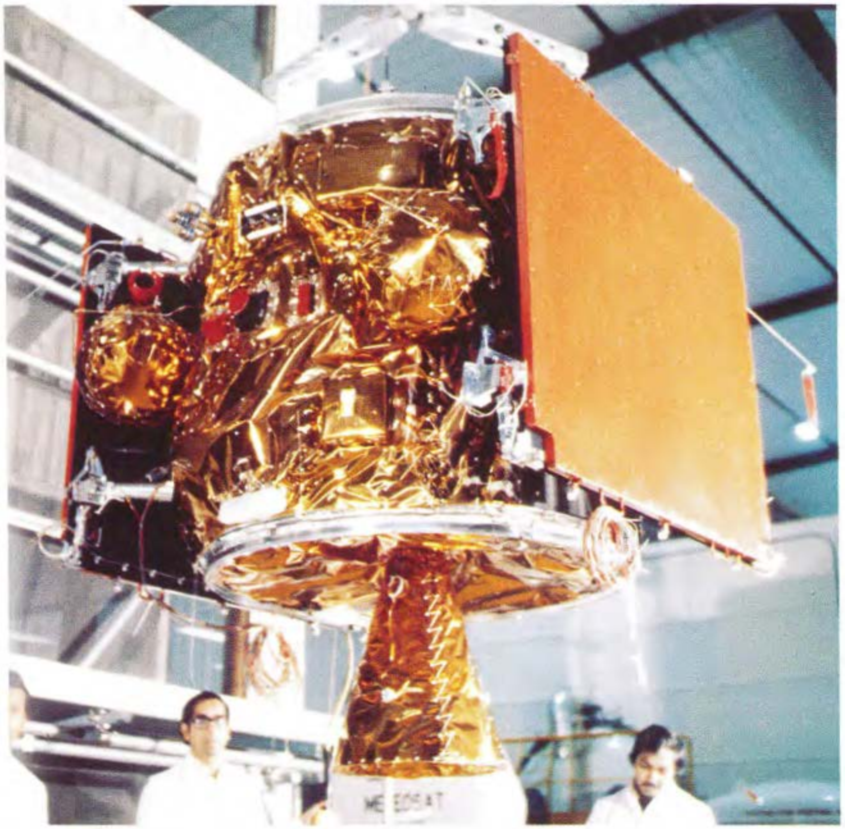
The Indian Space Research Organisation (ISRO) has had and continues to have cordial and fruitful relations with the European Space Agency (ESA) as well as the national space agencies of the constituent Member States of ESA. In its relations and cooperation with ESA, ISRO has experienced an amalgam of its relations with the individual ESA member nations, which has certain dimensions different than the simple sum of the individual relations.

Conscious political decisions

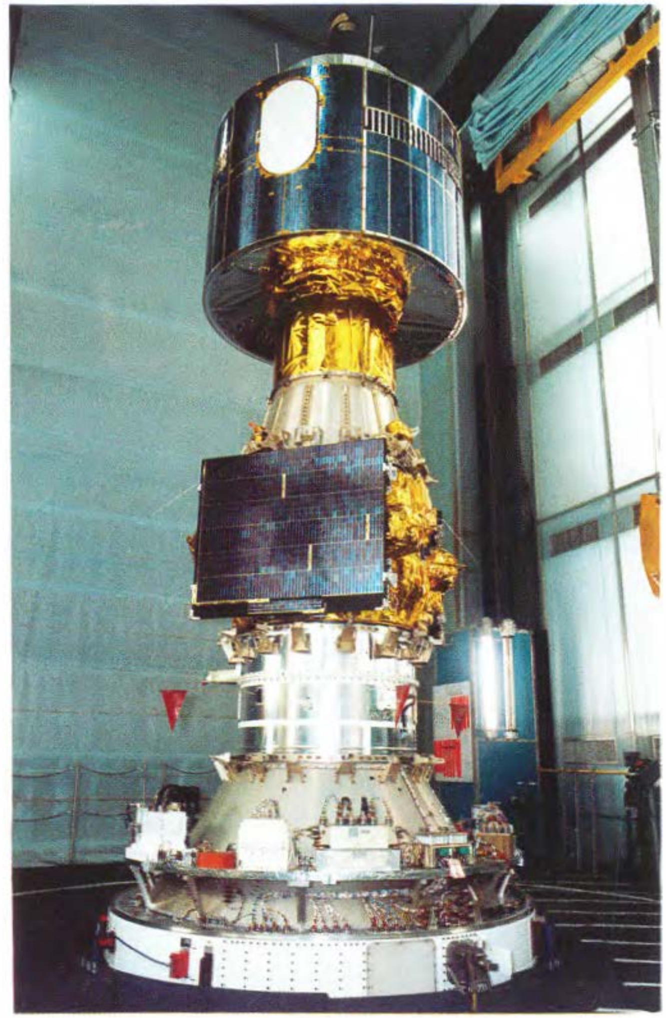
Cooperation between ISRO and ESRO, one of ESA's predecessor organisations, began in March 1971 with an exchange of letters providing for scientific and technical information exchange and use of each other's tracking network in case of need. When ESRO's TD-1A satellite, launched in March 1972, developed certain problems, the provision of satellite tracking support by one agency to another was invoked by ESRO in 1972–73. The 14th of April 1978 was an important day in the history of ISRO-ESA relations as on this day the existing umbrella agreement on broader cooperation between the two agencies was executed. I was personally involved in the ISRO-ESA dialogue that resulted in the existing cooperation agreement. Despite known dissimilarities in the scope, magnitude, means, focus and some of the thrusts of their respective programmes, in my view certain similarities in the basic philosophy and approach of the two organisations drew them together. For one, both organisations were created by conscious political decisions for furthering to the maximum self-reliant capabilities for space technology and utilisation – ESA for Europe and ISRO for India. Secondly, the activities of both are for the peaceful uses of outer space. Thirdly, both have enjoyed and continue to enjoy wide international cooperation with various nations and entities outside of their respective spheres of activity in developing their respective capabilities and programmes and in ensuring that mankind benefits from the rapidly expanding field of space technology and systems.

An important milestone

The launching of the Indian geostationary communications technology satellite, APPLE, on 19 June 1981 by the third development flight of Ariane constitutes a very important milestone in the history of ISRO-ESA cooperation. APPLE was conceived by ISRO in response to an ESA announcement in April 1975 for 'small' satellite flight opportunities on board development flights of Ariane. Every phase of APPLE activity – conception, development and launching, had varying measures of ESA cooperation; the success of the APPLE mission (19 June 1981 – 19 September 1983) is in many ways a reflection of ISRO-ESA cooperation and the determination on both sides to make this cooperation a success. APPLE grew from a 150 kg 'lateral' passenger to a 670 kg central passenger and from the initially conceived relatively simple satellite to a more sophisticated three-axis stabilised spacecraft with sun tracking solar arrays, bearing the European satellite Meteosat-2 on top during the dual launch. At the time of signing of the APPLE carriage agreement in October 1977, it was the most sophisticated spacecraft project undertaken by ISRO. Despite initial scepticism in many quarters, APPLE was realised within 38 months of the signing of the carriage agreement and delivered well in time for the Ariane L03 launch. The Indian efforts to realise APPLE were significantly strengthened by the high-order technical advice and inputs from ESA specialists in the various design reviews, test programme development, certain procurement surveillance in Europe, and in mission operations planning as well as in launch operations. It is my belief that the cooperation and assistance extended by ESA to ISRO in making available the APPLE flight opportunity and in the realisation of



Flight model of APPLE satellite



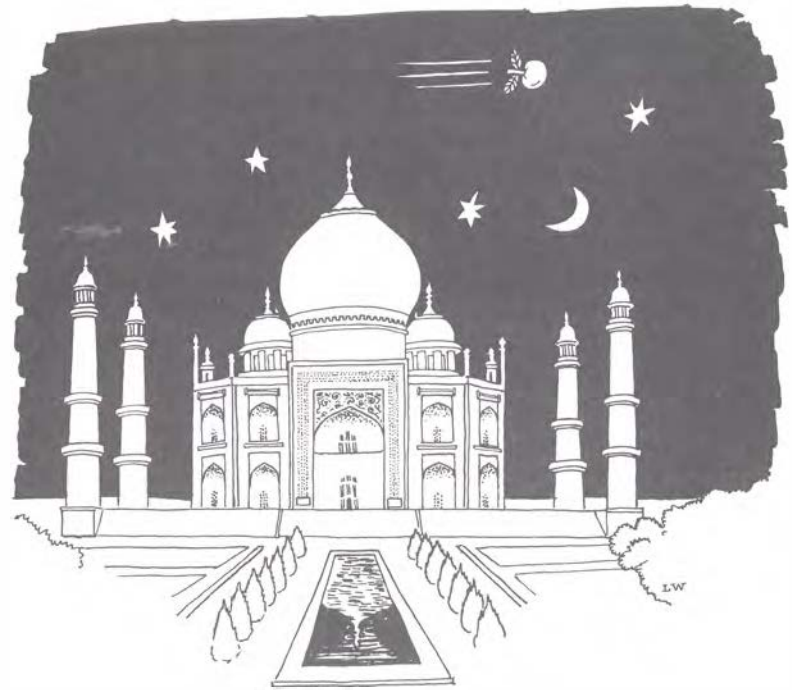
Meteosat mounted on top of APPLE prior to dual launch

APPLE exemplifies the real assistance and cooperation that more technologically advanced space agencies can extend to the not so advanced ones. In this way such space agencies are able to realise and mature their inherent strengths and capabilities in the service of their constituencies in the most self-reliant fashion possible. Only if the cooperation and assistance are in such a form that they are really absorbed and assimilated, do they bear fruit.

New avenues for future cooperation

I remain quite optimistic about the future of ISRO-ESA cooperation and interaction. There is no doubt that the differences in the focus and thrusts of the programmes of the two agencies, as they mature, are growing; this is natural considering the differences in the applications area focus and the means available to the two agencies. While ESA is looking into the permanent presence of man in space, the focus of ISRO activities is still earth-, and in particular India-bound. Despite these differences, there are still a number of areas where the two agencies can gainfully cooperate in mutual interest. The developing Earth Observation programmes of both agencies offer an important avenue for cooperation. Projects and systems on an international scale and involving international participation, such as a global civilian satellite navigation system, are another prospective area. Without sacrificing the basic tenet of maximum self-reliance, which is common to both agencies, the two agencies can use each other's facilities and hardware developments in their respective programmes in a cost-effective manner. During the visit of the last ESA mission led by the Director General in December 1983, I believe that we made a promising start in exploring, in a hard headed and businesslike manner, new avenues for future cooperation and I am hopeful that this will yield positive results. However, apart from the cooperative programme/project possibilities under exploration, the dialogue and interaction afforded by the ISRO-ESA cooperation have certain important and positive features. By sharing experiences and learning from them, one can sometimes avoid the pitfalls that the other had to experience. Bridges of understanding are also built through actions such as ISRO participation with observer status in the activities of the European Association of Remote Sensing Laboratories (EARSeL), as an associate member in the Space Components Coordination Group (SCCG) of Europe, and as a member in the Space Frequency Coordination Group (SFCG), that have come about as a result of the ISRO-ESA dialogue.

On the occasion of the completion of the first twenty years in space, I take this opportunity to convey fraternal greetings from ISRO to ESA and to wish it greater success and achievements in the coming decade and beyond. ESA has already brought the combined European efforts in space to a grand success. I am confident that ESA will handle the challenges ahead with equal adeptness. I am equally confident about the success of the future of the continuing ISRO-ESA cooperation.



International cooperation in space: a cornerstone of United States' policy

James M. Beggs

Administrator, National Aeronautics and Space Administration, Washington DC, USA

The past two and one half decades have encompassed a period of explosive technological and scientific progress, more rapid than in any period in history. Much of this progress has been made in the course of mankind's efforts to gain new knowledge of our last and endless frontier, space.

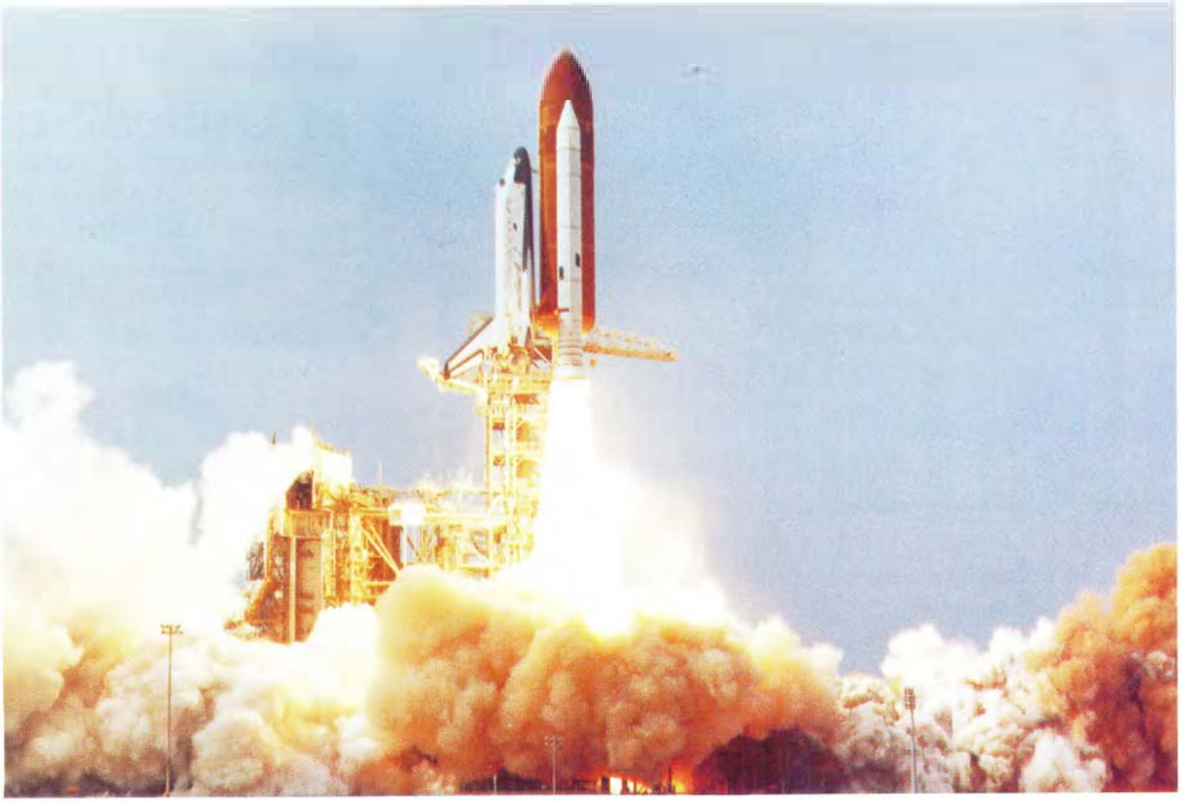
When NASA was created in 1958, there were only two nations involved in space-related activities, the United States and the Soviet Union. Shortly thereafter, the United States began to concentrate on the Apollo programme, in which 12 Americans landed on the moon, examined its surface and returned safely to Earth.

In the course of Apollo, and in the Skylab programme that followed, we established the ability of humans to function in space for an extended period of time. We also vastly increased our technical knowhow and the world's scientific knowledge. Since then, there have been many important achievements by the United States, the nations of the European Space Agency and a growing number of other countries in the exploration and peaceful uses of space.

A sustained cooperation

Joint efforts with ESA and individually with its various Member States over the past two decades have formed the cornerstone of the NASA international cooperative programme. Since 1968, starting with the International Radiation Investigation Satellite, ESRO-2B/IRIS, and the ESRO-1A/Aurorae spacecraft, major pioneering advances were made jointly in the emerging studies of solar and cosmic radiation and the effects of such energetic particles on our ionosphere. These early and invaluable experiences in working together produced the mutual respect and confidence necessary to go on to much larger joint programmes like the very successful and scientifically valuable International Sun Earth Explorer (ISEE) programme launched in 1977. Next followed the equally valuable International Ultraviolet Explorer (IUE) launched in 1978, which has produced a veritable wealth of new data and is still going strong.

Signature of the Spacelab Memorandum of Understanding at the State Department, Washington DC, on 24 September 1973, between ESRO and NASA. (Photo shows seated, left to right, Dr. Alexander Hocker, Director General ESRO; Minister Charles Hanin, Chairman of the European Space Conference; Mr. Kenneth Rush, Acting US Secretary of State; and Dr. James C. Fletcher, Administrator NASA).



Launch of Columbia Shuttle (STS-9) with Spacelab-1 on board (28 November 1983).

The Scout rocket with ESRO-1B spacecraft in launch position (1 October 1969).

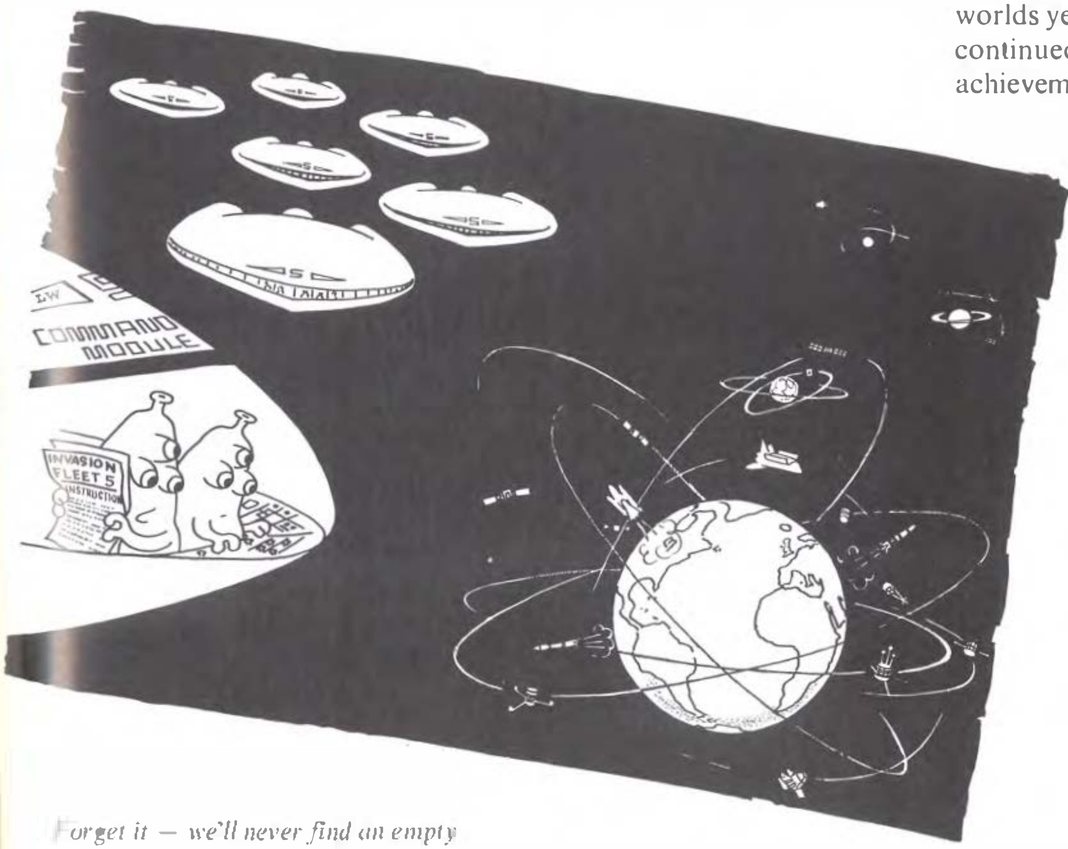
At the same time that these projects were being implemented jointly with ESA, NASA was also pursuing mutually interesting joint spacecraft projects with individual ESA Member States. During the 1970's, the Azur, Aeros and the very successful Helios spacecraft with Germany made significant contributions and provided the basis for even more advanced joint projects underway for the 1980's. The Eole project with France, the San Marco series of satellites with Italy, the Ariel series of spacecraft with the United Kingdom, and the immensely successful Infrared Astronomical Satellite (IRAS) with the Netherlands all have produced splendid science which might not have been possible without US-European cooperation.

During the rest of the 1980's we will see continuation of this remarkable cooperation. Spacelab is now available to the scientific world with entirely new capabilities for putting the scientist in space with his experiments. In a few years, we will be launching the NASA/ESA International Solar Polar Mission (ISPM) which will return unprecedented data about our star the Sun from journeying far above the solar poles, followed almost immediately by launch of the US-German Galileo mission for detailed extended study of Jupiter. In the same timeframe we will be launching the Space Telescope with its valuable contributions from Europe, that will make available to US and European scientists a truly revolutionary facility and greatly expand our knowledge of the character, extent and origins of our Universe. Thus in the 1980's, as in the previous decade, US-European cooperation in space science will continue to yield a wealth of new information which might not have been possible if we had not joined forces.

As we continue our very close relationship we are again planning new and far reaching joint programmes for the 1990's. For US-European cooperation has been truly extraordinary, both in terms of how well we have worked and continue to work together, and in terms of the scientific achievements that benefit us all. It is indeed difficult to imagine where we would be now without it.

A space-faring civilisation

United States policy is founded on the premise that the use of space holds the highest promise for mankind. On this horizon are new materials, medicines and energy sources to raise the quality of life everywhere; new food sources; improved means to preserve the Earth's environment; and perhaps, most important, a new force for preserving the peace through cooperation, rather than competition in the quest for new resources and new habitats.



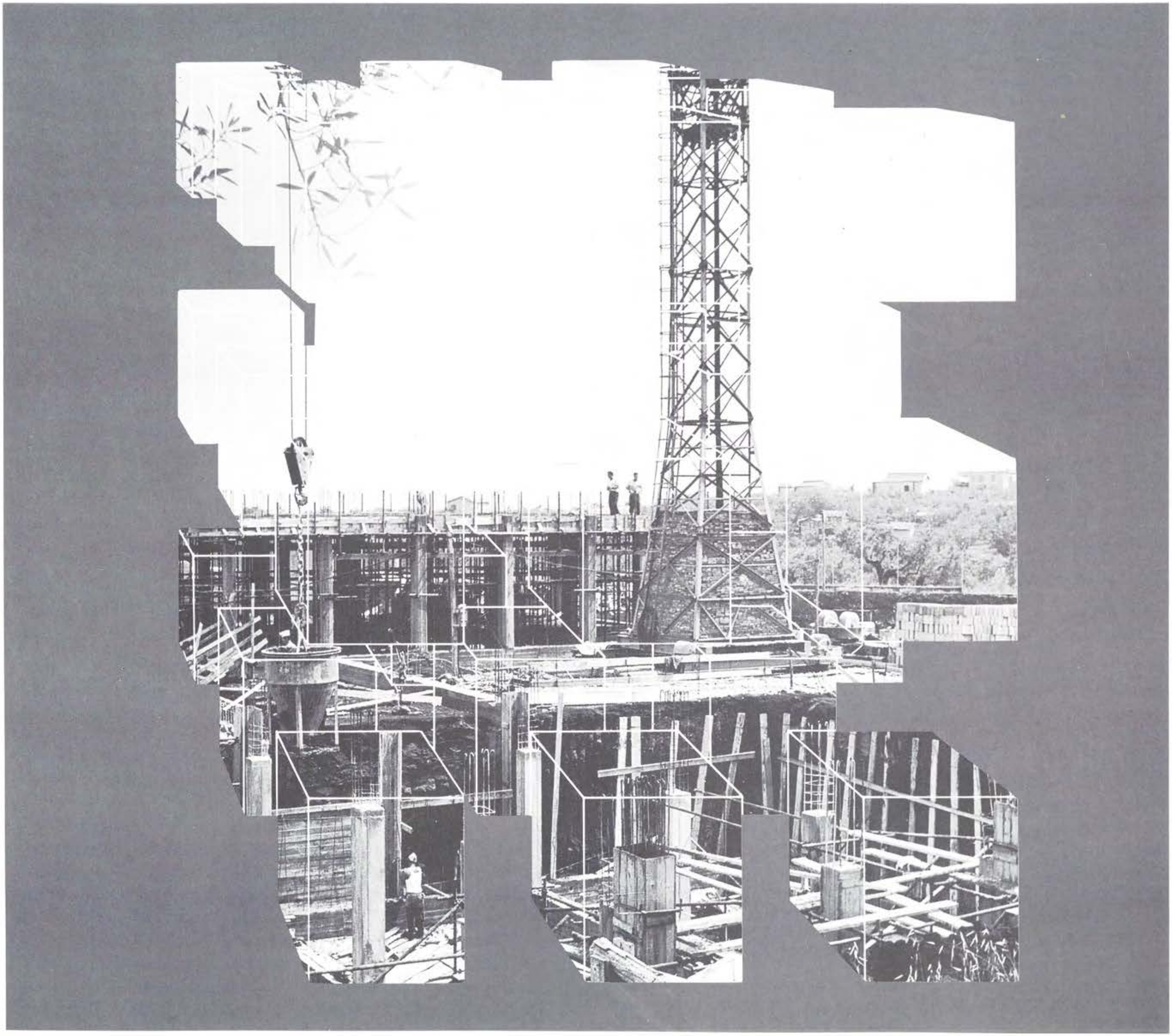
Forget it — we'll never find an empty parking orbit!

Over the past quarter century there has been extraordinary progress towards attaining these goals, not only by the United States, but by our friends in ESA and by a growing number of countries around the world. In a global sense, we are on the verge of becoming a space-faring civilisation.

More than two thousand years ago, the great Roman orator-statesman, Cicero, wrote: 'Friendship makes prosperity more brilliant, and lightens adversity by dividing and sharing it.'

As friends and as free people, we have made a magnificent start in pushing forward the frontiers of knowledge. But our greatest opportunities lie ahead.

As we move forward together across the frontiers of the unknown, may we continue to share the joys of knowledge newly found, of worlds yet unseen and of wonders not yet imagined. And with continued cooperation and mutual support, our future achievements will surpass even those of the past quarter century.

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The Industrialists

Competition and cooperation in space – 20 years' apprenticeship

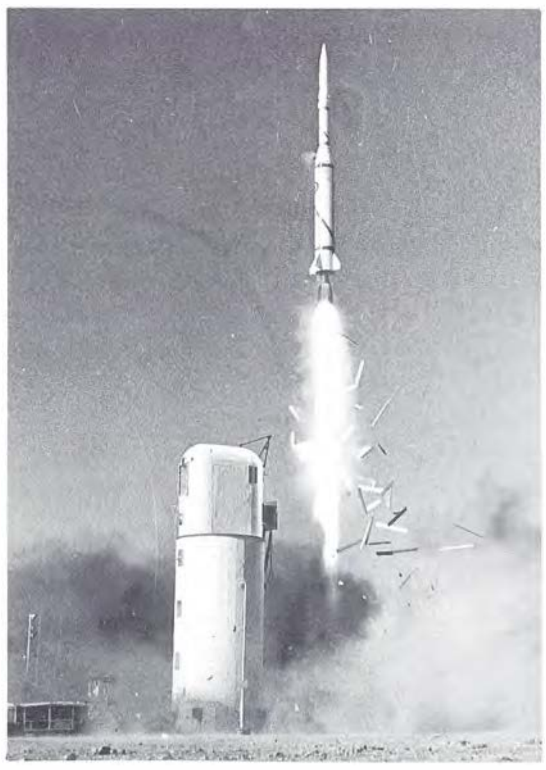
Pierre Usunier

Director of the Ballistic and Space Systems Division, Aérospatiale, Paris

So twenty years have already passed since the beginning of European cooperation in the space sector... Even in 1963 it was clear to the aeronautical industry that space was a major issue, but who would have thought that less than twenty years later we would have changed our name from 'aeronautical' to 'aerospace'? From 1963 onwards there was an awareness that cooperation within Europe was a necessity – a ladder, as we saw it then, that we needed to confront the two superpowers. However, the finalities of this co-operation had yet to be imagined, its modalities yet to be found. We knew that the day would come when space would exchange its status as a 'luxury craft' for that of an industrial activity with customers to satisfy and an operating account to balance. Here again, the 'how' was something no one knew. The European Space Agency (ESA) provided most of the background against which the industrial interests served their apprenticeships – learning not only to cooperate but also to compete. The story is a long one, and we shall confine ourselves here to a few details which seem to be significant for industry and to illustrate the problems encountered.

From competition...

Competition is already flourishing as regards the two main products of the space industry – launchers and satellites. However, the two plays have different casts. In the case of the launchers, the actors are the Agencies which have taken responsibility for developing them, ESA and CNES for the Ariane family, NASA for the expendable American launchers and the Space Shuttle. Even when, in the early days of launcher activity in France, the SEREB (Society for the Study and Manufacture of Ballistic Missiles) was responsible for Diamant, it was in effect acting as an agency. In any case, it quickly handed on this responsibility to a true agency, CNES. Attempts made by OTRAG in the Federal Republic of Germany, and by companies recently set up in the United States, are far from demonstrating that industrial companies can efficiently undertake the development of new launchers. However, industrial organisations are taking over the commercial and industrial business of selling launchers (Arianespace). The space stations and Spacelab are, and will long remain, agency matters. By contrast, satellites are in the great majority of cases developed and sold under the auspices of industrial concerns. These firms, therefore, do compete.



On 26 November 1965 France became the world's third space power with the launch of Diamant-A, which successfully placed satellite A1 in orbit

Ariane launcher in ESA's integration site at Aérospatiale (Les Mureaux).

... to cooperation

Industrial cooperation on launchers, too, takes place against a different background to cooperation on satellites. The agencies responsible exert a long-term guiding influence on every aspect of launcher activity.

They can create competition between the industrial concerns – testing their technological creativity when concepts are being studied and projects drawn up, and their industrial capabilities when it comes to putting theory into practice, but, in the end, they form a group of industrial partners who are 'selected' and not just thrown up by worldwide competition. By way of example we might recall that the industrial structure for building the Ariane launchers was forged by CNES and ESA.

The major American industrial concerns have shown that in the satellite field, coordination through an agency is not always necessary because they have the facility to choose and work directly with subcontractors and to sell their satellites on a competitive market. The genesis of Europe as a space power has largely been through agencies, and has resulted in narrower industrial specialisation than has been the case in the United States.

Nevertheless, it is sometimes more expedient to offer certain clients, for example major international organisations (Intelsat, Inmarsat, etc.) tenders putting forward a trans-national grouping. Thus even the American manufacturers have become involved in cooperation, notably with the Europeans and Japanese. It is worthy of note that the cooperative tenders (among which we may instance Ford's offer for Intelsat V) have proved competitive even as regards price, and that Hughes Aircraft also followed the cooperative path in tendering for Intelsat VI.

'Fair return'

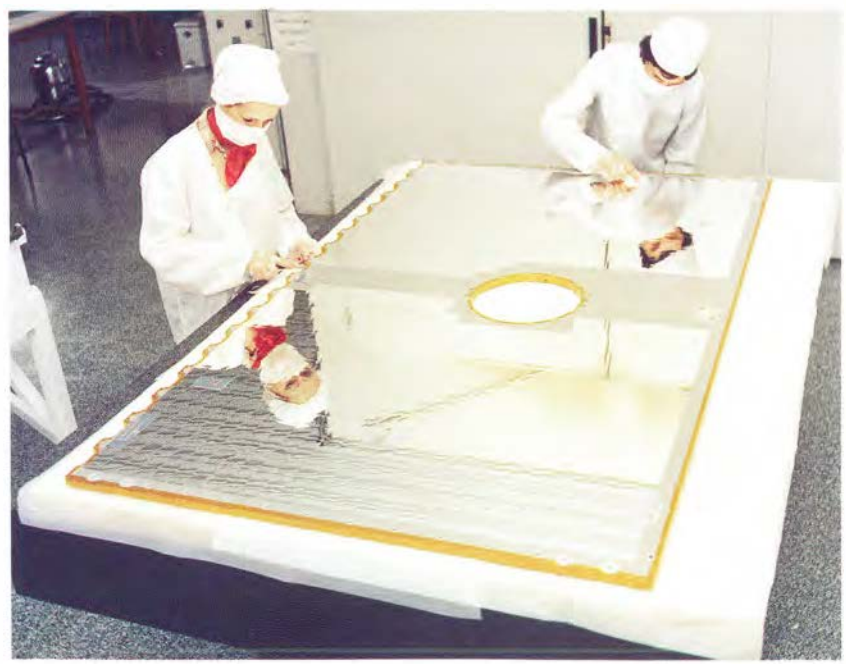
Industrial cooperation in Europe has been dominated by the principle of 'fair return'. In simple terms, this means that the technical and economic spin-off from the programmes financed should 'fairly' return to the various countries in proportion to their respective financial contributions. In the first place, this rule protects small countries against the real or imagined 'imperialism' of larger nations, and preserves a certain balance between the latter. A manufacturer has no reason to philosophise about a rule imposed by his customer when that rule is not 'against public policy'. He must comply with it when dealing with ESA in the same way as he complies with other rules when he offers his products or services to his other customers, but neither ESA, as the principal, nor the manufacturer should be blind to the possible counter-productive effects of the principle of fair returns. It can lead to parcelling-out of tasks, to the point where subdivision becomes 'mincing'. Technological interfaces become political, and managing them proves a very difficult task. Prices rise and competitiveness declines. The rule can also lead to excessive specialisation, bringing about a threat to a manufacturer when the one thing in which he has specialised becomes useless or obsolete. More subtly, the rule of fair returns has sometimes played a negative part in relations between prime contractors for a project and those who supply components for it, i.e. subsystems. Some European hardware suppliers had developed, with the encouragement of ESA or under contract to it, interesting technological solutions which those with overall responsibility for projects wanted to take advantage of by using them in those projects. In several cases they have been prevented from doing so because prices were still too high (the law of competition) and/or because the supplier in question was based in a country which would have benefited too much under the law of fair return.

European manufacturers have survived the excesses of the rule of fair return. The fact is that these excesses were tolerable. As the rule of fair return is one of the, probably intangible, modalities of European cooperation, it must be applied, but with discretion.

Advantages and disadvantages of consortia

The consortia have become a privileged factor in the European interplay of cooperation and competition. These informal organisations – born of the need for long-term cooperation between complementary resources, containing a careful balance of nationalities and specialisations, and based on previously existing habits of cooperation – were recognised by ESRO, then by ESA. In fact, ESA's major invitations to tender for satellites have been addressed to the three consortia set up around 1970. In responding, the manufacturers divided up the work to be done by mutual agreement, to be able to submit tenders which were attractive in terms of technology, price and delivery dates, and which were also in line with the rule of 'fair return'. The need to submit a quality tender acted as a stimulus to cooperative efforts by subordinating egoist reflexes to the obvious common good: winning the tender, supplying a satellite which would have a long and efficient life in orbit, and not losing money. Having served their apprenticeship, the partners gradually learnt to appreciate their colleagues, to listen to the voice of reason and to accept sensible compromises. Gradually, mutual confidence triumphed over misunderstandings and, sometimes, grudges. For the first time the frontiers between groups of industrial companies had followed different lines from national frontiers without producing multi-national companies as a result. A lingua franca grew up which was based on English, though it was impossible to swear that it actually *was* English. Clear testimony to the success of the method is provided by the fact that members of the same consortium elected to work together in the long term on more industrial ventures which were free of the European rule of 'fair return'.

Nevertheless, the consortium system does have obvious disadvantages. It leads to widespread splitting up of responsibilities, leaving each of the participants no more than a modest share in the overall programme – barely 25% for a prime contractor responsible for integration, and at most 10% for a contractor involved at subsystem level. The type of competition it



Optical solar reflectors are bonded to the Intelsat V structural panels by Aerospatiale's technicians to ensure the spacecraft thermal control

... impossible to swear that it actually **was** *English!*

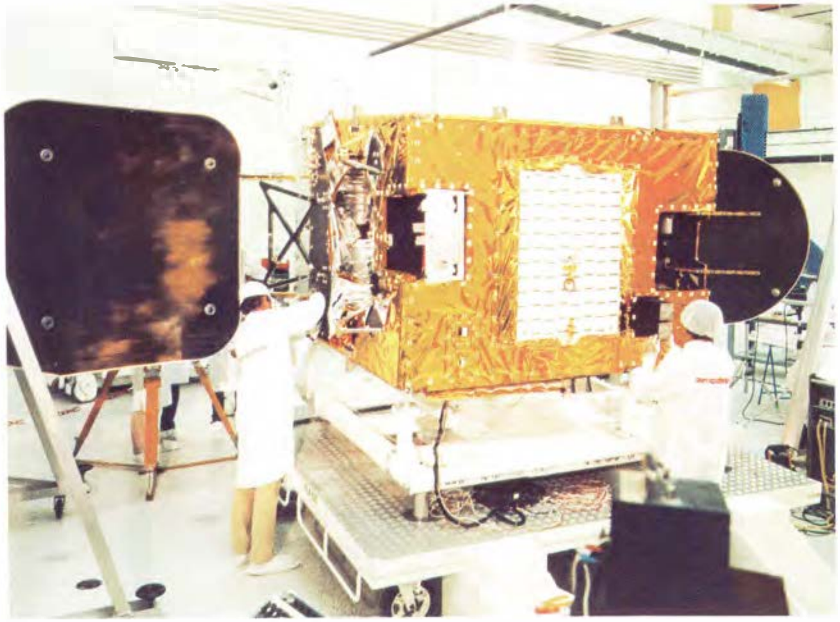
introduces is not direct preparation for the competition that will have to be faced at major international level.

The consortium system has also exposed limitations in the satellite programmes, where ESA was induced, for reasons of technical or industrial policy, to impose the use of certain equipment and hence to cause a significant disturbance of the free play of the consortium mechanism. The influence of States, through their representatives, has also helped to diminish the purity of the interplay of the consortia, principally in cases where States have been involved at a level which justified them in taking a particular role, but, that said, the consortia have left a valuable and enduring mark on the development of European space industry.

The Europa saga
Is cooperation a stimulus or a handicap when it comes to supplying a high-quality and, in particular, ultra-reliable product? Let us start by considering a melancholy case in point. The Europa launcher programme was abandoned after the failure of Europa I (F9) on 12 June 1970, the premature discontinuation of the Europa II after a single test (F11) on 5 November 1971, and the abandonment of Europa III in 1973. What was most notably lacking was any unanimity of opinion among the Participant States as to the finality of the programmes. Was a European launcher needed, or would it be necessary to fall back on the goodwill of NASA for the launching of European payloads? Above all, technical difficulties and the overrunning of financial budgets were the essential factors contributing to the decision to stop the programme. It was clear that the inadequacy of the overall project systems management was a bitter handicap to Europa I, which was more a pyramid of separate stages than an integrated launcher. Programme management techniques among the manufacturers were rudimentary, and interface management was weak. It would have been unfair to condemn European cooperation on the basis of this single case. Fortunately, these handicaps have subsequently been corrected. By the time of Europa II, great efforts were being made to set up effective programme management, and these efforts have since been sustained. The end is not yet in sight, as long-term organisational improvements are still needed to trace the causes of failure and to produce, without delay, the necessary reliability.

Rigorous management = quality factor
At the systems management level, cooperation calls for exceptionally detailed definition and a minute description of the component tasks and their interfaces, so that no lack of coherence

Intelsat-V spacecraft.



Arabsat being integrated by prime contractor Aérospatiale.

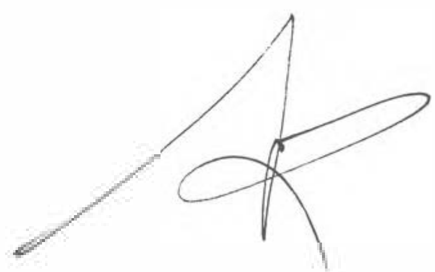
should be able to compromise the integrity of the whole. Any modification carried out locally must be considered not only in terms of the subsystem to which it applies, but also in terms of its repercussions on adjacent subsystems. This elimination of grey areas and ambiguities of definition has a beneficial effect on the quality of the product, and is indispensable when the cooperating teams are working in widely separated locations. The thermal equipment of the Intelsat V satellite was made on the Côte d'Azur, while the project management team was in California. Both the initial definition and the inevitable modifications went virtually without a hitch. Management methodology has been enriched by the introduction of new methods of transmitting information at high speed (teleconference, facsimile, data transmission, etc.).

Because of the strictness it engenders, then, cooperation is a quality factor. It fulfils the same function by means of the discussions it produces on the choice of the most suitable participant to perform a given task with maximum efficiency; and, again, by means of the mutual assistance the participants render one another if one element of the programme is causing problems.

Of course, cooperation has its price. Scrupulous work means expensive work, but, then again, what could be more expensive than that lack of foresight which causes belated exposure of major defects, entailing a chain reaction of catastrophic modifications?

Further evidence that cooperation, properly run, is a quality factor can be found in the success of a large number of projects, not all of them European, where cooperation has played its part.

When he casts an analytical eye back over a long period, a responsible representative of a State organisation or a manufacturer is sometimes tempted to make light of the problems he has encountered. What could be more natural? Solving problems, keeping the machine moving forward – these are the essence of his job. Similarly, reflecting upon the modalities of an activity is indispensable to increase its efficiency. When the eye that is cast back is a corporate one, one gets a better view of the road behind. These past twenty years have brought us to technological and industrial maturity, and have enabled us to create the framework within which our work for and with ESA will continue, as will our role as manufacturers exporting to customers all over the world.



Dornier System and ESA

Dr. Helmut Ulke

Dornier System GmbH, Friedrichshafen, Germany

The first successful launches of satellites in the late fifties evoked strong interest in the use of this new dimension 'Space'. All European countries intensified their considerations and especially the prominent aircraft developing countries of the past acted promptly in defining procedures and concrete programmes.

Historical significance

For Germany the year 1962 was of historical significance when the government passed a four years budget proposed for its first space programme. This national budget included already a considerable share (more than 50%) for the contributions to the European organisations ESRO and ELDO. In the same year Dornier System was founded as an independent subsidiary of Dornier, first of all aiming at the development of space technology and its application to different systems. Accordingly, there was major Dornier involvement at that time in the areas of basic technology investigations, sounding rocket manufacturing with special emphasis on recoverable systems like the paraglider, and payloads, subsystem design for satellites and launchers and construction of ground facilities.

With the backing of experience gained in national contracts Dornier System was, from the first minute on, interested to become a contractor of the European Agencies as well. Our young team of engineers interfaced with the excellent European team recruited from all European countries and concentrated in two technical groups. In addition competition increased tremendously due to the number of competing companies of ESRO's Member States.

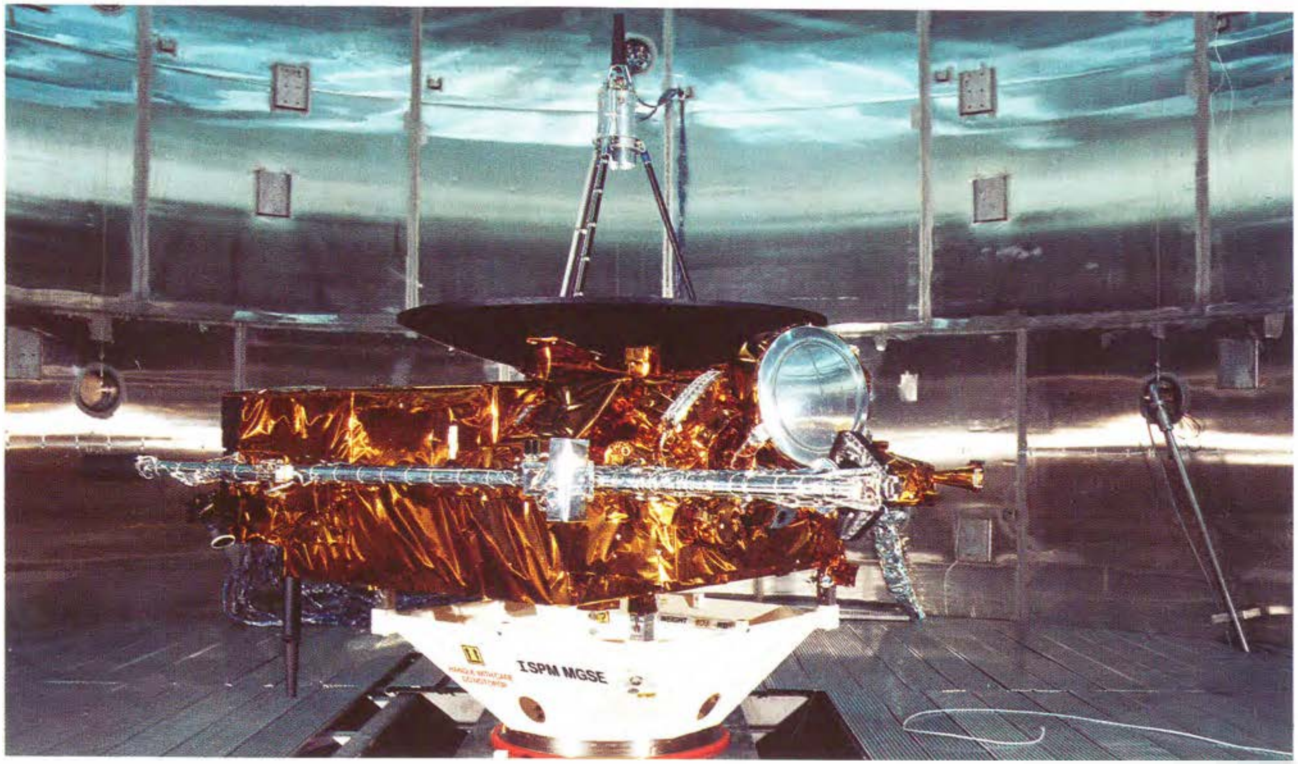
It was this challenging situation, educating our engineers and improving our techniques under the guidance of these European teams, which after a 'learning' period of about five years led in 1968 to Dornier System's first important prime contract: the integration of 20 sounding rocket payloads, five each year between 1968 and 1971. In the same period we were selected as prime contractor for our national satellite Aeros (1969) and participated in many additional European and national contracts. On 22 January 1972 our hundredth sounding rocket payload was successfully launched at Kiruna in Sweden.

... pupils had become accepted partners ...

Accepted partners

The first European satellite prime contract ISEE (leading the STAR consortium) and the remarkable participation in the Ariane and Spacelab developments in the years around 1972 demonstrated a milestone in the evolution of our company. Dornier System teams had proved their suitability and their capabilities for space activities; pupils had become accepted partners of the ESA team.

During the period of the last ten years ESA and Dornier System have established an excellent cooperation. It was basically this cooperative climate which gave Dornier System the chance to



ISPM spacecraft (Dornier as prime contractor) in ESTEC's Dynamic Test Chamber.

support ESA in their continued efforts to educate smaller companies of countries which entered later, and with smaller shares in the European space activities.

Especially in the scientific field we practised this educational transfer of European space procedures and technologies to relevant companies as one of the leading system companies of the STAR Consortium.

Included in the earliest space programme considerations had been the ideas of those with commercial interest in space technology towards possible application satellite systems. But after all the painful efforts in the seventies — especially of the European Space Agency – to convince potential customers of the advantages of space systems, nobody expected the overwhelming success of space communication systems experienced during the last few years.

New competitive objectives
Nowadays in the mid-eighties this commercialisation changes rapidly the complete scenario of space in Europe. New customers appear with yearly budgets of about the same order of magnitude as ESA, commercial demands call for small and effective company groupings. Some ESA rules have lost their general validity; prime contractors have to orientate themselves for new, competitive objectives; international cooperation and worldwide demands require reconsideration of everyone's position and interest.

Nevertheless the European Space Agency will continue to have a most important role for the further evolution and commercial success of European space business. New and enormous tasks like the permanent presence of man in space are just being recognised, and first projects started. More powerful European launchers will have to be developed by the Agency to launch future satellites.

It is Dornier's goal to remain a reliable industrial partner of the Agency for the years to come and to contribute our share to the continuation of the excellent performance of ESA for future European space projects.

Spacelab – European cooperation without duress

Hans Hoffmann

ERNO, Bremen, Germany

In 1973 when the decision to go ahead with the new European space programme was taken ESA was, de facto, created. With the development of Spacelab within the framework of a transatlantic cooperation a completely new element had been decided for the European space activities of the seventies. Launcher development and satellite development had been carried out by ELDO and ESRO during the previous ten years, but in this early period the contacts with the United States had largely been of necessity, concerned with the launch of European satellites on US launch vehicles. Because of this, an interface coordination between the launcher and the payload had been required and the European satellite makers had, to a certain extent, to participate during the launch campaign.

With Spacelab however, Europe embarked in 1974 into a new dimension of cooperation with NASA and US industry. On the European side ten countries decided to cooperate; nine of the founding members – Sweden being the exception – plus Austria.

In this environment ESA decided to conduct the Spacelab programme under a clear industrial prime contractorship. The money for the development of Spacelab was given to the prime contractor who had the responsibility for the further distribution to the co-contractors and subcontractors. At first sight this seemed to be an American approach as this kind of management solution was known only from the other side of the Atlantic. On closer scrutiny, however, one had to recognize that the prime contractor was not free to select his co-contractors and subcontractors but had to respect the geographical distribution given by the participating governments.

This selected management solution, however, was a tremendous step forward in the management scheme of the European space programmes. It gave a clear interface between the customer and the industrial contractor, and it created for the prime contractor the possibility to utilise the money as a controlling management element vis-à-vis the co-contractors. A similar arrangement existed between the co-contractors and the subcontractors and suppliers.

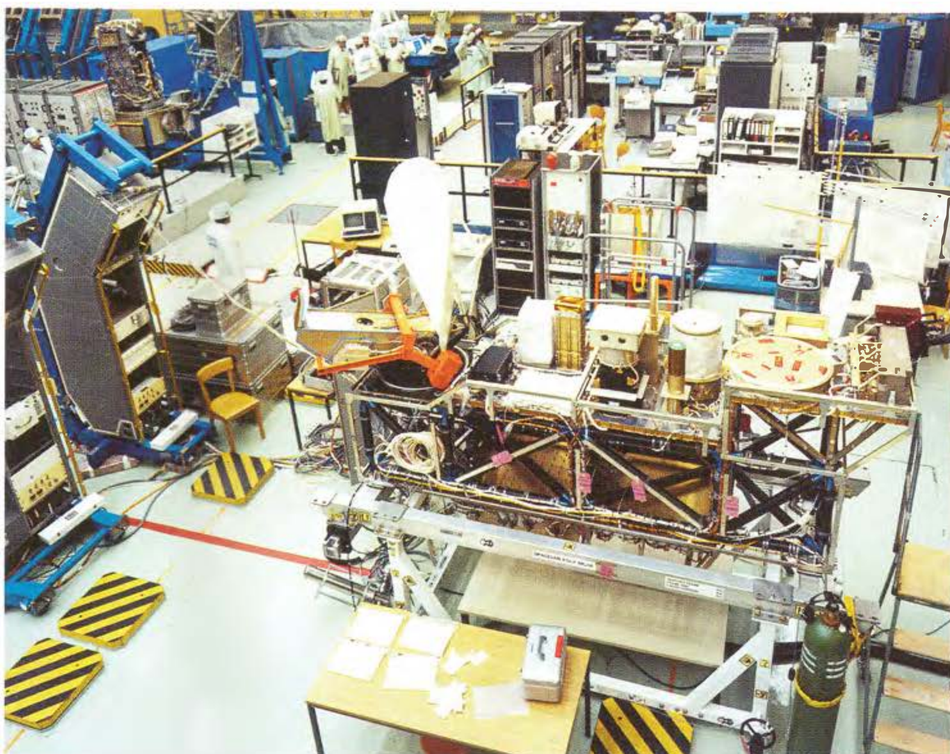
This all seemed to be a very clear and forceful management solution. However, this scheme would not have worked without the good will of each partner playing his allotted role. For this reason

Hard mock-up of Spacelab pressurised module in ERNO integration hall (Bremen).

The prime contractor had to respect the geographical distribution ...

ERNO proposed to form a Board of Directors outside the official contractual relationship between prime contractor, co-contractors and subcontractors in order to create a voluntary platform of top management people to support the programme. This board was in fact created during the period of the proposal preparation, i.e. before the contract award, in such a way that the proposal could be presented to ESA with a board of this kind already functioning.

The board has been chaired throughout by the Chairman of the Board of Administration of ERNO and it accepted the discipline of conducting the meetings, of the regularity of the meetings, and of the different roles within the meetings, which are normal for boards of a legal or functional status within an organisation. From the beginning the board functioned well. It took up important issues which inevitably accompanied the large project through all its phases and through all its problems. In this capacity it has served its purpose extremely well.



Assembly of first Spacelab module.

First Spacelab Payload during preparation at ERNO.

Meetings were held in turn at the different consortium members' establishments such that each member had the opportunity about every tenth meeting to host the board and to take the occasion of such a meeting to show to his colleagues the progress of his work on Spacelab, and the other activities taking place within his company.

In this way the feeling of equality among those participating in the Spacelab programme was created and each member understood the individual responsibility he was bearing for the success of the whole.

The good spirit of cooperation in the Board of Directors reflected also in the working relationship of the teams in the companies where equally good cooperation contributed to the fruitful final result of the Spacelab development.

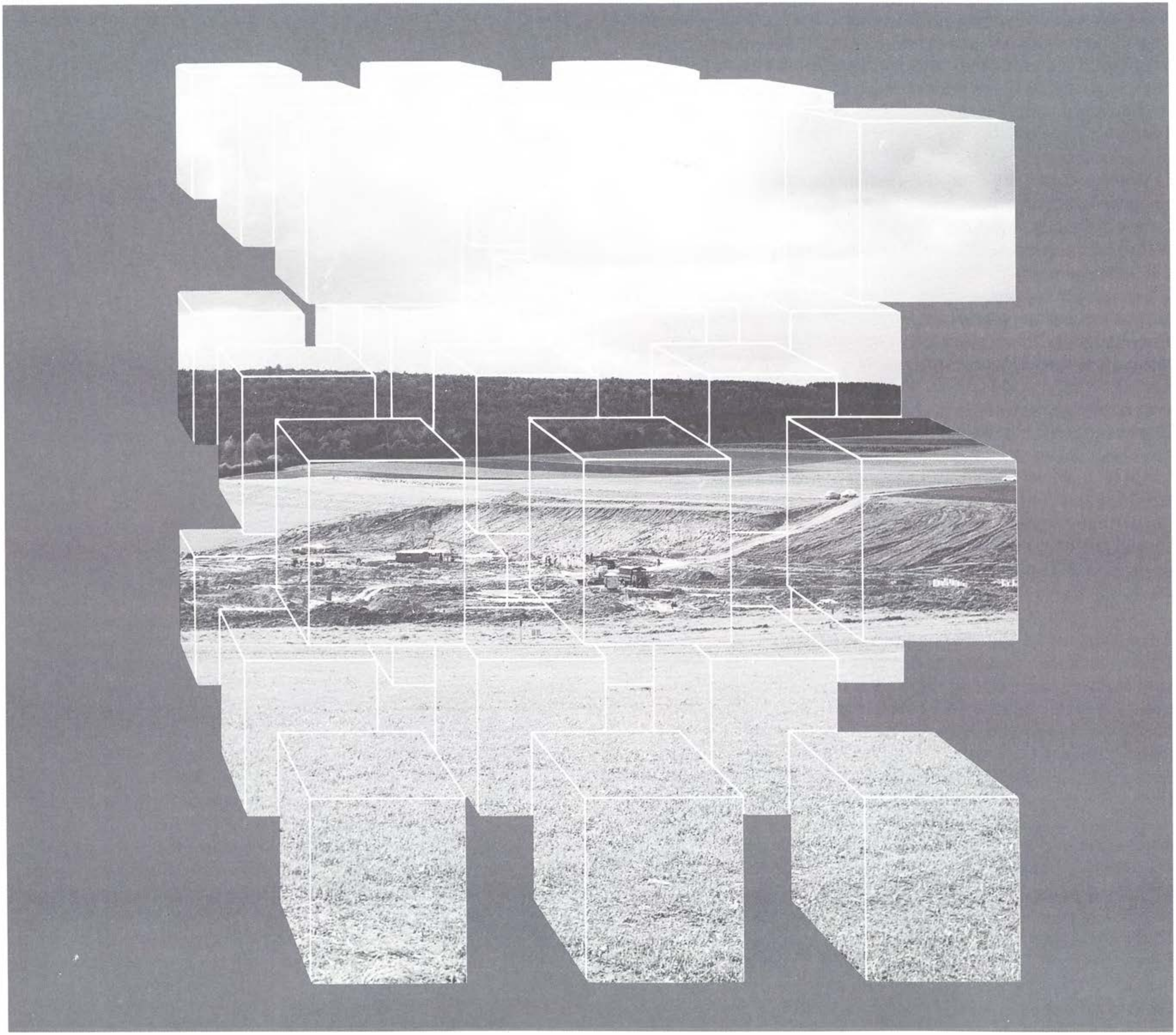
About once a year a meeting took place to which the Director General ESA, the Spacelab Director and the Spacelab Project Manager ESA were invited. This gave all parties the opportunity for direct top level contact and an exchange of ideas between customer and contractors. On such occasions the ESA representatives could directly inform all members of the Spacelab consortium about the overall situation of the project, especially those aspects not of direct concern to the prime contractor so that all were aware of the total picture to which they contributed.

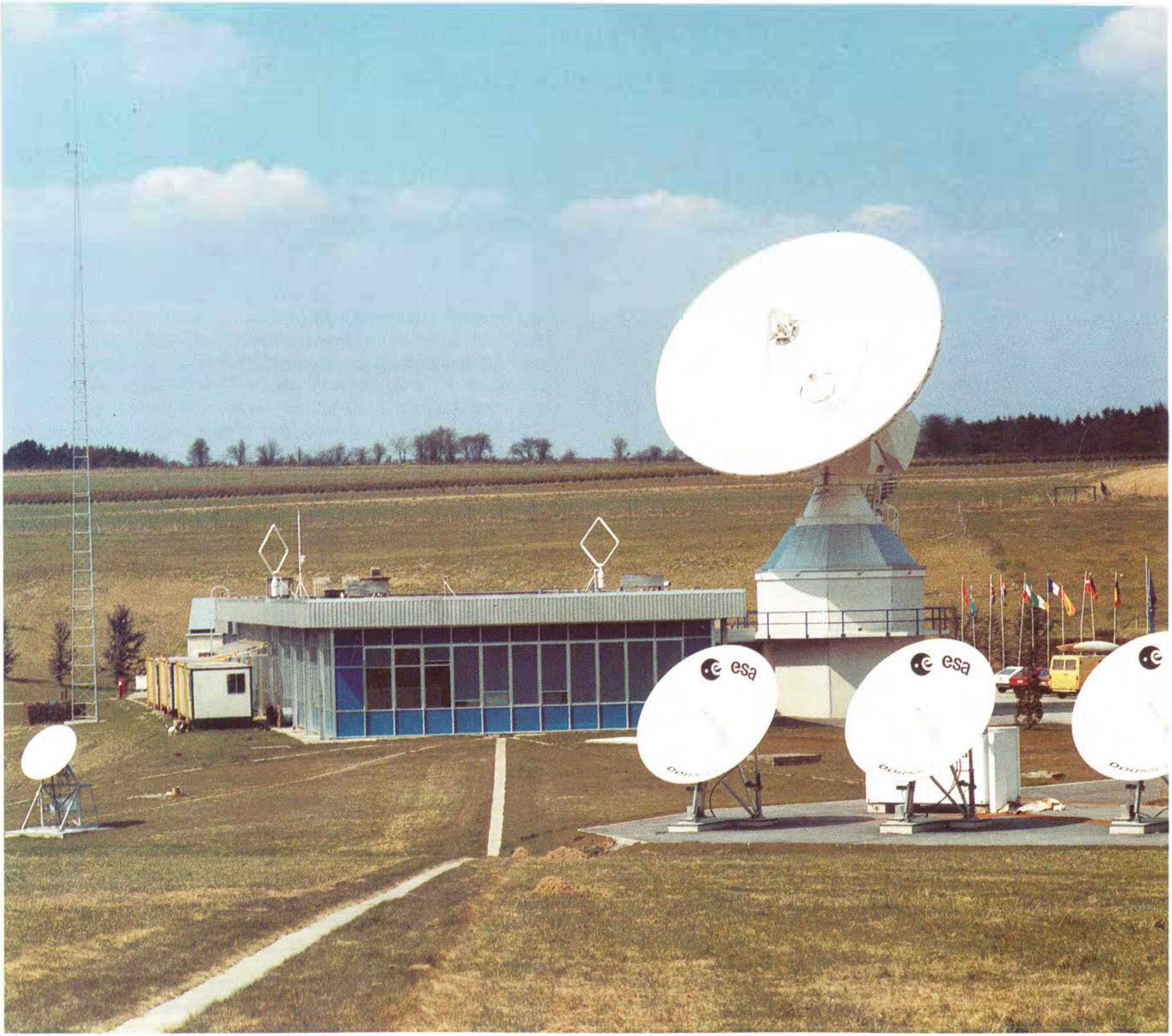
ESA payload specialist, Ulf Merbold, working on the Gradient Heating Facility of the Materials Science Double Rack during first Spacelab flight.

Keeping in mind that this institution had no legal role and no legal status within the Spacelab project one can say today that with this voluntary organism a good solution had been found to create mutual confidence, to solve problems from the top level of the companies, to sponsor a good relationship with the customer. At the same time it has been possible by good will and a clear and strong management scheme to overcome those shortcomings of the European type of prime contractorship which had been selected by ESA, especially the need to obey the present rules of geographical distribution.

In the meantime Spacelab has flown for the first time successfully, and a number of years ago the Spacelab Board of Directors decided to continue its work into the future. This meant that the Follow-on-Production Programme was approached along exactly the same lines as the initial Spacelab development. For the FOP contract a fixed price could be agreed with NASA.

Agreement had also been reached to deal with future development questions, and in this respect Eureca has found the full support of the Spacelab board during the initial phases. Today, when Europe is preparing to participate in the manned space station of the United States, the Spacelab consortium is prepared to take its role also in this big project which is the direct continuation of the Spacelab development. For the United States' representatives who have met the board at two official locations, i.e. at the Apollo-Soyuz launch and during the Spacelab I launch and landing campaign, this organism represents the united effort of the European industry to come up with the best possible technical and managerial solution for the big transatlantic space programmes in which Europe will participate.

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Maritime communications by satellite – Europe's contribution

Sir Peter Anson

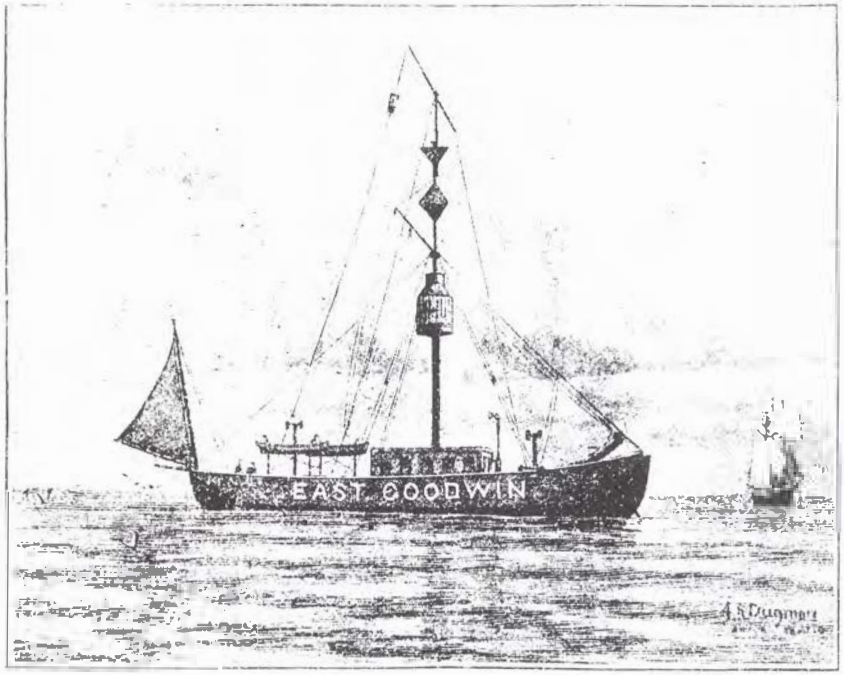
Marconi Space & Defence Systems, Portsmouth, UK

For a ship at sea, radio communications are vital for her safety and that of her crew. Guglielmo Marconi, the father of radio communications realised this and in 1899 set up a demonstration for Trinity House between the Goodwin Lightship and a shore station installed in the South Foreland Lighthouse. Later that year the SS RF Mathews collided with the lightship and, following distress signals the first sea rescue through wireless took place.

Despite improvements in equipment over the years, communications to ships at sea have never been wholly satisfactory. Operation of the system is slow and cumbersome; fading due to weather or atmospheric conditions common, and on occasions I have personally experienced total communication failure for many hours aboard ship in northern waters. The introduction of satellites has brought about a revolution in maritime communications, allowing ships and oil rigs to enjoy the same quality and range of services which we enjoy on land.

Today over the Atlantic the European satellite Marecs carries all the traffic from ships and oil rigs fitted with the necessary ship-earth station (SES) equipment through the onboard Marconi communications payload. The quality of communications can only be described as Hi-fi, the reliability virtually absolute. Guglielmo would be proud!

The European achievement in Marecs is both rewarding and remarkable. Rewarding because all the effort put into the project is clearly bringing benefit to the maritime community. Remarkable because the technical, financial and political problems which threatened the project had to be overcome in a period of uncertainty as to whether or not a satellite communications service to ships would be firmly established.



The East Goodwin lightship – used by Guglielmo Marconi to demonstrate ship-shore communications in 1899. The Marconi apparatus is seen suspended from the spar at the masthead.

Only the combined efforts of Europe through the European Space Agency could have succeeded in making Marecs the success it is, and as we enter a new phase in the evolution of ESA's programme we should learn from this experience and look for pointers for the future.

Mobile Satcoms

Satellite communications to mobile terminals such as those carried on board ships are referred to as Mobile Satcoms to distinguish them from the service provided by INTELSAT between large fixed terminals known as a 'fixed' Satcom service.

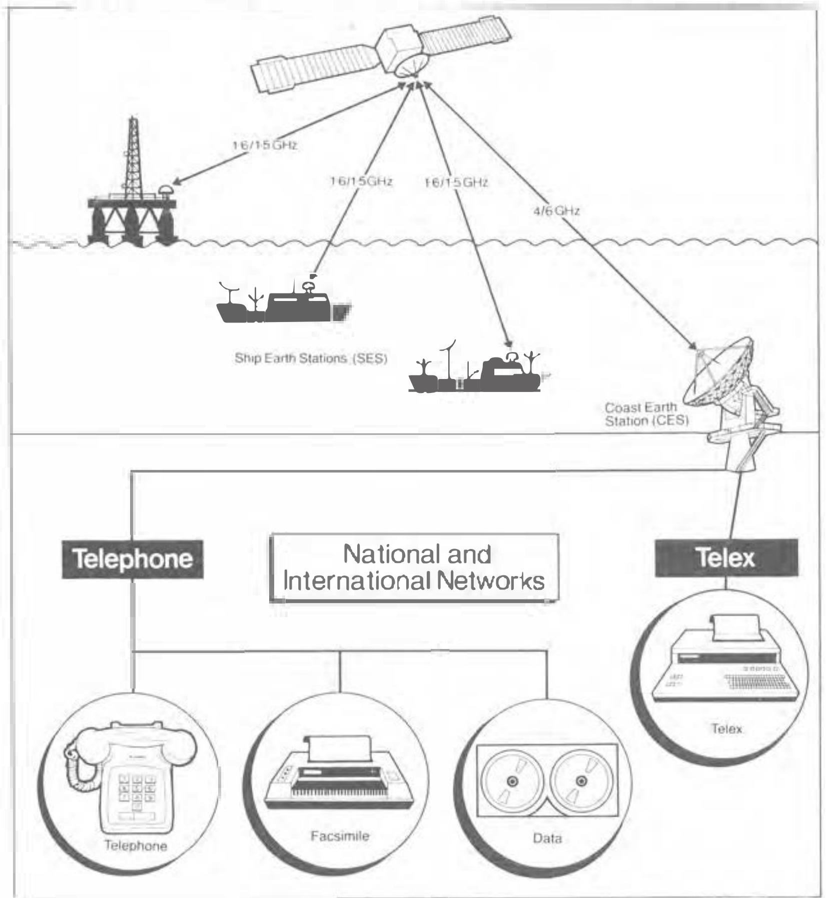
Apart from ships the mobile Satcoms service can provide communications to aircraft, trucks, indeed anything that moves and carries the necessary equipment. The system is unique in that it cannot ever be replaced by a cable system as can the 'fixed' service.

The service has clearly to be worldwide to be of value, and therefore requires a world body to manage and run it. This body is the International Maritime Satellite Organisation (Inmarsat) established in London in 1979 after some six years of negotiation within the Intergovernmental Maritime Consultative Organisation. On 1 February 1981, Inmarsat brought their system into operation. It can therefore be seen that Marecs which was launched in December 1981 had to be developed without a customer to specify the requirements, or the assurance that a customer would ever exist at all, let alone one who would want to use Marecs. ESA stepped into this vacuum and with a good deal of faith set about sizing the system, anticipating system architecture and thus arriving at the requirements for the satellite. It was probably inevitable that we did not always get them right as you will now see but the early start was essential.

Work started in 1973 on defining a satellite to be known as the Maritime Orbital Test Satellite (Marots), to be launched on Thor Delta. This was to be an experimental/demonstration satellite which would anticipate the need for an Inmarsat service. However, it did not have eclipse capability and the communications payload was specified to link the coastal earth stations to the satellite at Ku-band and the satellite to ship at L-band.

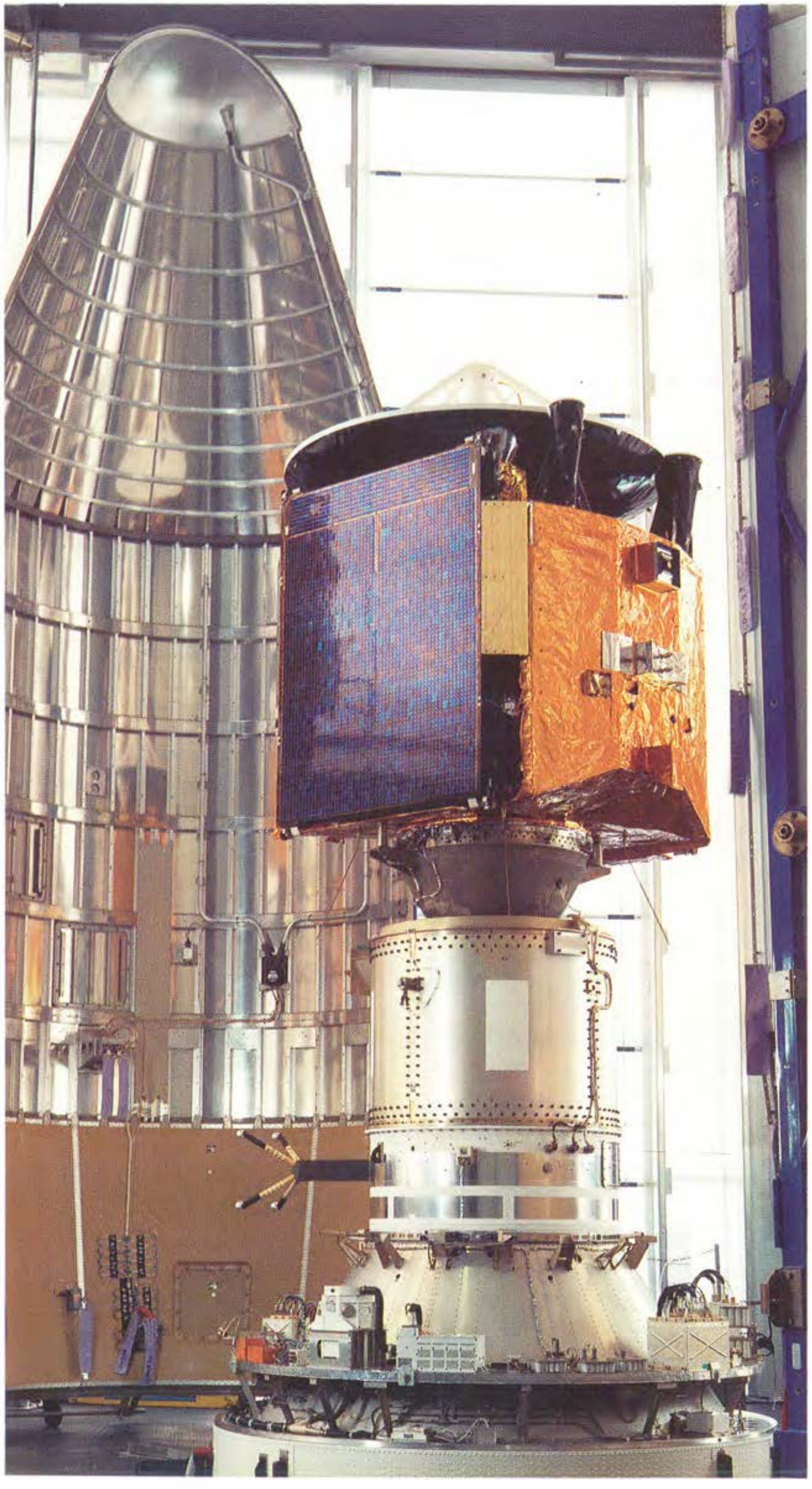
By 1977 three Marisat satellites had been launched by Comsat General (USA) providing full eclipse operation and working to coastal earth stations at C-band which inevitably was to become the system standard. It was therefore necessary to change Marots

Outline of maritime satellite communications



to Marecs (Maritime European Communications Satellite) which provided full eclipse capability and made use of the Ariane launcher. The payload communications link to the coastal earth stations was changed from Ku-band to C-band. The establishment of 'interim' Inmarsat in 1976 supported by 28 countries (later 38) increased confidence in the ultimate demand for Marecs, so two satellites were ordered, Marecs A and Marecs B.

The next hurdle to overcome was the preference expressed by non-European countries for the Inmarsat service to be provided by Intelsat V satellites. Stirred into this argument were claims that a



mobile Satcom payload carried piggy back on an Intelsat satellite must be cheaper than a satellite dedicated to Inmarsat. This was countered by the disadvantages of shared satellites in which the payloads may have conflicting operational requirements. The real driving factor is of course the amount of traffic to be carried and at this time there were less than 500 ships equipped, and only three coastal earth stations operational. No one knew whether or how the demand for the service would develop. Eventually an agreement was reached by which Marecs A would service the Atlantic Ocean Region (AOR) backed up by an Intelsat V, the Pacific Ocean Region (POR) would be served by an Intelsat V backed up by Marecs B and two Intelsat V satellites would cover the Indian Ocean Region (IOR).

Thus ESA had guided Marecs through the period of great uncertainty when the technical requirement was not fixed, the customer newly established and not knowing if and how traffic demand would increase, and a strong lobby was insisting that INTELSAT should provide all the required satellite capacity.

The technical challenge

The essential difference between mobile Satcom systems and others is that the transportability of the ship-earth station, its robustness and need for simplicity have all to be compensated by the capability of the satellite in the communications link. In fixed service systems the opposite applies, that is the costs and complexity of the space segment are minimised by providing sophistication in the ground stations.

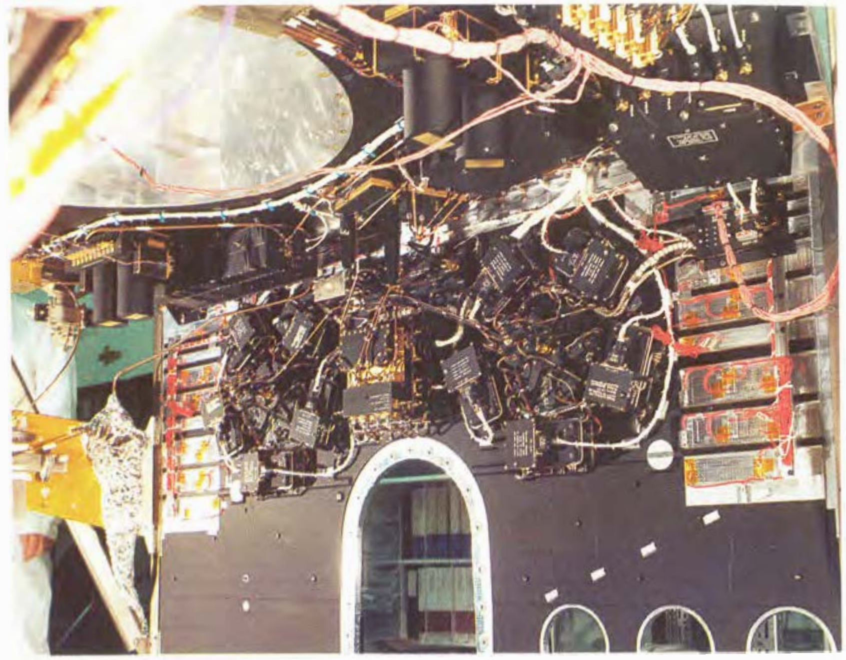
For a service to mobile terminals the most critical part of the overall communications link is the 'forward link' between the satellite and the mobile terminals. The mobile terminal antenna is small and has low receive performance. At the same time the power available from the satellite is limited by the need to provide an economic number of channels, within the physical limitations of the solar array and the requirement to provide global coverage.

Marecs A satellite, on the Ariane launcher, prior to launch.

It will be recalled that a fixed service system 'knows' where the sophisticated ground terminals are positioned and can therefore use shaped coverage beams from the satellite to serve the high traffic regions. The result is that a fixed service satellite like Intelsat VI dedicates only 5 mW of power to a telephone voice channel, but provides 33 000 such circuits within a bandwidth of 3 GHz.

By contrast the mobile system has to serve simple terminals which could be anywhere within the global coverage of the satellite. To do this about 1 W of RF power is used for each channel of voice communication. A further penalty is that the bandwidth available for this service is 4.75 MHz, and to use this efficiently and avoid intermodulation products at these relatively high powers the L-band transmitter must be highly linear and this reduces its efficiency to 25 per cent. Put another way, this means that if the communications DC power of Intelsat VI (1500 W) were dedicated to providing mobile service channels, less than 300 would be available compared with 33 000 fixed service circuits.

The critical L-band transmitter for Marecs was developed by Marconi. It is a high-power transistorised power amplifier (TPA). The major feature of this design is that the critical power amplification takes place in a number of modules whose outputs are combined. This helps to solve the problem of dissipating the heat from the TPA. Only three modules from each of two groups of five are required to give full output and so high reliability (graceful degradation) is achieved.



The L-band transistorised power amplifier (TPA) key to the critical link from satellite to ship station.

. . . communications to ships at sea have never been wholly satisfactory . . .

During the development of the TPA several major technological problems arising from multicarrier operation have been overcome and proved in orbit. These were principally the achievement of linearity and efficiency, the control of ripple currents, the elimination of potential multipaction and gas discharge breakdowns, and the suppression of the products of passive intermodulation.

A success story
All the hard toil, persistence and faith have borne fruit. Marecs A communications have performed faultlessly since it was launched in December 1981. No doubt the quality of service has helped generate the confidence of ship owners to invest in ship-earth stations at a time when the shipping industry is very depressed.

Example of equipment used on board ships as part of the Inmarsat ship-shore communication system of which Marecs is an integral part.

Over 2000 ships are now fitted and by 1984, 23 coastal earth stations will be operational. The 60% traffic growth in the first year of Inmarsat leads to a forecast that by 1988 the 40 telephone channels provided by Marecs will no longer be sufficient and so Inmarsat has invited proposals for satellites able to provide 125 telephone channels. These satellites will be able to service aircraft and carry data at 56 Kb/s for the oil industry as well as detect signals from distress buoys which automatically start transmitting when they 'float' off a ship in distress. Such is the confidence in the Inmarsat system that the Safety of Life at Sea (SOLAS) authorities are ready to accept satellite-ship-earth station equipment in place of the traditional high-frequency equipment which has been standard for many years.

ESA has been the catalyst for developing and introducing new space systems to serve Europe at a time when the user community was not yet organised to define, procure and fund its requirements. This activity has brought enormous benefits to our industry as well as the provision of services through systems such as Meteosat, ECS and Marecs. Marecs has been the first to become commercially operational and international in the widest sense. The ERS-1 programme is a continuation of this role and perhaps a navigation system which also offered communications to the polar regions is a candidate programme for the future.

Peter Quinn

'Twenty years after'

Jean-Luc Lagardère

Chairman and Managing Director of SA MATRA, Paris

Twenty years is the age at which to draw up the first balance sheets and plan major projects, for men and for the space industry, in Europe.

In twenty years, European space programmes and the European space industry have undergone four important metamorphoses, in which the European Space Agency has played a decisive part.

Learning the ropes

The late sixties were devoted to programmes which gave industry the opportunity to 'learn the ropes' of dealing with spacecraft. In those days, one still talked about the 'conquest of space'. Everything had yet to be invented: the techniques, technologies and industrial structures which would enable the various companies to cooperate across the barriers raised by nationality, language and personal interest. The establishment of stable consortia, like MESH, from 1966 onwards was to weave a network of strong relationships at European level, relationships which still exist and which have frequently led to preferential industrial cooperation extending well beyond space matters.

This fascinating period had its failures, of course, but it also had brilliant successes like ESRO-II and TD-1A. It opened the door to the major technological and political decisions of the early seventies, when Europe decided to provide itself with the capacity to utilise space independently, with a launcher, Ariane, a pre-operational telecommunications satellite, OTS, a meteorological satellite, Meteosat, and the space laboratory Spacelab which was to enable Europe to put a man into space. Industry then had to learn to 'make operational hardware' capable of providing users with a reliable service. It also had to specialise within the limits laid down by its capacities, its strategy and the industrial policies of the various governments. In this difficult environment, already stamped by future commercial prospects, industry made ready to compete in a commercial market, abandoning the sheltered environment in which the existence of the customer justifies the existence of the industry and vice versa. Early efforts in the export field showed the ground which had still to be covered, and the importance of the domestic market as the basis for experience and competitiveness.

Learning to sell

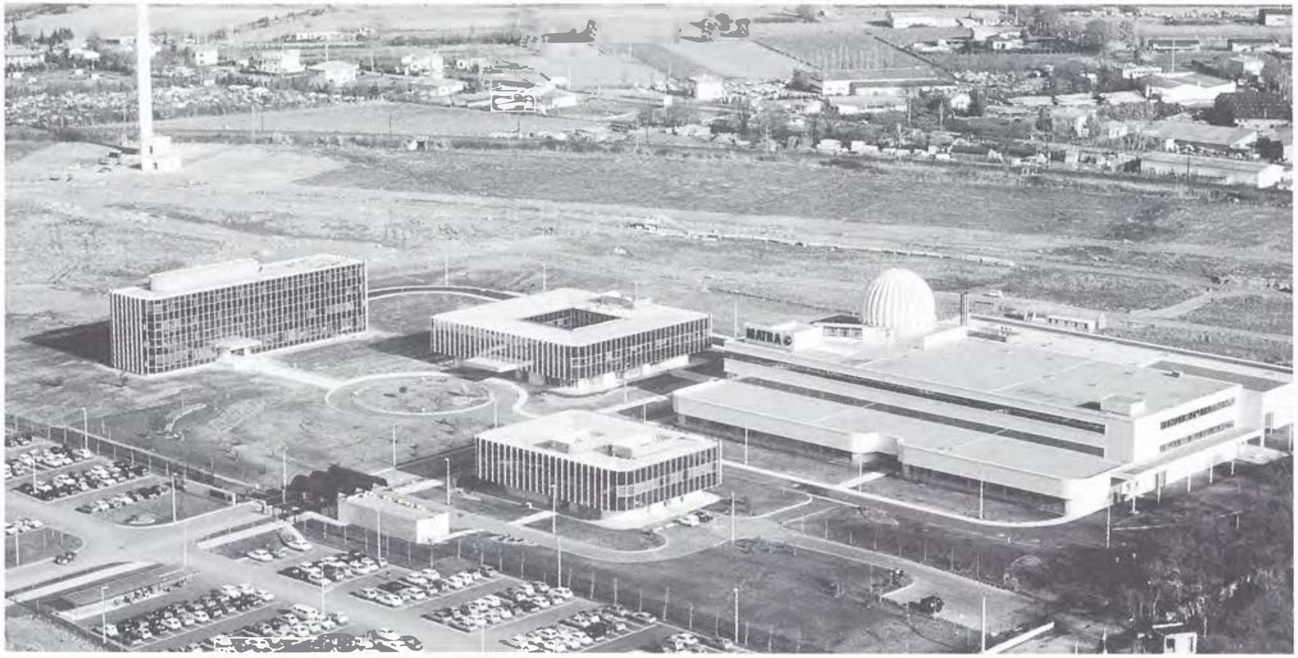
This operational domestic market was to open up at the end of the seventies. The products decided upon at the beginning of the decade were launched, and their operational offshoots went into production for customers who saw in satellites an alternative – or a supplement – to their traditional means of communication.

The Ariane family developed, with a clientele extending well beyond Europe. A specialised commercial organisation, Arianespace, was set up to promote and sell Ariane.

ECS and Marecs have taken over from OTS, and are used by two international organisations, EUTELSAT and INMARSAT, combining national telecommunications authorities, some of which, including the French PTT, have even decided to adopt a national system, Telecom 1.

Meteosat would definitely go operational, and other earth observation satellites were under construction.

For industry 'learning the ropes' was no longer enough; it was necessary to 'learn to sell' and produce a credible, competitive product. This called for industrial and commercial resources, and



View of MATRA 'Space System & Integration' Centre at Toulouse

products which were optimised in terms of customer requirements and in terms of their production and launch costs. During this fourth phase, industry had to invest money in order to ensure a presence in the future space markets; invest in production facilities, invest in products incorporating the latest technology, and invest in new, more efficient industrial organisations.

This requirement had, and would continue to have, a far-reaching influence on the space industry, as the sums at stake were very large in terms of a space market, which was still too limited in Europe, and worked on low profit margins.

To break into the export markets, therefore, the existence of national markets and the active support of the national authorities became essential to counterbalance the advantages gained by our American competitors.

Their domestic market, not only civil but in particular military, enabled them to develop technologies far in advance of civilian requirements, and prove those technologies in orbit.

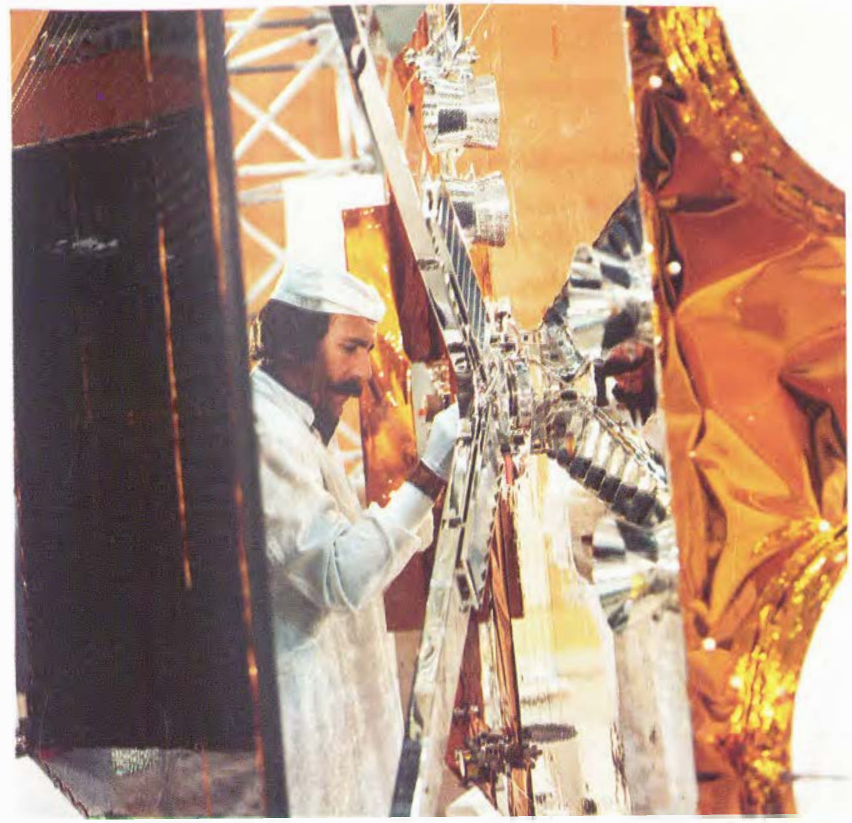
The size and the characteristic features of this market enabled every American manufacturer to have sufficient capacity available, internally, to produce most of what was needed for a satellite whilst still obtaining a reasonable return on his investment. Americans could thus export at marginal cost.

The bringing together of major European industrial concerns should thus have made it possible to make more economical use of human material resources. On the contrary, the absence in Europe of a market resembling the American market created problems when it came to keeping technologies abreast of the state of the art. In fact, the understandable conservatism of the operational satellites' customers meant that it was impossible for technology to be pushed ahead sufficiently quickly.

It is amusing to note that the same methods used now, were also used 20 years ago, by the European Space Agency among others, to help set up a space industry, namely a combination of scientific programmes, and technological satellites. The latter were to become an essential element in sustaining advanced space technology in European industry, as they would make it possible to develop, and prove in orbit, the necessary technologies for the future operational satellites.

Hence the importance of scientific satellites such as Hipparcos for an industry attempting to capture a significant share of the international commercial market.

ECS solar array deployment mechanism



A gamble on the future

But the eighties will not be just a period of consolidation and exploitation of existing product lines. Manned flight and the manufacture of equipment in space are opening up a vast field of activity, from which it is important, both politically and industrially, that Europe should not be absent.

After the notable technological and political success of Spacelab, there can certainly be no further question about the value of putting men into space, nor is there any doubt that manned space stations will exist and will also make use of robots.

This need to put men and results into space, and bring them back to earth, will mean that a new generation of reusable launchers has to be developed in Europe.

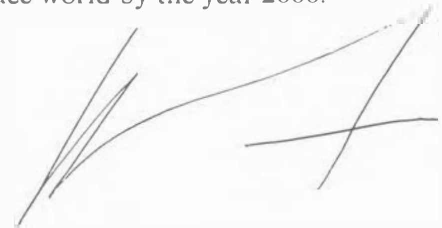
In time, certain manufacturing industries are bound to benefit from the space environment, the most likely ones being the pharmaceuticals and components industries.

'They're demanding equal rights, captain, plus a shipment of female robots and a signed photo of Isaac Asimov for their mess'

What we are talking about here is a gamble on the future, but the history of modern industrial society has been based on gambles: the cinema, the radio, the telephone and space all show us the value of an open-minded approach to new technologies.

Europe has proved its ability to deal with the challenges made to its independence, and the European Space Agency its ability to combine national efforts by setting itself ambitious objectives.

Bearing in mind the political, economic and industrial stakes involved, Europe in the space age should similarly set itself ambitious targets and do so as soon as possible, if it is to enjoy its due position in the space world by the year 2000.



Christian Rovsing A/S's rapid expansion – An outcome of the company's work with ESA

Christian F. Rovsing

Christian Rovsing Ltd., Herlev, Denmark

It all started in 1969, when Christian Rovsing A/S sent three software specialists – then 10% of the employees – to the European Space Research and Technology Centre, ESTEC, in Holland. These specialists were followed by more, and within a few years the company had 30 engineers working at the various ESRO sites.

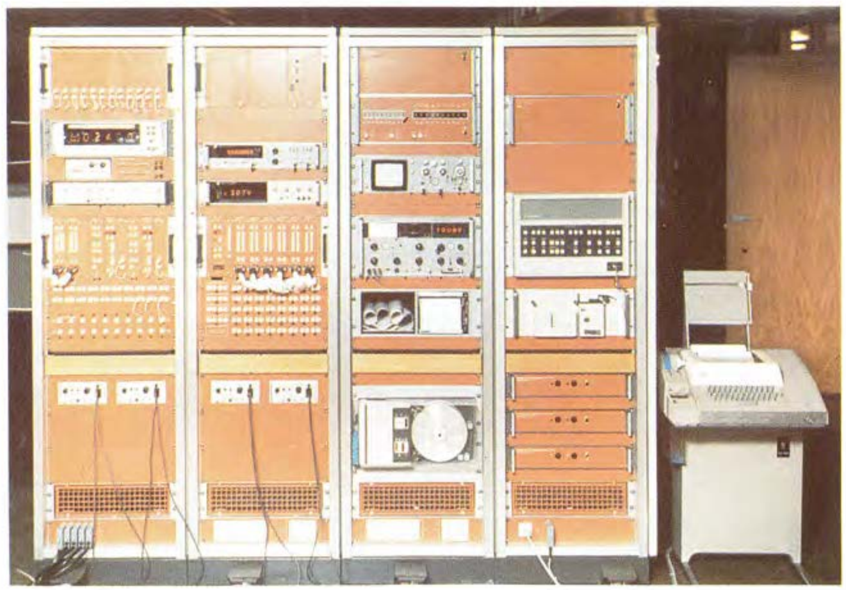
In the beginning of the 1970's, the company was awarded a number of ESRO contracts involving development of both ground systems and space electronics. Christian Rovsing A/S realised the strategic importance of space projects, and decided to increase its involvement in this area. In heavy competition with major European electronic and data processing companies, Christian Rovsing A/S won a series of important contracts. This involvement was the backbone of the expansion in the late 1970's.

Today Christian Rovsing A/S, founded in 1963 as a systems house, is a company of approximately 1200 employees. To a large extent, the company owes its rapid expansion to a number of ESA programmes.

The CR80 computer family – a spin-off from space technology
Today the company's main products are computers. The CR80 computer family is a fault-tolerant multiprocessor system, used worldwide for data communication, process control, administrative data processing, and word processing.

CR80 originated from the Automatic Power System Evaluation Facility, APSEF, – a computer controlled station for testing satellite power distribution systems. The APSEF system was used for testing equipment for the Meteosat and Geos satellites. It was delivered to ESRO in 1973. APSEF required design and construction of a bus system, which was later used in the first CR80.

Another important milestone in the development of the CR80 was its use as an array processor for handling data from the meteorological satellite, Meteosat, in real time.



The Automatic Power System Evaluation Facility – APSEF – a computer-controlled station for testing satellite power distribution systems.

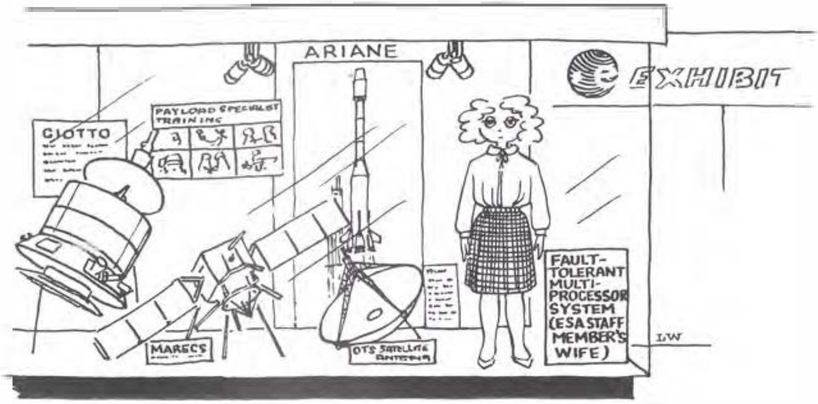
Quality control procedure – an important parameter – developed through our involvement with ESA
The competitive advantages of the computer is, to a large extent, due to its high quality, which stems from its origin as a product developed for space programmes. Through its involvement with ESA, Christian Rovsing A/S has learned to set up efficient quality control procedures, which give the customer a guarantee that the product lives up to its specifications. This is true whether the customer is from the space, military, industrial or private sector. We do not apply the same level of quality to computers delivered to all these sectors. Space quality requirements would normally make our products non-competitive for the industrial and private markets. However, the overall quality control procedures are the same. The detailed procedures are then tailored to meet the specific market requirements. Through this approach all our customers benefit from the company's experience in space programmes, without paying for a more expensive product.

Cleanliness is of specific importance for space hardware production. The company has therefore established a clean room production, which is not only used for space products, but also for other products.

'Fault-tolerant' computing – outcome of an ESRO study
The architecture of the CR80 is 'fault-tolerant': the system will continue its processing, despite the presence of a number of hardware failures and software errors. The fault-tolerant concept of the CR80 stems from a 1974 ESRO study in which Christian Rovsing A/S participated. Today the fault-tolerant feature is one of the main areas in which the CR80 has proved its superiority. It has been one of the decisive factors in winning large communications contracts for computer networks for American Airlines and Air Canada.

Fault tolerancy is one of the areas of 'reliability engineering'. Through its work with development of space hardware the company has gained extensive experience in this field.

Reliability considerations are inherent in all phases of a development project, from the conceptual phase to the final qualification and production. The engineer must consider the consequences of the failure of each part of the system, choose properly qualified components, design the necessary test tools and test procedures, and use mathematical models to predict the lifetime of the system. As an example, the company's involvement



in the production of electronic subsystems for the OTS satellite enabled the engineers to be trained in reliability engineering. This experience is now applied to all areas of our development and production.

Software management procedures imposed by ESA
Large software systems have only been developed during the last 20 years. Project management procedures have, to a certain degree, been missing in the software world. The consequences have been everything from project delays, and cost overruns, to complete disasters.

The development of the software system for Spacelab is an excellent example of how ESA has forced the European software industry to adapt the necessary procedures for controlling large and complex software projects. Christian Rovsing A/S participated in the Spacelab software project. As a result, we learned how to manage the construction of large systems. This experience gave us the necessary credibility to win a 30 million dollars NATO contract in 1980, for the construction of a complex communications system.

CR-PROCOS – a process control system developed for Ariane
A major milestone in the development of the industrial process control system (CR-PROCOS) was its installation at the second launch site in Kourou, French Guiana, for the European heavyweight launcher, Ariane. The system supervises and controls the fuelling, count-down and launch of Ariane. The installation comprises about 16 000 process signals. The extremely high

reliability and performance requirements of the system were met, and today the system represents an important marketing reference.

International project via ESA

ESA has brought together companies from a number of European countries. The companies have been trained to work together, crossing national borders and language barriers. This experience has introduced a flexibility in the European industry which is already proving successful in the Third World when Europe has to compete with the other large industrial nations. Specialists starting as contractors at the various ESA sites have turned out to have an excellent background for working in the Third World. They are experienced in solving complex problems, communicating their ideas to others, using foreign languages, and working with different nationalities.

The experience from space projects has created a major European computer manufacturer

Christian Rovsing A/S has grown to be one of Europe's most advanced aerospace and computer companies. The turnover for 1983 was 600 million Danish Kroner (approximately 46 million dollars). Exports accounted for 71 percent of its sales.

The company has come a long way since its first space contracts in the 1960's. Today, space projects are only one of the company's many activities. However, it is primarily due to the space contracts in the 1970's that the company is now ready to face the challenges of the 1980's and the 1990's. Christian Rovsing A/S will also use space projects in the future as a method of acquiring the newest and most up-to-date technology to ensure its continued expansion.

The industrial process control system (CR-PROCOS).

Selenia Spazio: an Italian achievement of an ESA objective

Pietro Masarati

Managing Director of Selenia Spazio

The European Space Agency is now celebrating its twenty years of presence in the space world scenario. The ESRO convention, giving official birth to the European Organisation, was in fact signed in early 1964, even though its actual activity had been performed since 1962. Although Selenia Spazio was officially founded in November 1982, it too can trace its roots back to 1962. For it was then that the mother company was given the task on behalf of Telespazio, to design and develop the tracking subsystem for the Telstar antenna for the Fucino Station. Selenia Spazio is the eventual outcome from such beginnings.

When space was revealed to be not only a field of technological promotion, but a potential self-developing market as well, Selenia created a separate group completely dedicated to space which became a division of the company in 1969. During the first years its activity was mainly related to the formation and growth of basic resources and capabilities: the design and development was devoted to the area of antennas, TT&C transponders and data handling subsystems in the framework of the ELDO programme.

By giving its contributions to scientific and technological satellites (ESRO IV, Cos-B, Exosat, Meteosat) the company increased its technical level to the state of the art of onboard telecommunications and data handling equipment, thus enabling it to orbit sophisticated space-qualified hardware. It also played leading roles in managing and integrating complex satellite subsystems involving hardware and services supplied by other subcontractors.

Sophisticated payloads

This background enabled Selenia as early as 1968 to enter the commercial telecommunications satellite market as a partner of leading American companies such as Hughes and Ford with the supply of onboard antennas for all Intelsat IV and IV-A series and INSAT. Later on it obtained an important role within the Aerospatiale/Ford team for the development of Arabsat, a regional communication system for the Arab League.

At this point, it should be pointed out that the active participation in ESA programmes under its highly qualified technical staff and careful management has permitted Selenia to achieve the necessary competitiveness; such assistance and supervisory care being one of the main objectives of the European Space Agency. When in the early seventies Selenia's control was entrusted to the financial holding STET, which was already controlling most of the Italian communications, the activities of the Space Division were rationally oriented mainly towards telecommunications and application systems.

In national programmes, the company played a leading role in the development of Sirio 1 (still fully operational after six years of orbital life and now positioned over the Indian Ocean to favour the training and familiarisation of Chinese PTT technicians) not only by supplying its sophisticated k-band telecommunications payloads and most of the satellite electronics, but also by providing management and system integration resources to the prime contractor CNS, which is part of Selenia Spazio.

At the same time, within ESA the participation in telecommunications, meteorological and earth resource programmes was continually increasing, both at the hardware and system level, from OTS to its successors the ECS series, to the meteorological communications satellite Sirio-2, and finally to the ambitious multi-purpose telecommunication satellite Olympus. For the ECS

The OTS antenna platform.

series, the company supplied and is presently supplying the advanced k-band antennas and TT&C transponders.

For Sirio 2 the company developed and manufactured the complete s-band communication payload (including the mechanically despun antenna) and various platform equipment.

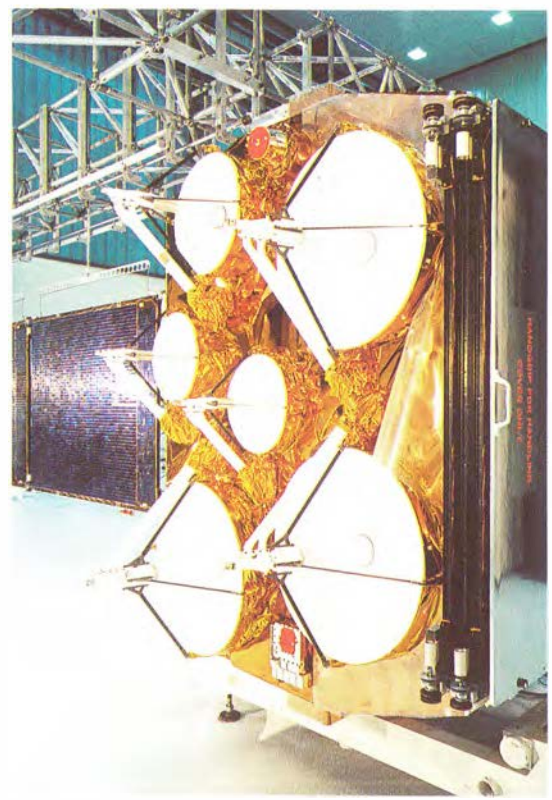
For Olympus, the company is responsible for the multi-mission payload consisting of four payload elements – direct TV broadcast (two channels), 20/30 GHz teleconference, 12/14 GHz special services and 20/30 GHz propagation, and it will provide the first two elements of the payload itself. To this 'growth' two important developments should be added. One is the recent acquisition of an important contract with Hughes for Intelsat VI for the supply of TM/TC transponder and telemetry subsystem plus telecommunications (k and c band), and TM/TC antennas. The other is the company's deep involvement in the ongoing Italian national programme for Italsat, the main features of which are the use of the 20/30 GHz band associated with the self-pointing multi-beam antennas and onboard switching of baseband signals (TDMA). This programme will be the forerunner of the Italian domestic communication satellite service.

Competitiveness in the world market

The industrial resources in Italy cover most of the areas involved in satellite communications, leaving nevertheless some gap to be filled with outside buying. It is essential that Italian industry concentrates mainly in the areas where considerable background already exists in order to achieve competitiveness in the world market.

To improve this situation, proper selection of technologies and products having a good chance of becoming competitive is essential. The determining factors for success are first, the maturity of the company, and second, the support of the government with the Italian space programme and through ESA.

The optimisation of the management structure, essential for competitiveness, involves some key aspects such as the need to interface the client with a structure similar to his own, the need to operate in international teams with extensive subcontracting, and the integration of technical system resources with management resources.



ECS-1 during solar array development tests.

Catalysing competence and capabilities
As far as ESA is concerned, its role is essential in creating the necessary background of industrial competence and a technological level which is a prerequisite for commercial ventures, but its natural function is also the one of 'catalysing' the concentration of competences and capabilities to face world competition.

The determination of STET on the one hand and the statutary ESA assistance on the other, together with simultaneous pressures arising from the national plan, have given birth to the new company: Selenia Spazio.

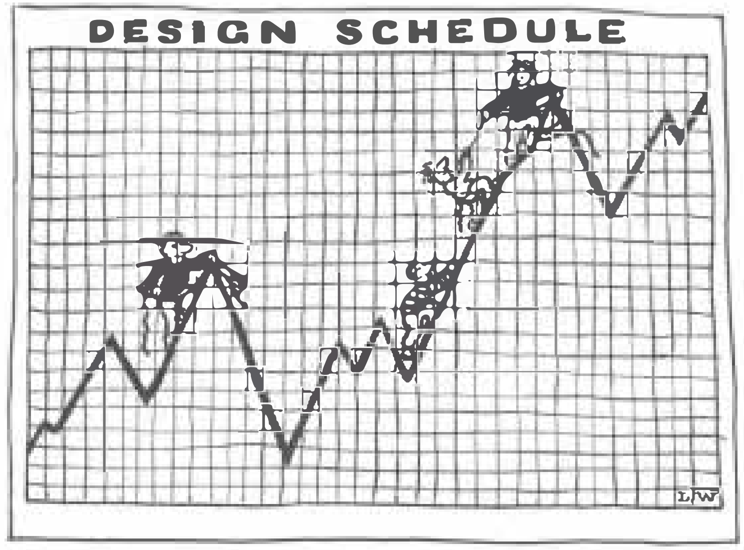
Selenia Spazio was created on November 24, 1982 as a fully independent company within the Selenia-Elsag Group owned by the STET holding. Selenia Spazio is the result of the merging of the following groups and companies into an independent company: Space Division of Selenia; Space Division of Italtel; CNS (Compagnia Nazionale Satelliti); and STS (Sistemi di Telecomunicazioni via Satelliti). The capital share is 60 percent Selenia, 25 percent Aeritalia and 15 percent Italtel.

CNS was the prime contractor for both Sirio 1 and Sirio 2 satellite programmes and has transferred to Selenia Spazio the role of prime contractor for the Italsat space segment.

STS is a consortium which gained world-wide experience and reputation in the supply of ground stations (18 standard A-type stations and 4 standard B-type stations for INTELSAT) and has transferred to Selenia Spazio its present activity, in addition to the role of prime contractor for the Italsat ground segment.

The facilities of the new company are located in Rome, L'Aquila and Catania, with a manpower force of more than 800 people. The sharing of some services and facilities with the mother company in the Rome area, in addition to favoring general cost reductions, will guarantee the transfer of know-how in very advanced technological areas and the easy temporary assignment of qualified personnel to overcome any unforeseen design and development peaks.

With Selenia Spazio a new industrial system group is born, capable of offering the experience gained in the space domain to compete in the international market. The main purpose of Selenia Spazio is the design and commercialisation of complete telecommunication and remote sensing systems comprehensive of both space and ground segments. The company has been created to provide space systems for the development of national telecommunication services and to participate in the supply of international services by procuring the necessary ground stations for traffic exploitation and orbit control. A great role has been played by ESA in the Italian achievement to which, on this occasion of your 20th anniversary, we wish to express our gratitude.



.... easy temporary assignment of qualified personnel to overcome any unforeseen design and development peaks.