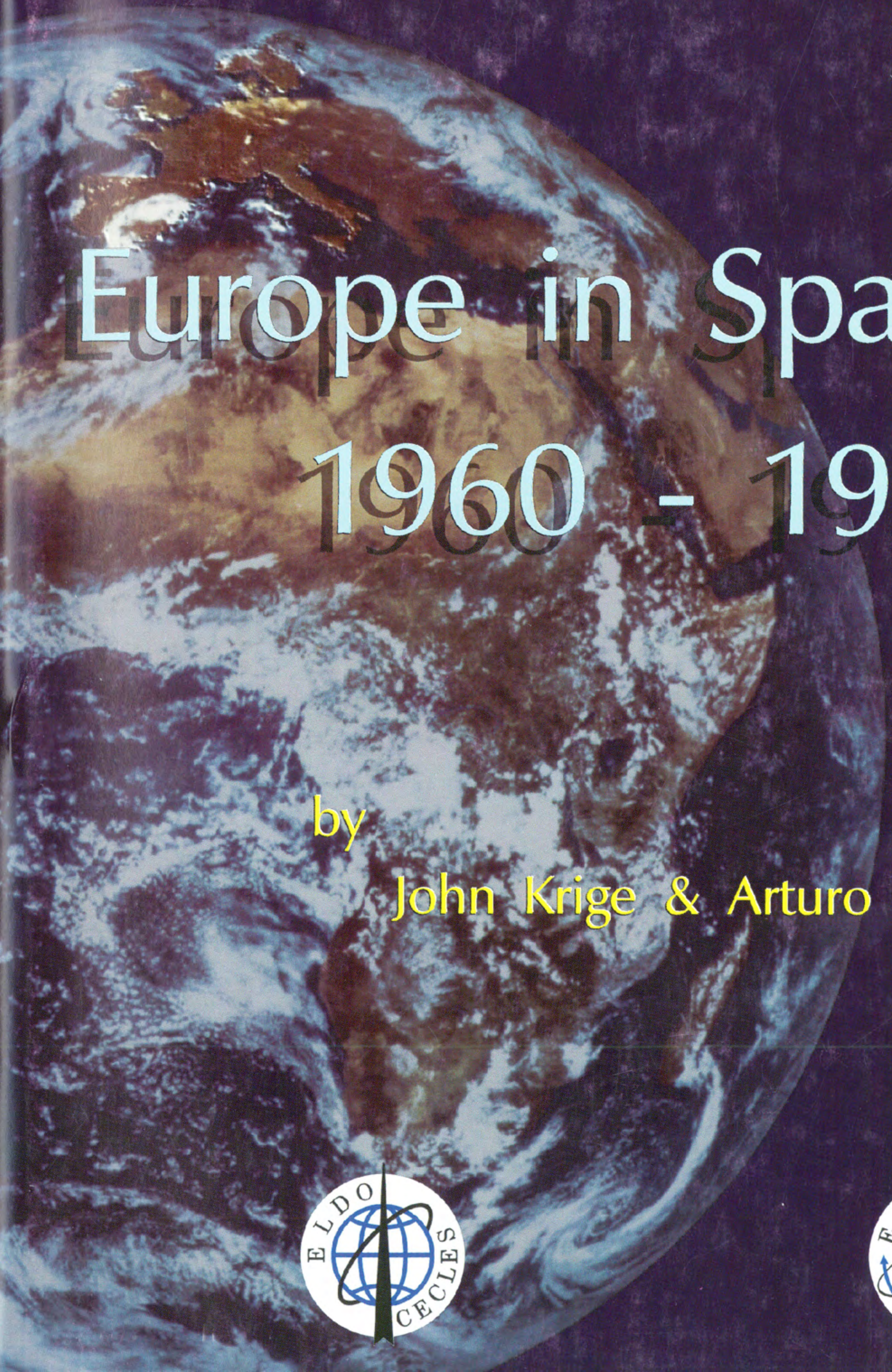
esa SP-1172

Europe in Space 1960 - 1973



by

John Krige & Arturo Russo

ELDO CECLES

ESRO CERS

esa SP-1172

Europe in Space 1960 - 1973

by

John Krige & Arturo Russo

esa SP-1172
September 1994

Europe in Space
1960 - 1973

by
John Krige & Arturo Russo

with the assistance of
Lorenza Sebesta

esa
european space agency
agence spatiale européenne

Published by: *ESA Publications Division*
ESTEC, Noordwijk
The Netherlands

Editors: *N. Longdon & B. Battrick*

Price: 70 Dfl **ISBN: 92-9092-125-0**

Foreword

Henry Ford's opinion that 'history is bunk' is not one that we can share after even the briefest of glances at this short history of the early years of the European space ventures. Although the complete history of the European space effort covers only some thirty-four years, time has massaged the memories of those who have lived through an exciting start to a continent's attempts to keep pace with the high-technology developments that the space era has brought.

It is natural that the memory should dwell on the dramatic successes, and the inevitable occasional failures. What are not so clearly remembered are the birth and growing pains of an organisation such as ours. It is timely, therefore, that the authors of this book should remind us of our early history.

This turns out to be a story full of twists and turns that could have led, on several occasions, to the premature demise of the European space venture. The very existence of one or other of ESA's forebears – ESRO and ELDO – often hung by a thread as member states argued their beliefs and ambitions. The reader will therefore undoubtedly wonder at several points why the nations ever continued to seek a solution to their sometimes apparently diametrically opposed views. Yet continue they did, and a strong European Space Agency, with great successes in science, applications satellites and launchers, is the result.

I recommend this book to all who are interested in the European space endeavour.

Jean-Marie Luton
Director General
European Space Agency

Contents

Preface

Of all the postwar initiatives in Europe to combine its scientific and technological potential, cooperation in space research is one of the most visible and truly great achievements, and one where Europe has succeeded in becoming a united force. ESA and CERN, the other model of a scientific cooperative venture in Europe, are outstanding examples of European success through collaboration. Despite differing perceptions and interests, ESA has shown and continues to show that scientists, engineers, industries and governments can overcome national and institutional barriers in pursuing a common cause.

From an endeavour started originally by a handful of scientists, mostly physicists, as a multinational collaboration limited to conducting space research with satellites and sounding rockets, Europe has over the last thirty years managed to develop a strong capability in all sectors of space activity, ranging from space science to using space techniques for applications and in the field of launchers.

In those pioneering days at the end of the 1950s and the beginning of the 1960s, when Europe possessed only about 300 scientists with a known interest in space research, few people could imagine the range of disciplines and the diversity of people that make up today's space community. Without their commitment to space and their optimism and enthusiasm to pursue their goals – in particular that of Edoardo Amaldi, Pierre Auger and Harrie Massey – none of this would have happened. They were firm believers in the great future that lay ahead for this new branch of science.

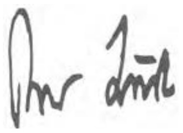
When I was approached in early 1989 as the then Director General of ESA about a project to write a history of European cooperation in space, I was immediately enthusiastic since I felt that, after three decades of European cooperation in space, it was both timely and opportune to share the multi-faceted story of the European journey into space with a wider audience interested in space affairs.

This is the first part of a two-volume history covering Europe's cooperative space efforts, which traces their beginnings from the late 1950s and the subsequent developments of a European space programme from that time up to the early 1970s. It recounts the efforts of the fledgling space community that launched ESRO (the European Space Research Organisation) and ELDO (the European Launcher Development Organisation), with much government support, and shows how those two organisations gradually evolved, and how the foundation was laid for a single European Space Agency.

Drawing on the ESA documentation in the Historical Archives of the European Community at the European University Institute in Florence, and the many interviews with key players involved in the build-up of the European space programme, John Krige and Arturo Russo provide a lively picture of the complex and at times dramatic process of Europe's slow, but determined, efforts in establishing a cooperative space programme.

This volume provides an important contribution to our understanding of the development of science and technology in postwar Europe. It should thus be of interest not only to those who were directly involved in Europe's fascinating venture into space the space scientists, and those concerned with the organisation and implementation of the space projects in government and industry, but also to the general public who watched, and simply by virtue of their support became participants in, one of the most remarkable successes of European integration.

I hope that the reader will get a feel for what drove the pioneers in their efforts to set up a European space programme and their enthusiasm for that cause, and will read this fascinating story with a similar sense of attachment and participation as I have read it and look forward to the second volume of the study



Reimar Lüst
Chairman of the Advisory Committee to the ESA History Study

Introduction

About thirty years ago a number of European governments, in consultation with scientists, engineers and industrialists, decided to enter space. To compete with the superpowers was, of course, out of the question. Europe had neither the resources nor the political interest to enter the space race. Indeed the initial aims of the main actors were relatively modest.

Firstly, they sought to maintain and increase scientific research in the upper atmosphere and beyond with sounding rockets and satellites. This would extend the activities already under way in national programmes in some countries, and build on the cooperative network established during the International Geophysical Year (1957/58). Secondly, they wanted to build a heavy satellite launcher together. Their aims here were to strengthen their political alliances, to ensure themselves a degree of autonomy in space and to foster the development of their high-technology industries.

To achieve these objectives two multinational, independent non-military organisations were established. The first, called ESRO (European Space Research Organisation) started with ten member states. It was modelled, at least in the minds of some of its pioneers, on CERN, the European high-energy physics laboratory in Geneva which had been established a decade before.

The second, called ELDO (European Space Vehicle Launcher Development Organisation) was set up by six West European countries plus Australia. Given the costs of launcher development, and the military connotations of launchers at the time, the smaller, neutral European countries who joined ESRO were not interested in being members of ELDO.

Both ESRO and ELDO had great difficulty realising their initial objectives in the following years. After passing through a series of bruising crises a compromise was found which effectively fused ESRO and ELDO into a single organisation ESA, the European Space Agency. ESA officially came into being in 1975.

The first difficulties emerged a year or two after ESRO and ELDO were formally established. Part of the problem was financial: it was soon clear that the money originally set aside by governments for the space effort (a small fraction of that being spent in the USA) would be far too little for the agreed programmes. Part of the problem was technical: there were doubts whether the rocket that was being built was not already obsolete, its technological content of little or no interest to industry. But above all there were doubts about the general policy to be followed by Europe in space, a problem triggered by the growing importance of application satellites, a domain not covered initially by ESRO or ELDO.

Satellite telecommunications: an important application of space technology

The demonstration that telecommunications by satellite was technically feasible and commercially viable profoundly, if painfully, re-oriented the scope and priorities of the European space effort. In 1965 the USA put a small spacecraft called Early Bird into geostationary orbit. It provided 240 voice circuits across the Atlantic. By the end of the decade global coverage was assured with United States-built satellites over the Atlantic, Pacific and Indian Ocean regions. Scientific research was all well and good, but the development of application satellites, especially for telecommunications, and the guarantee of access to the rockets needed to launch them, became far more important for many European governments and industries. If Europe did not secure a foothold here, they argued, it would be excluded from what would be the most important commercial activity in space from the 1970s onwards.

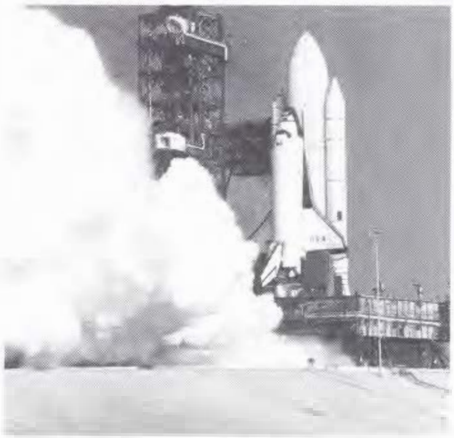
Four main issues bedevilled the subsequent definition of a coherent European space policy. The first concerned the institutional framework. At the European level, telecommunications by satellite were the responsibility of a 'European Conference' called the CETS (from the French equivalent) which grouped together representatives from the PTTs of 19 European countries. And while it seemed clear that a single European space organisation should be created out of the existing ESRO, ELDO and CETS, their amalgamation was far from easy, owing to the great differences, above all, in the membership and objectives of the three.

The second issue was the question of industrial policy. This became increasingly sensitive as the 1960s wore on and fears about the 'technological gap' between Europe and the USA took hold. It had two related dimensions. One was the idea, enshrined in the principle of 'fair return' ('juste retour'), that technologically interesting contracts should be distributed among member states in the same proportion as their financial contributions to the organisation. The other was the formation of industrial consortia. This was put forward in the late 1960s as a solution to the difficulties of applying fair return caused by the small scale of the space effort and the uneven level of development of the space industry in different countries. Questions of cost and efficiency apart, these industrial policies caused endless difficulties. Those countries that did not have a national space programme strongly advocated them, while those that did were far less enthusiastic. They felt that their dynamic industries were being shackled and their competitivity jeopardised by ponderous arrangements in which they were forced to share technological and managerial knowhow with firms imposed on them from without.

The third problem lay in the relationship between the existing national space programmes (notably in France, Germany, Italy and the United Kingdom) and the joint European effort. Each country, in fact, wanted to implement a European space policy coherent with its national interests and this often led to conflicts at both the political and economic levels. France and Germany, in particular, whose national space programmes were the most ambitious and whose industry was the most advanced, regarded European cooperation in space as complementary to their own national efforts. The smaller countries, by contrast, felt that they could best safeguard their interests by supporting a fully fledged joint European effort and insisting on a strict 'just return' policy. Here, as elsewhere in European projects, cooperation in space has always been an indispensable part of the construction of national autonomy, the pursuit of national interests by means other than direct rivalry.

Finally, probably the most divisive issue of all concerned the question of the European launcher, namely whether Europe should pursue the aim of complete independence in launch capability or should rely on the United States' space transport systems. This pitted France and Britain against one another for almost a decade. Gaullist suspicion of 'les Anglo-Saxons' and the determination to build an independent force de frappe was matched only by Britain's trust in the USA as enshrined in that 'special relationship' that had been built up between them since the war. Matters were further complicated in the aftermath of the American lunar landing in July 1969. Promising a revolution in space techniques, the USA invited the Europeans to collaborate in their post-Apollo programme.

The United States' post-Apollo programme included the development and construction of the Shuttle, a reusable launcher which, it was said, would dramatically reduce the cost per kilogramme in orbit. It was clear that Europe could not both build its own launcher and participate extensively in post-Apollo which — some felt — was deliberately intended to kill the development of an autonomous launch capability on this side of the Atlantic. By 1970/71 the technical, industrial and political stakes involved, coupled with the frustratingly poor performance of the ELDO launcher itself, very nearly sabotaged a joint European space effort once and for all.



The Shuttle: the core element of the USA's post-Apollo space programme

The resolution of these conflicts was achieved in the early 1970s with two so-called 'package deals'. Recognising that compromises were only possible if they respected the different priorities of the participating partners, these new arrangements made allowance for optional programmes in a so-called 'menu à la carte' system. In this system, which would also be adopted by the European Community, each country was free to contribute only to those programmes that interested it: there was no need for all member states to participate in all programmes. Only science, which had been a key motivation for governments to enter space, and which, through ESRO was proving highly successful, was protected by making it a small but mandatory component of the overall space effort.

Europe was now endowed with a space policy that could command general assent and it was finally possible to set up a single organisation, ESA, to implement it.

* * * * * *

This book will describe in summary form the historical evolution of these events. It is divided into three main parts. In the first (chapters 1 to 4) we narrate the background to Europe's entry into space and explore the circumstances surrounding the setting up of ESRO and ELDO and the implementation of ESRO's first scientific programme. The next major part describes first the attempts to re-orient the European space effort towards the development of telecommunication satellites (chapter 5). It then fleshes out the painful and divisive efforts to define the place of launchers in European space policy from the mid-1960s onwards (chapter 6), and discusses the new possibilities opened up by the American offer to participate in the post-Apollo programme (chapter 7). Finally, in the last part of the book, we show how the conflicts that so characterised the latter part of the 1960s were resolved and the foundations laid for ESA. Here we describe the new scientific programme that was approved (chapter 8), and the 'package deals' that were arranged (chapter 9). In the conclusion (chapter 10) we look back over the fifteen years we have surveyed and identify some of the main changes characterising the European space effort in this period.

Of course, in tackling our topic in this way, we have made a number of drastic choices. For example, we have chosen to give only a few technical and engineering details on the sounding rockets, the launchers and the spacecraft. We also only touch on the scientific results achieved. Some of this material is dealt with in a number of separate insets liberally dispersed through the book. The role of industry, both as a lobby and as that group of engineers, managers and entrepreneurs actually responsible for building space hardware, is also not handled in any depth. This is partly because of the enormous difficulty one has finding valuable primary source material for this kind of research. It is also because our main aim, as we have said, is to lay open the decision-making processes whereby ESRO and ELDO's programmes evolved and to show how European governments formulated a policy for space which they deemed institutionally sound, economically feasible and politically viable.

The sources we have used reflect our intellectual concerns. Our main primary source has been the ESA collection itself deposited by the Agency in the Historical Archives of the European Community at the European University Institute in Florence (see Appendix 3). This impressive collection of papers covers very thoroughly the period dealt with in this book, and we would like to thank Gherardo Bonini for his invaluable assistance in using it. It has been supplemented by interviews with some of the most important personalities involved in the European space effort up to the early 1970s (see Appendix 3). In addition we have consulted a few personal collections and some national archives, e.g. the papers of Jean Mussard (in Florence), Edoardo Amaldi (in Rome) and Thomas Paine (in Washington) as well as documents in the Public Record Office in London, and in the National Archives and the NASA History Office in Washington.

To make this book appealing to a broader public we have not cluttered the text with the usual scholarly apparatus of footnotes. Almost all of it is, however, based on extensive, properly documented research which has been reported at conferences, in scholarly journals and in over a dozen working papers. This material is listed in Appendix 3.

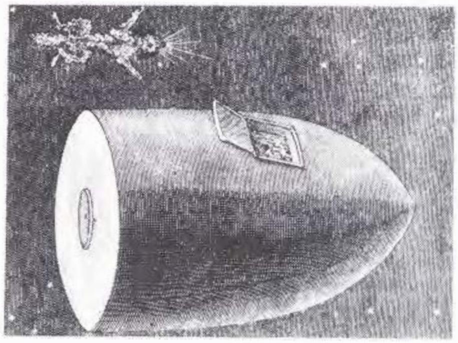
This project, which is based at the European University Institute, has been made possible by the generous and unflinching support of the European Space Agency. We should stress that, while this will inevitably come to be seen as an 'official' history of ESA, we have always been free to write what we think: no pressure of any kind has been put on us to align our history with the official policy of the Agency.

In closing we should like to thank those most closely associated with the project from conception — the previous Director General Prof R. Lüst, as well as K.-E. Reuter and F. Lagarde of ESA, and Prof R. Griffiths at the EUI — for their confidence in us and for their encouragement. Michelangelo De Maria was a stimulating colleague and collaborator until he was unfortunately forced to withdraw from the project due to circumstances beyond his control. Beatrijs de Hartogh has not only been a highly efficient project secretary; she has also done an excellent job typing and laying out our many texts.

Chapter 1 — The beginning of the space age

The prehistory

For centuries people have fantasized about exploring space. Such fantasies were doomed to remain unfulfilled, however, until rockets had been developed with sufficient thrust to escape the pull of the Earth's gravitational field. This was the problem that was tackled, theoretically at first, by pioneers such as Robert Goddard in the USA, Konstantin Tsiolkovsky in the USSR, Robert Esnault-Pelterie in France and by Hermann Oberth in Germany.



Jules Verne's space projectile

Many of these early rocketeers were inspired by the science fiction they had read when young, books such as Jules Verne's *De la Terre à la Lune* (1865) and *Autour de la Lune* (1870), and Edgar Rice Burroughs' series of novels in Martian settings. One of their most notable contributions was Oberth's *Die Rakete zu den Planetenräumen* (The Rocket to Planetary Space), published in 1923. It showed the advantages of using liquid fuels for rockets rather than the solid fuels based on gunpowder and its derivates which had been in vogue until then. With a liquid fuel, Oberth argued, it was possible to make a very large manned rocket capable of reaching the Moon or other planets. In fact he even designed such a spaceship and identified the necessary equipment for sustaining people in space.

The work of these pioneers inspired the formation of a number of rocket societies in the 1920s and 1930s; small clubs of amateur enthusiasts dedicated to the cause of rocketry. These societies performed a number of important functions. They publicised and legitimised spaceflight, giving scientific credibility to an enterprise that had previously been seen as the domain of fiction writers and cranks. Their members conducted a considerable amount of systematic research into rocketry, often at great personal risk. They also served as training grounds for some of the most important rocket engineers of this century, notably Wernher von Braun, a dominant figure in the postwar American space programme, and Sergei Korolev, his Soviet 'counterpart'.

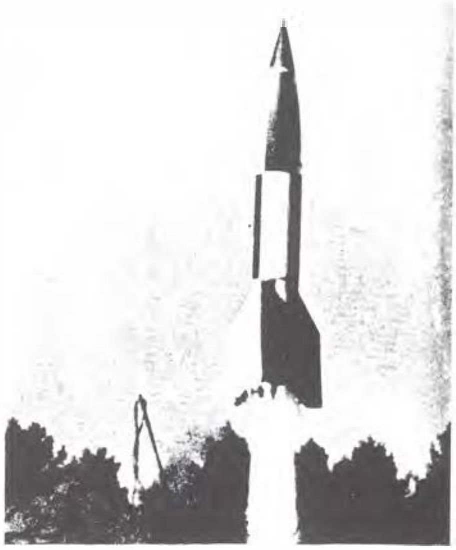
The rocket societies did not have the resources or the institutional base to sustain an ongoing programme of rocket research and development, let alone production. The military did have, and did so, notably in the Soviet Union and in Nazi Germany. Important contributions were made to rocket technology in both Moscow and Leningrad under military auspices in the 1930s, only to suffer a serious setback in the Stalinist purges in 1937-8. By this time there were probably well over 2000 rocketeers at work in the Soviet Union. Many of them were killed, humiliated, or discouraged. Some of the key figures in the postwar Soviet programme survived these purges, notably Korolev, who spent the war years improving military aircraft in a prison camp for technical experts. Soviet rocketry thus made few important advances during World War II.

The great interest of the military in rocket development in pre-war Germany sprang from a general concern to rebuild the country's military capability, coupled with the more specific fact that rockets were not subject to the restrictions placed on German rearmament in the Treaty of Versailles. The first military initiatives were taken in the late 1920s, stimulated by intense public interest and the active publicity of the newly-formed German rocket society, the Verein für Raumschiffahrt or VfR (The Society for Space Ship Travel). In 1932 three senior members of the German army visited the VfR's test facilities at the so-called Raketenflugplatz in Berlin. They were not impressed by the progress made by the amateur society; but they discovered Wernher von Braun, who was barely 20 years old at the time.

That same year von Braun became the first VfR member employed in the German army's rocket programme, which was being conducted secretly at Kummersdorf, south of Berlin. Five years later, with war clouds gathering over Europe, von Braun was appointed technical director of the rocket programme at the army's new premises established at Peenemünde on the Baltic sea.

One of von Braun's first tasks was to develop an operational version of his experimental rocket the A2. In 1942 he had what was wanted: his so-called A4 rocket rose 80 km into the air, and fell to the ground 190 km downrange. By this time there were almost 2000 scientists and engineers and 4000 other employees working at Peenemünde on missiles for the German army and airforce. The A4 was rebaptized the V2 (Vergeltungswaffe 2, or Vengeance Weapon 2, apparently so named because it was thought to be the weapon that would restore German pride after the humiliations imposed by the Treaty of Versailles).

Wernher von Braun (left)



Firing of a V2 rocket

Mass production of the missile soon got under way. The factories were dispersed over Germany after August 1943, when the Royal Air Force bombed Peenemünde, causing considerable loss of life but little material damage. On 6 September 1944 the first V2 fired from the Netherlands fell on the outskirts of Paris. Two days later a major V2 offensive targeted on the south of England got under way. Indeed more than 5000 V2s were constructed in Germany in 1944 and 1945. One factory alone, the Mittelwerk factory in Nordhausen, was allegedly producing almost 900 V2s a month by 1945, using slave labour.

With the Red Army advancing on the eastern front, von Braun decided to evacuate Peenemünde early in 1945. At the end of February he, along with over 500 of his best people and the Peenemünde archives, began to move south in the hope of restarting activities at a new centre. This was not to be. They found southern Germany in chaos. The archives were buried in a disused mineshaft. In April the Americans captured the V2 factory in Nordhausen, and immediately began shipping missiles back to the United States. On 2 May 1945 von Braun, his brother, his close friend and confidant General Dornberger, and several other German rocket engineers surrendered to the Americans. A special mission was hastily sent north to recover the Peenemünde files. The last convoy of V2s left Nordhausen for Anvers and New Orleans under the nose of the Soviet troops on 31 May 1945.

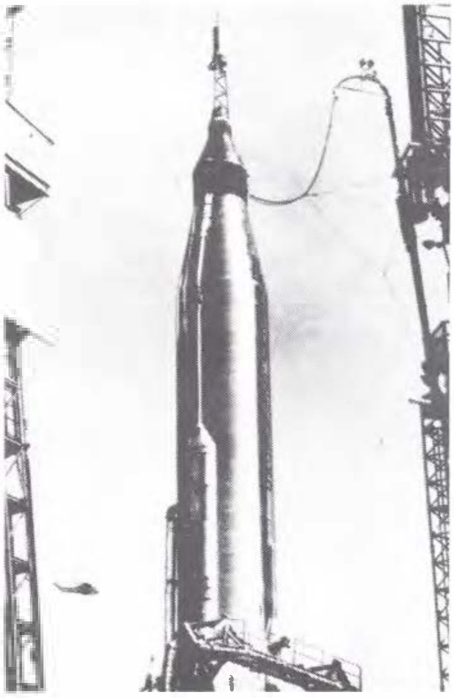
Within a few months von Braun and about 120 of his best engineers had signed contracts with the US Army Ordnance Corps. By the autumn of 1945 they were installed at Fort Bliss in Texas and at the White Sands Proving Grounds about 80 miles north in New Mexico. About 60 of their captured rockets were at their disposal. In 1950 the team was moved to the Army's new missile centre at Redstone Arsenal, Huntsville, Alabama.

The United States was not the only country to benefit from Nazi rocketry, but it captured the richest prizes. The Soviets certainly let the leading experts slip from their grasp, but they did round up about 200 of the rank and file engineers and technicians of the German V2 programme, notably those with experience in mass producing the missile. These experts were taken, along with the entire V2 factory at Nordhausen, back to the Soviet Union in 1946 and 1947.

With the knowledge and the technology that they already had, and with the injection of new ideas, new people, and new resources from a defeated and depleted Germany, both of the superpowers were now poised to take major initiatives in the field of rocketry. A new era in missile development was beginning, and with it the promise of ultimately exploring and exploiting space.

The legacy of war: ICBMs and IRBMs

Within days of surrendering in Germany, von Braun and his team had explained the possibilities opened up by the development of rocketry to an admiring US technical mission. They spoke of launching artificial Earth satellites, of manned space stations, and of interplanetary voyages. However, any hopes that they might have had of actually developing the heavy launchers required for such ventures were to be frustrated for almost a decade. In fact it was only in 1954 that top policy makers in the United States seriously committed resources to the development of rockets which were powerful enough to launch payloads into Earth-orbit or to carry warheads long distances. This required the prior development of relatively lightweight 'dry' nuclear weapons and the recognition that the bomber was not the only appropriate long-range weapon-delivery system. It also required the stimulus of 'the Soviet threat'.



Atlas, the US Airforce's ICBM in its new role as launcher for the Mercury capsule

In the summer of 1953 the Soviet Union successfully tested a 'dry' hydrogen bomb; the USA wiped the Bikini atoll off the map with a similar device in March 1954. This suggested that intermediate-range and intercontinental ballistic missiles (IRBMs and ICBMs) would be technically feasible delivery systems in the not-too-distant future.

In February 1954 a committee chaired by the brilliant mathematician John von Neumann expressed 'grave concern' about the United States' comparative disadvantage in rocket technology. By June 1954 that 'grave concern' had become an instruction to reorient and to accelerate the US Air Force's Atlas ICBM programme. The next year, the USAF was authorised to build a second-generation ICBM, the Titan, and programmes to develop intermediate-range ballistic missiles were also initiated.

The Army set von Braun and his team to work on developing a missile, later called Jupiter, which was capable of delivering a one-ton payload over about 1600 miles (2600 km). The Air Force, not to be outdone, won permission to develop the Thor missile, which was technically almost identical to its Army rival. Finally, the Navy, after briefly collaborating on the Jupiter project with the Army, decided that it needed a solid-fueled IRBM for its submarines, rather than a liquid-fueled missile like the Jupiter and Thor, and in 1956 it was authorised to develop the Polaris. That same year the Pentagon approved Air Force plans for developing a solid-fueled intercontinental rocket, lighter and cheaper than Atlas or Titan, that could be launched within sixty seconds of an alert: hence its name, the 'Minuteman'. While becoming obsolete as weapons, Atlas, Titan and Thor were an efficient and diversified family of boosters for launching military and civil satellites. The foundations had thus been laid for the United States' military power in the decades ahead and for its entry into space.

The Minuteman, successor to Atlas and Titan

What of developments behind the Iron Curtain in this period? From what little we know, one point is patently obvious: that Soviet Union policy makers believed it was necessary for the country to develop intercontinental delivery systems almost immediately after the war, before they even possessed the atomic bomb. This could not happen overnight, of course. The Peenemünde contingent were installed at Kapustin Yar, east of Stalingrad, where they supervised test launches of captured V2s and developed new rockets, including an IRBM labelled the R-14, an atomic bomb carrier designed to send a 3-ton warhead 1800 miles (3000 km). Korolev, for his part, began upgrading V2s at another new rocket test range in the desert east of the Aral Sea, near the town of Tyuratam in Kazakhstan, later known as Baikonour. By 1949 he was supplying the Red Army with the T-1, or Pobeda, a modified version of the V2 having a range of some 900 km.

At the same time, along with his colleague Valentin Glushko, he was developing ever more powerful rocket engines. By 1952 Korolev and Glushko were already designing a military rocket with a range of 7000 km, which was to become the first successful ICBM to fly and which was the rocket that put Sputnik 1 into orbit. In short, by following a very different policy on the development of ICBMs immediately after the war, planning in the Soviet Union on the deployment of giant rockets was considerably ahead of that in the USA in 1954. This 'lag' was one important reason why the Soviets were in space before the Americans.

The International Geophysical Year (IGY)

In addition to developing rockets, the idea of launching unmanned spacecraft into orbits around the Earth was also suggested in the USA in the immediate post-war period. As early as May 1946, a report by the Rand Corporation analysed the technical aspects of such an undertaking and underlined the great value that such artificial satellites could have for scientific research and national defence.

The political and military implications of Earth satellites were again discussed at length in another Rand report in 1950, which set the stage for the future satellite programme of the United States. Strategic reconnaissance was the main objective of satellites from the military point of view. This, however, posed a severe political problem, for a spacecraft overflying foreign territory and gathering photographic data beyond the range of retaliation risked being taken as an act of aggression. A vigorous Soviet protest, in particular was to be expected, with an appeal to international law or even threats against neighbouring states housing United States' tracking stations. The idea of the 'freedom of space' had to be established worldwide before space activities could be undertaken without becoming snarled up in the complexities of Cold War politics.

The International Geophysical Year (IGY) offered a solution to such a problem. The IGY, originally proposed in 1950 as the Third International Polar Year was a cooperative scientific venture supported by 66 nations. Its aim was to gain basic information about the upper atmosphere during a period of maximum solar activity in 1957-58. The 'year' lasted from 31 July 1957 to 31 December 1958. It is of relevance to our story because in October 1954 the Special Committee for the IGY (CSAGI), following a suggestion by the United States' delegates, recommended that governments try to launch Earth satellites in the interests of global science during the 'Year'.

On 28 July 1955 the White House Press Secretary announced that the President had agreed to the launch of 'small, Earth-circling satellites' as part of the USA's participation in the IGY. Within a day or two the Kremlin announced that the USSR planned to do likewise. These would be the first satellites into space.

The two superpowers took very different policy decisions on satellite deployment. The Soviet Union unhesitatingly decided to use a military launcher for the scientific mission envisaged in the IGY framework. The United States reasoned differently The Eisenhower administration wanted to stress the scientific image of the venture, partly because they wanted to use their participation in the IGY to establish the freedom of space for peaceful purposes before probing the Soviet's reaction to military reconnaissance satellites. Their most advanced rocket was von Braun's Redstone (or Jupiter-C), a military medium-range missile evolved from the Nazi's V2 weapon and built by an army arsenal. They chose instead the Naval Research Laboratory's Viking, a rocket designed to probe the upper atmosphere for scientific purposes. It was also based on the V2 plus a small upper stage called the Aerobee, which was built by a private company. This became Project Vanguard, and it was intended to put the USA's first satellite into space, all the while preserving its non-military image. It was a tactical choice for which the Eisenhower administration was to pay heavily.

Sputnik, Kaputnik, and Explorer

Laika — the first 'cosmonaut'

On 4 October 1957 Moscow radio announced that the Soviet Union had successfully launched Sputnik 1, the first artificial satellite to orbit the Earth. The reaction, at least in certain United States circles, bordered on the hysterical. A wave of recriminations and self-criticism swept through the country stimulated by the media. A myriad of explanations were put forward for what Life magazine called 'defeat for the United States': interservice rivalry between the various sections of the military leading to parallel rocket programmes, underfunding of basic research and development, a philistine attitude towards 'egghead' scientists, an educational system that was not turning out enough scientists and engineers, and a President who was more interested in golf than in guiding the nation.

Indeed the whole American way of life, with its laisser-faire approach and its consumerism, was called into question. Perhaps 'totalitarianism', with its ability to mobilise resources and to direct them to a single objective, had some advantages after all.

Not all shared this view, of course. General Curtis LeMay, for one, was disparaging. In his opinion Sputnik was 'just a hunk of iron'. The President also played down its importance, at least in public. The United States' satellite programme, he said, was intended to reap maximum scientific benefits within the framework of the IGY. A small test sphere was to be launched in December, and the launch of the first fully-instrumented satellite was planned for March 1958. The United States, he told scientists a week later, was not intent on 'competing with any other nation for first place in a sputnik race...The serving of science, not a high score in an outer space basketball game, has been and still is our country's goal'.

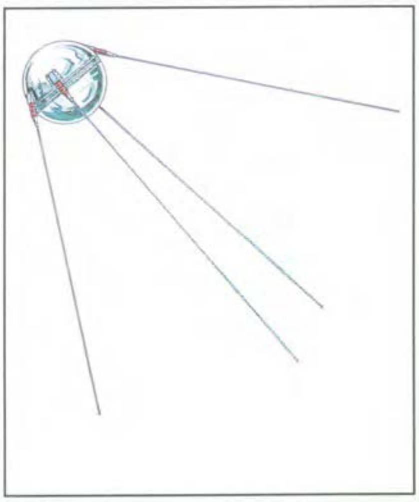
He was soon forced to revise his public stance. Early on the morning of 3 November Sputnik 2 was successfully launched. This satellite, dedicated to the fortieth anniversary of the October revolution, was more than six times heavier than Sputnik 1 (it weighed about 500 kg), and was placed in an orbit almost twice as high as that achieved by its predecessor. What is more, it carried the first living being into space, the dog Laika, who was wired up for medical and biological studies. The metaphor of the country having suffered something like a new 'Pearl Harbour' became commonplace and 'catching up with the Russians' became something of a national slogan in the United States. Space had become a key domestic issue fuelled by the tensions of the Cold War.

The launch of Sputnik 2 led Eisenhower to increase the pressure on the Vanguard team. The team was instructed to bill the first scheduled test flight of their rocket as a full-blown attempt to orbit a satellite. It also forced him to change his ideas about using the Army's Redstone missile developed by Wernher von Braun as a backup to Vanguard. Indeed the President used the recovered nose cone of a Jupiter missile as a prop at a televised press conference a few days after Sputnik 2 first orbited the Earth. 'This object here in my office is an experimental missile nose cone. It has been hundreds of miles to outer space and back. Here it is, completely intact...' On the same day the Department of Defense gave the Army, which had the rocket, and the Jet Propulsion Laboratory in Pasadena, California, which was responsible for the associated satellite, authority to prepare for launch.

The competition proved too strong for Vanguard. Early in December reporters from around the world gathered at Cape Canaveral to witness the United States' reply to the Soviets. After two days of suspense the countdown finally reached zero just before noon on 6 December 1957. Vanguard rose four feet off its pad, and slumped back to Earth in a ball of thunder and flame.

The press was unrelenting. Vanguard was Kaputnik, Stayputnik, Flopnik. Soviet delegates at the United Nations reputedly asked if the USA was interested in receiving aid to underdeveloped countries. The Navy desperately prepared for a second launch, but too late. At the end of January the Army's 'Missile 29' carrying the JPL's satellite Explorer 1 was prepared for launch under conditions of great secrecy at Cape Canaveral. The Jupiter-C rocket blasted off successfully on 31 January 1958. and placed its 14 kg Explorer 1 satellite — one sixth the weight of Sputnik 1 — into orbit. On 17 March the Navy evened the score when the diminutive (1.5 kg) Vanguard-1 reached orbit. A second Explorer was launched on 26 May, preceded on the 15th of that month by the 1.3-ton Sputnik 3. The space race between the two Superpowers had definitely started.

Sputnik 1 and Explorer 1



Sputnik 1

Explorer-1

On 3 August 1957 the first successful Soviet ICBM, the S.S.6 (or Sapwood in the West) rose from its launch pad, and dropped into the Pacific Ocean 100 degrees of longitude to the east near the Kamchatka Peninsula. A second successful launch followed a few weeks later. On 4 October 1957 the space version of the missile, the R-7 or Semyorka, placed the first artificial Earth satellite, Sputnik 1, into orbit.

Sputnik 1 was an aluminium sphere with a diameter of 58 cm and weighing about 84 kg. The satellite circled the Earth once every 96.3 minutes in an elliptical orbit with a perigee of 228 km and an apogee of 947 km. Its two radio emitters sent its familiar 'beep-beep' sound into homes all over the world for 21 days. Due to its relatively low apogee, Sputnik 1 re-entered the Earth's atmosphere soon after, and burnt out on 4 January 1958. The scientific instruments on board the satellite carried out the first measurements of atmospheric density and the first investigations into the transmission of electromagnetic waves through the ionosphere.

The Soviet success frustrated no one more than Wernher von Braun. More than a year before, his Jupiter rocket had successfully reached an altitude of 1000 km. On the night of 4 October 1957 he begged the new Secretary of Defense to 'turn us loose and let us do something'. In the wake of Sputnik 2 and the Vanguard debacle, von Braun got his way. On 31 January 1958, four months after the USSR, America's first artificial satellite Explorer 1 was carried aloft by a Jupiter-C rocket.

Explorer-1 was essentially the last stage of a Jupiter-C rocket. It was cylindrical in shape, a little over 2 m high and 15 cm in diameter. It weighed just under 14 kg and was placed into an elliptical orbit with a perigee of 356 km and an apogee of 2548 km. The satellite carried two micrometeorite detectors and a Geiger counter designed by James Van Allen for studying charged particles. This experiment led to the discovery of the radiation belts around the Earth which were subsequently named after him. Explorer 1 burned out over the South Pacific on 31 March 1970.

The creation of NASA

In parallel with these developments the Eisenhower administration began to think about the appropriate institutional framework for the United States' space programme. The debate over how to do this was intense and vociferous, and dominated by the question of the relationship between the civil and military aspects of space.

As all existing satellite programmes were run by the military, the Administration decided in January 1958 to create the Advanced Research Projects Agency (ARPA) within the Department of Defense. Its aim was to run the USA's space programmes on an interim basis under the authority of the Secretary of Defense. Subsequently, however, a growing consensus emerged that, apart from reconnaissance satellites, the major goals of spaceflight in the near-term were scientific and political, and that a civilian-run space agency would best serve the interests of the United States by building the image of an open, peaceful programme in contrast to Soviet secrecy.

This opinion was supported in particular by the newly established President's Science Advisory Committee (PSAC). The PSAC also recommended that an existing agency, the National Advisory Committee on Aeronautics (NACA), be expanded and upgraded to take over all aspects of the nation's space programme except those having direct military application (such as reconnaissance satellites). The NACA was set up by the Federal Government during the first World War to supervise and direct the study of the scientific and technical problems of aeronautics. It had a modest budget until 1940, which by 1945 had increased tenfold to about US$ 40 million.

One of the strengths of the 'Committee' was that it had some of the best in-house research facilities in the world. And while much of its attention was directed to solving aeronautical problems, by the mid-1950s it also carried out a good deal of advanced research and development in support of missile projects, much of it for aircraft manufacturers and the Department of Defense. NACA also maintained close links with a segment of the scientific community through a university research programme.

On 5 March 1958 Eisenhower approved the recommendation that the leadership of the civil space effort be lodged in a strengthened NACA, and one month late the National Aeronautics and Space Act was submitted to Congress. This was quickly signed into law and on 1 October 1958, almost a year to the day after Sputnik 1 was launched, the National Aeronautics and Space Administration (NASA) officially came into being. It inherited NACA's vast organisation and facilities and a workforce of some 8000 people.

It expanded rapidly, taking over all space activities currently under way except those strictly of military interest, mainly concentrated in the USAF programmes. In December 1958 the Jet Propulsion Laboratory in Pasadena came under NASA's control. In May 1959 the key personnel in the Navy's 'Project Vanguard' were transferred to a new facility at Greenbelt, Maryland, later named the Goddard Space Flight Center in honour of the American rocket pioneer.

By October 1959 the NASA space programme acquired the Army team at Huntsville, Alabama under Wernher von Braun. The centre at Huntsville was renamed the George C. Marshall Space Flight Center and von Braun was appointed its first Director. His specific task was to develop the heavy launchers for the man-in-space programme, which was also under NASA's control. In fact by the end of 1960 NASA's staff had doubled to 16000 and its annual expenditure was over US$ 500 million, three times that of NACA in 1958.

The situation in Europe

While the nations in Western Europe could not hope to compete on an equal footing with the military space efforts of the superpowers, some of them had considerable potential for entering the space age at the end of the 1950s. To conclude this chapter we shall quickly survey the situation prevailing in France, (West) Germany, Italy and the United Kingdom. This will provide the national backdrop against which we begin to look, in the next chapter, at the initiatives taken to have a collaborative European space effort.

Not all of the German rocketeers fled the war-ravaged continent. A small group of about 40 settled in France in 1946-7, where they formed the nucleus of the first French rocket teams. In 1949 the French government set up the Laboratoire de Recherches Balistiques et Aérodynamiques in Vernon, on the Seine northwest of Paris, with the aim of developing ballistic missiles for military use. Though its budget was initially rather small, it did develop one important sounding rocket, Véronique, modelled on the German V2s. The first operational flight of Véronique took place in 1954 from the French military base at Hammaguir, in the Algerian desert.

A Véronique sounding rocket

The Skylark sounding rocket

In 1957 the French military Comité d'Action Scientifique de la Défénse Nationale (CASDN) decided to fund the construction of 15 improved Véronique rockets to carry out high-altitude atmospheric research in the framework of the IGY.

Despite these achievements, the French effort tended to limp along until 1958, when it benefitted from the happy conjuncture of the launch of Sputnik and the arrival of General de Gaulle in power. De Gaulle's determination to develop an independent nuclear capability gave an enormous boost to rocket/missile development in the framework of the government's strong support for scientific and technological research. His initial wide-ranging programme included IRBMs, submarine-launched missiles and reconnaissance satellites. In 1959 the French government set up the SEREB (Société pour l'Etudes et la Réalisation d'Engins Balistiques) the aim of which was to develop the inhouse knowledge and technology required for this military programme. In the same year it established a Comité de Recherches Spatiales to coordinate scientific research in space. Finally, by a law voted on 19 December 1961, CNES (Centre National d'Etudes Spatiales) came into being. Its prime task was to develop a satellite launcher based on the military ballistic missiles that France was developing for its strategic deterrent.

The fruits of these investments were soon to be seen. On 26 November 1965 the Diamant rocket rose from the Hammaguir launch pad and placed the first French satellite, Astérix, into orbit. France thus became the third space power and confirmed its claim for an independent role in this important strategic field.

The only other European country to have a substantial national programme in the 1950s was the United Kingdom. The British worked on the development of solid-fuel guided rockets during the war, and as early as October 1945 launched three captured V2s with the help of German specialists. In 1946 a Controlled Weapons Department was established at the Royal Aircraft Establishment (RAE) near Farnborough, and an agreement was signed between the governments of the UK and Australia to establish a joint launching range at Woomera in South Australia.

In the decade that followed there were two important developments at the RAE which are of relevance to our story. Firstly, a series of small rockets was developed capable of carrying payloads of about 200 kg to heights of around 150 km. One of this series was offered to scientists for research purposes in 1953. It was renamed Skylark, and was an ideal sounding rocket for upper atmosphere research. The Skylark was first tested at Woomera on 17 February 1957.

Secondly, in 1955, the UK, in collaboration with the USA, undertook the development of its own IRBM, called Blue Streak, with a range of about 2500 km. This was intended both to maintain an independent British deterrent and to complement the United States' ICBMs with medium-range missiles in the European theatre. For several reasons, to be discussed later, the UK government decided to cancel the military programme in 1960 and to recycle the rocket as a civil satellite launcher, in collaboration with partners across the Channel if possible. Thus were the foundations laid of a European launcher organisation which we will look at in more detail in chapter 3.

Blue Streak, as modified to be the first stage of the ELDO Europa launcher

Another notable feature of the UK in this early period was the strength and organisation of its space science community. In addition to a distinguished history in astronomy, which was continued with the installation of giant radio-telescopes at Jodrell Bank in the 1950s, there was a long tradition of 'space research' as such. This included the important work done by E. Appleton in the 1920s on the properties of the ionosphere. British space science was given a boost by the availablility of the Skylark, by an active participation in the International Geophysical Year, and by close contacts with colleagues in the United States. In December 1958 a British National Committee for Space Research (BNCSR) was established. Its chairman was Harrie Massey and it had representatives from a wide variety of government departments and scientific societies. Within a few years the first scientific payloads were in orbit.

In March 1959 NASA had offered to launch scientific equipment for scientists from other countries. Massey and his colleagues reacted immediately and by 1960 a cooperative programme was agreed. It foresaw the launch of three satellites with UK instruments on board at roughly yearly intervals. The first in the series, Ariel 1, carrying seven instruments built in four British universities, blasted off from Cape Canaveral atop a Thor-Delta rocket on 26 April 1962.

To conclude this chapter, just a few words about the other two countries of the 'big four,' Italy and Germany, in the postwar period. The military played an important role in stimulating developments in Italy. The Italian Navy invited the German expert Hermann Oberth to their arsenal at La Spezia for several years to advise on rocket development. The Air Force, in collaboration with various firms developed both solid and liquid-fuelled sounding rockets. And in 1959 the Consiglio Nazionale delle Ricerche (CNR), responsible for funding scientific research, and the Air Force, put Colonel Luigi Broglio in charge of upper atmosphere research. Broglio was quick to react to NASA's offer of collaboration. In 1962 Italy and the USA signed an agreement for the so-called San Marco project. Two years later, on 15 December 1964, the country's first satellite, San Marco-1, weighing no less than 115 kg, was put into orbit by an American Scout rocket from Wallops Island on the east coast of the USA.

The situation in the Federal Republic of Germany was quite different. Throughout the fifties there was increasing pressure for the development of a national space effort. A number of space societies were revived and a space research institute was established. Scientists and technicians from the Peenemünde project were prominent in both. Contacts were made with major industries. However, it took some time for their efforts to bear fruit. The V2 weapon had damaged the public image of space in the country, and restrictions imposed by the Allied Powers did the rest. For a decade after the war all activity in rocket technology was forbidden. And even though the Paris Treaties of May 1955 relaxed the constraints a little, the construction of guided missiles with a range greater than 70 km was still not allowed.

Blocked by the legacy of the past, many interest groups in Germany were thus particularly receptive to the initiatives taken at the end of 1959 to launch a collaborative European space programme. They were seen as legitimising Germany's re-entry into a field of research from which she had been effectively excluded for many years. They served as a platform from which to launch an independent national programme. And they dovetailed neatly with Minister of Defence Franz Josef Strauss's conviction that the strength of the western alliance, and of Germany's place in it, rested on the development of modern technologies, including missiles. Germany at the end of the 1950s was thus 'lagging' behind the other three major European countries in the space field, and yet the country was endowed with a group of scientists, engineers, businessmen and politicians who were determined that she should rapidly play a leading role in this sector.

First European satellites

The first all-European satellite to reach orbit was the Italian San Marco-1, built by the University of Rome's Centro di Ricerche Aerospaziali under the direction of Luigi Broglio. It was launched by a United States' Scout rocket on 15 December 1964 from Wallops Island, on the east coast of the USA, and placed in an orbit with a perigee of 198 km and an apogee of 856 km. The satellite was a sphere with a diameter of 66 cm and weighed 115 kg. On board was a dynamometric balance (known as 'Bilancia Broglio') which measured variations in the density of the atmosphere and, indirectly, the average temperature and molecular weight of the air. Three other San Marco satellites were launched by Broglio's group — in 1967, 1971, and 1974 — from a platform anchored in the Indian Ocean off the coast of Kenya.

Less than one year after the San Marco launching, on 26 November 1965, the French rocket Diamant-A put Astérix, a 42 kg test satellite, into orbit, thereby making France the third space power. Ten days later, on 6 December 1965, a Scout rocket launched France's first scientific satellite, FR-1. This satellite was developed by CNES and carried instruments for studying irregularities of ionisation in the magnetosphere and ionosphere. In the shape of a polyhedron, its diameter was 68 cm and its height 1.32 m. It weighed 76 kg. It was launched from Vandenberg Air Force Base, California, and placed in a near-circular orbit about 750 km high.

In 1966 and 1967 France launched three small scientific satellites developed by CNES. All of them were launched by Diamant rockets from the Hammaguir base, and their scientific mission was to make geodetic experiments based on the study of the Doppler effect. The first satellite, called D1-A (Diapason), was launched on 17 February 1966 into an elliptical orbit with a perigee of 500 km and an apogee of 2700 km. The two others, called D1-C and D1-D (Diadéme), were both launched in February 1967. They were followed, in April 1971, by the D2-A (Tournesol) satellite and, in September 1975, by D2-B (Aura). Weighing 96 and 110 kg, respectively, they were designed to study the distribution of stellar hydrogen and the ultraviolet radiation emitted by the Sun. Both were launched from the French base in Kourou, Guiana, by a Diamant-B rocket.

We should also mention here the Franco-German scientific satellite Dial/Wika, launched on 10 March 1970 from Kourou by a Diamant-B. It had a weight of 63 kg and carried four experiments for studying the belt of particles around the Earth.

Britain entered satellite space research in 1962, when instruments designed and built by scientists from UK universities were carried on board the satellite Ariel-1, developed in conjunction with NASA. In the shape of a cylinder, diameter 58 cm and height 53 cm, the satellite weighed 60 kg. It carried out seven experiments on the Van Allen particle belt, solar radiation and cosmic rays. Ariel-1 was launched on 26 April 1962 from Cape Canaveral by a Thor-Delta rocket and placed in an orbit with a perigee of 389 km and an apogee of 1214 km. A second Ariel satellite, weighing 68 kg and carrying three British experiments, was launched on 27 March 1964 from Wallops Island by a Scout rocket. The third of the series was built in the UK. It weighed about 90 kg and carried five experiments. It was launched on 5 May 1967 from the Vandenberg base by a Scout rocket. The Ariel series included three other satellites launched in 1971, 1974 and 1979.

French Diamant rocket used to launch scientific satellites developed by the French Space Agency (CNES)

Chapter 2 — The launch of ESRO

The first initiatives by European scientists

The first important steps towards setting up a European space organisation were taken by the Italian physicist and scientific statesman Edoardo Amaldi in mid-1958, in the exciting days following on the successes of Sputnik and Explorer. Between July of that year and March of the next he sounded out the views of a number of colleagues about the possibility of setting up a space organisation dedicated to the development and construction of satellites and launchers to be used for purely scientific research. While their responses were cautious — there was the problem of cost, and of the inevitable military associations of a rocket programme — Amaldi was sufficiently encouraged to take the idea further. In February 1959 he met with Pierre Auger in Paris. Auger, like Amaldi, was originally a cosmic ray physicist, and a fellow pioneer of CERN, the European Organisation for Nuclear Research established in Geneva, and was now the Director of UNESCO's Department of Exact and Natural Sciences.

Edoardo Amaldi

During a peripatetic conversation in the Jardins du Luxembourg the two men discussed how next to proceed. Shortly thereafter Amaldi drafted an important document entitled 'Space Research in Europe', which he circulated widely. It drew together the ideas that had been maturing in his mind over the previous nine months. An essentially similar French version of the text was published in December 1959 under the more explicit title 'Créons une organisation européenne pour la recherche spatiale'.

The timing of the publication of this article in French was no coincidence. Indeed, it was sandwiched between the successful commissioning of CERN's giant new powerful accelerator, the protron synchrotron (PS), in November 1959, and the first official meeting of the COSPAR, an international committee on space research which grew out of the IGY, which was due to be held in Nice in January 1960. The commissioning of the CERN PS was potent proof for governments that European scientists and engineers could collaborate successfully in the construction of big equipment comparable to the best that the United States could offer. The COSPAR meeting was explicitly intended to promote international cooperation in the new research fields opened by the advent of space technologies. The Nice meeting, in Auger's view, would play for space a role analogous to that which the 1955 Geneva Conference on the Peaceful Uses of Atomic Energy had played for the atom, i.e. it would regenerate international collaboration in the field, superpower rivalry notwithstanding. It was this happy coincidence that Auger and Amaldi sought to exploit.

Auger convened two informal gatherings during the course of the COSPAR meeting. The first was attended by representatives of countries which already had organised national space committees (i.e. Belgium, France, Italy, Netherlands, Sweden and the United Kingdom). Germany and Switzerland, which were hoping to set up similar bodies in due course, attended the second. The most striking feature about these meetings was the enthusiasm shown by the UK. Indeed Harrie Massey, who was also the president of the British National Committee for Space Research (BNCSR), not only proposed the kind of scientific topics that a future European organisation might study; he also suggested a solution to the question of the launcher. Britain, he said, might soon decide to develop a satellite launcher for civil purposes and a future European organisation could play an important role in persuading her to go ahead with this scheme.

Encouraged by these reactions, another meeting was arranged in Auger's flat in Paris on 29 February 1960. All eight of the countries involved in the Nice discussions were represented by high-level scientists including Amaldi, Auger and Massey. Once again Massey took the lead in confirming the interest which British scientists had in European collaboration. Going further he suggested that, to place the discussions on a more formal footing, the BNCSR invite suitable delegates to a meeting in London in late April with a view to setting up a recognised international committee or working group.

Harrie Massey (left) with Pierre Auger

About 20 European space research scientists from ten west European countries (the eight that we have mentioned together with Norway and Denmark) duly met in the rooms of the Royal Society, London, on 29 April 1960, under the chairmanship of the Society's Physical Secretary W. Hodge. After representatives from several countries had reported on their national activities, the discussion focussed on three main issues: the possibilities for cooperation using existing or soon to be developed national facilities, the possibilities for a jointly-funded European cooperative effort in space research, and the most desirable procedure to be followed for implementing such an initiative.

The British delegates explained in some detail the experiments that they might like to perform during the next five years, in particular the construction of large space telescopes for studying ultraviolet and X-ray stellar spectra. Massey's earlier suggestions about the possible collaborative development of a launcher were also fleshed out. In fact, a fortnight before, the British government had officially announced its decision to abandon the development of its ballistic missile Blue Streak as a military weapon, and to explore the possibility of developing it jointly with other European partners as a civil satellite launcher (see chapter 3). Blue Streak, it was said, could be used as the first stage of such a launcher with a modified version of the British rocket Black Knight as the second stage. Going even further, the chairman of the meeting enquired 'if any country represented would be prepared to indicate the possible order of their contribution should the Blue Streak rocket be used to place a European satellite in orbit.'

The British idea was generally well received. The only recorded qualms were those expressed by Amaldi and by the Dutch astrophysicist Hendrik van de Hulst. They made it clear that their governments would obviously not be willing to contribute to the development of a British rocket if that rocket was not properly integrated into a European programme. There were also doubts raised by these two delegates and by Auger over Britain's wish to have Australia associated with any collaborative European space effort. The UK made extensive use of a launching range in the south of the country at Woomera for its missile programme, and wanted to continue doing so. In the event, and these hesitations notwithstanding, the meeting passed a resolution which stated that those present were 'strongly in favour of a cooperative effort by European nations towards further research in space science including the placing in orbit of artificial satellites by a launching vehicle developed and financed cooperatively'.

European scientists interested in space research, in short, were thinking of creating a single civil organisation which, like NASA, would be dedicated to the development of both launchers and satellites.

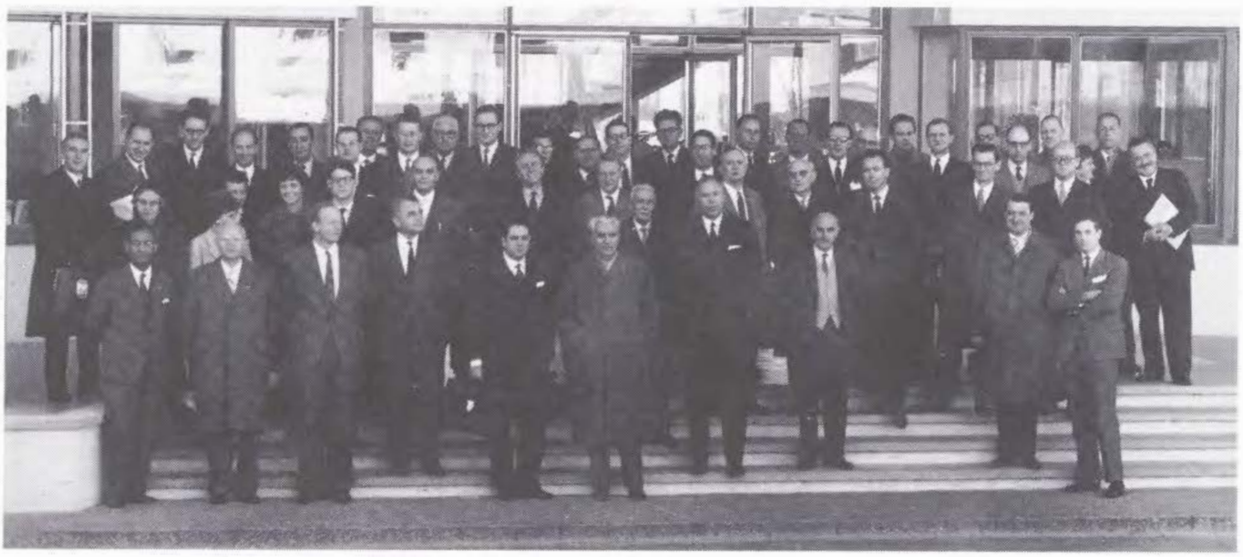
From GEERS to COPERS: the 'Meyrin Agreement'

Auger left London with instructions to convene a meeting of senior scientists and administrators whom, it was hoped, could commit their governments to studying the possibilities of having a European space effort. They duly met in Paris in June 1960 to discuss his 'Draft Agreement Creating a Preparatory Commission for European Collaboration in the Field of Space Research'. It immediately appeared that it would not be possible to set up any such commission there and then. For one thing the precise domain which would be covered by the organisation was not clear, at least not to the British. Massey, in particular, wanted to know whether or not other states were willing to collaborate in the development of a launcher based on Blue Streak as well as in the construction and orbiting of satellites. Then there was the problem of Australia whose presence, some felt, would tarnish the European character of the new organisation. Finally, it was clear that those present simply did not have the authority to take decisions which would be binding on their governments. In the light of these considerations it was decided that it was first necessary to establish a study group whose main task would be to define the areas in which European cooperation would take place. Thus the meeting constituted itself as the GEERS (Groupe d'Etude Européen pour la Collaboration dans le Domaine des Recherches Spatiales or, in the English version, the European Space Research Study Group) and nominated its bureau. H. Massey was elected chairman. L. Broglio (I), M. Golay (CH) and L. Hulthén (Sweden) were elected vice-chairmen and P. Auger was nominated executive secretary.

The GEERS met again in the rooms of the Royal Society on 3–6 October 1960. The meeting was attended by some three dozen scientists and engineers, about half of them from Britain and France. The foundations of the envisaged European organisation for space research began to emerge here. In particular it was decided that ESRO's scientific programme should include both a sounding rocket programme and a satellite programme. It was also agreed that two main establishments should be created: a technical centre responsible for the engineering of satellites and large scientific payloads and a data analysis centre for the gathering and elaboration of data received by the tracking and telemetry facilities.

Finally, two important points of policy were established at this meeting. Firstly, those present were emphatic that the envisaged international organisation should not compete with national activities and programmes, but rather 'enhance their efficiency'. In other words, the European organisation was to be developed in parallel with national space research efforts, and was not to supplant them. Secondly, there was a new attitude on launchers. This issue could not be discussed openly because the British delegation had been instructed not to make any reference to the ongoing diplomatic discussions about the Europeanisation of the Blue Streak/Black Knight combination. However, the use of Blue Streak and of Woomera were now being considered simply as one option among others, which included using United States' launchers and French and United States' launching bases. Apparently, the organisation the scientists were designing would no longer include the development of launchers in its programme.

A meeting of government representatives with powers to set up the envisaged Preparatory Commission was held shortly after the London meeting of the GEERS. Significantly it took place at CERN in Meyrin, just outside Geneva, from 28 November to 1 December 1960. At the outset, the British and French delegations made it clear that the conference should not discuss the question of launchers. It was feasible, they said, to create in Europe an organisation dedicated solely to scientific research, which was not concerned with commercial applications such as telecommunications or with the construction and development of rockets. Leading representatives of the scientific community concurred. On the one hand they feared that launchers would inevitably swallow up all the funds dedicated to scientific research inside the new body. On the other, they had the alternatives of national rockets and of taking up the offer made by NASA to provide launchers for carrying European payloads into orbit.



Delegates to the Meyrin conference

Splitting off space research from launcher development also guaranteed a wide participation of European states, particularly the smaller countries which might otherwise be reluctant to participate for fear of incurring heavy expenditure and/or jeopardising their neutrality (which was particularly important for countries such as Sweden and Switzerland). It would also solve, or rather dissolve, the problem of Australia, as this country would have no particular interest in joining the organisation if it were not committed to using Woomera.

The delegates to the Geneva meeting formalised the so-called 'Meyrin Agreement' setting up a 'Preparatory Commission to Study the Possibilities of European Collaboration in the Field of Space Research' (the COPERS, from its French initials). Its tasks were to 'consider arrangements for the design, development and construction of space research satellites, and arrangements for the launching of satellites.' A budget of some one million new French francs for its first year of operation was defined, and a scale of contributions similar to those in force at CERN (i.e. proportional to the gross national product of the participating states) was drawn up. The agreement was opened for signature on the afternoon of 1 December 1960 and signed immediately without reserve by representatives from five countries. It entered into force on 27 February 1961.

M. Golay signing the Meyrin protocol on behalf of Switzerland

Delegates to the 1960 Meyrin conference. Left Pierre Auger, centre Harrie Massey

Two months after the Meyrin conference Britain and France, at a jointly convened meeting in Strasbourg, proposed to their European partners that they collaborate in the setting up of an organisation devoted to the common development of a heavy satellite launcher. In short, by February 1961 it was evident that Europe would enter space with not one organisation, as Amaldi and Auger had hoped that spring day in Paris almost two years before, but with two.

The setting up of ESRO

The Meyrin Agreement which created COPERS was due to terminate after one year, when it was expected that the convention establishing the European Space Research Organisation (ESRO) would be ready for signature by the new body's member states. In the event, due to delays in the preparation and ratification of the convention, the Agreement was prolonged four times and the work of COPERS extended up to March 1964 on the basis of an interim programme. Twelve countries finally participated in this work. These were Austria (which joined in October 1961 but withdrew later), Belgium, Denmark, France, the Federal Republic of Germany, Italy, the Netherlands, Norway (which withdrew from membership in June 1962), Spain, Sweden, Switzerland and the United Kingdom. At its first meeting, held in Paris on 13 and 14 March 1961, the COPERS elected its bureau — chairman H. Massey, vice-chairmen L. Broglio and H. van de Hulst, and executive secretary P. Auger. It also established two working groups. One, which was chaired by A. Hocker, was to deal with legal, administrative and financial matters (the LAFWG). The other, the interim scientific and technical working group (STWG, also called GTST, from its French initials), was to prepare the short and long-term scientific programmes for ESRO. L. Hulthén, from the Royal Institute of Technology in Stockholm, was nominated chairman of this group and R. Lüst from the Max-Planck-Institut für Physik und Astrophysik in Garching, near Munich, was nominated its coordinating secretary.

The scientific programme

In the summer of 1961 the STWG and its subgroups defined a draft scientific programme and a launching schedule for ESRO's first eight years. Their proposals were gathered together in a report laid before the third session of COPERS held on 24 and 25 October 1961 in Munich, where it was warmly received. The report, popularly known as the Blue Book, divided the projects into three main categories (short-, medium-, and long-term projects) according to when they would first produce scientific results. Short-term projects were those that could be started immediately using sounding rockets and resources which already existed or which could be quickly developed. The most important field of study in the short-term programme was the investigation of upper atmosphere phenomena in the auroral zone, taking advantage of a sounding rocket launching range to be established in northern Sweden, near the Kiruna Geophysical Observatory.

Esrange — the sounding rocket launching range — Kiruna, Sweden

The mediumterm projects included experiments involving small satellites in near-Earth orbits and small space probes, each spacecraft carrying about five experiments. A long list of scientific objectives was included in this part of the programme, covering all fields of space research from ionospheric and magnetospheric physics to cosmic rays, from cometary evolution to solar physics, and from radio-astronomy to geodetic measurements. No explicit priority was given. As for long-term projects, the development and launching of large stabilised satellites for astronomical studies was proposed and, later, the development of lunar satellites. The number of launches put forward in the Blue Book, and eventually accepted by the conference of plenipotentiaries which signed the ESRO Convention in June 1962, was rather ambitious (Table 1). It proposed that the organisation should have a sounding rocket programme which built up to a steady level of about 65 'standard' vehicles per year by the third year of its existence. It was also to launch about three small satellites and space probes from year four onwards and one large satellite annually from year six onwards.

Table 1
Number of sounding rockets and spacecraft to be launched during ESRO's first eight years as proposed in 1961 in the Blue Book *

<table>
<tr><th>Year</th><th>Sounding Rockets</th><th>Small satellites</th><th>Space probes</th><th>Large satellites</th></tr>
<tr><td>1</td><td>< 10</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>40</td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>65</td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>65</td><td>2</td><td></td><td></td></tr>
<tr><td>5</td><td>65</td><td>3</td><td></td><td></td></tr>
<tr><td>6</td><td>65</td><td>2</td><td>1</td><td>1</td></tr>
<tr><td>7</td><td>65</td><td>2</td><td rowspan="2">3</td><td rowspan="2">1</td></tr>
<tr><td>8</td><td>65</td><td>2</td></tr>
<tr><td>Total</td><td>~ 435</td><td>11</td><td>4</td><td>2</td></tr>
</table>

* Two points are to be noted about the figures in this table. Firstly, the number of sounding rockets was based on a 'standard' vehicle capable of firing a 50kg payload to an altitude of 150km. Secondly, it was assumed that two launchings would be required to orbit one successful spacecraft, so that the number of satellite and space probe launchings budgeted for was double the numbers given in this table.

Two aspects of the scientific programme presented in the Blue Book should be underlined. Firstly it was stressed that ESRO was not supposed to build the scientific paylods to be carried by spacecraft and sounding rockets. All the scientific work, including the design and construction of the experiments and the interpretation of results, was to be the responsibility of scientific groups outside the Organisation. ESRO's role was to provide technical and managerial services such as engineering of satelites, launching operations, tracking and telemetry, data reduction, etc. Scientific institutions in member states were also supposed to fund the scientific payloads to be carried on board the Organisation's rockets and spacecraft, with the exception of the large satellites in the long-term programme, which were to be totally funded by ESRO.

The second point to stress about this first draft programme is the vagueness and lack of priority in the list of research fields. This reflected the intentions and hopes of the emerging European space science community, and was more a declaration of intent than a definite programme of work. It provided a rough and, as we shall see in chapter 4, a highly optimistic basis for a first estimate of costs, and a framework in terms of which the various sections of the community would later set their priorities by hard bargaining.

The eight-year budget and the mechanisms evolved for keeping it under control

The first estimates of the costs of ESRO were prepared by the STWG immediately after COPERS was set up. They were laid before its second session in May 1961. The spending plan showed costs rising steadily for the first five years as the necessary capital facilities were acquired, and the medium-term scientific programme came into operation. Costs then jumped to a plateau for years six to eight as the large satellites became operational. After some minor revisions the scientists' estimate for the eight-year programme came to about 1550 million French francs (MFF).

These estimates were deemed too low by the LAFWG's budget subgroup. The science administrators pointed out that Europe had as yet no experience in any satellite project taken to completion, and no-one in the world had experience of very large projects. Cost overruns were therefore unavoidable. In addition, there was the question of the cost of the launcher. For budgetary purposes the Blue Book had assumed that European scientists would make use of the ELDO launcher to put their large satellites in orbit (see chapter 3). If this launcher was not successful, and ESRO was forced to rely on the United States' Thor and Atlas rockets, the costs of launching such satellites, it was argued, would be much higher than the figures given in the initial estimates.

Finally, the members of the budget subgroup pointed out that provision should be made during the later years of ESRO's life for starting programmes which would come to fruition after the initial eight-year period. In line with these convictions, the subgroup revised the estimates of expenditure proposed by the STWG from about 1550 to about 2100 MFF, including large margins for contingency in the last three years of ESRO's life.

These debates took place against the backdrop of a determined initiative, led by the British government, to impose global and intermediate ceilings on ESRO's expenditure, and to limit the costs of the first eight-year programme to 1500 MFF.

There were two reasons for this. The first, based on the UK's experience at CERN, was the need to restrict the power of the ESRO Council. The second was their estimate, made towards the end of 1961, of the maximum acceptable levels of UK expenditure on space science at both the national and the international levels for the next six to eight years.

Ever since 1957 the British government had tried unsuccessfully to impose two or three-year ceilings on expenditure at CERN. Their proposals had been greeted with widespread hostility both by the CERN management and by many of the member states' delegates. Matters had come to a head towards the end of 1961. Frustrated by the apparent impotence of its Council delegates to limit expenditure, the Foreign Office took the then unprecedented step of approaching other governments directly, and suggesting that a three-year ceiling on CERN's budget should be settled between them. The Council's powers would be restricted to voting the annual programme within these limits.

This attempt to bypass the CERN Council was violently rejected at a meeting in December 1961, and the British had to step down.

The UK's various proposals within ESRO were articulated in parallel with these moves. What the British government had learned from its experience in Geneva was that firm ceilings should be legally enshrined in the convention establishing any new scientific facility working at the leading edge of research and development, along with mechanisms for ensuring that those ceilings were enforced. Indeed the British National Committee for Space Research had been planning its activities on the basis of the first STWG estimates and the UK government was now determined to stick to the early figure of 1500 MFF come what may.

It goes without saying that the British triumphed at the conference of plenipotentiaries held to sign the ESRO Convention and a number of associated protocols on 14 June 1962.

The conference adopted an overall eight-year ceiling of 1500 MFF at price levels ruling at the date of signature of the protocol. (This was equivalent to 306 million accounting units (MAU), where 1 AU was defined as the value of about 0.88867 grams of fine gold, and at the time was equivalent to US$1.) Against the advice of the scientists, it was also agreed that, within this level, the Council would determine every third year by unanimous decision of all member states the level of resources for ESRO for the succeeding three-year period. This was set at 384 MFF (78 MAU) for the first three years of ESRO, and a provisional ceiling of 601 MFF (122 MAU) was agreed for the second three-year period after the entry into force of the convention (all at 1962 price levels). The annual budget was to be adopted within these limits by a simple two-thirds majority of the Council.

ESTEC's original home in the University buildings, Delft, the Netherlands

The ESOC control room for the first successful ESRO satellite mission

ESLAB's home in Noordwijkerhout, the Netherlands

The establishments and their functions

The scientists who drew up the first plans for ESRO in 1960 and 1961 were more or less unanimous on the main facilities which they required and whose functions were described in the Blue Book. In the event, COPERS accepted these recommendations and the initial structure of the new Organisation was mainly based on the following facilities:

— The European Space Technology Centre (initially abbreviated to ESTeC, but later changed to ESTEC, which we have used throughout this book), ESRO's main technical establishment, responsible for the engineering and testing of satellites and their payloads, the integration of scientific instruments into these payloads, and for making arrangements for launching. It would carry out this task either itself or through placing contracts with industries and with national research institutes. In the first phase of ESRO, ESTEC hosted also the Control Centre responsible for the monitoring and control of ESRO's spacecraft during their orbital life. Subsequently this task was moved to the Data Analysis Centre;

— The European Data Analysis Centre (ESDAC), the task of which was the collection, reduction and distribution of scientific data received from spacecraft and ground observatories, and the provision of facilities and services to assist research groups in their analysis. It was also responsible for making predictions on satellite orbits in anticipation of the launch. In 1968 the Centre also took over from ESTEC the responsiblity for the control of satellites in orbit and was renamed the European Space Operations Centre (ESOC);

— Esrange, the ESRO launching range established at Kiruna, in northern Sweden, for carrying out a sounding rocket programme in the auroral zone. The Organisation could also avail itself of national ranges existing in Italy (at Salto di Quirra in Sardinia), Norway (in Andoya), Australia (Woomera), and France (Ile du Levant). A temporary range was also established on the Greek island of Karistos for a solar eclipse campaign in 1966;

— Estrack, a network of four telemetry, telecommand and tracking stations required to control the spacecraft once in orbit and to receive data transmitted back from the satellite. These stations were established in Redu (Belgium), Fairbanks (Alaska), Port Stanley (Falkland Islands) and Ny Alesund (Spitzbergen Islands).

Besides these main facilities, a small scientific laboratory was also foreseen. Called ESLAB, its tasks were defined in the Blue Book as 'to undertake theoretical studies and fundamental theoretical research of importance to space science' and 'to provide experimental facilities to enable individuals and small institutions to undertake research in space science'. The establishment of this laboratory caused some controversy in the discussions during 1961 and 1962. One faction was emphatic that all scientific work should be done in home institutions. Those in favour of ESLAB, however, felt that without it ESRO would be reduced to what was essentially a service function for the European space science community. They argued that the organisation should have a scientific role in its own right.

After a 'long and difficult discussion' it was finally agreed that a small laboratory be set up near ESTEC to do scientific research. However, according to the scientists' tenet that ESRO should not compete scientifically with national research groups, ESLAB's staff was so defined in the Blue Book as to be below the minimum which they felt was necessary to prepare experiments to fly on satellites. After some years ESLAB was closed and its research staff incorporated into ESTEC's new Space Science Department (SSD).

The negotiations over the sites for the ESRO establishments were long and difficult. The compromises finally arrived at placed the headquarters in Paris (where the Directorate and the staff responsible for the overall administration of the organisation were housed), ESTEC in the Netherlands — initially at Delft but later at Noordwijk — and ESDAC/ESOC in Germany at Darmstadt. The negotiations were complicated at the last minute by the fact that Italy, finding itself without a site on its soil, made a bid for ESLAB. This move was most unpopular because the draft of the convention, agreed on after months of deliberations, specifically stated that ESLAB had to be near ESTEC, and there was no suggestion that ESTEC should be in Italy. The deadlock was broken by Broglio suggesting that his country would be satisfied to host a research institute with a rather different focus from ESLAB. Thus was born ESLAR (later renamed ESRIN): a laboratory for advanced scientific research set up at Frascati outside Rome

ESRO Head Office in Neuilly, Paris

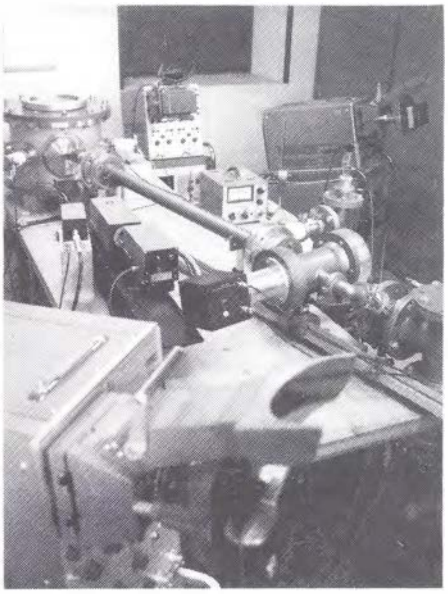
ESTEC's site

The Dutch government originally intended to establish ESTEC just outside Delft. Problems emerged almost at once, notably concerning the stability of the soil in the polder (Dutch term for land reclaimed from the sea) on which the establishment was to be built. 'I know now why the cows are always running on the land offered to us by the Dutch', Freddy Lines is reputed to have joked to Jean Mussard, a senior colleague in the COPERS secretariat, 'as soon as they stop, they sink'.

More technically, a group of experts pointed out that a building on the site at Delft would need to be located on piles driven 16 metres into the ground so as to reach the firm underlying layer of sand. In response to this report the Dutch government offered a new coastal site at Noordwijk. This site, too, was less than ideal. Ground conditions were better than at Delft. On the other hand, the proximity to the sea created additional concerns regarding the effects of salinity and of sand blowing on delicate apparatus.

The question of ESTEC's site was one of the major preoccupations of the ESRO Council during the first six months of its life. There was general disillusionment among the member states' delegates over the inadequacy of the accepted location in Delft, and several countries demanded that the whole question be reopened. Finally, in October 1964, as the possibility of reaching a compromise through normal procedures seemed increasingly remote, Massey implored the Council to accept the Noordwijk site 'in the interests of European collaboration and the future of ESRO'. This they did, and on 1 March 1965 the first foundations of a 33 000 m^2 building planned to house 800 people were laid at Noordwijk.

ESTEC's permanent home in Noordwijk, the Netherlands, takes shape in 1966



ESRIN's first experiment Solo (solar radiation experiment)

ESRO's decision making structure

To conclude, a few words about the legislative arm of ESRO The organisation's supreme governing body was the Council. Its main tasks were to determine the organisation's scientific. technical and administrative policy, to approve its programme and annual workplans, and to determine its level of resources both annually, and every third year for the subsequent three-year period.

Each member state had one vote in the Council, where it was represented by not more than two delegates and a number of advisers. Both scientists and science administrators were usually included in national delegations. All member states were also represented on the Council's two subordinate bodies, the Administrative and Finance Committee (AFC) and the Scientific and Technical Committee (STC). The latter, whose representatives were spread over many scientific institutions and universities in ESRO's member states, considered ideas and proposals for space experiments received from a set of advisory committees and expert groups.

The most important of these was the Launching Programme Advisory Committee (LPAC), a small body of four or five scientific experts nominated by the STC. Its task was to define the scientific missions of ESRO spacecraft and their launch programmes, and to combine the various experiment proposals into integrated payloads for sounding rockets, satellites and space probes. The LPAC was advised by six expert groups whose chairmen, also appointed by the STC, were generally invited to LPAC meetings. The groups dealt with atmospheric studies (ATM), with ionospheric and auroral phenomena (ION), with solar astronomy (SUN), with the moon, planets, comets and the interplanetary medium (PLA), with stars and stellar systems (STAR), and with cosmic rays and trapped radiation (COS) (Table 2).

Table 2
Chief officers in ESRO's decision making structure in 1964-65

Council
Chairmen H. Massey, A. Hocker
Vice-chairmen M. Golay, H. van de Hulst

Scientific and Technical Committee
Chairman R. Lüst
Vice-chairman B. Peters

Administrative and Finance Committee
Chairmen Sassot, Obling
Vice-chairmen Ferrier, Mangon

Launching Programme Advisory Committee
Chairman R. Lüst
Members J. Blamont, R. Boyd, C. de Jager

Chairmen of expert groups

ATM	R. Frith
ION	B. Hultqvist
SUN	C. de Jager
PLA	L. Biermann
STAR	P. Swings
COS	G. Occhialini

The six expert groups reflected the variegated and rapidly evolving state of space research at the time. Space science can be divided between disciplines interested in the Earth's atmosphere and the Sun-Earth relationship (roughly speaking, geophysics) and those interested in the study of celestial bodies (astrophysics). The most important research field in the first group concerns the study of the ionosphere and the magnetosphere, and their modulation under the influence of solar radiation. This was the province of the ION group, and since it required relatively small and simple spacecraft to explore the properties of the ionosphere it rapidly rose to prominence in the 1960s. The astronomers were more heterogeneous. The advent of the space age offered them the opportunity to study the Moon and planets at close range, and to explore sources of electromagnetic radiation from the Sun and other celestial bodies at wavelengths which were absorbed by the upper layers of the Earth's atmosphere, notably UV and X-radiation. The PLA group was somewhat disadvantaged in having to compete with major planetary missions of the superpowers. The STAR and SUN groups would concentrate on UV astronomy The higher energy region of the electromagnetic spectrum, X-ray and gamma-ray astronomy, required the use of detector techniques drawn from experimental physics, and this opened the domain of astrophysical research to cosmic ray physicists. Through the COS group they became one of the most dynamic and successful users of ESRO.

The ESRO convention entered into force on 20 March 1964. The founding states were Britain, France, (Federal Republic of) Germany and Italy, Belgium and the Netherlands, Sweden and Denmark, and Spain and Switzerland. Austria and Norway had observer status. The first meeting of the Council opened in Paris three days later with Massey in the Chair

Chapter 3 — The launch of ELDO

In the previous chapter we explained how, during 1959 and 1960, the European space science community took a number of initiatives directed towards establishing a collaborative enterprise in their field. We stressed that, while the original idea was that Europe should have just one organisation dedicated to both the development of launchers and of satellites, by the end of 1960 it was generally accepted by scientists and politicians alike that these activities should be split from each other.

The deliberations among scientists and administrators in 1960 took place against a background of important political negotiations between Britain and France over the desirability of developing together a European heavy satellite launcher. The cost of this venture, the technical and managerial risks that it entailed, its unavoidable military connotations, and the availability of United States' launchers all persuaded scientists that their space research organisation should be kept quite distinct from the Anglo/French rocket project.

We now want to explore in greater depth the intergovernmental negotiations that led to the signature, in April 1962, of the convention establishing ESRO's sister organisation, ELDO.

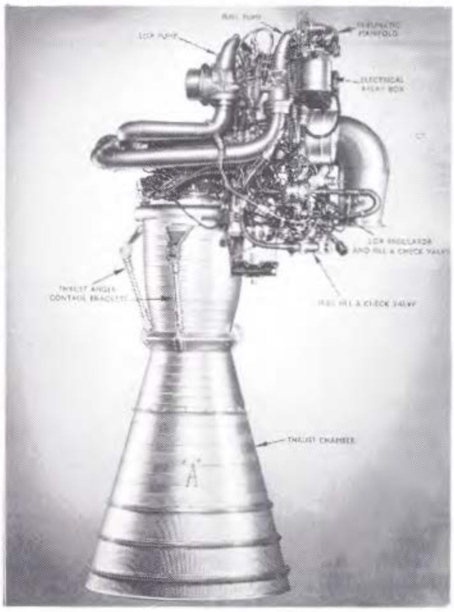
Europa 1 with Blue Streak as the first stage

The UK military origins of Blue Streak and its recycling as a civil launcher

The origins of the ELDO can be traced back to the mid-1950s. In the spring of 1954 the US Secretary of Defense, Charles E. Wilson, suggested to the British Minister of Supply, Duncan Sandys, that Britain might like to collaborate with the United States in the development of ballistic missiles. Wilson indicated that whereas Britain could work on intermediate range missiles (IRBM) which could strike at distances of about 2500 km, the USA would concentrate on intercontinental ballistic missiles (ICBM) with a range of some 8000 km. While the American motives for making this stunning offer are not clear, it seems that they were inspired by the realisation that IRBMs would be of strategic interest to the UK, and by an unwillingness to divert relatively scarce resources away from their own ICBM programme.

The British, for their part, were at this time redefining their military strategy, and had decided to build an H-bomb. The development of an IRBM was one component of a new will inside the country to establish an independent nuclear deterrent.

In the event, the two countries very soon went their own ways. It quickly emerged that the United States was far ahead of the British in the development of missile technology, and had little to learn from them through any kind of 'joint venture'. In addition a reassessment of United States needs by an advisory panel under the President of MIT, James Killian, indicated that a crash programme in both intermediate and long-range missiles was essential if the USA was to maintain its defences against a Soviet attack.



The Blue Streak RZ-2 engine from Rolls Royce

In the light of these developments, in November 1955 Wilson informed all the United States' armed services that a IRBM was to be developed 'at the maximum speed permitted by technology'. Within weeks, Wernher von Braun and his army team had the Jupiter missile authorised. Very soon after, the Air Force put forward plans for its rival, Thor. In parallel and probably some time in 1955, Britain too embarked on its own IRBM programme, with the assistance of USA industry, the product of which was the Blue Streak missile. The test range for Blue Streak was the Anglo-Australian base at Woomera.

The United States rapidly overhauled the British. In February 1958 an agreement was signed for the installation of 64 Thor missiles on British soil. At the same time, to avoid duplication, Blue Streak's range was increased to 4000 km, and provision was made for housing the missile in hardened underground silos. Even this could not save the weapon. Blue Streak was a liquid fuel rocket which took

General view of the range at Woomera, Australia, with Europa 1

about 30 seconds to prepare when in a state of readiness and some seven minutes otherwise. In addition, it was not mobile. In using it the military thus had to choose between launching the missile rapidly, and so risk starting a nuclear war, or delaying launch until they were certain that the use of the missile was essential, and so risk having the deterrent destroyed before it had left its silo. Reviewing the programme early in 1960, high-level British officials decided that it was unwise to rely any longer on Blue Streak. They preferred instead to buy the United States' Skybolt missile, which could be launched by the V-bomber force, and to supplement it later with Polaris missiles which could be launched from submarines.

Rather than cancel Blue Streak altogether, the government took up the idea, already in the air since 1958, of recycling it as a satellite launcher for non-military purposes. This solution would not only save the £60 million already spent on the development of the missile, it would also preserve the inhouse skills and industrial infrastructure which had gone into its development, resources that could later be deployed if Britain wanted once again to develop its own missile capability.

Bringing the French on board

The decision to cancel Blue Streak as a missile was announced to the British parliament on 13 April 1960. Immediately thereafter, steps were taken to encourage continental states to join with the UK in the construction of a heavy satellite launcher comprising Blue Streak as its first stage, a modified version of the British research rocket Black Knight as its second stage, and a third stage still to be decided. At the same time Britain took pains to reassure Australia that she would insist on using Woomera as a launching pad for any eventual European rocket. The United States was also advised that, in converting Blue Streak to a civil launcher, it would be stripped of all military characteristics. This was a delicate point as it was United States policy not to do anything which might help either France or Germany develop an independent IRBM capability.

In September 1960 the British Minister of Aviation, Peter Thorneycroft, made a tour of several European capitals to consult his counterparts about the willingness of their governments to form a European organisation for the construction of an all-European jointly-funded heavy satellite launcher. The initial reactions were very encouraging. It was the position of the French though, regarded as the potential cornerstone of the international organisation, that mattered most to the British government. France, as we have seen, had developed the Véronique rocket in the 1950s and was in the throes of embarking on a major new rocket programme for both civilian and military purposes (the so-called 'Precious Stones' programme culminating in the Diamant launcher). What is more, the British government certainly hoped that French President Charles de Gaulle would see Thorneycroft's offer as a sign of Britain's wish to draw closer to the continent both politically and economically. Towards the end of 1960, in fact, Prime Minister Harold Macmillan was convinced that Britain should apply for entry into the European Common Market, and it was well known that de Gaulle's France would be the major obstacle on the path to full membership.

Artist's impression of Blue Streak at altitude

By mid-November 1960, the French had clarified their position regarding the British proposal. They were certainly interested in studying the possibilities of producing a heavy satellite launcher in Europe. However, there were two aspects that they wanted to stress. Firstly, the second stage had to be built in France, rather than it being Britain's Black Knight rocket. Secondly, the cost of any joint programme would have to be studied very carefully. The French space scientists were particularly emphatic about this, insisting that under no circumstances was any joint project with the British to be funded at the expense of their national research programme, the budget for which had just been voted.

The British response was spelled out by Thorneycroft during a visit to Paris in December. He was certainly in favour of the two countries undertaking a joint programme to build a launcher based on Blue Streak as a first stage, a French second stage and a third stage to be developed on the continent too. There had already been certain technical criticisms in the UK regarding the coupling of Blue Streak with Black Knight, so this was a small price to pay for collaboration. However, Thorneycroft argued that such a rocket would undoubtedly cost more than the Blue Streak–Black Knight alternative and proposed that the financial burden be shared between the two countries on a 50:50 basis, the absolute amount being reduced by the contributions made by other countries who might want to participate in the project.

The French could not agree to this cost-sharing formula. By now, mid-December 1960, the Geneva conference setting up COPERS had been held, and it had been effectively decided to separate launcher development from the construction and orbiting of satellites. This meant, said the French, that while the money for satellites would be provided by the ministry responsible for scientific research, that for the envisaged launcher would have to be taken from the military budget. And expenditure of the required magnitude was only possible if the British were willing to share knowledge of important military technologies such as inertial guidance systems and the characteristics of nosecones designed to re-enter the lower layers of the atmosphere. Unfortunately for the UK, these were just the technologies that Britain had promised the Americans to strip from Blue Streak when it was marketed as a candidate for a European civil launcher.

As the British grappled with the implications of this request, the French became increasingly unwilling to commit themselves to a joint project with their partners across the Channel. In mid-December Thorneycroft and the French Minister for the Armed Forces (Messmer) had agreed that they should jointly call an intergovernmental conference for the second half of January 1961 to discuss in a wider forum the possibility of setting up the envisaged organisation for developing a European heavy satellite launcher. However, when the invitations were drawn up the French refused to have any reference made to the fact that they wanted to build the second stage of the launcher. The British in turn refused to give any estimate of the costs of the venture. At the same time, a request by London that a technical team be allowed to visit installations in France to assess the feasibility of coupling first and second stages built in different countries was refused.

France's attitude changed dramatically a few days before the conference, scheduled to start on 30 January 1961 in Strasbourg. Technical exchanges were reinstated and, even more importantly, the French appeared to drop their demand that their participation was conditional on the provision of militarily sensitive technology by the British. The main reason for this seems to have been the pressure that de Gaulle put on his negotiators. From 27 to 29 January the French President met with Macmillan for one of their frequent tête-àtêtes at the Château de Rambouillet. This was also one of the first occasions which Macmillan had had to sound out de Gaulle's views on a possible UK application for Common Market membership.

The two men discussed the heavy satellite launcher during a walk on the afternoon of the 28th. According to a British record of their conversation, de Gaulle said that he was 'attracted by the idea of Europe becoming the third space power' and that he would take a constructive line at Strasbourg. He made no mention of the military aspect.

Persuading Germany and Italy to join

The jointly called Anglo-French conference was duly held in Strasbourg from 30 January to 2 February 1961 with Thorneycroft in the chair. Eleven countries were represented at the conference (Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland and the United Knigdom) and Austria sent an observer. After three days of deliberations, the text of an Anglo-French memorandum summarised the main conclusions reached. The new organisation, should it be set up, would 'study, plan, develop and manufacture a rocket system using Blue Streak as the first stage and a French rocket as the second stage. The development and manufacture of the third stage,' the memorandum went on, 'would be carried out on the continent'. Provision was also made for the planning and construction of a first series of satellite test vehicles.

Britain and France made it clear that the existing facilities which had already been created would be put at the disposal of the organisation at no extra charge. All existing or new technical information would also be freely available to the participating states. The only unusual requirement was that the contracts for the work to be done on the various stages of the rocket and the satellites would not be placed by a central authority with executive powers, but by the national governments themselves.

A distribution of costs was provisionally agreed upon. The British hoped that these could be based on gross national income and that no single participant would have to pay more than 25% of the organisation's budget. France and the smaller countries found this unacceptable. In the event, desperately wanting the project to go ahead now that she had committed herself thus far, Britain agreed to pay one-third of the budget of any new organisation. France, Germany and Italy were to pay the same percentages as they were contributing to CERN for 1961/62 i.e., France 20%, Germany 19% and Italy10% approximately. The remaining 17% would be shared between other countries who joined in the scheme, also according to their gross national incomes.

The political and financial viability of this arrangement required, of course, that Germany and Italy in particular participated. First reactions in Germany were ambiguous. Foreign Affairs Minister von Brentano and the Minister of Economics Erhard were both strongly in favour of collaboration. Both had a conception of European political and economic integration which included the United Kingdom, and both saw collaboration around Blue Streak as a way of binding the United Kingdom closer to the European Economic Community. Against them were Minister of Transport Seebohm, and the formidable Minister of Defence Franz Josef Strauss.

Seebohm's motives were twofold. Firstly, his main adviser was the brilliant rocketeer Eugene Sänger. The latter believed that conventional heavy launchers such as those based on Blue Streak were primitive and uneconomical, and that the future of space transportation lay in the development of a reusable shuttle. He and the Minister thus came out unequivocally against the scheme on 'technical' grounds. Secondly, Seebohm knew that if the conception of a space shuttle gained hold, his ministry would take over responsibility for this, one of the most important and costly new fields of technological development. His ambitions for himself and for his government department thus also shaped his assessment of the British offer.

Strauss's position was quite different. For Strauss the establishment of a strong technico-industrial infrastructure was an essential dimension of power politics in the 1960s. The nuclear stalemate meant that direct armed conflict between the superpowers was unlikely. The technological Cold War had taken its place: it was at once the way to beat the Soviets and to strengthen Germany's position in the West. And the Minister of Defence thought that one of the best ways of doing this was to build advanced weapons systems under licence from the United States. Suspicious of de Gaulle and so unwilling to commit himself to the French-built Mirage fighter, in 1960 he concluded a deal to build 210 Starfighters (F-104's) in the Federal Republic under licence from the United States.

His initial opposition to the Anglo-French initiative for the joint development of a launcher followed a similar line of thinking. The technology was well established and the Americans were not directly involved. Far better, said Strauss, to build a technologically superior US rocket under licence — a solution that was of course unacceptable to the British.

As early as September 1960 the German research council DFG (Deutsche Forschungsgemeinschaft), in a report to the government, declared itself categorically against the British proposal of developing a European launcher based on Blue Streak. Reluctant to abandon the idea altogether, the German government set up a special expert group after the Strasbourg conference. This group contained space scientists, engineers, the directors of several big research institutes, but also financial experts, and representatives of the aviation and electronics industries. It unanimously recommended that the German government participate in the construction of a European satellite launcher. Participation in ELDO would enable German industry to build a third stage which embodied advanced technologies. It was also a way of jettisoning the historical burden of Peenemünde and the V2 and it served as a booster for starting up a national space programme. A month later, and on the basis of this report, the Federal cabinet recommended that Germany join ELDO. On 29 June 1961 Chancellor Konrad Adenauer personally informed Macmillan that the Federal Government had approved the project the day before, provided that the interests of German industry were protected. He hoped, Adenauer added, that this agreement would pave the way for a European organisation 'to secure for European science and technology a proper place in the field of space travel and space research'.

With Germany building the third stage of the rocket, only the test satellite was left for Italy. Not surprisingly then the scheme was initially lukewarmly received. Amaldi and Broglio spelt out their doubts to an Anglo-French technical delegation which visited Rome in September 1961. Amaldi raised three main objections to the scheme. Firstly, there was nothing of interest in it for Italian industry as this would be excluded from the most important part of the project. Secondly, it was managerially absurd to try to build a rocket whose three stages and the test satellite were built in four different countries. Finally, the projected rocket would require investments to develop a technology (that of Blue Streak and of conventional propellants in the first two stages) which was already available in the United States and which would undoubtedly be obsolete by the time the rocket was ready, in five or more likely seven years.

Behind Amaldi's arguments there was also the determination to protect a blossoming Italian national space programme. The month before the meeting with the Anglo-French team, the Italian government had approved a threeyear space programme which included the construction, in collaboration with the United States, of the San Marco near-equatorial launching platform. Indeed, ten days later Broglio left for Washington to define the details of this project with his NASA colleagues. In short, in September 1961 the Italian experts' main concern was to place their national programme on a sound footing within the framework of collaborative ventures with the United States. At this stage they were not keen to be involved in a European undertaking so heavily biased towards an existing British project.

The role of European industry

Behind these moves at the highest levels of government, and sometimes impinging directly on them (as in the case of the German expert panel), there was the lobbying by industry. At the end of June 1961, the British Interplanetary Society organised an important symposium on space technology, held in London and attended by senior representatives of the European aerospace industry. Those present strongly supported a collaborative European space initiative including launchers and application satellites for weather forecasting, navigation and communications. Speaking for all at the end of the meeting, F. Vinsonneau of the French company SEREB (Société pour l'étude et la réalisation d'engins balistiques) openly supported the use of Blue Streak as the first stage of a satellite launcher, stressing the importance of Britain to continental Europe: 'What we did say, and repeat with conviction' said Vinsonneau, 'was that the only solution in the [space] field was a united Europe ...The experience and methods gained by the United Kingdom formed a large part of our common fund of knowledge and it would be our duty to support them and prevent their dispersal.'

Shortly thereafter, in September 1961, the European space industry established a supranational body called Eurospace, which included all the leading companies in aircraft and missile manufacture. Its aim, according to its statutes, was 'to promote the development of aerospace activities in Western Europe ...' More specifically it offered its services to both ESRO and ELDO as 'a valid representative of industry', willing to 'help them efficiently to carry out their space programmes'. By April 1962, when the ELDO convention was signed, about 1000 companies were grouped in Eurospace, either directly or through trade associations, 81 of which were individual members with a total labour strength of more than a million workers.

The Lancaster House Conference and the start of ELDO

With the pressure mounting on Macmillan's government to bring matters to a head, the British and the French called another meeting of all European states represented at Strasbourg, plus Australia, for 30 October in London. Its aim was to discuss the draft of a convention for establishing a European launcher development organisation. A week before the meeting, however, Britain was still far from sure that a suitable basis for collaboration could be found. Amaldi was intensifying his efforts against the venture and the Italians seemed to be insisting that Blue Streak be abandoned as a condition for their participation. The French, for their part, had suggested cancelling the meeting if their Latin neighbour withdrew. On top of that there were persistent problems with the Australians who felt that the use of Woomera should serve as the country's contribution in kind not only to the initial programme of any European launcher organisation, but also to all subsequent programmes.

Notwithstanding these ongoing uncertainties, the British government duly convened the meeting of ELDO potential member states at Lancaster House in London. It lasted from 30 October to 3 November 1961. Thorneycroft was again in the chair, and representatives were sent by Australia, Belgium, Denmark, France, Germany, Italy, the Netherlands and the United Kingdom. Norway, Sweden and Switzerland only sent observers. After the opening plenary session, in which the Italian delegates explained the doubts they had about the project, the conference broke up into an administrative and financial working group and a technical working group. They presented their results to plenary sessions and, after lengthy discussions, agreement was reached on the guiding principles for the ELDO convention.

The question of Italy could not be formally resolved at Lancaster House. In fact, the problem of how to make up the shortfall should the Italians not join was actively debated both at the meeting and in the weeks immediately following. At the same time, strong pressure was put on the Italian government to make a favourable response. It was obviously politically desirable for Italy to join the other major European countries in this undertaking; and some Italian experts also came around to the view that, for all its faults, participation in ELDO might have some benefits for the country. The development of a test satellite would dovetail neatly with Italy's own plans for building scientific satellites at the national level. They also hoped, with the support of Germany, to push ELDO in the direction of doing research on new rocket technologies, in particular on advanced forms of propulsion.

Europa 1 — Woomera, Australia

In the event, and much to the relief of the British, the green light was given by the Italian government. When the ELDO convention was signed on 30 April 1962 Italy was one of the seven participating member states, the others being Britain, France, Germany, Belgium, the Netherlands, and Australia. In the agreed division of labour the Italians were given responsibility for the development of the satellite test vehicle, while the two smaller countries would provide the down-range guidance station (Belgium) and the long-range telemetry links, including the requisite ground equipment (the Netherlands).

In 1963 negotiations started between Britain, France and Germany on how to share the shortfall in contributions to the budget of a little under 12%, due to the withdrawal of some of the countries that had participated in the early discussions. Britain's final share rose to almost 39% while France paid 24%, Germany 19% and Italy 10% of the costs. Belgium and the Netherlands, each a little under 3%, made up the balance. As for Australia, it was understood that Woomera would act as a contribution in kind to the initial programme, and that its request for participation as a full member in subsequent programmes on the same basis would be rediscussed as and when the occasion arose.

The convention establishing ELDO came into force on 29 February 1964.

ELDO's Initial Programme

ELDO's Initial Programme comprised the design, development and construction of a three-stage launcher, initially called ELDO A and later Europa 1, capable of launching large satellites (i.e. 500 to 1000 kg) into circular near-Earth orbits or smaller satellites into highly eccentric orbits. The cost of the programme was estimated at £70 million. Britain's Blue Streak was Europa-1's first stage, while the second stage, which was called 'Coralie', was to benefit from post-war French rocket developments. The German third stage (eventually named 'Astris') was to be based on a completely new design using advanced technologies. The Satellite Test Vehicle (STV), to be developed in Italy, was conceived as a means of measuring the performance of the rocket in terms of the characteristics of the orbit and the accuracy of injection.

Assembly of the French-built second stage 'Coralie'

Work got under way immediately after the Lancaster House conference. Even before the signature of the convention a Preparatory Group (PG) was established. It met first in London, and then moved to Paris in June 1962, remaining in charge until the ELDO convention came into force. Chaired initially by the Italian Air Force general E. Cigerza it was taken over by D.W. de Havilland (UK) at the end of 1962. G. Bock (FRG) was nominated to head the Technical Committee and M. Depasse (B) the Administrative Committee. The PG also created a permanent Secretariat, prefiguring ELDO's Secretariat General, and Ambassador R. Carrobio di Carrobio (I) was nominated to head it. W.H. Stephens (UK) and H. Costa (FRG) were appointed as his assistants with the roles of Technical Director and Administrative Director, respectively.

Europa 1 second stage being lifted into position

The main tasks of the PG were to supervise the first implementation of the programme in the member states, each of which was to take a 'leadership' role in the development of its sector of the programme, and to define the directions in which the rocket should be developed. These tasks, it should be said, were not facilitated by the fragmented division of labour between seven countries, by the usual restrictions on expenditure imposed during the two years that it took to ratify the convention, and by continual haggling between the partners over the Preparatory Group's working budget.

All the same a considerable amount of progress was made both with the rocket and with plans for the future. One of the first things the PG did was to revise the timescale for the Initial Programme. They estimated that the first launch of Blue Streak alone would take place in November 1963, and hoped to have the first orbital firing of the entire rocket in the spring of 1966 — a slippage of about a year with respect to the estimates made fifteen months before.

The mission of the launcher was also re-evaluated. In the very earliest negotiations this had been primarily defined in terms of possible scientific satellites and, in particular, ESRO's planned Large Astronomical Satellite (see next chapter). Now, in consultation with Eurospace, the ELDO Preparatory Group also began to think more concretely about applications, in particular for telecommunications. In April 1963 it was suggested that the ELDO A launcher should be able to put a series of twelve communications satellites in near-Earth orbits. Two more powerful versions of the same rocket, to be ready around 1968-69 and 1970-71, should also be developed, said the industrialists, to put two telecommunications satellites into geostationary orbit (i.e. at 36 000 km).

The ELDO Council met for the first time on 5-6 May 1964, about two months after the ELDO convention had been ratified. It elected G. Bock (FRG) as its chairman. Carrobio di Carrobio was confirmed as Secretary General, as were Stephens and Costa in their earlier provisional posts. A month later there was a near text-book launching of Blue Streak alone from Woomera. A second perfect launch occurred on 20 October. Yet all was not well with ELDO. There were the slippages in the Initial Programme. Costs were threatening to spiral out of control. And Britain apart — and she had been working on the first stage for six or seven years already — all of the other major partners were finding it more difficult than expected to develop the technologies for which they were responsible.

Indeed the success of Blue Streak, while gratifying, not only served to expose their delays and to increase the pressure on them, but also, and predictably, triggered a re-assessment of the interest of ELDO for the British. As the Minister of Aviation, Julian Amery, commented, 'With the successful launching of Blue Streak and our experience already acquired with Black Knight, we are well on the way to having a national [heavy satellite launching] capability, if we choose to develop it ...'

Ambassador R. Carrobio di Carrobio, first Secretary General of ELDO

Couple this technical possibility with the bitter rebuff of de Gaulle's veto in January 1963 of the UK's application to enter the Common Market, and there were more than enough ingredients for a cooling of the Conservative government's earlier enthusiasm for ELDO. The organisation survived 1964 without undue difficulty, but plunged immediately afterwards into a series of crises which we shall begin to explore in chapter 6.

Blue Streak and Europa 1

Blue Streak was 3 m in diameter and about 24 m long. Its weight when fuelled was about 90 tons. Its two RZ-2 engines, powered by liquid oxygen and kerosene, had a combined thrust of about 136 tons. The rocket was developed by Hawker Siddeley Dynamics. Its engines were built by Rolls Royce under licence from the Rocketdyne division of North American Aviation, Inc.

The complete rocket was shipped to Australia at the end of 1963. After the usual false starts, it was first successfully launched on 5 June 1964. It almost fulfilled expectations: the only disappointment was that its engines switched off six seconds before they were scheduled to do so, due to lateral oscillations of the vehicle. As a result it impacted about 1000 km downrange in the Australian desert, rather than the expected 1500 km. The second firing, on 20 October 1964, by contrast, was a triumph. The rocket worked as planned, reaching an apogee of 200 km and impacting 1400 km downrange.

Blue Streak was the largest rocket available in Europe in 1960 and, leaving aside the political aspects of the negotiations leading to the creation of ELDO, there were sound technical and financial considerations underpinning its choice as the first stage of the European launcher.

The Europa 1 launcher (or ELDO A) was a three-stage rocket consisting of Blue Streak as the first stage, and two upper stages. The structural part of the second stage, the French Coralie, was developed by Nord Aviation, while the engines were designed by LRBA (Laboratoire de Recherches Balistiques et Aérodynamiques). The third stage, the German Astris, was a new design based on sophisticated concepts, including a titanium structure. Its propulsion system included two thrust engines and two small vernier (steering) engines.

A consortium of two German industrial groups, Bölkow and ERNO (Entwicklungsring Nord) was responsible for its development. The nose-cone and the satellite test vehicle (STV) were built by several Italian firms.

The complete Europa 1 vehicle had an overall length of 31.7 m and a launch weight of approximately 104 tonnes. The rocket was designed to launch an 850 kg payload into a 500 km high circular orbit, when fired to the North from Woomera, or a 1150 kg payload when fired to the East from an equatorial site.

To reach an 800 km orbit, the payload capacity was reduced to 700 and 950 kg, respectively. For elliptic orbits the capacity depended on the apogee. For an apogee of 5000 km (and perigee at 400 km), the payload capacity was 350 kg from Woomera and 550 kg from an equatorial site. These figures were reduced by 40 and 150 kg, respectively, for an apogee of 20 000 km.

Chapter 4 — Implementing ESRO's first scientific programme

In chapter 2 we described briefly the first scientific programme defined for ESRO in the famous Blue Book and presented to COPERS in October 1961. These were heady days indeed. The scientists saw a dream slowly becoming reality and, while they realised that they had done little more than sketch an 'ideal' programme, they were reassured by the positive attitude of governments towards their proposals. Indeed their suggestions were accepted almost intact when ESRO's Convention was signed in June 1962 and the programme defined in the Blue Book came to serve as an essential point of reference for the activities of COPERS and in the early days of ESRO.

Inevitably these early plans were to come up against all sorts of difficulties, and cuts were necessary in the scale of the operations. This was only to be expected. What was perhaps surprising was the depth of the cuts, and the extent to which early expectations were to be disappointed.

There were several reasons for this, but the most important was undoubtedly the initial underestimate of the cost of spacecraft. This problem was compounded by changing priorities in the scientific community — partly due to the availability of more powerful rockets in the USA — away from small simple satellites to medium sized spacecraft carrying complex payloads. As a result, the number of satellites launched by ESRO (and indeed the number of sounding rockets too) had to be reduced drastically to remain within the imposed financial envelopes.

This chapter will chart this first confrontation of the space science community with these realities, describing quickly the early sounding rocket programme before moving on to look in more detail at how the first set of ESRO satellites was decided.

Sounding rockets

The first sounding rockets were launched under the auspices of ESRO from the Salto di Quirra range in Sardinia on 6 and 8 July 1964. In both cases a boosted (British) Skylark rocket carried a canister which released barium and ammonia 'clouds' into the ionosphere. The experimental packages were provided by researchers from the Institut d'Astrophysique in Liége and the Max-Planck-Institut für Extraterrestrische Physik in Garching.

An ionised barium cloud of the type released from a sounding rocket payload

A dual-purpose ruin in Sardinia: cow shed and sounding rocket observation post

One other launch, somewhat less successful, was carried out that year. A (French) Centaure rocket was launched from the Ile du Levant on 30 October 1964 but no useful data were obtained as the scientific instruments failed.

Man-handling a Centaure rocket in Sardinia

The first launches from ESRANGE took place in November 1966 and their number increased rapidly. Indeed when the sounding rocket programme was terminated in 1972 about half of all launches had been made from Kiruna. The number of launches carried out annually climbed gradually during the following years (Table 3).

Table 3. ESRO sounding rocket launches and success rate

Year	*Launches*	*Success rate (%)*
1964	3	100
1965	8	38
1966	27*	52
1967	18	67
1968	20	80
1969	26	77
1970	26	85
1971	28	85
1972	12	93
Total	168	75

* Includes ESRO's participation in the solar-eclipse campaign on the island of Karystos, Greece, in May 1966, when ESRO launched seven rockets (2 Centaures and 5 Arcas) within a 3 h window centred on the time of the total eclipse plus one Centaure and one Arcas some five days earlier.

The French Centaure and British Skylark rockets were the workhorses of the programme, supplemented by the American Arcas (Table 4).

Table 4. Sounding rocket types used by ESRO

Rocket type	*Country of origin*	*Launches*
Arcas	USA	14
Bélier	France	2
Centaure	France	64
Dragon	France	4
Petrel	UK	1
Skylark	UK	83
Zenit	Germany/Switzerland	1

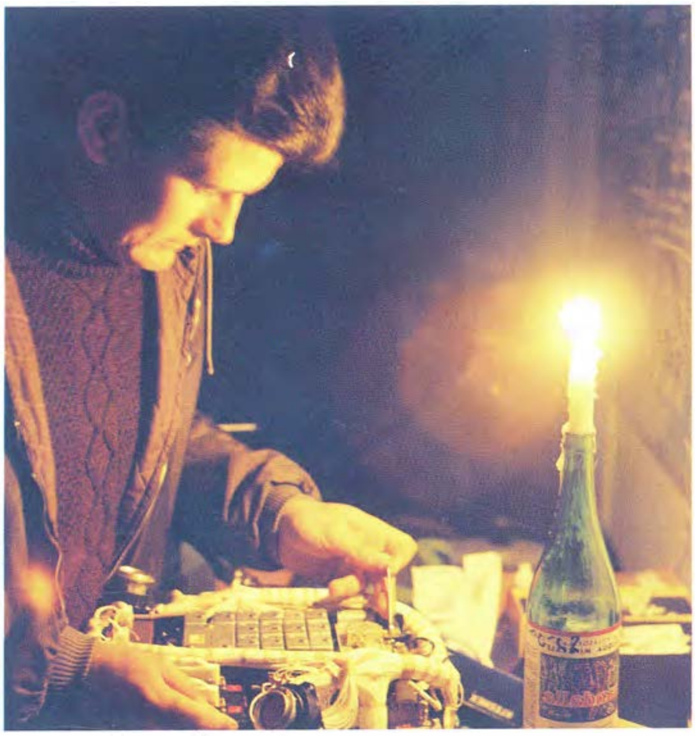
It is noteworthy that the size and length of the payload sections (i.e. excluding the rocket itself) increased considerably during this period. The first Skylark and Centaure payloads weighed 140 kg and 40 kg, respectively, and their lengths were 2.7 m and 1.2 m. During the course of the programme these parameters increased to maximum weights of 310 kg and lengths of 5.55 m. In fact, each payload generally included more than one experiment, with the exception of the larger and more complicated astronomical experiments.

Of the 168 launches carried out between 1964 and 1972, about half were dedicated to ionospheric and auroral studies and about a quarter to atmospheric physics. Solar, stellar and gamma-ray studies were made on about 20% of the launches. It was general ESRO practice to have duplicate launchings of each payload, but for the much more expensive pointing rockets only single payloads were built. At the other extreme, some experiments were launched as many as 25 times. With an average of over three experiments for each payload, ESRO's sounding rocket programme provided a service to over 40 scientific groups from the various member states. British and German scientists were the most conspicuous users, contributing about two-thirds of the experiments launched. By contrast there were surprisingly few experiments from French groups, their number being roughly the same as those from Belgium, the Netherlands and Sweden. Italy was almost completely absent.

These figures, when compared with those foreseen in the Blue Book (Table 1), suggest that there was a large gap between planned and actual annual launch rates. The gap, however, is much lower than this evidence would imply; in fact the ESRO sounding rocket programme did not fall that short of earlier expectations. The figures in Table 1, it must be remembered, refer to 'standard' launchings of a 50 kg payload to an altitude of 150 km. As we have seen, from the very beginning the average capability of ESRO rockets was better than this and kept increasing in the course of the programme's implementation. The payloads became increasingly heavy and complicated both technically and organisationally; the scientists increasingly calling for stabilisation, attitude control, and payload recovery.

This is not to say that the programme did not suffer from difficulties and setbacks. There were teething troubles with the rockets at the beginning, notably the French Centaures and Dragons. These caused some experiments to be postponed and others to be abandoned.

The Aurora Borealis above Esrange, Kiruna, Sweden



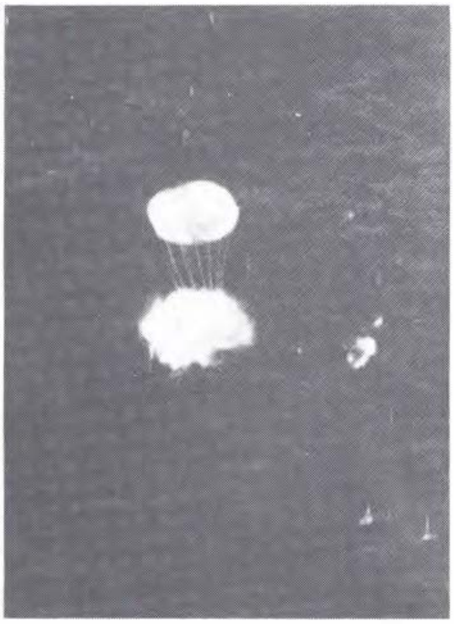
Pioneering days: Sardinia

There were budgetary difficulties due to the fact that no additional funds were made available when the greater complexity of approved payloads called for increased expenditure on facilities and launching services provided by ESRO. There were staff problems. The failure to recruit personnel at ESTEC for payload assembly caused delays and more payloads than expected had to be contracted out to industry.

Esrange imposed constraints of its own. Besides the severe climatic conditions at a site well beyond the Arctic Circle, the ionospheric and auroral phenomena studied there seldom occurred and were frequently of short duration. Launch windows were correspondingly narrow, and were sometimes missed altogether. Prevailing wind directions and the limited size of the range meant that a firing could not take place for fear that the rocket would be dragged out of the allowed impact area. Nature, too, did not always behave as was hoped. In 1968 eleven rockets were set aside for a polar cap absorption campaign at Kiruna. It did not take place because no solar proton event of sufficient magnitude occurred during the two months allocated for the programme. In short, the sounding rocket programme combined the pleasure of risk with the frustration of opportunities missed, the exhilaration of success with the disappointment of failure.

Sounding rockets, and in particular the early launching campaigns, played an important part in the life of the young ESRO. They provided opportunities for scientific research during the long waiting period until the first satellites were orbited, and established a nucleus around which a European space science community could grow and accumulate technical knowhow. The very nature of the work at the time generated durable bonds of comradeship and solidarity. These campaigns were adventures, and those who took part in them still recount with pleasure the many unforgettable experiences that they had — from shovelling cow-dung out of a casamatta in Sardinia to prepare a 'clean room' for developing film, to banquetting on the fish that took the place of a lost payload in the hold of the boat sent out to recover it. This was the world of 'little science', with relatively small budgets, relatively short delays from payload approval to launch, and with that sense of involvement which came from people having hands-on experience in the design, construction, test and launch of flight hardware. Add to this the romance of experiencing a solar eclipse on a remote Greek island, and the closeness that comes from spending long nights together waiting for appropriate launch conditions at Kiruna, and one has all the ingredients for building a community tied together by strong bonds of professional and personal allegiance. Their spirit of companionship was heightened by the feeling that they were the underdogs in an organisation with far greater ambitions, and that theirs was a vanishing world which would sooner or later have to yield to the anonymous rationality of large and complex technological projects.

A happy sounding rocket crew, typical of the team spirit shown throughout the history of ESRO's sounding rocket campaigns: on this occasion celebrating the successful recovery of payload S69 after 'splash down' in the sea



Indeed as sounding rockets became increasingly sophisticated, as failure became more costly, scientifically, financially, and personally, so the risks were reduced, but at a price. Sounding rocket activity was institutionalised, and its pioneers looked back with nostalgia on those early days in which, together, they had laid the foundations of ESRO's space science community.

Satellites

The Blue Book defined a list of scientific fields to be explored by experiments on board satellites and space probes and a tentative launching rate. Implementing such a programme was now the task of ESRO and of the European space science community. Schematically this implied the choice of a scientific mission for each satellite (e.g. ionospheric physics, cosmic rays, solar astronomy, etc.); the definition of a group of experiments to be included in its payload; and the selection of the instruments required to carry out the experiments and of the groups or laboratories responsible for them.

This was a long process involving frequent and repeated interactions between scientists, engineers, industry and the decision-making mechanism of the organization. The process was characterised by a 'bottom-to-top' approach, which reflected the peculiar relationship between ESRO and the European space science community. As we have discussed in chapter 2, apart from a small group of scientists integrated into the organisation, this community remained essentially external, being spread over many scientific institutions and universities in ESRO's member states. Scientists, however, were involved in a set of advisory committees and expert groups which provided ideas and made recommendations about possible missions to be included in the ESRO programme.

The process started when the expert groups discussed the experiment proposals put forward by research groups and suggested a mission and, eventually, a possible payload for one of the ESRO spacecraft. The various suggestions were submitted to the LPAC and evaluated in the light of ESRO's overall programme and its financial and technical resources. In this phase, ESTEC engineers, in consultation with the proponents, were called to assess the various experiment proposals from the technical point of view. Finally, the LPAC defined the mission and launching schedule of one or more satellites, and combined various experiments into integrated payloads. The LPAC's recommendation was eventually presented to the STC and then to the Council for final approval.

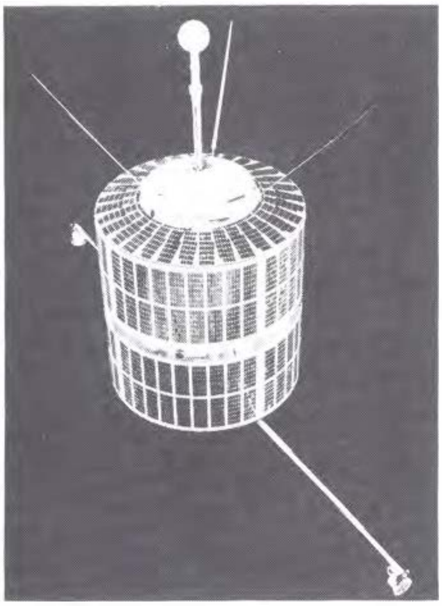
When the green light was given to a certain payload by the LPAC the experiments and the associated instruments were still defined in general terms. The refinement of the experimental goals and the technical definition of the payload hardware were then shaped by scientific, technical and financial considerations. The technical compatibility of different experiments in the same payload had to be assured (e.g. the possible influence of the magnetic field created by one instrument on another). Their effects on the behaviour of the satellite had to be considered (e.g. a long antenna could severely affect the dynamic behaviour of the spacecraft). The satellite itself imposed limits of weight and of power consumption on the instruments which, above all, had to be sufficiently robust to withstand the shock and vibration loads during the launch. It was only after all these constraints had been met — and the payload modified accordingly — that the technical specifications of the project could be drawn up, and a call for tenders issued for the construction of the satellite and its subsystems. These tenders were then submitted to the AFC for approval, and accepted in the light of available funds bearing in mind the need to distribute contracts on a geographical basis.

It is clear then that it took several years for the design of even a relatively simple satellite to be frozen. During this time the payload was constantly renegotiated. And as the payload evolved so new decisions were needed, and new battles fought, within the ESRO committee structure.

A last word before ending this section must be said about the management of a satellite project during its implementation. As we mentioned before, the instruments were built by scientific groups in the member states, with the help of national industry where necessary. Payload integration in the spacecraft took place in ESTEC, or under the supervision of ESTEC engineers, in consultation with the scientists flying experiments on the mission. It must be stressed that both from the physical and the financial points of view the scientific payload was a minor part of the project as a whole. For example, the scientific instruments of ESRO-I and ESRO-II, the Organisation's first satellites, weighed about 20 kg out of a total of 80 kg for the whole satellite. Similarly, the scientific payload of the 470 kg TD-1 satellite (launched in 1972) weighed about 120 kg.

Each satellite project (including supervision of industrial contracts, control and testing, payload integration and launch operations) was under the responsibility of a Project Manager in ESTEC, while the interests of the scientists vis-à-vis the limitations imposed by technical and financial constraints were protected by a Project Scientist from ESLAB (later from ESTEC's Space Science Department).

Defining the first satellite programme



ESRO-I satellite in flight configuration

The first problem the LPAC had to face after the official inception of ESRO in the spring of 1964 was the revision of the eight-year (1964-71) programme in the light of information acquired since the writing of the Blue Book. At the same time it was called to define the missions and payloads of ESRO's first satellites, following preliminary work done in the COPERS period. One year later, after extensive deliberations among the scientists in the ad hoc working groups, in the LPAC and in the STC, a new programme was laid before the Council.

The satellite programme had evolved along two main axes. Firstly, interest shifted away from small unstabilised satellites to be launched by Scout rockets, towards larger stabilised satellites which could be launched by the Thor-Delta rocket. The latter would be more complex, but the cost per kilogram put in orbit was considerably lower: about 1.5 MFF for a Scout-type vehicle and about 1 MFF for the larger launcher. Secondly, the idea gained ground that it might be advisable to develop a 'streetcar' vehicle for the Thor-Delta (TD) satellites, i.e. a standard platform which housed different successive experimental payloads.

The proposed launching programme for the first eight years was reorganised accordingly. The eleven small satellites foreseen in the Blue Book were cut back to just two. Six medium-sized TD satellites of essentially similar basic design were added. The number of space probes was retained at four and it was agreed that they would consist of small, highly eccentric orbiting satellites (HEOS) with an apogee of some 200 000 km. The number of large satellites was also kept at its original number of two, though the possibility of launching a third in 1972 was also canvassed.

In short, compared to the very earliest proposals put forward by the scientists in October 1961, the launching programme as proposed by the LPAC and the STC in the spring of 1965 did not involve a major reduction, but rather a reorientation towards more complex experimental packages.

This programme, it was suggested, could be achieved within the agreed financial limits. Firstly, there had been an important shift in resources away from launching costs towards spacecraft development. The scientists achieved this by eliminating back-up launches, as had been proposed in the Blue Book, and by re-evaluating downwards the cost of each launch. Whereas the first estimates of ESRO's scientific programme evaluated launch costs as being roughly 1.5 times the cost of spacecraft development, the proportions were now more than reversed. Some 225 MFF would be needed for launching costs, including that of the large satellite, while 455 MFF would be set aside for spacecraft development, plus 40 to 50 MFF for the realisation of a deep-space telemetry network for the HEOS-type satellites.

Secondly, it was argued that there would be financial advantages accruing from the streetcar design, for once the first satellite in a series had been developed the costs of the later models would be drastically lower. Thus it was suggested that whereas it would cost 60 MFF to develop the first stabilised TD satellite, the next five would cost only 15 MFF each. Similarly the cost of the first HEOS would be 35 MFF, the cost of the next three 15 MFF. Finally, and dramatically, the cost of the first large satellite would be 160 MFF, the cost of the next two only 20 MFF each.

ESRO-II on the lateral vibration rig

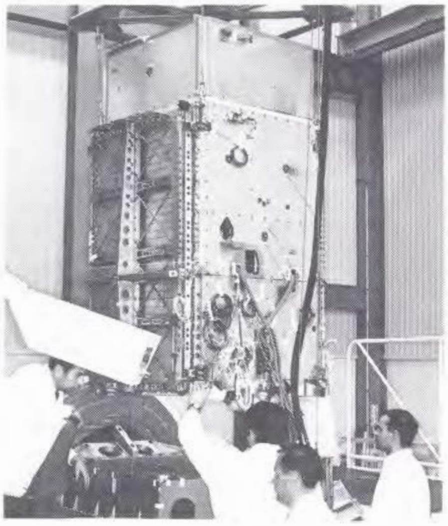
Concerning the scientific content of the programme, it had been agreed as early as the spring of 1963 that the two small Scout-type satellites would be designed to fulfil two different scientific missions. ESRO-I was to study the polar ionosphere; ESRO-II was for solar astronomy and cosmic ray studies. After some revision of the provisional payloads due to weight considerations, the 'final' payloads were approved by the Council at the end of 1964. Experiments by British groups dominated in their composition, confirming their leadership in this field at the time. The launching of both satellites was planned for 1967, as anticipated in the Blue Book.

The priorities and payloads for the first two HEOS satellites had also been established. HEOSA, as it was called, satisfied the scientific interests of the COS group. Its payload comprised experiments for the simultaneous measurement of plasma, magnetic field and cosmic-ray particles. HEOS-A was scheduled for launch in 1968 and was to be followed, ideally a year later by a second HEOS satellite devoted to studies of the interplanetary medium. Its payload was to consist of experiments proposed by the PLA group, which had been the COS group's main rivals for experiments in this part of the programme. The adoption of HEOS-A by the Council was delayed by concerns over the additional expenditure needed to provide a deep-space telemetry network. The Estrack system, in fact, which was essentially devised for low-orbit satellites, was of limited use both geographically and technically for satellites and probes on highly eccentric paths. In the event, a cheap solution was found which combined the Estrack and the French CNES stations with an ELDO station to be built in Australia.

As for the TD satellites, the missions of four of the hoped-for six had been defined early in 1965 by the LPAC. TD-1 was to be devoted to stellar astronomy, and a provisional payload had already been agreed. TD-2 was planned to be for solar astronomy, TD-3 for ionospheric studies and TD-4 for atmospheric studies. The second and third of the series were to be launched in time for the solar maximum anticipated in 1968/1969, in order to study the correlation between solar activity and ionospheric phenomena.

Finally, regarding the large satellites of the long-term programme, it was suggested that the first should be a Large Astronomical Satellite (LAS) for fine resolution spectroscopy of stars in the ultraviolet region of the electromagnetic spectrum. Two other large satellites for astronomical studies were to follow, the missions of which had not yet been defined, while a proposal had been made that the second large project should consist of a cometary mission.

Three main areas of controversy surrounded this programme, which eventually led the Council to approve only a part of it. Firstly, there was the distribution of funds between the various interest groups. The policy of the LPAC, as chairman Lüst specifically said, was 'to maintain a fair distribution in the scientific programme between the various fields of activity in space science'. This was obviously intended to give each discipline in the variegated field an opportunity to do satellite research. However a 'fair' balance in scientific opportunity entailed major imbalances in resource allocation — in particular the large satellite projects required for astronomical studies were estimated to absorb well over 40% of the available resources. This share bore no relation to the interests of the community as measured by experimental proposals submitted to ESRO, only 24% of which had come from the SUN and STAR groups. Members of other groups, particularly the ION group, were quick to object to this.



TD-1 being lowered onto the 14 ton vibrator at ESTEC

The second major area of dispute concerned the 'streetcar' concept for the TD series of satellites. This concept was introduced precisely to satisfy as many different interest groups as possible without unduly increasing costs. The French and German delegations insisted that it was inherently contradictory. It was a mistake, they said, to think that one could hope to get useful scientific results from four very different payloads integrated into a single spacecraft design. 'There would be such great problems of adaptation', the president of the French CNES and a senior member of the French delegation in the Council, J. Coulomb, said, 'that the final cost of the four vehicles [might] well be greater than that of the four ad hoc vehicles'. These severe reservations about the feasibility of the proposed TD programme simply reinforced the French view that the estimates for the cost of the entire launching programme were much too low.

Finally, there was the problem of the first major project, the large astronomical satellite (LAS). Two sources of controversy had emerged over this key project, thought by many to be the kind of costly and complex venture which provided ESRO with its raison d'être. Firstly, there were its specifications. In 1963 the LAS's instrument was specified as being able to make observations from 912 Å to 3500 Å with a resolution of 1 Å. The telescope was to be mounted on a platform which could be stabilised to a few minutes of arc. These criteria were tightened up in mid-1964 in the light of developments across the Atlantic. The resolution was increased to a few tenths of an Ångstrom, and the pointing accuracy was increased to one minute of arc.

When proposals were called for to build this payload, a British consortium led by a group from the Culham Laboratory, as well as a combined German–Dutch group (Ger-Ne-LAS), submitted proposals coherent with the new specifications. A Belgian–French–Swiss group, however, refused to do so, feeling that the new requirements were technically over-ambitious and unrealistic. Faced with the impossibility of finding a compromise, in January 1965 the STC awarded design contracts to all three groups, all the while, and without much hope of succeeding, exhorting them to try to combine their proposals.

In parallel with this debate there was a simmering conflict over project management. Although ESRO was paying for the LAS and its scientific payload, the British, supported by the French, wanted authority for the project to rest with the national groups. This was intended partly to avoid the growth of a large inhouse staff at ESLAB and partially to preserve the autonomy of their national scientific teams. On the other hand, the British and French proposals seriously jeopardised the 'international' character of the project which was supposed to be one of its main attractions. To meet this objection, the UK suggested that not one but two, three or even four LASs be flown on the streetcar concept. This proposal was accepted by the Council in 1964 with some hesitation, as it risked jeopardising the second large project, and was reflected in the budget figures drawn up by the STC in March 1965. It certainly also influenced their decision to award design contracts to all three groups who had proposed payloads.

Besides the controversies within the scientific community, the Council also had to cope with a great deal of uncertainty about the financial aspects of the programme. The idea that space science should cost less in Europe than in the USA (the so-called 'trans-Atlantic factor') was soon revealed to be an illusion, and the lack of industrial experience and technical know-how added to the difficulty. For the ESRO management it was becoming almost impossible to assess the financial implications of the scientists' proposals and to present long-term plans on the basis of definite cost estimates. In the event, the Council adopted a conservative attitude. Provisional approval was given to the small satellite programme and to the TD programme, 'on the understanding that should costs prove much higher than anticipated, TD-3 and TD-5 might be abandoned'. The HEOS-A payload was also approved, while no definite decision was taken about the number of LAS-type satellites to be included in the programme.

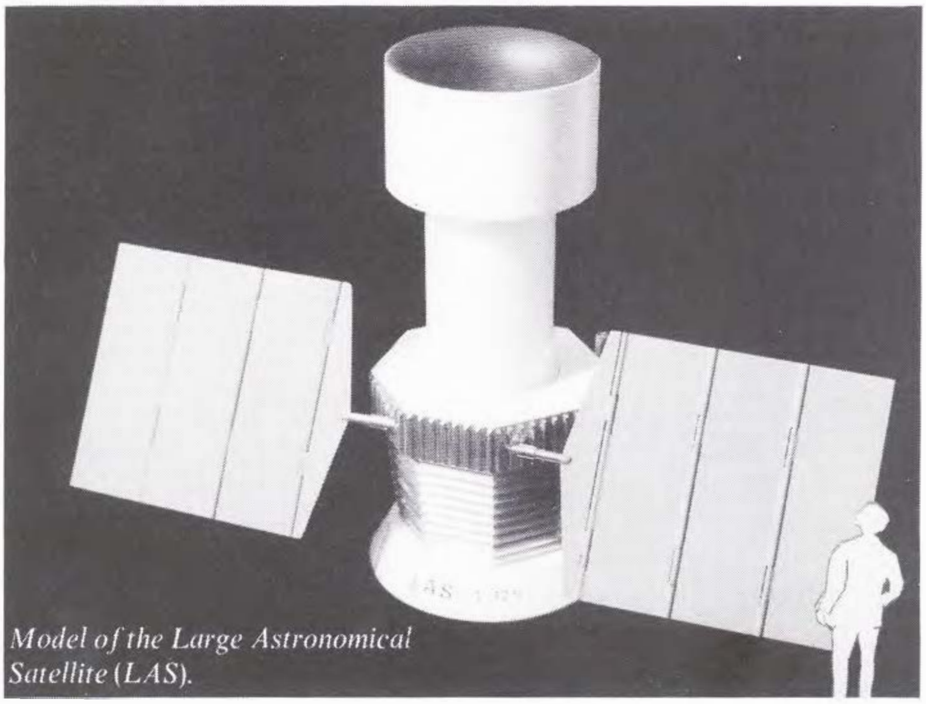
Reducing the programme: the budget crisis of 1966

For the next 15 months, from the spring of 1965 to the summer of 1966, the debates on the scientific programmes were dominated by fears that financial constraints would force important cuts. The TD programme was the first to suffer: It was decided to abolish TD-3, and to merge its payload with TD-2. The latter now became a 'solar, ionosphere and geophysical satellite' rather than simply a satellite dedicated to solar astronomy, and new proposals for experiments were solicited. This decision caused resentment in some quarters. The main experiment on TD-3 had been a German proposal to study the top side of the ionosphere with a special sounder, the so-called 'top-side sounder experiment'. It was proposed again for TD-2, with strong support from the ION group. The LPAC, however, turned down this experiment on the grounds that its inclusion would force major changes in the design of TD-2 and these in turn would impede the implementation of the streetcar concept.

After a furious protest by the ION group, who accused the LPAC of bias, the STC and the Council insisted that the top-side sounder be included on TD-2. However, when it came to trying to fit the instrument into the payload it was found that it would absorb about half the total telemetry capacity of the satellite. The top-side sounder also pushed up the then estimated cost of the TD-1/TD-2 pair from 80 MFF (when a standard streetcar spacecraft was used) to 160–275 MFF. It was thus decided to build two standard TD satellites and to find an alternative solution for the top-side sounder.

One idea was that it should be launched on a Scout-type satellite. Even this, at 30 MFF, was deemed too expensive by the LPAC. The STC and the Council shared this opinion and, in June 1966, the latter lamely recommended that NASA be approached for help in flying the German group's experiment.

This was also an unhappy period for the LAS. The three scientific groups who had been authorised to submit the designs for its payloads did so early in 1966. They were assessed by a board of consultants who judged the British (Culham-led) high-resolution instrument to be the best. They also thought that the low-resolution instrument proposed by the Belgian–French–Swiss (BFS) collaboration was the weakest of all. This verdict was heavily contested by the losers who argued that their instrument was at least as useful scientifically, was technically feasible and avoided unnecessary risks, and would cost far less than the more complex and sophisticated Culham design.



Model of the Large Astronomical Satellite (LAS).

However, despite a vigorous campaign by the BFS group in the STC and the Council, the verdict of the consultants was upheld. In July 1966 it was finally agreed that there should be one basic design for the LAS, that a back-up unit should be built in case of failure, and that the primary scientific package was to be in the hands of the Culham group. The management structure remained unsolved. The French and British delegations felt that it should be confined to the national team, while other delegates, notably those from the smaller countries, felt that ESLAB should have an important role in the project.

By mid-1966, then, ESRO's first satellite programme had been more or less settled regarding both the spacecraft and their payloads. It comprised the two small unstabilised Scout-type satellites, ESRO-I and ESRO-II scheduled for launch in 1967, one highly eccentric orbit satellite (HEOS-A) whose final contract had been negotiated but was not yet signed, two stabilised and similarly designed Thor-Delta satellites, TD-1 and TD-2, for which tenders had been solicited, and one large project, the LAS, with its back-up unit, which was still in a preliminary design stage. No progress had been made yet, however, with the next phase of the eight-year operational programme foreseen in the Blue Book because of the persisting uncertainties about the financial aspects. Indeed the key question on everyone's minds was the amount that the Council would allocate to ESRO for its next three-year period, running from 1967 to 1969. Its decision proved to be a nasty shock.

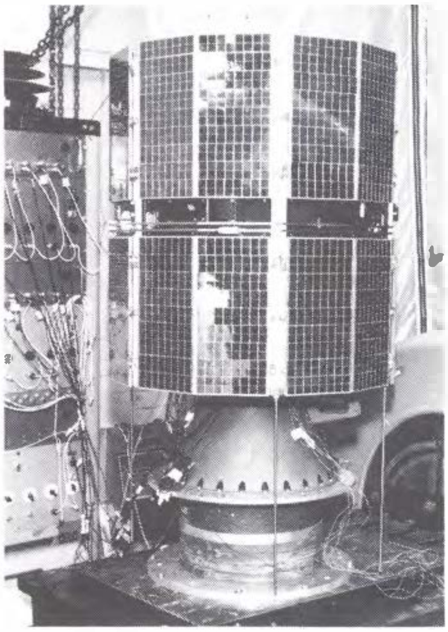
The extent of the budgetary difficulties emerged in July 1966. The Council, advised by the AFC, were to determine, inter alia, the ceiling for ESRO's second three-year period (originally set at 602 MFF in 1962 prices), and the level of expenditure for each of 1967, 1968 and 1969. The secretariat had put forward a figure of 808 MFF in 1965 prices for these three years. This was arrived at by adjusting the 602 MFF figure for inflation, and adding 122 MFF of monies that had not been spent between 1964 and 1966 to the draft budget for the following triennium. The surplus had arisen because the build-up of capital facilities had not been as rapid as expected during the first three years of ESRO's life.

To the secretariat's dismay, the Council refused to carry over these unspent funds. With internal expenditure at 50% of total outlay, rather than the 'required' 45%, several delegations criticised the organisation for its 'lack of financial discipline, its too heavy investment and [its] staff plans'. The ESRO secretariat was instructed to prepare a budget for the next three years of 690 MFF (in 1965 prices), being the original ceiling of 602 MFF increased for inflation. At the same time, the draft budget for 1967 was not to exceed 230 MFF at 1965 prices.

The Council's refusal to carry forward some 120 MFF to the period 1967–1969 placed enormous strains on the operational programme. With many construction contracts awarded and with most staff recruited, there was little scope for savings in internal expenditure at this stage. In August 1966 the LPAC considered various alternative scenarios for making cuts in the research programme, all the while trying to ensure 'the viability of ESRO as a reputable scientific organisation'. It was clear that it was not possible to keep the TD programme and the LAS within the first eight-year period of ESRO. After lengthy debate, the LPAC finally resolved that the highest priority should be given to the TD-1/TD-2 programme, that a ceiling of 300 MFF should be imposed on the LAS of which a maximum of 200 MFF should be spent in the first eight-year period, and that some money should be set aside for starting new medium-sized (TD) and HEOS-type satellite projects. Their aim was to ensure that, on average, two launchings took place each year compared with the four originally hoped for.

The LPAC's recommendations were endorsed by the STC, after extremely divisive debates and painful votes, and eventually approved by the Council at its December 1966 session. The Council also took the minimum steps needed to keep these options open. Realising that if work did not begin on the TD pair in 1967 they would lose their scientific rationale — TD-2 had to be launched to coincide with a period of maximum solar activity — the Council instructed the secretariat to find 47 MFF in the 1967 budget to initiate the construction of the two spacecraft. As for the LAS, the STC had recommended that work on its scientific payload be temporarily halted. To have some idea of its costs, a tender action was to be initiated for the spacecraft on the basis of the Culham group's design. A ministerial conference, scheduled for the following year, would then examine the new cost estimates and decide on the future of the satellite (and indeed on the whole of European space policy, as we shall discuss in the following chapter).

The Council endorsed these recommendations, which incensed the British, adding that ESRO should provide minimal finance for the continuing work of the Culham group until the ministerial conference was held. The shape of the long-term programme was left obscure in December 1966. Indeed the Council failed to agree on the level of expenditure for the next three-year period as it was supposed to do. Instead, it accepted, somewhat reluctantly, to adopt a budget for 1967 of 240 MFF (in 1966 prices) without having first agreed unanimously on the level of resources for the next triennium. It was left to the planned ministerial conference to provide guidance for the future funding of ESRO.



ESRO-II renamed Iris after launch

A few brief words to conclude the story of the LAS. In January 1967 tenders were called for and a NASA consultant employed to evaluate the project. The cost of the spacecraft soared to 400–500 MFF, double the figure quoted less than a year before, though the new figure did include the costs of the launch and of ground support equipment. Such expenditures were way above the ceiling of 300 MFF accepted by the LPAC late in 1966. Furthermore, the technology of the LAS was judged to be at the limit of what Europe could do. In the light of these difficulties the most ambitious project in ESRO's first eight-year programme quietly disappeared from its schedules in 1968 — only to reappear some years later in a new guise as a UV spectrometer with relaxed specifications.

ESRO'S first satellites: Iris, Aurorae and HEOS-1

After the lengthy and tortuous debates of the preceding six years the great moment, the launch of ESRO's first satellite, finally came around on 30 May 1967. ESRO-II was launched atop a four-stage Scout rocket provided by NASA from the Vandenberg Range in California. To the distress of all, the third and fourth stages of the rocket malfunctioned, and the satellite was dumped in the Pacific. Arrangements were made to launch the second flight model of the satellite as soon as possible and, almost a year later, on 17 May 1968, ESRO-II was successfully placed in orbit and renamed Iris after launch. The spacecraft weighed about 85 kg, some 20 kg of which was for seven experiments. Its scientific mission called for an orbit which scanned the Van Allen belts at heights between 360 km and 1100 km and in which the satellite remained in sunlight as long as possible, so that the requirements for the solar X-ray experiments could be satisfied.

ESRO-I was of a similar weight. It was launched on 3 October 1968 into an orbit with an initial apogee of 1533 km and a perigee of 261 km. Renamed Aurorae after launch, the satellite's mission was to explore the polar ionosphere. The main emphasis of the eight on-board experiments was the investigation of the fine structure of the aurora borealis and correlation studies between auroral particles, auroral luminosity and ionospheric composition and heating effects.

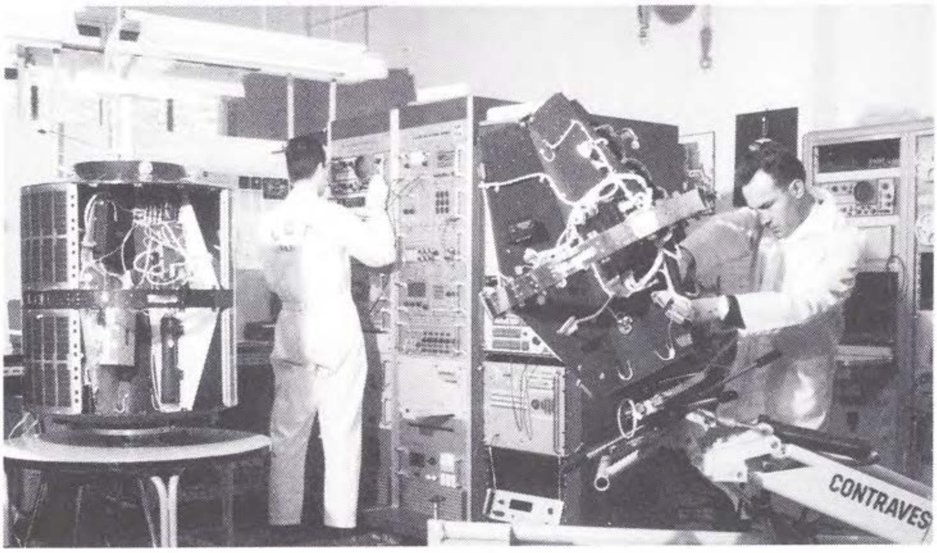
Finally, on 5 December 1968 HEOS-A (then renamed HEOS-1) was put in orbit by a Thor-Delta rocket. HEOS-1 weighed about 108 kg. A highly elliptical orbit was selected, with apogee 225 000 km, i.e. about two-thirds of the distance to the Moon and well beyond regions perturbed by the Earth. The primary scientific mission of the satellite's seven experiments was to study interplanetary physics, particularly magnetic fields, cosmic radiation and the solar wind outside the magnetosphere and the Earth's shock wave. It was a fitting conclusion to what the chairman of the STC called 'ESRO's first glorious year [...] against the background of the growing pains of ESRO's formative years'.

HEOS-1 — ESRO's first highly eccentric orbiting satellite

Some Human Moments in the Life of the Early ESRO Satellites Captured on Film

ESRO-II countdown rehearsal

HEOS-1 fit check at Kennedy Space Center, Florida



Integration of ESRO-I. development model (left) and flight unit (right)

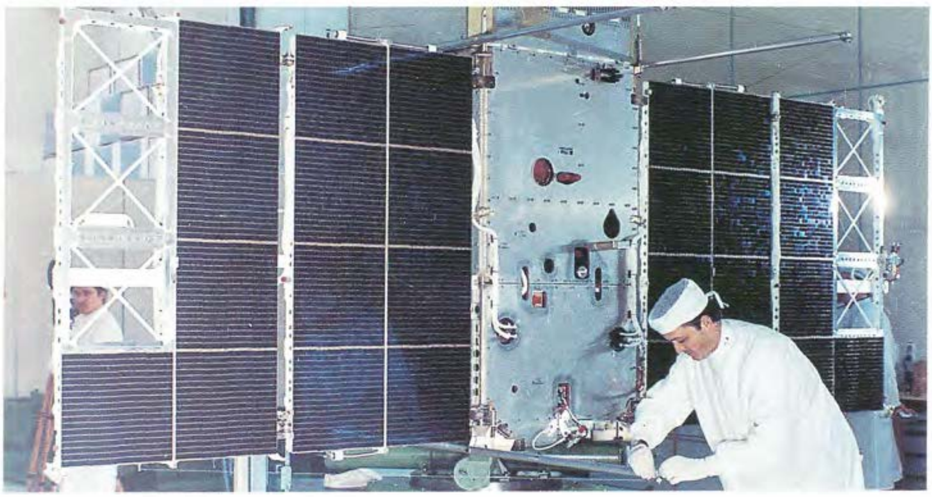
HEOS-1 with the project, science and contractor teams

The crisis of the TD programme

The ministers responsible for space duly convened at the European Space Conference in Rome in July 1967, where all aspects of Europe's space policy were extensively discussed. These included the proper integration of the space research programme pursued by ESRO, ELDO's launcher development programme and the new programmes for application satellites, as well as the co-ordination of joint European and national programmes. We shall report in detail on these discussions in the following chapter and we would only mention here that no solution was found for ESRO's major problem, namely the unanimous agreement of its member states (as required by the Convention) on a level of expenditure for the three-year period 1967–69. This meant that long-term plans remained pending and, moreover, that the 1968 budget had to be decided in the Council by unanimous vote, whereas it would otherwise have been adopted by a two-thirds majority.

The consequences were dramatic for the TD programme. Early in 1968 the industrial consortium chosen to build the TD-1/TD-2 pair doubled its original cost estimate to about 220 MFF which, the ESRO Directorate warned, could easily increase by a further 50% when all aspects of the programme were considered. This would obviously have major repercussions on the rest of the scientific programme. It also had important industrial implications. Italy, whose firms were poorly represented in the consortium building the satellites, was simply not prepared to see a large slice of the budget swallowed up by this project. It therefore refused to pay any more than its share (i.e. 11.72 %) of the original estimate of the two satellites (i.e. 109 MFF plus 40 MFF for launchings). Since any member state had the power to veto the 1968 budget, after a bruising discussion in the March 1968 Council session Italy used it, effectively paralysing the TD programme.

The new Director General, Hermann Bondi, was determined to find a way around the problem. Firstly the eventual cancellation of the TD-1/TD-2 satellites meant the complete loss of 72 MFF already committed to the programme, while the facilities installed at ESTEC and Estrack to cater for them were destined to remain idle for a long time. Secondly, it was essential to save the programme if the space science community's confidence in ESRO was to be sustained. Finally, Bondi also wanted to demonstrate to member states that ESRO could not be held hostage to the policies of any single delegation. He proposed that one of the two satellites be treated as a Special Project as defined in Article VIII of the Convention, i.e. a project developed by ESRO on behalf of only a group of member states, after approval by a two-thirds majority in the Council. The other TD would be cancelled, and a special effort made to save its experiments within the limits of available resources. The STC endorsed Bondi's proposal, which was also approved by the Council. As no clear priority could be established on scientific grounds, technical and financial considerations guided the choice of which of the two satellites was to be kept in the programme.



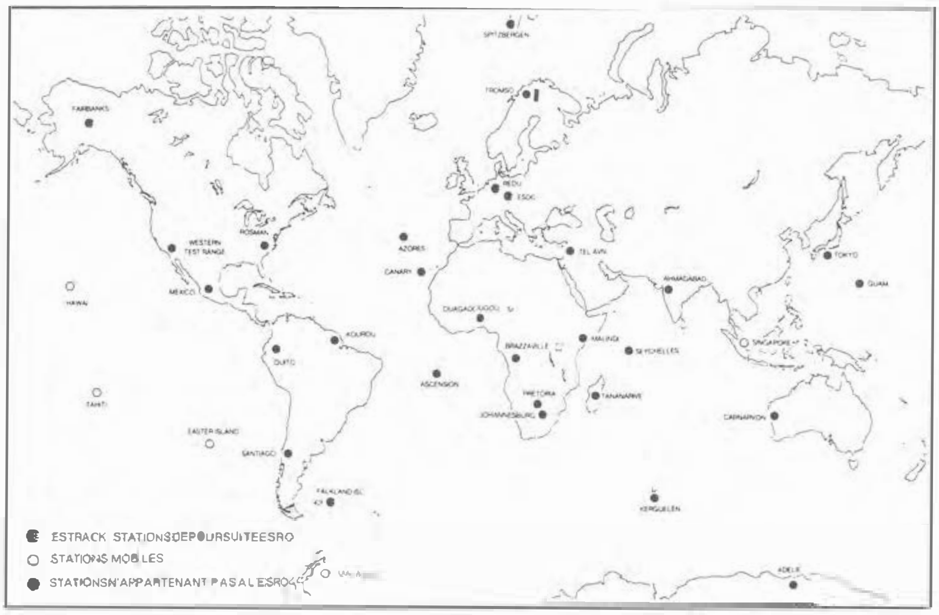
TD-1 with solar panels extended

Considerable savings could be made if the planned spacecraft were stabilised only when in sunlight, and not also when passing through eclipses, as originally foreseen. This condition, it was found, was compatible with the scientific goals of TD-1, but not TD-2. The former was thus transformed into a Special Project and TD-2 cancelled.

What was to be 'rescued' from the TD-2 payload ? Essentially the question came down to finding a solution for four solar pointing experiments: several of the other seven experiments foreseen for the payload could be easily and cheaply accommodated on an unstablised satellite of the ESRO-I or ESRO-II type. One way of saving the pointing experiments was to use one of NASA's OSO (Orbiting Solar Observatory) spacecraft. Another was to build in Europe a small (Scout-type) solar-pointing satellite. Either alternative called for a policy decision involving two important aspects: the role of solar physics in ESRO's programme and the willingness of ESRO member states to spend money 'buying American'.

There was a general feeling in the LPAC in early 1969 that solar physics, a rapidly evolving field, deserved ESRO's support. In addition several national groups had already invested a considerable amount of money in their solar pointing experiments for TD-2. At the same time, if these experiments were to be worthwhile scientifically they had to be launched before the end of 1972. This ruled out building a European spacecraft from scratch and the Committee finally recommended that ESRO buy an OSO spacecraft from NASA, a solution which was also less expensive than the European option.

This was not to be. At a time when member states were emphatic that money had to be spent in national industries to improve their 'geographical returns', there was no hope of getting such a scheme through the Council. The LPAC thus had to climb down and recommend that only the non-pointing experiments be flown. Five out of seven of them could be accommodated on an ESRO-II spacecraft with improved solar cells, eventually called ESRO-IV. It also asked that a feasibility study be started at once for a sophisticated solar satellite to be included in the proposals for the next phase of the programme. In the event, the solar physics community was again to be disappointed — but that is a tale we reserve for a later chapter.



The first ESRO 'rescue' operation — some 40 stations taking TD-1 data in real time

ESRO's 1972 satellites: HEOS-2, TD-1 and ESRO-IV

In 1967, in the framework of preliminary discussions about future satellite projects, the LPAC recommended that the design of HEOS-A should be used for a second highly eccentric orbit satellite (HEOS-A2). The scientific mission of this satellite and the payload composition were defined in 1968 after recommendations from the ION, PLA and COS expert groups. The only difficulty surrounding this payload was created by the competing claims for an experiment from a group at ESLAB and a French team from Saclay. This raised again the thorny debate about the role of inhouse scientific groups. The issue was settled in favour of the ESLAB team, much to the anger of the French delegation.

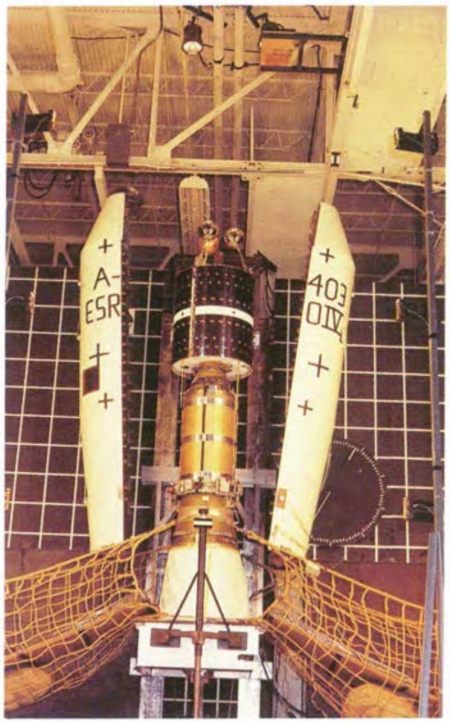
HEOS-A2 was launched on 31 January 1972 into a polar orbit, with an apogee at about 40 Earth radii nearly above the north pole of the Earth. It was renamed HEOS-2 after launch and it was the last HEOS-type satellite to be built and launched. HEOS-2 carried seven experiments designed to study cosmic rays, interplanetary fields and particles, and physical phenomena at the boundary between the magnetosphere and interplanetary space.

HEOS-2 ready for vibration testing

Six weeks after the launch of HEOS-2, on 12 March 1972, ESRO launched the most ambitious satellite among those of the first phase of its lifetime, the astronomical satellite TD-1. It was injected into a circular Sun-synchronous orbit, with the satellite some 540 km above the Earth's surface. TD-1 carried seven experiments the combined mass of which was about 120 kg out of a total mass of 473 kg for the spacecraft. Its primary scientific mission was to conduct a sky survey in the ultraviolet, X- and gamma-ray regions of the electromagnetic spectrum. In addition, one experiment measured heavy cosmic-ray nuclei and two instruments measured X- and gamma-rays from the Sun.

The TD-1 mission risked being seriously jeopardised at the very beginning of its life. Within two months of launch, in fact, both on-board tape-recorders failed. A seeming catastrophe initially, a dramatic rescue operation was undertaken by ESRO in order to prevent any serious loss of data. About 40 ground stations were set up around the world in collaboration with other space agencies, and it was possible to record about 70% of the data transmitted in real time.

A third satellite was launched by ESRO in 1972, the small satellite ESRO-IV. This was essentially based on the ESRO-II design and carried five experiments originally included in the payload of the ill-fated TD-2 satellite. Three experiments concentrated on an analysis of the atmosphere and ionosphere, and two were devoted to the investigation of the radiation belts and the penetration of solar-flare protons and electrons into the magnetosphere. The spacecraft weighed 130 kg and was launched on 22 November 1972 into an elliptical, polar orbit with an initial apogee and perigee of 1177 km and 245 km, respectively.



ESRO-IV fairing ejection tests

Chapter 5 – Communications satellites: the new linchpin of the European space effort

In the previous chapters we have described how the two European space organisations ESRO and ELDO came into being and got their first programmes under way. These were not easy years. The excitement and enthusiasm of 1960/61 inevitably gave way to a new air of realism as the managerial and financial problems encumbent on setting up two new organisations gradually emerged. What is more, member states' governments now found that they had to contend with the possibilities created by the advent of peaceful applications of space technologies.

By the mid-1960s, in fact, space was no longer seen merely as a frontier for esoteric scientific investigation or as an arena for a spectacular race between the two superpowers. Social and economic objectives were coming to the fore, and space was emerging as an important sector for technological innovation in industrialised countries. In this framework, satellite telecommunications presented itself as the privileged area for the development of high technology. Not only was there a vast potential market for both television broadcasts and telephonic linkages, there was also the possibility of gaining new political and cultural footholds in the so-called 'global village'.

In this chapter we describe the convoluted process that led, in the period from 1965 to 1971, to the establishment of a European communications satellite programme. This process involved a reassessment of Europe's priorities in space and, closely allied to this, the question of whether or not Europe needed to develop a more ambitious programme for an autonomous launch capability so as to guarantee her access to the benefits expected to be offered by satellite telecommunications.

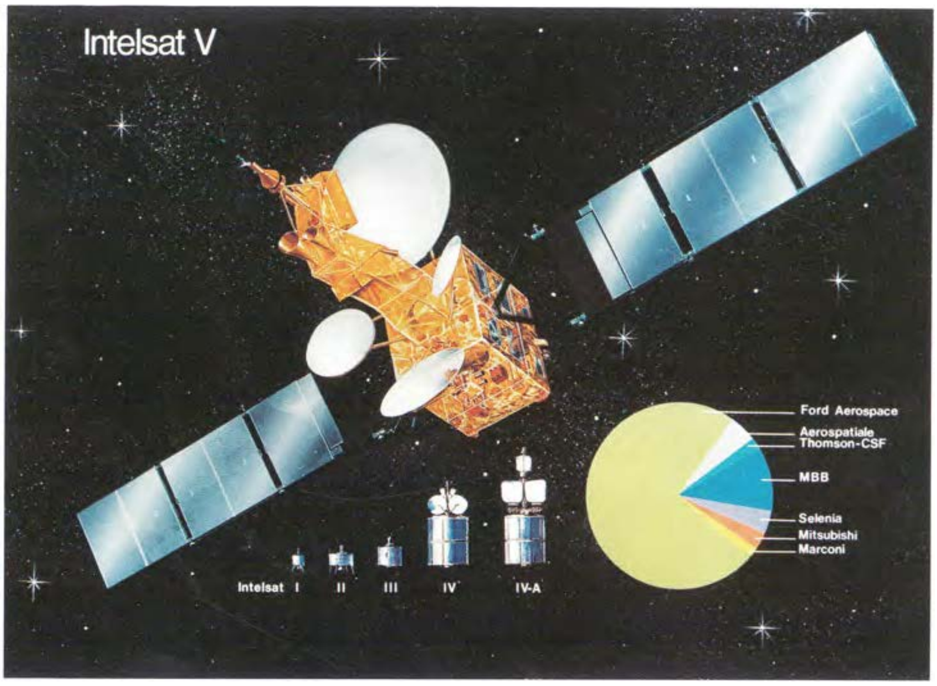
This question in turn was intertwined with assessments of the USA's attitude on providing launch services for European applications satellites. To simplify this extremely complicated story, the launcher question will only be alluded to here, and to the extent that it is relevant to our main line of argument. The struggles over the construction and development of a launcher, which went on in parallel, will be described in greater detail in the next chapter, where we pick up again the story of ELDO. Then, in chapter 7, we will explore in greater depth the American–European negotiations about possible cooperation in space in the post-Apollo period.

The lure of communications satellites

On 28 June 1965 the United States' satellite Early Bird inaugurated a commercial satellite communications service between Europe and the USA, providing potential users with a capacity of 240 telephone circuits or one television channel. After several years of experimentation with satellites such as Echo, Telstar and Syncom, this small spacecraft — it weighed less than 40 kg — orbiting 36 000 km above the Atlantic Ocean demonstrated the technical feasibility and economic potential of geostationary communications satellites, and marked the beginning of a new era in the history of telecommunications.

In parallel with these technical developments, moves were made at the political level to formalise the commercial aspects of satellite communications. In 1962 the United States Congress entrusted the realisation and exploitation of commercial systems for international traffic to the newly created Communications Satellite Corporation (Comsat). Comsat was owned jointly by the main USA communications firms such as ITT and RCA, and by 'private' investors (including the aerospace industries). While formally a private corporation, Comsat had been created in pursuance of the United States' national policy in the field of satellite telecommunications. Its Board of Directors had members appointed by the US President, and controls and regulatory powers were entrusted to the Federal Communications Commission and the State Department.

One of Comsat's tasks was to create the appropriate international framework needed to regulate a telecommunications system on a global scale. To this end it helped establish Intelsat, the International Telecommunications Satellite Consortium. Intelsat was set up to 'design, develop, construct, establish, maintain and operate the space segment of a single global commercial communications satellite system'. The so-called 'interim' agreements establishing Intelsat were signed on 20 August 1964 by 13 nations plus the Vatican City. Its membership grew rapidly reaching 48 by the end of 1965, 63 in 1968, and 83 in 1972.



The Intelsat 'family' of satellites


The first human footprint on the Moon. Television images of the first Moon landing were transmitted by Intelsat III to over 600 million viewers (photo courtesy of NASA)

Shares in the organisation were apportioned on the basis of forward projections of the likely use of the system. As a result, the USA (represented by Comsat) dominated the body and its position was strengthened by the fact that Comsat itself was appointed as the operating manager of Intelsat. The 1964 Intelsat agreements were to be renegotiated five years later, by which time other member states, including the Europeans, hoped to have strengthened their bargaining position in the organisation. In fact, an international conference was called in February 1969, and after two years of discussion the permanent agreements were opened for signature in August 1971.

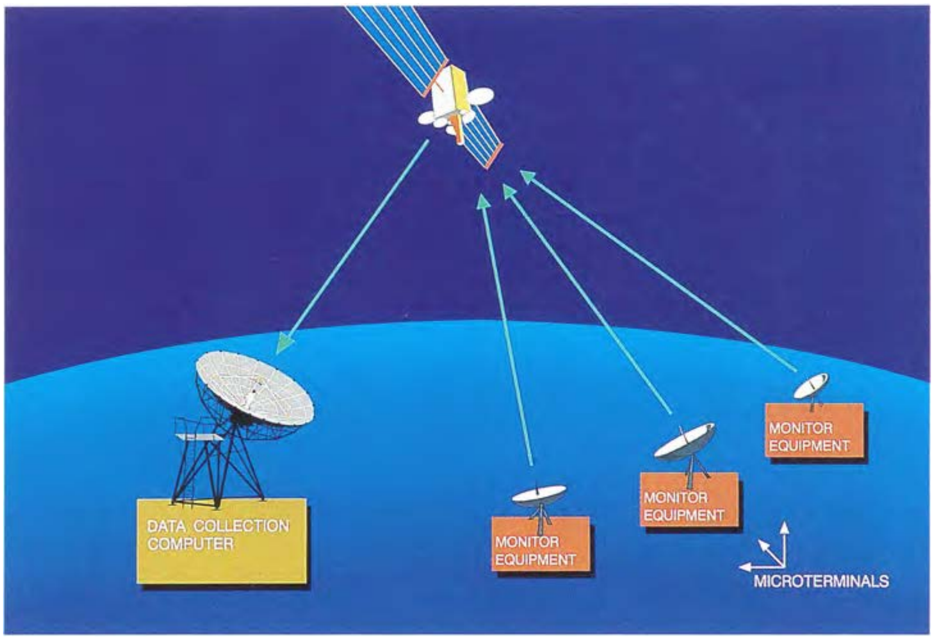
The technology of telecommunications satellites advanced by leaps and bounds throughout the sixties. Early Bird, eventually renamed Intelsat I, was followed in 1967 by three Intelsat II satellites. Two years later, the third generation of Intelsat satellites established a world-wide service, with one satellite over each of the Earth's oceans and many ground stations spread all over the globe. The most striking success of the Intelsat III satellites was the transmission of the television images of the first Moon landing, in July 1969, to an estimated worldwide audience of 600 million people.

All important developments in satellite communications in the 1960s and early 1970s occurred in the USA. Europe was a latecomer in the field. While development work was being actively pursued in both military and civilian circles on the other side of the Atlantic, the European space effort was in fact still struggling to its feet: ESRO and ELDO were being set up, the existing national programmes were still in their early stages, and no plan existed, either at national or international level, which was specifically directed towards communications satellites. Europe's involvement in the area was limited to the construction of two ground stations, one in France and the other in the United Kingdom, to participate in the experimental programme of the American Telstar and Relay satellites. Subsequently, a large station was built in Germany and a smaller one in Italy, and both were used to receive signals from Early Bird.

Once the experimental phase of satellite telecommunications had demonstrated the feasibility of this new technology it was clear that European countries had to undertake research and development programmes in this new and promising field. There were two main reasons for doing so. The first was the economic importance of participating in the Intelsat development and procurement contracts at a level consistent with Europe's financial contribution to the consortium. This could only be achieved by qualifying European industries through the implementation of advanced communications satellite programmes. The second was the political determination to challenge the USA's monopoly of a potentially valuable new technology.

The need for economic growth, political independence and national prestige which were emerging in West European countries two decades after the war's end called for vigorous initiatives to bridge the technological gap between Europe and the United States. With the Americans heading to the Moon, with the Soviets lifting heavier and heavier payloads beyond the Earth's atmosphere, and with Japan, China and Canada already on their way to space, Europe had to consider embarking on a more ambitious space programme. Moreover, the European countries could not risk finding themselves completely dependent on foreign technology in such a vital field as communications.

Four main difficulties impeded the rapid implementation of a European collaborative effort in satellite telecommunications. Firstly, there were the initial doubts about the competitiveness of a communications satellite system outside the Intelsat framework. While the latter was improving communications across the oceans, satellite links within the European continent appeared uneconomical compared with the time-hallowed use of cables. The European PTTs (national post, telephone and telegraph administrations), which would be responsible for the ground segment of any regional communications network, were making major new investments in a tried and tested technology which was known to be reliable and for which a massive infrastructure was already in place. Satellites could never displace cables completely but the precise niche that they would fill in communications inside Europe and its periphery was far from clear.



Basic concept for telecommunication by satellite

Secondly, Europe lacked a launcher capable of putting a satellite into a geostationary orbit. The Europa 1 rocket under development in ELDO was not qualified for this. If Europe wanted to launch competitive telecommunications satellites it either had to upgrade its own launcher considerably or rely on the USA to supply the launch facilities. The dispute over which alternative to pursue led France and Britain into a head-on confrontation that, on more than one occasion, threatened to sabotage a collaborative European space effort altogether.

A third difficulty governments faced was institutional. Two multinational space organisations had already been created in Europe, ESRO and ELDO, but none existed for building and operating application satellites. All agreed that the creation of a third organisation would be unwise. At the same time any involvement of ESRO and ELDO in the new field implied important changes in their charter and operational programmes. This was not easy, however, due to the different aims, structures and memberships of the organisations. We should recall in this respect that only six European countries, plus Australia, were members of ELDO, the programmes of which were mainly defined at governmental level, while ten were in ESRO, with the European space science community as its constituency. A much larger number of countries needed to be involved in a joint European communications satellite programme, their interests being mainly represented by the traditionally conservative PTTs.

The Member States of ESRO, ELDO, CETS and the CEPT in 1966

	CEPT	CETS*	ESRO	ELDO
Australia**				x
Austria**	x	x		
Belgium**	x	x	x	x
Cyprus	x	x		
Denmark**	x	x	x	
Finland	x			
France**	x	x	x	x
Germany**	x	x	x	x
Greece**	x	x		
Iceland	x			
Ireland**	x	x		
Italy**	x	x	x	x
Liechtenstein	x			
Luxembourg	x	x		
Monaco**	x	x		
Netherlands**	x	x	x	x
Norway**	x	x		
Portugal**	x	x		
Spain**	x	x	x	
Sweden**	x	x	x	
Switzerland**	x	x	x	
Turkey	x			
United Kingdom**	x	x	x	x
Vatican City**	x	x		

* All states listed participated in the CETS meetings, but some did not attend regularly
** Signatories of the Intelsat Interim Agreements

Telstar, Early Bird and beyond

The first experimental communications satellites (Score, Courier) were developed by the US Department of Defense at the end of the 1950s. In 1960 NASA launched the Echo satellite, a plastic balloon coated with aluminium which flew at a height of about 1500 km. It was used as a passive reflector of telephone signals. The era of satellite communications for the general public began in July 1962 with Telstar, the first real-time transponder, i.e. a system capable of relaying signals from one ground station to another. This satellite, a sphere 1 m in diameter and weighing 80 kg, provided the first live broadcast of television images across the Atlantic. In May 1963, Telstar II established an analogous connection over the Pacific.

The first communications satellites were placed in near-Earth orbits and each of them was therefore visible simultaneously to widely-separated ground stations for only a few relatively short periods each day. The Syncom satellite, launched by NASA in July 1963, was the first geostationary satellite, i.e. it was placed in an orbit 36 000 km above the Earth's surface, where its orbital period is exactly 24 hours. In this condition the satellite revolves with the Earth, and effectively remains stationary above the same spot on the planet, thereby always being visible from an entire hemisphere.

Syncom was followed in April 1965 by Early Bird, which definitively demonstrated the superiority of geostationary satellites for space communications and inaugurated Intelsat's commercial services. Early Bird (or Intelsat I) was a small, spin-stabilised, cylindrical spacecraft, 72 cm in diameter and 60 cm long, weighing only 385 kg. Its power capability was limited to 240 telephone circuits and multiple access was not possible. In other words, it was rather like a submarine cable in the sky, providing point-to-point communications between two ground stations. The Intelsat II satellites, three of which were launched in 1967, had the same telephonic capacity as Early Bird, but allowed multiple access, i.e. they could be accessed by several ground stations simultaneously.

In 1969 the 152 kg Intelsat III satellites started operations, providing 1200 telephone circuits. An important technical innovation on Intelsat III was that its antenna was provided with a despin motor to keep it pointed in the direction of the Earth as the spacecraft was spinning.

Finally, in the period covered in this book, we must mention the Intelsat IV satellites, seven of which went into service between 1971 and 1975. These satellites weighed 730 kg and were equipped both with a global-beam antenna, like their predecessors, and with two spot-beam antennas, steerable in orbit under ground command towards a particular area on the Earth's surface.

All communications satellites in this period were spin-stabilised and operated in the 6/4 GHz frequency band, i.e. that mostly used in terrestrial microwave telecommunications. This was to reduce sources of noise. This frequency band, however, rapidly became overcrowded and it was proposed that future communications satellites should be designed to operate at frequencies above 10 GHz. To do that it was necessary to develop more sophisticated spacecraft and communications technologies, such as three-axis stabilisation and frequency re-use, i.e. the possibility of transmitting two signals at the same frequency but with different polarisations. These technologies were actually implemented in the European OTS project.

The OTS — Orbital Test Satellite — thermal model being assembled

The fourth and final obstacle to hammering out a joint European policy on telecommunication satellites was the wish of some of the major countries to build such spacecraft nationally also. This would enable them to reap directly the promised commercial and industrial benefits. It would also put their industries in a very strong position when it came to competing for contracts to build key components for any European satellite.

Bitter and prolonged arguments broke out between some of the big countries. who insisted on their right to pursue a two-track approach, both national and European, and the small countries, who could not afford to go it alone To resolve this problem it was essential to define a spacecraft for Europe which was both technically novel compared to what was being done in national programmes, and industrially interesting to all the member states, especially the smaller countries.

The identification of a technically and industrially interesting spacecraft, the emergence of an important and reliable customer for it, the acquisition of a launcher with geostationary capability, and the definition of a suitable institutional framework, were all necessary preconditions for the successful implementation of a European communications satellite programme. It was not an easy task and, as we shall see in this chapter, it was only in the early 1970s that European governments, after years of debate and haggling, finally managed to agree to fund jointly Europe's first experimental communications satellite

ESRO, ELDO and CETS: defining the first programmes

The first plans for an all-European communications satellite programme were elaborated during 1965 by the so-called Technical Planning Staff (TPS) of the European Conference on Satellite Telecommunications (CETS from its French initials). CETS was established in May 1963 with the twofold aim of coordinating the positions of European countries in the Intelsat negotiations and developing a joint European communications satellite programme. In December that year its TPS proposed that Europe embark on a five-year programme costing 370 Million French Francs (MFF) to develop three or four experimental satellites placed in a low inclination orbit. This, it was argued, would enable European industry to compete better for contracts inside any new global system or subsystem required from 1970 onwards. At the same time, and precisely to avoid Europe being constrained by international agreements, the TPS suggested that other applications of clearly regional scope (television distribution and broadcasting, navigation assistance to ships and aircraft, etc.) should also be explored.

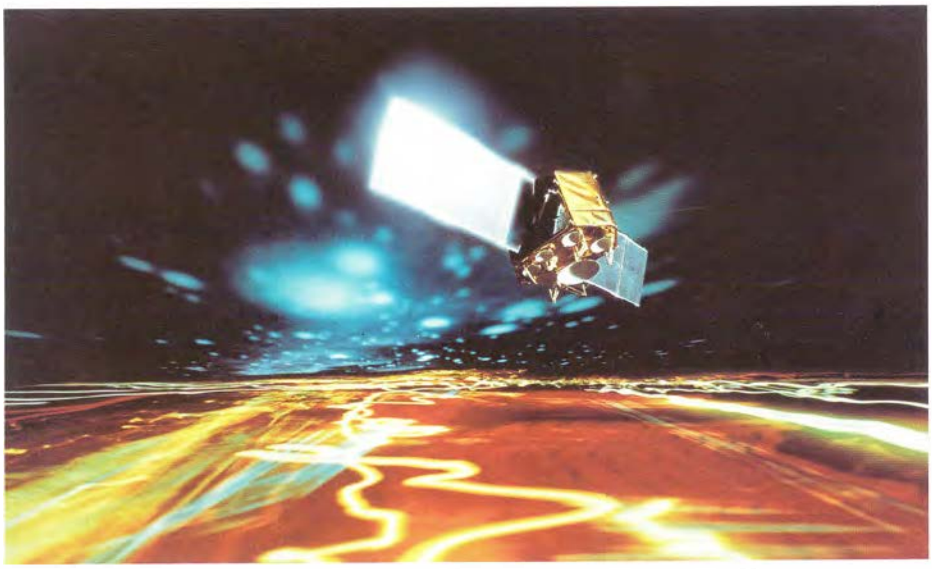
The success of Early Bird and the decision to develop the Intelsat III series of geostationary satellites led the TPS to place greater emphasis on this latter aspect, leaving aside the field of trans-oceanic telecommunications, where so little room existed to compete successfully. At a meeting of the CETS held in The Hague in November 1966, it was suggested that Europe develop an experimental satellite comparable to the Intelsat III then under development (i.e. weighing about 150 kg) and suitable for providing telephony and television services within the European continent and the area of its cultural influence in North Africa and the Near East. The total cost of the programme was not to exceed 435 MFF, including the development of the satellite as well as studies on second-generation telecommunications systems and other application fields.

At the same meeting, a tentative institutional framework was agreed on for the implementation of this programme. ESRO would be entrusted with design studies and management, in close collaboration with ELDO; it was assumed that ELDO would supply the launcher.

By entrusting the design of the applications satellite to ESRO, CETS took a major step towards reorienting that organisation's mission. This raised a legal problem, for ESRO's Convention did not explicitly foresee the development of such satellites. And even though certain clauses were suitably general to permit such an activity, it was clear that sooner or later a new legal document would be required.

There were also the sensitivities of the scientists to consider. Here it must be said that, while the scientific community undoubtedly feared that their research would be rapidly swamped by applications, the majority accepted that a shift in priorities was more or less inevitable. Indeed, not only governments but also ESRO's management and technical staff heartily welcomed the move. A programme involving both scientific and application satellites implied a more efficient use of capital resources, a more equitable distribution of industrial contracts among member states, and the attraction of the best engineers to ESTEC via the appeal of large challenging projects.

That granted, most scientists realised that rather than oppose head-on the re-orientation of ESRO's activities, it would be more prudent to see in it a guarantee for the long-term future of 'their' organisation, and to demand a secure place for scientific research within its newly evolving structure.

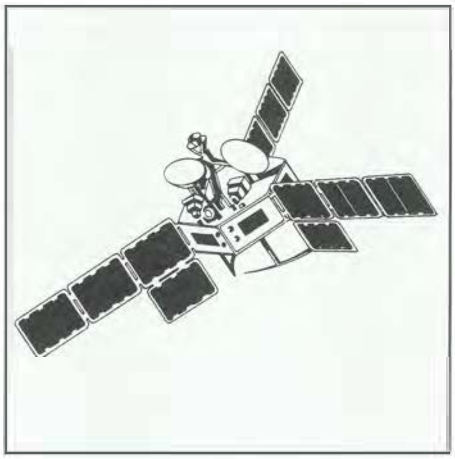


A 'public relations' view of OTS in orbit. This signalled a change in presentation, which was perhaps to be expected with the advent of an applications programme

A word or two is also needed about the launcher. As we shall see in the next chapter, by the time of the CETS conference in The Hague, ELDO member states had agreed on a programme aimed at upgrading the Europa 1 rocket by the addition of the so-called PAS (perigee–apogee system). The new launcher (named Europa 2) would be able to inject a 150 kg satellite into the geostationary orbit. It was this launcher that member states of CETS had in mind when defining the weight of their first spacecraft.

Searching for a coherent European space policy: the European Space Conferences

Within six months of The Hague meeting, a team of about 30 ESTEC engineers, responding to CETS's request, had come up with the designs for two satellites meeting its criteria. The one, CETS A, was rather conservative in concept and foresaw the construction of a spacecraft in four years using Europe's available industrial capabilities. The other, CETS B, involved more advanced technologies for television broadcasting and looked to a future when the pressure to get into the business quickly had abated.



Symphonie — the Franco–German telecommunications satellite

The results of the ESTEC study were presented at the meeting of the European Space Conference (ESC) held in Rome on 11–13 July 1967. This body was set up on the initiative of ELDO member state governments. When they agreed in July 1966 to embark on the ELDO-PAS programme, the ministers took a number of steps intended to provide a solid and durable backbone to the European space effort. In particular they resolved that they should meet at least once a year, and that these gatherings, or European Space Conferences as they were called, should be enlarged to include representatives from the member states of ESRO and of CETS.

The first European Space Conference took place in Paris on 13 December 1966. All the member states of ESRO and ELDO, and most of those of the CETS were represented. Six months later the ministers met again in Rome, determined to try to define a coherent space policy for Europe which included science, applications and launching facilities.

The Rome conference took place in dramatic circumstances: indeed every sector of the European space effort was in crisis. As we have seen in the previous chapter, ESRO's budget for its second three-year period had been blocked by disagreements between its member states; its most important single project, the Large Astronomical Satellite, was jeopardised by rising costs and managerial disputes; and it was clear that its initial programme would have to be drastically revised. With regard to ELDO, the approval of the Europa 2 programme had not removed the reasons for conflicts between its member states. Foreseeable developments in satellite telecommunications and other application fields called for much heavier satellites and more powerful rockets, but Britain still had serious doubts about the viability of Europa 2 and was adamantly against undertaking new projects. Finally, the ESRO/CETS communications satellite projects were threatened from two quarters.

Firstly, there were doubts raised over the cost. An economic study by the European Conference of PTT Administrations (CEPT from its French initials) concluded that a European communications satellite system would be more expensive than conventional ground links, and that it would be cheaper to use the Intelsat system.

Secondly, and more fundamentally, there were important developments at national level. The British Post Office opposed any direct involvement in communications satellites, arguing that very few possibilities existed for autonomous European action in this field, both because of the strength of the United States' presence and because of the foreseeable small commercial demand for the kind of satellites Europe could build and operate. European countries, the British said, should concentrate all their efforts on obtaining more favourable conditions for their industrial interests within the Intelsat framework. The government was thus advised in 1967 not to take part in the CETS programme, and rather to build an all-British satellite within the framework of the Anglo–American Skynet military space communications system.

The other major European countries, on the contrary, were strongly committed to developing civilian communications satellite systems and were implementing national programmes. France and Germany had already embarked on building their own communications satellites in 1966. Early in 1967 they decided to fuse their efforts and to build an experimental satellite together called 'Symphonie'. Italy, for its part, insisted that the test satellite on top of the ELDO launcher, which her industry was developing, should be used for experiments on high-frequency telecommunications equipment. Italy also decided, in 1968, to build its own national spacecraft, called Sirio, essentially derived from the PAS satellite.

These initiatives, and the Franco–German decision to develop Symphonie in particular, created considerable resentment in some quarters which was voiced at the Rome meeting. Delegates from smaller countries were infuriated, questioning the wish of France and Germany to cooperate. On the one hand they feared that Symphonie simply duplicated the CETS programme, so rendering it technologically redundant. On the other, they saw in this initiative an attempt by France and Germany to steal a march on their European partners, and to put their industries in a commanding postion for the award of contracts for any future 'European' telecommunications programme. In short, despite the enthusiasm of the engineers, there were major financial and political disagreements to be resolved before Europe embarked on a joint telecommunications programme — if it did so at all.

The ESC Rome meeting did not resolve the major problems on the table. The French and the Germans tried to reassure their partners that theirs was not a rival, but a complement to the CETS projects but the fact remained that Symphonie was actually very similar to CETS-A; the British insisted that any such programme should, above all, be assessed economically; and the Italians refused to make any payments to ELDO without guarantees that the test satellite on the Europa 2 launcher would be useful for telecommunications purposes.

The meeting was also unable to solve ESRO's major problems, as we have discussed in the previous chapter. Above all there was a marked unwillingness to press ahead rapidly with the amalgamation of the European space organisations. The smaller countries, in particular, were extremely prudent. Fusion was only possible, they said, once there was agreement on the content of Europe's collaborative space programme.

To meet this need, the ministers meeting in Rome set up the so-called Advisory Committee on Programmes. It was chaired by J-P. Causse, the head of the French CNES centre at Brétigny. The Causse Committee had the task of elaborating a coherent and balanced space programme for Europe.

The European Broadcasting Union and the Eurafrica project

Pending the report of the Causse Committee, ESRO was granted a new contract to design an experimental satellite distinct from Symphonie and meeting the needs of a new potential client: the European Broadcasting Union (EBU), the association of television companies that operated Eurovision. The EBU had approached ESRO as early as January 1967, when ESRO was starting its studies for CETS. Soon after the Rome ESC meeting, the EBU confirmed its interest and asked ESRO to design a satellite systems for its Eurovision network. The cost, it was stipulated, should not exceed 450 MFF.

The EBU's interest in communications satellites stemmed from the fact that the transmission of Eurovision programmes was realised through a wide-band cable network provided by the PTTs on a commercial basis. However, the activation of such a network took several hours; the cost of the service was considered too high; and distribution was limited to those countries connected to such a network. A satellite relay system could provide the EBU with its own distribution network, which it could operate in real time at short notice, reaching all countries from which the satellite was visible, from Iceland to Lebanon and from Scandinavia to North Africa.

The EBU study contract had several advantages. Firstly, it allowed ESRO to keep its technical team united instead of dispersing its members. Secondly, it offered CETS a way out of the embarrassing situation of having a 'European' project similar to that developed by two of the most important European countries. Finally, it provided an example of a communications satellite more oriented towards operational activity for a definite customer than towards experimentation.

By the end of 1967, ESRO's engineers were ready with their design for the new satellite, called 'CETS C' or 'Eurafrica'. Technologically speaking, it went beyond both earlier USA satellites and Symphonie, in that it embodied 'four-axis stabilisation', i.e. three-axis stabilisation of the body with respect to the Earth, and a Sun-tracking solar array. The EBU liked the design. In July 1968, its General Assembly decided that it was ready to bear the cost of the operational satellites following the experimental spacecraft, provided that the annual average expenditure of the system did not exceed that of the existing terrestrial network.

Defining a 'balanced' European space programme: the Causse report

The Causse report, which was circulated at the end of 1967, was the first attempt to formulate a genuinely European space programme. In addition to defining the general outlines of a long-term European space programme, it strongly recommended that the Eurafrica project be started immediately. Causse stressed its technological interest, its financial viability and, above all, the relative ease with which a transition could be made from experimental to operational activities.

The 'balanced programme' presented in the Causse report assumed that the European budget for space would grow annually by 10% from 1967, climbing from 150 MAU to about 250 MAU by 1973. Within this envelope, the report suggested, Europe should aim to launch an average two scientific satellites per year in the early seventies, and develop more sophisticated application satellites following CETS C (for direct television broadcasting above all, but also aeronautical, meteorological and Earth resources satellites).

Two new generations of launchers were to be developed and adapted to the needs of application satellites. Europa 3 would involve the addition of a cryogenic stage to Europa 2 and be able to put 500 kg into geostationary orbit. Europa 4 would include the addition of strap-on boosters and be able to put 2 tons into geostationary orbit, so being suitable for a direct TV satellite.

A typical distribution of resources between these three activities, which could vary slightly depending on which of three possible science programmes was chosen, was 100 MAU for science for 1972, about half as much for applications (47 MAU) and about the same amount for launcher development (90 MAU).

To implement this programme, the Causse report recommended that a single European organisation be created for space research and development. Its statutes, they said, should be such as to allow member states to take part in certain programmes only, i.e. it should make provision for optional programmes.

The 1968 crisis, and the ESC meeting in Bad Godesberg

The implementation of the programme discussed in the Causse report required a political decision which was expected from the forthcoming meeting of the European Space Conference scheduled for spring 1968. It was delayed for six months, however, owing to a series of political crises. In March 1968, ESRO's member states were unable to vote the budget for that year, due to the cost escalation of the TD project (see previous chapter). In April, and in the light of two failed launches of Europa 1, Britain announced that it would not undertake any further financial commitments to ELDO, adding that it would also not participate in the Eurovision satellite project. Finally, in May 1968, CETS failed to agree on a joint position to adopt in the forthcoming negotiations over the permanent Intelsat agreements. As ESRO's Director General, Hermann Bondi put it, 'in the early summer of 1968 it was hard not to despair of a European space future'.

After several months of intense negotiations, a tentative compromise over the launcher issue was finally brokered by Belgian ELDO delegate J. Spaey (see chapter 6). The delayed European Space Conference was called on 12–14 November 1968 in Bad Godesberg, near Bonn.

A number of important decisions were taken by the ministers meeting in Bad Godesberg. Firstly, following Spaey's recommendations, they suggested that one European space organisation should be created out of the existing three with a basic programme, which included launchers, and a minimum programme (still to be defined) that did not. This left member states free to opt out of launcher development. To protect further the interests of non-launcher states, it was resolved that, while every effort would be made to use a European launcher, countries that had not participated in its development would not be required to buy it at more than 125% of the cost of an equivalent non-European launcher if one were available on the market. These compromises were intended above all to keep Britain tied into a joint European space effort and to guarantee a clientele for ELDO's rockets.

ESRO's scientific programme was also given a new stability. The Council was invited to approve the requested level of resources for the three-year period 1969–71 (i.e. 860 MFF). The organisation was also authorised to enter into financial commitments for scientific projects which went beyond 1971, i.e. beyond the eight-year period covered by the ESRO convention. Add to this the first successful launch of two scientific satellites earlier in 1968, and a third immediately after the meeting, and one can appreciate why ESRO Director General Hermann Bondi could report that there had been a 'dramatic change in ESRO's standing and self-confidence' during the preceding few months.

The situation concerning application satellites was more ambiguous. On the one hand, and in a dramatic shift of policy, the British government came out strongly in favour of applications, but at the expense of launchers. The launcher priority was the wrong priority, said its delegate, the Minister of Technology Anthony Wedgwood Benn. He had only voted for the '125% rule', he insisted, on condition that the UK was released from its existing financial commitments to ELDO. If the other member states of ELDO agreed, he went on, the money thus saved would be shifted from launchers to developing application satellites in the European framework, including CETS C. This was not accepted by other delegations, however, and all decisions were postponed pending a clarification on this issue. Therefore, and much to ESRO's disappointment, the ministers meeting in Bad Godesberg only granted it 1 MAU a year to pursue preliminary studies on various applications programmes, but did not authorise the start of development work on the Eurovision Eurafrica satellite.

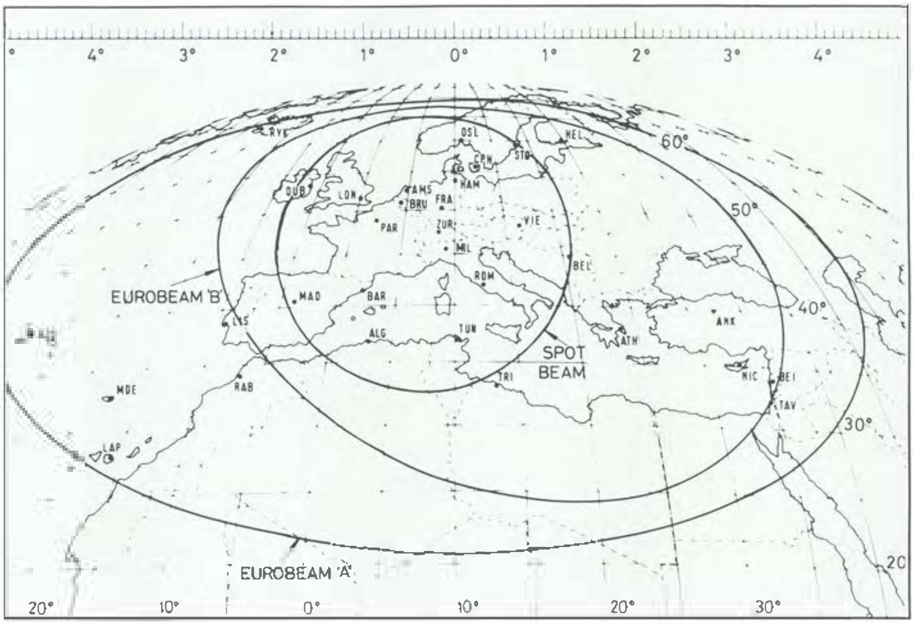
Interested governments were instead given until March 1969 to decide whether or not they wanted to participate. A decision would be taken thereafter on the basis of the available economic and technical information. Two weeks after the Bad Godesberg conference, there was another Europa 1 failure; this unsuccessful critical first orbital flight test with all three stages operational frustrated all hopes of an easy compromise. The British and Italian governments announced that they were unwilling to pay their full shares for the completion of current ELDO programmes and were not interested in participating in future programmes.

A new ministerial conference of ELDO member states was called in April 1969 in order to find a solution. As we shall discuss in detail in the next chapter, France, Germany, Belgium and the Netherlands agreed to make up the difference resulting from the British and Italian shortfalls. They also decided to start studies on a new launcher, called Europa 3, capable of launching geostationary satellites with a mass up to 800 kg, the weight of the communications satellites foreseen for the late 1970s.

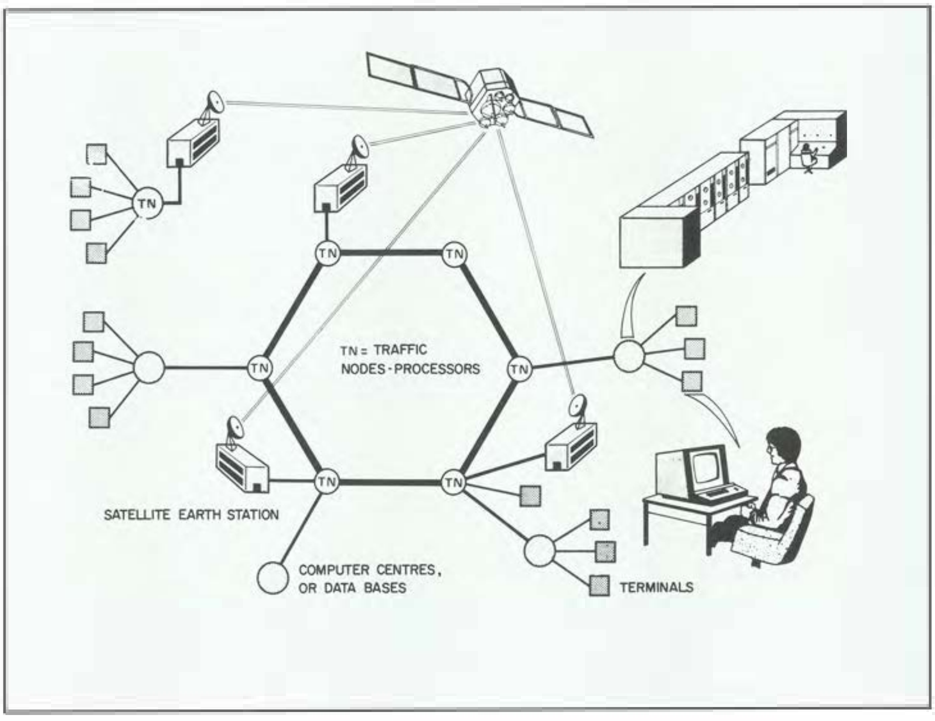
The PTTs re-enter the picture

The March 1969 deadline for a decision on the Eurafrica project proved, once again, to be too optimistic. There were ongoing technical and financial problems over the use of Europa 2 and it was suggested that perhaps a United States' Thor-Delta rocket should be used instead. There were conflicts over the selection of an appropriate prime contractor for building the spacecraft. There were competitive threats from the industrial consortia building Symphonie, which had designed new versions of the satellite to meet the EBU's requirements. Finally, the EBU itself, which had always said that it would only support the satellite system if it were to prove competitive with the terrestrial network it was intended to replace, concluded in autumn 1969 that it would not in fact be so.

At the same time, however, a new potential client came back on stage: the European PTTs. The member states of CEPT announced that they wished to explore the feasibility of a communications satellite system allowing for intra-European telephony, telex, and data transmission, besides the TV relay system demanded by Eurovision. The reasons for CEPT's new interest in communications satellites are easily identified. In July 1969 the Intelsat III satellites started providing world coverage for telephonic traffic and the technical reliability, commercial value and social importance of communications satellites could no longer be doubted. Moreover, in the framework of the ongoing negotiations for the definitive Intelsat agreements, it had finally been accepted in principle that regional (i.e. continental and sub-continental level) systems of communications satellites could, under certain conditions, be established alongside Intelsat's global network.



A concept highlighting the potential for European telecommunications satellite coverage



One of the 'applications' that quickly emerged when the possibility of a European telecommunications satellite was under discussion

A working group of all interested parties was set up by the ESC Committee of Senior Officials and a new programme designed in the first half of 1970. Its objective was to provide, by the 1980s, a satellite system capable of handling a significant fraction (say one half) of the total telecommunications traffic between CEPT member states, and of distributing two Eurovision programmes. One or two large (700 to 800 kg) satellites were proposed as the basic element of the system, which would also include 30 to 35 stations in Europe, North Africa and the Near-East. The cost of the programme was estimated at 450 MAU.

At the fourth meeting of the ESC, held in Brussels in July 1970, it was finally agreed that ESRO should undertake such a programme. The Conference, however, only authorised and funded its very first phase, i.e. the preliminary studies on the system and the development of the first experimental ground and orbital elements. The sum of 5 MAU was made available to ESRO to pursue this preliminary work up to mid-1971, when a decision to proceed to the next phase of the programme would be taken by the participating countries by a double qualified majority, i.e. a positive vote of two-thirds of states covering at least two-thirds of contributions.

With the coming of the PTTs and the approval of the programme by the ESC, the ESRO executive felt confident that a reliable partner had finally been found and a politically appropriate framework created. On the one hand, the PTT administrations were part of the governments that were to be involved in the programme and held legal monopolies on telecommunications. On the other hand, a coherent European space policy appeared to be emerging at last out of the ESC negotiations. For three years ESRO had, in Bondi's words, been 'like an athlete limbering up in anticipation of the starter's gun, at the same time being somewhat uncertain when the gun would, in fact, be fired'. Now it seemed reasonable to expect that governments would finally give their full approval to the communications satellite programme.

The crisis of the ESC and the ESRO 'package deal'

Bondi's optimism was not justified. In fact, the second session of the Brussels ESC meeting, in November 1970, did not succeed in reaching an agreement on the critical issue of launchers. The choice of how to proceed was overshadowed by the repeated failures of the Europa 1 rocket and a suggestion from the USA that the Europeans should abandon their plans to build an expendable rocket and participate in their 'post-Apollo programme,' which included the construction of a reusable space transportation system, the Shuttle (see chapter 7). France Germany and Belgium, fearing that the USA could not be trusted to launch commercially competitive communications satellites, insisted that Europe develop an independent launcher capability; Britain took just the opposite line.

Frustrated, the pro-launcher countries threatened to sabotage the entire collaborative effort by reaching a tripartite arrangement between themselves. While governments and ESC delegations tried to find a compromise which kept the European family intact — a struggle that was to last until July 1973 — ESRO's member states succeeded in keeping the telecommunications programme, as well as the very idea of a European joint effort in space, alive.

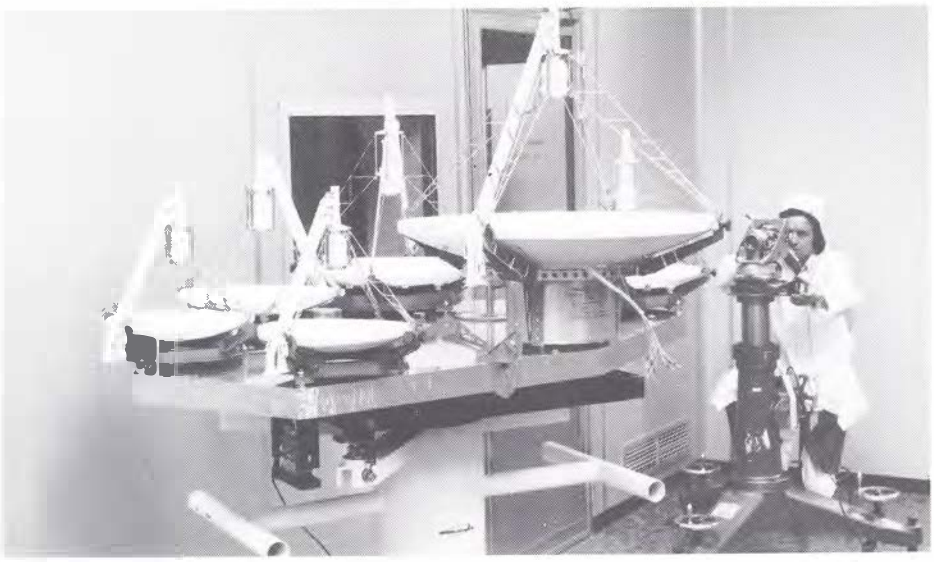
Soon after the failure of the November ESC meeting, in fact, the ESRO Council adopted the programme budget for 1971 as agreed at the July meeting of the ESC (i.e. 5 MAU) and authorised the undertaking of hardware development for the proposed CEPT/EBU satellite. At the same time, they decided to start negotiations between themselves for a revision of the ESRO Convention in order to include application satellites and to provide for optional participation in the various programmes, instead of mandatory participation in all.

The Council asked its new chairman, the Italian physicist G. Puppi, to devise a 'package deal' acceptable to its member states and to lay the foundation for a new institutional framework. This 'first package deal', adopted in December 1971 (see chapter 9), transformed ESRO from an organisation devoted solely to space research, into one mainly involved in application programmes, with only a minor fraction of its budget devoted to science. The scientific programme was made mandatory for all member states, however, while the application programmes were optional. On this basis, and leaving aside the controversial question of launchers, the start of the telecommunications programme was finally approved by eight of ESRO's ten member states (Belgium, Denmark, France, Germany, Italy, Sweden, Switzerland and the United Kingdom) and a budget of 100 MAU was granted to ESRO to develop an experimental satellite as a first step towards the realisation of an operational system. Five years after the first studies undertaken by ESRO, real development work could finally get under way.

The approval of the OTS project

The outline programme designed in 1970 to satisfy the requirements of the CEPT and EBU foresaw the development of advanced spacecraft and communications technologies intended to leapfrog the technological gap that had opened up between Europe and the United States. Three-axis stabilisation, Sun-tracking solar arrays, carrier frequencies above 10 GHz, spot-beam antennas, and frequency re-use were among the most distinctive aspects of the design, which demanded an important R&D effort both in ESRO and in industry. As a consequence, the programme was divided into three consecutive phases. The preliminary phase, then near completion, was to be followed by an experimental phase (phase 2) to be devoted to developing the required technology and testing critical equipment onboard an experimental satellite, and an operational phase (phase 3) for the development of the operational satellites meeting the users' requirements.

The decision taken by the ESRO Council in December 1971 to fund only phase 2 to the tune of 100 MAU was essentially due to the ongoing uncertainty about the economic aspects of the anticipated European communications satellite system. According to a study prepared by the CEPT in July 1971, the total investment required to operate such a system in the 1980s (i.e. not considering the R&D costs and the building and launch of the first operational satellite) would far exceed the savings in the terrestrial network achieved by transferring part of the telecommunications traffic to the satellite system. The CEPT made it clear, also, that the costs of supporting Europe's space industry were not to be borne by telephone subscribers. Besides financing R&D activities through ESRO, the CEPT said, governments had somehow to take responsibility for the difference between the actual operating costs of the satellite system and those which the PTTs would normally have to bear. As a consequence, while agreeing to undertake the experimental phase, the participating countries reserved a decision about the start of the operational phase until the economic aspects were clarified and the commitment of potential users obtained. Such a decision, it was hoped, could be taken by 1975.



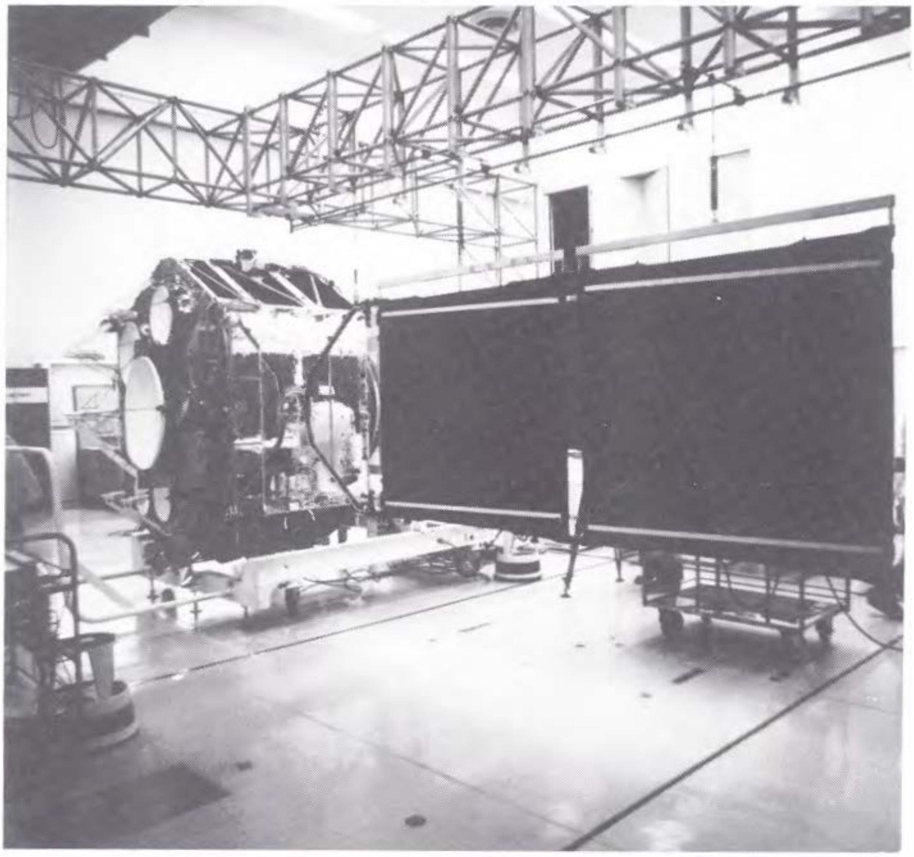
Qualification model of OTS's antenna subsystem, at Selenia, Italy

The start of the programme brought to a head a major battle between the member states over the best design for the test satellite. France and Germany, supported by Italy, argued that ESRO should take advantage of the technology and expertise available as a consequence of national efforts, and insisted that the experimental satellite should be essentially based on the Symphonie (or Italy's Sirio) design.

The countries without a national programme in communications satellites, by contrast, opposed any national bias in the joint European programme, and advocated a new design for the experimental satellite. Good technical reasons existed for both arguments but the real issue, of course, was not technical: at the start of an R&D programme with such important economic implications, all countries wanted to guarantee their home industry the most favourable conditions. By mid-1972 this controversy brought ESRO to a deadlock, with France and Germany insisting on Symphonie, Italy advocating the use of a modified version of Sirio, and even Britain announcing its intention to develop a national communications satellite called UKATS (United Kingdom Application Technology Satellite) for the European programme.

In a situation in which the main member states blocked each other, the ESRO executive decided to 'play European.' Bypassing the national delegations, it asked industry to design a dedicated experimental satellite, the configuration of which was to be as close as possible to that of the operational spacecraft which industry itself was then beginning to study. This project, which was named OTS (Orbital Test Satellite), had clear advantages from the technical and financial points of view, and was whole-heartedly supported by ESRO's smaller member states. In the event, after one more year of negotiations on the financial aspects, OTS was finally approved by the participating countries in September 1973 and its construction contracted with industry in November of that year.

OTS in a whirl — almost as big a spin as the member states had been in before they approved the telecommunications programme



OTS-B solar-panel deployment tests at Kennedy Space Center, prior to launch

Tragedy strikes the first OTS launch

A happy ending with the successful second launch

Commemorating a much longer lifetime in orbit for OTS than was foreseen

The Orbital Test Satellite (OTS)

The Orbital Test Satellite (OTS) was an experimental geostationary satellite developed in preparation for a European Communications Satellite (ECS) system. It was designed to provide in-orbit verification of the technology that would be used on Europe's later operational programmes, to experiment with and demonstrate new telecommunication techniques and services, and to provide pre-operational satellite communications capacity for the European PTT administrations.

The OTS, a three-axis stabilised satellite weighing about 900 kg, was designed according to a modular approach. It consisted of a service module, providing all the basic service functions, and a communications module, carrying the payload. This modular concept allowed the spacecraft to be adapted easily and economically for different missions, like that of the maritime satellite Marots.

The OTS communications payload provided for the reception of signals at 14 GHz, their frequency translation, and retransmission at 11 GHz after amplification. The paylaod itself was split into two parts, called Modules A and B, the former devoted to pre-operational activity and the latter to be used for propagation experiments and narrow-band transmission tests. Both modules were arranged in a frequency re-use configuration, Module A employing orthogonal linear polarisations and Module B using orthogonal circular polarisations. Six different antennas provided for receiving and transmitting signals with different coverage of the European continent, North Africa and the Near East (Eurobeam 'A' and 'B', and 'spotbeam').

Most of the OTS Orbital Test Programme (OTP) was carried out using the Satellite Control and Test Earth Station (SCTS) established by ESA and the Italian company Telespazio at the Fucino site, near Rome, where the Italian Intelsat station was also located. Three other large ground stations were used in the OTS experimental programme: that of the French PTT administration at Bercenay-en-Othe, near Troyes; that of the Deutsche Bundepost at Usingen, near Frankfurt; and that of the British Post Office at Goonhilly Downs in Cornwall. Moreover, about 30 smaller stations scattered throughout Europe participated in the propagation tests.

The first OTS was launched from Cape Canaveral on Friday 13 September 1977. The Delta rocket exploded shortly after lift-off and the spacecraft was lost in the ocean. Fortunately enough, a back-up policy had been established for the OTS project and a second flight unit could be integrated in six months. This was successfully launched on 11 May 1978. The planned lifetime of OTS was only three years but its good performance in orbit suggested that this should be extended in order to pursue further experimental programmes. In fact, after completing almost 13 years of operational activity, OTS was retired from service in January 1991.

Chapter 6 — The difficulties in ELDO and the conflict over the need for a European launcher

The emergence of space applications, and of telecommunications in particular in the mid-1960s dramatically changed the mission of Europe's heavy launcher being built by ELDO. When the organisation was set up, the payloads its rocket would launch were but vaguely defined: political and industrial pressures were sufficient impetus to get the programme underway. The success of Early Bird and the subsequent commitment by Intelsat to the use of the geostationary orbit gave better shape to the desirable design features for any European rocket. On the other hand, as the technical requirements became clearer so the political issues became murkier.

At the heart of the debate was, of course, the question of whether Europe needed to develop its own heavy launcher at all. The enormous resources required and the disappointing performance of the Europa rocket were balanced against the conviction, widely held in some countries, that it was simply incoherent to build telecommunications satellites in Europe (be that nationally or jointly) unless Europe developed its own launcher. The industrial, commercial, political and cultural stakes involved were so high, they argued, that one could never be sure that competitors, and the USA in particular, would accede to a request to launch.

Our aim in this chapter is to describe the debates over launchers in ELDO and in the European Space Conferences from 1965 to 1969, when some member states decided to go ahead with preliminary studies of Europa 3. These debates, it must be stressed again, can only be separated from those over the telecommunications programme, treated in chapter 5, for analytical purposes. The two issues were obviously intertwined, as also was the question of the USA's attitude to providing launches. That topic will be addressed in chapter 7.

Launch of Europa 2 from Kourou, French Guiana

1965. The French crisis and the reaffirmation of the Initial Programme (Europa 1)

By the time the ELDO Council met in December 1964, its Scientific and Technical Committee had arrived at a revision of the Initial Programme which seemed to be broadly acceptable to the member states. Its specific aim was to give Europe a launcher capable of putting an operational telecommunications satellite into geostationary orbit by the early 1970s. This was to be approached in two phases, at the end of which all that would remain of the initial rocket was a suitably adapted version of Blue Streak. Firstly the ELDO A/S launcher would be developed. Based on ELDO A, it would include the development of an apogee stage (A/S), using a solid propellant motor, and having inertial guidance. It could be used to flight test 20–40 kg of telecommunications equipment in polar orbit.

The ELDO B programme involved successively replacing first the second and then the third stage of ELDO A with liquid hydrogen–oxygen stages. Both ELDO B rockets had a geostationary capability up to 1000 kg, their performance being enhanced if they were fired in an easterly direction from an equatorial launching site. This programme required major new investments from governments. The Secretariat estimated that ELDO A/S and ELDO B together would cost between 360 and 440 MAU (including a 40% contingency margin), the difference depending on the costs of the equatorial base (estimates here varied from 70 to 150 MAU). In addition, at the end of 1964, governments were informed that the estimated cost of the Initial Programme had more than doubled from the original, admittedly tentative estimate of 198 MAU, to 400 MAU (including contingency).

The ELDO Council felt that only a higher authority could commit member states to a reorientation of the programme and an expenditure of this magnitude. Intergovernmental consultations at plenipotentiary level were accordingly held in Paris on 19–21 January 1965. Here the French delegation made an 'important and revolutionary proposal', with the 'slight suggestion' that continued French participation in ELDO was conditional on other member states accepting its new scheme. The French proposal, in a nutshell, was that work on the second (French) and third (German) stages of ELDO A be stopped, and that the organisation's entire activity be directed towards building ELDO B with two high-energy stages and an apogee stage. Put differently, France proposed that the organisation go straight on and build a heavy launcher based on Blue Streak plus state of the art cryogenic technology without developing ELDO A/S first.

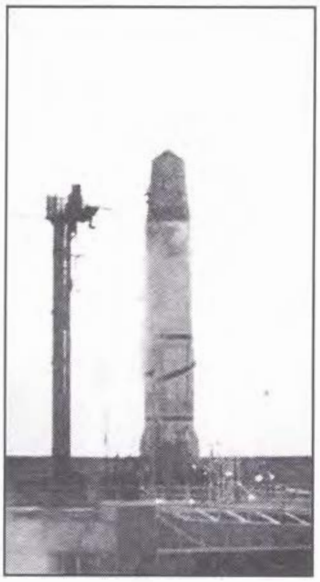
The French recognised that this plan was technologically risky and would require a major industrial re-organisation, but this, they felt, was a 'necessary evil'. Money, they claimed, would be saved and Europe would have a launcher capable of putting operational satellites into geostationary orbit by 1971. In addition – though this was left unsaid – the new scheme would avoid undue technological duplication with the French national programme. Indeed, within the year France would place a 42 kg satellite in orbit with its own Diamant launcher. It saw little interest in developing a costly European launcher with second and third stages relying on 'a classical technique with only limited scope for further development'.

Launcher control at Woomera Rocket Range, Australia, from which the first stage of Europa 1 was succcessfully launched several times

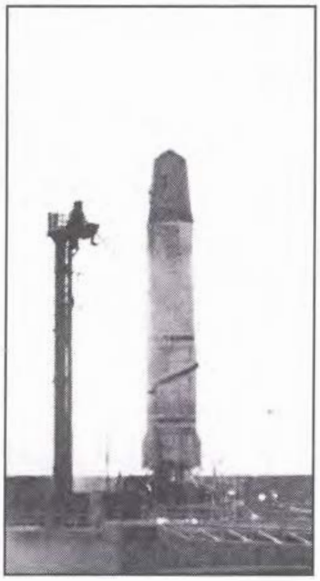
France's partners in ELDO were somewhat taken aback by these proposals. They shared the French concern with spiralling expenditure, and the vagueness which still surrounded the figures for the cost to completion of the Initial Programme. Nevertheless, they were not at all sure that the French proposals were the best way forward. Public opinion would be alarmed, industry would be seriously harmed, there would be cancellation fees to pay, and existing teams which were building up skills would be dispersed. Above all, though, there was the fear that, by trying to leapfrog over the intermediate technological stage represented by the ELDO A/S programme, Europe might find itself embarked on an advanced project for which industry, engineers and project managers did not yet have the requisite skills. In that event, rather than saving money and closing the technological gap with the superpowers more rapidly, the French proposal would have just the opposite effect.

Unmoved, and much to the distress of her partners, France would not accept to fund ELDO for more than the first six months of 1965, and that at a level well below what the other delegations thought suitable. Her final decision waited on the report of a working group which was immediately convened to study the implications of the French proposals.

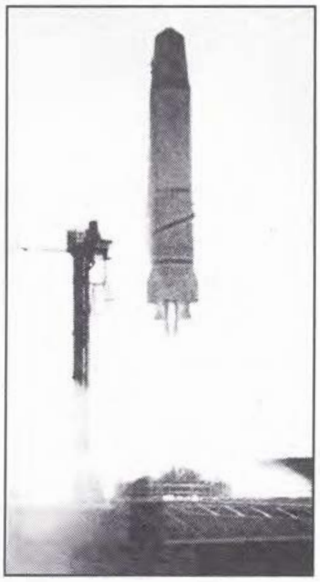
The working group reported in March 1965. Its conclusions confirmed the fears expressed by France's opponents in January. While accepting that ELDO B was the most desirable objective for the 1970s, its members – the French apart – insisted that the risks incumbent on omitting ELDO A/S far outweighed its putative benefits. The group also stressed that little if any money would be saved by such a scheme. An alternative was proposed, namely that a two-stage ELDO A be developed consisting of only the British and German rockets. This of course would mean that 'French firms engaged on the Initial Programme would suffer a break in activity and the first orbital experiments would take place with no important part played by France'. Needless to say, the French delegates to the working group did not support this suggestion.



Ignition



Launcher release



'Up'

and 'Away'

A successful firing of Europa 1, stage one

The intergovernmental consultations were reconvened in April to discuss the report. There was unanimous agreement that the Initial Programme should go ahead for the time being, and the funds necessary for it in 1965 were voted. This meant already breaking the 198 MAU ceiling agreed on in Lancaster House to the tune of 60 MAU. At the same time, no one was prepared to commit themselves to a future programme involving the ELDO A/S and ELDO B rockets. Such future programmes, the delegates decided, could not be agreed until they had a clearer idea of the costs involved. But not only that: other conditions would have to be met. Italy, disturbed about the low returns to its industry from the Initial Programme, wanted ELDO to ensure that 80% of each member state's contributions would flow back to it in the form of contracts. Italy also insisted that steps be taken to coordinate space activities better between ESRO, ELDO and the CETS so at least ensuring that the European launcher was adapted to the technical constraints imposed by the European satellites, and vice versa.

The deliberations in January and April were indicative of a new realism in governmental circles about the desirability of ELDO. This was sparked by the combination of a general economic recession with the spiralling costs of ELDO's programmes. Governments were still prepared to invest in a launcher, many of them believing that this was the only way to secure European autonomy in space. But they needed assurances that their industries would benefit, that the final product would embody the most up to date technology, and that a market of some kind existed for it. When ELDO was launched in 1961/2 it was, as Secretary General Carrobio di Carrobio put it, created 'without any clear prospects of a use for the initial launcher ...'. That kind of vagueness was no longer good enough.

1966. The British crisis, and the decision to build ELDO PAS (Europa 2)

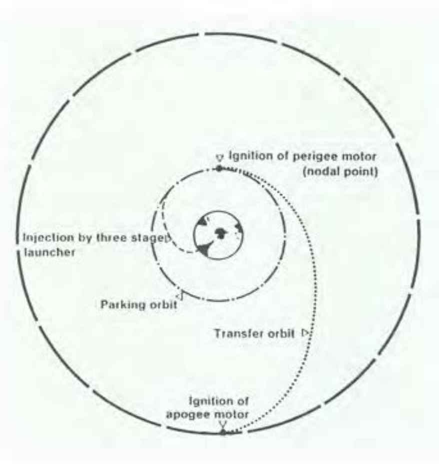
The plenipotentiaries meeting in April 1965 had hoped to reconvene again that autumn to decide on whether or not ELDO should embark on the upgraded programmes. In the event, the date of the next round of discussions slipped steadily. The UK became increasingly concerned about the rapidly rising cost of the Initial Programme and, at the end of the year, refused to adopt the 1966 budget until there had been a thorough re-examination of ELDO's programmes and policy. This was debated at an ELDO ministerial meeting, the first of many at this level, which was held in Paris from 26 to 28 April 1966. Delegates had before them an aide mémoire circulated by the UK government on 16 February 1966.

The British government, the document stated, had serious doubts as to whether ELDO was 'likely to produce a worthwhile result, and whether it would be in the general interest to continue to contribute to and participate in its work'. Costs were galloping out of control. The latest estimates for that of the Initial Programme plus the extensions discussed the year before, including an equatorial launch site, amounted to about 730 MAU without contingency – at least four times the figure agreed on at Lancaster House. The technology being developed was rapidly becoming outdated. The performance of the upper stages of ELDO A had fallen below expectations, their weight had been increased, their payload capability reduced and the target date for the rocket's completion had slipped from September 1966 to mid-1969. Finally, the market for satellites was small, and could in no way justify the huge expenditures on the range of ELDO programmes envisaged. The British delegate stressed that, by the end of the decade, Europe would be saddled with a launcher that was 'obsolescent and uncompetitive in cost and performance with launchers produced by the United States'. In his view it was preferable to try to have European industry participate in consortia with American and other international firms, rather than to build an autonomous launch capability.

The other member states, while sharing Britain's worries, insisted that the performance of ELDO should not be measured by commercial criteria alone. The organisation was set up to build the scientific, engineering and industrial knowhow needed to construct a launcher, and to promote advanced aerospace technologies. It did not matter therefore if the first generation was more costly and less sophisticated than the most modern USA launchers. There was a market for relatively out-of-date rockets, as the United States' experience showed. There was also a need to develop an autonomous launch capability, both to negotiate and collaborate with the USA from a stronger position, and to ensure that Europe could launch satellites – including commercially competitive satellites – whenever she wanted. For Britain's partners, ELDO was an essential component of a long-term industrial strategy intended to narrow the technological gap with the USA, and its performance should be assessed above all else in those terms.

This commitment to the future of the organisation was reinforced by the possibilities offered by a new technique developed in the USA for placing a satellite in geostationary orbit. It involved launching a payload first into a low, circular 'parking' orbit, from which the satellite was transferred to an elliptical 'transfer orbit' by a perigee rocket stage. Finally, an apogee motor built into the satellite itself would fire the spacecraft into the required geostationary orbit.

Interested in the prospects of using this technique, the French proposed that ELDO should develop an ELDO A launcher equipped with the so-called perigee–apogee system (PAS), namely a fourth stage and a satellite including an apogee motor. If launched from an equatorial base, it was claimed, ELDO PAS would enable Europe to put about 150 kg in a geostationary orbit, i.e. satellites of the class of Intelsat-III.



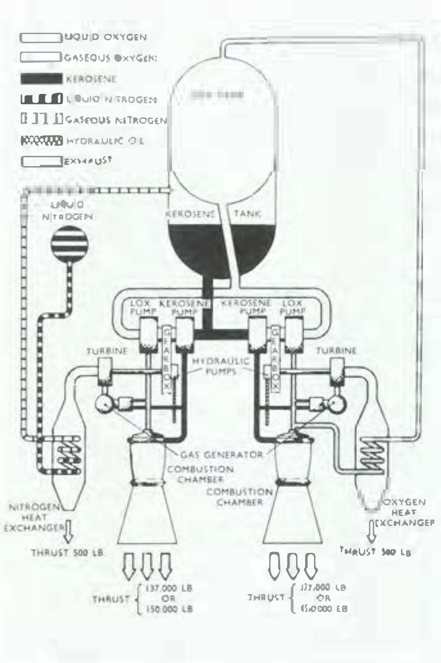
The proposed ELDO PAS method of placing a spacecraft into geostationary orbit

France made its participation in such a programme provisional on certain conditions being met. The management of ELDO had to be strengthened by improving the Secretariat's powers of control, notably over certain national programmes. More controversially, while accepting that Woomera could still be used for trials, the French insisted that ELDO's site for operational launchings had to be the new base she was then constructing for her national civilian programme at Kourou in French Guiana (latitude 5.2° N). If these conditions were met, and the latter was a 'sine qua non', and subject to her partners 'making a similar effort', France was 'ready to consider the purchase of two ELDO A launchers' for its national programme. Confronted with these new proposals — and offers for the construction of a near-equatorial base from the Italians (a mobile platform similar to their San Marco) and the Australians (at Darwin) — the ministers decided to reconvene in June.

In anticipation of this meeting, on 3 June 1966, the UK government submitted yet another aide mémoire to its partners in ELDO. It asserted that 'taking into account the technical merits, financial implications and probable uses of the end-product', the proposals to develop an ELDO PAS rocket did not 'constitute a sufficient basis for continuing United Kingdom participation in ELDO'. The UK, the statement went on, would therefore not participate in the development of the perigee/apogee system, nor continue to contribute to the Initial Programme beyond its existing commitments.

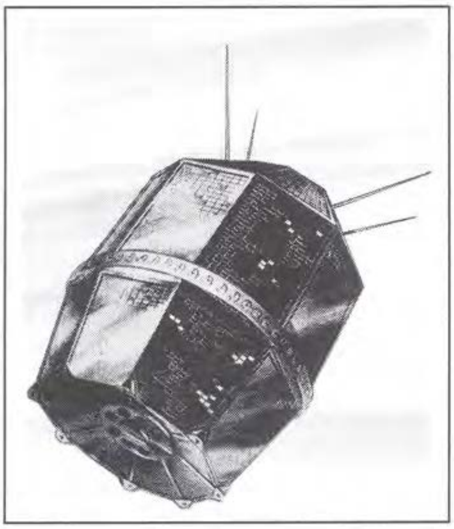
The second session of the ELDO ministerial conference convened a week later, on 9 June. The climate was tense, several delegations openly expressing their hostility to Britain's seemingly unilateral threat to withdraw. The British delegation, embarassed and embattled, retreated. They let it be known that they would be prepared to contribute to the extension of ELDO's programme after all, but on condition that their financial contribution, which stood at 38.79%, be reduced. This concession was readily accepted. The ministers decided provisionally on a new scale of contributions and met again on 7 and 8 July to formalise their positions.

What was behind the UK's threat and why did their delegation 'yield' so readily ? Britain's position reflected a major re-orientation of her research and development philosophy then being implemented by Harold Wilson's newly elected Labour government. More specifically it was indicative of a policy much in favour in Wedgwood Benn's increasingly powerful Ministry of Technology to disengage from high-cost, high-prestige projects with poor commercial prospects, particularly those with military overtones, and to buy in the advanced technology from the United States wherever possible. The money thus saved would be redirected into other sectors of science which had been relatively starved at the expense of the nuclear and space efforts, and into 'social' projects. Added to this, one cannot but note that the UK's technical contribution to the Initial Programme was effectively over. Indeed the UK's second aide mémoire was circulated less than ten days after the first and highly successful firing of the complete Europa 1 configuration with a live first stage and dummy upper stages and satellite test vehicle. Blue Streak had functioned perfectly four times out of four. As one delegate put it rather angrily, the UK had not only 'been able to try out completely' their rocket; they had also 'received more work than their own contributions'. Doubtless then, some people in the UK wondered why they should remain involved in an organisation that was a commercial disaster when the UK was going to get so little out of it in the future.



Blue Streak (Europa 1's first stage) propulsion and pressurising systems

Part of the answer to that, and indeed one reason for the volte face of the British government in June, was Wilson's growing conviction that the time was ripe to try again to lead the country into the Common Market. Hoping not to jeopardise



Artist's impression of the Italian Satellite Test Vehicle (STV)

an eventual initiative. in its aide mémoire of 3 June the government was at pains to stress that its position on ELDO did not imply any weakening in its willingness 'to engage in fruitful collaborative projects', nor 'any general criticism of other existing and projected examples of European collaboration in advanced technological fields'. The UK's partners in ELDO did not agree. The Dutch delegate was particularly blunt. Not only did the UK attitude 'spell bad luck for all other technological and scientific cooperative efforts', it had also been a 'matter of grave concern and bitter disappointment' to his government, which had always championed the inclusion of Britain in European collaborative ventures. In the face of this mounting emotional and political pressure, the UK chose to back down over ELDO rather than to lose the support of some of its staunchest allies in its application for EEC membership.

* * *

Having overcome for the moment the 'British crisis', the ministers reconvened for two days on 7 and 8 July. A number of important decisions were taken at this meeting. They were intended to coordinate European space activities through establishing the European Space Conference, to ensure the continuation of ELDO's programmes, and to tighten up its organisation and the benefits to be expected from it by the member states. The ministers agreed to confirm the implementation of the Initial Programme up to the qualification of ELDO A (Europa 1). They also decided to start a Supplementary Programme consisting of the upgrading of ELDO A by the addition of inertial guidance, the development of ELDO PAS (Europa 2), and the realisation of the equatorial base in Kourou. For this they committed themselves to spending another 331 MAU on ELDO, bringing their total expenditure since its inception to 626 MAU, i.e. more than three times the figure adopted in 1961. This, as we shall see, became an unbreakable ceiling on ELDO's expenditure. imposing tight constraints on the organisation's planning from then on.

The scale of contributions was revised. As from 1 January 1967 the UK's share would drop to 27%, most of the difference being absorbed by Germany (increased from 22% to 27%), Belgium and the Netherlands (increased from 5.5% to 9%) and Italy (up from 9.78% to 12%).

A distribution of work was also agreed in July. Britain would have prime responsibility for the inertial guidance system. France was granted the equatorial base needed for the operational phase of the PAS programme. though only after she had accepted that ELDO's contribution to its costs would be fixed at 25 MAU — just the estimated cost of the range offered by Australia at Darwin. Italy made its participation in the PAS programme conditional on having prime responsibility for the apogee motor and the test satellite into which it would be integrated. New rules for geographical return were also proposed and finally adopted the following year. They required that all member states received a minimum return of at least 80% over the entire programme, and of at least 50% of their contribution to the Supplementary Programme.

Finally, proposals to improve structural weaknesses in ELDO's managament and financial control were also implemented over the following months. The Secretariat was given more authority to place contracts directly in the member states and measures were taken to ensure more efficient management and the avoidance of further slippages. A separate directorate was set up for each of the Europa 1 and Europa 2 programmes.

In addition, and with some difficulty, an 'Industrial Integrating Group' was established. It was called the SETIS (Société pour l'Etude et l'Intégration de Systémes Spatiaux), and its shareholders were the main European aerospace contractors for ELDO. By the end of 1967, about 50 engineers from almost a dozen European firms were assisting the Secretariat in its technical planning, coordination and supervision of the development work being carried out in the member states.

1968–69. Brought back from the brink: the interest in Europa 3

The agreement reached by ELDO member state governments in July 1966 gave new impetus to European collaboration in space. As we discussed in the previous chapter, the European Space Conference met for the first time at the end of the year and ESRO started studying the communications satellite programme on behalf of CETS. The deliberations at the second ESC meeting in July 1967 and the proposals made in the Causse report at the end of that year gave further encouragement to those member states that wanted to develop a European launcher. Causse stressed that an application satellite programme did not make sense unless Europe had its own launch capability and identified the precise mission for a future ELDO rocket: to place a 2-ton satellite for direct TV broadcasting into geostationary orbit by the late 1970s.

As we have said, this goal was to be achieved in stages via two new rockets. Europa 3 and 4. Both would use Blue Streak as their first stage. This proposal had the obvious advantage that it was based on existing, highly successful technology. It was thus the least expensive option, and would lead to a launcher with the minimum risk and delay. On the other hand, while it might have been technically and economically desirable, it required the political commitment by the UK, if not to continue as a member of ELDO, then at least to guarantee a continuous supply of the rocket.

Even as the Causse report was being drafted, the ELDO programme suffered a number of setbacks that could not but undermine the vision of a coherent European programme articulated around a launcher, and widen the rift between Britain and her partners. In August and then in December 1967, the Europa rocket was launched for the first time with a live second stage, the French-built Coralie (firings F6/1 and F6/2). Blue Streak worked faultlessly on both occasions. But Coralie's motors failed to ignite in trial F6/1 due to difficulties with the electronic circuitry, while in the second trial the two stages did not separate from one another and the motors of the second stage again failed. At the same time, it was estimated that the cost-to-completion on the Europa 1 and Europa 2 programmes would far exceed the 626 MAU ceiling imposed by the ministers in 1966. This overspend, aggravated by the rocket's disappointing performance, triggered a grave crisis in ELDO in 1968.

When the original new ceiling had been agreed in 1966, the ministers had also taken a number of measures intended to manage any possible overspend. This procedure was set in motion by the ELDO Council in February 1968. A working group was set up to explore and to justify a new plan for ELDO. Its proposals, however, were overshadowed by the British announcement in April that they were not prepared to accept any further financial commitments to ELDO. In an attempt to appease them, the Secretariat drafted an Austerity Plan, also known as 'T8/A'. It fixed the ceiling at about 675 MAU (615 MAU plus some 60 MAU for reserves). This was done by cutting back the number of planned firings (and so increasing the technical risk) and, more fundamentally, by reducing the technical objectives of the PAS test satellite to 'the minimum necessary for the full qualification of the launcher system (propulsion and guidance)'. More specifically, plan T/8A eliminated those aspects of the spacecraft that were normally 'the responsibility of the customer', including precise geostationary positioning and the inclusion of ESRO and Italian passenger experiments. The Italians, who had only accepted to finance the overspend in 1966 on condition that they were allocated work which was 'representative' of a telecommunications satellite, found this totally unacceptable. Paralysed, the ELDO Council referred the matter to an ELDO ministerial meeting, the first session of which was held on 11 and 12 July 1968.

It is difficult to capture in a few words the menacing atmosphere that prevailed at this meeting. After two days of debate a resolution was passed which accepted only that ELDO continue on the basis of plan T8/A for a couple months until the ministers reconvened. Every major clause was subject to different reservations by different delegations. The chairman of the conference, the Belgian Minister of Scientific Policy, Th. Lefèvre, was asked to visit his counterparts in the member states with a view to finding a compromise. He could not. Indeed, when the ministers met again on 1 and 2 October 1968, Lefvère admitted that there seemed to be 'no solution [to the crisis] within the framework of the present ELDO programme [...]'. The Italian delegation felt that the situation had detoriated so badly that the enlarged European Space Conference, scheduled for November in Bad Godesberg, should be postponed.

At the core of the dispute were again the differing positions of the French and the British. The former were convinced that Europe should have a heavy launcher, and had developed a national space programme without that capacity on this assumption. They wanted guarantees from the British delegation that, come what may, they would be willing to make Blue Streak available as the first stage of the family of launchers proposed in the Causse report. The French were also insistent that all member states, including the UK, should contribute to plan T8/A. They particularly resented the idea of spending money on a supplementary programme the principal beneficiary of which, the British, had refused to contribute beyond a total of 626 MAU.

The British, for their part, insisted again that there was no need for Europe to have an independent launch capability. The Europa programme was beset by technical difficulties, time delays and cost overruns, and when completed the rockets would be far more expensive than a comparable launch vehicle purchased from the USA. They were not convinced either of the need for telecommunications satellites, they 'would not contemplate participating in the additional cost of the [ELDO] programme', and they were only prepared to guarantee the continued delivery of Blue Streak 'for a limited number of years'. This last stipulation obviously threatened to sabotage completely any long-term programme based on the UK's rocket as the first stage.

Finally Italy categorically refused plan T8/A, which was acceptable in one form or the other to all of her partners bar Britain. The plan had been stripped of that technical content which was particularly important to the Italian government. It also gave them a return coefficient of 79% instead of the 80% agreed on in 1966. Italy was so emphatic about this that at one stage in the negotaitions, and to the 'astonishment' of the French, the Italian delegation actually threatened to go back on their commitment to fund ELDO up to 626 MAU unless their demands were met.

There was no way that the ministers could break the deadlock in October; indeed the gulf between the parties seemed to be growing wider. They thus set up another committee, this one chaired by J. Spaey (Belgium), with the task of trying to 'elaborate the broad outline of a European space programme' which could command widespread support. Spaey was to report to the third session of the ELDO ministerial conference, scheduled for 11 November 1968 in Bonn. The European Space Conference would open the next day.

Spaey's goal was clear. It was to find a compromise which enabled the UK to remain a member of ELDO without participating financially in the development of launchers. This compromise was also intended to meet the requirements of those members of the ESC who, while wanting to participate in a broadly-based collaborative European space effort, shared the UK's misgivings about its goals. Spaey's suggestion, inspired by a Dutch proposal, was that a single European space organisation be set up out of ESRO and ELDO, with a basic programme that would include scientific and application satellites, and launchers. Within such a basic programme only a minimum programme, which excluded launchers, would be mandatory for all member states. Any member state would thus have to 'adhere' to the basic programme, and to participate 'effectively' (i.e. financially) in the minimum programme.

What did this mean in real terms? 'Adherence' to the basic programme meant being willing to give priority to the use of European launchers for scientific and application satellites if they could be supplied on 'reasonable' terms. 'Reasonable', it was suggested, could be taken to mean a price that did not exceed by more than 50% the price at which non-European launchers could be purchased on the basis of a 'genuine, durable and commercial supply', i.e. free of restrictions on the use of the launcher . As for the content of the minimum programme, it was proposed that, for the period 1969 to 1976, it would comprise the development, through several phases, of a satellite capable of beaming television programmes to individual receivers. Other applications (meteorology, navigation, etc.) would not form part of the minimum programme, 'but could give rise to additional projects'.

The science programme, for its part, while an essential element in the minimum programme, and costing about as much as the applications programme, would be subservient to the latter in the sense that the spacecraft technology developed for scientific research was to be transferable to the telecommunications satellite (an example of this was the geostationary scientific satellite GEOS then under study). To facilitate these activities the report stressed the need for setting up interstate industrial consortia capable of guaranteeing the efficient execution of programmes. It also identified some of the conditions necessary (voting rules, withdrawal procedures, etc.) for ensuring commitment to programmes which 'would end with the achievement of precise objectives and no longer simply by the expiration of a time limit or the using up of a sum of money', as had been the case in the past.

As the Spaey committee was trying to find a compromise on the launcher question agreeable to all ELDO member states, the organisation staggered into yet another financial and political crisis. In October the ELDO Council, concerned now that even target plan T8/A could not be completed within the 626 MAU ceiling, invited its Scientific and Technical Committee to explore alternatives. Three main plans were put forward. One, the so-called German plan, cut from T8/A the qualification of the apogee motor and the demonstration of Europa 2's ability to inject a representative payload into geostationary orbit from the Guiana base. The second, the so-called 'French plan', was even more drastic: it limited ELDO's programme to the qualification of Europa 1 from Woomera. Finally, there was the Italian plan. The Italians, who were already opposed to the cuts in T8/A, were not prepared to accept further austerity measures. They suggested a scheme that preserved the apogee motor and ESRO's passenger experiments. To finance the cost overspend above 626 MAU, Italy proposed that each member state should bear the extra costs in its industries which could be attributed to technical causes, so keeping the PAS in being.

The only Europa 2 firing from Kourou, French Guiana

The ELDO Council rejected the Italian proposal. It was, it said, contrary to the decision already taken by ministers in 1966 to grant the ELDO Secretariat more technical and financial control over the programme. At the same time it could not decide between the German and French plans, and invited the Ministers meeting in Bonn on the eve of the European Space Conference to make a choice. Here France, Germany and the Netherlands all agreed that it was necessary to complete the Europa 2 programme even without the PAS test satellite (i.e. France was inclined to accept the German austerity plan rather than its own more drastic alternative). The Italian Minister, by contrast, stated his 'formal and decisive rejection of the austerity formulas [...]' proposed by France and Germany. All the same he insisted that Italy was 'unreservedly interested politically, scientifically and industrially, in the development of both scientific and application satellites' and – here was the basis for a comromise – was willing for its industry to be compensated for the cancellation of the PAS satellite by doing work of similar technological importance on Symphonie.

Talks on this subject had, in fact, been going on for some time between the Italian and the French and German authorities. So far, the Italian minister stated in Bonn, they had 'not produced any concrete results whatsoever.' To appease him, in a late night session on the eve of the European Space Conference, the French and German ministers offered Italian industry the development of Symphonie's apogee motor. Italy was not satisfied. After all, said the minister, Italy was seeking compensation for the cancellation of the entire PAS system, not just a part of it. Italy, he concluded, would accept the Franco–German offer but only on condition that it was coupled with a reduction in her contributions to ELDO.

The European Space Conference met in Bad Godesberg in this tense atmosphere from 12 to 14 November (see also previous chapter). The compromise worked out by the Spaey committee — the distinction between a basic programme which included launchers and a minimum programme which did not (but which was otherwise still be defined) — was generally well received. Indeed it laid the groundwork for a resolution in which a majority of the delegates committed themselves to using European launchers for scientific and application satellites. There were two conditions attached to this resolution, however. Firstly, the ESC's non-launcher countries were only prepared to pay an excess of 25% over the costs of other launchers available on the market. Secondly, and more importantly, the British minister only accepted it on condition that the UK was 'released from its existing financial commitments to ELDO', transferring the money thus saved from launchers to applications satellites.

As the year drew to a close, ELDO's prospects grew even bleaker. After four false starts, the F7 firing of Europa 1, the first with all three stages live, took place on 29 November 1968. Blue Streak functioned perfectly again, as did Coralie this time. However, the German third stage, Astris, failed to function correctly and the rocket did not inject its test satellite into orbit as had been hoped. A few weeks later, the UK government, taking its position in Bonn a step further, informed its partners in ELDO that it regarded the new austerity plan put forward by Germany (and now labelled target plan T9) to be a 'further programme' within the meaning of Article 4(3) of the ELDO Convention. This allowed Britain to declare herself 'not interested' in the plan and so not obliged to contribute financially to it.

The Europa 3 concept — its first stage later became the Ariane first stage

The ELDO Council met on 19 and 20 December to vote the 1969 budget. This proved impossible. The UK made its agreement conditional on having its outstanding contribution to ELDO reduced to £ 10 million (24 MAU) for the years 1969, 1970 and 1971 (this was later increased to £ 11 million). The balance of the amount Britain would otherwise have contributed to ELDO — £ 7 million — would be put towards application programmes, long-term technological research programmes, and for the production of Blue Streak. Italy alone among the countries represented supported Britain's interpretation of plan T9, and also declared itself not interested, and so not willing to vote the 1969 budget. Italy also formally rejected as inadequate the offer to have the prime contractorship of the apogee motor in the Symphonie programme. These new developments 'put the organisation back in the situation in which it had been half way through 1968' (Germany). Frustrated and angry, the delegates agreed that yet another ministerial meeting would be needed to break the deadlock.

The problems were finally resolved at the ELDO ministerial meeting on 15 April 1969. Here France and Germany and Belgium and the Netherlands committed themselves to completing the Europa 1 and Europa 2 programmes on the basis of target plan T9 up to a ceiling of 626 MAU. They also agreed to share the shortfall in the British and Italian contributions (about 15 MAU and 10 MAU, respectively) between themselves. This left them paying together almost 61% of the ELDO budget. Britain's overall share amounted to 30% and Italy's was reduced to a little over 9%. With this agreement reached, ELDO's budget for 1969 was unblocked. Italy also accepted to release its contributions to the 1967 and 1968 budgets (totalling over 50 MAU), which it had refused to pay pending a satisfactory settlement of its claims. To give 'concrete proof' of its wish for ongoing collaboration with its European partners, it also indicated that it would be prepared to participate in the studies and experimental work on future programmes at the rate of 12% of the 1969 budget on condition that this brought it a measure of 'technological prestige'. Finally the conference authorised ELDO to study the conditions for producing not only prototype rockets, but ready-to-use Europa launchers to be purchased by potential users. This production programme, which involved a commitment by the UK to continue producing Blue Streak, was much sought after by France and Germany, who wanted to use two Europa rockets for launching Symphonie.

The reference in April to the need for future programmes is significant. For at this meeting all the ELDO member states apart from Britain also resolved to begin studies, within the framework of ELDO, of a new launcher. Labelled Europa 3, it was to be capable of placing 400 to 700 kg into geostationary orbit. At the same time, the ministers agreed to establish a new office within the ELDO Secretariat called the Directorate of Future Activities. Its director would have the rank of Deputy Secretary General, its funding would be separate from that of the rest of ELDO, and its task would be 'to set up new structures for the study and production of launchers' and to define a new launcher programme. In short, in April 1969 the political, economic and technical foundations were being laid for a new European heavy launcher initiative.

Concluding remark: The new determination to build a European rocket

The compromises reached, and new directions taken, in April 1969, were indicative of a major change in thinking about how to develop a European rocket. This change had been maturing for at least six months: there is clear evidence of it in the Spaey report. Essentially it amounted to a decision by Belgium, France, Germany and the Netherlands to press ahead with the development of a heavy launcher without Britain. This change demanded a refocussing of policies at several levels. Firstly, it amounted to decoupling technological collaboration from broader European political cooperation, and UK membership of the Common Market in particular. Until 1967 these two had been closely linked, in the minds both of the UK government and of its continental partners. The summary dismissal by De Gaulle in August that year of UK Prime Minister Wilson's application to join the European Community effectively killed all hopes of an imminent British entry, and probably played an important role in shaping Britain's negative position inside ELDO during 1968.

The new launcher policy also amounted to accepting that the differences in priorities between the partners in ELDO (and the ESC) was so great that one could not hope to have them all participate fully in a European space programme covering not only scientific and application satellites, but also launchers. The institutional implications of this had been recognised in the Causse report and in the distinction drawn in the Spaey report between the basic and minimum programmes. They were further reinforced in a report prepared for the ESC meeting in Bad Godesberg by the Dutch science administrator J. H. Bannier. Here it was stressed that a collaborative European space effort was only feasible within the framework of an à la carte system in which each country could decide on a case by case basis those projects in which it wanted to participate. The launcher countries, it should be said, were not that happy about this. They were developing a rocket, the Belgian delegate noted, to ensure that Europe could launch commercially competitive satellites when it chose, and to strengthen its bargaining position with the USA. Those who did not contribute were guaranteed the benefits of the policy without bearing its costs.

The decision to begin studies of Europa 3 was indicative of a determination by France in particular to develop a heavy launcher which did not depend on Blue Streak. The assumption that the highly successful British rocket would remain the first stage of successive generations of European rockets had permeated the Causse report. It was dropped by the Spaey committee. The Wilson government's unambiguous determination to withdraw from rocket development — itself part of a broader policy to redirect R&D funding in the country away from military and prestige-inspired projects — meant that it was now precarious for those who wanted to develop a launcher to rely on the UK for a key component. What is more, and even under intense pressure from the French, the UK Minister in Bad Godesberg would do no more than guarantee the supply of Blue Streak and its components 'at least up to 1976.' It was precisely to cover the needs after

The Europa 2 and Europa 3 launchers

In July 1966, the majority of the Ministers of the ELDO Member States agreed to a supplementary programme intended to add the capability of placing useful payloads in geostationary orbit. This included the establishment of an operational equatorial launching base at Kourou in French Guiana, some improvements to Europa 1 and the development of the PAS (Perigee Apogee System). The resulting rocket was called Europa 2. The first and second stages of this rocket were essentially as in Europa 1; its third stage differed by the addition of an inertial guidance system. These three stages were used to put the PAS system into a circular 'parking orbit' some 300 km above the Earth. Thereafter, two further motors were added to the Europa 1 configuration. There was a solid-propellant fourth stage (the perigee motor), which was fired as the PAS system crossed the equator, placing it into an elliptical transfer orbit with an apogee of 36 000 km. Shortly thereafter, the solid-propellant apogee motor, built into the satellite on top of the launcher, was fired as the satellite passed through apogee, transferring the payload of some 170 kg into a geostationary orbit.

By the late 1960s, some member states felt that Europa 2 was still not powerful enough for Europe's telecommunications needs: a heavy launcher capable of placing 400–700 kg into geostationary orbit was required. In April 1969 and November 1970, four of them – Belgium, France, Germany and the Netherlands – agreed to fund studies of a new rocket labelled Europa 3. Europa 3 was a two-stage rocket. The first comprised four motors each having a useful thrust of 60 tons and powered by nitrogen peroxide (N_2O_4) and unsymmetric dimethyl-hydrazine (UDMH). The second stage was cryogenic, with one motor which had a useful thrust of 20 tons. It was powered by 20 tons of liquid hydrogen and oxygen.

Europa 2 was test-fired for the first time on 5 November 1971. The rocket exploded in flight after 150 seconds. The planned second test firing never took place. Europa 3 as such was never built, but was a first step towards the development of Ariane.

that time that an alternative 'filiation' was proposed in the Spaey report. This was based on replacing Blue Streak by a new rocket known as L95 while keeping the Coralie, Astris and the PAS stages of Europa 2 unchanged. L95, the design of which was being studied in France, would comprise a single 3 m diameter tank (to be built by the French firm Nord Aviation) holding 95 tons of liquid propellant and equipped with four motors each giving 40 tons of thrust. With suitable modifications this rocket could be used to place first 400 kg and then 700 kg in geostationary orbit. It was of course precisely this alternative filiation that the member states wanted ELDO's new and powerful Directorate of Future Activities to study when they set it up in April 1969.

The resolution they passed on that occasion put the name of the future rocket, 'Europa 3', in quotation marks. It was a sign that plans for developing a new and quite different generation of European launchers were in the making.

One last remark. The determination in France and Germany to proceed with the development of a heavy launcher early in 1969 was undoubtedly influenced by their growing conviction that the United States would not in fact launch Symphonie. Indeed, on 11 October 1968 the directors of the Franco-German project wrote to NASA asking if it would be willing to provide launch vehicles and services for two such satellites. The request claimed that they were to be used for experimental purposes only; other sources led NASA Administrator Thomas Paine to believe that the Europeans had commercial objectives as well. The reply, sent three weeks later, reflected these concerns. NASA would be willing to launch the two Symphonie spacecraft 'if we could arrive at a mutual understanding of the experimental character of the project,' meaning satellites 'used exclusively for experimental and demonstration purposes, not for the transmission of regular commercial or governmental traffic or broadcasts.'

This was doubtless enough to convince France and Germany that Europe had to develop its own launcher if it was not to be held hostage to USA interests — even if that meant developing an entirely new rocket wthout British help.

Chapter 7 — US-European collaboration: The post-Apollo programme

As we have stressed in the previous two chapters, the determination of European governments to develop telecommunications satellites gave a new impetus to the European space effort and, at least for some of them, provided the dominant rationale for developing an autonomous European launch capability. This rationale was independent of the delays and difficulties experienced in getting a collaborative European applications programme off the ground. The need to orbit Symphonie was, at least for France and Germany, justification enough, and goes a long way to explaining the positions they adopted in ELDO. That said, it is important to realise that in the Causse report, for example, it was stressed that European autonomy was desirable not simply to create a niche alongside the USA, but also to collaborate better with the United States. Certainly it was intended to strengthen Europe's bargaining position in the renegotiation of the Intelsat agreements scheduled for 1969, and to give Europe greater control over the launch of her commercially competitive satellites.

But Causse was also at pains to point out that by strengthening its space industry Europe could reap greater technological benefits in cooperative ventures with the USA. Europe sought independence, the report stated, not to pursue an 'illusory competition' with the superpowers, but precisely so as to 'practise the closest collaboration' with them.

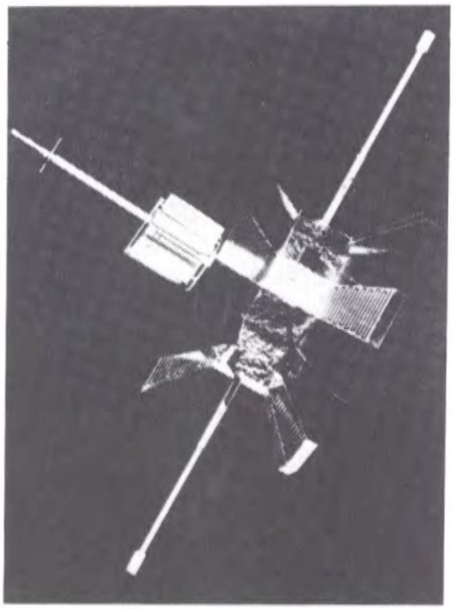
The Americans, for their part, were not unsympathetic to Europe's needs. The launch of Sputnik in October 1957 had reshaped their thinking about the United States' national security and the role of its western allies in the global balance of power. It was not simply that the satellite opened up an entire new world for scientific exploration and commercial and military exploitation. The fact that it had been placed in orbit at all showed that the Soviet Union had developed the skills, the technology and the infrastructure needed to produce intercontinental ballistic missiles. Domestic reforms in the USA, which included setting up NASA, were coupled with a renewed political determination to strengthen US–European relationships.

Science and technology were not forgotten. The Eisenhower Administration took a number of steps towards removing previous restrictions (e.g. liberalisation of the MacMahon act, the Atoms-for-Peace programme). Also, as we have said, in March 1959, well before the plans for a joint European space effort had even matured, the US offered to support and collaborate on a bilateral basis with European space scientists who wanted to fly experiments on US satellites.

The United States' offer was coherent with Eisenhower's determination to build an image of his country's space effort as open, unclassified, and visibly peaceful. The tradition of free exchange in science, and the relative remoteness of the results of most basic research from practical applications, made it an ideal vehicle for these purposes. Indeed, there were ongoing and, by and large, very positive relations between NASA and ESRO during the 1960s, as well as important bilateral scientific arrangements between the USA and several European countries. Technological collaboration, by contrast, was far more problematic, not only for the United States, but for any major nation. As a NASA document put it rather bluntly in 1965, 'the technological balance of power [was] increasingly the major concern of the leaders of both weak and strong nations'. By sharing technical and managerial knowhow, a nation risked losing its advantages in the technological cold war, and damaging its immediate commercial interests.

Unlike science, then, the path towards technological collaboration was strewn with difficulties in the 1960s, both within Europe itself and between Europe and the USA. The protection of national autonomy was never far below the surface of any negotiations over possible joint technological ventures.

Despite the dangers, in the mid-1960s the Johnson administration began to think about ways of extending collaboration with the Europeans to include meaningful



Helios – the result of a bilateral agreement between the USA and Germany

technological exchanges. Their first suggestion was that the USA and Europe should 'pool their resources in a major spacecraft project as an advanced technological exercise of considerable scientific merit'. This led eventually to a bilateral agreement with Germany to develop together two solar probes called 'Helios'. Going further, in 1969 NASA Administrator Thomas Paine offered Europe a stake in the agency's so-called post-Apollo programme which included, at least in its initial conception, the development of a space station and of the Shuttle. From one point of view this was a highly seductive offer. True partnership in a venture of this kind and complexity offered Europe access to American advanced technology, industrial experience and management skills.

On the other hand, it posed a distinct threat to the European launcher. It was not simply that governments felt that they could not afford both the Europa programme and a major financial contribution to post-Apollo. The Shuttle itself, a reusable space transportation system, was heralded as opening a new era which would render expendable launchers such as Europa uneconomic. On both counts, therefore, Europe had to weigh the putative benefits in terms of technological sharing against the risk of losing an autonomous launch capability.

In this chapter we will describe the complex negotiations surrounding this offer. They were marked by uncertainty on both sides of the Atlantic over the content of any joint venture. European demands for meaningful partnership, essential in their eyes if they were to sacrifice their launcher, were matched by an increasing reluctance on the part of the United States to share technology; itself a reflection of a re-orientation of priorities under the Nixon administration. In the end the two parties agreed that Germany should take prime responsibility for building a scientific laboratory called 'Spacelab', which could fit into the Shuttle's payload bay. It was a project not without interest but, as far as technological sharing was concerned, it was a far cry from what the Europeans had hoped for when the negotiations got under way in 1969.

A Spacelab module being prepared for acoustic tests at IABG, Munich

The post-Apollo offer and its context

The willingness of the United States to go beyond mere technical assistance and support to actual technological sharing can be traced back to her sensitivity to the criticism that she aspired to technological domination of the Old Continent. These charges reflected the growing concern in Europe about the 'technological gap' that had opened up between the two sides of the Atlantic. In a much acclaimed book by Jean-Jacques Servan-Schreiber, *Le défi americain*, published in 1967, the French journalist berated what he saw as the United States' technological and financial imperialism and blamed European governments for their inability to extricate themselves from a subordinate relationship with their major ally.

Now that the cold war had passed its hottest phase, and Europe had definitely recovered from the damage wrought by World War II, the time was ripe to meet the 'American challenge' through economic competition, scientific and technical achievements, commercial success and cultural influence.

It was partly to assuage such fears that the Johnson administration singled out space, described by Servan-Schreiber as the 'greatest industrial adventure of our time', as an ideal sector in which to launch substantive collaborative ventures. It included a high technology, state-subsidised civilian programme which could offer much to the fledgling European organisations with which NASA had had close ties from the start. Following on the joint satellite projects, in 1966 the National Security Council recommended that collaboration should be extended to the field of launchers. In August that year, the State Department informed the member states of ESRO and ELDO that it favoured the development of an independent European launch capability and that it would do what it could to support it.

To illustrate, it proposed that NASA could put its test facilities at ELDO's disposal, could welcome ELDO staff in its technical management training seminars, could enable the procurement of crucial items of flight hardware in the USA, and could assist in the long-range development of high-energy cryogenic rocket stages.

European governments were not yet ready to react to these initiatives in 1966. However, with the European Space Conference set up and the Causse report available, they began to define what they wanted from the USA. In June 1968, it was decided that a high-level mission should be sent to the USA. Its brief was to explore the possibilities of closer cooperation, particularly in the field of launchers. This did not simply concern the terms under which the United States would supply launchers to Europe, notably for its telecommunications satellites. Going further, and encouraged by a State Department official to make concrete proposals, the Europeans suggested the 'joint development' of launcher systems with 'major tasks' divided between the two continents, and 'joint supporting programmes' on advanced propulsion techniques.

In the opening round of discussions in July 1968 it was the first issue – the terms under which the USA would supply launchers – that tended to dominate the proceedings. As we saw in the previous chapter, ELDO was staggering from one crisis to the next at the time. At the heart of the dispute was whether Europe needed to develop its own launcher at all, an issue that was intimately tied up, at least for some, with the question of whether the USA would supply launchers with no strings attached for application satellites. Paine's reply to the request to launch Symphonie, made in October that year – that there was no problem if it was to be used only for experimental purposes – undoubtedly added weight to the arguments of those who felt that the United States could not be trusted. And in April 1969 France, Germany, Belgium and the Netherlands agreed that ELDO should study the Europa 3 rocket.

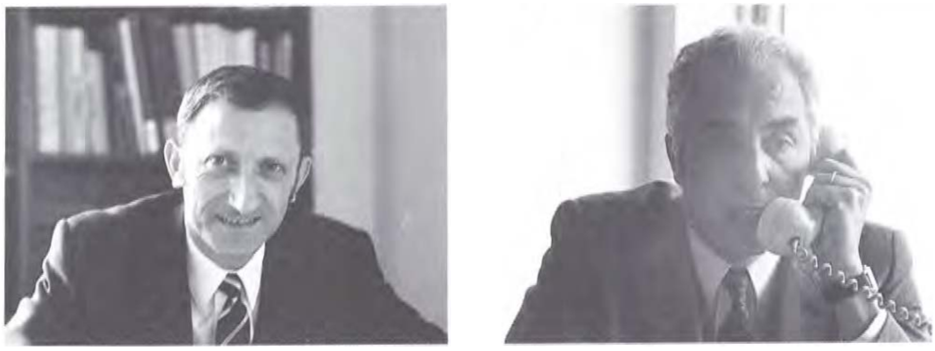
From the sources we have, it is difficult to assess the significance of this new determination in Europe on USA thinking. We do know that in August that same year, and a month after Americans landed on the Moon, Paine wrote to the newly elected President Nixon proposing that there should be a qualitative leap in US–European space cooperation. Europe, he suggested to Nixon, should be encouraged to abandon its 'trouble-plagued and obsolescent vehicle programme' and rely on US launchers. This would both free European resources for 'more constructive cooperative purposes,' and reinforce the United States' leadership in Western Europe, which had been badly battered by criticisms over involvement in Vietnam.

The substance of what the Americans had in mind for this 'post-Apollo' programme had just been defined in a report by the Space Task Group nominated by Nixon, comprising Paine himself, Vice President Agnew and Robert Seamans, Secretary of the Air Force. Nothing less than a revolution in technology was heralded, leading to a permanent presence in space of non-professional astronauts. Some of the major developments foreseen included the construction of a space station module, one of a number that would eventually be coupled together to form a space base, a reusable space transportation sytem (the Shuttle) to ferry people and material to and from the base, a space 'tug' to be used for transferring payloads from the Shuttle's orbit into higher orbits and a nuclear propulsion rocket stage (NERVA) to be used for interplanetary transportation.

In addition to allowing foreign astronauts to participate in NASA missions, the Task Group suggested that the USA should provide technical assistance to countries wishing to develop their own capabilities. In particular, it said that the administration should be willing to provide launch services and to 'share technology wherever possible', even involving 'foreign experts in the detailed definition of future United States space programmes and in conceptual and design studies required to achieve them'.

The first reactions in Europe

In October 1969 Paine presented the Task Group's report to a meeting of the ESC's Committee of Senior Officials and officially invited European governments to participate in the programme. Paine's offer made a considerable impact in Europe. It was the first time that the United States seemed willing to share important space technology with its partner, albeit under certain conditions. It also forced a reassessment of the value of Europe's own launcher, which Paine had called its 'trouble-plagued and obsolescent vehicle programme'. To explore its implications, a joint ESRO/ELDO working group chaired by J.A. Dinkespiler and J.-P. Causse was set up. It concluded, in the spring of 1970, that participation in post Apollo should not force any major reorientation in Europe's space programme. Cooperation, it suggested, would be valuable in sectors that were crucial for the system as a whole, so ensuring Europe a measure of control over the project, yet sufficiently independent for her to be able to take full management responsibility. Of interest too were subcontracts for a variety of elements that would enable the Europeans to have access to a wide range of new technologies. Such participation could be traded, it was suggested, for a 'guarantee that launchers would be supplied for peaceful missions corresponding to European objectives [...].' In any event, the working group did not feel that work should stop on Europe's own launcher. The Shuttle, they argued, would only be routinely available by the end of the 1980s. This would leave the Europa 3 launcher at least 8 to 10 years of active service.



J.A. Dinkespiler and J.-P. Causse – joint chairmen of the ESRO/ELDO working group to explore the implications of NASA's offer

In the light of this report, ELDO agreed to fund industrial studies of the tug, the propulsion techniques of which were thought to be of some use for Europa 3. ESRO, for its part, chose to study the scientific module to be attached to the space station. Eurospace began to interest industry in the post-Apollo programme and technical discussions and exchanges got under way between NASA and ESRO/ELDO. In July 1970, the fourth European Space Conference authorised its President, Theo Lefèvre, the Belgian Minister for Scientific Policy and Programming, to open negotiations on the terms of European participation in the post Apollo programme.

Lefèvre reported on his activities when the ministers reconvened in November 1970. Three main questions pertaining to the post-Apollo programme emerged at this meeting. Firstly, there was the issue of technology transfer, namely how much of their technical and managerial knowhow the Americans were willing to share with their European counterparts. Their expectations raised by the novelty of Paine's offer, the Europeans were determined to be partners in the venture, not customers. They wanted prime contractorship to ensure that their industries had a key role in the design and development of any project. The Italians even insisted that Europe try to secure participation at all levels of management and the right of access to all the technology in the programme, and not just that part of it financed by the Europeans.

The second issue discussed in November was that of launcher availability. Here Lefèvre reported that if Europe participated substantially in the post-Apollo programme, the United States would relax its conditions on the availability of launchers. Previous United States policy had been to treat each application to launch by a foreign government on a case-by-case basis, reserving the right to reject any request unilaterally. The new United States position, he said, started from the opposite point of view; NASA would launch any satellite provided it was for peaceful purposes and consistent with the USA's international obligations. In practice, this came down to a guarantee to launch, at commercial prices, scientific and specialised application satellites.

The stipulation regarding the USA's international obligations, however, meant that the United States would only launch European commercial telecommunications satellites 'in those cases where there was no negative finding' on the request made by the appropriate Intelsat organ. Even if the Intelsat Assembly voted in favour of a regional system, the US could impede implementation of its (non-binding) recommendation by virtue of its launch service monopoly. 'Put simply', concluded the ESC president, 'this means that the American assurances, as formulated, do not specify whether or not we can count on launchers for public service, conventional operational communication satellites, even if their operation is limited to the European zone'. This was a formal recognition that, the new policy notwithstanding, the United States would probably try to block the launching of satellites such as Symphonie or Eurafrica if they were intended for commercial purposes.

The third point discussed was the question of cost. Here the United States was suggesting that Europe may like to spend about $1 billion or 10% of the total estimated cost of Shuttle development, spread over 10 years. This was about double the estimated cost of the Europa 3 launcher ($550 million) and, as the studies were still at a very preliminary stage, the figure was likely to increase considerably.

Lefèvre's report opened the rift between Britain and France over launchers even wider. Certainly, for financial reasons, they were both lukewarm over committing themselves to the post Apollo programme at this stage. Britain, however, refused to see in this a reason for developing a European launcher. They were sure, the UK delegate said, that the USA would supply launches on an ad hoc, case-by-case basis even if Europe did not participate in the post-Apollo programme. France's position was diametrically opposite. France had said in July that it could not afford to contribute both to post-Apollo and to Europa 3. Before dropping the latter she would need a 'total guarantee of availability of existing and future American launchers'. This Lefèvre had not secured. It would therefore be imprudent for Europe to 'envisage giving up a necessary element of its own space programme on the grounds of an uncertain participation in a programme which [was] itself uncertain'.

In the light of these divergences, the November space conference broke up in disarray. Belgium, France and Germany were convinced that post-Apollo participation should be seen only as a possible supplement to a comprehensive European programme. They were mindful that the renegotiation of the Intelsat agreements, which had started in 1969, would soon draw to a close – in fact, as we mentioned earlier, the permanent agreements were opened for signature in August 1971 – and they were frustrated by the seemingly endless disputes over the launcher question, which they were sure could only damage Europe's international standing and weaken her bargaining position.

Much to the distress of many other delegates, they threw down the gauntlet and threatened to go ahead on their own. There was no point, they said, in trying to build a single organisation when the priorities of the potential partners were so different. Those who were interested in space but not in launchers could join their venture, though with associate membership status. As for post-Apollo collaboration, the meeting agreed to continue discussions with the United States, though the Scandinavians and Britain abstained from voting on the resolution.

The gathering momentum inside the United States against the project

While the Europeans threatened to disband, there were developments too on the United States' side. The great inhouse champion of the programme, Thomas Paine, resigned abruptly and left NASA in September 1970. Around the same time – and doubtless they had influenced Paine's decision – budgetary constraints moved the Shuttle to the centre of the post-Apollo programme. Instead of building the space station at once, it was proposed to pass through an intermediate phase, the so-called research and application module (RAM). This was intended to be a free-flying semi-permanent laboratory which could be placed in orbit by the shuttle itself. Along with these institutional and technical changes, new voices opposed to a joint venture with the Europeans began to be heard in the Nixon administration in 1971. The head of the newly created Office of Telecommunication Policy, Clay T. Whitehead, argued that NASA was trying, through a 10% European collaboration, to lock the President and Congress into its 'grand plans', and was prepared to give away 'space launchers, space operations and related knowhow at 10 cents on the dollar' to achieve its objectives.

The Shuttle returns from an early mission (photo courtesy of NASA)

Some administrators also felt that the United States' policy on launching telecommunications satellites was now too liberal, and a more restrictive interpretation was placed on the meaning of there being a 'negative finding' by Intelsat to a request to launch a telecommunications satellite. The Europeans were in some confusion over how best to participate in the revamped post-Apollo scheme. The Dinkespiler/Causse working group suggested the tug should be the 'essential nucleus of European participation'. Cooperation on other aspects of the programme should only be undertaken if Europe could afford them. Eurospace, on the other hand, was singularly unenthusiastic about the space tug since it seemed to have poor commercial prospects. They preferred, they said, to 'manufacture operational equipment in quantity and to be able to master the management and operation of the applications systems'.

With the Europeans vacillating, and attitudes inside parts of the US administration hardening, the State Department feared that the collaborative project was losing momentum. To regain the initiative, Under Secretary of State Alexis Johnson informed Lefèvre on 1 September 1971 that henceforth the question of launcher availability was independent of participation in the post-Apollo programme. A few months later, formal discussions on cooperation between experts from both sides of the Atlantic got under way.

The discussions immediately ran into difficulty. The Europeans were still demanding major participation in all aspects of the programme, from developing critical hardware elements, to sharing in key technologies, and maximum participation in management and decision making at all levels. What they found instead was that a new, more conservative configuration had been adopted for the Shuttle which was of little interest to them. In the view of the European experts, the only novel features left were the heat shielding and the propulsion system – and Europe was excluded from both.

The Americans for their part, were desperately trying to disentangle themselves from an engagement that looked increasingly unattractive to them. There were renewed concerns in the administration about the dangers of technological sharing, and NASA began to feel that it would far prefer to do the whole programme domestically. If there was to be cooperation it should be across 'clean interfaces', with each party developing and delivering discrete pieces of hardware embodying its own technology. And although the President officially endorsed the Shuttle in his State of the Union message in January 1972, Nixon seemed far more interested in fostering détente with the Soviet Union through an Apollo–Soyuz link-up than in strengthening space collaboration with his European allies. In fact, the only loud voice being heard in favour of continued collaboration was that of Alexis Johnson at the State Department. Johnson's argument was, however, weak – that to withdraw now would harm the United States' image abroad. What is more, he had little political weight – he was regarded with suspicion inside NASA on the grounds that he had 'sold out' Thor Delta technology to Japan when he was US Ambassador there in the late 1960s.

The scale of post-Apollo collaboration is further restricted

In June 1972 the Europeans were informed that the USA had decided to withdraw the Shuttle and the tug as candidates for a collaborative venture. The reason given by Herman Pollack, who directed the Bureau of International Scientific and Technological Affairs in the State Department, was European indecisiveness. Pollack went on to stress that Europe's further involvement in the post-Apollo programme was not of any commercial or technical importance to his government. Whatever Europe did – and the focus would now shift to cooperating in the use rather than in the development of the Shuttle – it could not hope for any substantial technological sharing. This was nothing less than a complete reversal of the policy advocated by Paine when the possibility of a joint project was first mooted by the United States in 1969.

While Europeans were not too disappointed about the withdrawal of the Shuttle – there was little left for them of technical interest, as we have seen – the removal of the tug was a bitter pill to swallow. Indeed, after the dramatic failure of the first (and actually the last) test launch of Europa 2 in November 1971, the future of ELDO was to some extent tied up in this venture and its cancellation was one factor leading to ELDO's demise, as we shall see later. The official reason given for the change of policy was that the United States was not sure how, when or indeed if the tug would be built. Other reasons given in the secondary literature suggest that the United States doubted that Europe's industry was up to building the tug, did not want to transfer sensitive technology across the Atlantic, feared housing the tug with its cryogenic propulsion system in the Shuttle's payload bay, and that the military wanted to take over complete control of the item anyway. With these restrictions now imposed by the major partner, all that was left for Europe was the so-called 'sortie module', or 'Spacelab' as it was later called This was a selfcontained scientific laboratory which could be carried aloft in the Shuttle's cargo bay and in which astronauts could perform a variety of experiments and observations. The sortie module was simpler than the RAMs, and was supposed to be ready in time for the first scheduled launch of the Shuttle (1978)

The Spacelab Intergration Hall, at ERNO in Germany

Germany was extremely interested in participating in this project and eventually it decided to take on prime contractorship for Spacelab. The terms on which it did so were entirely coherent with the policy that had evolved inside NASA with the departure of Paine. As David Lord, the NASA Spacelab project director, has put it, 'It was as if NASA had hired a development contractor, only in this case the contractor was in Europe and would use its own money'. 'Clean interfaces' were thus assured.

It would be easy, from a European perspective, to feel that the United States had played fast and loose with its most important western allies in the post-Apollo negotiations. Certainly, there was a huge gulf between the level of technological cooperation that Paine seemed to offer them in 1969, and that which they finally got in 1972. Certainly, various sections of the Nixon administration, as well as NASA and the President himself, were indifferent to European criticisms about the technological gap, were unwilling to share critical technology, and were far more interested in forging space links with the USSR. The technically interesting parts of the post Apollo programme in which Europe was invited to participate shrank accordingly, spurred on by fears that the Europeans had neither the industrial knowhow nor the political will to deliver key components for what was, after all, a highly risky programme to put people into space. At the same time, one cannot but be struck by the high, even unrealistic hopes entertained by the Europeans from the start, hopes that bore no relation to the technological balance of power between the two partners. It is striking too that Europe tended to stick rather inflexibly to its demands for a major involvement in the programme even when it was clear that the United States would never concede this. If it did so, it was partly because some European governments were determined that they would only collaborate with the USA if they could secure 'technological benefits commensurate with her efforts', to quote the Causse report

A major participation in post-Apollo would have seriously squeezed the funding for an autonomous European launcher, and might even have killed the project altogether, along with the political and cultural security which it embodied. From the beginning then, the Europeans were cautious, and unwilling to commit themselves to an expensive collaborative project unless there were important technical and managerial advantages in it for them. They upped the benefits they demanded in proportion to the costs they thought that collaboration would entail. Seen from this point of view, Spacelab was not without interest. Although very little technology transfer took place, it kept US–European collaboration intact, particularly for Germany, at relatively little cost ($150–250 million compared to the estimated $500 million for the tug). As we shall see in chapter 9, this made it possible for European governments to treat it as just one element of a package deal that they hammered out in 1973, a deal that included the development of the highly successful, expendable European launcher called 'Ariane'.

The Shuttle

Generally speaking, launchers are developed in families, i.e there is a progressive improvement in the power of the rocket and so in the useful payload that it can place in orbit, without the basic design of the launcher being changed. For example, the Delta, one of the most successful light launchers ever built, was developed in a range of successive models by employing additional and more powerful boosters with a basic architecture. Between 1960 and 1982 its useful payload was increased from 45 to 1312 kg (in transfer orbit). Similarly, Europe's highly successful civilian heavy launcher, Ariane, which had its first successful test flight on Christmas Eve 1979, has passed through four 'generations', and a fifth is soon to enter production. The useful payload (in transfer orbit) has increased from 1.75 tons for Ariane I to 6.8 tons for Ariane V.

The pattern of rocket development by accretion was dramatically changed in the United States in the post-Apollo period. To gain congressional support for a major new programme in a period of budgetry restraint, NASA proposed to build a re-usable launcher, the Space Shuttle. The Shuttle was announced as a revolution in space transportation systems which, by virtue of its re-usability, would dramatically reduce the cost per kilogramme of putting a useful payload into orbit. In the event, compromises on expendability had to be made in the final design. The Shuttle itself, which looks rather like an aeroplane, is attached to a gigantic fuel tank which is lost after launch, though the two solid-fuelled boosters that provide the necessary additional thrust at lift-off are then parachuted back into the ocean. Along with the development of the Shuttle, the United States began to phase out its expendable launchers. The production of the Delta series was almost stopped entirely, while the Saturn V made its last flight in 1973.

The decision not to continue producing heavy expendable launchers has since been heavily criticised in some circles in the United States. It was not simply that the cost of developing the Shuttle was far greater than originally estimated. The system also has the disadvantage that satellites (which are carried aloft in its cargo bay) always have to be accompanied by people, even when the presence of humans is not necessary. The Shuttle's problems were dramatically exposed by the Challenger disaster in January 1986, which led to further delays and cost escalations in the programme to improve security. All of these considerations have added enormously to the cost/kg and have left an important market niche for conventional, expendable heavy launchers. It is a niche that Europe's Ariane series of rockets has filled with great success.

Chapter 8 — Defining ESRO's new scientific programmes

By the end of 1968, having overcome the political and financial difficulties described in chapters 4 and 5, ESRO could look to the future with some optimism. Three satellites had been put in orbit and were functioning very well; an arrangement had finally been found for the TD-1 satellite; more authority had been transferred to the Executive following the recommendations of a group of experts chaired by J.H. Bannier; and the Bad Godesberg meeting of the European Space Conference had found a tentative way out of the controversial question of the role of Europe in the three domains of space — science, applications and launchers.

What was more important for ESRO, as we mentioned earlier, was that the Conference agreed to fund the scientific programme in the period 1969–1971 to the tune of 172 MAU, as requested. In a further act of confidence in the organisation's future, the Conference authorised the necessary commitments for individual projects that would extend beyond 1971, namely beyond the eight-year period covered by the ESRO Convention. In March 1969, the ESRO Council then approved the three satellite projects ESRO-IB, HEOS-A2 and ESRO-IV. The time was now ripe to choose new projects and to put long-term programming on a more efficient basis.

It was now clear that ESRO's budgetary constraints would not permit it to support all fields of space science in a viable way, as had been hoped for in the Blue Book. The time when any scientific group interested in space research could expect to get an experiment onto one of ESRO's satellites was definitely over, and hard choices had to be made in the framework of an established scientific policy. This chapter describes how this policy was defined and implemented between 1969 and 1973.

Physicists versus astronomers: the selection of Cos-B and Geos

From early 1966, the LPAC and its expert groups had been discussing ESRO's second-generation scientific programme. As it became evident that no large project in addition to the LAS could be funded, attention focussed on missions that could be realised with medium-sized satellites of the TD class. Several feasibility studies were performed in ESTEC in 1967, on the basis of proposals coming from the scientific community, but no decision could be taken before the Bad Godesberg conference.

When, in the spring of 1969, the LPAC resumed discussions on ESRO's future programme, eight projects were on the table. These were presented and evaluated at a symposium in Paris on 5–6 May. Two of them, named Cos-A and Cos-B were devoted to the field of high-energy astrophysics, i.e. the study of high-energy emissions (X- and gamma-rays) from celestial objects other than the Sun.

Cos-B: work in progress on the payload assembly

Cos-*B*

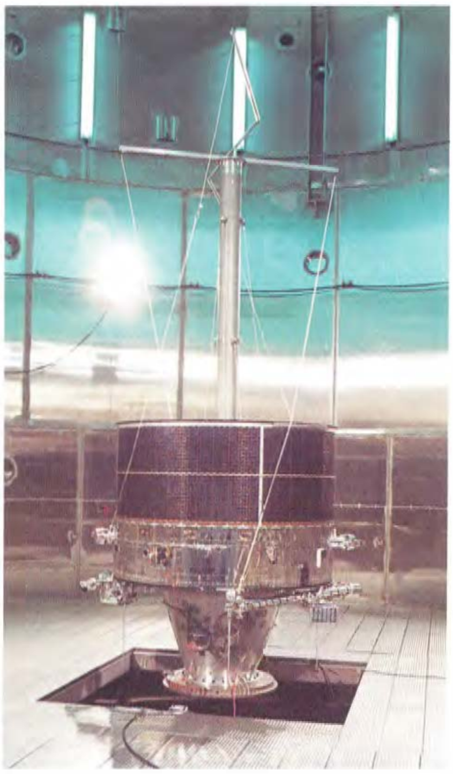
This new field of astrophysical research was essentially dominated by cosmic-ray physicists who had mastered the required detector techniques. Cos-A was designed as a circular orbiting satellite carrying two different instruments, one for detecting high-energy gamma rays and one for X-rays; Cos-B, on the contrary, was a highly eccentric orbiting satellite devoted purely to high-energy gamma-ray astronomy. The third project was called Geos, a geostationary satellite for studying physical phenomena in the magnetosphere and Sun–Earth relations.

Two other projects had been proposed by the astronomical community, i.e. two space telescopes devoted to ultraviolet (UV) astronomy. The first, called 'Wifas', was a wide-field instrument aimed at obtaining a sky-map of stars using low-resolution spectroscopy (1 Angstrom); the second, called 'Uvas', was simply a less ambitious version of the LAS, i.e. an instrument for high-resolution (0.1 Angstrom) spectroscopy of single stars.

Finally, the three other projects were a satellite for ionospheric research, a satellite for atmospheric research and a fly-by mission to the planet Mercury. All main fields of space research bar solar physics were thus represented at the Paris symposium.

In subsequent debates the expert groups reduced the number of projects to five. The COS group, in fact, recommended Cos-B over Cos-A; the STAR group recommended Uvas over against Wifas; and the ION group recommended Geos over the ionospheric satellite. All the chairmen of the expert groups (except for the SUN group), the president of the STC, and a large group of the ESRO Executive (including the Director General, the Director of ESTEC and the Director of Programmes and Planning) attended the crucial LPAC meeting in July 1969 called to propose the organisation's second-generation satellite programme.

The atmospheric satellite and the Mercury mission were rapidly discarded, the first because of the need for a further definition of its scientific objectives in the light of ESRO's eventual involvement in a meteorological satellite programme, the second essentially for financial reasons. The final choice was therefore between Cos-B, Geos and Uvas. A careful consideration of the available financial resources suggested that the alternatives were Cos-B and Geos, on the one hand, or Uvas on the other. All three projects were scientifically sound, technically well designed, and well supported by (different sectors) of the scientific community. The choice thus hinged on a question of scientific policy, i.e. whether to prefer physics or astronomy; whether to select one ambitious project on the borderline of ESRO's budget or two less challenging, properly timed satellites covering a wider range of disciplines; whether to explore a new research field or to search for new knowledge in a classical field; whether to give a chance to one or another scientific laboratory, and to one or another group of scientists.

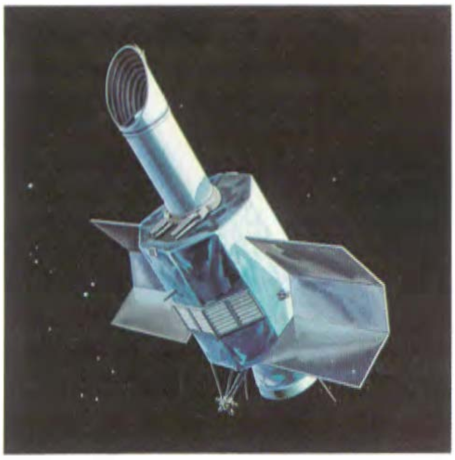


Geos: ready for boom deployment tests

In the event, the final decision was left to a restricted meeting of the LPAC members. They chose Cos-B and Geos. The LPAC recommendation had to be endorsed by the STC and then approved by the ESRO Council. The discussion at the STC meeting was impassioned and dramatic, involving scientific and financial consideratons as well as personal feelings and ambitions. The British delegation was particularly vociferous. The rejection of Uvas, a project in which the UK scientific community and British industry had invested so much, was another defeat for space astronomy and followed hard on the heels of the abolition of the LAS project.

Cos-B and Geos prevailed again, however, and two weeks later the Council finally approved (but not without some controversy) the inclusion of these two satellite projects in ESRO's scientific programme.

Before concluding this section, a few words about the further evolution of the Uvas project. The telescope designed for such a satellite was proposed by the UK Science Research Council to NASA for an Explorer-type satellite in the SAS (Small Astronomical Satellite) series, and eventually became the SAS-D project. In the autumn of 1970, ESRO was requested to participate in such a project by providing a ground station in Europe and supplying the spacecraft's deployable solar-cell array. In exchange for this limited contribution (of the order of 4 MAU), European astronomers would be granted a significant fraction of the observing time. The STAR group obviously advocated ESRO's involvement in SAS-D and the LPAC recommended the project. Eventually, both the STC and the Council approved this recommendation and SAS-D was renamed the International Ultraviolet Explorer (IUE). The satellite was launched in January 1978 into a geosynchronous orbit, where it was operated for eight hours a day by a ground station built by ESRO/ESA in Villafranca, near Madrid.



The International Ultraviolet Explorer (IUE): at the time of going to press this satellite remains active some 16 years after launch

Cos-B and Geos

Cos-B was an observatory-type satellite built to study the extraterrestrial gamma radiation with energies above 30 MeV. The scientific payload was provided by six research groups (so-called 'Caravane Collaboration'), whose leaders constituted the Steering Committee responsible for the scientific direction of the mission and for the publication of its results. The satellite, weighing about 280 kg, was launched in August 1975 into an eccentric orbit with 100 000 km apogee, 350 km perigee and 90° inclination. It provided a continuous flow of useful data until April 1982. In particular, Cos-B provided the first gamma-ray map of the sky and provided the means to study the intensity, energy spectrum and temporal variation of several gamma-ray sources.

An important aspect of this project was the fact that the Space Science Department (SSD) at ESTEC participated in the building of the scientific payload on an equal footing with outside groups. It was also responsible for the management and integration of the equipment. This experience helped qualify Space Science Department as a laboratory in its own right in the eyes of the European space science community.

Geos was a multi-experiment satellite placed into geostationary orbit 36 000 km above the Earth's surface. Its scientific mission was to study the physical phenomena in the magnetosphere by making integrated measurements of particles, fields and plasma. Its scientific payload consisted of seven instruments provided by 10 European laboratories. Because of its unique orbit and the sophistication of its payload, Geos was selected as the reference spacecraft for the world-wide 'International Magnetospheric Study'. The satellite, weighing 573 kg, was launched in April 1977 but, as a result of a launcher malfunction, the planned geostationary orbit could not be attained. The launch of the refurbished qualification model was then approved and successfully executed in July 1978. Geos satellite operations were terminated in June 1982.

Although Cos-B's main function was to scan outwards for gamma-ray sources, this look-back at the Earth was an unusual 'bonus' for the scientists

Working out a scientific policy

The four-year period that followed the selection of Cos-B and Geos was the most important in the history of European cooperation in space. As far as ESRO was concerned, the 'first package deal' agreed in 1971 definitively transformed the organisation from one solely devoted to scientific research to one mainly engaged in developing application satellites. At the same time, the ministers were struggling to agree on the outlines of an overall space programme, finally adooting the so-called 'second package deal' in 1973 (see next chapter). No new scientific satellite project could be approved in this turbulent period (apart from the decision to participate in the SAS-D project).

This is not say that nothing was achieved: on the contrary, ESRO blossomed into a mature organisation, the success of which (particularly in contrast to the failures in ELDO) did much to maintain governments' faith in the possibility of European space collaboration

Three aspects of this maturing are to be stressed. Firstly, with the successful development and launch of three new satellites (HEOS-2, TD-1 and ESRO-IV, all launched in 1972) and the initiation of two other satellite projects (Cos-B and Geos), ESRO acquired invaluable experience and proved that it was able to manage important industrial contracts. Secondly, although the adoption of the 1971 package deal went along with a sharp reduction in the funds for science, it did at least make the scientific programme mandatory. Money started to flow from members states continuously and predictably, and long term planning became possible for the first time. Finally, ESRO's policy-makers definitely dropped the idea that the Organisation could pursue the ambitious programme proposed in the Blue Book and tried to set priorities on the basis of the financial and technical resources available, taking into account the parallel development of national space programmes in Europe and the United States.

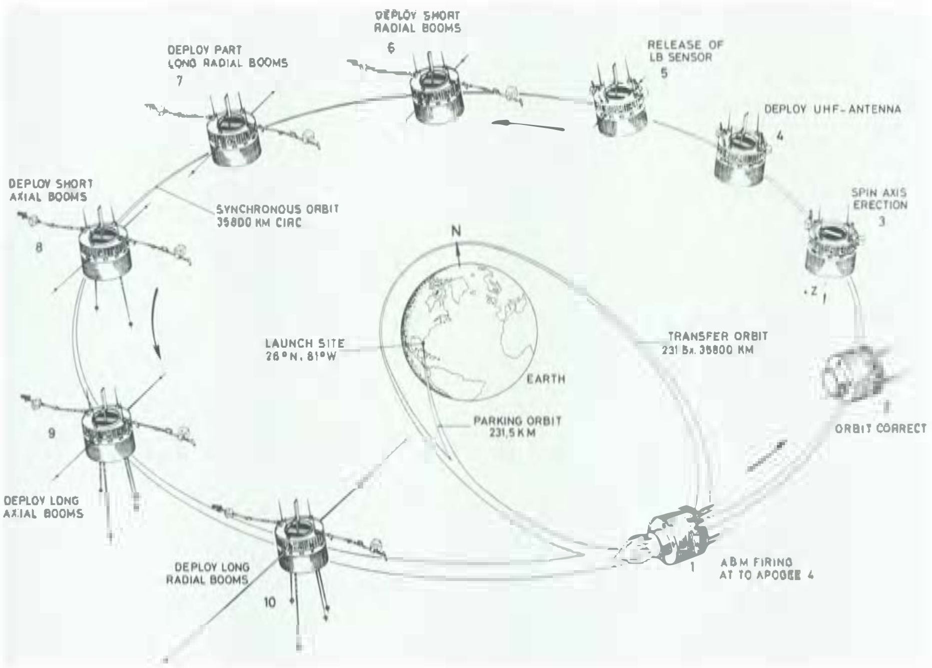
The LPAC's policy statement and the new structure of the expert groups

After the selection of Cos-B and Geos, the LPAC was asked to provide guidelines to the Executive for desirable future projects. The Committee set up two groups of experts, a Geophysics Panel and an Astrophysics Panel, which were requested to discuss and report on the prospects for the different fields of space research from the point of view of the European scientific community's interests, and taking into account the available resources. Both panels had several meetings in late 1969. Their findings were discussed by the six expert groups before being passed to the LPAC, which was called on to issue a general policy statement.

It was not difficult for the Geophysics Panel to identify the most promising fields for research falling within its terms of reference. More precisely, it suggested that two fields ought to be excluded from ESRO's programmes: that of planetary and interplanetary studies by fly-by missions and space probes, and that of atmospheric and ionospheric studies The former was to be excluded for financial reasons, the latter for lack of real scientific interest. There remained the wide domain of magnetospheric studies, for which ESRO's resources were sufficient to establish a viable programme and for which there was sufficient scientific interest to merit such an effort. The Geos project had set the ball rolling and the Geophysics Panel felt that it would be wise for ESRO to retain the momentum now acquired

The Astrophysics Panel had a more difficult task Competition was unavoidable between the three most important research fields falling in its terms of reference — high-energy astrophysics, solar physics and stellar astronomy. Solar physicists and stellar astronomers argued that their turn had come, particularly now that the LAS, Uvas and TD-2 projects had been abandoned. Cosmic-ray physicists, for their part, were interested in pursuing further the study of high energy phenomena in celestial objects, which had started with the Cos-B project, and advocated ESRO's involvement in the promising field of X-ray astronomy. As a consequence, no explicit priority was indicated in the Panel's report. It confined itself to describing the status of the various sub-disciplines and the different programme options, including possible cooperation with NASA, taking into account the envisaged availability of manned space stations. At the end of

February 1970 the LPAC considered the two panels' reports and the comments from the expert groups. The outcome of their deliberations was a policy statment which essentially confirmed the trends established with Cos-B and Geos by giving priority to magnetospheric studies and high-energy astrophysics projects in the X-ray and low-energy gamma-ray regions. Moreover, following a recommendation of the Astrophysics Panel, the LPAC stressed the interest in space experiments aimed at testing fundamental physical theories, in particular gravitational theories.



Initial events in the Geos mission sequence

At the same time, the Committee definitely excluded solar physics and stellar astronomy from ESRO's satellite programme. These research fields, in its opinion, were to be be restricted to rocket experiments and, eventually, to NASA's foreseen post-Apollo programmes with manned space stations.

With these decisions, for the first time since the COPERS years, the representatives of the European space science community explicitly recognised that even a joint effort in space could not cover all research fields, and that a niche had to be carved out in which ESRO could profitably use its limited resources. The exclusion of solar physics and stellar astronomy certainly offended two of the most important sectors of the space science community, and excluded research fields in which the use of space technologies had stimulated a dramatic breakthrough in scientific knowledge.

There were three important reasons why they 'lost.' Firstly, there was the importance of the United States' effort in these two fields with their OAO (Orbiting Astronomical Observatories) and OSO (Orbiting Solar Observatories) programmes, to be followed, it was hoped, by larger telescopes on board manned space stations. Secondly, there was the different instrumental tradition and, indeed access to alternative resources, of the astronomers. These impeded their working out good projects and lobbying efficiently through ESRO's policy makers.

While a few astronomers did in fact accept the challenge of space technologies, most of the community was mainly interested in the development of ground-based facilities, like those of the European Southern Observatory (ESO), which had also been set up in the early 1960s. Finally, there were undoubtedly a number of strong points in favour of the 'winners'. They represented the two most important physics communities involved in space research: those who had already benefited from the choice of Cos-B and Geos.

The studies of the magnetosphere and the new astronomical X- and gamma-ray regions of the electromagnetic spectrum were typically two research fields that had been created by the advent of space technologies, in which many dynamic groups coming from research in geophysics, ionospheric physics and cosmic ray physics could exercise their talents with a large variety of experimental possibilities

The LPAC decided that its policy statement should not be submitted for approval to the STC and the Council Rather it was agreed that it should be considered as providing a framework both for future discussions and recommendations of the LPAC itself and for the planning activities of the ESRO Directorate. Such a statement would also provide the European space science community with clear ind cations about ESRO's scientific policy, and would help orient research groups and laboratories and define national space programmes. The LPAC also decided to streamline the structure of its advisory groups towards the research fields that had been given priority in the future ESRO programmes. Two new working groups replaced the six existing expert groups the Solar System Working Group (SSWG) to cover geophysics and solar terrestrial relations, solar physics, and planetary studies; and the Astrophysics Working Group (AWG) to cover stellar astronomy, high energy astrophysics, and cosmic rays Moreover, a Fundamental Physics Panel (FPP) was also created, to advise on possible space missions to test gravitational theories.

All fields of space research were still formally represented in the new working group structure, but this was made much more coarse grained and the number of scientists involved was reduced by roughly 50%

X-ray astronomy gains momentum: the HELOS project

In line with the policy statement of February 1970, the LPAC requested the ESRO Executive to study the feasibility of three new satellite projects, an X ray astronomy satellite, a series of small standardised magnetospheric satellites, and a space experiment on gravitation theories. These studies were available in the spring of 1971 and, even though the still uncertain political situation of ESRO did not allow any decision to be taken on the start of new projects, the LPAC decided it should express its preference. The real choice was between the first two alternatives. The gravitation project, in fact, was of great technical complexity and a vigorous programme of laboratory research was required to demonstrate its feasibility and to asses its cost The LPAC decided to postpone a decision on undertaking such a research programme and concentrated its attention on the two main projects, the X ray mission HELOS (Highly Eccentric Lunar Occultation Satellite) and the magnetospheric project

The former was better defined and seemed the most promising. It consisted of a highly eccentric orbital satellite carrying a detector sensitive to photons in the energy range 0.3 to 20 KeV, and using a lunar occultation method to determine the position and geometrical shape of X ray sources Its timing was particularly fortunate, as it was to be launched between the first X ray satellite, NASA's SAS-A (later called 'Uhuru'), which would provide the first large scale survey of the X-ray sky, and the second generation of NASA's satellites of the HEAO (High Energy Astrophysics Observatory) series Finally it was strongly advocated by the same scientific coalition that had supported Cos-B, with the important addition of the groups that had been involved in the former Cos A project and of ESTEC's Space Science Department.

The alternative magnetospheric project was based on the realisation of one or two satellites carrying several experiments for studies of magnetospheric dynamics and plasma physics. When, at the end of April 1971, the LPAC was called on to issue its recommendation about which project should be developed further, it not surprisingly chose HELOS, thus confirming ESRO's engagement in the field of high-energy astrophysics inaugurated with Cos-B. In December that year, the ESRO Council agreed that the industrial development contract for a new satellite should start in January 1975. A formal decision on which project to implement was therefore expected by spring 1973. Pending this decision, during 1972 the HELOS project was studied in detail by both the ESRO technical staff and by the scientific community interested in its mission. It was demonstrated that, besides lunar occultation, the spacecraft's pointing system assured the possibility of making observations in any celestial direction, and it was also possible to study temporal variations in the intensity of X-ray sources in a range between a few tens of microseconds and a few tens of hours.

ISEE-B (later renamed ISEE-2) mass model being made ready for vibration tests

Choosing ESRO's new satellite projects: ISEE-2 and Exosat

In early 1973, with the choice of the next satellite now imminent, in addition to HELOS there were two other projects on the table, both involving cooperation with NASA. The first, called IMP M/D (Ionospheric and Magnetospheric Physics, Mother/Daughter), was consistent with the LPAC's policy of fostering magnetospheric studies. It envisaged the simultaneous launch of two satellites into adjacent orbits for the study of small-scale spatial and temporal variations in the magnetospheric plasma and solar wind. The 'mother' and 'daughter' satellites were to be developed by NASA and ESRO, respectively. The second project foresaw the joint development of a Venus orbiter and it represented for ESRO and European scientists a unique opportunity to enter the fascinating field of planetary exploration at low cost. The Solar System Working Group underlined that not less than 25 scientific groups might be involved in such a project.

The importance of this choice could not be underestimated: it was to be made as long as four years after the previous round of satellites had been selected, and in an entirely new organisational context. The event was given all the official prominence it deserved.

The three projects were first discussed at a two-day symposium on 26–27 February 1973 at ESRIN, attended by about a hundred scientists from all over Europe. The symposium was then followed by meetings of the Astrophysics and Solar System Working Groups, whose conclusions were reported to the LPAC. The latter finally held its meeting and, in a restricted session, issued its recommendation to the Scientific Programme Board and the Council.

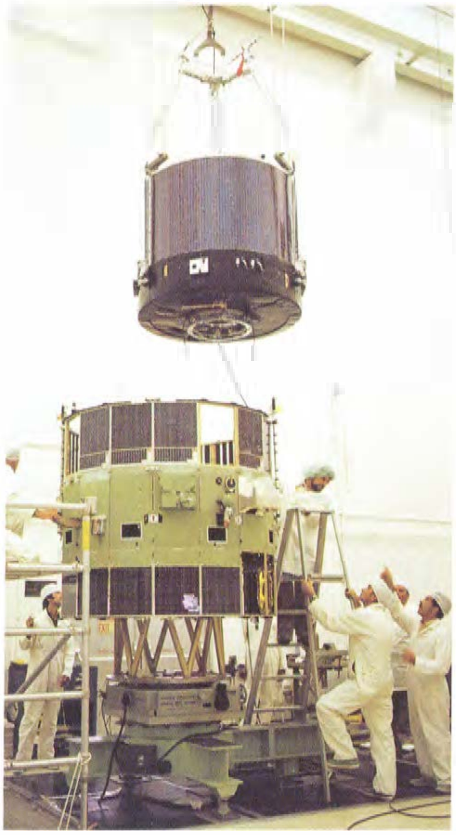
As usual in the case of major LPAC decisions, the choice involved scientific, financial and political aspects. From the scientific point of view, the three projects were all considered 'fully worthy of adoption by ESRO'. Financial limitations, however, suggested that only two of them could be carried out, the first to be started in 1974 and the second in a later year. The Venus probe, however, had not yet been approved by the appropriate bodies in the United States and this project could not start before 1975 or even later. The LPAC therefore had to decide whether to recommend HELOS or IMP as the first undertaking.

If it recommended HELOS, its development cost would prevent the start of a second project before 1976, thus making ESRO's participation in the IMP project incompatible with NASA's timetable. If, on the contrary, the latter was adopted, it would have been possible to undertake a second project (HELOS or the Venus Orbiter) one year later. In this situation, and given the advanced state of IMP (the scientific payloads of both satellites had already been approved), it was logical to choose to do this first.

Exosat: Integration of the low-energy X-ray imaging telescopes

And thereafter? There were two alternatives. The first was to postpone the decision on the second project to the following year, when more information on the Venus orbiter would be available from the USA. With that, the degree of interest in both this project and HELOS within the European scientific community could be assessed by appropriate tender actions for the realisation of their respective scientific payloads. The second alternative was to make a decision immediately and then to recommend the simultaneous adoption of two projects, the first being IMP. In this case, owing to the relatively undefined nature of the Venus orbiter as against the X-ray satellite (an all-European project under study for several years), the latter would be the obvious choice.

In the event, and not without controversy, the LPAC decided to follow its three-year old policy statement and recommended the simultaneous adoption of IMP and HELOS, the former to be started in 1974 and scheduled for launch in 1977, the latter in 1975 and scheduled for launch in 1979. The LPAC's decision, with the endorsement of ESRO's Director General, was then approved by the SPB by a majority of one vote, and finally approved by the Council in April 1973. The two projects were eventually renamed ISEE (International Sun–Earth Explorer) and 'Exosat'.



ISEE-2 being mated with ISEE-1 prior to launch. Following the NASA custom of the time, the spacecraft were known as ISEE-B and ISEE-A prior to launch, and renamed after reaching their orbits

The ISEE Mission

The International Sun–Earth Explorer (ISEE) was a joint ESA/NASA three-spacecraft mission designed to measure the dynamic properties of the magnetosphere and the solar wind in front of the magnetosphere. ESA's contribution to this programme was the ISEE-2 spacecraft. The first two spacecraft, ISEE-1 and ISEE-2, weighing 340 kg and 157 kg, respectively, were launched in tandem in October 1977 and placed in the same highly elliptical orbit with an apogee at about 138 000 km (orbital period 58 hours) so that a good coverage of all magnetosphere regions would be achieved in one year. The separation between the two satellites could be varied from 50 to 5000 km to make it appropriate to the scale of the feature being studied.

The third spacecraft, ISEE-3, weighing 469 kg, was launched in August 1978 into a halo orbit around the so-called 'Lagrangian point', i.e. the point on the line between the Earth and the Sun, some 1.5 million km from the Earth, where the gravitational forces of the two and the centrifugal forces balance. The instruments carried by this spacecraft served to monitor the solar wind and to measure the properties of the solar-wind plasma, magnetic and electric fields, and cosmic rays.

More than 100 investigators from 33 different institutes were involved in the ISEE mission, representing most of the magnetospheric scientific community. The principal investigators of the 28 experiments were formed into a Scientific Working Team responsible for the scientific management of the mission. All three spacecraft were planned with a lifetime of three years, but in fact ISEE-1 and ISEE-2 operated for almost 10 years, until their re-entry into the Earth's atmosphere in September 1987.

ISEE-3, for its part, started a second life in mid-1982 when it was moved from its initial position in front of the Earth to a position behind it, in order to study the unexplored distant region of the Earth's magnetotail. By one of the most complex series of manoeuvres ever undertaken with a spacecraft, involving the use of the Moon's gravitational force, the satellite was commanded to perform a sequence of looping trajectories enabling it to study the Earth's magnetic tail out to a distance of 1.4 million km.

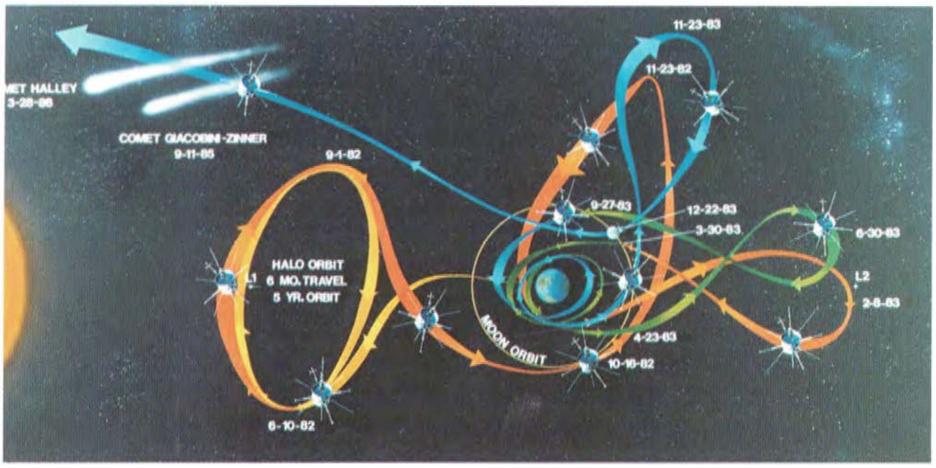
Finally, in December 1983, another lunar swingby sent the spacecraft, now renamed ICE (International Comet Explorer), into an interplanetary escape trajectory for a two-year journey towards Comet Giacobini-Zinner. ICE passed within about 8000 km of the comet's nucleus on 11 September 1985, providing remarkable results on the comet's plasma tail.

Exosat

ESA's X-Ray Observatory Satellite (Exosat) was operational from June 1983 until April 1986 and in that time studied the X-ray emission from most classes of astronomical objects. More specifically, it measured the locations of cosmic X-ray sources, their structural features, and spectral as well as temporal characteristics in the wavelength range from the extreme ultraviolet (EUV) to hard X-rays. The payload of this small (510 kg) but powerful X-ray observatory consisted of three instruments producing images, spectra and light curves in various energy bands (0.04–50 keV), built by groups from eight institutes in Germany, Italy, the Netherlands and the United Kingdom (including ESA Space Science Department).

Exosat was the first ESA (ESRO) scientific satellite totally funded by the Agency. Its observations and data were not restricted to the groups that had built the scientific payload, but were made available to a wider community. Exosat was operated as a true astronomical observatory, with the majority of the observing time assigned on a competitive basis by a scientific committee including physicists and astronomers from ESA member states.

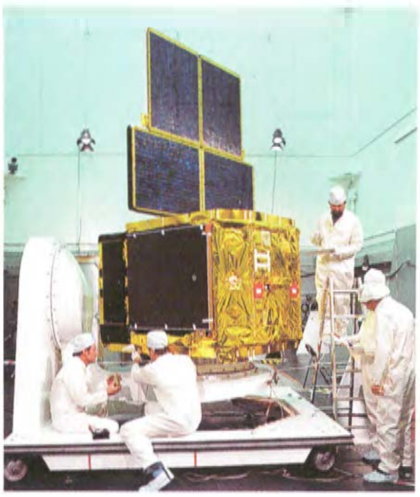
An observatory team was provided by ESA to support the implementation of the observing programme, instrument calibration, data archiving and data analysis. At the end of the operations, an Exosat database was established in ESTEC, containing a summary of the results from each observation and the final products from the mission (images, light curves and spectra).



ISEE-3 manoeuvres from launch to halo orbit to comet exploration

ISEE-2 mounted in the dynamic test chamber at ESTEC

One of the many 'images' from Exosat



Preparing Exosat for launch

Chapter 9 — Laying the foundations of ESA: the first and second package deals

As we pointed out earlier, and notwithstanding the achievements of the science programme, the collaborative European space effort reached its nadir towards the end of 1970. Disillusionment, frustration and anger separated governments which, for about five years, had been struggling to put together a coordinated programme involving science, applications and launchers. Pressure increased for a decision on priorities, including the nature and scope of participation in the post-Apollo programme, and for a commitment for funding for such projects as would be embarked upon in the next decade. There was also a strong determination that the cracks in the ever fragile consensus between member states should no longer be papered over. The entire joint European space effort was once again on the brink of collapse, the only alternatives being to disband or to find a compromise that could satisfy the needs of Belgium, France and Germany, who would otherwise go ahead on their own.

Six months later the climate had changed appreciably. The new ESRO Council Chairman, Italian physicist G. Puppi, had brokered a package deal that irreversibly re-oriented ESRO's mission away from science and towards applications, and which guaranteed the organisation's future. This was followed about 18 months later, and after the disastrous failure of the Europa 2 rocket on its maiden test flight, by a second package deal worked out between ministers at the ESC. It consisted of three major programmes, each supported by one of the three major contributors — Britain, France and Germany:

— a maritime telecommunications satellite;
— a new heavy expendable launcher (Ariane), and
— Spacelab, the scientific laboratory to be housed in the Shuttle's payload bay.

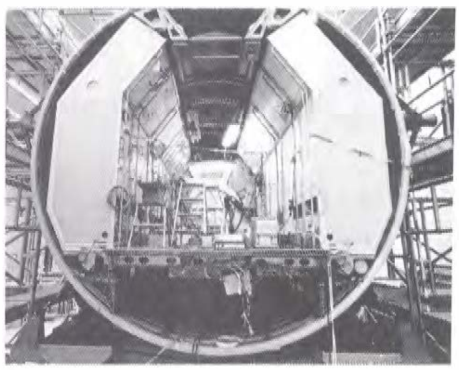

Ariane — the first launch

With these decisions taken, and with appropriate procedural mechanisms put in place for their implementation, the basis was laid for the new single European Space Agency, which officially came into being in May 1975.

The background to the first package deal

When the ministers met in Bad Godesberg in November 1968, there were high hopes that they would make a substantial commitment to the future of ESRO and to a space applications programme involving, among other projects, telecommunications, navigational and meteorological satellites. In the event, they only voted resources for ESRO up to the end of 1971. Although they authorised ESRO to embark on projects that extended beyond its original eight-year mandate, some governments refused to commit themselves to a provisional level of resources for the period 1972–1974. What is more, while accepting that ESRO should continue its studies on applications, they were unwilling to give the go-ahead for the development of the Eurovision satellite. Nor were they willing to increase ESRO's resources for work on applications beyond the figure of 1 MAU annually.

To make matters worse from ESRO's point of view, Britain only agreed to extend its involvement in this sector if it was released from its obligations to ELDO. This was agreed after some difficulty in April 1969, four other member states in ELDO taking on an increased financial burden to see the Europa 2 programme through to completion.


Spacelab's long module

The ministers met once more in July 1970. Again there were hopes that they would commit themselves to a broadly-based space programme adequately funded for its first three years, and to the establishment of a single agency to execute it. Again this proved overoptimistic. In particular, some countries felt that before taking a final position on the launcher question they needed precise guarantees from the United States that it would launch operational European telecommunications satellites. Pending such guarantees, the ministers, while adopting an applications programme, restricted their engagements. They agreed to the execution of a comunications satellite programme satisfying the requirements of the CEPT and the EBU to be ready by about 1978–80 and costing some 450 MAU. They also agreed to develop, in conjunction with NASA, an air traffic control satellite, and to begin studies, in consultation with potential users, of possible meteorological satellites. While they allocated 12.5 MAU overall to these programmes, they were again not prepared to enter into commitments extending beyond end 1971. As for science, the ministers meeting in Brussels in July accepted ESRO's estimates of its needs for 1971–1973, and agreed (though see below) to a financial envelope of 112 MAU for this slice of the European space programme.

That said, it must be added immediately that many of these decisions were only tentative, either being taken 'ad referendum', or being surrounded with crucial qualifications by one or more member states. Belgium and France, for example, would accept no new commitments to the science programme (i.e. beyond the end of 1971), and along with Germany were the only three countries prepared to support the Europa 1/2 development and manufacturing programme, and to fund the development of Europa 3 beyond the end of 1971. Indeed, while the 'general atmosphere of the conference was one of optimism [...]' (Bondi), the ongoing strife over the launcher question 'led to serious doubt on the coherence of the programme and cast a shadow on the whole conference'. Clarification would ensue, it was hoped, when the Ministers reconvened on 3–5 November that year.

In the event, the second session was reduced essentially to one day. The Conference Chairman and Belgian Minister of Scientific Policy and Planning, Théo Lefèvre, reported on his post-Apollo discussions in the USA (see chapter 7). He indicated that Washington was thinking of a European contribution of about $1 billion over the next decade – which 'broadly speaking corresponded to the effort we should have to make in order to continue the development of our own launchers'.

At the same time he pointed out that, as regards telecommunications which crossed national frontiers, the United States' 'assurances, as formulated, do not specify whether or not we can count on launchers for public service, conventional operational communications satellites, even if their operation is limited to the European zone'. This was enough to convince Belgium, France and Germany that development studies of Europa 3 should get underway, and that participation in the post-Apollo programme, while desirable, should not be at the expense of European launcher autonomy. Faced with UK opposition in particular, they declared that there was no point in trying to set up a single organisation if all partners were not prepared to support a three-pronged programme. They also added that, if necessary, they were prepared to go it alone on a trilateral basis, offering associate status to any other member state who wished to contribute to only a part of it. As a sign of their determination, and much to Bondi's distress, Belgium and France refused to vote ESRO's budget for 1971.

On 12 November 1970, the German Minister for Education and Science, Leussink, in consultation with Ortoli, the French Minister of Industrial Development and Scientific Research, and Lefèvre, sent a letter to the appropriate ministers in the other member states of the ESC. Reaffirming the views expressed the week before, it asked them 'to review their attitude and state whether they were prepared to support a complete European programme, including participation in launchers and the post-Apollo programme'.

At the subsequent ESRO Council meeting on 25 November, delegates from the three countries insisted that, until this issue was clarified, they would block those parts of the ESRO budget concerning expenditure to be made in 1972. What is more, France said, if a budget for 1971 was imposed on her by a two-thirds majority (as was legally possible), she would simply veto the next three-year ceiling for 1972–74 which had to be unanimously agreed before the year was out. Escalating the tone, this delegation then also refused to vote the ESC figure of 12.5 MAU for applications for 1971. That agreement, said the French, formed part of an overall package, and in the absence of a consensus on the package she would only accept that 1 MAU should be spent on applications studies in the year ahead (i.e. the amount previously devoted to this).

To resolve the crisis, it was decided that an extraordinary Council session should be held just before Christmas. The delegations from Belgium and France again took the floor. The gist of their remarks, which were supported by Germany, was that, since only a few countries were prepared to spend money on a launcher which they deemed essential, sacrifices would have to be made elsewhere in the programme. They singled out science for special mention. Insisting that they had no wish to destroy ESRO, but that this kind of activity could more profitably be pursued at the national level, they proposed to reduce the three-year ceiling for science to 70 MAU (as against the 112 MAU proposed by the ESC in July).

This change of emphasis, said the three, was to be coupled with a whole series of organisational reforms that made allowances for optional programmes. New procedures would have to be worked out to ensure that partners were committed to pursue programmes through to completion, with voting powers weighted according to the respective contributions of each participant. ESRO would have to introduce management and accounting methods compatible with each project being treated as a separate entity. Existing national resources would have to be exploited to the full, and greater use would have to be made of national 'promoters' who would be responsible for system design and inspection in industry, with multinational prime contractors taking care of hardware development. To ensure at least a minimum market for the European launcher, satellites would need to be so designed that they would be compatible with it. To put teeth into these proposals, France then signalled her intention to withdraw from ESRO in 1972 if a suitable compromise embodying her key requirements could not be found.

Hermann Bondi who, as ESRO Director General, sounded the alarm when several countries threatened to leave

This strong line 'amazed' some of the other delegates, who feared that it would have a 'disastrous psychological effect' on public and parliamentary opinion and on the morale of ESRO staff. The small countries were particularly bitter, feeling that they were being bullied into submission; and as first the UK then Sweden threatened to follow France and denounce the convention, Director General Bondi sounded the alarm. This course of action, he said, whereby several countries bound themselves either to getting their own way or to leaving, could only lead to the dissolution of ESRO. Time was needed to seek a compromise.

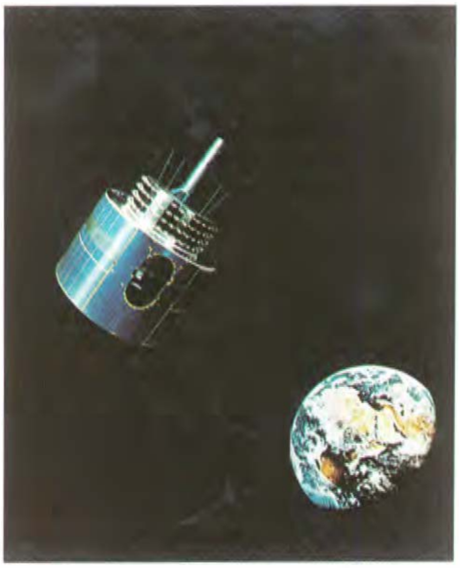
It was in these inauspicious circumstances that the incoming Council Chairman Puppi was instructed to conduct negotiations with the member states with a view to coming up with suggestions for the reform of the organisation. These were to be submitted no later than 30 June 1971, until which time the French agreed to suspend temporarily their threat to withdraw.

The first package deal

Puppi spent the first few months of 1971 in preliminary discussions with the member states' delegations before entering into negotiations with them in March and April. He came up with his suggestions for the reform of the organisation early in May. Three points are to be noted about this first stab at a solution. Firstly, he identified a transitional period, lasting from 1972 to 1974, during which ESRO's role would be reoriented towards applications. There would be a progressive redistribution of resources away from science in this period, and the role of Esrange and ESRIN would have to be reassessed. The decision-making structures would need to be reformed and better coordination and harmonisation between national and European activities would be sought.

Secondly, regarding the programmes themselves, Puppi noted that it was generally assumed that the applications programmes should be optional. Regarding science, he suggested that it remain mandatory only until the end of the transitional period, after which it should be optional too. In fact Puppi suggested that, from 1975 onwards, to qualify for membership of the new organisation a country would only be obliged to participate in what were called 'basic activities (notably a space technology R&D programme) and common costs', and in any one additional programme of its choice.

Finally, as regards funding, he saw the overall ESRO budget doubling from 74 MAU (in 1971 prices) to 150 MAU by 1974, after which it would be pegged for the rest of the decade. Within this profile, Puppi proposed that the scientific satellite programme be gradually reduced to achieve a fixed level of 35 MAU a year (in 1971 prices) from 1974 onwards. This, he said, seemed to be the minimum required for a viable scientific satellite programme. As for applications, they should rapidly climb to a fixed level of 90 MAU by 1974.



A meteorological satellite, one of the proposals in the package deal

These proposals were discussed by the ESRO Council at the end of May. The debate, which was intended primarily to solicit first reactions, concentrated on the status and funding of the scientific programme. Here it emerged that, while there was considerable sympathy for the idea that the sounding rocket programme should become optional, most delegations were emphatic that the scientific satellite programme should remain mandatory beyond the transitional period. This programme, it was argued, would give cohesion and stability to the organisation, and would serve as a sign of European determination and European unity.

As for funding, these delegations confirmed that 35 MAU annually (at 1971 prices) seemed to be the minimum needed for a viable programme (though even that was well below the 43–47 MAU the scientists sought). The most important discordant voice was that of France. France was not against having an optional science programme. In addition her delegation stated quite categorically that it would not support a mandatory science programme to the tune of 35 MAU annually.

The Council met again in July 1971. The most striking development here was that the 'big four' had accepted that there should be a dramatic restriction in their scope for optional participation in programmes. More specifically – and this was the substance of the package deal – they accepted that the scientific satellite programme be mandatory for all and that they treat an applications programme as if it were mandatory for the four major member states, other member states being free to join them on an optional basis. Contributions, as before, remained pegged to each participating state's GNP.

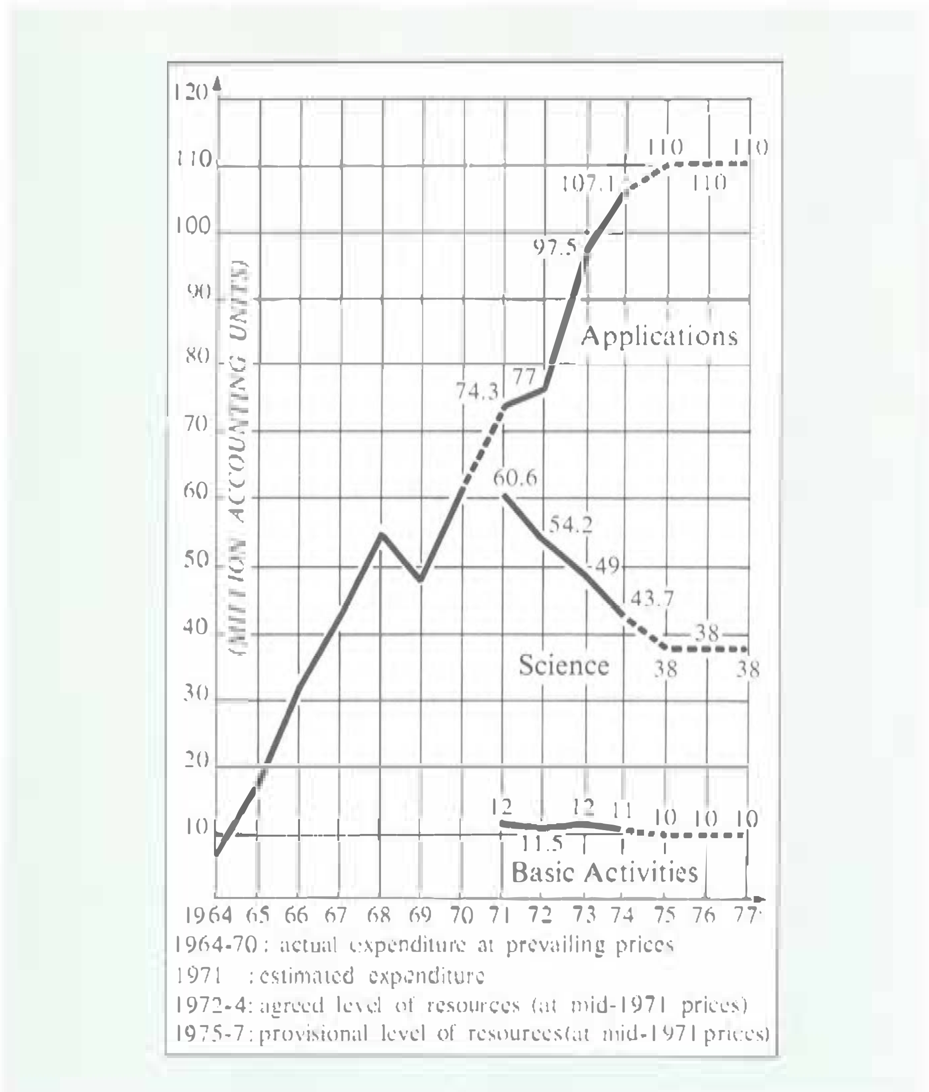
To give substance to this commitment, Britain, France, Germany and Italy agreed to guarantee together 70 MAU a year (at 1971 prices) for applications from 1974 to 1980. In the first instance, this money would be spread between a telecommunications, an aeronautical and a meteorological satellite. As for the level of the science budget, France insisted that it be fixed at 27 MAU a year from 1974 onwards, though conceded that it could be a little higher before that. This ceiling, it remarked, would enable one scientific satellite to be launched every two years. The package deal agreed by the major member states of ESRO formed part of a wide-ranging resolution which was discussed in draft by the Council in July 1971, and finally voted in its entirety, after several revisions, in December of that year. Let us briefly survey its highlights.

Nine member states – Belgium, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom – agreed in principle to participate in a joint aeronautical satellite programme, with at least the USA and Canada, which was to cost no more than 100 MAU (at mid-1971 prices.) (The tenth state, Denmark, was reconsidering its membership of ESRO and did not commit itself to any programmes). The same nine states also ageed to fund together an as yet undecided meteorological satellite programme to a ceiling of 115 MAU. Finally, all of them bar Spain agreed to participate in a communications satellite programme, and to contribute a maximum of 100 MAU from 1972 to 1976 for its experimental phase. A further decision on its content, and on whether to undertake succeeding phases of the programme, would be taken in 1975 by a double two-thirds majority (chapter 5).

Regarding the science programme, the satellite component was made mandatory, as we know, and its annual resources were set at not less than 27 MAU (plus 1 MAU contingency) from 1972 to 1977 – essentially the French figure. Additional funds were made available in the transition period. These reductions could only be achieved by delaying somewhat the start of the Cos-B and Geos projects (see chapter 8), and by cutting back the activities at Esrange and at ESRIN.

Of the 36 approved sounding rocket firings, only 16 were authorised, and a small sum of money was made available for the scientists concerned with the remaining 20 firings to enable them to complete their payloads. Arrangements were made for Sweden to take over Esrange from July 1972, and it was regretfully concluded that ESRIN's scientific research activities would have to be terminated by September 1973. Thereafter, it was suggested, its main activity should be to run a technical information service.

Distribution of financial resources between science, applications and basic activities agreed by the ESRO Council in December 1971.



The amount to be spent on basic activities and common costs (finally set at 10 MAU a year) was not easily settled. Puppi originally suggested that this be pegged at about 15 MAU, more than half of which was to be for basic technological research. This figure was forced down by the French, who felt that the development of space technology could be done exclusively in national programmes. Sweden, in particular, protested vigorously, insisting that it was the only way in which a small country without a major national programme could acquire the skills and knowhow needed for it to participate meaningfully in future programmes. In the event, only about 4 MAU was set aside annually for technological support, about half the figure first proposed by the Council chairman

Launchers were another thorny issue. The first version of the draft resolution discussed in July 1971 reaffirmed the decision taken by the ESC at Bad Godesberg some three years before (the so-called '125% rule' – see chapter 6), but with one important twist. The rule that priority would be given to the purchase of a European launcher provided that it did not cost more than 125% of the equivalent US launcher – would only be invoked provided that the USA formally agreed to provide launchers for all missions referred to in the resolution, including the operational stages of applications satellites. Failing that, a European launcher would be acquired or developed either with ELDO or with European industry. This text was obviously intended to secure guarantees for a European launcher industry unless the United States could give (impossible to have) cast iron commitments that it would always meet European needs.

As we would expect, this text was backed by the French, opposed by the British, and revised at the last minute in a spirit of compromise, and to accommodate the new situation that arose after the dramatic failure of Europa 2 in November 1971 (see below). The final arrangement was complex It satisfied the British in that it reaffirmed the 125% rule without making its application conditional on the USA guaranteeing in advance that Europe could use its launcher for any (civilian) mission Also, it satisfied the French in that it stated that the 125% rule would fall away if the USA ever refused to launch a European satellite, so clearing the way for a continuous and assured market for a launcher developed and built on this side of the Atlantic.

It would be misleading to suggest that the agreements formally reached in 1971 were readily accepted by all Indeed, as in all such cases, the texts were so worded as to identify the points on which all could agree and left considerable scope for interpretation and conflict. And conflict there was. Italy was most distressed about the change in ESRIN's role, even threatening to withdraw from the package deal if an activity more 'noble' than a space documentation service was not attributed to the only ESRO establishment on its soil. There were bruising debates over the content of the communications satellite programme, as we have seen in chapter 5

There was some disagreement over the meteorological programme. The French, who ultimately prevailed, wanted it to be the 'europeanisation' of a geostationary satellite they were designing with NASA, called 'Meteosat'. They also wanted the project management team to be based at the CNES Space Centre in Toulouse, with staff drawn equally from ESRO and from their national project Finally, after several more years of protracted negotiations, the joint aeronautical satellite project was in fact abandoned

That granted, it would be just as misleading to allow these difficulties to obscure the importance of the compromises involved in the first package deal For one thing, they ensured that ESRO, or a suitably reformed European space organisation, would continue beyond 1972, when its initial mandate expired, so breathing new life into the collaborative effort For another, they guaranteed the funding needed until the end of the decade to get a meaningful applications programme off the ground. Finally, and related to this, they sealed the participation of the smaller countries in the organisation and in the à la carte system.

In guaranteeing the adhesion of the major contributors to the applications programmes, they reassured the smaller states that they would not find themselves saddled with an intolerable financial burden because one of the big four decided not to join in. In this respect, they laid the basis for a new European space agency, an agency that inherited both a new programmatic framework in which to operate, and the historical residues of the disagreements that preceded its birth

esa
agence spatiale européenne
european space agency

The background to the second package deal

We have already mentioned that the development programmes agreed on in 1971 were supplemented in 1972/3 by a second three-element 'package deal' adopted at ministerial level. The background to the inclusion of one of those elements, Spacelab, was described in chapter 7. Here we want to concentrate on another: the Ariane launcher. This effectively means picking up the threads of the ELDO story where we left it in chapter 6.

In April 1969, the ELDO ministers resolved the crisis that had arisen from the fact that the UK and Italy, for different reasons, refused to fund fully the Europa 1/2 programme up to the established ceiling of 626 MAU. At this meeting, the other four European member states agreed to make up the corresponding shortfall in contributions. The conference also instructed ELDO to examine ways of implementing a production programme for the Europa 1/2 launchers with a view to satisfying the needs of potential users, notably ESRO and the Franco-German Symphonie telecommunications programme. In addition, all member states bar the UK expressed an interest in studies of a Europa 3 launcher able to put a 400 to 700 kg satellite into geostationary orbit.

Three months later, Europa 1 was launched from Woomera with all three stages live (launch F8). The third stage malfunctioned again, as it had in November 1967 (flight F7). An intensive investigation of the causes of the failure of the German-built stage and its interface with the (French) second stage revealed that the failure of both F7 and F8 was most likely due to an electrical fault which triggered the self-destruct system. Full confidence was expressed in the success of the next, and last test flight from Woomera (F9), the date of which was postponed from November 1969 to May 1970.

Launch F9 duly took place on 12 June 1970. The rocket was essentially a slightly improved version of that used for F8, with the addition of inertial guidance as a passenger in the third stage. It also included in its payload some experimental telecommunications equipment. Once again the rocket failed to achieve its objectives. A plug was disconnected during the powered flight of the first stage, and the nose fairing was not jettisoned. Then a defective valve in the third stage vented helium into the atmosphere, causing a progressive reduction in the thrust of the rocket. Europa 1 failed by about 10% to achieve its intended orbital velocity, and the combined third stage and nose fairings enclosing the satellite came down in the Caribbean north of Guiana.

The disappointment caused by this setback did not deter those who were convinced that Europe should develop her own launcher. In April 1969 the ELDO Council had agreed to adopt a configuration for a new two-stage rocket Europa 3 without Blue Streak and including advanced cryogenic techniques. In November 1970, four member states – France, Germany, Belgium and the Netherlands – agreed to finance 18 months of preparatory studies on this rocket and three of them made it clear that if other European governments were not interested in continuing with the launcher programme they would go ahead with it on their own. As a further gesture of confidence in its future, ELDO was authorised to place industrial contracts to make systematic studies of the space tug within the framework of the post-Apollo programme (see chapter 7).

All attention was now focussed on the maiden test flight of Europa 2. Early on the morning of 5 November 1971, the day foreseen months before for the launch, tense optimism reigned in ELDO and at Kourou. The new French-sponsored equatorial base had been successfully commissioned six months before with the static filling of a multistage reference vehicle fully representative of the rocket. The countdown went without a hitch. Europa 2 blasted off on schedule before a crowd of assembled dignatories and journalists. The trajectory was normal for the first 130 seconds. Then, to everyone's dismay, a number of simultaneous anomalies, including the failure of the inertial guidance computer, caused it to incline gradually towards the right. The rocket broke up in flight 20 seconds later.

General R. Aubinière, ELDO Secretary General

The ELDO Council met on 18 November. The potentially grave consequences of this setback for the future of ELDO were clear to all. A commission of enquiry was established immediately. It was chaired by the incoming ELDO Secretary General, General R. Aubinière, the then Director General of CNES. Aubinière was asked to submit his report by May 1972. He was specifically instructed not only to look into the technical causes of the failure but also at the management structure of the entire project.

Aubinière's report was laid before the ELDO Council on 8 June. It did not mince words, and was a damning indictment of the management of the Europa programme both by ELDO and inside industry. The heart of the problem was the limited technical authority of the Secretariat, which had been restricted from the outset by the demand of the founder members of ELDO that national agencies be responsible for placing contracts with their industries. This was compounded by the poor internal organisation of the Secretariat itself, which lacked an adequate chain of command and in which responsibilities were not clearly defined. As a result there was no central, project-oriented team in ELDO which could or did take overall technical authority for piloting the programme, dealing with vehicle integration and acting as a coordinator of firms.

Due to the remoteness of the technical staff from actual design and development, most of the contracts placed by ELDO were deficient in several respects (e.g. completeness of specification, freezing of procedures and design): even some of the most basic technical documentation was lacking. The matter was not helped by the firms, which tended to regard ELDO personnel as bureaucrats rather than technical authorities. This lack of overall control over industry had some startling consequences. In particular, there was a serious lack of integration of electrical systems in the third stage. For example, the wiring between the upper section of the electrical system manufactured by MBB and the lower manufactured by ERNO obeyed 'none of the elementary rules concerning separation of high and low level signals, separation of signals and electrical power supply, screening, earthing, bonding, etc'.

No one look responsibility for this, not even the firm ASAT (Arbeitsgemeinschaft Satellitenträgersystem), the stage manufacturer for which MBB and ERNO were working. Simple technical deficiencies of this kind, the commision thought, were probably responsible for the computer stoppage. The computer itself, they pointed out, was a prototype initially used in the development of the British Jaguar fighter aircraft programme, and subsequently replaced. It was not being used operationally anywhere but in the Europa 2 project and, in the view of the commision, it was inevitably defective due to the resulting inadequate standards of manufacture, inspection and acceptance.

Aubinière's commission concluded that the Europa 2 rocket 'in its current configuration [was] unflightworthy'. However, it was confident that the enormous technical and managerial defects in the Europa programme could be overcome if suitable measures were taken immediately. In particular, it was insistent that the ELDO Secretariat be turned into a centralised technical authority with overall responsibility for the project and with the competence and power needed to impose its wishes on the contractors. It estimated that if this was done and a further 21 to 27 MAU was made available for the programme, the next launch of the rocket could reasonably be scheduled for the summer of 1973 — a slippage of about 18 months. While success could not be guaranteed, Aubinière's commission felt that, if their conditions were met, there was no reason why the Europa 2 vehicle would not 'achieve a normal probability of correct functioning to match that of comparable space projects'.

The ELDO Council meeting on 8 June 1972 considered Aubinière's report. It was loath to take a decision on whether or not to continue with the Europa 2 development and production programme. It preferred instead to leave this to ministers who were scheduled to meet a month later on 11 and 12 July. In the event, the ministerial meeting was postponed due to developments across the Atlantic. On 14–16 June, a European delegation went to Washington to continue discussions on the terms of participation in the post-Apollo programme.

They were stunned to find that the USA had withdrawn the space tug as a possible item for a European contribution, and could only offer participation in a few of the Shuttle's elements on 'discouraging' terms. All attention, in fact, was focussed on the sortie module, which was presented in detail to the Europeans by NASA officials two weeks later (see chapter 7).

The Committee of Alternates of the ESC decided that, with the situation as fluid as this, it was pointless to hold the next ministerial meeting in July as planned. In fact, the Europa 2 setback and the reduction in the scope of European participation in the post-Apollo programme set in train a major revision of Europe's space priorites in some governments. It also left ELDO in limbo, with a dark cloud hanging over its existing programme, no commitment to continue with the Europa 3 programme, and the space tug, for which it had been responsible, summarily cut from its activities.

The second package deal

The most important immediate political repercussion of the events we have just described was that Germany, which had always been one of the most ardent supporters of a European launcher, now began to have second thoughts. On the one hand it felt that Europe had much to gain from participation in the post-Apollo programme, particularly at the level of system management. On the other hand, it came round to the view that the costs of developing a European launcher were unjustifiably high in relation to the very small number of satellites that the USA was likely to refuse to launch.

An informal meeting of space ministers was held on 8 November to identify what common political ground, if any, existed between them. Here the German delegate, strongly supported by Italy, pointed out that his government had lost considerable faith in the European launcher concept after the failure of Europa 2, saw little reason for continuing the programme, and thought that the estimated $1.5 billion development cost of Europa 3 was not worth the effort. The French by contrast, and some of the smaller countries, insisted that it would be foolish to abandon Europa 2 at this stage, when it was almost complete, but announced that a new launcher similar to Europa 3 but differing in managerial and technical solutions was being studied.

At the same meeting, the British Minister for Space in the recently elected Conservative government, Michael Heseltine, signalled a sharp turn in his country's position. He proposed that Europe be endowed with a single space agency built from ESRO and ELDO, and that national programmes be gradually phased out, the preference being for collaborative European solutions. He also suggested that in this new agency there should be room for specialised programmes in which member states could participate to the level that they wished, and not necessarily proportionally to their GNPs which, he said, 'has always been the stumbling block up to now'.

Spacelab, the eventual European contribution to the post-Apollo programme, seen here in the Shuttle's cargo bay

The ministers met again formally on 20 December 1972. Here, in a dramatic series of statements, the dilemma of post-Apollo participation or European launcher was resolved. The French Minister of Industrial and Scientific Development, Charbonnel, announced that his government would shoulder the major part of the funding and bear the development risks of a launcher equivalent to Europa 3. Tentatively labelled LIIIS, it would be able to put 750 kg into geostationary orbit for about 550 MAU. France would put up 60% of the costs of the project, which would be managed by CNES and executed by a French firm as the prime contractor, which would choose other European partners. Germany, in turn, indicated that it would favour the construction of the sortie module in a European framework. By the end of the day, the ministers had agreed: to form a new European space agency by 1 January 1974 if possible; to go ahead with the sortie lab and LIIIS launcher on terms still to be defined (which meant cancelling Europa 3 immediately); and to integrate national programmes into the European effort as soon as possible (which at this stage meant, above all, Europeanising the UK's GTS communications satellite, a maritime satellite derived from the UKATS that was mentioned in chapter 5).

An intensive round of negotiations followed between the major member states' delegations. At the ELDO Council meeting on 27 April 1973, the German delegate confirmed that, since mid-1972, his government had increasingly come round to the view shared by the UK, and later Italy, that it was more economical to buy launchers from the USA than to develop them in Europe. He therefore proposed that the Europa 2 programme be abandoned immediately. Indeed, he said that Germany would continue contributing to the programme for only three more days and that, from 1 May 1973, Germany would only share in its rundown costs.

France immediately accepted the proposal, leaving the Belgian delegate bewildered – this was the first he had heard of the proposal to cancel Europa 2 he said – and the already demoralised ELDO staff embittered; they had been stripped of their last remaining programme literally from one day to the next. Indeed the determination of the member states to liquidate ELDO rapidly was such that by October 1973, 223 staff had already been dismissed, of whom only 68 had found other employment.

The ministers met again in Brussels on 12 and 31 July 1973. After successive rounds of horse-trading the percentage participations agreed in the various programmes that together comprised the second package deal were:

Country	**Launcher LIIIS** **%**	**Spacelab** **%**	**Marots **** **%**
Belgium	5.00	4.20	1.00
Denmark	0.50	—	—
France	62.50	10.00	15.00
Germany	DM 320 million	52.55	20.0
Netherlands	1.00	2.00	—
Spain	2.00	2.80	—
Switzerland	1.15	1.05	—
United Kingdom	11.25 MAU	6.30	56.00
Italy and others	6.00	21.10	8.00

* Germany agreed to contribute four annual contributions of DM 40 million and after re-evaluation, a further 4 x DM 40 million.

** Marots was derived from the UK's GTS and ESRO's OTS

With these agreements reached, a sound basis had finally been laid for the next decade of Europe's space effort. Of course, a good deal of work still had to be done before the new Agency could come into being – indeed the hope of setting it up early in 1974 was to be disappointed for a year. In the event, the convention establishing the European Space Agency, and its five annexes, was signed on 31 May 1975 by representatives of ten European governments: Belgium, Denmark, France, the Federal Republic of Germany, Italy, the Netherlands, Spain, Sweden, Switzerland, and the United Kingdom. It came into force in 1980, when France deposited her instruments of ratification.

The procedure for implementing optional programmes

It is beyond the scope of this small book to enter into detail on the debates between 1973 and 1975 on the drafting of the convention and the establishment of ESA. However, as in this chapter we have concentrated on the formulation of the programmes which were to provide the backbone of its initial activities, we think it fit to end by briefly describing the procedures adopted for their implementation. As we have stressed, the system of optional programmes was fundamental to the continuation of the collaborative European space effort, and the rules agreed for carrying them through to completion were just as important as their content in securing the adhesion of member states to the à la carte system.

The first attempt to formalise legally the notion of an optional programme was made in response to Italy's withdrawal from the TD project (see chapter 4) Article VIII of the ESRO convention which made allowance for special projects in which all member states need not participate, was invoked to permit the project to continue without an Italian contribution A provision of this kind was retained in the ESA Convention However, that document also made a clear and formal distinction between mandatory and optional programmes and in an Annex, specified the rules for implementing the latter.

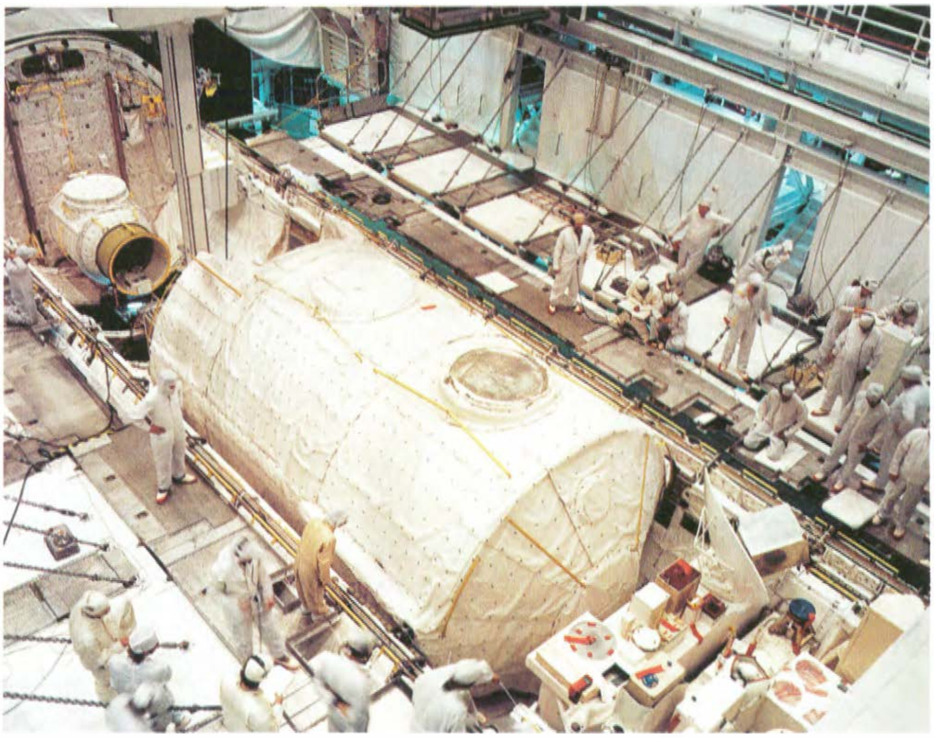
The first striking feature of these arrangements is the degree of autonomy enjoyed by the participating states in the carrying out of the programme Certainly, an optional programme cannot get under way unless the majority of all the members of the Council agrees to it Any member state that does not wish to participate must so inform the Council within three months. These procedures being satisfied, however, the countries that want to have an optional programme are given enormous latitude in managing it through a so called 'Programme Board They draw up a declaration specifying the phases of the programme the indicative financial envelopes and sub envelopes relating to these phases. and the scale of contributions of each participant which, if they so choose, need not be correlated directly with a country's GNP. They control the movement from one phase of the programme to the next They decide among themselves whether or not to discontinue a programme.

The Council as a whole is informed of some of these developments: it has no power to impede them. Also noteworthy are the financial safeguards built into the system. The decision to move to the next phase of a programme must be taken by a double two-thirds majority (a positive vote of two-thirds of the participating member states who pay two thirds of the contributions). If the project includes a project definition phase, and this shows that the overall cost will be more than 120% of the initially indicated financial envelope, any participating state is free to withdraw Similarly, states are entitled to withdraw if the cumulative over-run is more than 20% of the relevant financial envelope. At the same time – and this is a third significant feature of the optional system, it is quite impossible for any participating state to stop others who wish to proceed with a programme from doing so.

Every decision cited in the previous paragraph is coupled with the formal proviso that 'the participating states that wish, nevertheless, to continue with the programme shall consult among themselves and determine the arrangements for such continuation'. The only case where this does not apply is the decision to stop a programme altogether, but that is taken by a double two-thirds majority anyway

It would be naive to think that this system has worked in practice 'according to the rules'. For example, sometimes programmes get under way with only 80% or less of the financial envelope guaranteed by the participants, leading to all manner of problems later because they cannot afford to make up the difference themselves. It has also been difficult to decide just when the 120% threshold has been passed. in the case of Spacelab, where the problem arose for the first time, the participating states agreed to raise the threshold to 140%. The technical, political and institutional problems notwithstanding, the fact remains that the system of optional programmes introduced in the first and second package deals remains (in 1994 at the time of writing) a key to ESA's functioning.

Indeed, according to one estimate there are no less than 40 such programmes in operation in ESA today, with 70 budgets, different participants, and different scales of contribution.



Spacelab being prepared for one of its flights (photo courtesy of NASA)

Ariane 1 — up, up and away!

Spacelab and LIIIS

Spacelab, or the sortie module as it was originally called, consists of pressurised laboratory modules which can accommodate astronauts and unpressurised instrument platforms (pallets) suitable for conducting research and application activities in conjunction with NASA's Space Transportation System. It was designed to occupy the whole of the Shuttle Orbiter's 15 ft diameter by 60 ft long payload bay, and to carry a multitude of different payloads with different characteristics. The first Memorandum of Understanding, which formally launched the programme, was signed in 1973. It held that Europe would define, design, develop, qualify and deliver to NASA one prototype engineering model, one flight unit and other supporting material. The USA, in turn, would support the European effort and operate Spacelab within the Shuttle Programme. NASA undertook to procure a second Spacelab if it met its design requirements and if an agreed price could be established. An industrial consortium with the German firm ERNO as prime contractor was selected after a request for proposals was issued in 1974. Spacelab completed its first mission in December 1983 with European astronaut and payload specialist Ulf Merbold on board.

In its initial configuration the LIIIS launcher, soon renamed 'Ariane', was a three-stage vehicle 47.6 metres high and weighing 202 metric tons at lift-off. The first stage, L140, with a diameter of 3.8 metres, contained 140 tons of N_2O_4 and UDMH stored in separate, identical steel tanks. The stage was powered by four Viking-2 engines, which together gave a thrust of 240 metric tons at lift-off and had a burn time of 150 seconds. The second stage, L33, with a diameter of 2.6 metres, carried 33 metric tons of the same propellants, which were pressurised by helium. It was equipped with a single Viking-4 engine derived from Viking-2 by adapting the nozzle for operation in vacuum. The third stage, H8, had the same diameter as L33, and carried eight metric tons of liquid hydrogen and oxygen stored in tanks made of a light alloy specially chosen for its low-temperature behaviour. It was powered by an HM7 engine with a thrust of 6 metric tons.

LIIIS was designed to place 1500 kg into transfer orbit, so enabling the injection of satellites of some 750 kg into geostationary orbit using an apogee motor. It was aimed at a potential market estimated at 35 to 50 geostationary satellites weighing between 400 and 800 kg in the decade ahead. In 1973 its development was planned to cover seven years, with production starting around mid-1978. It was estimated that 2.06 billion French francs (or about 371 MAU at the conversion rate in force in January 1973) would be required for the vehicle's flight qualification.

The first successful launch of Ariane 1 took place on Christmas Eve 1979.

Chapter 10 — Conclusion

In the preceding chapters we have charted the tortuous steps that led to the establishment of the European Space Agency. That organisation, which officially came into being in 1975, was born in a very different context from its two predecessors, ESRO and ELDO, and its goals were shaped by very different considerations. In this the final chapter of our short book, and at the risk of some repetition, we want to try to delineate the main outlines of that context, and to identify some of its implications for the new European organisation.

When ESRO and ELDO were set up the Cold War was shifting from confrontation to competitive co-existence. USA/USSR rivalry, sparked by the Korean War in the early 1950s, had been fuelled by the launch of Sputnik. The increase in tension during the early 1960s — between February and August 1961 alone the first Minuteman ICBM was successfully launched, the CIA sponsored a disastrous invasion of Cuba at the Bay of Pigs, and the construction of the Berlin wall began — was accompanied by a number of major space spectaculars. During these same six months, Yuri Gagarin became the first human to orbit the Earth and Kennedy announced the Apollo programme with the objective of placing a man on the Moon before the decade was out.

Military programmes for satellite reconnaissance and rocket development were in full swing in both the United States and the Soviet Union. At the same time, civilian space programmes in both countries were given an enormous boost, with considerable impact on public opinion. The Gagarin feat, which heralded the start of the Soviet 'man-in-space' programme, was countered by the mighty project Apollo, which opened the floodgates of government funding to the tune, eventually, of $30 billion. Space was at the heart of a 'race' for political, ideological, military and technological superiority between the superpowers.

The European governments that had set up ESRO and ELDO were pushed, and dragged, into a collaborative space venture at this time for rather different reasons. They had neither the spur of superpower rivalry to drive them, nor the resources to compete meaningfully with either the USA or the USSR. Certainly some of the major nations, notably France, were determined to enter space if only because they felt that unless they did so they could have no pretensions to big power status. Even then, France apart, none of them was really interested in developing important (national) military programmes. They collaborated essentially because they saw space as a newly developing domain for scientific research, as having potential for applications of commercial interest at some time in the future, and as a channel for state investment in advanced technology. A joint European venture enabled them to share costs in an area the benefits of which were as yet somewhat obscure, and also enabled them to seal and extend the newly-established political alliances that had led to the creation of the European Economic Community and of Euratom in 1958.

By the mid 1970s, when ESA was created, the global and the European political contexts had changed sharply. The Apollo programme to put people on the Moon had reached its dramatic climax in July 1969. The 'space race' was past history, as were the dangerous Cold War confrontations of the early 1960s. Space activities had become routine. The success of communications satellites and the attraction of other important satellite applications (meteorology, Earth observation, air and maritime traffic control, etc.) had made economic and commercial interests, rather than the logic of political and military confrontation, a driving force of space activities. Both the USA and the Soviet Union sought international legitimisation, the one as it painfully disengaged itself from Vietnam, the other after its suppression of revolts in eastern Europe, and in the face of increasing difficulties with China.

The emphasis was on accommodation within a mutually acceptable framework of peaceful co-existence. This was encouraged, of course, by the balance of military force and the fear that a nuclear war would inevitably lead to mutual destruction. If space, for the Kennedy administration, had been a tool to illustrate the USA's superiority over the USSR, for Nixon it was a politically and

The ESA 'thumb-print' logo

The eleven original member states of ESA, together with Austria, Norway and Finland which have since joined.

ideologically appropriate means for cementing 'friendship' with the Soviet bloc, of which the Salt disarmament talks were another facet.

This general climate of international détente was paralleled in Europe by a new openness to the enlargement of the EEC. With the departure of De Gaulle in France, and an ongoing wish by the UK government to be part of the European Economic Community, the barriers to British entry were soon removed. On 1 January 1973 the Common Market was enlarged for the first time to include Denmark, Ireland and the United Kingdom.

The effects of these changes were reflected in ESA's membership. If Europe entered space with two organisations in the early 1960s it was partly because the military associations of rocketry, not to speak of the cost, led the neutrals and some of the small countries to keep out of ELDO. By the early 1970s, rockets had lost much of their bellicose symbolic value. All ten member states of ESRO signed the Convention for the single new organisation, which included the development of Ariane in its panoply of activities. What is more, consistent with the enlarged Europe, they were joined by an eleventh, Ireland.

The entire focus of the European programme had also become sharper, and its mission re-oriented. Applications satellites, especially for telecommunications, and the 'guaranteed' access to a launcher powerful enough to put them into geostationary orbit, were the backbone of ESA's programme. As we saw in chapter 9, the first package deal agreed in 1971 committed governments to spending about 100 MAU for each of three applications programmes: one for telecommunications, expected to cost about 400 MAU overall (only the phase 2 expenditure was agreed at this stage), one for meteorology, and one for aeronautical navigation (subsequently cancelled after a bruising dispute with the USA). This went along with a major de-emphasis of the science programme, which was only allocated 27 MAU annually (all in 1971 prices). In compensation, the science programme was made mandatory, essentially as a way to secure the participation of all member states, and notably France, in an activity that some thought need not be pursued at the European level.

An early Ariane launch – a major outcome of the decision to form a single European Space Agency

The scientists, understandably, were not entirely happy about this. It was they, after all, who had put a joint European space effort on the agenda in 1959/60. It was they too who, through ESRO, had proved, and that against considerable odds, that European collaboration in space could actually work. By any measure, their position shifted, during this first decade, from centre to periphery. The ceiling imposed on their budget in 1971 remained unchanged throughout the 1970s and beyond, even when there were major increases in the overall level of resources available for space. The space science community recognised that it was 'inevitable' that the weight of science in the programme would decrease. At the same time they resented seeing it reduced so sharply. The shortage of funds was particularly acute because, in addition to choosing from wide ranging 'classical' programme based on unmanned satellites and space probes, there were new opportunities for experimentation opened up by the development of Spacelab both in the traditional space disciplines and in new sectors such as material and life sciences. If the space science community has accepted these constraints, it was partly because they had little choice, and partly because ESA was never the only avenue open to them for launching space experiments. In the 25 years since 1962, almost 40 scientific satellites have been launched in European national programmes, compared to only 15 through ESA. Add to this the possibilities of cooperating with NASA, and we see that the space science community has not lacked for opportunities. Indeed, from a relatively small, young and inexperienced group in the early 1960s, the space science community in the ESA member states numbered more than 2500 people in 1988.

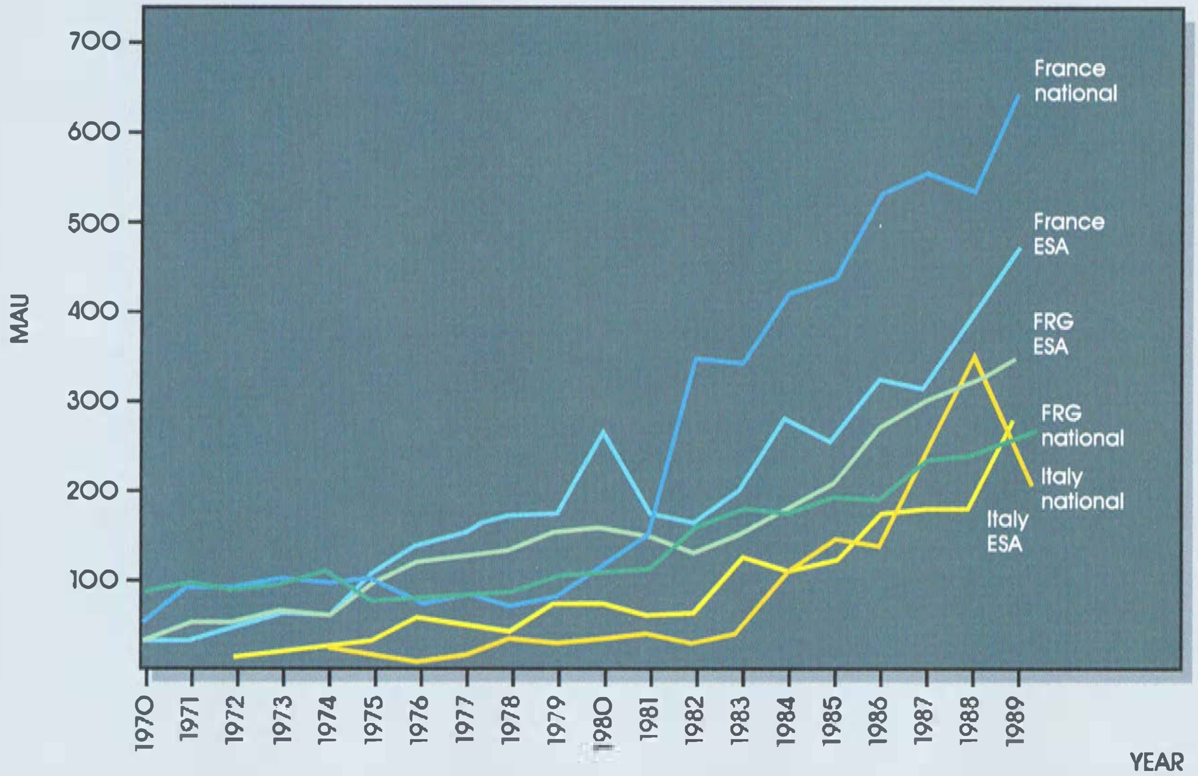
The new 'coherence' in the European space effort, as seen by governments, and the de-emphasis of science over the decade, was facilitated by a number of key developments both in Europe and across the Atlantic. For one thing, the technical feasibility and commercial potential of telephone, telegraph, and television links by satellite had been demonstrated in the USA. This helped convince the initially very reluctant and vacillating European PTTs of the technical benefits of telecommunications satellites, which they ultimately felt obliged to exploit notwithstanding their ongoing doubts about the economics of a space-based system. At the same time, and giving further encouragement to the Europeans, there was an important redistribution of power inside Intelsat. The interim agreements setting up this organisation in 1964 reflected the dominant position of the United States in the technology of satellites and launchers. The 'final' agreements signed in 1971 gave more weight to other countries. In particular, the Europeans had managed to secure the right to develop telecommunications systems which would cross their national boundaries as well as reaching North Africa and the Middle East. Certainly Intelsat's priority over global coverage was recognised, and the agreements insisted that no 'regional' system could be built which would cause it significant economic harm. At the same time, the sting was drawn from this requirement for Intelsat was not permitted to enforce sanctions against the violators of this principle; all it could do was issue them with non-binding recommendations.

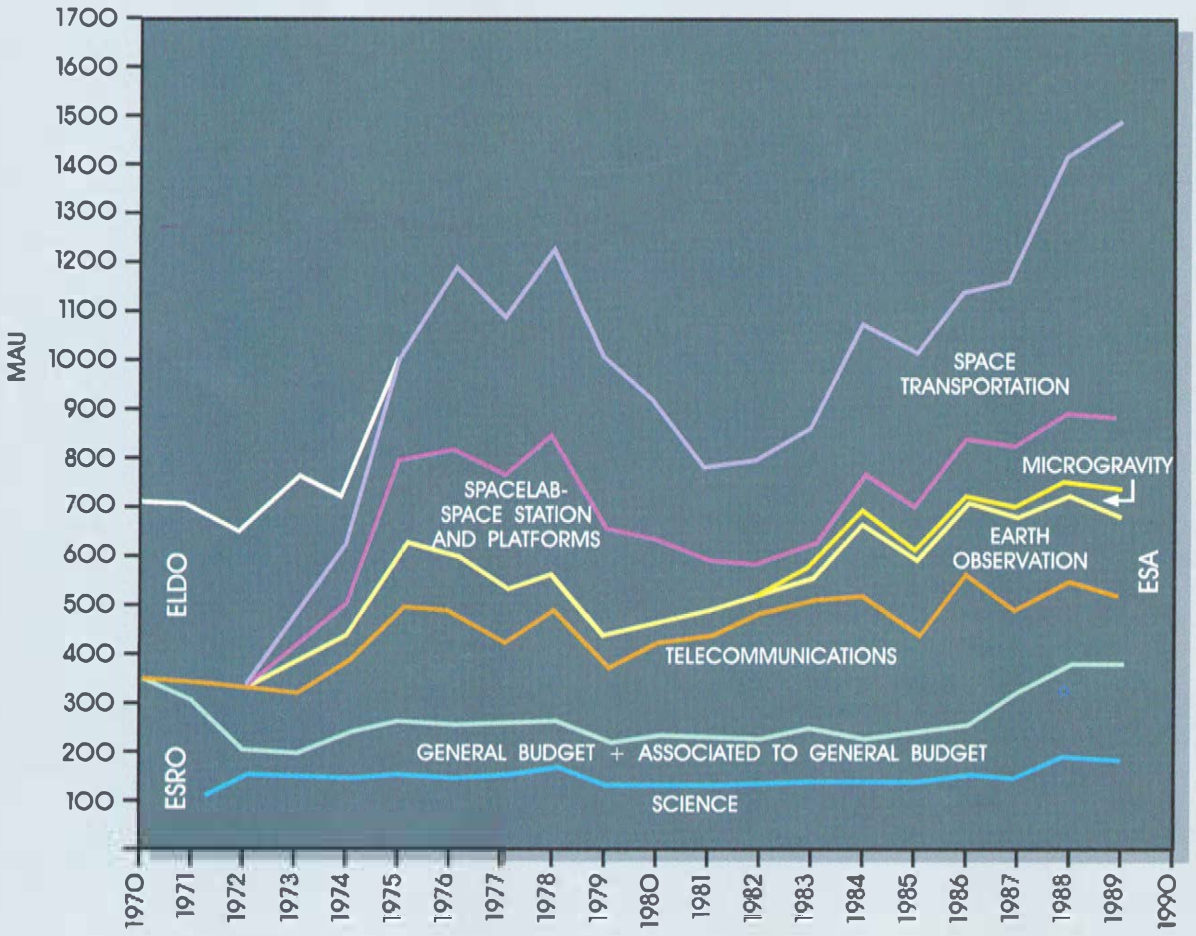
A resolution to the launcher question had also been found. Essentially it involved accepting that Britain would not play a role in the development of a new European rocket even though the outstanding success of Blue Streak showed that she had an immense pool of industrial knowhow and technical skills in the field. The French took on prime responsibility for developing Ariane, encouraged no doubt by American attitudes over Symphonie. This was supposed to be launched by the Europa rocket and used to transmit television pictures of the 1972 Munich Olympics. In the event the Europa programme was a technical disaster and the USA refused to launch anything but an experimental telecommunications satellite. For many, this experience confirmed that it simply made no sense to commit oneself to a telecommunications programme without having an independent launch capability.

As we have stressed, this launcher policy had always had two aspects in the minds of those who supported it. It was intended to improve Europe's bargaining position with the USA, both so as to ensure her autonomy in space and to enable her to cooperate with the USA from a position of strength. Indeed, by the early 1970s, Europeans were no longer mere apprentices of the USA in the space sector as had been the case in the early 1960s but had, in the words of Reimar Lüst, become 'junior partners.' There might have been widespread disappointment in Europe over the outcome of the post-Apollo negotiations, and considerations like the 'clean interfaces' policy which led to Spacelab might have restricted the sharing of technology with the USA. But the very fact that European engineers and industries were building a scientific laboratory to be flown aboard the Shuttle, and to be used also by United States' astronauts, demanded intense trans-Atlantic technical and managerial collaboration. A similar trend was seen in the science programme. Whereas in the 1960s collaboration had been restricted mostly to launching European satellites, or to placing European experiments on United States' satellites, as well as to data-sharing, now there were genuinely joint, coordinated satellite projects such as the ISEE 'mother' and 'daughter' pair

Spacelab, Europe's contribution to the post-Apollo programme being prepared for a trip aboard the Space Shuttle

Along with a single organisation, a coherent programme and a new confidence in dealing with the USA, the governments that set up ESA committed themselves to a massive increase in funding for the joint European space effort. In the ten years from 1963 to 1972 they spent in total around $1 billion on ESRO and ELDO. By contrast they spent about the same amount on ESA in just three years in the mid-1970s (1975 to 1977). Much of this was, of course, for the development of Spacelab and Ariane. At the same time, there was an effective redistribution of resources between national and European programmes. The former had absorbed about $1.5 billion between 1963 and 1972; some 50% more than the joint European effort. The relationship was reversed between 1975 and 1977, Historical Evolution of European Space Expenditures





when European governments invested about $0.6 billion in national programmes, or about 60% of what they were spending on the collaborative programme in the same period.

This new financial commitment was only possible because, unlike in the early 1960s, governments were clearer about what they wanted out of the European space effort. Neither ESRO nor ELDO had sharply defined objectives when they were set up. Governments, initially unsure, and later divided about what the long-term aims of the space effort should be, were loath to commit themselves to additional funding beyond the limits laid down in the early 1960s. This led to a constant redefinition of the content of the science programme, and to repeated threats to the very survival of the launcher programme. With the advent of applications satellites and a launcher programme, some of the uncertainty inherent in this arrangement disappeared. Governments now set overall priorities and, while there could still be bitter disputes over just how to achieve specific objectives and at what cost, there was also a new willingness, and an appropriate institutional flexibility, to see projects through to completion.

At the heart of this flexibility there was the system of optional programmes and the procedural rules defining the practices of ESA's Programme Boards (see chapter 9). From the mid-1960s onwards, both ESRO and ELDO had been plagued by a rigid structure that effectively enabled a single, discontented member state to block funding for a programme that it did not like, and so hold the entire organisation to ransom. The TD crisis in ESRO and the fundamental differences in priority between Britain and France in ELDO taught everyone that it was impossible to expect European collaboration in space to succeed if all programmes were mandatory. Compromises that took account of the different needs of different countries had to be built into the system. In the space sector, and indeed later in the European Community itself, the à la carte system was the preferred if pragmatic solution.

The idea of having optional programmes to which individual countries could contribute if they wished might have disillusioned those who identified a united Europe with a willingness of all partners to contribute to every activity. But if a joint European space effort were to survive, this idealism had to go. As the ESA Convention recognised, Europe was a patchwork of nation states with very different and sometimes conflicting interests that had to be respected.

The new commitment to invest in space, and indeed the whole concept of optional programmes, went along with a new determination by governments to use the joint space effort as an arm of industrial policy. One of the most divisive issues in the late 1960s (it was at the heart of Italy's frustrations in both ESRO and ELDO) had been the question of 'fair return' and of industrial policy in general. This was barely alluded to in ESRO's convention; in fact it took several years before ESRO's AFC came up with a workable policy of 'juste retour.' ELDO was of course based on entirely different premises, with governments ensuring from the start that most of the money that each invested on developing a multistage European launcher was spent at home. By the late 1960s, it was clear that with a space programme of limited scope, and with tight financial constraints (which led to both the TD and the ELDO PAS crises), it was extremely difficult to ensure that all countries had return coefficients of even 0.8.

Their concerns at the time were heightened by the growing conviction in some European circles that a 'technological gap' had opened up between the two sides of the Atlantic in advanced technology. To close this gap, it was argued, one needed to encourage specialisation and, where possible, to integrate European high-tech firms. The principle of just return was one instrument which, it was hoped, could do this. By encouraging groups of industries competing for contracts to form themselves into a number of consortia, one would be able to avoid unnecessary duplication (eg. in the production of solar arrays) while maintaining competition. ESA was thus intended to be not merely an agency dedicated to space, but also an organ for wedding technology policy with industrial policy at the European level.

It would be misleading, to put it mildly, to suggest that, with the foundation of ESA, the problems that had so plagued European space policy in the 1960s were removed at last. On the contrary, some issues that surfaced in the period covered by this book became even more pressing and intractable in the following years. ESA's industrial policy is a prime example here. Indeed ESA's Convention never managed to tackle this question head on, and the principle of 'fair return', insisted on ever more strongly by governments, has remained an underlying source of difficulty for the organisation.

We have already briefly alluded to the conflicts surrounding the implementation of the OTS programme. Behind conflicts like this lay, of course, the determination of the member states to defend their national space industries. The principle of just return, so favoured by the smaller, and by the technologically less advanced, countries in Europe, has been little more than a thorn in the side of France and Germany. Their national programmes have been sufficiently large to sustain a more or less autonomous space industry and they have been repeatedly frustrated by the need to see contracts that could have gone to their firms necessarily allocated elsewhere so as to spread the work through Europe in proportion to a member state's contribution to an ESA programme.

These difficulties are a useful reminder that in space, unlike in high-energy physics for example, many governments have persisted with a two-track approach, the national and the European. The formation of ESA, like European collaboration in general, was seen by its founders as a way of pursuing their national interests by means other than direct rivalry. Throughout the sixties, a constant question was: 'just why is a collaborative European space effort needed, and what should its aims be ?'. The major countries, which saw the political, industrial and commercial values of space, and which were determined to exploit them with strong national space programmes and bilateral agreements, frequently wondered why they also needed an inevitably more ponderous European-wide programme. These questions were not resolved when ESA was born, and they still persist in different guises to this day.

An early image from Meteosat, one of the applications missions made possible by the advent of optional programmes in ESA

Appendix 1
Abbreviations and Acronyms

AFC	Administrative and Finance Committee (ESRO)
ARPA	Advanced Research Projects Agency (USA)
AWG	Astrophysics Working Group (ESRO)
BNCSR	British National Committee on Space Research (UK)
CASDN	Comité d'Action Scientifique de la Défense Nationale (France)
CEPT	Conference Européenne des Postes et des Télécommunications
CERN	Centre Européen pour la Recherche Nucléaire
CETS	Conference Européenne des Télécommunications par Satellites
CNES	Centre National d'Etudes Spatiales (France)
CNR	Consiglio Nazionale delle Ricerche (Italy)
COPERS	Commission Préparatoire Européenne de Recherche Spatiale
COS-B	Cosmic Ray Satellite B
COSPAR	Committee on Space Research
CSO	Committee of Senior Officials (ESC)
CSAGI	Comité Spécial pour l'Année Geophysique Internationale
DFG	Deutsche Forschungsgemeinschaft (Germany)
EBU	European Broadcasting Union
ECS	European Communications Satellite
EEC	European Economic Community
ELDO	European Launcher Development Organisation
ESA	European Space Agency
ESC	European Space Conference
ESDAC	European Space Data Acquisition Centre
ESLAB	European Space Research Laboratory
ESOC	European Space Operations Centre
ESRANGE	European Space Range
ESRIN	European Space Research Institute
ESRO	European Space Research Organisation
ESTEC	European Space Technology Centre
ESTRACK	European Space Tracking and Telemetry Network
EXOSAT	European X-ray Observatory Satellite
FPP	Fundamental Physics Panel (ESRO)
GEERS	Groupe d'Etude Européen pour la Recherche Spatiale
GEOS	Geostationary Scientific Satellite
GTST	Group de Travail Scientifique et Technologique (COPERS, also STWG)
HELOS	Highly Eccentric Lunar Occultation Satellite
HEOS	Highly Eccentric Orbit Satellite
HSD	Hawker Siddeley Dynamics
ICBM	Intercontinental Ballistic Missile
ICSU	International Council of Scientific Unions
IGY	International Geophysical Year
IRBM	Intermediate Range Ballistic Missile
ISEE	International Sun – Earth Explorer
IUE	International Ultraviolet Explorer
LAFWG	Legal, Administrative and Financial Working Group (COPERS)
LAS	Large Astronomical Satellite
LPAC	Launching Programme Advisory Committee (ESRO)
MARECS	Maritime European Communications Satellite
MAROTS	Maritime Orbiting Test Satellite

MAU	Million Accounting Units
MBB	Messerschmitt-Bölkow-Blohm
MFF	Million French Francs
MIT	Massachussetts Institute of Technology
NACA	National Advisory Committee on Aeronautics (USA)
NASA	National Aeronautics and Space Administration (USA)
OAO	Orbiting Astronomical Observatory (NASA)
OSO	Orbiting Solar Observatory (NASA)
OTS	Orbiting Test Satellite
PAS	Perigee – Apogee System (ELDO *Europa 2* rocket)
PG	Preparatory Group (ELDO)
PSAC	President's Science Advisory Committee (USA)
PTT	Post, Telephone and Telegraph Administration
RAE	Royal Aircraft Establishment
SAS	Small Astronomical Satellite (NASA)
SEREB	Societé pour l'Etude et la réalisation d'Engines Balistiques
SETIS	Societé pour l'Etude et l'Intégration de Systèmes Spatiaux
SIRIO	Satellite Italiano per la Ricerca Industriale Operativa
SPB	Scientific Programme Board (ESRO)
SPC	Science Programme Committee (ESA)
SSD	Space Science Department (ESTEC)
SSWG	Solar System Working Group (ESRO)
STC	Scientific and Technical Committee (ESRO)
STV	Satellite Test Vehicle (ELDO *Europa 1* rocket)
STWG	Scientific and Technical Working Group (COPERS, also GTST)
TD	Thor-Delta (rocket)
TPS	Technical Planning Staff (CETS)
UKATS	United Kingdom Application Technology Satellite
UNESCO	United Nations Educational and Scientific Organisation
USAF	United States Air Force
UVAS	Ultra-Violet Astronomy Satellite
WIFAS	Wide-Field Astronomy Satellite

Appendix 2

From ESRO and ELDO to ESA: A Selective Chronology of Events

(those of general interest appear in italics)

4 October	*Launch by the Soviet Union of Sputnik 1, the first man-made Earth satellite.*	**1957**
3 November	*Launch of Sputnik 2, carrying the dog 'Laika'*	
31 January	*Launch of the first United States' satellite, Explorer 1.*	**1958**
20 May	*De Gaulle becomes Prime Minister of France.*	
1 October	*Creation of NASA*	
April	E. Amaldi and P. Auger, walking in the Luxembourg Gardens in Paris, discuss the possibility of a joint European space effort.	**1959**
12 September	*The Soviet Luna 2 spacecraft impacts on the Moon.*	
25 November	*The CERN proton synchrotron accelerator, the biggest in the World, goes into full operation for the first time*	
December	E. Amaldi's article entitled 'Créons une organisation européenne pour la recherche spatiale' is published, with supporting comments, in the French magazine 'L'Expansion de la recherche scientifique'	
12 December	*Creation of the United Nations Committee on the Peaceful Uses of Outer Space.*	
11–15 January	First General Assembly of COSPAR in Nice. Amaldi's proposal discussed by European space scientists.	**1960**
29 February	Meeting of European space scientists in P. Auger's flat in Paris.	
13 April	The UK government announces its decision to cancel its *Blue Streak* rocket as a missile for military use.	
29 April	Meeting of space scientists from ten West European countries at the Royal Society in London: plea for 'European co-operation in space research'	
23–24 June	At a meeting in Paris, the GEERS is established.	
12 August	*Successful launch by NASA of the balloon satellite Echo 1, to test space telecommunications by passive reflection.*	
19 August	*The dogs 'Strelka' and 'Belka' successfully put into orbit and returned safely to Earth aboard a Soviet spacecraft.*	
September	The British Minister of Aviation, P. Thorneycroft, tours several European capitals to invite governments to participate in the development of an all-European satellite launcher with Britain's *Blue Streak* as the first stage.	

1960	3–6 October	Scientific experts, convened at the Royal Society by GEERS, outline the principles of a possible space organisation.
	4 November	*J.F. Kennedy elected President of the United States.*
	28 November –1 December	Delegates from 11 West European governments, meeting at CERN in Geneva, adopt an agreement setting up COPERS.
1961	30 January –2 February	At an intergovernmental meeting in Strasbourg, it is agreed to go ahead with the development of a European launcher.
	27 February	Agreement establishing COPERS comes into force.
	12 April	*Yuri Gagarin (USSR) becomes the first human to orbit the Earth.*
	25 May	*President Kennedy, in an extraordinary State of the Union message, announces a plan for a manned Moon landing by the end of the decade.*
	31 July	*The British Prime Minister, H. Macmillan, announces the opening of negotiations for the participation of the UK in the European Economic Community (EEC).*
	24–25 October	The third plenary session of COPERS approves the initial eight-year programme of ESRO (*Blue Book*).
	30 October –3 November	Delegates from six West European governments plus Australia, meeting at Lancaster House in London, agree on the ELDO programme and establish a Preparatory Group to start its implementation.
	7 December	*France and the UK agree on a collaborative venture for the development of a supersonic airliner (eventually called 'Concorde').*
1962	20 February	John H. Glenn becomes the first American to orbit the Earth.
	29 March	The ELDO Convention is opened for signature.
	26 April	*The first of the Ariel series of satellites carrying experiments built by British scientists is successfully launched from Cape Canaveral.*
	14 June	The ESRO Convention is opened for signature.
	10 July	*Successful launch by NASA of the Telstar satellite, carrying the first transponder for real-time space telecommunications. On 23 July, television pictures are transmitted across the Atlantic for the first time.*
	29 September	*First Canadian satellite, Alouette-1, successfully launched from Vandenberg, California, by a Thor-Agena rocket.*
1963	*29 January*	*Because of French opposition, negotiations on the UK's admission into the EEC are suspended.*
	22 November	*President Kennedy assassinated in Dallas, Texas.*

1964

29 February — The ELDO Convention enters into force.

20 March — The ESRO Convention enters into force.

23–24 March — First meeting of the ESRO Council: P. Auger appointed Director General.

5–6 May — First meeting of the ELDO Council R Carrobio di Carrobio appointed Secretary General

15 June — Firing F1 of first stage of ELDO rocket (Blue Streak alone) carried out successfully from the ELDO range at Woomera in Australia

6 July — First ESRO sounding rocket successfully launched from Sardinia.

20 August — *The (interim) agreement setting up Intelsat signed in Washington*

15 October — *General elections in the UK give majority to Labour Party after 13 years of Conservative rule. H. Wilson becomes Prime Minister.*

20 October — Firing F2 of first stage of ELDO rocket (Blue Streak) carried out successfully

15 December — *Italy's (and Europe's) first satellite, San Marco 1, successfully launched from Wallops Island by a Scout rocket*

1965

1 March — First foundation pile laid for ESTEC at Noordwijk.

18 March — *Astronaut A. Leonov (USSR) becomes the first man to leave a spaceship and float freely in outer space*

6 April — *United States' communications satellite Early Bird successfully launched into geostationary orbit. On 28 June it inaugurates commercial services in satellite telecommunications.*

September — First major vacuum test facility installed at ESTEC.

26 November — *The first French satellite, Asterix 1, successfully launched by a French Diamant rocket from the Hammaguir range in the Algerian Sahara.*

1966

1 January — ESRIN opens its doors in the old Park Hotel near Frascati

31 January — *The Soviet spacecraft Luna 9 achieves the first successful soft landing on the Moon.*

1 March — *The Soviet spacecraft Venera 3 impacts on the planet Venus, becoming the first spacecraft to reach another planet*

15 20 May — ESRO solar eclipse sounding-rocket campaign, Karystos, Greece.

24 May — Firing F4 of ELDO *Europa* rocket first stage and inert upper stages – carried out successfully

1966	7–8 July	ELDO Ministerial Conference approves the ELDO-PAS (*Europa 2*) programme. British financial contribution to ELDO drastically reduced.
	24 September	Inauguration of ESRANGE, Kiruna, Sweden.
	14 October	Fire destroys part of ESLAB and ESTEC buildings.
	20 November	First sounding-rocket launch from ESRANGE.
	30 November –2 December	The ESRO Council fails to agree unanimously on a three-year level of resources. The Organisation loses legality and all future budget decisions require unanimity. The Council, however, agrees that ESRO should undertake a study on a European communications satellite programme, on behalf of the CETS.
	13 December	First meeting of the European Space Conference (ESC), in Paris.
1967	30 May	ESRO's first satellite (*ESRO-II*) launched from Vandenberg range by a Scout rocket. Owing to rocket malfunctioning, the launch failed and the satellite was lost.
	June	*Franco–German agreement for joint development of the experimental communications satellite Symphonie.*
	11–13 July	Second ESC meeting, Rome. Creation of the Causse Committee to work out a coherent European space programme. ESRO requested to design a television-relay satellite meeting the needs of the European Broadcasting Union (EBU).
	4 August	Firing F6/1 of ELDO *Europa* rocket, the first with a live second stage. The second stage does not ignite.
	8 September	Inauguration of ESDAC in Darmstadt, Germany.
	18 October	*The Soviet spacecraft Venera 4 makes a soft landing on the planet Venus.*
	1 November	H. Bondi replaces P. Auger as ESRO's Director General.
	5 December	F6/2 Firing of ELDO *Europa* rocket: separation between first and second stages achieved, but ignition of second stage did not proceed as planned.
	19 December	*As a result of strong French opposition, the EEC Council of Ministers drops any further negotiation with the UK, Ireland, Denmark and Norway on their applications for membership.*
	December	ESRO presents its *Eurafrica* communications satellite project meeting EBU specifications.
	December	Publication of the Causse report, presenting a long-term comprehensive European space programme, including science, applications and launchers.
1968	3 April	Inauguration of ESTEC.

16 April	The British government rejects the Causse report and announces that the UK will not increase its financial committtment to the existing ELDO programmes or take part in any additional projects. Moreover, the UK would not participate in the *Eurafrica* project	**1968**
25 April	Preliminary industrial contract for the ESRO TD-1/TD-2 satellites cancelled because of cost escalation.	
17 May	ESRO II (Iris) successfully launched by Scout rocket from Western Test Range, California It is the first ESRO satellite in orbit	
1 September	ESLAB integrated into ESTEC, and called the 'Space Science Department' (SSD)	
27 September	ESRIN foundation stone laid in Frascati, Italy.	
3 October	ESRO I (*Aurorae*) successfully launched by Scout rocket from Western Test Range.	
8 9 October	The ESRO Council agrees to fund the TD-1 satellite as a special project excluding Italy	
11 November	The ELDO Ministerial Conference, in Bonn, decides to drop apogee motor and test satellite from ELDO PAS in order to stay within financial ceiling.	
12–14 November	Third ESC meeting, in Bad Godesberg It agrees on creating a single European space organisation out of ESRO and ELDO, with a minimum mandatory programme and a number of optional programmes. It also agrees that European launchers can be used at no more than 125% of the cost of a US launcher. Finally, the meeting agrees on the level of resources for ESRO in the three year period 1969 71	
30 November	F7 firing of ELDO rocket, the first one with all three stages live Launch failure due to premature cut out of third-stage engines.	
5 December	HEOS-A (HEOS-1) successfully launched from Cape Kennedy.	
19 20 December	Failure of the ELDO Council session because of strong disagreement between member states budget for 1969 not approved.	
24 December	*The United States spacecraft Apollo 8 with three astronauts onboard, orbits the Moon*	
23 January	*The Italian government approves the Sirio project, an experimental communications satellite essentially derived from the PAS test satellite.*	**1969**
2 March	*Maiden flight of the Anglo French Concorde supersonic airliner.*	
27 March	The ESC Committee of Senior Officials set up at Bad Godesberg meets for first time and nominates G Puppi as Chairman	

1969 15 April — ELDO Ministerial Conference adopts 1969 budget, but Italy and the UK withdraw from the *Europa 2* programme. Belgium, France, Germany and the Netherlands agree to continue this programme and to start studying a new rocket project (*Europa 3*).

28 April — *Resignation of President de Gaulle following government defeat in referendum on constitutional reform.*

10 June — *United States–German agreement on extensive technological co operation in space research*

1–2 July — The ESRO Council approves next ESRO satellite programme: the gamma ray astronomy satellite COS-B and the geostationary GEOS for magnetospheric studies.

3 July — Firing F8 of ELDO *Europa* rocket: new failure of the third stage.

21 July — *First manned lunar landing by the Apollo 11 mission.*

17 September — *The post-Apollo programme worked out by the US President's Space Task Group is announced. It proposes development of a space shuttle, a space station in orbit around the Earth, and a manned expedition to Mars.*

28 September — *Following general elections in Germany, W. Brandt becomes Federal Chancellor.*

1 October — ESRO-IB (*Boreas*) launched from Vandenberg. Because of injection into a lower orbit than planned, its lifetime was only 52 days.

14 October — NASA Administrator T. Paine meets the ESC Committee of Senior Officials, offering opportunities for cooperation in post-Apollo programmes.

8 November — *First German satellite, Azur-1, successfully launched from Vandenberg.*

10 November — The *Eurafrica* project considered not economically viable by the EBU. The ESC Committee of Senior Officials decides to set up a Working Group to study a communications satellite programme meeting the needs of the European PTTs, in collaboration with the CEPT (European Conference of European Postal and Telecommunications Administrations)

1970 *11 February* — *First Japanese satellite, Ohsumi, successfully launched.*

April — The Working Group on telecommunications presents its programme for a European communications satellite (ECS) system to be operational by 1980. The European PTT ministers endorse the programme

24 April — *First Chinese satellite, China-1, successfully launched*

27–28 April — The ELDO Council decides to go ahead with study and pre-development work on *Europa 3*. It also decides to conduct a study on a tug for transporting payloads between the space shuttle orbit and a geostationary orbit, in the framework of the NASA post Apollo programme.

12 June	F9 launch of *Europa 1*: the third stage fails to reach full thrust and launcher fails to reach escape velocity	**1970**
18 June	*General elections in the UK. The Conservative Party returns to power.*	
22–24 July	First session of the fourth ESC meeting in Brussels. It is agreed that negotiations be started with NASA over post-Apollo cooperation, and in particular over availability of US launchers for European commercial satellites. The meeting also agrees on the undertaking of the ECS programme, but only the preliminary phase of it is funded.	
4 November	Failure of the second session of the fourth ESC meeting in Brussels. Facing the ambiguous USA position regarding launchers, the disagreement between the countries concerning an independent European launcher is of such a magnitude that the meeting breaks up on the first day	
22 December	Trying to recover from the ESC crisis, the ESRO Council instructs its new Chairman, G. Puppi, to negotiate a new institutional framework for the development of application satellite programmes	
1 March	A. Hocker replaces H. Bondi as ESRO's Director General	**1971**
21 May	*Definitive Intelsat agreements signed in Washington.*	
13–14 July	The ESRO Council agrees that ESRO should contribute to the joint NASA/UK SAS-D satellite for ultraviolet astronomy. The satellite is eventually renamed IUE (International Ultraviolet Explorer)	
29–30 July	European firms present results of 12 months of studies of Space Tug to representatives of ELDO, ESC and NASA	
5 November	Test launch of the *Europa 2* rocket from Kourou, French Guiana. vehicle breaks up about 150 seconds after firing.	
20 December	The ESRO Council agrees on the first 'package deal'. Only the science programme is made mandatory. All application satellite programmes (aeronautical, communications and meteorological) are optional, but the four major countries commit themselves to contribute 70 MAU per year from 1974. The use of a European launcher is foreseen at a cost not higher than 125% of the cost of an equivalent non-European vehicle. The Council also agrees that the sounding-rocket programme and the scientific work at ESRIN be terminated.	
1 January	R. Aubinière replaces R. Carrobio di Carrobio as ELDO's Secretary General.	**1972**
5 January	*Nixon approves the development of the Space Shuttle.*	
22 January	*The UK, Ireland, Denmark and Norway sign the Treaty of Accession to the EEC. Membership enters into force on 1 January 1973.*	
31 January	Successful launch of HEOS-A2 (HEOS-2) from Western Test Range.	

1972	12 March	Successful launch of TD-1 from Vandenberg.
	April–May	Both tape recorders on TD-1 fail and a rescue operation is started to retrieve as much data as possible in real time by using tracking stations around the world
	June	Crisis in USA/European negotiations on the post-Apollo programme. The USA withdraws offer to collaborate on the space tug and drastically restricts possibilities of subcontracting on the Shuttle in Europe. The sortie module (Spacelab) alone is left for collaboration.
	1 July	Swedish authorities take over ESRANGE from ESRO.
	12 July	The ESRO Council authorises the Director General to sign an agreement with the French CNES concerning the development of Meteosat.
	22 November	Successful launch of ESRO-IV from Western Test Range.
	11 December	*Apollo 17 mission – the sixth and last manned landing on the Moon.*
	20 December	Fifth ESC meeting, in Brussels. It agrees on undertaking the Spacelab project and on carrying out the French LIIIS launcher project (eventually renamed *Ariane*) in a European framework. The *Europa 3* programme is cancelled.
1973	11–12 April	The ESRO Council approves the new scientific satellite programme: the X-ray astronomy satellite HELOS (Exosat) and the magnetospheric satellite IMP-D (ISEE-2), the latter being coupled with a NASA spacecraft (ISEE-1).
	27 April	The ELDO Council decides to liquidate the *Europa 2* programme and to wind down ELDO.
	31 July	The sixth ESC meeting, in Brussels, agrees on the second 'package deal', thus paving the way for the creation of the European Space Agency, hopefully by 1 April 1974. The new agency will be based on the 'programme à la carte' concept. France, Germany and the UK take major responsibility for funding the Ariane, Spacelab and MAROTS (maritime communications satellite) projects, respectively.
	21 September	The arrangement between ESRO and participating states in the first phase of the telecommunications programme enters into force. It foresees the development of the experimental satellite OTS (Orbital Test Satellite).
	21 September	The ESRO Council approves the draft arrangement between ESRO and European governments for the execution of the Ariane programme, open for signature from 15 October.
	24 September	Signature of the Memorandum of Understanding governing NASA/ESRO cooperation on Spacelab.

1 July	R. Gibson, ESRO's Director of Administration, takes over as Acting Director General	**1974**
2 August	Signature of the Memorandum of Understanding governing the Aerosat programme between ESRO, the US Federal Aviation Administration, and Canada	
30 August	*First Dutch satellite, ANS (Astronomical Netherlands Satellite), launched from Western Test Range.*	
15 November	*First Spanish satellite, Intasat, successfully launched from Vandenberg*	
15 April	The last ESC meeting, in Brussels, adopts the text of the Convention for the new European Space Agency R. Gibson nominated Director General The Convention was eventually signed by eleven states Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden, Switzerland and the United Kingdom.	**1975**
17 July	*Docking in orbit of American Apollo and Soviet Soyuz spacecraft.*	
9 August	Successful launch of COS-B, the first ESA satellite.	

Appendix 3

Source Material

Primary sources

The work reported here is based essentially on the large collection of documents in the files of ESRO, ELDO and ESA deposited in the European Communities Historical Archive at the European University Institute, in Florence, Italy. These documents give detailed information on the activities of the several bodies and advisory committees of these organisations. Originally scattered in several hundreds of folders sent from ESA's establishments, most of them are now arranged in a master set by their original reference code, running number and date, and are easily accessible for scholarly work.

The authors also used a number of tape-recorded interviews with pioneers and other protagonists of the early history of Europe in space, realised by P. Fischer, J. Krige, A. Russo and L. Sebesta in the framework of the ESA History Project. While we would like to acknowledge the value of these interviews, which are listed below, we want to stress that the conclusions contained in this book are the sole responsibility of the authors.

R. Aubinière, 17 December 1991 (LS)
M. Bignier, 16 December 1991 (LS)
J. Blamont, 11 December 1991 (LS), and 9 April 1992 (AR)
L. Bölkow and D.E. Koelle, 12 July 1993, (PF)
H. Bondi, 5 November 1992 (JK)
R. Boyd, 9 December 1992 (AR)
W. Brado, 13 July 1993 (PF)
J. Coulomb, 12 December 1991 (LS)
J. Geiss, 26 January 1993 (AR)
H. van de Hulst, 5 November 1992 (AR)
C. de Jager, 28 December 1992 (AR)
M. Lévy, 6 November 1992 (JK)
R. Lüst, 22 April 1993 (PF)
M. Mayer, 27 April 1993 (PF)
J. Ortner, 17 December 1992 (AR)
P. Piganiol, 13 December 1991 (LS)
G. Puppi, 5 November 1992 (JK)
F. de Rose, 13 December 1991 (LS)
H. Schramm, 13 July 1993 (PF)
J. Tassin, 1 September 1993 (JK)
J. Tiné, 12 December 1991 (LS)

Finally, among primary sources used extensively in our work, we should also list the ESRO and ELDO Annual Reports (1964 – 1974) as well as the collection of ESRO and (since 1968) ESRO/ELDO Bulletins.

Reports published in tbe ESA History series

In 1992, the European Space Agency's Publications Division at ESTEC, Noordwijk, started producing working papers emerging from the ESA History Project. This collection, coded ESA HSR (History Study Report), currently (spring 1994) includes thirteen numbered reports and one 'special' report. These constitute the main 'secondary' source for this book, both with regard to detailed historical analysis and for proper references, including bibliographies. A list of these reports, in chronological order, is given below.

J Krige, *The Prehistory of ESRO. 1959/60 From the First Initiatives to the Formation of the COPERS*, ESA HSR 1, July 1992.

A Russo, *ESRO's First Scientific Satellite Programme, 1961 – 1966*, ESA HSR 2. October 1992

A Russo, *Choosing ESRO's First Scientific Satellites*, ESA HSR 3, November 1992

J Krige, *The Early Activities of the COPERS and the Drafting of the ESRO Convention (1961/62)*, ESA HSR-4, January 1993

M De Maria, *Europe in Space: Edoardo Amaldi and the Inception of ELDO*, ESA HSR 5, March 1993

A Russo, *The Definition of a Scientific Policy: ESRO's Satellite Programme in 1969 – 1973*. ESA HSR 6, March 1993.

J Krige, *The Launch of ELDO*, ESA HSR-7, March 1993

J Krige, *Europe into Space The Auger Years (1959 – 1967)* ESA HSR-8, May 1993

A. Russo, *The Early Development of the Telecommunications Satellite Programme in ESRO (1965 1971)*, ESA HSR-9, May 1993.

A Russo (Ed), *Science Beyond the Atmosphere. The History of Space Research in Europe*, Proceedings of a Symposium held in Palermo. 5 7 November 1992, ESA HSR Special, July 1993.

M De Maria, *The History of ELDO Part I: 1961 – 1964*, ESA HSR-10, September 1993

J Krige & A Russo, *Reflections on Europe in Space*, ESA HSR 11. January 1994

P. Fischer, *The Origins of the Federal Republic of Germany's Space Policy 1959 – 1965 European and National Dimensions*, ESA HSR 12, January 1994.

A. Russo, *ESRO's Telecommunications Programme and the OTS Project (1970 – 1974)*, ESA HSR 13, February 1994

Other papers from the ESA History Project

The following is a list of papers reporting on the work performed in the framework of the ESA History Project and published in scholarly journals, books and conference proceedings:

M De Maria, 'Italy in Space Edoardo Amaldi and the take off of the Italian space programme', in ESA HSR-Special, pp 113 124

M De Maria & J. Krige, 'Early European attempts in launcher technology', in J. Krige (Ed), *Choosing Big Technologies* (Chur: Harwood Academic Publishers, GmbH, 1993), pp. 109 137

J Krige, 'The rise and fall of ESRO's first major scientific project, the Large Astronomical Satellite (LAS)', in J. Krige (Ed), *Choosing Big Technologies* (Chur: Harwood Academic Publishers, GmbH, 1993), pp. 1 – 26.

J. Krige, 'Britain and European space policy in the late 1960s and early 1970s', *Science and Technology Policy*, 5 2 (1992), pp. 13 – 18.

J Krige, 'How space scientists and governments saw ESRO in the early 1960s', in ESA HSR Special, pp. 29 40

J. Krige, 'An historian looks at the ESA Convention,' in *The Implementation of the ESA Convention. Lessons From the Past*, Proceedings of the ESA/EUI International Colloquium, Florence, 25 26 October 1993, (Dordrecht: Markus Nijhoff Publishers, 1994), pp 13 19

J Krige, 'The European space system', in ESA HSR-11, pp. 1 – 11.

J. Krige, 'Politicians, experts and industrialists in the launch of ELDO: some pitfalls and how to avoid them', in ESA HSR-11, pp. 13 25

J Krige & L Sebesta, 'US – European cooperation in space in the decade after Sputnik' to appear in G. Gemelli (Ed), *Intellectual Cooperation in Large Scale Cultural and Technical Systems*, in press.

A. Russo, 'Choosing big projects in space research: the case of ESRO's scientific satellite COS-B', in J. Krige (Ed.), *Choosing Big Technologies* (Chur: Harwood Academic Publishers, GmbH, 1993), pp. 27 – 61

A. Russo, 'Cooperation and competition: the European space science community and ESRO', in ESA HSR Special, pp. 81 – 88.

A. Russo, 'The early development of the telecommunications satellite programme in the European Space Research Organisation (ESRO)', in ESA HSR-11, pp. 27 – 36.

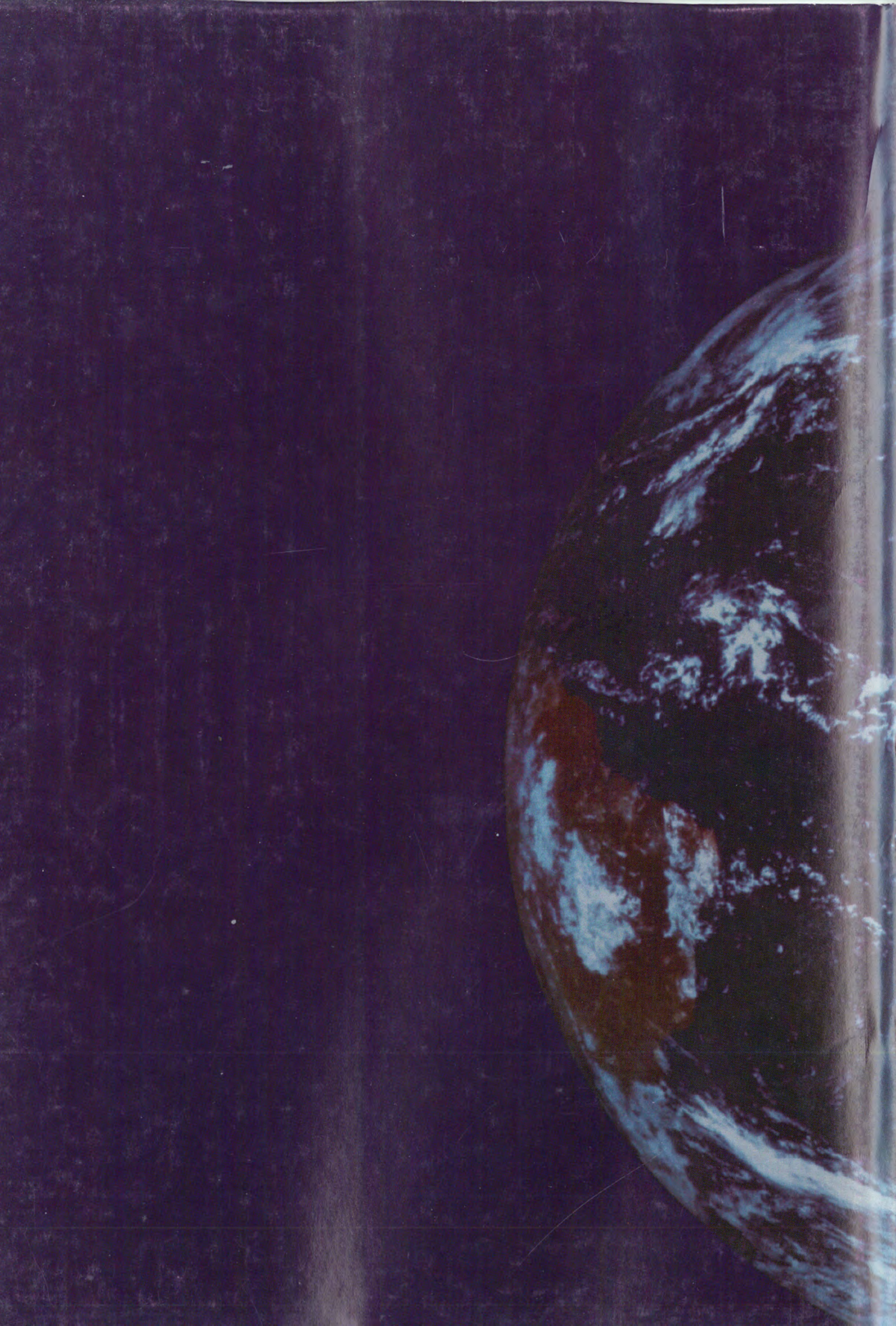
A. Russo, 'Big science in space: the case of the Giotto mission of the European Space Agency, in ESA HSR-11, pp. 37 – 49.

L. Sebesta, 'La science: instrument politique de securité nationale? L'espace, la France et l'Europe, 1957 – 1962,' *Revue d'histoire diplomatique*, (1992), pp. 314 – 341.

L. Sebesta, 'The politics of technological cooperation in space: US – European negotiations on the post-Apollo program', *History and Technology* (1994) 11:3. pp. 317 – 341.

Index

Index compiled by Katharine Anderson



esa SP-1172 Europe in Space 1960 - 1973