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A History of the European Space Agency

1958 – 1987

Volume I

The story of ESRO and ELDO, 1958 - 1973

by

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with contributions by M. De Maria and L. Sebesta

European Space Agency
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The Advisory Committee to the ESA History Study

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Foreword by Prof. Reimar Lüst

Chairman of the ESA History Project Advisory Committee

There is no doubt that Europe's history of excellence in space is one of the most visible achievements of European co-operation in science and technology which started some thirty five years ago. Today the European Space Agency, which brings together the resources and expertise of 14 nations, has achieved a high profile in many sectors of space activity, in particular in space science and launchers and is a strong partner in global space co-operation.

Not only should ESA staff and those working in industry and national institutions feel proud of what has been accomplished, but also future scientists and engineers of Europe should know about and be inspired by Europe's current achievements in space.

As someone who accompanied Europe's journey into space from the beginning until a few years ago, I know that progress in an institution such as ESA is never easy and success is impossible without co-operation. It is a lengthy and complicated process of persuasion to assemble the right package of programmes which has a reasonable chance of acceptance by the Member States. As with most major European technological ventures, the space programme requires a delicate equilibrium between the political, technical, and industrial interests of the various partners.

For anyone approaching the history of European space activities, the present volume will not only provide valuable insights into this turbulent but exciting period of the first ten years of European co-operation in space, but also be important for those who create the future of ESA.

I am convinced that Europe possesses all the resources and talents necessary to move forward in the exciting adventure of space and that ESA should be supported and strengthened as the centre of European space policy.

Finally, I would like to take this opportunity of offering my personal thanks to my friends and colleagues on the Advisory Committee who have contributed their expertise and dedication to the activities of the panel in guiding the ESA History Project.

Foreword by Mr Antonio Rodotà

ESA Director General

Among the institutions in the family of science organisations in Europe, the European Space Agency stands out as a shining example that international co-operation in science and technology can work. Building on the lessons learned from ESRO and ELDO, ESA has become an outstandingly successful model of European scientific and technical collaboration. Its contribution to the development of a collective European space capability has been fundamental. The Agency has played an important role not only in space but also in uniting Europe.

This success has resulted first of all from a sustained political will on the part of our respective governments and a long, productive partnership between the governments, ESA, industry and the user communities.

This study traces the history of the European collaborative space programme from the beginnings in the late 1950s to the creation of a single space agency in the early 1970s up to the recent developments in the light of its main actors and policies. It provides valuable insights into the complex decision making processes in a unique multinational organisation which often involves a delicate balancing act between the various interests of its Member States.

After some thirty five years of remarkable achievement in the advancement of cooperation in space, ESA now integrates a wide range of activities, from basic scientific research to advanced technology and applications, to launchers and Europe’s contribution to the International Space Station.

European co-operation in space provides a living history of science and engineering, of patient steps forward, of some setbacks and remarkable achievements. The story of the laborious but ultimately successful effort is thus not only of interest and importance to the Agency itself, but also to all those concerned with the managing of large co-operative scientific programmes in science and technology in general.

The philosopher George Santayana exhorts us to remember that “those who do not learn the lessons of history will be forced to repeat them”. I am convinced that the history of the development of a joint and distinct European capability conveyed in this book, can teach us some lessons about the leadership and vision that were needed to plan and implement a co-ordinated European space effort, in order to cope better with the challenges that lie ahead.

I warmly recommend this book to anyone with an interest in the birth and development of the European space programme and look forward to the second volume.

Foreword by K.-E. Reuter

Head of the Director General's Cabinet, ESA

The space age is relatively young and has not as yet, therefore, been the subject of extensive historical research. This is true above all for Europe, the old continent, as it did not participate in the space race of the 1960s. The European Space Agency, which has co-ordinated and implemented the exploration of space in Europe for more than 30 years, thus responded with great interest to an initiative by three professional historians of science to write an independent, academic history of ESA and its predecessor organisations ESRO and ELDO. Following a first contact in 1989, a feasibility study was conducted in the first half of 1990, the encouraging results of which were decisive for ESA giving full support to the history project.

The success of the project was supported by the fact that following the suggestions made in the feasibility study, the ESA History Project has been based on three cornerstones:

- Firstly, the research efforts of three professional, independent historians of science. Dr John Krige, who had already for some years headed the History of CERN Project, agreed to direct the project. Professors Arturo Russo and Michelangelo de Maria from the Universities of Palermo and Rome, respectively, were appointed project scientists and contributed substantially to the project. The latter left the project for personal reasons in 1993. His tasks were taken over by Dr Lorenza Sebesta of the University of Bologna.

- Secondly, the hosting of the project at an independent academic institution. Since the historical archives of ESA were set up in 1989 at the European University Institute in Florence, this institution appeared to be the best place for hosting the ESA History Project and to install Dr Krige as a scientist at the EUI. The Principal of the Institute agreed to this proposal and to jointly supervise the project with ESA. After five years the contractual co-operation with the EUI was terminated and the Project leader, Dr John Krige, moved to Paris where he became Director of the "Centre de Recherche en Histoire des Sciences et des Techniques" at the Cité des Sciences et de l'Industrie.

- Finally, the establishment of an Advisory Committee to monitor the progress of the research work and to advise ESA on administrative and academic aspects of the project. This Committee consists of a number of ESA pioneers (Michel Bignier, Peter Creola, George Van Reeth) and outstanding European professional historians (Prof. Paolo Galluzzi, Florence, Prof. Guido Gambetta, Bologna, Prof. Svante Lindqvist, Stockholm, Dominique Pestre, Paris, Dr Walter Rathjen, Munich). The chairmanship of the Advisory Committee was entrusted to Prof. Reimar Lüst, the Agency's former Director General, who has been actively involved in the European space activities since their very beginning and helped to inspire the History Project.

The ESA History Project which I have been overseeing as the ESA project manager since the initiation of the feasibility study in 1990, has produced an impressive output, including more than twenty self-standing reports in the ESA-HSR series, many presentations, seminars, and publications in the specialised literature, and now as the final product two large volumes summarising the history of European co-operation in space between 1960 and 1987.

But besides this rich production the thorough and scientific approach of the team of historians has also led to the rediscovery of many hidden facets of the European space effort that may otherwise have been forgotten forever.

It is therefore that I would like to pay a particular tribute to the historians John Krige, Arturo Russo and Lorenza Sebesta for their unceasing efforts that made this project such a fascinating experience.

Authors' Preface

This is the first of two volumes dealing with the history of the European Space Agency (ESA) and its predecessors, the European Space Research Organisation (ESRO), and the European Launcher Development Organisation (ELDO). It covers the period from the birth of ESRO and ELDO, in the early 1960s, up to 1973. In that year the decision was taken to bring ESRO and ELDO together in a new organisation (ESA) and the programmatic basis for the new agency was laid with the adoption of the so-called Second Package Deal. This arrangement, and the First Package Deal of 1971, allowed for a mandatory scientific programme to be supplemented by optional applications programmes in various fields, as well as two major undertakings, the Ariane launcher and Spacelab, a scientific laboratory to be carried on board NASA's Space Shuttle.

The detailed evolution of these programmes is not discussed here. They are taken up in Volume II, which concludes the history of ESA up to 1987. An epilogue schematically describes the re-orientation in the Agency's priorities in the decade thereafter.

These two books derive from the work of a team of professional historians, much of which has already been circulated in the ESA HSR (*History Study Report*) series. These volumes are not simply a collage of published texts however; unnecessary repetition and overlap have been avoided. New material not published before has been added. Together they thus constitute a major description and analysis of the broad lines of over 30 years of the space activities collectively undertaken by European governments through ESRO, ELDO and ESA.

The results presented here are essentially based on the excellent ESRO, ELDO and ESA archives housed at the Historical Archives of the European Community at the European University Institute in Florence (Italy). By concentrating on this vast collection of documents, freely available for scholarly research, we have been able to develop in detail the decision- making processes at the intergovernmental level which underpinned the formulation and evolution of the programmes in ESRO, ELDO and ESA. For more recent documents (from 1983 onwards), the authors have been granted access to the archives at the Agency's Headquarters in Paris.

Useful papers related to the history of Europe in space have also been consulted at the Public Record Office in Kew (London), at the US National Archives (Washington DC) and at the NASA History Office (at NASA Headquarters in Washington DC). Other important sources were the papers of Italian physicist Edoardo Amaldi at the University of Rome "La Sapienza", and of former NASA Administrator Thomas Paine (also in Washington, DC).

The main source we have used has provided documentary material which is fundamental to an understanding of the dynamics of European space policy. But it does not tell the whole story. The results of the scientific programmes, the evolution of the application programmes and of the user communities and their institutions (PTTs, meteorological services, as well as bodies like Eumetsat, Inmarsat, etc.), the internal decision making processes within different national bureaucracies, all of these remain to be studied in depth.

Much work is still to be done then. These volumes are presented primarily as an essential resource and reference work, the foundation stones for additional studies of the collaborative European space effort.

The authors owe an immense debt of gratitude to the European Space Agency, which promoted and supported this history for almost a decade, to those responsible for its archive at the European University Institute in Florence, to participants in the story itself, many of whom we interviewed in the course of this study, and to countless members of the European space community and colleagues who read our texts in draft and made valuable comments on them. Even if this will inevitably be seen as an

official history of ESA it has to be stressed that at no time has the access of the historians to archival material been impeded, nor have they been asked to suppress any material in their reports. Their academic freedom has been fully respected and the authors are entirely responsible for their findings and the interpretations they put on them.

The support, encouragement and help of some people deserve special mention. First and foremost, Professor Reimar Lüst, who promoted this project when he was ESA's Director General, and who has watched over it with fatherly care for almost ten years in his capacity as Chairman of the ESA History Advisory Committee. Then the ESA Director-General's Head of Cabinet, Mr Karl Reuter who, in consultation and collaboration with the ESA History Advisory Committee, has ensured the continued good functioning of the venture and helped to bring it to fruition.

Sound historical scholarship requires rich and accessible archives. The material possibility of this project has rested on the determined efforts of Gabriel Lafferranderie, ESA Legal Adviser, and of Eva Vermeer who put the archival programme on a solid basis. They could count on the support and collaboration of the head of the archive in Florence, Jean Marie Palayret, and of Gherardo Bonini, the archivist who was made directly responsible for the collection. We are also pleased to acknowledge the help of Dr Roger Launius of the NASA History Office in Washington D.C. Our debt to them, and that of the scholars who will follow us in this exciting field of research, is immense.

* * *

A few words need to be said about the organisation of the book. After a brief introduction, which sketches quickly the background to the collaborative European space effort, the volume is divided into five main parts. The first two deal respectively with the launch of ESRO and ELDO, which were both officially established in 1964. Part III deals with ESRO's scientific programme and part IV deals with the rise of a telecommunications satellite programme, also undertaken under the auspices of ESRO. The fifth and last part describes the tortuous process to establish a European space programme, a process which was bedevilled by deep disagreements over launcher policy, and which terminated with the so-called First and Second Package Deals adopted in 1971 and 1973. Included in part V are also two chapters dealing with the politics of US-European relations in space, which culminated in a major collaborative venture, the post-Apollo programme.

The way we have cut our material imposes an artificial logic on it, and separates out different threads which were, in practice, intimately interwoven with one another. Experience has taught us that it is simply impossible to build a chronologically linear narrative of this period. If we had divided our documents predominantly by date rather than by theme the tale we have to tell would have been unintelligible. The reader will hopefully thus forgive us for repeating in different sections some elements of debates which took place in key meetings. We have chosen to leave each part of the book as a unified whole in the interests of internal coherence, rather than making a fetish of avoiding minor repetition between sections.

The secondary literature on space history is vast, notably as regards the United States. We barely scratch its surface in these volumes. This is mostly because so little has, in fact, been written on the European space effort. These volumes not only fill that gap in the literature. They are precursors to more reflective and comparative studies in which we plan to contextualise our results and to relate them to other research in the field.

Abbreviations and Acronyms

AFC	Administrative and Finance Committee (ESRO, ESA)
AGARD	Advisory Group for Aerospace Research and Development (NATO)
ARPA	Advanced Research Projects Agency (USA)
ATT	American Telephone and Telegraph
AWG	Astrophysics Working Group (ESRO)
BAC	British Aircraft Company
BNCSR	British National Committee on Space Research
CALTECH	California Institute of Technology
CASDN	Comité d'Action Scientifique de la Défense Nationale (France)
CCTS	Coordinating Committee on Telecommunications Satellites (CEPT)
CEPT	Conférence Européenne des Postes et des Télécommunications
CERN	Centre Européen pour la Recherche Nucléaire
CETS	Conférence Européenne des Télécommunications par Satellites
CNES	Centre National d'Etudes Spatiales (France)
CNR	Consiglio Nazionale delle Ricerche
COPERS	Commission Préparatoire Européenne de Recherche Spatiale
COS-B	Cosmic Ray Satellite "B"
COSPAR	Committee on Space Research
CRS	Comité de Recherches Spatiales (France)
CSAGI	Comité Spécial pour l'Année Géophysique Internationale
CSO	Committee of Senior Officials (ESC)
CTS	Communications Technology Satellite (Canada)
DFG	Deutsche Forschungsgemeinschaft
DVLR	Deutsche Versuchsanstalt für Luft- und Raumfahrt
EBU	European Broadcasting Union
ECS	European Communications Satellite
EEC	European Economic Community
ELDO	European Launcher Development Organisation
ERS	Earth Resources Satellite
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 (Sounding Rockets and Related Research Programmes)
ESRIN	European Space Research Institute
ESRO	European Space Research Organisation
ESTEC	European Space Research and Technology Centre
ESTRACK	European Space Tracking and Telemetry Network
EUI	European University Institute
EXOSAT	European X ray Observatory Satellite
FIAT	Fabbrica Italiana Automobili Torino
FPP	Fundamental Physics Panel (ESRO)

GEERS	Groupe d'Etudes Européen pour la Recherche Spatiale
GEOS	Geostationary (Scentific) Satellite
GTST	Groupe de Travail Scientifique et Technologique (COPERS, also STWG)
HAEC	Historical Archives of the European Community (EUI)
HEAO	High Energy Astrophyiscs Observatory
HELOS	Highly Eccentric Lunar Occultation Satellite
HEOS	Highly Eccentric Orbit Satellite
HSD	Hawker Siddeley Dynamics
IAPC	Interim Application Programmes Committee
ICBM	Intercontinental Ballistic Missile
ICSU	International Council of Scientific Unions
IGY	International Geophysical Year
IRBM	Intermediate Range Ballistic Missile
ISEE	International Sun - Earth Explorer
ITU	International Telecommunication Union
IUE	International Ultraviolet Explorer
LAFWG	Legal, Administrative and Financial Working Group
LAS	Large Astronomical Satellite
LPAC	Launching Programmes Advisory Committee (ESRO)
LPSC	Launching Programmes Sub 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	Massachusetts Institute of Technology
NACA	National Advisory Committee on Aeronautics (USA)
NASA	National Aeronautics and Space Administration (USA)
NATO	North Atlantic Treaty Organisation
OAO	Orbiting Astronomical Observatory (NASA)
OECD	Organisation for Economic Cooperation and Development
OEEC	Organisation for European Economic Cooperation
OGO	Orbiting Geophysical Observatory (NASA)
ONERA	Office National d'Etudes et de Recherches Aéronautiques (France)
OSO	Orbiting Solar Observatory (NASA)
OTS	Orbiting Test Satellite
PAS	Perigee-Apogee System (ELDO Europa II rocket)
PB-TEL	Telecommunications Programme Board (ESRO)
PG	Preparatory Group (ELDO)
PSAC	President's Science Advisory Committee (USA)
PTT	Post, Telegraph and Telephone Administration
RAE	Royal Aircraft Establishment
SAS	Small Astronomical Satellite (NASA)
SEREB	Société pour l'Etude et la Réalisation d'Engins Ballistiques
SETIS	Société pour I'Etude et l'Intégration de Systèmes Spatiaux
SIRIO	Satellite Italiano per la Ricerca Industriale Operativa

SNIAS	Société Nationale Industrielle Aérospatiale
SPB	Scientific Programme Board (ESRO)
SPC	Science Programme Committee (ESA)
SSD	Space Science Department (ESRO/ESA)
SSWG	Solar System Working Group (ESRO)
STC	Scientific and Technical Committee (ESRO)
STP	Supporting Technology Programme (ESRO)
STV	Satellite Test Vehicle (ELDO Europa I rocket)
STWG	Scientific and Technical Working Group (COPERS, also GTST)
TD	Thor-Delta (rocket)
TPS	Technical Planning Staff (CETS)
TWTA	Travelling Wave Tube Amplifier
UKATS	United Kingdom Application Technology Satellite
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USAF	United States Air Force
UVAS	Ultraviolet Astronomy Satellite
WIFAS	Wide-Field Astronomy Satellite
ZWO	Nederlandse Organisatie voor Zuiver Wetenschappelijk Onderzoek

Introduction: The Beginning of the Space Age

J. Krige & A. Russo

I.1 Prophets, pioneers and generals: from science-fiction to the V-2 missile

For centuries people have fantasised 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 like Konstantin Tsiolkovsky (1857-1935) in Russia, Hermann Oberth (1894-1989) in Germany and by Robert Goddard (1882-1945) in the United States. Many of these early rocketeers were inspired by the science fiction they had read when young: books like Jules Verne's *De la Terre à la Lune* (1865) and *Autour de la Lune* (1870), H.G. Wells' *War of the Worlds* (1898) and *The First Men in the Moon* (1901), and Edgar Rice Burroughs' series of novels in Martian settings published on the eve of World War I.

A mathematics teacher in the provincial town of Kaluga, about 150 km from the capital, Tsiolkovsky started thinking of spaceflight at the turn of the century, out of his early work on aerodynamics. He recognised that rocket propulsion could be used for driving a craft in the empty space beyond the Earth's atmosphere and envisaged using fuels similar to kerosene or, for better performance, liquid oxygen and liquid hydrogen. Tsiolkovsky published his ideas in a few articles before World War I, but his work remained almost unknown until the mid-1920s.

Oberth was also a mathematics teacher. He had studied in Munich and Heidelberg but then had returned to his hometown in Romania, where he taught in the local *Gymnasium*. After World War I, Oberth developed a strong fascination with rockets and, like Tsiolkovsky, he recognised that by burning modern liquid fuels, such as gasoline and liquid oxygen, a rocket could achieve performance far surpassing that of any solid fuel based on gunpowder and its derivatives which had been in vogue until then. Drawing from science-fiction writers, Oberth argued that with a liquid fuel it was possible to make a very large manned spaceship capable of reaching the moon or other planets. In 1923 he published the results of his theoretical research on rocketry in a book, titled *Die Rakete zu den Planetenräumen* (The Rocket into Planetary Space), in which he identified the necessary equipment for sustaining people in an orbiting station used for astronomical observations and telecommunications. Oberth's *Rakete* obtained great success among the public and inspired the famous German filmmaker Fritz Lang, the author of the classic *Metropolis* (1926), to produce the science-fiction movie *Frau im Mond* (The girl in the Moon), released in 1929.

The third prophet of spaceflight, the American physicist R. Goddard, gave a solid experimental reality to the dreams of Tsiolkovsky and Oberth. Goddard published his early ideas in 1920, in a pamphlet titled *A Method for Reaching Extreme Altitudes*, which reported on the first results of his experimental programme supported by the Smithsonian Institution. Six years later, in March 1926, he launched the world's first liquid-fuelled rocket from a test area located in a strawberry farm near Auburn, Massachusetts. It flew a distance of only about 50 m, but it was followed by other successful tests that helped to secure further support from the Smithsonian Institution and, more important, from the Guggenheim Foundation. This support allowed Goddard to establish a serious programme in rocket research in New Mexico and, in December 1930, an important success was achieved when a rocket flew at a speed of 800 km/hr up to an altitude of about 650 m. In his next rounds of experiments, Goddard introduced important new improvements such as cooling and gyroscopic guidance.

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.[1] These societies

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[1] Winter (1983). On the early history of rocketry see also Von Braun & Ordway (1969).

performed a number of important functions. They publicised and legitimated spaceflight, giving scientific credibility to an enterprise which 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. And they served as training grounds for some of the most important rocket engineers of this century, notably Wernher von Braun (1912-1977), a dominant figure in the post-war American space programme, and Sergei Korolev (1906-1966), his Soviet 'counterpart'. The former was an active member of the German *Verein für Raumschiffahrt* (Society for Space Travel), a group of rocket enthusiasts created by Oberth which operated a test area near Berlin, called the *Raketeflugplatz* (Rocket Airport). Korolev had joined in 1930 a new society of young rocketeers created in Moscow by the Latvian engineer Friedrikh Tsander (1887-1933), the Group for Studying Reaction Propulsion (GIRD).

The rocket societies did not have the resources or the institutional base to sustain a viable programme of rocket research and development, let alone production. The military did, and did so, notably in the Soviet Union and in Nazi Germany. In the former, important contributions were made to rocket technology in the 1930s under military auspices both at Moscow GIRD and at the Gas Dynamics Laboratory (GDL) in Leningrad. The latter had been created by Nikolai Tikhomirov (1859-1930) on the grounds of the Sts Peter and Paul Fortress and it served as training ground for another important Russian rocket engineer, Valentin Glushko (1908-1989). It was at the GDL that the famous Katyusha rockets were developed in this period. This brilliant work suffered a serious setback in the Stalinist purges of 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 post-war 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.[2]

The great interest of the military in rocket development in pre-war Germany sprung from a general concern to rebuild the country's war fighting ability, 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 *Verein für Raumschiffahrt* (VfR). In 1932 three senior members of the German army visited the VfR's test facilities at the *Raketenflugplatz*. 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 the technical director of the rocket programme at the army's new, expanded premises established at Peenemünde on the Baltic sea.[3]

One of von Braun's first tasks was to develop an operational version of his experimental rocket *Aggregat-2* or A-2, which had successfully flown in 1934. In 1942 he had what was wanted: in October that year, his so-called A-4 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. The A-4 was re-baptised the V-2 (*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).[4] 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 V-2 fired from the Netherlands fell on the outskirts of Paris. Two days later a V-2 missile hit Staveley Road, Chiswick, on the western fringes of London, killing three people and injuring another 18. London and Antwerp where the main target of

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[2] Harford (1997).

[3] Neufeld (1995). See also Ordway & Sharpe (1979).

[4] Kennedy (1983).

the major V-2 offensive launched by the Germans in the last few months of the war. Indeed about 6000 V-2's were constructed in Germany in 1944 and 1945. One factory alone, the Mittelwerk factory in Nordhausen was allegedly producing almost 900 V-2s 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 V-2 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 Walter 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 V-2's left Nordhausen for Antwerp 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, near El Paso 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.[5]

The Americans were not the only ones to benefit from Nazi rocketry, but they 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 V-2 programme, notably those with experience in mass producing the missile, and one high-level manager, Helmut Grottrup. These were taken, along with the entire V-2 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.

I.2 The legacy of war: ICBMs and IRBMs

Important progress in rocket technology had been realised in the US during the war years, which received new impulse after von Braun's arrival. Goddard had joined a Navy rocket project in Annapolis, where he made important technical improvements to his original liquid-fuel rocket programme, as documented by more that 150 patents. Meanwhile, Theodore von Kármán, a professor of aeronautics at the California Institute of Technology (Caltech), who had studied in Germany with Ludwig Prandtl, had established an important school in applied aerodynamics which raised the interest of the Air Corps. In 1940 he and his student Frank Malina developed mathematical techniques that allowed significant progress in solid-fuel rocket technology. Out of this work, and thanks to military support, two important institutions were set up in California before the war's end: the Jet Propulsion Laboratory (JPL), a rocket research centre managed by Caltech, and Aerojet General, a company devoted to battlefield missile production.[6]

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 carry atomic warheads long distances and eventually to launch payloads into Earth-orbit. This required the prior development of relatively lightweight "dry" nuclear weapons and the

5 Lasby (1971).
6 Koppes (1982).

recognition that the bomber was not the only appropriate long-range weapons delivery system. It also required the stimulus of "the Soviet threat".[7]

In August 1953, only a few months after the first American H-bomb test (November 1952), the Soviet Union successfully tested a lightweight hydrogen bomb. The US responded by wiping the Bikini atoll off the map with a more powerful device in March 1954 (Bravo test). On May Day that year, at the usual military parade in Moscow, a brand new long-range jet bomber was showed, dubbed *Bison* by NATO. The US long-standing superiority in strategic air forces was directly challenged. All this suggested that intermediate-range and intercontinental ballistic missiles (IRBMs and ICBMs) should be developed soon as delivery systems of nuclear weapons. In February 1954 a committee chaired by the brilliant mathematician John von Neumann expressed "grave concern" about the United States' comparative disadvantage in rocket technologies. By May 1954 that "grave concern" had become an instruction to reorient and to accelerate the US Air Force's *Atlas* ICBM programme "to the maximum extent that technological development will permit".[8] The next year the USAF was authorised to build a second generation ICBM, the *Titan*.

At the same time, several programmes to develop intermediate-range ballistic missiles were 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*, which was technically almost identical to its Army rival. Both *Jupiter* and *Thor* flew successfully for the first time in 1957. Finally, the Navy, after briefly collaborating on the *Jupiter* project with the Army, decided that it needed a solid-fuelled IRBM for its submarines, rather than a liquid-fuelled 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-fuelled 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*, *Jupiter* and *Thor* were an efficient and diversified family of boosters for launching military and civil satellites. The foundations had thus been laid for American military power in the decades ahead and for its entry into space.

What of developments behind the Iron Curtain in this period? 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. An important installation for research and development on missile technology, called NII-88, was established in the Moscow suburb of Kaliningrad, with Korolev in charge of long-range missile designs. A major engine development centre was established nearby in Khimki, under the direction of Valentin Glushko, who had headed a wartime rocket programme. The German contingent was divided into two groups: one of them, including Grottrup, went to NII-88, the other was installed on the island of Gorodomliya in a lake some 250 km away. A test range was realised at Kapustin Yar, 130 km east of Stalingrad, where the first V-2 was launched in October 1947.

Korolev, for his part, began upgrading V-2s. By 1949 he was supplying the Red Army with the R-2, a modified version of the V-2 having a range of some 600 km, twice its German predecessor. In the early 1950s, along with his colleague Valentin Glushko, he was developing ever more powerful, solid-fuelled rocket engines, which were particularly requested by the military because of their better capability for use on the battlefield. The first such missile, labelled R-11 in the USSR, was called *Scud* by NATO military planners and it became sadly familiar during the Gulf War of 1991, when Iraq's dictator Saddam Hussein authorised its firing against Israel.

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7 Among the numerous works on the arms race between the two superpowers are Stares (1985), Zaloga (1993), Holloway (1994), Rhodes (1995). Specifically devoted to the space race are McDougall (1985a) and Heppenheimer (1997). For an outline of the Russian space effort see Harford (1997).

8 McDougall (1985a), p. 107.

By 1952 Korolev and Glushko started designing the R-5, a IRBM with a range of 1200 km which flew for the first time in march 1953. At the same time they succeeded in convincing the Soviet government to support a major effort in ICBM development. The programme was approved in 1954 and the envisaged missile was designated R-7 or, more familiarly, *Semyorka* (No. 7). It was designed to carry a 5-ton warhead for 8,600 km and a new launch site was realised for it in the desert east of the Aral sea, near the town of Tyuratan in Kazakhstan, later known as Baikonur. By mid-1957 the huge rocket with its characteristic cluster of four strap-on boosters, was ready for flight. After two unsuccessful attempts which ended in explosion soon after take-off, another R-7 rocket flew successfully on 21 August to a range of 6000 km, thus becoming the first ICBM to fly. A second successful flight occurred a few weeks later, and Korolev was now authorised to modify the rocket in order to make it capable of putting a satellite into orbit as soon as possible. This would be *Sputnik 1*.

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 and maintained a lead in the space race for almost a decade.

I.3 The International Geophysical Year

In addition to developing rockets for delivering nuclear weapons, 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 American satellite programme.

Strategic reconnaissance was the main objective of satellites from the military point of view. In March 1955, a few months before the first test flight of the Central Intelligence Agency's U-2 spy plane, the Air Force requested industry to submit proposals for strategic reconnaissance satellite designated WS-117L. This, however, posed a severe political problem, for a spacecraft overflying foreign territory and gathering photographic data well 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 American tracking stations. The idea of the "freedom of space" had to be established world-wide 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 was originally proposed in 1950 as the Third International Polar Year, a follow up of two Polar Years which had taken place in 1882 and 1932. The initiative was taken by a small group of British and American scientists, notably Lloyd Berkner, head of the Brookhaven National Laboratory and a 1932 Polar Year veteran; Sydney Chapman, a leading expert in atmospheric physics from Oxford University; and James Van Allen, a physicist of the Applied Physics Laboratory at John Hopkins University involved since 1947 in an high altitude research programme based on Aerojet's *Aerobee* sounding rocket. The project was endorsed by the International Council of Scientific Unions (ICSU) and, following a wider definition of its scientific objectives, it received the name of International Geophysical Year. It would run for eighteen months, i.e. from 1 July 1957 to 31 December 1958, and one of its main scientific objectives was to gain basic information about upper atmosphere phenomena during a period of maximum solar activity in 1957-58. In the event, it was an important cooperative scientific venture supported by 66 nations.[9]

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[9] Sullivan (1961).

To organise the scientific activities of the IGY, the ICSU set up an international IGY committee (CSAGI), with Chapman as president and Berkner as vice president. It is of relevance to our story because it was at a meeting of this committee, held in Rome in October 1954, that the idea that governments should try to launch artificial Earth satellites for scientific purposes during the International Geophysical Year was suggested by the American delegates, and eventually endorsed by the other participants. On 29 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 contribution to the IGY. Within a day or two the Kremlin announced that the USSR planned to do likewise.

The two Superpowers took very different policy decisions on satellite development. The Soviet Union unhesitatingly decided to use a military launcher for the scientific mission envisaged in the IGY framework, and started planning the use of the future R-7 ICBM to launch a heavy satellite. The Americans 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 principle of freedom of space for civilian purposes before probing the Soviet's reaction to military reconnaissance satellites. Their most advanced rocket under development was von Braun's *Redstone*, a military IRBM evolved from the V-2 rocket and built by an army arsenal. By the addition of upper stages, von Braun explained, the rocket (renamed *Jupiter-C*) would be able to put a small satellite into orbit by mid-1957. The Administration chose instead the Naval Research Laboratory's *Viking*, a rocket designed to probe the upper atmosphere for scientific purposes, plus an Aerojet-built upper stage derived from the *Aerobee* rocket (Aerobee-Hi). This became Project Vanguard, and it was intended to put the US's first satellite into space all while preserving its civilian image. It was a tactical choice for which the Eisenhower administration was to pay heavily.

I.4 Sputnik, 'Kaputnik' and Explorer

On 4 October 1957 Moscow radio announced that the Soviet Union had successfully launched *Sputnik 1*, "the first-in-the-world artificial satellite of the Earth". It was an aluminium sphere of 58 cm diameter and weighing about 84 kg that circled the Earth once every 96.3 minutes on an elliptical orbit with a perigee of 228 km an apogee of 947 km. Its two radio emitters sent its familiar "beep-beep" sound into homes all over the world for 21 days. 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 reaction, at least in certain American circles, bordered on the hysterical.[10] 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": inter-service rivalry between the various sections of the military leading to parallel rocket programmes, under-funding 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. The head of the Strategic Air Command, General Curtis LeMay, for one, was disparaging. *Sputnik*, he opined, was "just a hunk of iron". The President also played down its importance, at least in public. Sputnik "does not raise my apprehensions, not one iota [...] They have put one small ball into the air", he claimed in the aftermath of the Soviet announcement.[11] The United States' satellite programme, Eisenhower argued, was intended to reap maximum scientific benefits within the framework of the IGY. A small test satellite was to be launched in December, and a fully-instrumented satellite was planned for launching in March 1958 (hopefully on board an Atlas

10 McDougall (1985a), pp. 141-156. See also Bulkeley (1991). For the reaction in the UK see Krige (1997).
11 McDougall (1985a), pp. 145, 146.

rocket). 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 basket ball game has been and still is our country's goal".[12]

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 of the first. What is more, it carried the first living being into space, the dog Laika, who was wired up for medical and biological studies. Against this striking achievement, the US Vanguard project, well known to the public, was due to launch a ten-kilogram satellite and was not ready to fly yet. 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 US national slogan. 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, who were 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 von Braun's Redstone missile 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. [13] "This object here in my office is an experimental missile. 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, who had the rocket, and the Jet Propulsion Laboratory in Pasadena, California, which was responsible for the associated satellite, authority to prepare for launch as soon as possible.

The competition proved too strong for Vanguard. Early in December reporters from around the world gathered at Cape Canaveral to witness America's reply to the Soviets. The launch had been prepared in haste. The first stage had only been tested once a few weeks earlier and the second stage had never flown at all. The satellite was nothing more than a small sphere weighing 1.5 kg with a diameter of 15 cm, barely larger than a grapefruit. 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* and *Flopnik* in London newspapers. "It seems there is a worm in the grapefruit", wrote the Paris-Journal, while the Ottawa journal compared the rocket's "loss of thrust" to the loss of thrust that "the Western democracies have been suffering from". Soviet delegates at the United Nations reputedly asked the American counterparts if the US was interested in receiving foreign aid under Moscow's programme of technical assistance to underdeveloped countries.[14] 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 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 *Explorer 1* satellite into orbit. *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 - one sixth the weight of *Sputnik I* - and was placed in an elliptical orbit with a perigee of 356 km and an apogee of 2,548 km. The satellite carried two detectors of micrometeorites and a Geiger counter for studying charged particles designed by Van Allen. This experiment led to the discovery of the radiation belts around the Earth which were subsequently named after him. On 17 March the Navy evened the score when the diminutive (1.5 kg) *Vanguard 1* reached orbit. Later that month, it was followed by Von Braun's second satellite, *Explorer 3*. In May, the Soviet Union launched the 1.3-ton *Sputnik 3*, a spacecraft full of scientific instruments. And finally, in December, the Atlas rocket put into orbit the 100-kg SCORE satellite, carrying a telecommunication equipment and a tape recorder with a Christmas message from Eisenhower which was relayed to Earth: "Through the marvels of scientific advance, my voice is coming to you from a satellite circling in outer space. My message is a simple one. Through this unique means, I convey to

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12 On the metaphor, see McDougall (1985a), p 148

13 *Ibid* p 150.

14 Heppenheimer (1997), pp. 127-128.

you and to all mankind America's wish for peace on Earth and good will towards men everywhere".[15] The space race between the two Superpowers had definitely started.

I.5 The creation of NASA

In parallel with these developments, the Eisenhower administration began to think about the appropriate institutional framework for America's space programme. The debate over how to do this was intense and vociferous, and dominated by the question of the relationship between the civilian and military aspects of space.[16] 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 US 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 space agency would best serve American interests 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 American space programme except those having direct military application (like reconnaissance satellites).

The NACA had been 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 $ 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 did a great 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.[17]

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 the 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) came officially into being. It inherited NACA's vast organisation and facilities and a workforce of some 8000 people. And it expanded rapidly, taking over all space activities currently under way except those of strict 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. And in October 1959 the NASA space programme acquired the Army team at Huntsville, Alabama under Wernher von Braun. The centre at Hunstville 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 16,000 and its annual expenditure was over $500 million, three times that of NACA in 1958. On 25 May 1961, one month and half after the Russian cosmonaut Yuri Gagarin had become the first human to orbit the Earth (12 April), the newly elected US president John Kennedy announced in an extraordinary State of the Union message its plan for "landing a man on the Moon and returning him safely to Earth" before the end of the decade.[18]

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15 Heppenheimer (1997), p. 131.
16 McDougall (1985a), 157-176. See also Rosholt (1966).
17 Roland (1985); Anderson (1981).
18 Logsdon (1970).

I.6 The situation in Europe

For both the United States and the Soviet Union, space was an important field of political and military confrontation. By demonstrating the superiority of their respective space programmes, the White House and the Kremlin wanted to show Third World countries the superiority of their ideology, the efficiency of their political institutions, the capacity of their high technology industry, and the strength of their armed forces. Nothing comparable to the American and Soviet efforts was of course possible in Europe. However, some of the major European countries had considerable potential for entering the space age in the late 1950s and did develop limited national space programmes. To conclude this chapter we will quickly survey the situations prevailing in the United Kingdom, France, Italy and (West) Germany in the 1960s. This will provide the national backdrop against which we begin to look, in the next chapter, at the initiatives to have a collaborative European space effort.

The United Kingdom was the leading country in the space effort in Europe. The British worked on the development of solid-fuel guided rockets during the war, and as early as October 1945 launched three captured V-2s with the help of German specialists.[19] 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 were developed which were capable of carrying payloads of about 200 kg to heights of about 150 km. One of this series was offered to scientists for research purposes in 1953. It was renamed the *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 American 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 the first stage of a civilian satellite launcher, in collaboration with partners across the Channel if possible. Thus were the foundations laid of a European organisation for launcher development which we will look at in more detail in chapter 3.

Another notable feature of the UK in this early period was the strength and organisation of its space science community.[20] 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 ionospheric research initiated by E.V. Appleton in the 1920s. British space science was given a boost by the availability of the Skylark, by an active participation in the International Geophysical Year, and by close contacts with American colleagues. 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, the 60 kg *Ariel 1*, blasted off from Cape Canaveral atop a *Thor-Delta* rocket on 26 April 1962 and placed in an orbit with a perigee of 389 km and an apogee of 1214 km. It carried out seven experiments built by scientists from UK universities to investigate the Van Allen particle belt, the solar radiation and the cosmic rays. A second Ariel satellite, weighing 68 kg and carrying three British experiments, was launched on 27 March 1964 from Wallops Island, on the east coast of the USA, by a Scout rocket. The

[19] Sharpe (1989), Becklake (1998).
[20] Massey and Robins (1986).

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, in California, by a Scout rocket.

Second to Britain came France. Not all of the German rocketeers fled the war-ravaged continent. A small group of about 40 settled in France in 1946-47 where they formed the nucleus of the first French rocket teams.[21] In 1949 the French government set up the Laboratoire de Recherches Ballistiques et Aérodynamiques in Vernon, on the Seine north west 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 V-2. The first operational flight of *Véronique* occurred in 1954 from the French military base at Hammaguir, in the Algerian desert. In 1957, the French military Comité d'Action Scientifique de la Défense 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 benefited from the happy conjuncture of the launch of *Sputniks* and the arrival of General Charles 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 Ballistiques) whose aim it was to develop the in-house knowledge and technology required for this military programme. In the same year, it established a Comité de Recherches Spatiales, chaired by the physicist Pierre Auger, to coordinate scientific research in space. Finally, by a law voted on 19 December 1961, the CNES (Centre National d'Etudes Spatiales) came into being. Its prime task was to develop a satellite launcher, called *Diamant*, based on the military ballistic missiles that France was developing for its strategic deterrent.[22] The fruits of these investments were soon to be seen. On 26 November 1965 the rocket Diamant rose from the Hammaguir launch pad and placed the first French satellite, *Astérix*, in orbit. France thus became the third space power and confirmed its claim for an independent role in this important strategic field.

Astérix was a 42 kg test satellite whose role was to confirm the rocket's ability to place it in orbit. Ten days later, on 6 December 1965, a Scout rocket launched France's first scientific satellite, FR-1. This satellite, weighing 60 kg, had been developed by the CNES and carried instruments for studying ionisation irregularities in the ionosphere and the magnetosphere. It was launched from Vandenberg, and placed in a near-circular orbit about 750 km high. In 1966 and 1967 France launched three small scientific satellites developed by the CNES. All of them were launched by Diamant rockets from Hammaguir, and their scientific mission was to make geodetic experiments based on the study of the Doppler effect. The first satellite, called D-1A (Diapason), was launched on 17 February 1966; the two others, called D-1C and D-1D (Diadème), were both launched in February 1967. We should also mention here the Franco-German scientific satellite Dial/Wika, launched on 10 March 1970 by a Diamant-B rocket from the new base of Kourou, in French Guyana. It weighed 63 kg and carried four experiments for studying the belt of particles around the Earth.

Italy also had an important national space programme, initially stimulated by the military. 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, together with the Air Force, launched a programme for upper atmosphere research under the direction of Colonel Luigi Broglio. A launching range was established at Salto di Quirra, in Sardinia.

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21 Villain (1997).

22 Sebesta (1992).

Broglio was quick to react to NASA's offer of collaboration in space research. In 1962 Italy and the USA signed an agreement for the so-called "San Marco" project and two years later, on 15 December 1964, the first Italian satellite, *San Marco-1,* was launched by an American *Scout* rocket from Wallops Island and placed in an orbit with a perigee of 198 km and an apogee of 856 km. It was a sphere with a diameter of 66 cm and weighed no less than 115 kg. Built by the University of Rome's Centro di Ricerche Aerospaziali under the direction of Luigi Broglio, this was the very first all-European satellite to circle the Earth. 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. A second San Marco satellite was launched by Broglio's group in 1967 from a platform anchored in the Indian Ocean off the coast of Kenya, and the programme continued in the following decade.

Finally, a last word must be said on the situation in the Federal Republic of Germany. Throughout the 1950s 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 V-2 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 legitimating 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' 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 at once "lagging" the other three major European countries in the space field, and endowed with a group of scientists, engineers, businessmen and politicians who were determined that she should rapidly play a leading role in this sector.[23]

These national efforts in Europe could not compete in any way with the aggressive space programmes developed in the United States and the Soviet Union. Both the super powers were motivated by strong political, ideological and military interests, and they were prepared to spend money, intellectual resources and industrial capability for the pursuit of their goals. Cold war confrontation, however, was not the only aspect of space. Launching instruments high in the atmosphere and beyond also meant opening new interesting fields of scientific research.[24] Moreover, important applications in civilian fields such as telecommunications and meteorology seemed possible in the future. Finally, space appeared to many European industrialists to be a key sector for technological development and economic success. In September 1961, the European industry created 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". It is against this background that in the late 1950s and early 1960s a few initiatives were undertaken for pooling European resources in a collaborative effort in space. Eventually, these initiatives led to the creation of ESRO and ELDO.

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23 Fisher (1994).

24 Important reviews on the promises of space research were published in those years: see, for example, Van Allen (ed.) (1956) and Berkner & Odishaw (eds.) (1961).

Chapter 1:
The Pioneers: From Amaldi's 'Euroluna' Vision to the Creation of COPERS

J. Krige & M. de Maria

The origins of a joint European space effort are generally traced back to a number of initiatives taken in 1959 and 1960 by a small group of scientists and science administrators, catalysed by two friends, physicists and scientific statesmen, the Italian Edoardo Amaldi and the Frenchman Pierre Auger. Neither Amaldi nor Auger was stranger to the cause of scientific collaboration on a European scale. Indeed it was they who, in the early 1950s, were key actors in the process which led to the setting up of CERN, the European Organisation for Nuclear Research. Now, as the decade drew to a close, they turned their attention to space. Success was rapid. Within a year of the first formal discussions being held amongst scientists, European governments had set up a preparatory commission to explore the possibilities for a joint space research effort.

The most striking feature of the story we are about to tell in this chapter is the transformation of the scientists' original project into one which was more modest in scope – and over which they could hope to retain a large measure of control. In the first meetings held in the early 1960s, they were thinking of setting up a European body dedicated solely to scientific research, but with sufficient funds to finance all that that required, including the construction of satellites and the development of the required launch vehicles. In parallel with these discussions, however, governments and industry were formulating their own ideas about the nature and purposes of a European collaborative venture in space. At the heart of their deliberations was the question of the launcher. For the scientists, a launcher was essentially a means to put a scientific experiments into orbit. For politicians and industrialists, it was a device whose development was intertwined with national European political, military and commercial strategy. Starting from very different perspectives, and seeking control over very different aspects of the space programme, by the end of 1960 it was understood by both parties that Europe would have not one, but two space organisations, one dedicated to scientific research and the other to launcher development. It was an arrangement that at the time pleased scientists and politicians in at least the prime movers, Britain and France. But it was an arrangement which was to cause endless difficulty for Europe throughout the 1960s.

1.1 Amaldi's dream of "a Euroluna before 1965"

According to Pierre Auger, the first ideas for a European organisation for space research were discussed by himself and Edoardo Amaldi during a peripatetic conversation in the Luxembourg gardens in Paris in April 1959.[25] This conversation, in fact, had been prepared by a number of initiatives of Amaldi during the preceding nine months, which aimed at setting up a scientific constituency for a joint European effort in space research, similar to that realised for CERN, the large laboratory for high energy physics established near Geneva in the early 1950s.[26] Amaldi's project sprang from political as well as scientific considerations. Like most of his European colleagues, he had been impressed by the important scientific results obtained by the first USSR and American satellites. The space race among the Superpowers was mainly motivated by political, ideological and military considerations, but Cold War confrontation was not the only rationale for space programmes. It also meant opening new interesting fields for scientific research, while important applications in civilian sectors such as meteorology or telecommunications seemed possible in the future. As a scientific statesman, Amaldi thought that Europe should not be left out of space: he considered it an urgent

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25 Auger (1984). There is a reference made to this event in a document entitled "Sur la création d'ESRO", in the Auger papers, HAEC. This document is undated, but it was probably written in the late 1960s or early 1970s.

26 Hermann et al. (1987).

necessity for Western European countries to enter space. The launching of a *Euroluna* (Euromoon) from a European space organisation would have, in his words, "a first order importance, both *moral* and *practical*, for all countries of the continent".[27]

Amaldi conceived such an organisation as one solely dedicated to scientific research and essentially controlled by the scientific community. In particular, it was clear to him that the military were to be left out of any future European space organisation, notwithstanding the obvious military interest in rocket technology. The conquest of space had to be a peaceful enterprise on behalf of the whole of mankind, he claimed, and the presence of the military would prevent a space organisation from pursuing this "moral" goal. Moreover, from a "practical" point view, the military environment would certainly be an obstacle to the best development of science, which is characterised by open co-operation and free exchange of ideas. As one of the founding fathers of CERN, Amaldi considered this Organisation as the ideal model to be followed in the new cooperative venture: CERN represented a very successful example of an organisation conceived and funded only "on the basis of scientific and technical principles and not on the basis of political and commercial arguments".[28] Accordingly, the new space organisation was to be free from any political, industrial and military interference, like CERN. Amaldi began thinking about the possibility of developing in Europe a collaborative effort in space towards the end of July 1958, after a conversation he had with his old friend Luigi Crocco in the home of the Rome physicist Giorgio Salvini. Crocco was at that time a professor of Aerospace Propulsion at Princeton University's Department of Aeronautical Engineering and a former scientific consultant of the Italian FIAT Company and of NATO's Advisory Group for Aeronautical Research and Development (AGARD). "If European experts in the field of satellites and launchers start moving immediately, by 1965 they will be able to give quite a substantial contribution to the study of space problems, in addition to American and Russian groups", Amaldi wrote Crocco later on. The development of advanced space technologies was not within the reach of individual European countries, for both technical and financial reasons, but could be realised on a continental scale, "like what has been done for big particle accelerators with the creation of CERN".[29]

After his conversation with Crocco, Amaldi talked to his colleague Luigi Broglio, one of the few Italian experts in rocket technology, who was at that time the director of the University of Rome's Institute of Aeronautical Engineering and a colonel in the Italian Air Force. Broglio expressed "a substantial agreement on the theoretical formulation of the problem but also a noteworthy scepticism regarding the real feasibility of a concrete project", Amaldi reported to Crocco. In fact, Broglio acknowledged that the development of launchers and satellites was an objective whose realisation was so complex that it could only be reached by a collaborative effort of several nations and considered Amaldi's initiative worthy of attention, "both for its important scientific aspects and for its high moral effects". However, he expressed many doubts for the difficulties that could arise in reaching an international agreement in a field where "military interest is highly pre-eminent".[30]

Following Broglio's rather cold reaction, Amaldi decided to discuss his idea with friends and colleagues in the international physics community, in particular with some of the CERN pioneers. In early September 1958, during a staying in Geneva, he spoke to Isidor I. Rabi. Rabi was one of the most important American physicists of the Los Alamos generation, who had contributed to shape US scientific and security policy during the late 1940s and early 1950s, serving in key scientific advisory committees of both the Defense Department and the Atomic Energy Commission. What was more important to Amaldi, in his capacity as a US delegate to UNESCO, Rabi had played a crucial role in the creation of CERN.[31] Rabi considered very favourably Amaldi's project and declared that should his

27 Amaldi to L. Crocco, 16 December 1958, Amaldi archive, Rome, box 212, folder 6.
28 Amaldi to J.B. Adams, 15 December 1961, Amaldi archive, Rome, box 210, folder 1.
29 Amaldi to Crocco, 16 December 1958, cit.
30 Broglio to Amaldi, 28 August 1958, Amaldi archive, Rome, box 248, folder "Corrispondenza con Broglio,
1958-1961".
31 Kevles (1978), pp. 368 and 376-377; Pestre in Hermann et al. (1987), pp. 82-89.

initiative be developed, he would do everything possible to assure US support. Moreover, given his capacity as a US delegate in NATO's Scientific Committee, Rabi suggested that this body could initiate the project. Amaldi, however, opposed this last point, for reasons that we shall discuss later.

In the following months Amaldi continued searching for support among his *confrères*. In November, again at CERN, he discussed the issue with Harrie Massey, an important space scientist and scientific statesman in the UK, who was about to become the chairman of the British National Committee for Space Research (BNCSR), set up by the Royal Society in December 1958.[32] Massey was "rather sceptical, but this is the normal British attitude in front of any continental initiative", Amaldi reported to Crocco. A more positive reaction came from Francis Perrin, one of the most influential leaders of the French physics community, whom he met at CERN in December. Perrin enthusiastically supported Amaldi's project and promised that he would find "some authority in the field of launchers in France to advocate [the project] and to establish the basis of a preliminary organisation".[33]

Following these first discussions, Amaldi wrote to Crocco in Princeton asking for advice and help.[34] On this occasion, he worded for the first time a fully-fledged idea of what he thought should be the main features of a future European organisation for space research, an idea which brought together his strong belief in the European ideal and his vision of scientific research as a free and peaceful international enterprise. Firstly, as regards its membership, Amaldi thought that, in addition to the six European Economic Community (EEC) Member States (Belgium, France, (the Federal Republic of) Germany, Italy, Luxembourg and the Netherlands), at least the United Kingdom and the Scandinavian countries had to be involved. Recalling however Massey's sceptical reaction, which echoed the early cold reactions to the CERN concept from across the Channel, Amaldi remarked that "in the first phase, England will only send some observers and will probably make some opposition, but I am sure that she will eventually give an important contribution when the project begins to assume a concrete aspect".

Secondly, as regards the promoters, Amaldi suggested that a small group of experts from the main countries of continental Europe - at least from France, Germany and Italy - should prepare in a few months' time a plan for the setting up of the organisation, including: a) a well defined objective, "sufficiently ambitious as to be comparable to those established by the USA and the USSR in this field and to justify the European dimension of the undertaking"; b) an evaluation of the required technical staff; c) a realistic time schedule. This programme should then be submitted for approval to Western European governments. Amaldi underlined, however, a difficulty on this path: while, in the case of CERN, UNESCO had played the role of "mother and wet-nurse", he wondered which international agency could now play the same role for the envisaged space organisation. Certainly this could not be NATO's Science Committee, as suggested by Rabi. It is "<u>absolutely essential</u>", Amaldi underlined, that the future organisation "has no military connotation and no connection with whatsoever military agency". It had to be "purely scientific [and] open, like CERN, to all kinds of cooperation, both inside and outside the member nations". Amaldi's ideas were not naively pacifist. He believed that an organisation free from any military influence would foster in all its Member States the strengthening of their scientific and technical capability, and this "would obviously produce great benefit also in the military sector, [...] but would not make the realisation of its programme more difficult and complicated, as it would happen if the military, directly or indirectly, were its masters".

Thirdly, as to the programme of the future organisation, Amaldi thought that it should include both the construction of common European laboratories and a number of cooperative projects to be developed in the participating countries. This organisation, he concluded, "would attract the brightest part of the young generation and make possible the recovery of scholars who work outside Europe".

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32 Massey and Robins (1986), p. 62.

33 Amaldi to Crocco, 16 December 1958, *cit*. Writing to Auger two months later (6 February 1959), Amaldi commented: "Massey en bon anglais s'est s'est montré plutôt sceptique".

34 Amaldi to Crocco, 16 December 1958, *cit.*

Amaldi asked Crocco to become an active supporter of this project and to indicate "the most competent and open-minded people in the [space] field in Italy, France, Germany, England and the Scandinavian countries". He also asked for the address of Theodore von Kármán, an important American physicist and a promoter of AGARD: "A man of his authority, if favourable, could exert a noteworthy influence", Amaldi noted. In early 1958, in fact, von Kármán had proposed to launch a peaceful NATO satellite as a reply to the *Sputnik*, but his idea was eventually dropped because the US State Department objected that NATO was a military organisation and "peace satellites were not its business".[35] In his wishes for a Merry Christmas to Crocco, Amaldi included a hope for "a *Euroluna* before 1965".

Crocco received Amaldi's ideas "with much interest and enthusiasm". He shared Amaldi's view that a non-military organisation would represent the best solution, "from both a diplomatic and a scientific point of view". However, he warned Amaldi about the risks and difficulties that the realisation of his project would meet, arguing that a straightforward application of the "CERN model" to space could hardly be realised, given the political and institutional differences among the two cases. Firstly, one had to cope with the military presence in the field, as demonstrated in the case of the setting up of NASA. The creation of the American space agency in the aftermath of the "Sputnik psychosis", Crocco explained, occurred after "considerable intestine fights, because everything done so far in the field of rocket and spacecraft development [...] had been realised by the military or under their patronage", and the corresponding technology was "private property of the military".[36] The situation was even more difficult in Europe, owing to the many borders which divided the various nations in the Old Continent. The question here was "winning a fight against the military not in one single country, but in each European country, and a failure in one country is sufficient to compromise the entire initiative". Nothing similar existed for CERN, since research in high energy physics was "a pie where the military had not yet put their finger".

A second problem regarded costs. Europe was poorer than the United States, Crocco wrote, and even assuming that costs on this side of the Atlantic were lower than in the US, or that one could "substitute at least in part the brute force of money with the less ostentatious but more penetrating force of the brain", it was impossible to realise such an ambitious project as building rockets and satellites without investing a "huge amount of money". Moreover, the organisation conceived by Amaldi was due to pursue only scientific research that did not have any short-term "utilitarian fall-outs in the civil field"; therefore, it would not be easy "to convince a number of Parliaments of the necessity of spending <u>huge</u> amounts of money only for science and prestige without a utilitarian perspective" [Crocco's underlining].

Thirdly, Crocco warned Amaldi that not only the "Euromoon project" required much more complex structures than CERN's, but while in the case of CERN, "the laboratories constitute 'an end in itself', in the case of *Euromoon* they represent only the means, and a very expensive one, for the development and testing of prototypes". Finally, a last problem regarded the technical staff. It was not easy at all, according to Crocco, to find in Europe a good number of specialists in the space sector. A possible shortcut, which might be necessary to resort to, "with some sacrifice of European pride", was to launch and develop the European programme with the help of some US experts: this implied, however not only the approval of the US Government, but also "its willingness to support Europe's undertaking by transferring people and technology".

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35 Von Kármán (1967), pp 323-339. Von Kármán had started thinking of NATO "as a 'pilot plant' to test out the feasibility of international scientific cooperation" immediately after the birth of this organisation in April 1949. After a long gestation, AGARD was set up in February 1952. Its scientific activities were focused only on "unclassified items", which gave AGARD, according to von Kármán, "greater freedom in the selection of scientific projects" and allowed AGARD scientists "to meet on an easier basis with scientists of other nations". See von Kármán (1967), chapters 40-42.

36 Crocco to Amaldi, 2 January 1959, Amaldi archive, Rome, Rome, box 212, folder 6. On the establishment of NASA, see McDougall (1985a).

Concluding his letter, Crocco suggested that he himself could make contact with von Kármán, Hugh Dryden, the scientific director of NASA and "very influential also in Europe", and James Killian, the president of the Massachusetts Institute of Technology (MIT) and President Eisenhower's scientific adviser, to sound out US reactions to Amaldi's project. If von Kármán was convinced, Crocco argued, "[this] would represent a great advantage not only for Europe but also in relation to the US". He also suggested that Amaldi contact Maurice Roy, the director of the *Office National d'Etudes et de Recherches Aéronautiques* (ONERA), who exercised "a sort of dictatorship on the developments of [military] aeronautics research in France", and his brother-in-law Giuseppe Gabrielli, the director of the FIAT Aviation Company, to sound out the reactions of industrial circles in Italy.

Amaldi considered Crocco's proposal to talk with von Kármán "very useful", but he also insisted in defending the two main tenets of his initiative: firstly, that the future space organisation should keep "a real European character" and should therefore not appear, at least in the beginning, as "a suggestion coming from the US"; secondly, that it should absolutely have "a peaceful character". "The answer to those who worry about European defence problems is that, once the technology of satellite launching is mastered in Europe, the military structure of all countries would automatically be strengthened as a result".[37]

At Amaldi's request, Crocco had a long conversation with von Kármán in New York on 27 January 1959, and immediately reported its contents to Amaldi. Firstly, von Kármán wanted to inform Amaldi that AGARD was already trying to develop a similar project, "although on a smaller scale". A provisional plan foresaw the launching of satellites entirely designed and developed in Europe, with US launchers supplied by NASA while control systems would probably be European. Secondly, von Kármán too perceived "the weakness of an initiative based on military or paramilitary organisations" and agreed that, in principle, excluding the military and not depending on US launch systems were "desirable" objectives. However, he believed that full European autonomy in space should follow a first collaborative undertaking with the US that would not entail large expenses for Europe. "It seems to me", Crocco commented, "that the AGARD solution, possibly supported by a civil committee, would have the advantage of breaking the ice, creating an interest and paving the way for more independent undertakings".[38] Amaldi, however, was not convinced by von Kármán and Crocco's arguments in favour of the AGARD solution and dropped their suggestion, as he had done with Rabi's, since the European involvement with NATO or the US was incompatible with the "peaceful and real European character" of the future space organisation.

In those days, Amaldi was defending the (Western) European character of his project on another front, i.e. the British physicist Cecil Powell's proposal of extending cooperation in space to the Soviet Union. Powell was a spokesman of the cosmic-ray physics community in the UK, a Nobel prize winner in 1950 for his discovery of the π meson and a member of CERN's Scientific Policy Committee. In his letter to Amaldi, Powell too dealt with the military question, expressing his concern that "if you attempt to make satellites in Western Europe without military support, you will be a long way behind", and proposed "to establish on an international scale the kind of cooperation which you had visualised for Western Europe. [...] What is required here is a genuine international cooperation involving world resources". In particular, Powell argued that Russian scientists should be included from the very beginning and he was ready, if Amaldi agreed with this idea, to speak with some of them during his forthcoming visit to Moscow, "entirely unofficially, without committing anybody to anything".[39]

Against Powell's argument, Amaldi defended his conception of scientific internationalism limited to Western European nations. Firstly, an international collaboration of the kind envisaged by Powell "should take place at a different level from that which I consider as an urgent necessity for the European countries". This was for Amaldi both "a matter of principle and of feasibility". He again presented the CERN model: "CERN has been built in spite of the existence of the [MIT's] Radiation

37 Amaldi to Crocco, 9 January 1959, Amaldi archive, Rome, Rome, box 212, folder 6.
38 Crocco to Amaldi, 27 January 1959, *ibidem*.
39 Powell to Amaldi, 2 February 1959, *ibidem*.

Lab. or the Brookhaven National Lab. [near New York]; and Dubna [the main high energy physics laboratory in the USSR] has been built in spite of the existence of all the above mentioned laboratories". In the same spirit, he believed that Europe should have its own organisation for space research, "a purely scientific organisation which collaborates with any other similar organisation in the world". Referring to the difficulties of collaborating with the USSR, Amaldi reminded Powell that when they were making the first steps towards the establishment of CERN, the official Soviet newspaper *Pravda* had written that "CERN was made by the USA in order to teach German scientists - in particular Heisenberg – how to make atomic bombs against the USSR". Amaldi himself had been put "in the list of warmongers" for this. In conclusion, such a large organisation, "including all the world's nations", was not desirable, not only because Europe was not yet prepared for such a big enterprise, but also because, in principle, one should avoid having"a single world Directorate for [space] research which decides the general lines of attack on scientific problems". Moreover, a world-wide organisation could not work from a practical point of view: CERN itself would be almost impossible to manage if delegates from 30 or 50 nations sat in its Council instead of twelve. "Twelve are quite enough, even too many", Amaldi concluded.[40]

Apparently, Amaldi's first round of consultations with his colleagues resulted in an almost unanimous chorus of warnings against a straightforward application of the CERN model to space. Firstly, because a certain amount of involvement with the military seemed to many unavoidable, if only because they already controlled the field. Secondly, because the purely Western European option met with various counter-arguments: the difficulty for Europe to fill the technological gap with the superpowers; the "huge amounts of money" required; the ideal of a world-wide scientific internationalism. Amaldi, however, stubbornly stuck to his original idea, and was soon rewarded when he met with the right man with whom to push forward his project. This was Pierre Auger, a French cosmic-ray physicist and Amaldi's old friend. Amaldi and Auger had been the leaders of the so called "Franco-Italian front" during the early discussions on the establishment of CERN.[41] Now this successful team was ready to go back in action for space.

1.2 Amaldi and Auger's first steps

Early in February 1959, Perrin informed Amaldi that Auger "was interested in the same problems". The Italian physicist wrote immediately to his French colleague, informing him of his previous contacts and making explicit the "essential points" that should characterise the envisaged European space organisation: firstly, that it "should be only civil and with a strictly scientific character, without military links or secrecy problems in general"; secondly, that it should comprise "a sufficiently large European basis, possibly like CERN".[42] The first problem, he wrote, was to identify an international organisation that could play the same institutional role as UNESCO in the establishment of CERN. This organisation should appoint a group of experts with the task of making the necessary preparatory work. One can start with two or three "trustworthy" experts in France, Germany and Italy, Amaldi wrote, "and the others would eventually follow". As regards Italy, Amaldi informed Auger that Broglio, finally convinced, was ready to serve as an expert on behalf of Italy, and that a number of FIAT managers "would be very interested in collaborating in this project from the industrial point of view".

Auger's reaction was very positive. He informed Amaldi that in January that year a *Comité des Recherches Spatiales* (CRS) had been set up in France under his chairmanship, with the task of establishing a national programme of research in the upper atmosphere and the outer space. Amaldi immediately realised that the creation of similar national space committees in other European countries, at least in Italy and Germany, would represent a more efficient institutional framework for the start of a European joint effort in space. Therefore, in early March 1959 he asked Auger to send

40 Amaldi to Powell, 6 February 1959; Powell to Amaldi, 20 February 1959, *ibidem*.
41 Pestre in *Hermann et al. (1987*), chapter 4.
42 Amaldi to Auger, 6 February 1959, cit.

him, "as soon as possible", some information on the CRS, including its membership and first programmes.[43] Auger replied immediately, asking however for discretion since the press had not been informed yet. He sent Amaldi the CRS member list and a copy of its founding decree, dated 7 January 1959.[44]

Amaldi thus learned that the CRS had outlined a two-phase programme: a "minimum programme", with a budget of about 2 billion French Francs, for researches with instruments carried on board of sounding rockets and devoted to atmospheric studies, solar investigation and cosmic ray physics; and a "more ambitious and much more costly" programme, including the launch of Earth satellites and, possibly, solar and lunar probes. According to Auger, this part of the programme, whose realisation "required an effort exceeding that that could be made by one European country", could be implemented by international collaboration. However, he did not think that the time was ripe for an immediate start at a European level: "Up to now there is no question of any international action besides the participation of France in COSPAR and in the United Nations' newly established Space Committee".[45] As regards rockets, Auger continued, the CRS had not yet considered the problem, since there were already a few types of French military rockets that could be used immediately for space research, while the realisation of satellite launchers "depended evidently in part on the military programme and also on the attitude of the French government towards a satellite programme". Evidently, Auger and the French space scientists did not have a direct interest in building launchers and considered the presence of the military in space with much greater realism than Amaldi, if only because they were already on the spot in France.

The two physicists, as we have anticipated, met in Paris in April and discussed their plans during a walk in the Luxembourg gardens. Shortly after that discussions Amaldi took two important initiatives. Firstly, he convinced the president of the Italian Consiglio Nazionale delle Ricerche (CNR), Francesco Giordani, to set up within the framework of the CNR a *Commissione per le Ricerche Spaziali* (CRS). This was officially established in September 1959 with the twofold task of assessing the national capabilities in this field and setting up a "collaboration among European nations in order to realise a common programme of work". Broglio was its President and Amaldi was one of its seven members.[46] Secondly, he wrote an important paper, entitled "Introduction to the discussion on space research in Europe" and dated 30 April 1959, which he sent to a small group of senior science administrators, asking that it be circulated within the European scientific community.[47] The list included Auger, in his capacity as the president of the French CRS, J.H. Bannier, the director of the Netherlands Organisation for the Advancement of Pure Research (ZWO), F. Giordani, the president of the Italian CNR, A. Hocker, at the German Bundesministerium für Atomfragen and, finally, J. Willems, the president of the Belgian Institut Inter-Universitaire de Sciences Nucléaires. Moreover, the paper was also sent to CERN's Director General, C.J. Bakker and to the president of the Euratom Commission, E. Hirsch, in order to encourage other European institutions to take an interest in the initiative.[48]

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43 Amaldi to Auger, 5 March 1959, Amaldi archive, Rome, box 12, folder 6.

44 Auger to Amaldi, 12 March 1959; Amaldi to Auger, 18 March 191959, *ibidem*.

45 The COSPAR (Committee on Space Research) had been set up by the International Council of Scientific Unions during the International Geophysical Year. See COSPAR (1998).

46 Giordani to Amaldi, 5 September 1959; Amaldi to Giordani, 8 September 1959; Broglio to Amaldi, 17 September 1959, Amaldi archive, Rome, box 248, folder "Ricerche spaziali - Corrispondenza con Broglio 1958-1961". The other members were Mario Boella, a professor of Electrical Communications at the Politechnic of Turin; Nello Carrara, a professor of Electromagnetic Waves at the University of Florence; Corrado Casci, a professor of Motors for Aeromobiles at the Politechnic of Milan; Giampiero Puppi, professor of Physics at the University of Bologna; Guglielmo Righini, professor of Astronomy at the University of Bologna.

47 A copy of this document can be found in Amaldi archive, Rome, box 212, folder 6, and in the Mussard files, HAEC, folder "Origine de la COPERS I".

48 Copies of these letters are in the Amaldi archive, Rome, box 212, folder 6. The list is also in "First mailing list – May 1959", Mussard files, HAEC, folder "Origine de la COPERS I". We shall say a little more about the significance of some of these personalities in due course.

In his paper, Amaldi began by describing the international initiatives which had been taken in the past few years to encourage scientific research in space using rockets and satellites. This had really got under way during the International Geophysical Year (IGY), which ran from 1 July 1957 to 31 December 1958. In anticipation of the ending of the IGY, Amaldi explained, the International Council of Scientific Unions had set up a number of additional committees to ensure that the scientific work which had been initiated during the preceding 18 months was continued on an international basis. One of these was the Committee on Space Research (COSPAR) which had the task of coordinating and promoting the development of space research on behalf of the world scientific community.[49]

Having sketched the international structures put in place in the second half of the 1950s, Amaldi went on to identify some of the important results which had already been obtained. The most significant was the so-called "Van Allen radiation" belts. These belts comprised charged electrons and protons with an energy between a fraction and several dozen million electron-volts (MeV). The particles were effectively trapped by the Earth's magnetic field, and seldom if ever penetrated into the atmosphere. They were first detected by a Geiger-Müller detector built by the American physicist J. Van Allen and mounted on *Explorer-I*, the first American satellite launched on 31 January 1958. This discovery, wrote Amaldi, was one of several of "exceptional importance, in that they open up a whole new field of hitherto unexplored and vast phenomena involving the properties of the Earth, the Sun, and cosmic radiation". They were, he went on to say, "no more than a modest beginning in a field of research so enormous and important that it far surpasses anything that can be imagined today".

The scientific importance of the field having been identified, Amaldi went on to stress how urgent it was for Europe to enter it. To date, he pointed out, only the Soviet Union and the United States of America were in a position to capitalise on the new possibilities being opened up by research into space using rockets and satellites. This gap could only become wider, if not "all but unbridgeable", if measures were not taken immediately to close it "both on the scientific and on the technological and industrial plane". Elaborating on the latter point Amaldi stressed that the launching of satellites required the development of a large number of fields of industrial significance, like propellants, metallurgy and electronics, "and this development in turn has its effect on the countries' entire industry".

What chance did Europe have of closing the gap, though? Countries having lesser financial, industrial and organisational capacities than the two superpowers, he said, would find it very difficult to establish themselves in this field. There was a danger then that this type of research was "destined to remain a monopoly of the United States and the Soviet Union", with the countries of Europe being "mere spectators of the grand endeavours to the East and West of our continent". There was a solution, however: "An International Organisation pooling the resources of, say, ten European countries might well be able to tackle the problem and to enable the scientists of Europe to make a valuable contribution to the exploration and study of outer space.

This organisation, he went on to say, "could achieve impressive results within four or five years" if it had a budget about twice as large as that of CERN, currently costing about 65 million Swiss francs per year. "The proposed *European Space Research Organisation* should have no other purpose than research and should, therefore, be *independent of any kind of military organisation and free from any Official Secrets Act*". This was not only necessary to ensure what Amaldi called "its moral authority". It was probably also crucial, he pointed out, to ensure the participation of a wide cross-section of European states.

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49 General information on these international organisations was provided by Amaldi in four extensive appendices attached to his document. The President of COSPAR's first Executive Committee was Professor H.C. van de Hulst, of Leiden in the Netherlands, and Professor H.S.W. Massey from London was one of its members. We shall meet them again soon. For some personal recollections on the COSPAR activities see COSPAR (1998).

Amaldi then turned to discussing the possible programme of the new organisation. While stressing that it would have to be "very closely defined", he was careful to avoid being too precise about its contents. He limited himself to suggesting that it concern itself with two problems phased in time. One "might be a standard problem of the kind already solved by the USSR and USA, so chosen that its solution could be expected within a relatively short time of, say, three to four years". The second problem would be much more ambitious and comparable to "the greatest enterprises" then being undertaken in the United States and the Soviet Union. This might last for six to seven years. The first problem would serve to give Europeans the time and the opportunity to develop the know-how and to train the personnel required for space research. The second would put them on a level comparable to that attained by the leading protagonists in the field.

Finally, addressing himself to procedural matters Amaldi proposed that a number of European countries - and here he identified Belgium, France, Germany, Italy and the Netherlands - could set up commissions to assess the resources available nationally, and to estimate the total effort required to make a meaningful contribution to space research. Their findings could then be laid before an international conference which would work out a detailed programme for submission to the governments of interested countries. Amaldi concluded by saying that this preparatory stage should not exceed one year. If a European organisation, "or at least a fairly well-founded provisional precursor of it", could begin operating before the end of 1960, Europe could hope to close the gap between "herself and the Soviet Union and the United States before 1970".[50]

The first reaction to Amaldi's paper came from Jean Willems, an influential member of the "CERN lobby".[51] Willems informed Amaldi of the situation in Belgium: a working group on space matters, chaired by Willems himself, came to be set up within the framework of the *Centre National d'Etudes et de Recherches Aéronautiques*, whose Secretary General, M. Freson, was a member of the Belgian delegation to the CERN Council. Another organisation, the *Centre National de Recherches Spatiales*, had also been established, but work was at the very beginning and the scientists involved in both these bodies had a strong interest in Amaldi's project. "What should be next? I believe that we should turn to you to know more", Willems concluded.

A second important answer came from another member of the "CERN lobby", Jan H. Bannier, a Dutch delegate in the CERN Council and the chairman of its Finance Committee. Bannier met Amaldi in Geneva and was immediately convinced of the actual feasibility of his *Euroluna* project. He started to discuss the project with a number of important Dutch scientists, in particular with J.F. Koksma, General Secretary of the Royal Netherlands Academy of Sciences, and with Hendrik C. van de Hulst, the president of COSPAR's Executive Committee. Although no definite conclusions were reached during these discussions, Bannier informed Amaldi that "the general impression was one of great interest in your plans".[52]

Bannier also touched the problem of the institutional framework for officially discussing the future organisation. He doubted that UNESCO could play the same role as it did with CERN since Auger's successor as director of UNESCO's Department of Natural Sciences, the Russian J.F. Kovda, would probably not be willing to undertake this task. "It may be difficult for him as a Russian to assist in the creation of a Western European Organisation; [...] he would probably prefer a more universal task". As an alternative, he suggested that the Western European delegates in the forthcoming General Assembly of COSPAR, scheduled for January 1960 in Nice, extend their stay in Nice for one more day in order to discuss Amaldi's plan. According to Bannier, the time was not ripe to bring the matter

50 The list of countries cited by Amaldi was anything but arbitrary. Indeed, his paper was circulated to senior science administrators in each of the five countries that he had mentioned

51 Willems to E. Amaldi, 22 June 1959, Amaldi archive, Rome, box 212, folder 6. For the concept of the "CERN lobby", see Pestre in *Hermann et al. (1990)*, chapter 7.

52 Bannier to Amaldi, 24 July 1959, Amaldi archive, Rome, box 212, folder 6.

up to government level in the Netherlands, since a national committee for space research had not yet been established. However, if a formal meeting of European space scientists was convened in order to discuss the creation a European organisation for space research, "it would be not so difficult to create such a committee" in the Netherlands. As a final joke, he proposed Amaldi to use the acronym EROS (European Research Organisation for Space), as "a nice abbreviation" for the future organisation.

In his answer to Bannier, Amaldi wrote that he had also reached the conclusion that UNESCO could not be proposed as the promoter of the envisaged European organisation and agreed that the COSPAR meeting in Nice was a good and timely framework. Regarding the approach to national governments, Amaldi pragmatically envisaged a two-phase strategy: in the first, one should convince "many peoples in each of our countries of the importance and feasibility of such an enterprise" and only after a few months one could start an action at government level. He informed Bannier that he was still waiting for an answer from Germany, which he expected would arrive soon, and was "trying to get Switzerland in the play". EROS, he concluded, "sounds very nice".[53]

We have no direct information about the reactions from other recipients of Amaldi's report. These must have been however encouraging if a French version of the text was published in December 1959 under the more explicit title "Créons une organisation européenne pour la recherche spatiale". This version differed only slightly from that circulated in May. But it was supplemented by extremely positive reactions from a number of high-level academics and administrators in Belgium, France, Germany and the Netherlands, and an additional statement by Amaldi.[54] In his statement, Amaldi stressed again that the new organisation should be kept out of the hands of the military, and devoted to strictly scientific and peaceful activities. It should have a central laboratory, its own launching range, and it should develop a European launcher. "If the military maintained the monopoly on the construction of rockets", he said, "each European country would build its own". "We must take CERN as a model", Amaldi stressed, estimating that one could do a "good job" with three or four times CERN's annual budget. Time though was of the essence. A small group of five or six people from interested European countries should be set up "as soon as possible" to study together a more detailed scheme. Within a matter of weeks Auger had taken the first steps in this direction.

These early initiatives call for two comments of a very different kind. Firstly, there is Amaldi's determination that the entire European space effort, from the development of launchers to the construction, launching and operation of satellites, be under civilian control and, more specifically, be essentially in the hands of the scientific community. Secondly, there is the precise role played by Amaldi and Auger in launching a European space effort, the sense in which they may be characterised as its "founding fathers".

Amaldi's insistence that a collaborative European space effort be civilian in character was partly a matter of temperament: he made a point throughout the post-war period of publicly distancing himself from the direct military applications of science, even setting down his day-to-day movements in a diary intended to "prove" that he had not been personally involved in such activities. His attitude was also that of a generation of physicists who had seen, and disliked, the restrictions placed on scientific research and on scientists by the military during wartime projects. Finally, it was indicative of the pragmatically inspired belief that only if the new body were solely dedicated to peaceful purposes could it be fully European in the sense that it could include all the Member States of CERN, notably the "neutrals" like Sweden and Switzerland.[55]

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53 Amaldi to Bannier, 30 July 1959, *ibidem*.

54 Amaldi (1959) and, for an English version of the text, Amaldi (1984).

55 It is important to recall here Amaldi's active involvement in the so calleed "Pugwash Movement", an organisation of scientists from the Eastern and Western countries devoted to arms control issues and peaceful coesistence of the two blocs.

Two considerations lay behind these sentiments and gave an added significance to Amaldi's demand for a civilian space programme. Firstly, there was the strategic nature of space itself, an activity in which the boundaries between basic research and commercial applications, and between peaceful and belligerent uses were quickly blurred. The technology developed for a scientific satellite could be transferred to a telecommunications satellite commissioned by a Postmaster General or by a Brigadier General. The rockets used to launch satellites could also be the intercontinental ballistic missiles used to launch nuclear warheads. Secondly, and most fundamentally, there were important moves being made inside the NATO at the time to shape European collaboration in space. In June 1957 NATO set up a Task Force on Scientific and Technical Cooperation. Its report was rushed directly to a meeting of the NATO heads of government in December that year. The launch of Sputnik a few months earlier weighed heavily on everyone's minds. The meeting affirmed that "the full development of our science and technology is essential to the culture, to the economy and to the political and military strength of the Atlantic community", and established a Science Committee forthwith.[56] Within months it had suggested that NATO organise a space research programme. In the face of considerable opposition from scientists, the Committee's second chairman and science adviser to the NATO Secretary General, F. Seitz, who held office in 1959-60, suggested that NATO sponsor a "European NASA" to work with the American NASA. It was against the backdrop of these developments that Amaldi contacted Auger in February and again in April 1959. Indeed the moves being taken inside NATO at this time might well have been the most important single consideration which spurred Amaldi to act when he did. Certainly the NATO science committee was quick to learn that the eminent Italian scientist was against any military involvement in a joint European space effort. Remember that his April 1959 paper was sent *inter alia* to Prof. F. Giordani, who was the president of the Italian Consiglio Nazionale delle Ricerche and also a founder member of the NATO Science Committee, on which he served from 1958 to 1961.

It was not only a civilian space organisation that Amaldi sought, however: it was also one in which scientists had the power to shape the programme free not simply from military pressures but also from bureaucratic and political "interference" by Member States' governments. Here lies the significance of his claim that any new body be "modelled on CERN". At one level, this simply meant that CERN provide practical guidelines for the new organisation, a precedent and a point of reference for its membership (assumed to be the ten core Member States of CERN), its annual budget (always specified in relation to CERN's), and its initial programme, defined as involving two phases, the first conventional (corresponding to the construction of the CERN synchrocyclotron), the second state-of-the-art (like the CERN proton synchrotron).[57] More fundamentally though Amaldi wanted the new institution modelled on the CERN in the sense that it was to be "depoliticised". On the one hand, this meant that governments should pay for the programme without trying to define its direction and content - whence Auger's remark, after considering the possibility of "modelling" the space research organisation on EURATOM, "that this was not an example to follow, since it was too subject to political contingencies".[58] On the other, it encapsulated the hope that the Member States delegates to

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56 For this and other information on the NATO Science Committee, see NATO (1973). The quotation is from p. 15. See also Massey and Robins (1986), 108-109.

57 For the launching of CERN, see Hermann et al. (1987). The first twelve Member States of CERN were Belgium, Denmark, (Federal Republic of) Germany, France, Greece, Italy, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom and Yugoslavia. In reducing these numbers to ten Amaldi undoubtedly eliminated Greece and Yugoslavia, the former presumably for predominantly financial reasons, the latter because of the changed international climate in 1960 as opposed to 1950.

58 When Auger and Amaldi first discussed their ideas in the Luxembourg Gardens in April, it seems as though they may have been torn between modelling a space research organisation on EURATOM or on CERN. Indeed it is possible that on this occasion Amaldi proposed to Auger that the name EUROLUNE, be used for "a daughter of the European Communities, like EURATOM": see paper by Auger entitled *Sur la creation d'ESRO,* undated but clearly late 1960s, in Auger papers, HAEC, from which the quotations are taken..

the organisation would believe in its importance, would leave the scientists and engineers who ran it to get on with the job with a minimum of external surveillance, and would be prepared vigorously to defend its interests before their national authorities - whence the circulation of Amaldi's May report to Bannier, Hocker and Willems, three of the staunchest members of the "CERN lobby", administrators who shared Amaldi's goals, administrators who saw themselves not simply as representing their national governments at CERN but also as representing CERN before their national governments.[59]

The second comment we want to make about this early initiative concerns the precise role of Amaldi and of Auger. These two were not the first to propose some sort of European collaboration in the general area of space. Indeed as early as November/December 1957 a plea was made for the "creation of a *European* centre for rocket research, which would be managed by scientists, on the model of the Centre Européen de Recherche Nucléaire (CERN)".[60] NATO was also actively canvassing the idea in 1958/1959 as we have seen. That there should be other suggestions of the kind made by Amaldi and Auger is hardly surprising. Granted the context in which the exploration of space was born in the late 1950s, it was inevitably at once a symbol of scientific and technological prowess, an index of political power, and a component of military strategy. Other governments could not stand by idly and allow the superpowers to monopolise the field. Indeed many countries (Australia, France, Italy, Japan, Switzerland ...) took steps to establish national space committees in the late 1950s. Amaldi and Auger brought two specific elements to this rapidly evolving situation.

Firstly, they were plugged into the appropriate national and international networks, appropriate in the sense that they knew personally the high-level science administrators whom they could count on to sympathise with their ideas and to do something about having them implemented. Throughout the 1950s Amaldi had enriched and extended his links into the CERN network through his ongoing activities in the Geneva laboratory.[61] By the end of the decade he was also a member of the newly-established EURATOM's Scientific and Technical Committee. As for Auger, through his presence in UNESCO he had played a key role both in the birth of CERN and in setting up an international computing centre in Rome in the mid-1950s. Now he was the chairman of the French national space committee established in January 1959, through which he had direct access to the French Minister of Foreign Affairs, for example.

Alongside their network of personal relationships - and this was their second trump card - there was Amaldi's and Auger's sense of timing. Indeed the Rome physicist's article calling for the creation of a European space research organisation, with its supporting statements, was published the month after a major achievement at CERN and the month before a major COSPAR meeting. In November 1959, CERN's proton synchrotron reached its design energy of 25 GeV for the first time. European physicists had the most powerful high-energy accelerator in the world at their disposal. European governments, by pooling their resources, seemed, at a stroke, to have made up the gap that separated them from the United States. By the end of 1959 then it was clear that European scientific and technical cooperation could work, and it was almost natural to consider extending it to the new and challenging field of space. And what better place to broaden support for such a project than the General Assembly of COSPAR to be held in Nice in January 1960. "It is the first time that such a conference has been held", wrote Auger, "and it will play for space a role analogous to that which the 1955 Geneva conference played for the atom".[62] It was clearly an opportunity too good to miss. Indeed, the ground had already been prepared. The journal in which the French version of Amaldi's

59 The last phrase in this paragraph is a paraphrase of a statement made by Bannier at a CERN meeting in 1957, in which he rapped the British delegate over the knuckles for what he felt was that country's lack of commitment to CERN. See Pestre in Hermann et al. (1990), chapter 7.

60 This plea was made in an unsigned article - in fact the author was J. Blamont - entitled "Les nations et la conquête de l'espace" which appeared in *Les cahiers de la Republique,* novembre/décembre 1957, No. 10, pp. 8-9. The aim of *Les cahiers...,* as described in a note written by P. Mèndes France in the first number issued in 1956, was to prepare the ground intellectually for action at the political level.

61 Between 1958 and 1960 he was the chairman of CERN's Scientific Policy Committee, and between 1961 and 1963 he was a vice-president, with Bannier, of the Council whose president was in fact Willems.

62 Document "Note sur la recherche spatiale en France", 11-15 January 1960, in Auger papers, HAEC.

report had been published in December 1959 had asked van de Hulst, the president of COSPAR's Executive Committee for his comments on the piece. They quoted him as saying that "we will offer our services to a European organism".[63] Sandwiched between CERN's achievement and COSPAR's conference, the publication of the plea for a joint European space effort could not but make an impact.

1.3 Building up a scientific constituency

The first General Assembly of COSPAR was held at the Centre Universitaire Méditerranéen in Nice from 9 to 16 January 1960. It was here that Auger discussed with a number of European scientists the possibility of creating a European space organisation, having CERN as a model of success. Amaldi could not attend the meeting because of other engagements with CERN and EURATOM, but he was duly informed by Auger of the main events and decisions taken. [64] Two different meetings had been convened by Auger. The first one was attended by representatives of "those countries which have organised a national commission in this field", i.e. Belgium, France, Italy, the Netherlands, Sweden and the United Kingdom. In the second one, "Germany and Switzerland asked to join, hoping to have very soon their own committees". But the real novelty in Nice was represented, contrary to Amaldi's early expectations, by the enthusiasm with which the British, represented by H. Massey, supported the idea of a European collaboration in space. Massey, in fact, played a major role in outlining the possible programmes of the future organisation. He endorsed Amaldi's suggestion that the future European space organisation should have a two-phase programme, like for CERN. The first-phase programme, according to Massey, should include research on the properties of high atmosphere (ionisation, turbulence, temperature), on space radiation (cosmic, van Allen and X-rays) and on astrophysics. For the realisation of this programme he envisaged the use of medium range rockets (200-500 km) and sounding balloons up to 30-40 km. As for the more ambitious, long-term programme, to be based on the use of Earth satellite and space probes, Massey informed his *confréres* that Great Britain was building military missiles with a range of some thousand kilometres and capable of launching satellites. He therefore suggested, according to Auger's report to Amaldi, that the future European organisation "should encourage Great Britain in her national [rocket] programme and induce her to decide the construction of these launchers (this in a few months' time)". This was the first hint to the eventual British initiative in the launcher field which will discuss in detail in chapter 3. As to the next actions, Auger informed Amaldi that the participants in the Nice meeting had decided to contact the various European national space committees in order to organise a more formal meeting, i.e. "a meeting of delegates in charge of establishing programmes and administrative mechanisms (funding included)", to be held in Paris on 29 February.

The meeting was duly organised by Auger at his home in Paris on 29 February 1960. It was attended by eight scientists from eight different countries, most or all of whom had important roles as science administrators. In addition to Amaldi and Auger were present:

- J. Bartels, from the Geophysikalisches Institut, Göttingen, Germany;
- E.Å. "Brunberg, E.", from the Royal Institute of Technology, Stockholm, Sweden, and secretary of the newly established Swedish Committee on Space Research;
- F.G. Houtermans, from the University of Bern, Switzerland, then involved in the setting up of a Swiss committee on space research;

63 Van de Hulst's offer was published along with the text of Amaldi (1959).

64 Auger to Amaldi, 26 January 1960, Amaldi archive, Rome, box 270, Folder "Spazio Europa - Corrispondenza e Relazioni, 1960-1962". See also Auger (1984), and a detailed chronology headed "Commission Préparatoire Européenne de Recherches Spatiales. Dates des reunions depuis l'origine", which can be found in the Auger papers, HAEC.

- H.S.W. Massey, from University College London, UK, who was the chairman of the British National Committee for Space Research;

- M. Nicolet, director of the Centre National de Recherches de l'Espace, Bruxelles;

- J. Veldkamp, from the Royal Dutch Meteorological Institute in De Bilt, Netherlands, who was the secretary of the Netherlands Committee of Geophysical and Space Research;

A ninth scientist, S. Rosseland, was invited but could not attend. Rosseland was the chairman of the Norwegian Space Research Committee and also a member of the NATO Science Committee.[65]

The meeting in Auger's flat was important for two reasons. Firstly, it confirmed that at least all those present were interested in a joint European space research effort. Secondly, it confirmed that the British were most enthusiastic about the scheme. Indeed, Massey apparently went out of his way to "make it clear that British scientists were favourably disposed towards European collaboration", and to suggest that "United Kingdom laboratories participating in the [British] space science programme could receive research workers from Western European nations". Reading the mood of the gathering, he then proposed that, "as the next step towards formalisation of the discussions, he would ask the British National Committee for Space Research to consider issuing an invitation to a meeting in London, in late April, with aim [sic] of setting up a recognised Committee or working group".[66]

An informal meeting of about 20 European space research scientists from ten West European countries (the founder members of CERN minus Greece and Yugoslavia) met in the rooms of the Royal Society of London on 29 April 1960. Sir William Hodge, the Physical Secretary of the Royal Society was in the chair, in the absence of Massey who was visiting Australia at the time.[67] After scientists from several countries had reported on their national activities, the discussion focussed on three main issues. Firstly, the possibilities for cooperation based on existing or soon to be developed national facilities. Secondly, the possibilities for a jointly funded European initiative in the field of space research. Thirdly, the most desirable procedure to be followed for implementing such an initiative.

Three main areas were identified in which European countries could profitably make use of one another's existing facilities. Visiting scientists could be exchanged between universities and some government funded institutions in different countries. Satellites tracking could be coordinated at a European level, and a joint plan agreed for the best distribution of stations and the most appropriate instrumentation with which to equip them. Finally the importance of cooperating in sounding-rocket experiments was stressed, particularly the advantages to be gained by scientists in one country using

65 The list of invited scientists is in Auger to Amaldi, 16 February 1960, Amaldi archive, Rome, box 270, Folder "Spazio Europa - Corrispondenza e Relazioni, 1960-1962". See also the minutes of the meeting at the Royal Society on 29 April 1960 (fn. 57 below) and Massey and Robins (1986), 110.

66 Massey and Robins (1986), 110. Massey's suggestion regarding European scientists to be received in British laboratories is quoted from the letter, dated 30 March 1960, sent by the Physical Secretary of the Royal Society, W. Hodge, to Amaldi, inviting him to participate in the London meeting: Amaldi archive, Rome, box 248, Folder "Spazio Europa - Corrispondenza fino al 1962".

67 Those present were: L.M. Malet (B), K. Thernøe representing J.K. Bøggild (DK), P. Auger (F), J. Blamont (F), A. Ehmert (D), R. Lüst (D), E. Amaldi (I), L. Broglio (I), H.C. van de Hulst (NL), H.S. van der Maas (NL), J. Veldkamp (NL), R. Rosseland (N), E-Å. "Brunberg, E." (S), M. Golay (CH), F.G. Houtermans (CH), W. Hodge (UK), R.L.F. Boyd (UK), H. Elliot (UK), A.W. Lines (UK), D.C. Martin (UK), J.A. Ratcliffe (UK), M.O. Robins (UK), R.L. Smith-Rose (UK). The minutes of this meeting are headed "Western European Space Research Meeting, 29 April 1960", Document NCSR/80a (60), dated 30 April 1960. They can be found in the folder "Origines de la COPERS I", Mussard files, HAEC. This folder also contains the agenda and other papers prepared for the meeting, notably national reports from the Germany, Netherlands, Norway, Sweden, Switzerland and United Kingdom. The draft minutes, Document NCSR/80 (60) are also in this folder. They differ from the final version in that they include more information on the French national programme and statements by Auger as to the kind of contribution that France would be likely to make towards a joint European satellite programme.

launching facilities in another, geographically different region. The Swedes pointed out that there was a site available near the Arctic circle and that the possibility of building a larger site was being discussed. They welcomed proposals for launching "foreign apparatus" from both. Norway was similarly considering a site in the northern coastal region, as well as launchings from ships. If these plans matured, they said, "European cooperative work there would be welcomed". The Italian military had developed a launching site at Sardinia, and the ministry of defence had agreed "that the facilities of the range could be put at the disposal of university workers". Finally, the French could offer their military base in the Sahara, which was particularly convenient as it was in a large uninhabited area. After some deliberation, those present decided that "it was a little too early" to set up a working group to investigate the possibilities offered by these proposals; the matter was better discussed again later.

Attention then focussed on cooperation in artificial satellite experiments. Auger pointed out that this could take place in two ways. There could be simple bilateral cooperation in which countries like Britain or France, which already had plans to launch their own satellites, could include experiments from other countries in the spacecraft. Alternatively, as Auger put it, "all the nations might join together in constructing and launching artificial satellites with each of them contributing to the cost". Attention rapidly focussed on the kind of programme this CERN-like organisation could have, the debate being dominated by the British whose plans were obviously well advanced.

The British scientists described the experiments that they might like to perform during the next five years, i.e. galactic noise measurements, the determination of cloud cover, the geodetic uses of flashing satellites, oceanographic studies from satellites, deeper space probes, etc. The project which they described in most detail, however, was a large satellite carrying an astronomical telescope to be used for obtaining ultraviolet and X-ray stellar spectra. This was to be a high resolution instrument (a figure of 1 Ångström was mentioned) stabilised for astronomical studies. The design study on the satellite had been in progress for six months and British scientists hoped to be able to place design contracts by the end of 1961. In parallel with these developments, there was an important civilian launcher programme being considered in Britain. The government, it was pointed out, was possibly going to cease the development of its *Blue Streak* ballistic rocket for military purposes.[68] If the UK decided to recycle it for civilian purposes, *Blue Streak* could be used as the first stage of a satellite launcher, with a modified version of the *Black Knight* rocket as the second stage. The British scientists explained that three satellites of various sizes had been considered in relation to the design studies of this possible British civilian launcher, of which the large astronomical satellite was the heaviest.

The details of the British five-year plan were spelled out before lunch. Immediately after lunch, if not before, it was clear that the British were not simply interested in informing their colleagues. They were also trying to gauge the level of interest in the European scientific community for a research programme based on the use of *Blue Streak* as a launcher. According to the minutes, the chairman opened the afternoon session by asking "whether any of those present were in a position to give details of their own proposed participation in any joint European satellite programme which might be formulated". He went on to ask for indications of the level of financial support which governments might be willing to contribute towards such a joint programme. Then, becoming even more specific, Hodge inquired "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 programme, it was said, would cost about £ 20 million a year for each of the first five years. This would be used for *Blue Streak* and for other stages of the launcher as well as for the development of the satellites, aiming at two launchings a year two or three years into the programme.

The British proposal was received very positively, and various delegates made suggestions as to the kind and level of contribution which their countries could make to a joint European programme. In the draft, but not in the final, version of the minutes, Auger suggested that a French contribution of

68 The decision to cancel the military rocket programme had in fact been taken by the Cabinet on 13 April, just two weeks before the Royal Society meeting.

£4-5 million per annum would probably be favourably considered in official circles. Several delegates (Amaldi, Houtermans, Malet, van de Hulst) felt that their countries would probably be willing to make contributions of at least the same magnitude as that which they made to CERN. All who spoke were also keen to see *Blue Streak* used as a civilian launcher, though Amaldi and van de Hulst were quick to stress that they were not interested in the rocket in itself. "The Italian government", said the former, "would certainly look very favourably on the use of part of its contribution for the further development of *Blue Streak*, provided that *Blue Streak* really became an important part of a common integrated European project". Similarly van de Hulst was careful to specify that any Dutch contribution was to be used "for the broader aim of placing a European satellite in orbit and not merely for the development of *Blue Streak* as a launching vehicle". These concerns did not impede the committee agreeing "unanimously that *Blue Streak* appeared to be the best possible solution to the problem of finding a suitable launching vehicle for a European satellite". And Auger, spelling out a seven-year programme, proposed that "its final climax [...] should be the placing in orbit of a heavy accurately stabilised platform".

The only jarring note in what seems to have been an otherwise enthusiastic response to the British proposals concerned the position of the Commonwealth in any joint programme. In particular there was the question of Australia, which had important launching facilities at Woomera in the north of the country. From the British point of view, the participation of this country was essential for both scientific and political reasons. Many others, notably Amaldi, Auger and van de Hulst, were not keen to include Commonwealth countries on an equal footing in a European programme, suggesting that an informal arrangement similar to that which existed between CERN and its non-Member States (like Israel) might be a suitable solution. It was decided to postpone consideration of this thorny issue to a later date pending, one imagines, on clarity about the UK government's intentions for *Blue Streak.*

How was the group to proceed? Auger suggested that it should constitute itself there and then as a provisional European Space Research Group. He hoped that this group could have considerable powers, including powers to decide what other Member States should be part of a joint venture. This proposal ran into difficulties immediately. A Swedish delegate pointed out that if this was done, the constitution of the group should be officially communicated "to the Russians" to protect Sweden's neutrality. The British participants in the meeting, for their part, said that they had no authority to constitute itself in this way, adding later that if they did so "any recommendations [...] would have little standing".[69] After some debate, it was decided that within two months Auger should call another meeting of delegates formally nominated by their national committees, and "empowered to create a Preparatory Committee for the establishment of plans for an extended European collaboration in space research". This body would nominate an Executive Secretary who would be expected to draft plans, with the help of experts, for a permanent organisation whose convention would be prepared for government signature "in the course of the next six months following the creation of the Preparatory Committee".[70]

As for infrastructure support, it was proposed that the Organisation for European Economic Cooperation (OEEC) might be a suitable base for the group's activities. Auger was clearly bothered by this idea, pointing out, according to the minutes, "that this should not involve the exertion of any influence by OEEC on the constitution or membership of the group". In fact what Auger feared was the dilution of the "purely" West European nature of any future organisation: a number of non-

69 The first objection on constitutional grounds was raised by Hodge. The second objection was raised by Ratcliffe, who took over the chairmanship towards the end of the meeting.

70 The quotations are from the resolutions attached to document NCSR/80a (60) and from a report written by Auger in his capacity as the chairman of the French Comité des Recherches Spatiales. The report is entitled "Rapport sur la reunion, à Londres, de savants europeens pour examiner les possibilités d'une cooperation dans le domaine des recherches spatiales", and is dated 9 May 1960 (folder "Origines de la COPERS I", Mussard files, HAEC.

European Member States, notably Canada and the USA, were about to enter the OEEC.[71] In response to these anxieties, Golay telephoned the appropriate office in Bern, and was authorised by his Federal authorities to offer all the necessary financial, administrative and diplomatic assistance for the preparatory arrangements for any approved cooperative scheme. It was left to Auger to explore both of these avenues as soon as possible.

The deliberations which we have described call for three comments. Firstly, there is the sense of urgency felt by the scientists. Indeed, it seems as though they hoped to have government agreement on a project within eight months of the April meeting. This feeling sprung partly perhaps from the fear that if they did not define a civilian space programme, quickly political and military-related interests would steal a march on them - space research was being discussed by the European Consultative Assembly and the OEEC in addition to NATO - leaving them with few resources and little or no control over the shape of a joint European space programme. In addition, at least for the British, there was the burning question of how to proceed with *Blue Streak* now that the government had decided to abandon it as a ballistic missile. Even as the scientists were deliberating at the Royal Society there were intense interdepartmental discussions going on inside the UK government around the possible options for the now obsolete rocket - including its use as a civilian launcher in a European space research programme (see chapter 3).

A second point to note is that at this stage the scientists interested in a European space effort were thinking of creating *one single organisation* dedicated to the development of satellites as well of the launchers needed for placing them into orbit. The details were of course still to be defined, notably the nature and the extent of the contribution to be made by continental countries towards the development of the launcher. But the principle was clear. In the words of the resolution passed by the group on 29 April 1960, 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".

This brings us to our third point - and here the contrast with CERN is striking - the British scientists' enthusiasm, already manifest in February, to become involved in a joint European venture. On the face of it one would have expected them to be as reticent in this case as they had been in the early 1950s about the setting up of a European nuclear physics laboratory. Now, as then, they were the undisputed leaders in Europe in the field, with a national research programme far more important than that of any of their potential partners. On the other hand, unlike then, they were now seeking partners in a field which was far more intellectually diverse and expensive than high-energy physics - and there was the problem of *Blue Streak.* One of those attending the meeting at the Royal Society was A.W. Lines, from the Royal Aircraft Establishment at Farnborough. Lines, Auger wrote afterwards, "was very explicit about his country wanting to see this programme [i.e. *Blue Streak*], now abandoned for military purposes, turned to civilian use". £56 million had already been spent on the project. With another £10 million per annum for three to five years, Lines said, the rocket could be used to put a 500 kg satellite into orbit. Reinforcing Lines' remarks, other British delegates present "stressed how encouraged their authorities would be if neighbouring European nations indicated their desire to cooperate civilly in space", referring to the list of CERN Member States several times.[72] In the case of CERN, British scientists had had to decide whether or not to participate in a programme whose outline was being progressively shaped by a group around Auger in 1951/52.[73] A decade later, in the case of space, British scientists had defined an ambitious satellite programme and British engineers had built

71 See the report cited in the previous note. In December 1960, the OEEC was enlarged to include Canada and the USA, whereupon it became the OECD (Organisation for Economic Cooperation and Development).

72 Auger, "Rapport sur la reunion, ...", cit.

73 For the changing British attitudes on participation in CERN, see Krige in *Hermann et al. (1987)*, chapters 12 and 13.

rockets, initially for military purposes, which could be used to place their experiments in orbit. "Europeanisation" was a way of sharing costs on the former, and of saving the money and the expertise already invested in the latter.

1.4 The formation of GEERS

Auger set about the task of establishing the preparatory commission, as instructed by the resolutions passed at the Royal Society meeting, in the weeks that followed. In May he discussed with the OEEC and with Swiss representatives the terms and conditions under which they would support and finance the commission. He also obtained offers of support from his own national authorities.[74] Keen not to lose the momentum that the new venture seemed to have picked up, he called a meeting of interested delegates in Paris on 23 and 24 June 1960 (Figure 1-1). The delegates had before them Auger's proposed "Draft Agreement Creating a Preparatory Commission for European Collaboration in the Field of Space Research".[75]

It rapidly emerged that it would be impossible to set up the preparatory commission at this meeting, as those who had gathered in April had hoped. For one thing, the scientific programme of any envisaged European joint venture was not clear. And the British delegation insisted strongly that the precise domain in which European collaboration was to occur had to be clearly specified before any intergovernmental agreement was put forward for signature. The greatest uncertainty, of course, concerned the launcher. Should the development of *Blue Streak,* Massey asked, "be part of European cooperation, or should this cooperation be more specifically dedicated to the development of instruments to be flown on satellites or on the construction of the satellite itself?"[76]

Then there was the question of the membership of the preparatory commission, and of Australia in particular. Massey, while stressing that his government was keen to be involved in the activities of the commission, "stated that the position of Australia was a serious difficulty in connection with United Kingdom participation in the work of the group". Several delegations (notably the Swiss) felt that the European character of the group should not be diluted. As S. Campiche put it, "the reason for having this meeting was exactly to set up collaboration at the European level in this key domain, just as for the case of CERN".[77] But Massey was emphatic: the CERN arrangements made for collaboration with non-European Member States would not suffice in this case, he said. Nor was he asking that an exception be made for the whole of the Commonwealth, as had been the concern of the British when the CERN Convention was drafted.[78] "The major United Kingdom launching site belonged to the Australian government", explained Massey, "and nothing must be done which would lead to the group being denied access to the launching facilities at Woomera". The form of words, Massey went on, was less important than the interpretation that may be put on them. These should not be such that they could "in any way lead to the withdrawal of Australian cooperation".[79]

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74 For brief information on Auger's activities during May, see the document "Date des Reunions Depuis l'Origine", cit.

75 There is a more or less verbatim French version of the minutes of this meeting, entitled "Groupe d'étude européen pour la collaboration dans le domain des recherches spatiales, reunions tenues à Paris les 23 et 24 juin 1960", distinguished by morning and afternoon sessions, and a briefer English version of the minutes, entitled "Western European Space Research Meeting, 23/24 June 1960", which was prepared, we believe, by the nominated British rapporteur, A.F. Moore, and dated 4 July 1960. These documents, along with other supporting material, including Auger's "Draft Agreement ...", dated 21 June 1960, are to be found in the folder "Origines de la COPERS, II", Mussard files, HAEC.

76 From the French version of the minutes referred to in the previous note, our translation.

77 *Ibidem*.

78 See Krige in Hermann et al. (1987), chapter 8.

79 From the English version of the minutes cit.

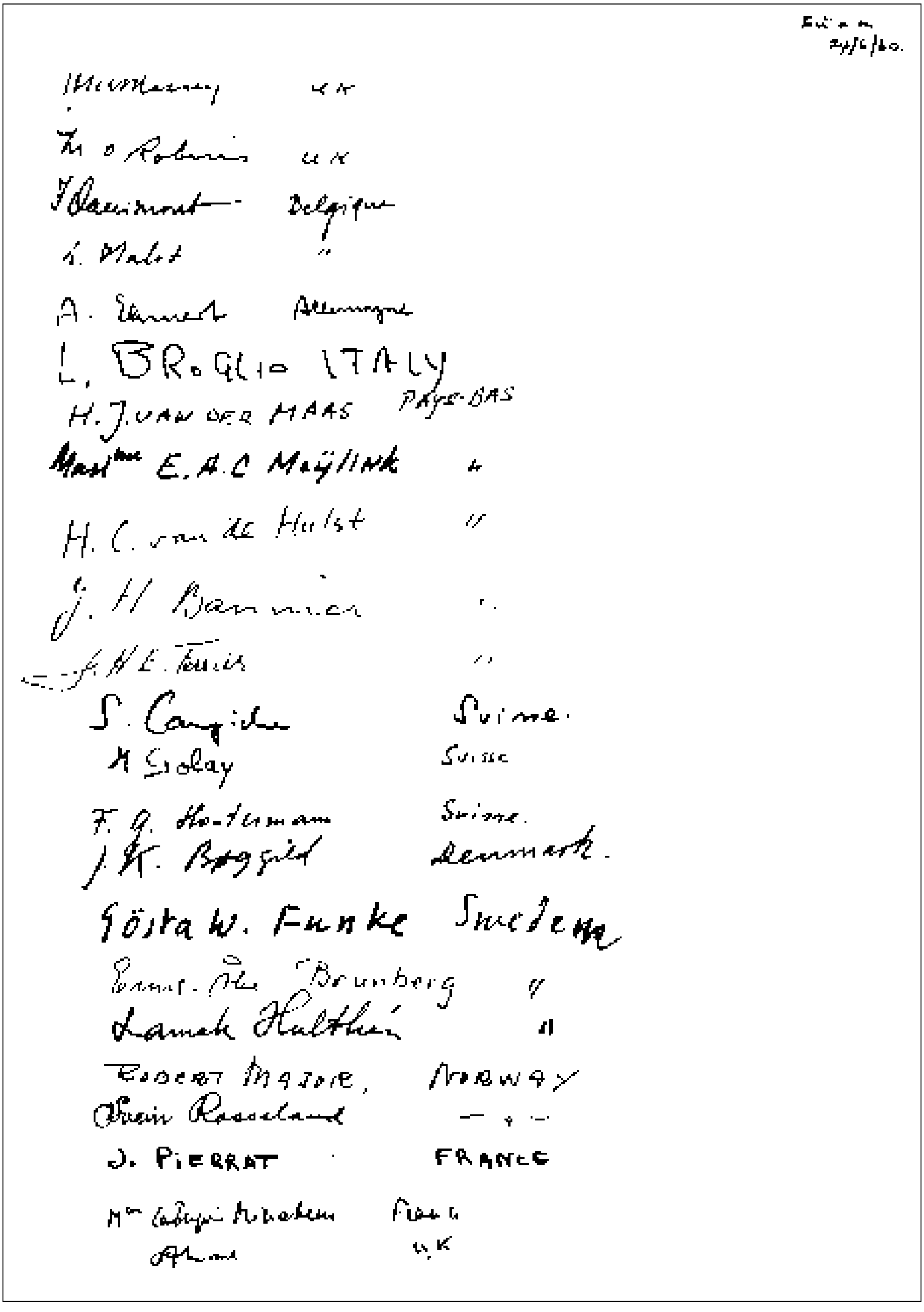

Figure 1-1: The attendance register of some of those present at the meeting constituting the GEERS on the morning of Friday 24 June 1960. R. Lüst was also present. (folder *Origines de la COPERS II*, Mussard files, HAEC

Finally, it was clear that those present simply did not have the authority to take decisions which would be binding on their governments. True some national authorities had sent senior members of the state apparatus to the meeting. France, for example, was represented by Auger along with a delegate from Foreign Affairs, from the Armées "Air", and from the Délégation Générale à la Recherche Scientifique et Technique. Similarly, Belgium, the Netherlands, Sweden and Spain sent high level officials, some of them well-known in CERN circles (Bannier, Funke and Campiche). On the other hand, important delegations like those from Italy and Britain were essentially represented by scientists - Broglio in the case of Italy (Amaldi did not attend), and Massey, Moore and Robins in the case of the UK - with limited powers. To accelerate matters, the Swedes proposed that the agreement be signed by representatives within the limits of the authority that each had, so that it would be a mixed or semi-governmental agreement. But it was not to be. The Belgian delegate F. Darimont stressed that "the group must not forget that in Europe governments themselves are directly concerned with problems of space research. Contacts at the highest level have already taken place on this subject between ministers". International organisations, Darimont went on, had discussed these questions, and the OEEC had already drawn up a broad outline of a possible scheme for collaboration in the field of space. That granted, the Belgians insisted, it would be fatal not to involve governments from the very start in the initiatives favoured by the scientists.[80]

In the light of these considerations - and much to the distress of Auger, Bannier and Funke - it was decided that it was first necessary to establish a study group whose main tasks would be to continue with scientific and technical studies to define more precisely the areas in which European cooperation would take place, to draft a new agreement establishing the preparatory commission, and to convene a meeting of duly authorised representatives to sign the agreement. This intergovernmental meeting, it was thought, could be held within the course of the year (i.e. 1960). The preparatory commission would come into being shortly thereafter, its main task being to draft a Convention and the associated protocols for a European space research organisation, which would be submitted to prospective Member States' governments for signature and parliamentary ratification.

The meeting duly constituted itself as the GEERS (Groupe d'Etudes 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 (UK), chairman, L. Broglio (I), M. Golay (CH) and L. Hulthén (S), vice-chairmen, and P. Auger (F) executive secretary. The French government's offer to host such a bureau was accepted on the grounds that it was more convenient since Auger would be the executive secretary. The Swiss in turn agreed to convene the intergovernmental meeting. A drafting committee was set up to modify the original paper prepared by Auger. It met under the chairmanship of Campiche on 5 July 1960 and rapidly converged on a new three-page draft agreement establishing the preparatory commission.[81]

With these procedural matters settled, the only remaining important point of discussion was the composition of technical study groups. According to the British version of the minutes, it was not clear whether these meetings should be attended by technical representatives from each of the countries present at the meeting, or "whether only those most intimately involved would be invited to the meeting regardless of nationality". Auger, in a brief set of remarks on the deliberations, was more explicit. Everyone understood, he said, that these meetings primarily concerned discussions between British and French experts (about the launcher).[82] All the same, several other countries - he mentions Italy, the Netherlands and Sweden in particular - insisted on being involved in technical discussions from the very beginning. Their argument was that only in this way could they begin to gain the

80 From the French version of the minutes cit., our translation.

81 The draft, entitled "Draft of an Agreement Creating a Preparatory Commission to Study the Possibilities of European Collaboration in the Field of Space Research" is document no. 1 rev. 3, Paris, 5 July 1960 in folder "Origines de la COPERS II", Mussard files, HAEC. The members of the drafting committee were S. Campiche (CH) (convenor), J.H. Ferrier (NL), L. Malet (B), A.F. Moore (UK) and P. Auger (F).

82 See the document entitled "Remarques", undated and unsigned, but clearly written by Auger just after the Paris meeting (folder "Origines de la COPERS II", Mussard files, HAEC.

necessary experience in space research which until then had been a monopoly of the larger European countries.[83] In the light of these requests, Auger thought that a possible composition of the technical group would involve four experts each from Britain and from France and one each from the other eight member countries.

One comment by way of conclusion. The importance of this meeting in June 1960 lay in the fact that it was the first in which scientists dealt face to face with administrators from a variety of European countries interested in space research and were confronted with the political implications of their project. For a space scientist *par excellence* like van de Hulst, there really seemed to be no need to complicate matters by holding a conference of government representatives to sign what was after all only "a preliminary agreement which would lead to the creation of a small organisation with rather limited powers".[84] But this was not in fact possible. And it was not possible because, *in parallel* with the initiatives being taken by the scientists, there were high-level negotiations taking place between European governments, above all over the question of launchers. The main actors here were Britain and France, with at least Belgium keeping a very close eye on developments. Indeed, according to an internal French document, from the time Britain decided to cancel its strategic military rocket *Blue Streak* in April 1960, it had "offered France the possibility of collaborating in the development of a satellite [launcher] using Blue Streak for the first stage, the experimental rocket Black Night (sic) for the second stage, and a third stage involving new ideas".[85] These negotiations were certainly behind Massey's insistence that, while it was most likely that Britain would join the work of the preparatory commission, it could not do so until it knew exactly what areas of collaboration were envisaged. Nothing concrete could now be done until the place of launchers in any future European scheme had been clarified.

1.5 Preparing for the intergovernmental meeting

Auger's expectation that the technical working group would be limited to about 16 people was not to be realised. Indeed, no less than 36 experts attended the gathering held in the rooms of the Royal Society from 3 to 6 October 1960. About half of these were from Britain (nine delegates) and from France (eight delegates). Most other countries sent two or three representatives. Among the several new faces at the meeting, which seems to have comprised almost exclusively scientists and engineers, was a representative from Australia. After the deliberations by the experts Auger combined their various reports into a single document. This was to form a basis for the meeting of governmental representatives to be called by the Swiss.[86]

Auger's synthesis comprised four main divisions. The first briefly described the scientific, technical, and economic advantages, as well as the indirect benefits deriving from European cooperation in the field of space research. This was followed by a section written by A.W. Lines and R.F. Boyd describing a possible scientific programme. Then came an outline, written by Auger himself, of the general principles and organisational structure of the envisaged European agency. Finally Auger's report described the activities to be undertaken by the preparatory commission which was to plan for the establishment of the permanent organisation. It was to have a secretariat and five working groups, it was expected to last for about a year, and its budget for that period was estimated to be of the order of 935,000 new French francs (FF), over half of which was intended for the working groups.

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83 See the British version of the minutes cit.

84 From the French version of the minutes cit., our translation.

85 Unsigned document entitled "Propositions britanniques de collaboration dans le domaine spatial", from the Délégation générale à la recherche scientifique et technique, Paris, 2/4/1960: in *Archives Nationales*, Mission Recherche, Paris, Re 130/31 Liasse 620.

86 The paper, entitled "Report on the London meeting. 3-6 October 1960", is document GEERS/3, 28 November 1960. A copy is in folder "Origines de la COPERS III", Mussard files, HAEC. An abbreviated version of the paper is published in Massey and Robins (1986), Annex 8.

One of the five working groups envisaged was to draft the proposed administrative and technical framework of the new agency. The other four would deal exclusively with scientific and technical matters. One would be responsible for defining the scientific programme, to be based essentially on sounding rockets and satellites. Another was to be a group of rocketry experts "whose task [would] be to study the existing possibilities in obtaining vehicles and using launching sites". This group would look into the possible use of European rockets like *Blue Streak,* as well study the conditions under which American rockets like *Thor* and *Atlas* could be obtained. As for launching sites, the report mentioned Colomb-Bechar - the French military base in the Sahara - Woomera in Australia and Cape Canaveral in Florida. A third group would be needed "to make proposals for scientific and technological research in such fields as propulsion, power sources, information storage and transmission, solid state physics". This activity, the experts suggested, should take up a rather important slice of the agency's budget since in addition to their intrinsic scientific interest, such studies promoted "general technological progress", as well as stimulating industrial development in the Member States. Finally, there would be a group of scientists responsible for exploring the possibilities of setting up and using networks of telemetry and tracking stations both for satellites orbiting the Earth and for deep space probes.

The underlying philosophy and a possible organisational scheme of the new European agency were also defined by the experts in the autumn 1960 meeting. It was essential, they said, that the agency be involved in all stages of space research, from securing vehicles and using launching sites to the exploitation of the scientific results and the processing of the data. Its international character, they went on, should be reflected in the geographical distribution of its establishments, in the composition of its scientific and technical personnel, and in the allocation of contracts to industry. At the same time, they insisted that it should not compete with national efforts in the Member States: it was to "help [...] and enhance their efficiency but in no case supplant them".

From the organisational point of view, the London meeting proposed that the main facility of the organisation should be an Engineering Centre responsible for the engineering of satellites and large scientific payloads. It was also suggested that a main Data Analysis Centre should be established, in addition to the tracking and data facilities which would be required.[87] In the scheme of the Organisation that Auger sketched on a blackboard chart at the meeting the most interesting feature is the equal status of the two main bodies controlling it: the Scientific Committee and the Council, both composed of national delegates.[88] The former had the task to examine all proposals for research, either from Universities and national scientific institutions or from within the organisation itself, and to decide about the actual scientific programme of the Organisation. The Council would have "overall control on policy and finance". Scientists would undoubtedly serve on both. It is evident that, by this time, the plans for the new European space research organisation were strongly affected by the determination of the scientists to control, as far as possible, the new Organisation: they were thinking of an international agency, funded by governments, whose policy had to be defined by an independent scientific body on the basis of pure scientific considerations. A striking aspect of this scheme was the omission of an administrative and financial committee composed of national administrators which, as in the case of CERN, would be responsible for recommending the organisation's budget and for advising the Council on financial matters. By lopping off the main organ through which national treasuries could make their presence felt, the scientists doubtless hoped to reduce bureaucratic and political influence on the shape of the organisation to the minimum.

The broad outlines of a possible scientific programme were also sketched in London. This should include both a sounding rocket programme and a satellite programme. The scientific aims of the former were to be a synoptic study of the atmosphere from 30 to 200 km and the study of solar activity. The Organisation would approve the scientific experiments, coordinate the buying and distribution of the rockets, integrate, engineer and test the payloads, obtain access for scientists to

87 These two centres became the European Space Research and Technology Centre (ESTEC) and the European Space Data Centre (ESDAC): see following chapter.

88 Massey and Robins (1986), 116.

existing launching sites, organise the testing and firing of the rockets, and, finally, collect and disseminate data on telemetry and tracking systems and equipment.

As for satellites, "the Agency should administer funds large enough to provide scientists with missiles enabling them to put satellites in orbit, and develop the required instrumentation". A three phase programme was described. The first, lasting about three years, would include putting into orbit satellites of approximately 100 kg carrying experiments in the fields of atmospheric physics, geodetic and time measurement problems, and cosmic rays. Although these experiments would not be sophisticated, they would serve "to build up European scientific teams with enough experiments to make a full contribution to space research". In the second phase, which would start after about five years, satellites of 500-1000 kg would be launched into terrestrial orbit and lighter payloads into the lunar field. Here more sophisticated experiments would be undertaken, such as the detailed study of stellar ultraviolet and X-ray spectra, the interplanetary and interstellar absorption, and the cosmic rays in interplanetary space. Finally, there was the third phase, to be developed in parallel with the first two. In this phase, the aim would be to study projects "likely to end up, during the following years, in the development of devices capable of landing scientific equipment on the moon, exploring other planets and studying the Sun's neighbourhood". For this it was necessary for the agency, *inter alia*, to undertake research from the start in the "advanced systems that this phase of the programme demanded". Examples were propulsion systems, power sources, information storage, solid state physics, high-vacuum technology and material science.

An important aspect of this meeting is that the delegates did not discuss, as they had in April, possible collaboration in the development of *Blue Streak* as a European launcher. This was partly because Anglo-French negotiations in this regard were still under way and, to quote Massey and Robins, "the UK delegates to the technical discussion meeting were asked not to refer to the matter in any way during the meeting".[89] At the same time it is noteworthy that, in so far as *Blue Streak* and Australia were mentioned at the meeting, they were seen as one option among others, which included using American launchers and French and American launching bases. In other words, whatever the outcome of the political negotiations over the launcher, the technical experts were already beginning to distance themselves from the issue, to consider alternative ways of achieving their scientific objectives. And to narrow the scope of "their" space organisation accordingly.

1.6 The Meyrin conference and the setting up of COPERS

The meeting of authorised governmental representatives was duly convoked by the Swiss government. It took place at CERN in Meyrin (a suburb of Geneva) from 28 November to 1 December 1960.[90] It was attended by mixed delegations of scientists and government officials (notably from the departments of foreign affairs) from the now usual ten countries plus Spain, which was initially admitted as an observer and later as a full participant in the conference proceedings.

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89 Massey and Robins (1986), 115. The authors remark that "this was somewhat embarassing because some of the delegates from the Continent already knew quite a lot about it".

90 A report on the proceedings of this conference drafted by J.H. Bannier, its rapporteur, and labelled document CIRS/4/rev is available in the ESA Collection, box 787, HAEC. Its annexes include the introductory speeches to the conference (Annex 1), amendments to the draft agreement proposed by the Dutch delegation (Annex 2), and the Resolution drafted by one of the working groups which was set up by the conference (Annex 3). In the same box one finds the draft agreement setting up the Preparatory Commission, document CIRS4/rev. 7, 1 December 1960. A copy of this report without the annexes can also be found in the folder "Origines de la COPERS IV", Mussard files, HAEC. This folder also contains a number of other documents and letters relevant to the conference, in particular a report of the proceedings written by Auger in his capacity as the chairman of the French committee for space research. It is entitled "Compte rendu sommaire de la conférence intergouvernementale sur la recherche spatiale tenue à Genève, du 28 novembre au 1er décembre 1960". There are two versions of this report, a preliminary version which is undated, and a final version dated 5 December 1960.

After being welcomed by Max Petitpierre, the president of the Swiss Confederation, and François de Rose, the president of the CERN Council and the head of the French delegation, those present elected their bureau. Massey (UK) was elected chairman of the conference by acclamation, Broglio (I) and Golay (CH) were appointed vice-chairmen, Auger (F) was appointed secretary, and Bannier (NL) was elected rapporteur. After a preliminary exchange of views, three working groups were set up. The first, chaired by Campiche (CH), was called on to study the legal aspects of the draft agreement. The second, chaired by Funke (S), was to study the proposed budget and scale of contributions to the envisaged Preparatory Commission. Finally and most importantly, there was the working group chaired by Golay, whose task it was to study the scientific and technical objectives of the organisation to be created. The working groups spent two full days in discussion, submitting their reports after lunch on 30 November. On the last morning the final touches were put to the draft agreement, arrangements were made for the interim period between the conference and the setting up of a "Preparatory Commission to Study the Possibilities of European Collaboration in the Field of Space Research" (COPERS, from its French initials), and a budget for the first year of the preparatory commission (935,000 FF) and scale of contributions (those in force at CERN) were settled. The agreement establishing the COPERS was opened for signature at 4 p.m. on the afternoon of 1 December 1960.

The proceedings at Geneva were overshadowed by new developments on the question of launchers. In the weeks before the Meyrin conference there had been intense activity in both Britain and France. According to a French source, in September 1960 there was mounting pressure on his government to react positively to the UK's proposal to have France collaborate in the development of a rocket using *Blue Streak* as a first stage, and possibly *Black Knight* as a second.[91] Several technical and ministerial exchanges took place between the two countries and a meeting presided by the Prime Minister was held in November to establish the French position. Here it was decided that "France was willing to associate itself with the British government in a proposal to other European states that a study be made of the technical and financial possibilities of building in Europe a rocket system able to put heavy satellites in orbit." In return, though, it was a necessary, but not sufficient condition for any such collaboration that the second stage of the rocket be built in France, and not be *Black Knight*.[92]

By the end of November, then, it looked increasingly likely that Britain and France would jointly propose a launcher programme to their European partners on terms and conditions still to be arranged. Neither wanted the issue discussed at Meyrin. At the outset, the leader of the British delegation, R.N. Quirk, made it clear that in his view, "the main purpose of the present Conference was to come to an agreement about the legal document that would establish the Preparatory Commission and about the budgetary arrangements which the creation of the Commission would entail". As for its scientific and technical objectives, he said a little later, "it would be desirable to define them briefly and exclude such questions as rockets and telecommunications from discussions at this stage". The leader of the French delegation, F. de Rose, was quick to support him: "The problem of rocket vehicles should not be considered by the Conference". It was possible, he went on, to separate the scientific aspects of space research from that concerning the development and construction of space vehicles in Europe. "The French government was prepared to consider the possibility of developing suitable rockets in Europe", said de Rose, "but not within the terms of reference of the present Conference or of the Preparatory Commission." An organisation, he went on, "could be set up in Europe to carry out space research without developing its own rockets".[93] The British and French governments, in other words, were now absolutely determined to keep scientific research in space separate from applications on the one hand, and, more fundamentally, from the construction and development of launchers on the other.

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[91] See the unsigned document "Proposition Britannique de Collaboration dans le Domaine Spatial", 21 November 1960, produced by the Délégation Générale à la Recherche Scientifique et Technique, in *Archives Nationales*, Mission Recherche, Re 130/31, Liasse 620.

[92] See the "Procès-Verbal de la 22ème Réunion du Comité des Recherches Spatiales tenue le 14 Décembre 1960", dated 20 December 1960, at which F. de Rose explained developments in the Anglo-French negotiations over the launcher: in *Archives Nationales*, Mission Recherche, Re 130/31, Liasse 620. Our translation of what appears to be a verbatim statement.

[93] From Bannier's report on the meeting, *cit.*

The main arguments given at the meeting against "creating an organisation that would not only carry out space research but also develop large rockets" (Quirk) were of a financial nature. Firstly, it was pointed out that since the latter part of such a programme would cost far more than the former, it was likely that the scientific part "would become a very small fraction of the whole project" (de Rose), so not only being swamped but also marginalised. Secondly, it was stressed that the added burden imposed by including rocket construction along with scientific research might frighten off some governments, notably those from the smaller Member States, from joining a space organisation. This would not only dilute its European character but increase the already heavy burden borne by the remaining Member States.

The weight of these considerations was reinforced by the fact that the scientific communities in some countries were becoming increasingly dubious about including launcher development along with space research in the same organisation. This was particularly so in Britain and France, where space scientists hoped to have important national research programmes. Both communities feared that if European research in space science was funded from the same source as the construction of launchers it could only be at the expense of their national plans. Massey posed the problem in terms of the danger to scientific research as a whole. "We do not want to set up a European NASA", he is alleged to have said. "The funds given to a new research agency must not be excessive with respect to the funds allocated to other scientific fields, and thus one cannot consider financing within this framework the development of costly vehicles or of important fixed installations". The role of any new organisation, Massey went on, should be directed exclusively towards scientific research.[94] A French committee for space research meeting about a fortnight before reached a similar conclusion. It remarked that the British government's proposal for building a satellite launcher in common was not without interest. If the scheme went ahead as hoped, it would rapidly enable French scientists to put payloads in orbit which were heavier than those then being launched by the United States. At the same time, the committee expressed its concern at the possibility of there being "an important disequilibrium" between the expenditure required for building launchers and what would then be available for the construction and exploitation of the scientific equipment. It was certainly useful for France to explore the possibility opened up by the British proposal, the committee concluded, but only on condition that "the national programme for space science research was not in any way reduced". And there was an alternative, i.e. the possibility of having NASA launch French satellites on the same terms as had recently been agreed with their British colleagues.[95]

At the Meyrin conference only the Swedish delegation, of those whose reactions are recorded in the minutes, was unambiguously in favour of the Anglo-French wish to hive off launchers from satellites. This was doubtless for reasons of cost and to protect its neutrality. "The development of launchers was a problem for highly industrialised countries and should be kept separate from the problem of space research", the Scandinavian delegate said. Apart from that, the Belgians, in particular, were strongly opposed. "There should be only one international organisation in Europe responsible for the design and development of rockets, space research and the exploitation of results", said their delegate M. Depasse. The Dutch, the Swiss, and the Italians were similarly concerned though not prepared to argue for a single organisation. The development of rockets, van de Hulst pointed out, required a considerable amount of scientific research, and Europe had much to learn in this regard. One should not exclude the development of rockets altogether, said Golay, since those available might not be adapted to the needs which European scientists had. While it was certainly of little interest to devote important sums to the construction of rockets in the short term, said Broglio, "as a long term project,

94 From Auger's "Compte rendu sommaire ...", *cit*.

95 See document "Examen de la Proposition Britannique par le Comité des Recherches Spatiales", 16 November 1960: in *Archives Nationales*, Mission Recherche, Paris, Re 130/31 Liasse 620. The committee pointed out that its five year plan for the years 196l-1965 was estimated to cost 130 million FF, and that a further 100 million FF would probably be required for a European collaborative effort in space science. The cost to France of collaborating with the British on launchers was estimated to be roughly the same as the sum of these together (250 million FF spread over five years).

however, the development of rockets by the Space Research Organisation might prove cheaper than purchasing launchers or having them developed under contract by other organisations".[96]

It was inevitably the view of the two most powerful countries (the German delegation having no authority to speak on the matter) that prevailed in the resolution passed by the meeting. The task of the preparatory commission would be to "consider arrangements for the design, development and construction of space research satellites, and arrangements for the launching of such satellites". The commission was then instructed to "take note of the negotiations separately in progress among certain Member States of the Conference for the collaborative development of a satellite launcher". In the event of an organisation being created for this purpose, it was to "consider the closest possible co-operation between this organisation and the contemplated European Space Research Organisation".[97] Countries like Belgium who feared that, if they did not participate in a rocket programme, they would be deprived of "knowledge and experience which would be of more direct economic utility than that which could be had from an organisation concerned principally with satellites", were compensated in the preamble to the agreement setting up the preparatory commission.[98] In line with a Dutch amendment, the scope of the envisaged organisation was expanded beyond "collaboration in the field of space research" to "collaboration in research in space science and space technology and in the pooling of the knowledge thereof".[99] The decision that the preparatory commission should not concern itself with launchers solved, or rather dissolved, one major problem: the question of Australia. The agreement establishing the COPERS, while insisting that new members be accepted unanimously, stated clearly that these should be European states. "Other states," it added, could "associate themselves" with the work of COPERS, again by unanimous agreement. There was no important debate over these now uncontroversial restrictions.[100]

The "Meyrin Agreement" setting up the preparatory commission was signed on 1 December 1960 without reserve by representatives from five states (Belgium and the Netherlands, Norway and Sweden, and the United Kingdom), and subject to reservation by representatives from five others (Denmark, France, Italy, Spain, and Switzerland). The German delegate had no authority to sign the document, but made it clear that this was for purely formal reasons and that he would do so in due course. With the deposit of the instruments of ratification by France (27 January 1960) and Switzerland (24 February 1960), and the subsequent signature without reserve by Germany, eight countries totalling 83.46% of the budget had become parties to the agreement. With the conditions satisfied (signature, with ratification if necessary, by six Member States contributing at least 70% of the budget), it entered into force on 27 February 1961. The first session of the European Preparatory Commission for Space Research (COPERS) was held a fortnight later in Paris from 13-14 March 1961.[101]

In parallel with these developments, the British and French governments continued their discussions about the launcher. Early in December, a UK technical mission was sent across the Channel to explore the implications of the French demand that they be responsible for the second stage of a jointly developed rocket. The conclusions they drew were explained to the French government on

96 All these quotations are from Bannier's report on the conference proceedings, *cit.*

97 See Annex 3 to Bannier's report, *cit.*

98 The quotation is from a "Note aux chefs de la division des organisations internationales", 17 November 1960, written by Campiche and copied to Auger, in which he reported on a meeting he had had with the Belgian Ambassador that day. According to this note, Campiche hoped that countries supplying rockets to the new organisation would allow the technicians from its Member States to take part in the elaboration of rocket projects. From the folder "Origines de la COPERS IV", Mussard files, HAEC.

99 The first formulation is from a draft of the agreement proposed by the French delegation, document GEERS/1/rev 4, 28 November 1960 in the folder "Origines de la COPERS IV", Mussard files, HAEC. The second formulation is from the final Agreement, document CIRS/1/rev 7, 1 December 1960, in box 787, ESA Collection, HAEC.

100 See Article 2 of the Agreement, document CIRS/1/rev. 7, cit.

101 For information on this paragraph see the minutes of the first session of the COPERS, COPERS/Min/1.

12 December by Peter Thorneycroft, the British Minister of Aviation. Britain, he said, was prepared to see a French rocket atop *Blue Streak* instead of its own *Black Knight,* and British firms would even be available to act as consultants to the French, who seemed to be technically somewhat behind their UK counterparts - but on condition that France paid the same fraction as Britain of the costs of the launcher. France made it clear that she could not accept a financial burden of this magnitude.[102] An agreement was hammered out at an intergovernmental meeting called by the two countries and held at Strasbourg from 30 January to 2 February 1961. A programme was adopted for the development of a three-stage launcher with the first built by the UK, the second by France and the third, as well as a series of test satellites, by other Member States. It was accepted that France, Germany and Italy would contribute to the costs of the programme, estimated at £ 70 million over five years for the vehicle, at the rate of their contributions to the CERN budget, which was based on national income (i.e. about 21%, 20%, and 10%, respectively, in 1960). Britain, for her part, instead of paying the 25% that she contributed to CERN would pay 33.33 % of the whole. The benefit of her additional investment was to be handed on to smaller contributors, whose shares would be reduced accordingly. "This British proposal was decisive for the future of the undertaking", we are told.[103] By February 1961 it was clear that Europe would enter space with not one organisation, as Amaldi and Auger had thought that spring day in Paris almost two years before, but with two.

[102] For details on the Anglo-French negotiations in this period as seen by the French, see the "Procès-Verbal ..." *cit*. above. Further details on these matters will be given in chapter 3.

[103] From the ELDO *Report to the Council of Europe 1965*, pp. 7-8.

Chapter 2: The Early Activities of the COPERS and the Setting up of ESRO[104]

J. Krige & A. Russo

The COPERS held its first session in Paris on 13 and 14 March 1961.[105] Its first task was to create the organs needed to define the scientific programme and the necessary infrastructure of the envisaged organisation, to draw up its budget, and to prepare a Convention for signature by those member state governments who wished to join it. To this end the meeting first elected its "bureau": chairman Harrie Massey, vice-chairmen, Luigi Broglio and Hendrik van de Hulst, and executive secretary Pierre Auger, all men who had played an important role in the debates in 1960 and, Auger apart, still active and eminent European space scientists. It then established two working groups. The first was the Interim Scientific and Technical Working Group (STWG). Its task was to prepare the scientific programme for the future space organisation, paying particular attention to the technical and financial implications of its proposals. Lamek Hulthén, from the Royal Institute of Technology in Stockholm, was nominated chairman of this group; Reimar Lüst from the Max-Planck-Institut für Physik und Astrophysik in Garching, near Munich was appointed its coordinating secretary. The second was the Legal, Administrative and Financial Working Group (LAFWG). Its chairman was initially left open, though it was recommended that he be someone from the German Federal Republic. In the event, Alexander Hocker, a senior bureaucrat from Bad-Godesberg who was also the chairman of the CERN Finance Committee at the time, took on this task. All Member States were to be represented on both working groups, which were empowered to set up subgroups to facilitate their work.

Most of this chapter will be devoted to a description of the main activities of these two groups, particularly in so far as they bore on the drafting of the Convention of the new European Space Research Organisation (ESRO). This Convention was laid before an intergovernmental conference in Paris on 14 and 15 June 1962. Three main aspects will be discussed in particular. The first is the preparation of the scientific programme for ESRO's first eight-year period, including an outline of the research fields to be pursued, the identification of the technical means to be used (sounding rockets, satellites and space probes) and a tentative launching programme. The scientific programme was worked out by the STWG and presented to the COPERS in October 1961 in a report eventually known as the "Blue Book" from the colour of its cover.[106] The second aspect is the definition of the facilities and technical infrastructure of the new organisation and the controversial decision about sites of its establishments. Finally, the third aspect we will discuss is the definition of ESRO's eight-year budget and the mechanism worked out for keeping it under control. In the last section, we will discuss some features of ESRO's institutional structure and its evolution in the first period of the Organisation's life.

By restricting our subject matter in this way, we do not, of course, deal with all matters handled by the COPERS and its working groups in this period, and not by the LAFWG in particular (staff policy and internal structure, privileges and immunities, etc.). We do however throw into relief the most significant issues which were "settled" in the run up to the signature of the Convention, so exploring in depth the history of some key clauses in that important legal document. Two striking features will be pointed out, in particular. First is the determination of the Member States delegates to keep the development of ESRO under tight control. This was so regarding the scope of its scientific programme, the extent of its facilities, and above all its budget, which was fixed for no less than eight years with difficult-to-dislodge ceilings on expenditure at regular intervals. Second, and more surprisingly, is the willingness of scientists to accept these constraints. In fact we even find scientists arguing *against* administrators who wanted to increase ESRO's budget during the first eight-year period, and who thought it prudent to introduce a large margin of flexibility into its funding profile.

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104 This chapter is essentially based on Russo (1992a) and Krige (1993a) and (1993b).

105 The minutes of the meeting are COPERS/Min/1, undated.

106 Report of the Scientific and Technical Working Group to the European Preparatory Commission for Space Research, 2nd edition, December 1961, hereafter referred to as the *Blue Book*.

The attitudes of both governments and scientists were, we believe, informed by their wish to develop robust national programmes in parallel with their European commitments. This inevitably meant that the scope of ESRO's activities and its cost had to be contained so as to stop the international initiative swamping the national efforts. It was yet another difference between ESRO and the CERN on which it was "modelled", a difference reflecting the very different perceptions which government's had of space - seen as a strategic activity directly affecting the national interest - and high-energy physics in the 1960s.

2.1 Working out ESRO's scientific programme:

2.1.1 The first discussions

The most pressing task facing the Preparatory Commission was the definition of the scientific programme of the new organisation. This was not simply because this programme formed the backbone, the raison d'être of the envisaged body. It was also for practical reasons: it determined the necessary infrastructure and, of course, the budget of ESRO. To this end, Hulthén and Lüst rapidly convened the first meeting of the STWG in Stockholm on 4 and 5 April 1961. It was attended by 23 delegates from the eleven Member States of the COPERS, the bulk of them scientists though there were also a few engineers. The main purpose of this meeting was to make a preliminary survey of suitable scientific and technical projects, and to set up working groups to elaborate them further. The meeting was necessarily preparatory. Not only had it been called in great haste. There was also limited overlap in participation with the GEERS working group which had met the previous October in London (see chapter 1). Ten of the delegates to Stockholm had not attended the earlier meeting, and many influential European space scientists were not present in Sweden.[107]

Following the deliberations of the GEERS, the participants in the Stockholm meeting agreed to organise ESRO's scientific programme into three kinds of projects: short-term projects, based on the use of sounding rockets; medium-term projects, requiring small satellites and space probes; and long-term projects, involving the use of larger and more complex spacecraft. This decision was not uncontroversial, however. Stimulated by some critical comments from the Italian engineer and space scientist Luigi Broglio, a lively discussion arose about the role and scope of the sounding rocket and small satellite programmes.[108] According to Broglio, these two programmes had to be mainly performed on a national basis (sounding rockets) and in close cooperation with the NASA (small satellites), while ESRO should concentrate its efforts on more ambitious projects, well beyond national resources. In order to get the small satellite programme started quickly, Broglio proposed that contact be made with NASA to establish what kind of launches and what technical assistance the American agency would be prepared to give to the Europeans. ESRO's small satellite programmes would then be "subordinated to the vehicles which might be available". As regards a "real, original and advanced long-term programme", Broglio insisted that Europe should pursue technology research on future propulsion systems (e.g. nuclear propulsion).

Broglio won little support for his idea that the sounding rocket programme should be left at national level. Apart the consideration that the geographical dependency of such projects and the joint provision of launch facilities required a collaborative effort, three main arguments were given for maintaining this programme within the framework of ESRO. First was the need to involve the smaller countries more effectively in ESRO's cooperative activities; second was the possibility for the European space science community to get significant results in a short time and independently from the American programmes; third was the consideration that such a programme would provide the

107 We have two versions of the minutes of this meeting, one in French and one in English, respectively in the Mussard files and in folder 1688 of the ESA Collection, HAEC. Both are unsigned. In addition there are twelve Appendices to the minutes which include a list of those present and the details of the various offers and scientific proposals made at the meeting. Mussard files (HAEC), folder "GTST intérimaire". See also Massey and Robins (1986), 120-123.

108 Broglio's statement is Appendix 8 to the minutes.

research groups and the new Organisation with useful experience in view of growing involvement in the more demanding satellite projects.

Broglio's suggestion that American launchers be used systematically created considerable controversy. Some delegates, obviously not wishing to have a European satellite programme defined simply by the availability of American launchers, feared that his proposal "would lead to extensive dependency upon American organisations". More generally, though, there was a "thorough discussion" of whether or not American launchers should be used *at all* in the European programme. According to one version of the meeting, there were "tense exchanges between representatives from the United Kingdom, Belgium, Holland, Italy, Germany and France" on this question and, after "a show of hands, the Working Group rejected the British request to take immediately a position for or against the possible use of American satellite launchers".[109]

There was probably one main reason why delegates to the Stockholm meeting baulked at the idea of systematically using American launchers to get started with a European satellite programme. As we shall discuss in depth in the following chapter, in April 1961 negotiations in government circles over ELDO membership were in a particularly delicate phase. Britain and France had proposed to their European partners a joint launcher development programme based on the British rocket *Blue Streak* as a first stage, but the initial reactions in Germany and Italy, in particular, were cool. It would be politically foolish to draft an ESRO programme now in which the scientists seemed committed to using American launchers. In the event, the Interim STWG decided that a decision on the question of launchers "was not appropriate under the present circumstances and that a subgroup would be a more suitable forum to discuss this question".

A coherent and well defined proposal on short-term projects was presented in Stockholm by the Swedish physicist Bengt Hultqvist, the director of the Geophysical Observatory in Kiruna. This listed 13 experiments to measure upper atmosphere parameters in the auroral zone by means of rocket-borne instrumentation, and included cost estimates for rockets (six for each experiment), personnel and equipment.[110] The proposal reflected the interest and experience of Scandinavian scientists, and Hultqvist's in particular, in ionospheric studies in the auroral zone and over the polar cap. An interest in this kind of investigation also existed in Great Britain, where a rocket programme for ionospheric studies had started in 1953 with launchings going on since 1957. Hultqvist's proposal was thus strongly supported at the meeting by the British physicist Robert Boyd, of University College London, in spite of some disagreement among the delegates "as to whether such a sounding rocket program was to be regarded as a true European cooperative project".[111]

Boyd himself, on behalf of the British delegation, presented a proposal for the long term programme.[112] This included two projects to be realised in 4-6 years, i.e. a series of astronomical observatories based on a highly stabilised satellite platform and a series of lunar satellites. Several scientific objectives were listed for the space observatories, with emphasis on astronomical studies in the ultraviolet (UV) and X-ray region of the electromagnetic spectrum, where atmospheric absorption hinders the use of ground based telescopes. Boyd mentioned in this respect that extensive preparatory work had been made in Great Britain for a satellite devoted to UV stellar spectroscopy with 1 Å resolution in the range 1250-3300 Å. The aims of the second project were the investigation of the physical properties of the moon and the provision of a long-life observatory for the study of the solar corpuscular radiation, of the interplanetary dust and of cosmic rays outside the terrestrial magnetic field. Lunar satellites were also considered a first step towards the direct study of planets.

While Hultqvist's and Boyd's proposals were accepted in principle as a basis for further elaboration of the short and long-term programmes respectively, no definite idea was discussed about the medium-

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109 The first two quotes are from the English and the last from the French version of the minutes.
110 Hultqvist' proposal is Appendix 9 to the minutes.
111 The British programme in ionospheric research is extensively described in Massey and Robins (1986).
112 Appendix 3 to the minutes.

term projects. The participants at the meeting received favourably a suggestion from the French delegation (P. Blassel and J. Kovalevsky) for a radio-astronomical satellite and a proposal from Lüst to use satellites and rockets to create artificial comets. Other projects were received coolly and ultimately given a very low priority by the STWG, e.g. a proposal by the Swedish physicist B. Bolin for a programme of sounding rocket research in meteorology and an offer from the Spanish delegation to establish a launching range as soon as possible on the Iberian peninsula or in the Canaries.[113] Bolin's proposal was retained in a first draft of the programme but eventually dropped. Other proposals were stifled at birth, notably a Dutch suggestion that ESRO conduct research into means of guidance and control for sounding rockets such that they could be safely launched from small sites (e.g. 5 km x 5 km) in built-up areas.[114] The meeting felt that the safety questions raised by this proposal should first be settled by international agreement before ESRO conducted such activities. Another important proposal made in Stockholm was not simply marginalised but actually subsequently excluded by the STWG. It was a suggestion from the Belgian delegation that the Working Group "leave open" the possibility of having European telecommunication satellites for telephone and television linkages. The STWG did just the opposite. In an early draft of the Convention, the Group, after its meeting of 27 and 28 July 1961, specifically excluded work of a potentially commercial nature from the activities of ESRO.[115]

Concluding its business, the meeting nominated the Norwegian delegate O. Dahl as Vice-Chairman of the Interim STWG and set up four subgroups of experts devoted respectively to Scientific Programmes (chairman B. Hultqvist), Technology (chairman A.W. Lines, from the Royal Aircraft Establishment at Farnborough), Tracking and Data Handling (chairman J.C. Pecker, from the Observatoire de Meudon, and subsequently C. de Jager, from the Utrecht Observatory) and Vehicles and Ranges (chairman J. Vandenkerckhove, from the Institute of Aeronautics of the University of Brussels). Eventually, the reports produced by these groups were included in the STWG's final report to the COPERS (the Blue Book).

After the London and Stockholm meetings, and with Boyd's and Hultqvist's proposals to hand, it was not a difficult task for the first subgroup to write down the outline of ESRO's future scientific programme. The first meeting of this subgroup, held in Kiruna on 27-29 April 1961, was attended only by Boyd and Hultqvist, by two other scientists from Sweden (E.A. "Brunberg, E." and J. Ortner) and by one from Norway (B. Landmark). The French engineer P. Blassel was also present on behalf of the COPERS Secretariat. Of the other Member States, only Belgium and Germany had nominated representatives in the subgroup but they were unable to attend.[116] The meeting confirmed the three-phase programme and made it slightly richer. The short-term programme included (with just a few additions) the rocket experiments in the auroral zone outlined by Hultqvist, with the addition of similar experiments in the upper atmosphere at medium and low latitudes and of rocket-borne astronomical experiments. A series of meteorological pilot studies was also included at this stage, to be performed by launching many small rockets (350 per year). This part of the programme, however, was eventually not included in the Blue Book. The long-term programme included Boyd's projects of astronomical satellites and lunar orbiters, with the addition of a project for geostationary satellites and a twin-satellite project for radio-interferometric studies of the upper atmosphere. Eventually, however, only Boyd's proposals survived in the Blue Book. Finally, the list of research fields in the medium-term programme remained quite generic. It included a wide range of topics such as ionospheric research; solar physics; geodetic studies; cosmic-ray physics and Van Allen radiation; gravitational, electric and magnetic fields in the Earth's space environment and in the interplanetary space; solar wind investigations; cometary evolution and interplanetary plasma. The list also included "study of

113 Appendices 10 and 11 to the minutes.
114 Appendix 7 to the minutes.
115 The Belgian proposal is prominent in the French version of the minutes. The change in the Convention is to be found in COPERS/AWG/18 (add. 1, rev. 3), 28 July 1961.
116 Hultqvist, *Report to the interim Scientific and Technical Working Group of the Preparatory Commission for European Space Research from the Subgroup for Scientific Projects, 4 May 1961*: Mussard files, HAEC, folder "GTST intérimaire". J. Ortner is actually Austrian but he worked at Kiruna at that time.

fundamental problems in long distance communication by means of satellites" which eventually disappeared from the Blue Book.

From the organisational point of view, the meeting proposed that the scientific projects to be supported by ESRO should be divided into two groups:

a. pure ESRO projects, totally funded and engineered by the Organisation: these were to be primarily large satellite projects in the long-term programme;

b. combined national and ESRO projects, in which the experiments were built by the scientific institutes proposing them and funded by national funds, while ESRO would take care of their integration in rocket or satellite payloads and would provide technical facilities for engineering, testing and launching.

For both kinds of projects, however, it was foreseen that all the scientific work - planning the experiments, design and construction of the scientific instruments, interpretation of the results, etc. - had to be done by research groups in the Member States, while no in-house scientific laboratory was to be established.

2.1.2 The question of in-house research in ESRO

The scheme worked out by the subgroup was discussed at the second meeting of the Interim STWG, held in London on 8-9 May 1961. The meeting was attended by 37 people, including not only scientists and engineers, but also some bureaucrats and representatives from industry. They accepted in principle the plan, which underwent in fact only minor modifications before being presented to the COPERS for final approval. On this basis, the STWG drafted an outline of the launching programme, the facilities and the budget of ESRO over the first eight years of its existence.[117] We shall discuss these elements in the following sections. Here we want to focus on some controversial aspects regarding the role and aims of the future Organisation which were lively discussed in this period.

Two major areas of conflict can be identified. The first regards the relative priority to be given to projects involving small- and medium-size satellites, on the one hand, and to those requiring larger and more complex spacecraft on the other. The first option met the interests of the physicists involved in the various fields of space research: they advocated a programme mainly based on a large number of multi-experiment satellites, capable of meeting the needs of numerous research groups. The second option was supported by the astronomers, whose scientific interest was in the realisation of a few space telescopes on highly stabilised, high-performance spacecraft.

The first option was more versatile and flexible but left ESRO mainly in the position of an agency providing managerial and technical facilities for a rather dispersed and fragmented set of activities. Moreover, this course of action left the Organisation's financially limited operational programme to competition between the various sectors of the space science community. The second option was more in line with the CERN model, establishing a principle of cooperation with the view of carrying out projects of interest to a large, relatively homogeneous, multinational scientific community, whose realisation required financial and technological means far beyond the capabilities of individual Member States.[118]

In the event, the programme of ESRO, as it was worked out in that very early phase, did not establish priorities: either between different kinds of projects or between scientific fields. It came to be presented as an ambitious list of topics covering almost all fields of space science, with the only exclusion of those involving manned flights. This was obviously the easiest course of action in a phase

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117 COPERS/20, 11 May 1961. No minutes of this meeting are available. For a list of those present and a draft of the report which emerged from it see folder "GTST intérimaire", Mussard files, HAEC.

118 For a discussion of this point see Golay (1984).

when space science in Europe was at its very beginning and no research group or disciplinary community had the experience and the prestige to advocate clear priority choices. As we shall see, a great deal of optimism about the technical and financial realities eventually led to gross overestimation in the number of spacecraft ESRO could actually realise, thus giving the illusion that this highly ambitious and unfocussed programme could be implemented.

The second area of controversy regarded the question whether or not ESRO was to be endowed with its own research laboratory and to make in-house research. Following the recommendation of its subgroup for the scientific programme, the STWG's opinion was definitely on the negative. The Working Group agreed in fact that ESRO should only be responsible for the engineering development of satellites and that it "should [not] compete with Universities and other Research Institutes in carrying out purely scientific research".[119] The whole of the scientific work would be under the responsibility of scientific groups outside the Organisation, while the latter was called to provide for technical facilities such as engineering of satellites and complex payloads; for general instrumentation like telemetry or stabilisation; for rockets, launching ranges and launching operations; for tracking of satellites, data recording and reduction; and so on. It was also proposed that ESRO provide scientific fellowship for training and research tenable at its technical establishment or, where appropriate, at any of the national laboratories. No mention was made of the applied research programme which had been recommended at the London meeting of the GEERS in October 1960.

The rationale "for ESRO not having its own scientific groups" was explained by Hultqvist on the basis of four arguments. Firstly, he feared that there would be a brain-drain from national scientific activities to the central scientific laboratory. Secondly, he feared that ESRO scientific groups would rapidly become privileged groups with the best staff, best facilities and the best experience, and so might come to monopolise the most sophisticated and challenging satellite experiments. Thirdly, he believed that if there were no such research groups within ESRO, the scientific activity would be more readily distributed among the participating countries, to the overall benefit of ESRO and of the European space effort in general. And finally, he was concerned that the in-house scientific staff would have privileged access to satellites. Proposals for space experiments from such groups, Hultqvist stressed, would have to pass through exactly the same channels as those coming from national teams.[120]

Hultqvist's position reflected the variegated character of space science as well as the lack of a common tradition within the space science community (a situation very different from that of particle physics). This community, in fact, could hardly accept a central research establishment when the power relations between its various sectors had not yet been tested and clear priorities had not yet been established. This position, however, was not held unanimously among those involved in the discussion on the role and aims of the future organisation. Introducing in fact the second session of the COPERS, held a few days after the STWG London meeting in The Hague, Massey invited the Delegations "[to] speak their minds quite frankly" on the suggestions contained in the STWG's report.[121] Hulthen, for his part, introduced this report recalling the specificity of space science and its various research fields. This, he argued, made ESRO quite different from an organisation like CERN and justified both the lack of a detailed scientific programme and the suggested organisation:

> *Obviously the scientific planning and responsibility in such an enormous field of research could not be left entirely to a relatively small group of scientists at a central institute. In a European Space Research Organisation, when it came to scientific initiative, ideas and*

119 COPERS/20, cit., p. 1.

120 COPERS/GTST/I/l, 15 June 1961. This is a letter from Hultqvist to Lines to be used in the discussions at the third meeting of the STWG. It is to be noted that friction between in-house staff and "outside users", and the tendency for the former to dominate the latter, is a common feature of high-energy physics laboratories. This matter has been discussed extensively by Pestre in Hermann et al. (1990), chapter 8, and by Krige in Krige ed. (1996), chapter 5.

121 COPERS, 2nd session (17-18 May 1961), COPERS/Min/2, 25 May 1961, p. 1.

planning, we would depend very much on the scientists all over Europe, not only those who were attached to the central establishments of ESRO.[122]

This restriction on ESRO's activities was supported by the Dutch delegation but strongly contested by the Belgian, French and Swiss delegations. Here is how the French put it:

It would be contrary to the Meyrin Agreement to consider that the sole aim of the European Space Research Organisation was to put at the disposal of Member States a certain number of technical facilities, the initiation and execution of scientific experiments being left entirely to national institutions. If scientific research were only to be conducted in national institutions, there was a risk that some of the smaller countries which did not possess the necessary resources would feel themselves badly served.[123]

The vagueness of the scientific programme was also criticised in The Hague, while the Belgian delegation blamed the STWG's report for not having "any mention of advanced scientific studies" and for limiting the role of ESRO "to the application of techniques already known". In the event, the Preparatory Commission requested the STWG to perform more detailed studies about the objectives of the scientific programme and the way to implement it. They also requested to examine the desirability of establishing ESRO laboratories for pure and applied research.

When the STWG met again, on 12-13 June 1961, the case for an active role of ESRO in pursuing original research was made by Vandenkerckhove, Pecker and M. Golay, the director of the Observatoire de Genève. According to these three scientists it was a serious mistake for ESRO "to keep outside the European programme the development of fundamental researches and new technologies as well as the exploitation of the results of this programme". On the contrary, ESRO had to play an important role in promoting and funding advanced research programmes both in pure and applied science, and this could be done by setting up new laboratories and research groups, partially or totally funded by ESRO, and by supporting already existing laboratories.[124]

No conclusion having been reached at the meeting, the STWG's subgroup on scientific programme was called to discuss the matter further and to suggest a new scheme. It in fact required two more meetings of this subgroup, a joint meeting of the members of the COPERS Bureau with the officers of the STWG, and a further meeting of the latter, in order to reach what Hulthen presented as "the result of a long and difficult discussion and [...] a compromise between two opposing points of view".[125] This compromise, carefully worded in the Blue Book, stated that ESRO, besides providing technical facilities, would also provide "opportunities for original research beyond those which exist in individual countries". To meet this aim a small research group was envisaged, "at the same place as the European Space Technology Centre but not under the same direction", whose main functions were so defined:

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.[126]

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122 *Ibidem*, p. 2.
123 *Ibidem*, p. 4.
124 M. Golay, J.C. Pecker, J.A. Vandenkerchkhove, *Remarques sur le programme de la COPERS*, COPERS/GTST/6, 12 June 1961. The quotation is our translation from the French original. STWG, 3rd meeting (12-13 June 1961), COPERS/GTST/11, 14 June 1961. A list of "arguments for and against the scientific laboratories of ESRO" was prepared by Pecker, COPERS/GTST/I/8, 20 June 1961. It should be noted that both Golay and Vandenkerckhove were members of the Swiss and Belgian delegations, respectively, which raised the objections made in The Hague.
125 COPERS, 3rd session (24-25 October 1961), COPERS/Min/3, 16 November 1961, p. 2. STWG, 4th meeting (27-28 July 1961), COPERS/GTST/22, 28 July 1961. See also: *Report from Subgroup I to the Scientific and Technical Working Group*, COPERS/GTST/I/21 (rev. 1), 13 July 1961.
126 *Blue Book*, p. 24. ESRO's research laboratory was eventually called ESLAB.

The Research Group would have its own building and a small permanent staff (typically 1 scientific director and 2 assistants, with technical, administrative and secretarial staff) and facilities for some 50 research workers (fellows and guests). Its running budget was fixed at 1 MFF (million French francs), namely 0.4 % of ESRO's total budget. ESRO's scientific activity also included a fellowship programme with a budget of 2.4 MFF.

The Blue Book also established that ESRO should perform applied research in space technology. A distinction was made between short-term research, whose aim was "to offer better facilities for a more advanced programme in space science", and long-term research, "associated with forward looking assessments of space missions, in order to indicate technical possibilities for space science". While it was clearly stated that short-term research had to be pursued at ESRO's technical establishment (ESTEC), with close links with the development of the agreed scientific programme, the wording about the long-term programme reflected the laborious compromise:

> *It is possible to envisage [long-term applied research] being carried out by some other means under ESRO control. [...] It is not considered desirable, at least in the initial period of build-up of ESRO, to set up separate institutes under ESRO control for carrying out long-term applied research. It is believed that such institutes would be less likely to produce results, which can form the basis of equipment development, than groups in contact with project work. However, it is considered that ESRO should support some applied research of a long-term nature for space application in universities and research institutes where work of an allied nature is already in progress.*[127]

If we consider the vagueness that still persisted in the scientific programme described in the Blue Book (see below), we can conclude that the compromise was much closer to the position of the majority of the STWG's scientists rather than to that of COPERS government officials and scientific policymakers. The former aligned on the conservative mode, looking at ESRO as an instrument to give international momentum to already established national research programmes and a technical institution not to be involved as a protagonist on a competitive ground. The latter considered the future space agency from the viewpoint of scientific and technical development in a strategic domain and thus were pushing towards a more advanced frontier.

2.1.3 The Blue Book

The so called "Blue Book" (this was the colour of its cover) is a 77-page report prepared by the STWG and approved by COPERS at its third session, on 24-25 October 1961 in Munich.[128] All the main features of the future European Space Research Organisation are established in this document. The report is divided into 5 chapters, devoted respectively to a general outline of ESRO, to the scientific programme, to the technology centre, to the data handling, and to the ranges and vehicles.

ESRO's scientific programme, as described in the Blue Book, extended over eight years and presented the usual division into short-, medium- and long-term projects. The first category covered rocket experiments "which could be carried out using means which exist or which could be quickly developed". Three fields of study were included in this programme, on the basis of 75 experiment proposals suggested by European research groups, following a questionnaire circulated to COPERS Member States. The first was essentially Hultqvist's original proposal to investigate upper atmosphere phenomena in the auroral zone. Fifteen experiments were listed in this field and the main characteristics of the envisaged programme were discussed in terms of scientific objectives and apparatus. Moreover, the establishment of a northern launching range of the Organisation, near the Kiruna Geophysical Observatory, was recommended (eventually called ESRANGE). The two other

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127 *Blue Book*, p. 38-39.

128 *Report of the Scientific and Technical Working Group to the European Preparatory Commission for Space Research*, 2nd edition, December 1961. This is the final version of the document approved by the COPERS at its 3rd session (24-25 October 1961), COPERS/Min/3, 16 November 1961.

fields of study were far less detailed. The first consisted in the extension, where possible, of the upper atmosphere research programme to lower latitudes, using existing national ranges in Europe. The second was generically indicated as "astronomical studies", including solar ultraviolet and X-ray radiation; lunar and planetary ultraviolet and infrared radiation; solar corona, zodiacal light and albedo. As to the time schedule and launching rate, the Blue Book considered that a small number of rockets could be launched in the first year of ESRO's existence, going up to about 40 rockets in the second year and reaching in the third year an annual launching rate of 65 "standard" rockets (50 kg payload to 150 km altitude).

The medium-term programme included experiments involving small satellites in near Earth orbits and small deep space probes, each spacecraft carrying about five experiments. About 75 experiments had been suggested by interested groups and the list of proposed fields of study included practically all fields of space science. No priority was given but it was underlined that, owing to the limited time for preparation of the answers to the questionnaires, "the list must be regarded as a very preliminary one".[129] The time schedule and launching rate forecast for this programme was rather ambitious: it envisaged the successful launching of two small satellites in the fourth year of ESRO and three small satellites and/or deep space probes per year from the fifth year. It was assumed that the small satellites should be launched by the American Scout launcher, while the space probes and the large satellites of the long-term programme, should be launched by a heavy launcher of the class of the forthcoming ELDO vehicle or the American Atlas-Agena B.[130]

As to long-term programme, it was proposed that one large project be commenced as soon as possible after the establishment of ESRO and that a second be established two years later. Following Boyd's original proposal, the first project foresaw the development and launching of satellite astronomical observatories stabilised in sidereal co-ordinates and the second foresaw the development of lunar satellites. The first large satellite was to be launched in the sixth year of ESRO, followed by a second one during the two following years. The lists of scientific objectives for both projects was very long and heterogeneous but it appeared that the first astronomical observatory would be the large satellite for high resolution, UV stellar spectroscopy already under study in Great Britain.

The Blue Book also reaffirmed that, for all projects, most of the scientific work, including the design and construction of the measuring instruments and the interpretation of the results, should be done by research groups in the participating countries. The costs of the experiments (a relatively small fraction compared with the cost of satellite development and launching) were to be borne by national funds in the case of small satellites and space probes and by ESRO for the long-term projects.

In conclusion, the Blue Book foresaw the firing of some 435 sounding rockets and the successful development and launching of 17 satellites in the 8 years covered by the ESRO Convention, namely 11 small satellites, 4 space probes, and 2 large satellites (Table 2-1). It must be noted, however, that it was assumed that 2 launchings would be required to orbit one successful spacecraft, so that the number of satellite and space probes launchings budgeted for was doubled.[131] The total cost of the satellite programme was estimated at 733.5 MFF, of which 450 MFF was for launchers and launch operations and 283.5 MFF for spacecraft development.

The launching programme and its scientific content proposed by the Interim STWG in the Blue Book and approved by the COPERS in October 1961 was accepted more or less unchanged by the Conference of Plenipotentiaries which signed the ESRO Convention in June 1962. They resolved that during the eight-year period the Organisation should aim to achieve the sounding rocket programme building up to a steady level of about 65 medium sized vehicles per year by the third year of its

129 *Blue Book*, p. 32.

130 The *Blue Book* also took into consideration the possible use of the British *Black Knight* and the French *Diamant* as light launching vehicles. At that time, however, the adaptation of *Black Knight* for satellite launching was still under preliminary study and *Diamant* was still at the design stage.

131 *Blue Book*, tables on pp. 15 and 38.

existence, as well as a successful launch of two small satellites in near-Earth orbits from year four onwards (so ten in all), and two space probes or major satellites from year six onwards (so six in all).[132] It was an aspiration which was to prove wildly optimistic in the light of available resources.

Concluding this section, a number of comments are called for. The first regards the significance of the large satellite projects in this programme. In a context in which major European countries, notably Britain and France, were willing to build up strong national space programmes, these "long-term" projects provided an important rationale for them to collaborate in a joint European effort. "The real raison d'être of Organisation", said Alexander Hocker, ESRO's second Council chairman, was "to carry out projects of a scale and technical complexity beyond what the European countries could achieve within the framework of their individual national programmes". And, he added, "this was the reason why, right at the outset, consideration was given to the project for a Large Astronomical Satellite".[133] In other words, the large projects were a way of cementing Britain in particular, with her important human and material resources, in a European programme. They also incidentally provided the rationale for a clause in the ESRO Convention stipulating that no member state could withdraw before the eighth year, and for establishing an eight-year budget for the body. This was seen in 1962 as a way of ensuring that funds would be available for a long-term project.[134]

Secondly, it must be stressed that when the scientific programme was initially put forward in May 1961 it was defined as the minimum programme, and a special provision was made in the Convention for its extension. In particular, taking CERN's Convention as a model, a distinction was drawn between a basic or initial programme, and a supplementary programme which could later extend the basic programme if two-thirds of the Member States agreed to it.[135] The whole idea was soon dropped on the insistence of the British. They claimed that no clear distinction could be made between a basic and a subsequent programme. They also refused to have the former defined in a formal document like a Convention in terms of a number of devices to be launched.[136] As a result, there was no provision made in the ESRO Convention for the organic growth of the agreed programme. Article VII dealing with launchings stipulated simply that the organisation would launch sounding rockets, and small and large satellites and space probes, the number of launchings to be decided by the Council, "with a view to providing reasonable opportunities for scientifically valuable experiments [...] to be carried out". This is not to say that no provision was made for new projects in the ESRO Convention. However these were not seen as extensions of some basic programme, and so necessarily springing from within the framework of the organisation. Rather they were treated as additional initiatives coming from within the Member States who sought certain forms of support from ESRO. The matter was covered by Article VIII of the Convention which read:

> *If, outside the agreed programme but within the scope of the Organisation, one or more Member States engage in a project in connection with which the Council decides, by a two-thirds majority of all Member States, to make available the assistance of the Organisation or the use of its facilities, the resulting cost to the Organisation shall be refunded to the Organisation by the State or States concerned.*[137]

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132 For the conference resolution see ESRO/Conference/3, 17 May 1962.

133 Forward by A. Hocker to *ESRO General Report 1966*.

134 See the report of the Budget Subgroup: COPERS/AWG/II/2 (rev. 1), 19 March 1962.

135 See Krige in Hermann et al. (1987), chapter 8.

136 See CPERS/AWG/18 (add. 2), 5 September 1961, a note by the British delegation on the article of the Convention dealing with the scientific programme *inter alia*.

137 A typical application of this clause would be a request by a member state to use the ESRO launching range at Kiruna for its national sounding rocket programme. We shall see in chapter 4 that Article VIII was also invoked for implementing the TD-1 satellite programme when Italy refused to continue supporting it.

In short, there was no legally-enshrined opportunity for expansion and increased expenditure inside the ESRO programme as there was in CERN's.

A third comment regards the role and aims of the new space organisation. Conceived and advocated as an international organisation devoted to space research, ESRO did not in fact come out as a scientific institution, with its own scientific staff, a scientific programme clearly defined according to established priorities and objectives, a recognised leadership role among similar scientific institutions in Member States, and a strong negotiating power *vis-à-vis* Member States' governmental institutions. It eventually presented itself in the twofold aspect of a rather cumbersome multinational bureaucracy and a technical establishment conceived to use most of its operational budget for industrial contracts in Member States according to the just return principle (see below). It rapidly became a sort of battleground where difficult and complex negotiations among various interest groups were required in order to reach compromise and agreement.

Finally, we should remark that the scientific programme that the COPERS' Scientific and Technical Working Group elaborated for ESRO was more of the kind of a *manifesto* of interests and expectations (should we say a book of dreams?) than a concrete working hypothesis. It reflected the intentions and hopes of important sectors of the European scientific community that lacked, however, the strength and the lucidity that can only derive from an established tradition, from a common patrimony of professional values, and from a substantial homogeneity of aims and methods. When ESRO moved its first steps from the inspired vision of a few pioneers to the hard political and financial reality of space policies and technical difficulties, it was inevitable that the transformation of the *manifesto* into a true operational programme should be a long and laborious process and the results sometimes disappointing.

2.2 Facilities and establishments

2.2.1 ESTEC and ESLAB

From the outset it was assumed by the scientists planning ESRO that its core facility would be an establishment responsible, either itself or through contracts with industries and national institutes, for the engineering and testing of satellites and their payloads, the integration of scientific instruments in these payloads, and for making arrangements for launching. These activities were to be undertaken by what was initially called a Payload Engineering Unit and, later, the European Space Research and Technology Centre (ESTEC). The organisation of the scientific work foreseen in the Blue Book divided experimental projects into three categories by source of funding. Firstly, there were pure ESRO missions, i.e. those paid for entirely by ESRO (typically, the large satellite projects). Such projects would be engineered at ESTEC though the scientific payloads, even if paid for by ESRO, would be contracted out to a large extent to European industries and scientific groups in universities and national institutions. Secondly, there were combined national and ESRO missions, in which the scientific instrumentation would be built in the Member States and paid for exclusively from national funds, ESRO's task being to engineer the satellites. This would be the case with most experiments. Thirdly, there were what were called national missions undertaken with ESRO help, in which once again the scientific payload would be paid for from national budgets, but ESRO facilities, e.g. launching ranges, would be used and perhaps even paid for by the national group. In all cases then it was assumed that the construction of scientific instruments flown on ESRO satellites would normally be under the control of national groups, even when all the costs were being borne by ESRO. The STWG stressed that an additional 16 MFF annually would be needed for such activities over and above the money required for the ESRO budget.[138]

The size of the ESRO in-house scientific staff allowed for by the Interim STWG reflected the determination to deny them space on satellite payloads. The laboratory (ESLAB), as we have mentioned, was provided with a building and equipment for about 50 research workers and technicians

138 COPERS/GTST/I, 15 June 1961. See also *Blue Book*, pp. 12-13.

as well as a permanent staff, typically comprising one scientific head with two scientific assistants along with administrative officers, technicians and a maintenance staff. This was in fact smaller than the so-called standard scientific group which the STWG estimated to be necessary for preparing experiments to fly on satellites, and which comprised four scientists, four technicians and three auxiliary staff.[139] These limitations were reflected in the Convention. According to Article VIb, ESLAB was to be situated "near" ESTEC and its task was "to undertake joint research programmes on the minimum scale deemed necessary by the Council [...] to complete or complement the scientific studies carried out in Member States". These formulations were not simply a victory for those who wanted to ensure that a strong in-house staff did not come to dominate the scientific programme. They were also a symptom of the determination of space scientists to protect their national efforts. And an index of their perception of the role of ESRO in European space science: for many of them it was, indeed, to be a service organisation.

2.2.2 ESRANGE, ESTRACK and ESDAC (ESOC)

Three other facilities were required in addition to ESTEC and ESLAB. These were a sounding rocket launching range, a data analysis centre, and a network of tracking and telemetry stations. The first, labelled ESRANGE, caused little difficulty. It was generally agreed that it was important to carry out a sounding rocket programme in the auroral zone, and for this reason it was essential that ESRO equip itself with a suitable range in the northern latitudes. The STWG considered three possible places for the launching range. The first was in Greenland (Narssarssuaq), the second in Norway (Andøya), and the third in Sweden (Kiruna). Of these three, the last was deemed the most suitable. Firings at the bases in Greenland and Norway would be respectively over the ice cap and over the sea, making payload recovery difficult. At Kiruna they were over the land. The first two were remote and accommodation was likely to be difficult. Access to Kiruna was good by air, road and rail, and the launching range was close to a fairly large town of the same name. Finally and perhaps decisively, ESRANGE could be located near Hultqvist's Geophysical Observatory. The only disadvantage with Kiruna appeared to be "the fact that one or two dozen Lapps may be in the area during certain periods". This safety problem, the STWG thought, was not a serious one and it strongly recommended that the Kiruna site be chosen as the location for the ESRO Northern sounding rocket range.[140] Apart from that, there seemed to be no need for ESRO to have any additional ranges of its own. Its sounding rocket programme in medium latitudes could, it was felt, be adequately supported by using existing national ranges. And although there were certainly some advantages to be had from creating a special satellite launching range under ESRO control, the STWG concluded that "up to the present the creation of such a new range does not appear to offer any scientific advantage".[141]

Data handling had two aspects. Firstly, it required the setting up of a network of tracking and telemetry stations which could receive signals from spacecraft (ESTRACK). Secondly, it required a central laboratory which would edit and process the information from the tracking network. This data centre would have scientists and engineers on its staff who would not only concern themselves with the technological problems of data recovery, processing and analysis, but also with fundamental questions associated with the prediction and analysis of satellite orbits. The facilities at the centre, initially labelled ESDAC (European Space Data Acquisition Centre), were essentially to be a large mainframe computer or computers, which would be made available both to its in-house staff and to visiting scientists and fellows who wished to use them to analyse and study the recovered data.

There only seemed to have been two points of ambiguity, and possibly of controversy, surrounding these several facilities. Firstly, there was the question of the relationship between ESDAC and ESTRACK. The first report prepared by the STWG in May 1961 explicitly stated that the data centre would, "in addition to data handling, also control a number of tracking and telemetry stations".[142] By October that year this seemed no longer necessarily to be the case. There is no explicit reference in the

139 *Blue Book*, pp. 24-25, 30 and 34.
140 *Blue Book*, pp. 35 and 64-67. See also COPERS/GTST/I/16, 6 July 1961.
141 *Blue Book*, p. 18.
142 COPERS/20, 11 May 1961, p. 2.

Blue Book to ESDAC actually controlling the telemetry and tracking stations and indeed when ESRO was born the control centre for managing tracking and data acquisition facilities was situated at ESTEC. It was an unhappy decision. Within a few years it was reversed and satellite tracking reverted to ESDAC which was renamed ESOC, the European Space Operations Centre.[143]

The second possible point of friction concerned the nature and distribution of the ESTRACK facilities. In the Blue Book it was proposed that ESRO set up four new radio tracking and telemetry stations, and three optical tracking stations. Three of the radio stations were to be distributed roughly along longitude 135° East, and the fourth around longitude l5° East. They could be supplemented by stations on these longitudes which were part of the U.S. Minitrack network. In this way, two new chains of stations, one running through Japan and Australia, and the other through Europe and the African continent, could be added to an American chain running roughly down longitude 75° West. As for the three optical stations, the Blue Book insisted that these were urgently needed to support a variety of studies, e.g. gravitational, geodetic and atmospheric structure studies as well as certain ionospheric investigations. There were far too few of these stations in existence in the world at the present time, claimed the report, and it seemed clear that ESRO should make as large a contribution as possible to their extension, in consultation with the COSPAR.

The STWG regarded this set-up of four radio tracking and telemetry stations and of three optical tracking stations to be an absolute minimum, a network "capable, if need be, of operating independently of existing networks, but capable also of being linked with them where possible".[144] Indeed the concept of having a network which could operate independently was built into one of the earliest drafts of the Convention.[145] It did not survive for very long. The British delegation soon objected, and at a meeting of the LAFWG in September 1961 it was decided to omit all reference to the coverage, and so location, of tracking and telemetry stations from the final Convention.[146] Thus Article VId of the ESRO Convention simply stated that in order to meet its initial requirements, the Organisation would establish and operate "a Data Centre and tracking, telemetry and telecommand stations" suitably equipped. Once again the Member States, apparently with little resistance from the scientists, had succeeded in pruning back the scope of the ESRO programme.

2.2.3 The sites of the main establishments

The choices of the locations of ESRO's three main establishments, i.e. the headquarters, the payload engineering unit with its associated scientific laboratory, and the data centre, were essentially determined by political considerations: there were no overriding scientific arguments for any particular site. By contrast, scientific concerns, as we have seen, were dominant as regards the siting of the sounding rocket launching range, which necessarily had to be placed in northerly latitudes so as to carry out geophysical studies in the auroral zone. Scientific as well as political considerations finally played a role in the siting of the tracking stations.

By October 1961 several Member States had expressed an interest in having one or more of the ESRO main facilities on their soil.[147] France and the Netherlands had submitted bids for the headquarters in Paris and The Hague respectively. Six Member States had proposed sites for ESTEC: Germany near

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143 For information on the control centre at ESTEC see Fraysse (1966) and Tootill (1967). The transfer of this centre to ESDAC was a consequence of the recommendations made by the Bannier report in 1967 (see below).

144 *Blue Book*, pp. 54-56.

145 The system of tracking stations, it was said, should "complement the existing world network", but should also be "capable of giving reasonable coverage by itself". See COPERS/AWG/18 (add. 1, rev. 2), 20 July 1961.

146 LAFWG, 4th meeting (28-9 September 1961), COPERS/AWG/38, 9 October 1961. See the UK note COPERS/AWG/18 (add. 2), 5 September 1961.

147 For the information that follows see the folder "Enplacement des Etablissements" in Mussard files (HAEC).

Munich; France at Bretigny, about 30 km from Paris and alongside the Centre d'Essais en Vol; the United Kingdom at Bracknell which was near the Royal Aircraft Establishment in Farnborough as well as other facilities engaged in space research; Switzerland at a site 15 km from Geneva, near the Observatoire de Genève and also close to CERN and to several universities; Belgium at Zaventem, near Brussels and close to several universities, aeronautical research centres and other research laboratories; and the Netherlands, adjacent to the Technische Hogeschool and the Central Organisation for Applied Scientific Research in Delft. At the third COPERS session in Munich at the end of October, the Belgian and Dutch delegations said "that they wished their separate proposals for ESTEC to be viewed as variants of one proposal".[148] As for ESDAC, by mid-October there had been just one offer of a site: from Germany, near Darmstadt.[149] In Munich the UK added the candidature of Bracknell.

The delegates to the Munich session instructed the COPERS Bureau to continue to collect factual information relevant to the various sites proposed. They also authorised it to set up, if need be, a Working Group on Sites to facilitate the final choice which, it was hoped, could be made by the COPERS at its fourth session scheduled for 23-24 January 1962. This session was, in fact, postponed by about a month. In the interim, on *25* January 1962, the Bureau decided not to set up a site panel. Instead, "in view of the delicate nature of the matter", it invited O. Dahl to study the proposals that had been received, "consulting with the appropriate authorities in the Member States as necessary, and [to] present a confidential report to the Bureau".[150]

Consistent with his brief, Dahl did not go on further fact-finding missions. Instead, he sounded out senior government officials and scientists in the several countries which had made proposals for sites. As he made his rounds, and explained the various offers and possible combinations, the number of candidate sites grew rapidly. Countries, wrote Dahl, tended to work "on the assumption that something is better than nothing", and it "became apparent that if a filed proposal were not to be upheld, a proposal for one or more of the other establishments would come forth". Thus when Dahl sat down to draft his report in March 1962 he found himself with a long "semi-official" list of proposals. France, Switzerland and the Benelux countries had all offered to host the Headquarters. Germany had effectively withdrawn its proposal for ESTEC, while Italy had added a site at the old airport just outside Rome and associated with Broglio's aeronautics experimental facilities. As for ESDAC, Switzerland had added its bid to those already on the table from Britain and Germany.[151]

In Dahl's report and in the subsequent debate, three considerations more or less explicitly informed the negotiations: whether the sites should be concentrated or dispersed, whether ESRO's headquarters should be close to ELDO's headquarters or remote from it, and whether or not it was desirable to put ESRO's headquarters near to ESTEC.[152] There were of course strong arguments on both sides as regards all three of these criteria.

Cost, efficiency, and the possibility of making a quick start to the European space effort weighed in favour of concentrating the establishments. As Dahl put it, "ESRO will cost relatively more, we will move slower and it will be more difficult to have control", if the establishments were dispersed. "There [would] be a tendency towards independent growth of establishments as administration and services must in certain ways be duplicated".[153] Against that, there were obviously strong political

148 COPERS, 3rd session (24-25 October 1961), COPERS/Min/3, 16 November 1961. For more on the Bracknell site and its advantages, see Massey and Robins (1986), p.127.

149 LAFWG, 3rd meeting (14-15 September 1961), COPERS/AWG/33, 27 September 1961.

150 This is the procedure outlined by Auger in a circular letter dated 7 February 1962 and sent to all delegations to the COPERS - see e.g. folder "Denmark" in Mussard files (HAEC).

151 Dahl's report is reproduced as Annex 11 in Massey and Robins (1986). There is also a copy in the Mussard files (HAEC), folder "Emplacement des Etablissements".

152 These considerations were spelled out in Dahl's report and in COPERS/87, 4 May 1962. The latter is a summary report of meetings held between the Bureau and the heads of member state delegations on 26-27 March and 4 April 1962.

153 From Dahl's report, cit.

considerations in favour of dispersing the establishments. Not only would it enable more Member States to have a direct stake in the joint effort, so making it more "truly European". It was also a means of stimulating space activities in those countries, particularly smaller ones, which were relatively backward in this regard. What is more, it was not obvious that dispersion necessarily meant a loss of efficiency. As the Belgian delegation and the LAFWG's budget subgroup pointed out, NASA's establishments were widely dispersed across the United States and this did not seem to create intolerable inefficiencies.[154]

Opinions were also divided over whether or not ESRO's and ELDO's headquarters should be in the same place. Massey, for example, was very much against the idea or even against any close cooperation. "His main argument [was] that ELDO [was] a 'commercial' set-up", while ESRO was strictly scientific.[155] Some delegations, e.g. Austria, also feared that if ESRO and ELDO were tied too closely together it would limit ESRO's freedom to purchase rockets from NASA. Against that, it was felt that there would obviously have to be very close contact between ESRO and ELDO, and that it was highly desirable that they share certain "neutral functions" (e.g. administrative services) in the interests of saving money and of efficiency.[156]

Finally, there were clearly advantages to having ESRO headquarters close to ESTEC, so facilitating the lines of communication between the administrative arm of the Organisation and the most important ESRO establishment. This in fact was the combination preferred by the scientists in the STWG.[157] The picture was however blurred by the fact that some people, particularly the British, felt that there should also be very close technical collaboration between expert groups in the ELDO headquarters and the engineers in ESTEC. Thus the question of whether or not the ESRO headquarters should be near the payload engineering unit became intertwined with the question of whether or not it should also be close to the ELDO headquarters.

When Dahl came to frame his proposals, it was already known that ELDO's headquarters would be in Paris. That granted he opted for moderate concentration, suggesting that ESRO's headquarters should be located together with ESTEC (and ESLAB) on the proposed site in Delft, Netherlands, while ESDAC and the tracking centre be located in Darmstadt, Germany. His report was laid before a joint meeting of the COPERS Bureau and the heads of the delegations on 26 and 27 March 1962, and his recommendations were summarily dismissed. A number of delegations, we read in one report of the proceedings, "while acknowledging the difficulty of Dr Dahl's mission and thanking him for the considerable amount of work which it had involved, considered that the report touched on matters of opinion as well as of fact and in this regard was not an appropriate basis for discussion".[158] Whereupon the hard bargaining and political horse-trading began.

Three points emerged at this very tense and difficult meeting. Firstly, it was generally agreed that ESRO's headquarters would be in Paris along with ELDO's. The French were extremely keen to have them there, letting it be known that they would withdraw the bid for ESTEC at Bretigny if successful.

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154 COPERS/87, cit. It is to be noted that in a trip to NASA at the end of 1961 by some members from the budget subgroup, NASA recommended that ESDAC and ESTEC be located in the same place: COPERS/AWG/II/2 (rev. 1), 19 March 1962.

155 *Memorandum for Prof Auger from Odd Dahl, Meetings in London, February 12*, in Mussard files, HAEC, folder "Emplacement des Etablissements".

156 From Dahl's report, cit. See also COPERS/87, cit, p. 2. Austria also stated that it was against putting the headquarters of ESRO and ELDO close to one another for "political reasons", by which it probably expressed a desire to distance itself from the military associations of the launcher development organisation.

157 COPERS/36, 19 October 1961. This document listed the STWG's criteria for the location of ESTEC which were: within some tens of miles of liquid oxygen and liquid nitrogen plants, near an international airport and central with respect to the Member States, near small electronic and electric factories, near an industrial area, near a technical college, near a university, suitable accommodation available, and near ESRO headquarters. All the sites offered satisfied the first seven of these eight criteria.

158 COPERS/87, 4 May 1962.

There were also some advantages to having ELDO's and ESRO's administrative and policymaking centres close to one another, as we have said. Secondly, the choice of a site for ESTEC was more or less reduced to a two-cornered contest between Bracknell and the Belgian/Dutch proposals. The other remaining candidates, Italy and Switzerland, were poorly supported. Finally, Italy, finding itself marginalised, made a bid for ESLAB. There was apparently "strong support" for this idea, even though the draft of the Convention, agreed after months of negotiations, specifically said that ESLAB should be near ESTEC, and there was "no suggestion at the meeting that ESTEC also should be in Italy".[159] No definite decisions were taking at the meeting in March. Those present agreed to reconvene on 4 April. This time the climate was, apparently, more relaxed. The British, having found that only the Scandinavians were in favour of having ESTEC in the UK, had decided in the interim not to press their case for the payload engineering unit, even though they were convinced that the human and material resources in and around Bracknell provided the best way "to ensure quicker development of a subject in which Europe was already a long way behind the United States and the USSR". The Swiss too came to the meeting willing to withdraw their candidature for ESTEC, "in order to facilitate a solution", they said, preferring to put up a fight for ESDAC.[160] A secret ballot was held on the location of the payload engineering unit, the vote being 6 to 4 in favour of Delft over Brussels (Belgium and The Netherlands did not participate). The voting for ESDAC, now a choice between the Swiss site in Commugny and the German site in Darmstadt, was 8 to 4 in favour of the latter, only the two "neutrals" Austria and Sweden, along with Spain, joining the Swiss in preferring the site near Geneva. The headquarters, as expected went to Paris, by 10 to 2 (Norway and Sweden), the latter insisting that its objection was not "to be construed as anything other than the expression of their conviction that the Headquarters should be located at ESTEC". It was also unanimously agreed that the Nordic launching base of the ESRANGE complex should be at Kiruna. In fact so sure were the Swedes of their case, and so keen were the scientists to get started, that there was already a bill before the Swedish Parliament, due to be passed in May, proposing that the existing site near Hultqvist's laboratory be made available to ESRO.[161]

2.2.4 ESRIN: a new research laboratory for ESRO

This left the thorny question of Italy's offer to host ESLAB. The British were strongly opposed to this. The laboratory, they said, had been conceived as a small centre close to ESTEC, which would now be in Delft. Hulthén, speaking on behalf of the Interim STWG, backed up the UK delegation. The Italian proposal was contrary to the "carefully worded compromise" regarding this facility which had been arrived at by the Group after months of discussion. One could not now redefine the nature of the laboratory without referring the matter back to the STWG, so introducing additional delays. Broglio, however, was emphatic, though he did imply that the laboratory which the Italians wanted need not in fact be ESLAB, but an additional facility with a rather different focus. This broke the deadlock. The majority of the delegations felt that the Italian demands had to be met, and voted 9 to 3 (Norway, Sweden and the UK) to recommend to the COPERS "that a laboratory of a size and scope to be decided by the Council should be established in Italy".[162] The COPERS accepted these proposals with some misgivings at its fifth session, and they were confirmed by the Conference of Plenipotentiaries on 14 June 1962.[163] Thus was born ESLAR: a laboratory for advanced research in addition to ESLAB. It was later renamed ESRIN, and acronym for European Space Research Institute. The problem was now to define a precise role for it.

When Italy made its unexpected bid for an advanced laboratory on its soil, it had an ambitious programme of activities in mind. It was proposed that ESLAR (as it was then called) set up groups to

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159 For this paragraph see Dahl's report on the French position, and Massey and Robins (1986), p. 129, COPERS/74, 28 March 1962 and COPERS/87, cit

160 Massey and Robins (1986), p. 127 and 129 on the UK, and COPERS/87, cit.

161 COPERS/87, cit., pp. 6-8, and Massey and Robins (1986), pp. 129-130.

162 COPERS/87, cit., pp. 9-10, and Massey and Robins(1986), pp. 130 et seq. The proposals for the sites are summed up in COPERS/82, 27/ April 1962.

163 COPERS, 5th session (10-11 May 1962), COPERS/Min/5, 12 June 1972, and ESRO/Conference/3/, 17 May 1962.

explore, e.g., the feasibility of planetary probes and to study drag-free non-relativistic satellites. The basis for theoretical and experimental research required for these programmes was also indicated, and included studies on advanced systems for energy conversion, on small nuclear rockets for satellite stabilisation and control, and on scientific spacecraft for solar sail propulsion. This programme was rapidly scaled down in the Council of the COPERS so as to keep the laboratory small. Its research was also reoriented, under the impulsion of the Council chairman Massey, so that when ESRO came into being, ESLAR's function was defined as being "to undertake laboratory and theoretical research in the basic physics and chemistry necessary to the understanding of past and the planning of future experiments in space". Subsequently, considerable stress was laid on plasma physics studies, the characteristics of a plasma most nearly corresponding, on a laboratory scale, to those of space.[164]

The first director of ESRIN, H.L. Jordan, was appointed on 29 July 1964. The two most eligible sites for his laboratory were at Arcetri, near Florence, which had an important centre in astronomy research, and which was preferred by the Italian delegation, and at Frascati, near Rome. A laboratory in Frascati would be close to a high-energy physics centre equipped with an electron-positron collider, and to Broglio's aeronautical research laboratory. Jordan preferred Frascati to Arcetri because of this concentration of establishments with similar interests, and the Italian delegation reluctantly respected his wishes in March 1965.[165]

Nine months later, a small group of five scientists, six technicians and four administrators were installed in temporary accommodation in the Park hotel near Frascati. They quickly arranged their first conference on plasma physics to be held in May that year. It took some time to find a permanent site for the laboratory – indeed the cornerstone for its new building was only laid in September 1968.[166] ESRIN was always the *Cinderella* of the ESRO establishments. Its building was hardly completed before there were serious proposals that the facility be closed down (see chapter 8 below). In the event it survived, but only with a sharp reorientation of its mission.

2.2.5 Choosing a new site for ESTEC

The difficulties of siting the ESTEC laboratories at Delft were quick to emerge. The temporary accommodation offered by the Technical University was inadequate for the rapidly increasing ESTEC staff. The assumed advantages of being attached to a centre of learning turned out to be limited, as the courses were all in Dutch. Local industry objected to ESTEC recruiting technical labour in the area, where it was in short supply. It was difficult to get secretaries and typists to move from The Hague, where they easily found work, to Delft, where living conditions were less attractive. Above all though there was the problem of the stability of the soil in the polder on which ESTEC 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, as a group of experts pointed out to the ESRO Council in June 1964, a building on the site at Delft would need to be located on stilts 16 metres above the firm underlying layer of sand, the 16 metres being filled with waterlogged soil. The characteristics of the soil in terms of vibration, transmission and stability were suspect and, concluded the experts, a site on coastal sand was preferable. It would be "more predictable in terms of foundations and more flexible in terms of internal modifications and extensions".[167]

In response to this report, the Dutch government offered a new coastal site at Noordwijk, which was in turn inspected by experts in July 1964. This site, too, was less than ideal. Ground conditions were better than at Delft but, on the other hand, the proximity to the sea created additional concerns regarding the effects of salinity and of blowing sand on delicate apparatus.[168]

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164 COPERS/89 (rev. 1), 9 May 1962, and Massey and Robins (1986), Annex 12.

165 ESRO Council, 5th session (25-26 November 1964), ESRO/C/MIN/5, 11 January 1965, and 6th session (24-25 March 1965), ESRO/C/MIN/6, 14 June 1965.

166 Jordan (1968).

167 ESRO/C/12, rev. 1, 5 June 1964; Lines (1966).

168 ESRO/C/43, 10 July 1964, and ESRO/C/53, 28 September 1964.

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 disillusion among the Member States' delegates over the inadequacy of the accepted location in Delft. Spain and Belgium were particularly militant, insisting that the whole question of the site should be reopened and, if necessary, another conference of plenipotentiaries held to settle the issue. Council chairman Massey, on the other hand, stressed the delays to the build-up of the organisation, and the dangers to staff morale and to ESRO's reputation, which would be caused by moving the laboratory out of the Netherlands. 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.[169]

2.2.6 Finding a role for ESLAB

The ambiguities surrounding the role of ESLAB, which were indeed the ambiguities surrounding the role of ESRO itself, persisted throughout most of the first years of the Organisation. Once it was clear that ESRIN would do fundamental research in physics and chemistry, the original concept of the laboratory was reduced to assisting visiting scientists, primarily from the smaller Member States, who lacked the financial and technical means for carrying out space experiments. This role was gradually refined and expanded between 1964 and 1966, though never fully clarified. To give the laboratory an identity of its own and to attract top-quality scientists who could liaise effectively between national groups and ESTEC engineers, it seemed essential that ESLAB do advanced scientific research in-house. This of course conflicted with the conviction, strongly held in some quarters, that a powerful in-house scientific staff with its own research programme would have a major competitive advantage over national groups.

The first formal steps towards placing senior scientific staff in ESLAB were taken in June 1964. At this time, the plans for the sounding rocket programme and the payloads for the first two small satellites, ESRO I and ESRO II, were well under way. The project scientists whose task it was to provide an interface between the national scientific groups and the engineers at ESTEC were, however, based at headquarters in Paris. This was plainly unsatisfactory: it was essential that they be geographically close to the payload engineering unit. Thus, soon after ESRO came into being, the Council accepted a proposal from the interim STWG that three or four posts for project scientists be created in or near ESTEC to ensure coordination with the technologists in the preparation of payloads. Later that year the role of ESLAB was defined as threefold: assisting visitors from Member States to prepare experiments (originally intended as its main function); providing the interface between national scientific groups and ESTEC engineering groups (project scientists); and coordinating the work on scientific payloads for the LAS, the large astronomical satellite. To implement this scheme, it was understood that it was essential to provide scientists at ESLAB with opportunities for doing their own research for as much as 50 % of their time.[170]

But what research were they to do? In an ideal world they would have been given a leading role in building the payload for the LAS. However, in endless and confused debates in 1965 and 1966 the British, whose group at Culham was eventually awarded the contract to build the telescope, insisted that the LAS project manager be based at their national facility.[171] In the light of this opposition, it was agreed in the latter half of 1966 that ESLAB's scientists conduct research in three main fields: particle

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169 ESRO Council, 3rd session, 28-9 July 1964, ESRO/C/MIN/3, 2 September 1964; and 4th session (22 October 1964), ESRO/C/MIN/4, 4 November 1964.

170 For this paragraph see ESRO/C/34, 16 June 1964; ESRO/C/110 10, 18 March 1965; ESRO/C/125, 13 July 1965; ESRO Council, 2nd session (15-17 June 1964), ESRO/C/MIN/2, 8 July 1964, and 5th session (25-26 November 1964), ESRO/C/MIN/5, 11 January 1965.

171 The LAS programme will be discussed in detail in chapter 5. See also ESRO/ST/158, 26 October 1965 and the comments by the Danish and Italian delegations on this paper: ESRO/ST/158, add. 1, 10 February 1966, and ESRO/ST/158, add. 2, 10 March 1966. See also ESRO/ST/182, 28 January 1966 and accompanying paper ESRO/C/178, 11 March 1966.

physics, ionospheric physics, and surface physics. Their work was set back by a fire on 14 October that year in the temporary premises they occupied at Noordwijk. All of the equipment as well as the personal files of the ESLAB staff members were lost and it was not until the summer of 1967 that the laboratory was fully operational. A year later, on 1 September 1968, and in line with the recommendations of the Bannier report (see below) ESLAB became a fourth department of ESTEC. It was renamed the Space Science Department (SSD).[172]

2.2.7 Setting up a tracking network

A word is in order about ESTRACK, if only to bring out the extent to which political considerations and national interests, along with a passionate determination by Member States' delegates to control costs, impeded the rapid establishment of the network. The network foreseen for the first phase of ESRO's programme consisted of four stations: at Redu, in the Belgian Ardennes, which was to be used for tracking and telemetry, at Fairbanks in Alaska, at Spitzbergen in Norway, and on the Falkand Islands off the coast of Argentina. Only the first of these was set up without considerable difficulty. The French consistently opposed the site in Norway, because this country had not joined ESRO after participating in the COPERS work. The site in the Falklands, which was foreseen as an enlargement of an existing British radio and space research station, was also most unpopular. Technically there was the danger that the UK's communications transmitter would interfere with incoming satellite data. Administratively there was the feeling in the Council that the case for the station had not been properly prepared by the ESRO Secretariat, which was anxious to get a site in the region approved quickly in anticipation of the launch of ESRO I and ESRO II. Politically, there were repeated objections from Spain against ESRO funding a station in, what it said, was a territory with disputed sovereignty. Despite these difficulties, the Council managed, in March 1966, to agree to install a telemetry station in the Falklands, the vote being six in favour with four abstentions - only to have the French delegation insist that, according to the Convention, this decision was null and void as it should have been taken by a two-thirds majority. The French let the matter pass at the time, but within a month the Ministry of Foreign Affairs had approached the Council chairman insisting that the issue be reopened at the next Council session. This it was, and in the face of a very determined statement by the United Kingdom, the Council voted by eight to one (Spain) to pay Britain for the work it had done to date on providing a telemetry station for ESRO on the Falkland islands.[173]

The establishment of a telemetry station at Fairbanks created a quite different set of difficulties. NASA, which was responsible for operating the station, demanded that it have the right of access to the scientific data received. The members of ESRO's Scientific and Technical Committee, supported by some Council delegates, were most unhappy about this. NASA's demand, they felt, violated their intellectual property rights, as well as ESRO's arrangements with its own experimenters. After lengthy negotiations, a compromise was reached. In December 1966, the Council agreed that ESRO should provide NASA with any raw or unreduced data that it wanted and was prepared to pay for. In turn, the use of unpublished data by the American agency required the prior permission of ESRO.[174]

2.3 The ESRO budget and its control

The first estimates of the level of ESRO's budget were quickly made by the Interim STWG. Their figures were then gradually revised upwards, initially by the scientists themselves and later by the administrators in the LAFWG's budget subgroup. In parallel with these developments, and partly

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172 For this paragraph see Manno et al. (1968), and ESRO/AF/613, 15 November 1966, ESRO/C/251, 29 November 1966, and ESRO/C/266, 14 February 1967 on the fire at Noordwijk.

173 See ESRO/C/171, 9 March 1966; ESRO/AF/472, 19 April 1966; ESRO/C/203, 22 June 1966; ESRO/C/236, 23 November 1966; ESRO/C/254, 15 February 1967. ESRO Council, 10th session, 24-25 March 1966, ESRO/C/MIN/10, 10 June 1966, and 11th session, 22-24 June 1966, ESRO/C/MINIl 1, 15 July 1966.

174 For the debate on the Falklands, see ESRO Council, 12th session, 18-20 July 1966, ESRO/C/MIN/12, 1 September 1966, and 14th session, 30/11-2 December 1966, ESRO/C/MIN/14, 20 January 1967.

spurring them on, some of the Member States began to worry about how best to keep ESRO's budget under control. The British were particularly determined to install a set of mechanisms to ensure that governments retained the power to limit ESRO's expenditure. The solution that they came up with, after some difficulty, combined the imposition of financial ceilings with the right of any member state in the Council to veto a proposal to exceed these ceilings. The UK delegation's determination to fight for this kind of solution was directly linked to a recent painful experience it had just had at CERN. If they achieved their objectives with far less rancour in this case, it was because in ESRO, unlike in Geneva, the British had wider support among the Member States and, indeed, were not strongly opposed by the European space science community.

2.3.1 ESRO's eight-year budget estimates

The earliest estimates of the costs of ESRO were prepared by the interim STWG in time for the second session of the COPERS, held at The Hague from 17 to 18 May 196l.[175] Their annual and overall eight-year figures are presented in column 2 of Table 2-2. It shows costs rising steadily during the first three years, when the construction of buildings and the acquisition of capital equipment dominate expenditure. As these fell off in years four and five, so their place was taken by the growing needs of the medium-term scientific programme based on the launching of small satellites. There was then a sharp jump in year six to a level of expenditure which remained constant in years seven and eight as the space probes and large satellites were launched. With this distribution of expenditure, over half the burden of financing ESRO fell in the last three years of the eight-year plan.

A word is apposite on how costs were distributed between the different sectors of the organisation's activity. Fifty per cent of the overall estimate of 1360 MFF was for the payload engineering unit. Of this, about half again was for the three project groups whose task it was to engineer sounding rocket payloads and satellites. The costs of acquiring and launching light and heavy launchers counted for another third of the overall expenditure. No provision was made by the STWG for the costs of building and running ESRO's headquarters. Nor did the figures include the 16 MFF per year required to fund the construction of scientific instruments in the various Member States.

In presenting this first budget the scientists insisted that the numbers that they had come up with were "to be a minimum below which it would not be worthwhile having such a programme at all".[176] Several "possible additions" to this programme were identified, including a new launching site for light and heavy satellite launchers (costing about 300 MFF) and an additional large satellite project (costing about 90 MFF).[177] The paper also stressed that the costs for vehicles had been calculated using figures provided for NASA's *Scout* launcher for the small satellites and the costs of *Blue Streak* as provided by the UK Ministry of Aviation for space probes and large satellites. The latter was "a marginal cost", and it assumed that ESRO effectively bought the rocket off the shelf. As we remarked earlier it was also assumed, for budgetary purposes, that two launchings would be required to put one satellite or space probe successfully into orbit. At the same time it was mentioned that if the *Atlas - Agena B* rocket was used instead of *Blue Streak* additional resources to the tune of 90 MFF per year during years six to eight would be required.

Despite its provisional nature and these various qualifications, the scientists in the STWG made relatively few additions to their first estimates. The main increases asked for in the *Blue Book* (column 3, Table 2-2) were some 35 MFF for expenditure in industry by ESTEC and an additional 12 MFF for ESLAB.[178] These estimates were further increased after a visit to NASA on 1 and 2 September 1961

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175 COPERS/20, 11 May 1961.

176 This is in fact the way in which the British delegation put it at the meeting in The Hague. See COPERS, 2nd session (17-18 May 1961), COPERS/Min/2, 25 May 1961, p. 8. Massey, who was the chairman of the session, replied to the British delegation that "there could be no doubt at all on this point".

177 Other new projects envisaged were a pilot meteorological experiment costing some 4 MFF per year and an additional project group to study advanced methods of propulsion (initially 2 MFF/year).

178 The arrival of ESLAB at this point has been explained in the previous sections. For an anticipation of the figures given in the *Blue Book* see also document COPERS/GTST/14, 19 July 1961 .

by a small party headed by C. de Jager. Their aim was to discuss satellite tracking and data acquisition facilities and to explore the possibilities of future collaboration with the USA in these fields. They came home convinced of the need to increase their earlier estimates of expenditure in these areas.[179] The cost of both was thus pushed up by a little over 30 MFF with respect to the *Blue Book* figures to give a final STWG estimate of 1473 MFF in January 1962 (column 4, Table 2-2). This was less than 10 per cent above the first estimate provided in May 1961. If the budget subgroup's costing of the headquarters is added we arrive at an estimate for the scientists' eight-year programme of a little over 1500 MFF (column 5, Table 2-2).

2.3.2 The debate on financial control

These relatively minor and carefully calculated increases to the STWG's global budget estimates took place against the background of a debate in the LAFWG and in the COPERS Council about how best to control ESRO's finances. It was a debate which led some members of the budget subgroup to insist that the scientist's figures would have to be revised upwards if the programme was not to be seriously reduced. The first steps towards defining a set of budgetary rules for ESRO were taken by the British, quickly supported by the French, in September 1961. They rapidly proved to be controversial and the LAFWG decided that the issues were best left to the Munich session of the COPERS to be held the following month.[180] There were two aspects to the problem. Firstly, Britain and France wanted the major contributors to the budget to have a veto over the expenditure on particularly costly developments. "Experience with CERN", said the French delegation in Munich, "whose annual budget was now twice as much as originally planned, had caused the larger countries to ponder what they might be letting themselves in for in ESRO's case".[181] Budgets at CERN were voted by simple majority. The British and the French felt that this would not do for ESRO. They suggested that any modifications to ESRO's programme of work or to its facilities should be agreed by a qualified two-thirds majority, the qualification being that each member state paying more than 10% of the ESRO budget (i.e. the "big four": France, Germany, Italy and UK) should be among the concurring majority. This effectively gave these states the power to veto the proposed expenditure.

The second way in which the British hoped to exercise some control over ESRO's expenditure was by establishing "a procedure for keeping the whole financial development of the organisation under review".[182] For this purpose the British proposed having three-year budgetary periods introduced, with the Council determining the level of expenditure in each year of the first three-year period and, at the same time, giving an indication to member state governments of the annual level of expenditure during the successive three-year period.

The first of these proposals was vigorously opposed by the Dutch delegation. They did not object to there being a two-thirds majority vote in certain cases; what they disliked was a *qualified* two-thirds majority. It was unwise in practice: complicated voting procedures impaired the efficiency of the organisation, they said. And it was offensive in principle: the low percentage contribution of a country

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179 COPERS/GTST/lII/9, 20 October 1961, with attached COPERS/GTST/1II/8.

180 COPERS/AWG/18 (add. 3), 5 September 1961; COPERS/AWG/18 (add. 4), 11 September 1961. LAFWG, 3rd meeting (14-15 September 1961), COPERS/AWG/33, 27 September 1961; and 4th meeting (28-29 September 1961), COPERS/AWG/38, 9 October 1961.

181 See COPERS, 3rd session (24-25 October 1961), COPERS/Min/3, 16 November 1961, p. 6. For the French determination to have a veto over expenditure see letter from the French president V. Giscard d'Estaing to his Prime Minister, 14 December 1961 (Mussard files, HAEC, folder "France"). In his letter, Giscard pointed out that France's contributions to international organisations had increased by a factor of 155 between 1955 and 1962. He was determined, he said, that his country should not be put before a "fait accompli" in terms of financial commitments at the international level, and that the only way to brake the growth in expenditures was by the means of a veto.

182 COPERS/Min/3, cit., p. 8.

like the Netherlands to ESRO's budget was, in absolute terms, a lot for it, and was not a reason to restrict its formal power to decide the level of the budget. In the event no decision was taken, the delegates being divided on the issue. The three Scandinavian delegations along with the Swiss supported the Dutch, while the German, Belgian and Spanish delegations favoured some kind of qualified majority.[183] The UK's proposals for forward planning were also greeted with some scepticism. Most delegates apparently agreed in principle with the idea. However, the French for one felt that it was "impossible to give meaningful figures, at this distance in time for the fourth or fifth year onwards". Undeterred, the British "suggested that informal discussions should soon take place between the Member States through diplomatic channels on the actual figures" to be inserted into the financial protocol to be attached to the ESRO Convention.[184]

In the month after the October session of the COPERS, the UK refined its proposals to control ESRO's expenditure. It suggested that, on further reflection and in the light of further informal discussions, there appeared to be a "strong desire [...] by many delegations" to have an overall eight-year ceiling imposed on ESRO's expenditure. This ceiling would need to be settled at an intergovernmental conference of the Organisation's Member States to ensure that it was binding. The same meeting would also set a ceiling for the first three years of ESRO's expenditure. It would agree on the annual budget for each year within that first three-year envelope, and it would provide an indication of expenditure for years four to six. Two alternative procedures were proposed for subsequent triennial reviews. Either the Council itself, meeting at ministerial level, could agree on a ceiling for the next three years by a qualified two-thirds majority. Or the Council could simply propose a level of expenditure, and leave it to governments to agree among themselves on a final figure for the next three years. Governments could settle this matter either through diplomatic channels or by an intergovernmental conference especially convened for the purpose.[185]

As the British grew more determined to tighten the controls on ESRO's expenditure, so the LAFWG continued to search, without success, for a compromise on the UK's proposals. Serious doubts were again raised at its sixth meeting, early in December, by both scientists and the members of its budget subgroup on the feasibility and advisability of setting firm ceilings for the later periods of ESRO's life. These doubts were reinforced after a visit paid by some members of the budget subgroup to NASA.[186] Three considerations in particular led the science administrators to conclude that it would be foolish to try to fix expenditure using firm and difficult-to-change ceilings for anything but the first three years. Firstly, there were the likely cost escalations in the large satellite projects. Europe, it was pointed out, had as yet no experience in any satellite project taken to completion and no-one anywhere in the world had experience of very large projects. Experience at NASA however showed that the initial cost would certainly rise as scientists and engineers modified their designs in the light of new information. Thus the cost of NASA's large astronomical satellite, due to be launched at the end of 1963, had risen from an initial estimate of $ 21 million to $ 75 million.[187] Secondly, echoing the earlier remarks made by the STWG, there was the question of the launcher. If instead of using *Blue Streak*, ESRO was forced to rely on American *Thor* and *Atlas* rockets for its large projects, the budget would have to be increased

183 *Ibidem*, p. 5-6.

184 *Ibidem*, p. 8, and document COPERS/AWG/18 (add. 8, rev. 2), 31 October 1961.

185 For the British memorandum see COPERS/AWG/19 (add. 9), 29 November 1961. We have described the content of this note in some detail because a very similar debate was occurring at CERN at this time. We shall go into this debate in more detail later.

186 LAFWG, 6th meeting (7-8 December 1961), COPERS/AWG/51, 2 January 1962. See also letter from F. Bath of the British DSIR (Department of Scientific and Industrial Research) to J.J. Beattie of the COPERS Secretariat, 16 November 1961, and letter F. Bath to C. Hoogeweegen, 17 November 1961, both in folder "AWG Budget Subgroup. Correspondence", Mussard files (HAEC).

187 This information is taken from a NASA trip report written by members of the budget subgroup which is Annex 3 to Document COPERS/AWG/II/2 (rev.1), 19 March 1962.

by almost 100 MFF annually from year six onwards.[188] Finally, as German delegate Frank pointed out, during the last few years of the eight-year period one needed to provide for an as yet undefined follow-on programme if the work of ESRO was not to be disrupted.[189] In sum the budget sub-group concluded, as an internal French document put it, that

> *The imposition of a "ceiling" is altogether illusory. NASA has concluded that it cannot foresee its expenditures more than three years in advance, and even then, has to make allowance for unforeseen expenditures of 20 to 30 per cent. In these circumstances, the STWG's estimates after the third year are uncertain and those after the fifth year are wholly illusory.190*

Consistent with these convictions, the budget subgroup revised upwards the estimates of expenditure proposed by the STWG. They increased the global estimate of some 1550 MFF by 100 MFF, most of the additional expenditure being for ESTEC (column 3, Table 2-3). And they proposed that a 20 per cent contingency be added on the total amount of the budget and that a 15 per cent allowance be made for growth during the last two years of the organisation's life. This brought the subgroup's proposal for ESRO's eight-year budget to a little over 2100 MFF (column 4, Table 2-3).

The British meanwhile, having just suffered a major setback in their attempt to impose ceilings at CERN, decided that the same mistakes (as they saw them) were not going to be made at ESRO.[191] In January 1962, Her Majesty's Government again circulated a document to the governments of the other Member States of the COPERS. In it they insisted on the need for "a system of really firm triennial ceilings", to be fixed by a unanimous vote of the Council, preferably meeting at ministerial level. These ceilings, the document went on, should be "coupled with the overall eight-year ceiling, reviewable every three years, but only in the light of major changes in scientific or economic circumstances". If their requirements were met, the British went on, they would no longer press for a qualified majority on the programmes, annual work plans and budgets of ESRO. A simple two-thirds majority would suffice. Nor would they seek to have financial ceilings determined by negotiations between governments outside the framework of the ESRO Council.[192]

This note was followed by another in February, this one concerned with the level of the eight-year ceiling and the shape of the expenditure curve. Here the UK objected to the upwards revision of the eight-year budget estimate from 1500 MFF to 2100 MFF, as well as to the provision for rising expenditure in the last three years of ESRO's life. This expenditure curve "puts Her Majesty's Government in the greatest difficulty", the note said. If implemented, it would push British expenditure on scientific space research beyond what was deemed reasonable, and the field would "claim for itself too large a share of the total national effort in pure science". Elaborating, the British stressed that it was of "cardinal importance" for the UK that ESRO's costs during the first eight years of its life should remain at 1500 MFF and that its rate of expenditure in the last three years of this eight-year period should be stable and should not exceed 240 MFF per year. The government realised that it may not be possible for ESRO to carry out the envisaged programme within these limits, as indeed the budget subgroup had stressed. However, it believed that if this were not possible the programme would simply have to be pruned back in line with the money available.[193]

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188 For a detailed analysis of the financial implications of replacing *Blue Streak* with equivalent US launchers, see the paper COPERS/GTST/IV/7, 10 November 1961.

189 See letter from Frank to Hoogeweegen, 22 December 1961, folder "AWG Subgroup Budget. Correspondence", Mussard files (HAEC).

190 We only have a section of this document which is initialled RR on notepaper headed "Finance Extérieur". It is available in folder "AWG Subgroup Budget. Correspondence", Mussard files (HAEC). The translation is ours.

191 We shall return to the difficulties which the British were having at CERN in a few moments.

192 For this material see COPERS/AWG/19 (add. 12), 19 February 1962, Annex 2.

193 COPERS/AWG/19 (add. 12), cit., and Annex 1 to the same document.

The British proposals were discussed in the COPERS by both scientists and science administrators during the first three months of 1962. As one might imagine there was considerable debate both on how ceilings ought to be set, i.e. by unanimity or by majority vote, and on what those ceilings should be. Regarding the former point, the members of the STWG were clear. A unanimous Council vote for a three-year ceiling, they said, "could paralyse the working of the organisation". To reach a compromise on such a ceiling, the STWG said, delegates may find themselves setting a figure which was too low to allow for effective work. Member states representatives in the LAFWG, on the other hand, were more or less split on the question. Britain and France, along with Sweden and Austria made it absolutely clear that they wanted unanimity for fixing ceilings and, in particular, would not support a German proposal that ceilings be settled by a qualified two-thirds majority.[194]

As for the level of the eight-year ceiling itself, the striking point is that it was the scientists, rather than the administrators, who were persuaded to accept the figures proposed by the British government. In January 1962 the budget subgroup insisted that the overall figure for ESRO should not be less than 2000 MFF for the first eight years. The majority of the LAFWG also apparently supported this figure.[195] The scientists, by contrast, were less convinced. At an inconclusive meeting of the STWG in January 1962, both Boyd and Lines (UK) claimed that there was probably no need to provide for a contingency on the total ESRO budget, "since certain items already included a safety margin and others did not need one". At the same meeting, Hultqvist (Sweden) "expressed the opinion that Europe could make a substantial contribution in space research staying within a limit of 1650 MFF" (column 3, Table 2-3).[196] This tendency to accept a lower level of expenditure than the administrators deemed advisable was confirmed once the British government had insisted that the overall ceiling be 1500 MFF. An ad hoc committee of experts chaired by van de Hulst was asked to report on what the scientists felt. In a highly uncharacteristic statement - at least if one takes the behaviour of the CERN scientific staff *vis-à-vis* their fund givers as one's point of reference - the expert group effectively accepted the British restrictions. The Blue Book, van de Hulst's committee claimed, did not represent a detailed scientific programme, and the budget figures presented therein and in its subsequent amendments were not to be regarded as highly precise. "It is considered improbable but not impossible that the approximate programme as outlined in the Blue Book", the committee went on, "can actually be carried out within the adopted ceiling of 1500 MFF". If it could not, it would be necessary simply to reduce the number of launchings. Despite these restrictions, the committee concluded, "the consensus of opinion was that a programme thus reduced would still yield valuable scientific results".[197] In other words, the STWG was no longer going to fight for its proposed programme on the grounds that it was the minimum compatible with a viable European space science effort, as they had stated less than a year earlier.

There was one other financial point that needed to be settled before the Convention could be signed. This concerned the ceiling for the first three years of ESRO expenditure. As we can see from column 4 of Table 2-3, the preferred figure of the budget subgroup was approximately 490 MFF. This was cut by removing the allowance for contingencies and by reducing the staff foreseen for headquarters.[198] It was reduced further at the fourth session of the COPERS in February. Here delegates from nine Member States agreed, without opposition, to allocate 380 MFF to ESRO for its first three years and 600 MFF for the second three years - roughly the figures proposed by the STWG (columns 4 and 5,

194 For the scientists' position see COPERS/AWG/18 (add. 27), 25 January 1962. For the debate inside the LAFWG see the summary report of its 7th meeting (23-25 January 1962), COPERS/AWG/58, 15 January 1962. (This document seems to have been incorrecfly dated by the COPERS Secretariat. The date should presumably be 15 February 1962).

195 See LAFWG, 7th meeting (23-25 January 1962), COPERS/AWG/58, 15 January 1962 for the opinion of the subgroup and COPERS/45 (rev. 1), 14 February 1962 for the opinion of the LAFWG as a whole.

196 STWG, 5th meeting (22 January 1962), COPERS/GTST/31 (undated).

197 COPERS/64, 14 March 1962.

198 COPERS/45 (rev. 1), 14 February 1962, and COPERS/AWG/1I/2 (rev. 1), 19 March 1962, summary table S3 in Annex 2. The 490 MFF were cut to 450 MFF in January by shuffling the envisaged conungencies in the first three years of expenditure and by reducing headquarters staff by 30 %. It was then further reduced to about 400 MFF by doing away with the allowance for unforeseen expenditure.

Table 2-2). Only the Belgian government abstained, not on principle, but because it had no information on how the programme would be reduced to remain within these limits.[199]

It goes without saying that the British triumphed at the conference of plenipotentiaries held in June 1962. Their various demands were enshrined in the Convention, in its associated financial protocol, and in an additional protocol concerning the financing of ESRO during the first eight years of its existence. Article X.4 of the Convention stipulated that the Council would determine every third year, by unanimous decision of all the Member States, the level of resources for ESRO for the succeeding three-year period. At the same time it would determine, on a provisional basis, and by unanimous decision of all the Member States, the level of resources for the succeeding three-year period. The annual budget was to be adopted within these limits by a simple two-thirds majority of Council. One of the protocols also stipulated that the overall eight-year ceiling was to be fixed at 1500 MFF, at price level ruling at the date of signature of the protocol. This corresponded to 306 million Accounting Units (MAU), a conventional monetary unit used for ESRO financial dealings, based on a gold standard.[200] Provision was also made for the Council unanimously to adjust this figure in the light of "major scientific or technological developments". As for the initial phases of ESRO's life, the budgets were set at 78 MAU (380 MFF) for the first three years, while a provisional ceiling of 128 MAU (600 MFF) was agreed for the second three-year period after the entry into force of the Convention.[201]

2.3.3 The factors at work in this debate

Two factors lay behind the British government's determination to impose a ceiling on ESRO's expenditure, and to ensure that it was binding on the Member States. The first, based on their experience at CERN, was to restrict the power of the ESRO Council. The second was their estimate, made towards the end of 1961, of the acceptable levels of UK expenditure on space science, national and international, for the next six to eight years. To appreciate the first point we need to digress for a moment and to explain the experience which the UK government had had at CERN. As early as 1957 it became clear that the costs of running CERN were going to be far greater than anyone had ever anticipated. As new and more powerful high-energy accelerators began to be commissioned in the United States in the mid-1950s, it emerged that sophisticated and complex detection equipment was required to exploit the machines properly. The CERN management were caught off their guard by these new developments and let it be known that they would need as much money to run CERN's new accelerators as it had cost to build them. Alarmed, the British government decided in 1957 that some sort of forward planning should be instituted at CERN, and that two or three-year ceilings should be imposed on expenditure.[202]

These proposals were greeted with widespread hostility both by the high-energy physics community and by many of the other member state delegates on the grounds that it was impossible to predict in advance the costs of research and development, and that the policy of ceilings would stifle the growth of the laboratory. Matters came to a head in 1961. On the one hand, the British Treasury had found its CERN Council delegates incapable of persuading their colleagues to accept a firm and binding ceiling policy. At the same time, there was growing pressure coming from within the laboratory and from

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199 COPERS, 4th session (21-23 February 1962), COPERS/Min/4, 13 March 1962, p. 3. See also letter from Holvoet to Auger, 15 March 1962, folder "Belgique", Mussard files (HAEC).

200 One Accounting Unit was defined as the value of 0.88867088 grammes of fine gold, and at the time was equivalent to one US dollar: see Article 6 of the financial protocol annexed to the convention for the establishment of ESRO, document COPERS/AWG/19 (rev. 6), 23 May 1962.

201 The "Convention for the Establishment of a European Space Research Organisation" can be found for example in Annex 1 to *ESRO General Report, 1964-1965*. The financial protocol annexed to the Convention is document COPERS/AWG/19 (rev.6), 23 May 1962. The protocol concerning the financing of ESRO for its first eight years is document COPERS/AWG/19 (add. 13), 12 March 1962. Alternative labels for these two protocols are ESRO Conference/5, 23 May 1962, and ESRO Conference/6, 23 May 1962.

202 For an extensive discussion of the debate described in this paragraph see Krige in Hermann et al. (1990), chapter 10, and Krige (1991).

some of the Member States, notably France, that forward planning should make allowance for an annual growth rate of about 8 % in real terms. Frustrated by the power of the CERN Council to thwart the preferred policies of the major contributor to the CERN budget, the Foreign Office took the unprecedented step (for CERN) of circulating an aide mémoire to its counterparts in the Member States in November 1961, precisely at the time when it was suggesting that similar steps would be needed at ESRO. In this aide mémoire it was proposed that, instead of leaving the CERN Council to set the levels of CERN expenditure, the level should be set between governments themselves, leaving the Council simply to adjust its programme within the limits decided between ministers.

The British government's move was greeted with intense hostility by the CERN Council at its meeting in December 1961. By challenging the authority of the Council in this way, said Dutch delegate H. Bannier, the British were challenging the very foundations of CERN's success. The French delegate F. de Rose went even further. Referring to ongoing and extremely delicate negotiations between the British and the French over the use of *Blue Streak* as the first stage of a jointly built European launcher, de Rose said that he would advise de Gaulle not to agree to the British proposals if they were not willing to abandon their attempt to impose firm ceilings on CERN, and to impede the "automatic" growth of the laboratory. In the face of this threat the British had little choice but to back down. The power of the CERN "lobby", a small core of senior science administrators and scientists dedicated to defending the laboratory's interests before their national bureaucracies, and determined to put up a united front along with the laboratory management in the face of any "external" threat, had carried the day.[203]

The British manoeuvres inside ESRO were a direct consequence of these experiences. Her Majesty's Government had learned a lesson. That lesson was that in future, when setting up any new organisation for scientific collaboration, strict limits should be imposed on the Council's power to decide budgets. The way they chose to do this was by insisting that appropriate safeguards be built into ESRO's constitution so as to ensure that financial control over the laboratory's expenditure was a legally enshrined principle. This is undoubtedly why the British were so emphatic about having ceilings written into ESRO's basic documents. It is also why they insisted that these ceilings would have to be set between ministers, and not by the ESRO Council, if their demands were not written into the Convention and its accompanying protocols. They were determined never again to be at the mercy of a CERN-like "lobby" as had happened in Geneva in December 1961. Governments also learn!

The second reason for the UK's firmness was the constraints that the government, in consultation with the its space science community, had decided to impose on expenditure in the field during the years ahead. As early as July 1961, Massey submitted to the British National Committee for Space Research an estimate of the UK's contribution to the costs of ESRO using the first set of figures available from the STWG (column 2, Table 2-2). He added the estimated costs of the national programme, including a budget line for UK/NASA bilateral arrangements. His paper foresaw annual expenditure climbing steadily until, in ESRO's sixth year, Britain would be spending a total of £5.65 million on space science, £4.1 million of which (i.e. about 58 MFF) was the estimated UK share of ESRO (25% of 232 MFF). These figures were submitted to the minister for science. After discussion within the government it was agreed, by the end of 1961, that Britain should be prepared to spend up to £6 million for what was called the "steady state" of funding for space research. From then on, according to Massey and Robins, this limit was "sacrosanct". Correlatively it was implied that, "for the balance of the UK programme", ESRO costs should be confined to about 250 MFF per year during the last three years of its first eight-year period. The British space science community, in other words, in consultation with their government, was quite satisfied not to see ESRO's budget go above an overall ceiling of 1500 MFF and to level off in years six to eight.[204]

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203 See Pestre in Hermann et al. (1990), chapter 7, for an elegant description of the activities of the CERN lobby.

204 For the material in this paragraph see Massey and Robins (1986), pp.117-127. The adoption of these figures by the COPERS was judged by Massey and Robins to have been "a completely satisfactory outcome for the UK". This quotation and the others are from pp. 124 and 126.

It was perhaps to be expected that the British space scientists would only be prepared to join the COPERS, "provided that the UK national space research programme was not prejudiced".[205] Yet it is significant that they apparently met little opposition from scientists from other Member States. This was possibly due to the wish to keep the British involved in the scheme - after all they were the most experienced and advanced community at the time and would bear a substantial fraction of the costs - and the realisation that they would only participate on their terms. At the same time, it is surely a symptom of a more deep-seated ambivalence of the continental space science community *vis-à-vis* "their" organisation. After an initial burst of enthusiasm, in fact, many members of the community seem to have been less than convinced of ESRO's merits and were not opposed to seeing its budgets severely restricted and brought under tight control.

Why should this be so? Part of reason lies surely in the fact that space science communities in both the larger and the smaller Member States, and not just in Britain, were more or less convinced that their governments would support national programmes. From this perspective ESRO was a potential competitor, a situation which the national bodies were determined to avoid, as the debate over ESLAB has shown. The interest of building a strong national programme was further reinforced by a generous offer made in 1959 by NASA. At an international meeting of space scientists in The Hague in March that year, the American delegate announced that his government, through NASA, would be willing to launch suitable experiments proposed by scientists from other countries. The technical support of NASA's experienced engineers was guaranteed. European scientists could either go and work in an American laboratory on the construction, calibration and installation of their equipment in the research satellite. Or, if the intention was to launch an entire payload comprising various experiments, NASA would be prepared to advise on the feasibility of the package, and on its design and construction, as well as help with the pre-flight environmental testing. In discussion, NASA made it clear that it was seeking bilateral agreements for joint programmes. It also let it be known, at least to the British, that it was prepared to launch at least some equipment free of charge.[206] That granted, why spend scarce resources on setting up an entirely new organisation, particularly if that meant a reduction in the funds made available for nationally built experiments and a "national" programme?

ESRO struggled into life then a fragile and vulnerable creature. Governments, though not uninterested, were not prepared to invest heavily in it. Scientists, though not uninterested, were not prepared to see it develop at the expense of national programmes. It could not compete with the United States, as CERN aimed to do. It was not to replace national programmes, as CERN was expected to do in many Member States. It is hardly surprising that it required a fundamental revision of ESRO's aims, to wit, a shift away from pure science to applications, to revitalise an organisation that had all but lost its way in the mid-1960s.

2.4 The organisation and functioning of ESRO in the "Auger years" (1964-67)

The ESRO Convention entered into force on 20 March 1964. The ten founding states were Belgium, Denmark, France, (Federal Republic of) Germany, Italy, Netherlands, Spain, Sweden, Switzerland and United Kingdom. Two other countries which had participated in the early COPERS activities, Austria and Norway, decided not to join the new Organisation and retained an observer status. The first meeting of the Council opened in Paris three days later with Harrie Massey in the Chair. Pierre Auger was appointed ESRO's first Director General. Thus it was up to one of its main founding father, to lead the European Space Research Organisation during the critical first three years of existence.

2.4.1 The "legislative" and "executive" arms

ESRO's institutional structure was very similar in conception to that of CERN. At the decision making level (the "Legislative" in the ESRO jargon), the supreme governing body was the Council, made of delegations from its Member States. Each member state had one vote in the Council, where it could be

205 Massey and Robins (1986), 117.
206 Massey and Robins (1986), Annex 11, describes the NASA offer.

represented by not more than two delegates, one of whom was generally a scientist, the other an important national science administrator. One or more advisers were usually included national delegations. The main tasks of the Council were to determine the Organisation's scientific, technical and administrative policy; to approve its programme and annual work plans; and to determine its level of resources both annually, and every third year for the subsequent three-year period. A. Hocker was the chairman of the Council in the period we are considering.

The Council was advised by two subordinate bodies, the Administrative and Finance Committee (AFC) and the Scientific and Technical Committee (STC). The AFC, which was composed of Member States' delegates drawn from the appropriate positions in national bureaucracies, advised it on legal, administrative and financial matters. It also took decisions in some key areas, notably on the award of contracts to industry. The STC, including delegates who were expected to be "competent scientists and technologists", had the task of advising the Council and the ESRO Director General on all scientific and technical matters affecting the work of the Organisation, including the recruitment of staff, the educational activities and the cooperation with non-Member States.

There was some debate over the composition of the STC. When ESRO was formed, it was suggested that scientific and technological matters be split from one another. This was because, in the light of the experience gained during the COPERS, it was clear that the STC would devote a great deal of its time to technical and financial affairs, at the expense of scientific debate, so proving a somewhat unattractive committee to the best scientists in Europe.[207] In the event, this proposal was rejected. ESRO's STC, unlike CERN's SPC (Scientific Policy Committee) was inevitably "politicised". The members of CERN's SPC were chosen essentially on merit. The delegates to ESRO's STC were not only scientific experts but also representatives of their Member States, two roles which could easily be in conflict with one another. Reimar Lüst was the first chairman of the STC, followed by Jean Coulomb and Hendrik van de Hulst.

The STC considered recommendations laid before it by a Launching Programme Advisory Committee (LPAC), whose task it was to define an appropriate sounding rocket and spacecraft launching programme in the light of proposals it received from the European space science community.[208] The LPAC, which was chaired by Lüst in the whole period considered here, was a small body of four or five eminent European scientists whose task it was to combine experiment proposals from the European space science community into scientifically and technically suitable payloads, taking account of the financial and other resources available. The experimental proposals considered by the LPAC were funnelled to it by six ad hoc groups representing various disciplines in the field and identified by easily recognisable acronyms: ATM (atmospheric physics and chemistry), ION (ionospheric and auroral phenomena), SUN (solar physics), PLA (moon, planets, comets and the inter-planetary medium), STAR (stars and stellar systems), COS (cosmic rays and trapped radiation).[209]

At the executive level, between 1964 and 1967 ESRO was managed by a Directorate based in Paris, including the Director General (Auger) assisted by a Scientific Director (B. Bolin, succeeding R. Lüst), a Technical Director (A.W. Lines) and a Head of Administration (J. Crowley). The directors of ESRIN, ESDAC and ESLAB reported to the Scientific Director; the director of ESTEC, who had also responsibility for ESRANGE and ESTRACK, reported to the Technical Director. The "Executive", as it was eventually called, was responsible for the implementation of approved programmes within the established financial envelope and under general control from the STC. It was also called to perform feasibility studies of space missions proposals coming from the scientific community and recommended by the STC, in view of their eventual adoption in the programme.

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207 ESRO/C/4, 21 March 1964.

208 ESRO (1966). See also ESRO Council, 1st session (23-24 March 1964), ESRO/C/MIN1, 21 April 1964, and 2nd session (15-17 June 1964), ESRO/C/MIN2, 8 July 1964.

209 A more detailed discussion on this scientific advisory structure is in chapter 4.

2.4.2 The "Bannier report" and the modification of ESRO's structure

Within a little over two years of ESRO being established, the Council began to have serious doubts about the proper functioning of this structure. It was finding its already crowded agenda cluttered with relative trivialities like the venue of a proposed summer school or the design of a suitable emblem for ESRO. The AFC was bogged down in seemingly endless debates over the award of individual contracts to industry, and in formulating a policy for the geographical distribution between the Member States. And there were growing doubts over the efficiency of the management in-house. Time and again the Executive was accused of preparing its case badly, so that the AFC and the Council were forced to take decisions in haste and on the basis of limited information. The internal staff structure and complements were causing concern and indeed a special committee was set up in order to advise on this issue very soon after ESRO officially came into being. Finally the organisation's expenditure profile was tilting heavily in favour of administrative expenses. In 1963 it had been agreed that internal expenditure should not exceed 45 % of total expenditure. By mid-1966 it had climbed to 50 %, placing enormous pressure on the operational programme.

In response to what was perceived to be a "state of crisis" in the Organisation, the Council, at its twelfth session in July 1966, set up a group of experts to study the internal structure, procedures and methods of work of ESRO. The chairman of this group was J.H. Bannier, who was the director of the Nederlandse Organisatie voor Zuiver Wetenschappelijk Onderzoek (ZWO) in the Netherlands and, as a former chairman of the CERN Council, was intimately aware of how ESRO's sister organisation functioned. Bannier was assisted by five experts selected from administrative, technical and scientific fields. The secretary of the group, W.O. Lock, was provided by CERN.[210]

The most important proposal made by the Bannier commission, as summarised by the chairman himself in one phrase, was "delegation of authority". There was a "crisis of confidence" in ESRO, Bannier wrote, because there was not a clear enough distinction between the legislative and executive arms of the organisation. The Council and the AFC were having to take decisions on so many minor matters because insufficient power had been concentrated in the hands of the Director General. As a result, neither body was able to concentrate on its main task. For Bannier, this meant that the Council should limit itself to discussing broad issues of policy and to taking decisions of major importance. The AFC's functions were to supervise the financial management of the Organisation and to concentrate on certain, particularly important executive tasks, notably the adjudication of certain contracts, the authorisation of certain expenditures, and the recommendations of budgets to the Council.

The AFC was particularly overwhelmed with work. In the 12 months from November 1965, for example, it had held 20 meetings spreading over 54 days and attended by 46 different delegates, compared to the theoretical minimum number of 10. The most significant practical recommendation which Bannier made for relieving this load was to change the limits below which the Executive could award contracts without first having to seek the committee's approval. The changes recommended were dramatic: from 100,000 AU (approximately 0.5 MFF) to 500,000 AU for normal contracts awarded competitively; from zero to 20,000 AU for contracts awarded to non-Member States, and from 20,000 AU to 100,000 AU for contracts placed by direct negotiation with the tendering firm. Bannier pointed out that in 1966 alone the AFC had discussed no less than 53 contracts at 15 meetings which had been either wholly or partly devoted to contract matters. If the limits which he proposed were adopted, this number would have been reduced to twelve. And only two of these contracts, the chairman noted, were worth more than 5 MFF.

Another important revision proposed by Bannier's group concerned the functions of the LPAC and the STC in the decision-making process. The LPAC, it was suggested, should put its proposals directly to the Directorate, rather than having them funnelled through the STC. It would then be up to the

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210 For this paragraph and for what follows, see the Bannier report, ESRO/C/APP/48, 29 March 1967, as well as ESRO/C/192, rev. 1, 21 July 1966.

Directorate to draw up a proposed programme for the Organisation in consultation with the STC and the AFC, before laying it before the Council for final approval. By this means, Bannier hoped to loosen the bonds between the LPAC and the STC. At the same time, he aimed to give the STC the status of an independent and "objective" judge of ESRO's scientific programme. Its membership, he proposed, should no longer be based on national representation but solely on recognised expertise in the scientific and technical aspects of the programme which the Organisation was following at any given time.

At the most superficial level, Bannier's proposals for redefining the decision-making structure for ESRO were simply an attempt to transport the CERN model into the space research organisation. His insistence that more authority be delegated to the Directorate, and his wish for "independent" scientific advice to be available through the STC were part of a general desire to roll back the influence of member state bureaucracies and their interests in the functioning of the Organisation. It was, he said tactfully, understandable that in the early days of ESRO each participating country wanted to ensure that its interests were properly protected inside the Organisation. Now that the body was established though, it was essential that the reigns be loosened, that confidence be placed in the Directorate, and that its newly granted executive authority be supervised by proper forward planning and careful *a posteriori* control.

All of the Bannier group's proposals for streamlining the committee structure of ESRO were welcomed bar that referring to the STC role. In mid-1967, in fact, the STC decided to maintain the *status quo* regarding its composition and its own terms of reference.[211] Bannier's recommendations were instead accepted as regards the LPAC, which became an advisory body of the Director General, the latter then reporting to the STC. As a matter of fact, it cannot be doubted that in the first period of its existence it was extremely difficult for the Directorate and the Council to have neutral advice on the content and direction of the scientific programme. Looking at the annexes to ESRO General Reports for these years, which list the membership of the Council and the various committees and working groups, one sees that a relatively small group of space scientists were present at several levels of the decision-making process, sometimes having key positions of power in more than one of the three main bodies concerned (i.e. Council, STC and LPAC).[212] As scientists they competed to have their preferred scientific payloads flown. As national representatives they competed to protect the interests of their own countries. The fragmentation of the field, and the limited resources available for satellites, meant that the battles between scientific groups to get a mission and an experiment accepted were intense. They were reinforced by the "political" exigencies of the national bureaucracies. Bannier's failure to push the system towards greater "objectivity" was indicative of the determination of scientists and of their governments alike to fight for every kilogram of a satellite payload.

The Council and its committees apart, the Bannier commission made a number of important recommendations regarding the internal organisation of ESRO. Their thinking was shaped by two main considerations. Firstly, they were emphatic that the executive function of the organisation should be clearly separated from the policy and the planning function. Secondly, as far as the scientific programme was concerned, they recommended that there be a clear institutional distinction drawn between spacecraft development and spacecraft operation after launch. To achieve these objectives, the Bannier group suggested that ESRO's top management structure be completely changed. The dichotomy between scientific and technical directorates was, in Bannier's view, wrong in principle for an organisation like ESRO. To overcome it, he suggested that the two posts be abolished. In its stead a new structure was proposed. It comprised the Director General (DG) plus four directors, two of whom were essentially responsible for policy-making and two for policy execution. A new post was to be created in the first category, a so-called Director of Programmes and Planning (DPP), whose task it would be to prepare draft programmes of the Organisation, based on the scientific, technical, financial

211 ESRO/C/303, 27 July 1967, and ESRO/C/306, add. 4.

212 A quick list should include J. Blamont (F), R. Boyd (UK), C. de Jager (NL), M. Golay (CH), B. Hultqvist (S) R. Lüst (D), G. Occhialini (I), B. Peters (DK), H. van de Hulst (NL).

and time implications of the different proposals. The second member of the directorate concerned with forward planning would be the Director of Administration (DA) whose task it would be to prepare policy on the future needs of personnel, finance and contracts, and to organise and implement the necessary procedures to maintain an *a posteriori* control over the Organisation's functioning. The two posts in the Directorate having executive authority would be filled by the director of ESTEC and of ESDAC, which was to be renamed ESOC, the European Space Operations Centre. As for ESRIN, the Bannier group judged its research to be marginal to the major activities of the Organisation. Its director, they felt, should not be a member of the directorate but should rather report directly to the DG.

The Bannier group did not doubt that the geographical dispersion of ESRO was detrimental to its proper functioning and was one important factor responsible for the prevailing malaise in the organisation. On the other hand, they realised that there was little that could be done to remedy the situation. What they did instead was to map the functional divisions they were recommending on to geographical ones. ESRO headquarters was to become essentially responsible for policy, planning and *a posteriori* control. ESTEC and ESOC would, roughly speaking, respectively have executive authority for spacecraft development and spacecraft operation. To fulfil these objectives it was recommended that ESLAB be merged with ESTEC and that the satellite control centre be moved from Noordwijk to Darmstadt. Being essentially responsible for launch and post-launch operations, ESOC's director would be responsible for ESRANGE and for ESTRACK.

By the end of 1968, the Bannier group's recommendations on internal structure had been more or less fully implemented.[213] J.A. Dinkespiler had been brought into the new key post of Director of Programmes and Planning, while the post of Head of Administration (occupied since 1967 by M. Depasse) was upgraded to Director level. A new director had been appointed for ESTEC, W. Kleen, who replaced M. Schalin, who in turn had briefly taken over from ESTEC's first director, E. Kesselring. ESOC too had a new man at the top, U. Montalenti, who had replaced S. Comet, the previous director of ESDAC. H.L. Jordan remained the director of ESRIN. Two deputy directors of ESTEC had also been appointed. One was P. Blassel, the head of the satellite and sounding rocket department. The other was R. Gibson, who had taken up post in January 1967, and headed a greatly expanded administrative department whose size reflected the increased executive authority of the Noordwijk establishment. The "geographical" reorganisation proposed by the group of experts was also implemented during 1967 and 1968. ESLAB was fused with ESTEC on 1 September 1968, though not without considerable regret being expressed by the scientists. As van de Hulst put it, they had found "a more pleasant welcome there [i.e. in ESLAB] than would have been possible in an establishment the size of ESTEC and basically devoted to technical activities".[214] ESLAB's director, E.A. Trendelenburg, was retained and became the head of what was now called the Space Science Department (SSD). The control centre was moved to Darmstadt, the timing being complicated by concerns that it would clash with the launching of the ESRO I and ESRO II satellites.[215] Finally, as part of the overall "rationalisation" of ESRO's activities, it was decided to move the headquarters from its temporary accommodation in 36 rue La Pérouse to new rented quarters in Neuilly-sur-Seine. This was a significant break with the past. For seven years the organisation's secretariat had been installed in the premises from which Auger's tiny group had helped lay the foundations first of COPERS and then of ESRO. It was also a pointer to the future. ESRO was to share accommodation in the building known as Neuilly/Hôtel de Ville with a rehoused ELDO headquarters. The change was indicative of a renewed determination in the Member States to forge a coherent, integrated space policy for Europe.

213 For the debate see restricted Council session, 25-26 April 1967, ESRO/C/APP/54, 22 May 1967, and Council Resolution ESRO/C/XVI/Res. 3, 27 April 1967.

214 From the minutes of the restricted Council session referred to in the previous note.

215 ESRO/C/292, 20 July 1967.

2.4.3 Relations with industry: the geographical distribution of contracts [216]

When ESRO's Convention was first drafted, no specific provision was made to distribute the contracts passed by the organisation on a geographical basis. The Convention was modelled on CERN's, in which major contracts were awarded competitively, the successful bidder being the one who made the lowest offer satisfying the laboratory's technical and delivery requirements. It was the Austrians who suggested to the COPERS that some attempt should be made to ensure that all Member States had a guaranteed return from the European space effort. As a result, the conference of plenipotentiaries which met in June 1962 resolved that "the Organisation shall place orders for equipment and industrial contracts amongst Member States as equitably as possible, taking into account scientific, technological, economic and geographical considerations. The principle having been affirmed, it took several years of discussion, notably inside the Administrative and Finance Committee, as to what interpretation should be put on the requirement of geographical distribution and how that interpretation should be administered. We do not intend to follow this extremely complex debate in detail. Rather, what we shall do is to identify the key issues which dominated the proceedings between 1964 and 1966, when a compromise satisfactory to the majority of the Member States was finally arrived at.

It was generally understood that the attempt to distribute contracts geographically would only be one criterion, and not necessarily the most important one, when ESRO awarded contracts. It was the last of the considerations mentioned in the resolution adopted in June 1962 and that, as the Swiss delegate pointed out, was indicative of the weight that it should have. Put differently, scientific, technical and economic considerations were to take precedence over geographical ones. Just what geographical distribution meant was also the subject of some discussion in the AFC. The principle adopted was that the distribution of contracts by value should be proportional to the Member States' contribution to the ESRO budget (the so-called principle of just return).

Three questions dominated the debate over the implementation of this principle. The first concerned the range of the contracts over which it should apply. It was obvious that the policy could only be applied to that part of the budget which was spent inside the Member States. The purchase of equipment and services, notably launching services, made in non-Member States fell outside its purview. But within that framework was the distributive principle to be applied to all expenditure, including buildings, land and even the salaries of the ESRO staff? Or was it to apply only to contracts involving a component of research and/or development, i.e. contracts of technical interest? The second main question was whether or not the financial advantages accruing to a host state from having an establishment on its soil should be taken into account when awarding contracts. There was a bias, insisted the British, in favour of firms in host states which built and furnished the facilities and supplied them with everything from paint to paperclips.[217] For some delegations affirmative action in the non-host states was required to redress these alleged imbalances. Of course, countries like the Netherlands and Germany, which had such establishments, disputed that there were any particular advantages accruing to them at all.

The third cardinal issue debated by the AFC concerned the time which should be allowed, and the procedures to be used, to establish rough parity between contributions and contracts. By mid-1965 some striking "inequalities" had already emerged. Consider the Dutch. About 7.8 MFF worth of contracts, the majority of low technical interest, had been awarded to the Netherlands. This was 8.7 % of the total value of contracts placed or authorised since 1962 - about double the Dutch percentage contribution to the budget. Similarly the French contract/contribution ratio was about two, with the

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216 This section is based predominantly on the debate surrounding ESRO's financial rules found in document COPERS/AWG/Fin/57, rev. 10, Addenda 1-17, 14 May 1965 to 31 August 1965 as well as documents ESRO/AF/361, 27 October 1961; ESRO/AF/461, rev. 6, 14 November 1966; ESRO/C/139, 16 September 1965; ESRO/C/139, rev. 1, and rev. 2, 10 March 1966 and 4 November 1966; and ESRO Council, extraordinary session, 24 September 1965, ESRO/C/MIN/8, 19 November 1965.

217 Krige, in Hermann et al. (1990), chapter 11, has illustrated the enormous advantages accruing to France and Switzerland in the award of contracts by CERN, which has no principle of just return.

added twist that no less than 48 % by value of all the technically interesting contracts had been placed in that country. This, it was said, was due to the strength of the French electronics industry. These imbalances perturbed most members of the AFC, and they spent a good deal of time trying to decide by *when*, and by *what means*, ESRO should aim to achieve a more equitable distribution of its resources.

It was obvious that the Netherlands were never going to support a distributive policy which treated contracts for "cement, bricks and stationery" as equivalent to those for a spacecraft. They made several proposals aimed at discriminating between these two categories. The procedure finally agreed on at the end of 1965 was to use a weighting factor for this purpose. Put loosely - for these concepts had to be translated into ESRO budget headings for procedural purposes - technically interesting contracts would be counted at 100 % of their value. The value of contracts for land and buildings, and for administration and transport equipment, would be counted at 25 % when calculating the amount of money spent in a member state for distributive purposes. Other expenditures, notably running expenses and, of course, expenditures in non-Member States, were effectively weighted 0 % on this system. As for redressing the already existing imbalances in returns between different Member States, it was accepted that these were initially unavoidable but that they should be gradually reduced over ESRO's lifetime. Typically it was proposed that excesses of 100 % (i.e. by a factor of 2) at the end of 1965 should not exceed 50 % three years later, 20 % six years later, and 10 % nine years later. Ideally this alignment should happen "automatically", as space industries in the relatively "backward" Member States acquired the capacity and the know-how to compete on a more equal footing with the advanced countries. Failing that, various measures were proposed to force down the contracts to contribution ratios which were in excess of unity. For example, it was suggested that countries which were above the agreed targets at a given date in time should be treated as if they were non-Member States. Their industries could still compete for ESRO contracts, but their tenders would only be considered if a substantial scientific or technical advantage, or a substantial price advantage (10-20%) could be obtained.

The French, with some support from the British, vigorously opposed this idea. Being the country whose space industry was the most likely to be "penalised" for having a "disproportionate" share of the contracts, it was not at all keen on the principle of just return being applied too rigidly. It was also totally against the idea that Member States which had exceeded their quotas should be treated as if they were non-Member States. As an alternative they proposed that ESRO promote close collaboration among European firms through the formation of consortia. By sharing the know-how and the skills acquired by the more advanced firms, engineers in new firms could make a significant contribution to the organisation's work. To implement this idea, the French proposed that countries which had been awarded contracts in excess of a certain percentage of their contribution, should be informed that from henceforth tenders submitted by their industry would only be valid if their firms linked up with firms in other, less favoured Member States. This was, in fact, a reflection of a trend which was already establishing itself inside the European space industry. Individual firms had competed for the contracts for the relatively simple satellites ESRO I and ESRO II. As the spacecraft became more complex, however, and under pressure from the debates regarding geographical distribution which were taking place in the AFC between 1964 and 1966, bids from individual firms began to give way to bids from consortia. Prime contractors began to choose some of their associates on geographical grounds so as to enhance the consortium's chances of being awarded the contract. Three consortia emerged in this period, which competed for ESRO contracts. These were the MESH consortium, including as its core members Matra (F), ERNO (D), SAAB (S), Hawker Siddeley Dynamics (UK) and Aeritalia (I); the COSMOS consortium, including as its core members SNIAS (F), MBB (D), Marconi (UK), Selenia (I) and ETCA (B); and the STAR consortium, including as its core members Thomson-CSF (F), Dornier (D), British Aircraft Company (UK), FIAR (I), Fokker (NL), Contraves (CH) and Ericsson (S).[218]

By the end of 1966, the Administrative and Finance Committee had more or less agreed on its policy regarding the geographical distribution of contracts. Weighting factors distinguishing technically interesting contracts (100 %) and contracts for lands and buildings as well as administration and transport equipment (25 %) had been accepted. No limit to the excess of expenditure over contribution was fixed, in order to retain flexibility in the award of contracts, though it was agreed that as soon as possible no Member States should be more than 100 % above its ideal share. As for affirmative action in favour of countries which were well below parity, it was accepted that the Organisation did have the right not to award a contract to a firm which made the most advantageous offer, if this was deemed desirable to achieve a more equitable geographical distribution of contracts. Following the French proposal, this derogation from the competitive criterion was to be particularly favoured if it encouraged an association of firms belonging to different Member States. At the same time, the AFC insisted that a tender could only be accepted to improve geographical distribution if its price was not more than 10 % higher than that of the lowest acceptable tender.

One of the first things that the new Director General Hermann Bondi did on taking office in November 1967 was to reorient ESRO's policy for the geographical distribution of contracts. In a major statement to the Council, Bondi undertook to ensure that by 1971 each member state would have achieved a return coefficient of at least 0.7, using the weighting factors for the value of contracts agreed under the Auger regime. This policy had two important advantages. Firstly, as Table 2-4 shows, Bondi's figure was already within striking distance for most of the disadvantaged states at about this time. It was thus realistic. Secondly, Bondi's policy completely inverted the procedures discussed previously for compensating inequalities in the geographical distribution of contracts. Whereas until this time the idea had always been to penalise states which were performing "too well", now the aim was rather to encourage those that were performing badly. In other words, it was less important that the percentage of contracts awarded to a country like France should be reduced than that the value of contracts awarded to countries like Spain or Denmark be increased. This is not to say that Bondi's proposals satisfied everyone, or that they resolved what was an extremely difficult problem. On the contrary, dissatisfaction over their share of the contracts was one of the main reasons leading the Italians to threaten withdrawing from ESRO in 1968, and eventually to withdraw from the TD satellite programme (see chapter 4).[219] The tortuous debate over the geographical distribution of contracts is noteworthy for the importance attached by Member States to the strategic significance of the space sector. Nothing comparable occurred in the case of CERN, for example, simply because it was believed that the technologies required for high-energy physics were of such little interest for research and development that it was not worth trying to hammer out an agreed policy of just return. At the same time, while ESRO's scientific programme undoubtedly provided firms in the Member States with opportunities to develop advanced technology, its importance should not be exaggerated. As the Executive pointed out frequently, only about half of the overall eight-year budget of 1500 MFF could reasonably be said to concern technically interesting contracts, i.e., on average about 100 MFF per year. Indeed it was the prospect of including telecommunication satellites in ESRO's mission, and so of applying its contracts procedure in this domain, that gave the debates in the AFC an added urgency in 1966. If compromises were reached after three years of tortuous discussion, it was also because the AFC realised that it needed to converge rapidly on a workable system in anticipation of calling for tenders in the potentially lucrative field of applications.

The debate was also protracted because the protagonists had very different conceptions of what the aims of a policy of just return were. At one extreme there were the British, who interpreted it in

[218] For the formation of consortia see Beattie & De la Cruz (1967). See also Schwarz (1979) and Dondi (1980a).

[219] FIN/WP/85, 21 December 1967 and ESRO Council, 20th session, 29-30 November 1967, ESRO/C/MIN/20, 13 December 1967.

strictly financial terms. For the UK it was important that as much as possible of its contribution to ESRO should be spent in the country of origin. Logically therefore, any distinction between different kinds of contracts was irrelevant in the UK's eyes. It made no difference whether ESRO spent its money on stationery or on spacecraft. What mattered was that the amount of money flowing back to a country roughly balanced the amount of money that it put into the central budget. For the majority of the Member States, however, the value of contracts was to be assessed *qualitatively,* and not simply quantitatively. For them, the prime aim of ESRO was to promote space research and technology in all the participating nations. It was not simply meant to channel their contributions back to the Member States in accordance with the policies and programmes adopted by the Council. These very different points of view, the one stressing the financial aspect, the other the technical, made it extremely difficult for the AFC to achieve a compromise. It led the British consistently to oppose the imposition of weighting factors for different kinds of contracts and indeed to object that the 25 % that was finally agreed on for non-technical contracts was far too low: they preferred at least 50 %. It also led the UK to insist that the benefits of the host state should be compensated. It was the amount of money that flowed back into the Netherlands, rather than what that money was spent on, that counted. The policy which the British adopted inside ESRO was, therefore, of a piece with their attitude towards ELDO. Whereas Britain tended to see both organisations in strictly commercial terms, their partners were more inclined to see them as involving long-term investments intended to build up a European capability in advanced sectors of high technology.[220]

2.4.4 Relations with NASA [221]

From its very inception, NASA showed itself willing to cooperate with a European space science effort. As we mentioned previously, as early as March 1959 the American delegate to the COSPAR undertook to launch "suitable and worthy experiments proposed by the scientists of other countries". NASA was prepared to launch single experiments as part of a larger payload or groups of experiments comprising an entire payload. To achieve these objectives, it offered a range of assistance, including advising on the feasibility of experiments, hosting foreign scientists in American laboratories, and performing the necessary pre-flight environmental testing. This offer was rapidly taken up, and arrangements quickly reached with Britain, France and Italy to fly nationally built experiments on American rockets. In addition, the Italians took steps to have American rockets built under licence in their country and to have NASA cooperate in their *San Marco* programme. This involved the construction of a launching range consisting of two towable platforms which could be fixed to the sea bottom by means of movable legs.[222]

This wish to collaborate continued once ESRO was set up. A Memorandum of Understanding concerning the preparation, launch and use of ESRO's first two small satellites ESRO I and ESRO II was signed by Auger on behalf of the European organisation and by Hugh L. Dryden for NASA on 8 July 1964. It had the unusual feature that NASA offered to launch these first two satellites with a *Scout* rocket free of charge as a "christening gift" for ESRO.[223] And in 1966 the American agency suggested a joint project to the Europeans. It was particularly interested in having them contribute 500 MFF to the costs of a Jupiter probe. The initiative failed, essentially for lack of resources. Despite the scientific interest of the venture, and the opportunities to gain experience in project management, the ESRO space science community were emphatic that this scheme was not to be funded at the expense of their existing, and already reduced, satellite programme. The need to find an additional 340 MFF during ESRO's first eight-year period, and the prospect of probably needing a new conference of plenipotentiaries to authorise the NASA/ESRO project were enough to kill off the scheme.[224]

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220 Krige (1992b)

221 On this topic see also Krige & Sebesta (1994) and Chapter 12 of this volume.

222 The San Marco programme was described in a memorandum submitted by Broglio to the COPERS Bureau meeting on 17-18 June 1963, Mussard files, folder "Bureau", in HAEC.

223 ESRO/25, 18 July 1964.

224 ESRO/C/199, 16 June 1966; ESRO/ST/200, 21 April 1966, and ESRO Council, 11th session, 22-24 June 1966, ESROIC/MINIl 1, 15 July 1966.

There was of course a large element of self-interest involved in NASA's approaches. The proposed joint venture to Jupiter was surely intended to help the Agency sell the programme domestically. It would save costs on an expensive mission at a time when space science was overshadowed by the vast Apollo programme: indeed, NASA made it clear that it was only seeking partners for a large project. It would also help foster the "peaceful" image of the American space effort at a time of heightened military competition with the Soviet Union, and increase NASA's good standing at home and abroad as a force for international collaboration. Strategic considerations were also certainly involved in the offer to launch scientific satellites built in Europe. As we have pointed out, by effect, if not by intention, the offer diluted European space scientists' enthusiasm for ELDO, and was one factor leading to Europe entering space with two rather than just one organisation. The offer to launch also served to keep Western Europe's space programme in the USA's orbit, and might well have been deliberately intended to discourage the French, in particular, from collaborating too closely with the USSR (in fact, a first French satellite was launched by a Soviet rocket in 1971). Finally, the availability of American launchers might also have been intended to impede, if not totally stop, Europe developing her own powerful rocket/missile. As we shall discuss in chapter 3, there was the wish of certain officials in the US Department of Defense to see Britain abandon the development of *Blue Streak*, not wishing the UK to gain control over IRBM launchings in the European theatre. There is no reason to think that this view no longer prevailed in the United States in the 1960s.

It goes without saying that ESRO was in a weak position when it came to negotiating the use of NASA's facilities. The enormous disparity of resources, both human and financial, between the two organisations, necessarily meant that NASA negotiators could impose conditions on their ESRO counterparts which the latter did not like. The negotiations over the Memorandum of Understanding concerning the furnishing by NASA of satellite launching and associated services, which took place throughout much of 1966, are a case in point. There was one clause in this document which the European scientists found particularly offensive. It was the clause granting NASA unrestricted access to the raw and reduced data from any satellite that it launched, regardless of the fact that the launch was paid for by the client and that the data were collected and processed in centres outside the USA. The ESRO scientific community found this to be an infringement of intellectual property rights, and a derogation of their responsibilities to the scientific groups who flew experiments on the satellite, and who obviously wanted prior and undiluted rights of access to the data obtained therefrom. NASA was however adamant. In the words of NASA Administrator James Webb, it was "important that NASA be in a position to report to Congress and the people that it [did], in principle, have full access to data acquired by any satellite launched from US territory". The only negotiable section of this clause, as far as he was concerned, regarded not the *access* to, but the *use* of, the raw or reduced data. Regarding the latter, NASA negotiators did agree to respect existing practice. They accepted that ESRO's experimenters could retain privileged use of the data for one year, and in any case not to violate the intellectual property rights of the scientists.

There was a lesson to be learned from this. In dealing with NASA, it was clear that ESRO would often have to stomach terms and conditions which, it felt, were against its interests. There were cases in which, as the Executive put it, if ESRO wanted an agreement, no constructive purpose could be served by its persisting with its demands. At the heart of the matter was the fact that NASA had launchers which neither ESRO nor any of its Member States could provide. If they wanted to pursue a space programme under these conditions, even a scientific programme, the Europeans necessarily had to make concessions. Put differently, European "independence" was impossible without of powerful European launcher. It was a point which was not lost on many European governments in the 1960s.[225]

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[225] For the negotiations with NASA see ESRO/C/198, 9 June 1961 and Add. 1, 18 July 1966; ESRO/AF/548, 7 July 1966; ESRO/C/233, 14 November 1966. See also STC, 10th meeting (21 June 1966), ESRO/ST/MIN/l0, 6 July 1966 and ESRO Council, 12th session (18-20 July 1966), ESRO/C/MIN/12, 1 September 1966 and 14th session 30/11-2 December 1966, ESRO/C/MIN/14, 20 January 1967.

The first three or four years of ESRO's official life were indeed sombre and difficult ones (we will discuss in detail in chapter 4 the difficulties in the development of ESRO's first satellite programme). The heady euphoria of the early 1960s, fuelled by the relative ease and rapidity with which European governments set up the organisation, soon gave way to disillusionment. There were the problems over the ESTEC site. There were endless discussions over relatively minor issues like the installation of the telemetry network, and over more important policy matters like the geographical distribution of contracts. There were sometimes strong disagreements inside the scientific community, which were sharpened by tight resource constraints imposed on the programmes. And there was growing criticism of the Executive by the Member States' delegates, who judged it incompetent and irresponsible. By 1966 there was, as Bannier noted, a crisis of confidence throughout the organisation. As if to confirm the malaise, first the Director General Auger and then his Technical Director Lines were forced to take a few months' sick leave that year. In summer 1967 the staff committees of ESTEC and ESLAB, in open revolt, addressed a note complaining about their working conditions to the Dutch queen. And to crown it all, the launch of the first small satellite (ESRO II) was a failure. The third stage of the *Scout* rocket which blasted off from the Western Test Range on 29 May 1967 malfunctioned, and the fourth failed to ignite. ESRO II was dumped unceremoniously into the ocean, and with it the hopes of all for at least one major success during Auger's term of office.

It was into this strained context that Hermann Bondi stepped as Director General in November 1967. Realistic about government intentions (he had already had considerable experience in dealing with the British Ministry of Defence) and sensitive to scientists' needs (he was one himself, a professor of applied mathematics at the University of London), he played a key role in rebuilding confidence in the organisation. He was helped, of course, by the lessons learned during the Auger years, and by the successful launch of the first three satellites during the first year of his office (ESRO II in May, ESRO I in October and HEOS A in December 1968). By the end of 1968, the future of ESRO seemed secured. Indeed its success was one key factor counteracting the powerful centrifugal forces which threatened to tear apart the fabric of the European space effort as the 1970s dawned.

Table 2-1
Launching programme as proposed in the *Blue Book*

Year	Sounding rockets	Small satellites	Space probes	Large satellites
1	< 10			
2	40			
3	65			
4	65	2		
5	65	3	1	1
6	65	2		
7	65	2	3	1
8	65	2		
Total	ca. 435	11	4	2

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

Table 2-2
Early estimates of the costs of ESRO (million French Francs)

Year	STWG May 1961	STWG Blue Book (Oct. 1961)	STWG Jan. 1962	STWG Jan. 1962 + Headquarters
1	61.9	69.7	73.8	82.4
2	123.0	121.2	104.9	115.5
3	150.6	148.7	157.5	169.0
4	156.0	162.2	168.2	177.7
5	172.5	181.2	187.7	198.5
6	232.1	243.2	262.0	272.8
7	232.1	243.1	259.4	270.3
8	232.1	242.6	259.6	270.6
Total	1360.3	1411.9	1473.1	1556.8

Sources: Column 2: COPERS/ 20, 11 May 1961; Column 3: *Blue Book*, pp.18-9; Column 4: COPERS/ 30, 22 January 1962; Column 5: as for column 4, with LAFWG's data on headquarters taken from same source.

Table 2-3
Estimates of the costs of ESRO made by the LAFWG's budget subgroup (MFF)

Year	STWG Jan. 1962 + Headquarters	LAFWG Jan. 1962	LAFWG March 1962
1	82.4	89.6	107.5
2	115.5	135.8	163.0
3	169.0	185.2	222.2
4	177.7	190.4	228.5
5	198.5	212.6	255.1
6	272.8	285.7	342.8
7	270.3	281.8	389.6
8	270.6	283.1	398.1
Total	1556.8	1664.2	2106.8

Sources: Column 2 & 3: COPERS/ 30, 22 January 1962; Column 4: Report of the budget subgroup, COPERS/AWG/II/2/Rev. 1, 19 March 1962, Annex II, Summary Table S5.

Table 2-4
Distribution of COPERS and ESRO contracts from 1963 to October 1966

Country	% Technical contracts (a)	% All contracts (b)	% Contribution (c)	All contracts/ contribution
Belgium	7.1	6.99	4.42	1.58
Denmark	0.1	0.68	2.21	0.31
France	41.4	38.90	19.10	2.03
Germany	12.8	12.30	22.60	0.54
Italy	9.7	8.90	11.70	0.76
Netherlands	2.5	6.40	4.24	1.51
Spain	1.1	1.00	2.66	0.38
Sweden	2.2	3.30	5.17	0.64
Switzerland	7.1	6.50	3.43	1.90
United Kingdom	15.8	15.09	25.00	0.60

Key:

a Percentage by value of technically interesting contracts (weighted 100 %)
b Percentage by value of all contracts both technically interesting and contracts weighted at 25 %
c Percentage contribution of the member state to the ESRO budget

Source: ESRO/AF1461, rev. 6, 14 November 1966

Chapter 3:
The Launch of ELDO

J. Krige

In chapter 1 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.[226] 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.

These 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 launcher. The cost of this venture, the technical and managerial risks that it entailed, its unavoidable military connotations, and the availability of American launchers all persuaded scientists that their space research organisation should be kept quite distinct from the Anglo/French rocket project.

We have already described, in chapter 2, the steps taken in 1961/62 to place European space science on a sound footing within the framework of what came to be known as ESRO, the European Space Research Organisation.[227] In this report we will explore in greater depth the intergovernmental negotiations which led to the signature of a convention in April 1962 establishing ESRO's sister organisation, ELDO, the European Space Vehicle Launcher Development Organisation. The initial programme of this organisation foresaw the construction of a three stage rocket capped by a satellite test vehicle, with the work on each component spread between the four major western European states. After describing the British military origins of the first stage, called *Blue Streak* we shall go on to explore how the UK managed to persuade first France, then Germany, and finally Italy to participate in the programme. We shall argue that it was a programme which was determined far more by political aims than technical realities, a programme which only managed to take shape because of the very specific political situation prevailing in Europe at the time, and in particular because of the simultaneous negotiations underway for Britain's entry into the Common Market.

3.1 The military origins of Blue Streak

In spring 1954 the US Secretary of Defense, Charles E. Wilson, suggested to the then British Minister of Supply, Duncan Sandys, that the UK might like to collaborate in the development of long range ballistic missiles. The British, said Wilson, could concentrate on a missile with an intermediate range of 1500 miles (an IRBM). The Americans, for their part, would work on an intercontinental ballistic missile of 5000 miles range (an ICBM).[228]

While it is difficult to be sure about American motives, it does seem that the division of responsibility proposed by Wilson may have been suggested to him by Trevor Gardner. Gardner was a recently appointed special assistant in research and development to the Secretary of the Air Force. A passionate believer in the importance of ICBMs, Gardner was most reluctant to see scarce resources diverted to IRBMs. He was aware that the Air Force was looking seriously at the possibilities of a 1000-mile range ballistic missile. Anxious to avoid a competition for human and material resources with his preferred ICBMs, "and cognisant of the fact that a missile of intermediate range would serve British

[226] Krige (1992a).
[227] Krige (1992b).
[228] Unless otherwise stated all of the information in this section is derived from Krige (1992c), where a lengthier account with more detailed references may be found, and from Twigge (1990), chapter 7, and section 8.3.5.

strategic needs, [Gardner] suggested that investigations be undertaken to determine whether the British were capable and willing to assume responsibility for its development."[229]

The stimulus from Britain's side for this invitation can apparently be traced back to a reassessment of the country's interest in IRBMs which occurred at about this time. The idea of developing such a missile had been mooted in military circles since the end of the war. None of the early discussions however came to much. The technology was sophisticated and costly, nuclear warheads were relatively heavy and would require an enormous thrust to launch them from the ground, and there was the inevitable opposition from the Royal Air Force, who saw missiles as a threat to their V-bomber force and to their monopoly on Britain's nuclear deterrent. In summer 1953, however, a systematic appraisal was made of the issue, and it was apparently concluded that an IRBM development programme was within Britain's capabilities, particularly if US help was forthcoming.

Sandys' interest in an IRBM also occurred against the background of a decision, taken in June 1954, that Britain should build its own H-bomb. Only if Britain had such a bomb, it was argued, could she hope to influence US policy in its use, and prevent its possibly "misguided" deployment. Fears were also expressed that the US could not be counted on to defend London from a nuclear attack once the Soviets could retaliate against New York with their ICBMs. Policy makers realised that the V-bombers would remain the major weapons delivery system for some time to come. But they also felt that they would have to be supplemented in the medium to long term by long range missiles capable of hitting Soviet targets from British soil. In short, British interest in building an IRBM was an important, if not central component in a renewed determination to develop an independent nuclear deterrent.

When Sandys first went to Washington to discuss the mutual development of a missile programme with Wilson, he was both optimistic and enthusiastic about the possibilities of UK-US collaboration. He felt that a 1500-mile range weapon would be of immeasurable strategic importance to Britain, and that it might be possible to agree on a "joint project" with the Americans in which the UK would have "complete access to their expertise." These hopes were soon dashed. For one thing the US Joint Chiefs of Staff quickly imposed security restrictions on certain crucial, militarily sensitive technological data. For another, mutual inspection of the facilities available for missile development on both sides of the Atlantic quickly revealed that, technically speaking, Britain was behind the US in most areas of interest. Indeed on 8 November 1955 Defense Secretary Wilson, spurred on by reports of America's vulnerability to surprise attack, decided to go ahead without the British. He informed all the armed services that an IRBM was to be developed at the "maximum speed permitted by technology." Within weeks Werner von Braun and his Army team had their *Jupiter* IRBM project authorised. The Air Force, not to be outdone, quickly advanced plans for their rival *Thor* missile, whose structural configuration was frozen by January 1956. In parallel, probably sometime in 1955, Britain too embarked on an independent IRBM programme, the product of which was the *Blue Streak* missile.

Though Britain embarked an IRBM programme of its own, it maintained important technical links with the US on some aspects of the project. De Havillands collaborated closely with Convair on the structure of the rocket. Rolls Royce acquired the design rights on the engines developed by the Rocketdyne division of North American Aviation. An official forum for an exchange of technical information was established where the British design of the rocket was evaluated by American experts.

While assisting the UK develop its own IRBM, the US also made a number of informal approaches in 1956 suggesting that its *Thor* IRBM should be deployed on British soil. One reason for this was the determination by some US officials not to "turn the control of the IRBM over to the British," so giving the US greater control over the deployment of the weapon in the European theatre.[230] The initiative was also partially intended to persuade Britain to abandon the development of *Blue Streak*, so avoiding

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229 Armacost (1969), pp. 59-60.

230 The quotation is from Clark and Angell (1992), p.155. This paragraph draws heavily on this paper, particularly pp. 153-9.

duplication of the American effort, and reducing British R & D in a sector where it was lagging behind the USA.

The American offer was attractive. It would enhance UK-US collaboration in the nuclear field. It would give Britain access to design information on the *Thor,* which would be useful for the development of *Blue Streak*. And it would provide the UK with an IRBM capability some five years before its own missile was due to be operational. The outcome of these discussions was an agreement in February 1958 for the installation of four squadrons (60 missiles) of *Thors* on British soil. At the same time, to avoid "duplication", *Blue Streak's* range was increased to 2500 miles, so bridging the gap between *Thor/Jupiter* and the *Atlas* ICBM, and provision was made to house the missile underground.

These modifications were not however enough to save the missile. For one thing, *Blue Streak* was a first-strike weapon. The fact that it was not mobile made it even more vulnerable to enemy attack. The resulting dilemma, as Twigge puts it, "was that in a time of crisis a choice would have to be made, to either show caution and risk being disarmed, or react immediately and risk starting a nuclear war."[231] Secondly, there was the question of cost. An internal British document circulated in February 1960 estimated that, in addition to some £60 million already spent on the missile, about another £240 million of research and development money would be needed to complete it. Added to this it was estimated that a further £200 million-odd would be needed by 1967/8 to produce and install 125 missiles in hardened underground silos.[232] In sum the deployment of *Blue Streak* as an element in Britain's independent deterrent was going to cost (at least) £500 million spread over eight years.

To assess the future of the rocket a special committee was set up in 1959 to report on all aspects of Britain's nuclear strike force. It submitted its report to the Chiefs of Staff early in February 1960, who in turn submitted their findings to the Defence Committee. This Committee met on the 24 February 1960. There was a general consensus that, as the Minister of Defence put it, "both militarily and politically it was unacceptable to rely on a "fire-first" weapon" and that, if better alternatives could be provided by the United States, *Blue Streak* should not be deployed operationally. The alternatives particularly favoured by the Minister were the WS 138A (*Skybolt*) missiles which could be fired from V-bombers and *Polaris* missiles which would be housed in nuclear submarines. The attraction of these systems was that, provided they were kept on patrol in times of tension, there was no need to use them as first-strike weapons.

Despite the feeling that *Blue Streak* was too vulnerable and costly as a weapon, the Defence Committee was loath to cancel it outright. They put forward several arguments for not doing so, of which the most important, in the Minister's eyes, was that the rocket could be used for conducting a wholly British programme of satellite space research. Indeed the possibility of using *Blue Streak* as the first stage of a satellite launcher, rather than just as a ballistic missile, had been actively considered by the engineers involved in the project for some time. This alternative was not only of potential interest for the UK's already well-advanced (civilian) space research programme. It would also serve the military's requirements for reconnaissance and telecommunications satellites.

A month later a British delegation headed by Prime Minister Macmillan himself visited the USA to seek further information on the American plans for *Skybolt* and *Polaris*. They were led to believe that the former would be deployed by the US Air Force in 1963, and that Britain could have the weapon a year or two later. As for *Polaris*, the Americans indicated that a first model would be introduced by the Navy in 1961 to be followed by a longer-range version in 1964. On returning home the British delegation found the Royal Navy unenthusiastic about *Polaris*. The Air Force, however, saw in *Skybolt* the means of preserving the operational life of its V-bomber force. In the light of these

231 Twigge (1990), p. 347. What follows owes much to his section 7.3.
232 For these figures see the document reproduced in Twigge (1990), p. 353.

attitudes the Cabinet formally decided to cancel *Blue Streak* as a military weapon and to purchase in its stead the *Skybolt* air-to-ground missile from the United States.[233]

The decision was announced to Parliament on 13 April 1960. It was justified by the new minister of defence, Harold Watkinson, on the grounds that an immobile *Blue Streak* protected in silos would be very vulnerable to Soviet missiles and that it were best replaced by weapons of considerable range which could be launched from mobile platforms. In the uproar that followed the main objection was not that *Blue Streak* had been cancelled as such, but that the decision had not been taken earlier. It was an argument which was to weigh heavily on the minds of those who sought to preserve the rocket in a new role.

3.2 Converting Blue Streak into a civilian satellite launcher

The cancellation of *Blue Streak* as an IRBM was followed by a detailed assessment inside the UK government of whether it should, indeed, be developed as a civilian satellite launcher. The issues at stake were spelt out in a long report of senior officials in the various departments concerned which was produced shortly after the April decision.[234] The best path to follow was far from clear; the costs and benefits of the various options were difficult to assess and sometimes incommensurable. A decision on this matter, said one of Prime Minister Macmillan's closest advisers early in July, is "like trying to do a calculation in imponderables" because the various factors involved could only be estimated "in the vaguest terms".[235] Predictably perhaps the ministers played it safe. Rather than take a decision with irreversible consequences they chose to let matters drift while seeking partners for a joint cooperative effort.

In deciding on what to do with *Blue Streak*, wrote the government officials, one had to bear in mind that space research was "opening a new field of human endeavour, which [might] have significant commercial, military, scientific and technological implications." Satellite communication systems, as well as meteorological satellites, were interesting for both civil and defence purposes. International telecommunications traffic was expanding rapidly, and "the high potential capacity and great flexibility" of satellites made them ideal candidates to supplement cables, which had a limited capacity and were susceptible to accidental or deliberate interruption. Satellite communication systems were also "the most promising means yet available for the world-wide relaying of television." In the purely military sphere there were potential applications in the field of photographic and electronic reconnaissance for intelligence gathering and as early warning systems against surprise attack by ballistic missiles. The interest in satellite applications was indeed so great that the Post Office had already started funding a development programme for items like the large steerable aerials and the radio equipment needed for a pilot satellite communications system; and the Minister of Defence had let it be known that his department would consider contributing up to £5 million a year to a space programme based on *Blue Streak*. Some scientists too were enthusiastic about the prospects opened up by having a research programme based on the use of heavy launcher, which would also "provide potentially valuable growing points for the physical and engineering sciences, replacing those provided in the past by the development of radar and nuclear energy." [236]

The exploration and exploitation of space by satellite was then clearly of great importance to a major world power like Britain, a national imperative even. Far more problematic was the policy to be adopted for the launchers needed to achieve these objectives. Here Britain was faced with two main

233 For this paragraph see Pierre (1972), Chapter 9.2 and Newhouse (1970), chapter 7. These authors describe the later drama surrounding the *Skybolt* offer in detail.

234 The memorandum *Space Research: Blue Streak. Report by Officials* is on file FO371/149657 in the PRO, London.

235 Memo headed *Blue Streak* from FB, doubtless Freddy Bishop, one of Macmillan's Private Secretaries, to Macmillan dated 5 July 1960, file PREM11/3098, PRO, London.

236 For this paragraph see the *Report by Officials* cited in note 10, section II.

alternatives: either to cancel *Blue Streak* altogether, and to rely on America for her future space needs, or to convert the missile into a civilian satellite launcher.

Several arguments were adduced for not cancelling the British rocket programme altogether. It would be a blow to national prestige. It would provoke a "row in some newspapers and from a small but vociferous body of starry-eyed space enthusiasts." Considerable sums had already been spent on the rocket, and these would simply have been wasted if the programme was halted. There would be some technological benefit.[237] It would create a delicate situation with Australia, whose range in Woomera was being prepared for *Blue Streak* launchings. By keeping *Blue Streak* alive, Britain would "retain current first-hand experience of the design and construction of large rockets, and would be free to develop them for military purposes," should this prove desirable at a later stage.[238] Finally, it would avoid dependency on the United States. Not only would the British have to fit their launches into the American schedule. More importantly there was no guarantee that the US would launch British telecommunication satellites at all. It was, the officials thought, unlikely that the Americans would impose "unfair conditions" on the use of one of their launchers in such cases, but there was always the risk "that they would pay some regard to their own interests, particularly if commercial applications emerged."[239]

For each of these arguments in favour of continuing the development of *Blue Streak* there was an argument against. Considerations of prestige cut both ways. The successful launch of a large satellite using a British rocket would undoubtedly be to the country's credit. On the other hand, if the development of *Blue Streak* as a satellite launcher "obviously strained our resources, it could be positively harmful to our prestige," warned the government officials. [240] The spin-off argument was weak. Technological spin-offs accruing from continuing the programme were difficult to evaluate, while cancellation would certainly "release valuable scientific and technical resources for other work." The claim that developing the rocket would preserve a useful technological capability was also of dubious merit. As the Chief Scientific Advisor, Sir Solly Zuckerman stressed, *Blue Streak* was a liquid fuelled rocket, and this was now an obsolete technology. [241] As for dependency on the US, its dangers were difficult to assess, as the costs and benefits fluctuated with the overall state of Anglo-American political relationships. Finally, and importantly, there was the danger that the continuation of the rocket programme, particularly if funded from the civilian science budget, would completely distort the pattern of science expenditure. Zuckerman was particularly emphatic about this, preferring, as he put it, "to spend the money on better instrumentation and better satellites using American launchers."[242] At the same time a vigorous debate was conducted among the British space science community through the columns of *New Scientist*, pitting two of the most eminent members of the field against one another. Bernard Lovell (Jodrell Bank), was in favour of developing an independent British launcher, while Fred Hoyle (Cambridge University) felt it would be "ridiculous" to devote so much money to one field of science.[243]

In the absence of unambiguous arguments as to how to proceed, Macmillan and his cabinet decided in July 1960 to continue the development of *Blue Streak* on a provisional basis until the end of the year, and to explore the possibilities of continuing thereafter in the framework of a cooperative programme with European countries and, at least, Australia. At an abstract level their reactions were typical of

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237 For these arguments see a briefing paper for Macmillan dated 5 July 1960, file PREM11/3098, PRO, London.

238 The argument of building up a strong in-house technical capability is in the *Report of Officials* cited in note 10, p.11.

239 See the *Report by Officials* cited in note 10, p. 6 and section VI.

240 These latter arguments are in their *Report* on pp. 11 and 12.

241 Zuckerman's rebuttal is in the document cited in the following note. Macmillan's advisers seemed to have laid great store by Sir Solly's claim — see the note for the Prime Minister dated 5 July 1960 in file PREM11/3098, PRO, London.

242 For Zuckerman's views a *Note for the Record* dated 5 July 1960 reporting a meeting between Macmillan, Zuckerman and Bishop, file PREM11/3098, PRO, London.

243 For their arguments see Hoyle (1960) and Lovell (1960).

decision-makers faced with alternatives neither of which was particularly better (or worse) than the other: they decided not to choose.[244] More concretely, political considerations seemed to have dominated their thinking. On the one hand the Prime Minister was reluctant to abandon a key symbol of British prestige, autonomy, and great power status, originally intended to keep Britain abreast of the latest developments in defence technology. "If we now cancel Blue Streak altogether", mused Macmillan, "will the decision generally be regarded as a further step in the direction of prudence and realism, or will it be held to mean that we are becoming increasingly, and to an undesirable extent, dependent on the USA."[245] On the other hand a joint European programme was perceived as a move towards closer cooperation with the continental powers, and with de Gaulle in particular. "Many recent developments confirm my belief," wrote Bishop to his Prime Minister "that we should consider the possibilities of closer collaboration with the French, not excluding collaboration in military fields and in policy towards NATO."[246] A cooperative effort around *Blue Streak* certainly fell within these spheres.

The first jointly developed launcher which Britain proposed to her potential European partners was based almost exclusively on UK technology. The launcher, it was suggested, would have three stages.[247] *Blue Streak* would be the first. *Black Knight*, a rocket which the UK had been developing for four years, and which had already undergone some test firings, would be the second. The third stage had still to be developed, though privately the UK government knew that this was not a significant part of the work.[248] The development of the first and second stages and the facilities required to test them had cost £60 million to date. Britain had no intention of recovering these costs. What she was hoping for was a participation by other countries in the cost to completion of the project, claimed to be some £50 million spread over five years.[249] In return, member countries would acquire the right to fire satellites (which might otherwise be denied them by the Americans).[250] Partners would also acquire first hand knowledge of the development and production of powerful rockets and their associated technology. "Each participating country," it was stressed, "would have rights of access to and information on the work proceeding in the other participating countries."

At the same time the British government sounded out reactions to its proposal in Canberra and in Washington. The Australians, while not objecting to Britain making a preliminary approach to European powers, had three main concerns. Firstly, they were worried that, if *Blue Streak* were cancelled, Britain might abandon rocket development not only for civilian but also military purposes. Secondly, they wanted assurances that if they participated in the further development of, say, a telecommunications satellite, the UK would not "hold them to ransom in any commercial exploitation [...]," and that they would have full partnership rights. Thirdly, and most importantly, they wanted assurances that the UK would not strike a deal in which Woomera was sacrificed for Colomb-Bechar,

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244 For a discussion of this feature of decision-making behaviour, see Schilling (1961).

245 See the note by the Prime Minister headed *Blue Streak*, written around 25 July 1960 in file PREM11/3098, PRO, London.

246 See a memo to the Prime Minister dated 5 July 1960 headed *Blue Streak*, and signed FB, file PREM11/3098, PRO, London.

247 For this information see, for example, telegrams 3498 and 3499 from the Foreign Office to Washington dated 12 August 1960 in File FO371/149654, PRO, London.

248 See the *Report by Officials* cited in note 10, section IV.

249 This figure is five times less than the estimate, made only a few months before, of what it would cost to develop *Blue Streak* as an IRBM. It seems, and indeed turned out to be, hopelessly unrealistic. The satellite launcher obviously did not need such a sophisticated guidance system as the missile, nor did it need a nosecone able to withstand the searing heat of re-entry into the lower layers of the Earth's atmostphere. It is hard to believe that these features of the weapon composed some two-thirds of the overall R&D expenditure though.

250 The weights and orbits of the kind of satellites that could be launched by the envisaged rocket were added by way of illustration. It was estimated that a further £12 million would be needed to develop them.

France's Saharan launching base. Such a deal, the British were warned, would have a "disastrous effect" on Anglo-Australian relations.[251]

Clearance from the United States was required on the commercial, political and military aspects of any collaborative European programme. North American Aviation and Convair had made major contributions to the development of *Blue Streak's* rocket engines and frame. And the State Department would have to be persuaded that there were no risks in having France and Germany, in particular, as partners. This was a delicate point as it was US policy not to do anything which might help either nation develop an independent IRBM capability. [252]

None of these difficulties seemed insurmountable in British eyes. In anticipation of Australian reactions they had told the French from the start that the UK regarded the use of Woomera as essential in any cooperative programme involving the use of *Blue Streak*.[253] To meet potential US objections, they undertook not to divulge any United States commercial information or classified defence information embodied in the first stage of the envisaged rocket. More to the point they stressed that, in converting *Blue Streak* from a missile to a satellite launcher, it would be stripped of its military characteristics. The civilian version would have no inertial guidance or re-entry properties, and would not embody any US classified information above the "confidential" level. [254]

The United States reacted very positively to the British initiatives. Consistent with its prevailing policy of encouraging collaborative European ventures, it was reported from Washington that the Department of State not only had no objection, but "might react favourably, to the proposed European organisation, including the United Kingdom [...]." The Americans saw no objection to the transformation of *Blue Streak* into a satellite launcher, felt that there was no great risk of military information being divulged if the vehicle was used for civilian purposes, and agreed that UK firms could have exploratory discussions with their American counterparts about the "Europeanisation" of the programme.[255]

The initial reactions of Britain's potential partners on the continent were also positive. It was the position of the French though, regarded by Minister of Aviation Peter Thorneycroft as "the potential cornerstone of an international organisation [...]," which mattered most, and which we shall now consider in some depth. [256]

3.3 Bringing the French on board

The idea that France may like to collaborate with Britain in the joint development of a launcher had been floated in Paris as soon as it was decided to abandon the rocket as a weapon. The issue was left on the back burner while the UK established the American position. Then, from September onwards, according to a French source, the pressure on Paris to reach a favourable decision increased substantially. Several French technical teams visited Britain and there were discussions at the

251 For these first Australian reactions see the telegram 827 from Canberra to the Commonwealth Relations Office, 31 August 1960, in file FO371/149675, PRO, London.

252 See Telegram from Washington to the Foreign Office, 27 July 1960, in file PREM11/3098, PRO, London.

253 See aide mémoire sent to the French on 25 July 1960, file PREM11/3098, PRO, London.

254 See telegram 3497 from the Foreign Office to Washington, 12 August 1960, file FO371/149654, PRO, London.

255 See telegram 1722 from Washington to the Foreign Office, 1 September 1960, file FO371/149655, PRO, London.

256 The quotation is from Thorneycroft's memorandum for the Cabinet Ministerial Committee on *Blue Streak* dated 28 November 1960 in file CAB134/1428, PRO, London.

ministerial level. The French space science community also looked into the British proposal in mid-November. Soon thereafter the Quai d'Orsay had clarified its position.[257]

The French were cautious. Certainly, they thought that it would be of "great interest to study the possibilities of producing in Europe a system of rockets to permit the placing of heavy satellites in orbit." [258] But they had serious technical and financial doubts about Britain's proposal. According to an internal French document, the use of *Black Knight* as a second stage was without interest. It would not accelerate existing developments, it would be of no use to French national military projects, which were judged to be more modern and technically very different, and it would be of little benefit to French industry. Then there was the problem of cost. The space scientists were particularly emphatic about this, insisting that if France entered this venture the funds for it — estimated at 250 MFF over five years — should not come from the allocations just made to the national scientific space research programme. At the same time to bring home to their government their lack of interest in the scheme, they pointed out that, like their British colleagues, they would be looking into an offer by the Americans to launch national satellites.[259] And indeed in December 1960 one of their number, Jacques Blamont, made a trip to Washington to discuss arrangements for a collaborative effort with the NASA authorities.[260]

The answer from the Quai d'Orsay reflected these concerns. The French government was willing, they said, to make a joint approach along with Britain to other European governments to discuss, without prejudice as to the final result, the possibilities of producing a heavy launcher in Europe. Their eventual participation however, depended on two considerations. Firstly, one of the stages of the launcher, preferably the second one, should be built in France. And rather than it being *Black Knight*, "they would want it to correspond to a type for which the French military authorities had already made provision in their plans." Secondly, the cost of any joint programme would "have to be made the object of a most precise study."[261]

The French wish to replace *Black Knight* with one of their own rockets did not worry the British unduly. The pairing of *Blue Streak* with *Black Knight* had already been criticised by G. Pardoe, a chief engineer at de Havillands at the time, on the grounds that it underexploited *Blue Streak*'s capabilities.[262] During the following two or three weeks technical missions from both Britain and France visited the installations of their potential partners across the Channel to explore the possibilities of building an Anglo-French launcher. On 12 December Thorneycroft himself came to Paris to spell out the UK's position, a position which, in the eyes of the French at least, completely changed the terms of the debate. The Minister's main point was that a launcher with a French second stage would cost more than one based on the *Blue Streak—Black Knight* combination. He was certainly in favour of the two countries declaring an interest in building together a launcher based on *Blue Streak* as a first stage, a French second stage, and a third stage to be built on the continent. However he felt that, in this case, costs would have to be shared on a 50/50 basis between Britain and France, the financial burden being reduced by contributions from other Member States who might want to participate in the project.

257 See *Examen de la Proposition Britannique par le Comité des Recherches Spatiales*, 16 November 1960, *Rapport personnel du Professeur Auger*, 16 November 1960, and *Proposition Britannique de collaboration dans le domaine spatial*, unsigned, from the office of Le Délégue Général of the Délégation Générale à la Recherche Scientifique et Technique, 21 November 1960, all in file Re130/31, liasse 620, Archives Nationales, Paris (cf. Note 1).

258 Telegram from Paris to the Foreign Office, 24 November 1960, file PREM11/3513, PRO, London.

259 The material in this paragraph is based on the documents cited in note 33. The government had agreed to spend 130 MFF over five years on the national research programme. The French contribution to ESRO was likely to cost a further 100 MFF between 1961 and 1965.

260 Minutes of the meeting of the Sous Comité des Programmes Scientifiques held on 24 February 1961, an annex to the minutes of the meeting of the Comité des Recherches Spatiales held on 8 March 1961, Re 130/31, liasse 620, Archives Nationales, Paris.

261 For this response see the telegram cited in note 34.

262 See his remarks cited by Goldring (1960), p. 1333.

The French reaction was immediate and firm: they were not willing to pay 50% of the cost of such an operation — except perhaps under one condition.... The money for the launcher could not come from the science budget. The minister responsible for scientific research (Guillaumat) pointed out to Thorneycroft that at the Meyrin conference of plenipotentiaries which had just been held it had been suggested to hive launchers off from satellites. His ministry was only prepared to take responsibility for the latter. It was therefore up to the Ministry for the Armed Forces to foot the bill. And as the representative of this ministry (General Lavaud) made clear, there was simply no way in which he could find 50% of the costs of a heavy launcher in the money that had been set aside for the development of rockets for space science. Savings of this magnitude were only possible from the military side of the balance sheet — notably in the areas of inertial guidance and nose cone re-entry. In sum, then, what the French were demanding was access to highly sensitive military technology in return for their participation in a joint venture to develop a heavy launcher with the British.[263]

French military interest in such a project came as no surprise in London. In line with de Gaulle's wish to develop an independent "force de frappe", in 1960 Parliament voted funds for the so-called "precious stones" rocket programme (Emeraude, Topaze, Saphir for the military and Diamant for the civil programmes). When the British first proposed a joint venture in spring that year, the French immediately sought to have a team appointed by their Ministers of Scientific Research and of the Armed Forces "to have access to some precise facts about certain technical questions connected with the missile [...]", and to establish the extent to which the British were prepared to share their know-how with their French counterparts.[264] In similar vein, the British government officials who had explored the arguments pro and contra the continued development of *Blue Streak* had remarked that Paris was likely to be interested in a joint venture "because the large rocket techniques involved [were] relevant to the delivery of nuclear weapons and other purposes," and more broadly "as promising closer Anglo-French activity in the nuclear field, and in aviation and weapons generally."[265] It was not the military dimension as such, then, that wrong-footed the British. It was rather the specific request for technical information on inertial guidance and the characteristics of re-entry heads, and the coupling of the provision of this information with French participation in a joint project.[266]

The diplomatic implications of acceding to the French request caused considerable concern in Britain. As one of Macmillan's private secretary's put it, to divulge militarily sensitive information on ballistic missiles to them would be "a reversal of current Anglo-American policy and could certainly not be done without deep consideration here and consultation with the United States authorities [...]." The Foreign Secretary, for his part, was sure that the Americans would be very unhappy about any such arrangement. "Do we and the Americans want France to get ahead quickly with the military side of rocketry?", he asked in alarm. "The Americans would certainly not give France information if there was the least danger she would hand it on, and who would say she would not?"[267] To circumvent these objections the proponents of the scheme pointed out that, in fact, Britain had made important contributions of her own to the key military components of *Blue Streak*. In particular, it was said that the re-entry head was of British design and that, although the guidance system was American, UK firms were producing similar equipment which might be of equal value to the French. The opinion

263 These two paragraphs are based on the (apparently verbatim) report of the meeting with Thorneycroft made by François de Rose at the 22nd meeting of the Comité des Recherches Spatiales held on 14 December 1960, Re 130/31, liasse 620, Archives Nationales, Paris. For the process leading up to the splitting of satellites from launchers at the Meyrin conference and to the birth of two European space organisations, see Krige (1992a).

264 Aide-mémoire from the French government dated 31 May 1960, file FO371/149654, PRO, London.

265 For these quotations see the *Report by Officials* cited in note 10, pp. 7 and 9.

266 For the growing realisation in Britain of the importance of the military interest of the heavy launcher to the French, see minutes of the meeting of the Cabinet Ministerial Committee on *Blue Streak* held on 30 November 1960, document BS(60), file CAB134/1428, PRO, London, and note for Macmillan signed PdZ (Philip de Zulueta) and dated 15 December 1960, file PREM11/3513, PRO, London.

267 For these reactions see the note for Macmillan signed PdZ and dated 15 December 1960 and the memo from the Foreign Secretary to the Prime Minister dated 30 December 1960, both in file PREM11/3513, PRO, London.

thus gained ground that it might be possible for Britain to draw up a bilateral arrangement with France for the transfer of that part of the militarily sensitive information which was "technically within our own disposition", so hopefully satisfying Paris without unduly offending Washington.[268]

As the British grappled with the implications of their request for military technology, the French became increasingly unwilling to commit themselves to a joint project. In mid-December 1960 Thorneycroft and the French Minister for the Armed Forces (Messmer) agreed that an intergovernmental conference should be called for the second half of January, and that the invitations would stipulate its aim as being to study the development in common of a launcher based on *Blue Streak* as first stage, a French second stage, and a third stage to be built on the continent. When it came to settling the wording of the joint invitation, however, the French would not agree to the inclusion of any reference to their building the second stage. What is more, according to UK sources, they refused to allow the visit of a British technical team who wanted to estimate the effect on the project in terms of time and money of substituting a French second stage for *Black Knight*. As a result there were also no specific proposals in the invitation as to how costs might be shared.[269]

Then, within days of the conference, scheduled for 30 January in Strasbourg, the French attitude changed. A British technical team was invited to Paris on 27 January. And on the eve of the Strasbourg conference they withdrew the condition that all funds for the new organisation had to be found from their military budget i.e. the release of military information was no longer a precondition for French participation in the project.[270] There is no single, or simple, reason for this change of heart. Perhaps the French always intended to join in the venture, and their request for military information was simply a bargaining card to be withdrawn at the last minute if it proved too difficult to satisfy.[271] They sought key technical data that the British had. They also knew that Britain's position was weak, and that the longer the negotiations dragged on the more concessions Thorneycroft would have to make. It was costing £350,000 a month to keep the *Blue Streak* team and facilities on hold, and there would be serious domestic political repercussions if the rocket was finally cancelled. It was only natural that they would try to take advantage of the situation, and wring every possible concession out of Thorneycroft and his team. Even then one must be careful. In mid-December one British observer remarked that the French had "now come out into the open and made it quite clear that what they [were] *really* interested in [was] knowledge about ballistic missiles (so-called inertial guidance and re-entry)." (my italics).[272] This is too simple. The explicit request for this knowledge arose in response to the scientist's demand that their funds not be cut, with the implication that the money for the Anglo-French launcher would have to be found in the defence budget. And, as the Minister for the Armed Forces explained, to have the French Assembly accept that some £20-30 million be spent from his budget for "a project that had no possible military application at all," it would useful if Britain could "make some gesture with regard to the re-entry head or the guidance system [...]."[273] The request for military know-how was thus less a point of principle than of domestic political need and, as the British soon realised, the precise content of the military technology that was transferred was negotiable.

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268 For this paragraph see minutes of the Cabinet Ministerial Committee on Blue Streak, meetings held on 19 December 1960 and 17 January 1961, documents BS(60) and BS(61), file CAB 134/1428, PRO, London.

269 For this material see the documents referred to in the previous note, the brief for the United Kingdom delegation to the Strasbourg conference, prepared by the Cabinet's Official Committee on *Blue Streak*, document BS(0)(61)6, 26 January 1961, and a document labelled SECRET from about February 1961 on file PREM11/3513.

270 See the minutes of the meeting of the Cabinet Ministerial Committee on Blue Streak, 1 February 1961, document BS(61) 2nd meeting, in file CAB134/1428, PRO, London.

271 For example Messmer told Watkinson, the UK Defence Minister, that "he thought his government was in general willing to support the idea of joining with other European nations in using Blue Streak as a space launcher [...]", record of a conversation between the two on 17 December 1960, file PREM11/3513, PRO, London.

272 From the note from PdZ to his Prime Minister cited in note 42.

273 See the record of the conversation between Messmer and Watkinson, the UK Minister of Defence, in Paris on 17 December 1960, in file PREM11/3513, PRO, London.

But the most important reason why the French position changed was that de Gaulle himself intervened. From 27-29 January Macmillan and the French President held confidential talks at Château de Rambouillet. The climate was cooperative: within six months the British Premier would announce that the UK would apply for admission to the EEC. The two men discussed the heavy launcher during a walk on the afternoon of the 28th. According to a British record of their conversation, de Gaulle was "attracted by the idea of Europe becoming "the third space power." He would take a constructive line about Blue Streak at Strasbourg. He did not mention the military aspect." [274] Confirmation of the importance of this meeting is provided by the remark, made many years later by a French source, that de Gaulle personally, and "against the advice of all the experts", took the decision in January 1961 to associate his country with the *Blue Streak* project. [275] Indeed even at the time the British believed that the General's intervention had been crucial. Later in that year the view was expressed that the conversation between Macmillan and de Gaulle at Rambouillet in January "had been decisive in persuading the French to join with us in sponsoring ELDO." [276]

De Gaulle's support for Macmillan at Rambouillet in January 1961 was informed by very different motives to those of the British Premier. De Gaulle and the French were keen to have access to British advanced technology for their "force de frappe." Collaboration in the development of a rocket, parts of which had been built under license from the USA, was a useful channel for gaining access to UK and, indirectly, US know-how which could be used for both civil and military purposes. Technological exchange was far less important for the British. In the 1950s they were one of the leading nuclear powers in the world, and had a very advanced aeronautical industry. There was little that the French could teach them. Their objectives in seeking a joint venture with the French were primarily political. London had originally stood aloof from the negotiations surrounding the formation of the Common Market and, indeed, had spearheaded a campaign to form an alternative free trade area (EFTA) with the "outer six" plus Portugal.[277] Doubts about the wisdom of this move, and the view that Britain should also actively seek full membership of the European Community, became increasingly widespread in the country in 1960, as the Common Market began to take shape. By the end of the year Macmillan had decided that an application should be made. His meeting with de Gaulle at Rambouillet in January 1961 was the first occasion he had to sound out the General's attitude to his plan. Correlatively, de Gaulle's willingness at Rambouillet to take a cooperative line at the Strasbourg conference doubtless encouraged Macmillan in his view, which grew increasingly immune to contradictory signals, that the French President would favour UK membership of the EEC. The French, or at least de Gaulle, decoupled technological collaboration from economic and political union. The British, or at least Macmillan, did just the contrary. Technological collaboration was one dimension of a wider strategy aimed at closer integration with the Six, and was seen in Whitehall as an important "proof" of Britain's (new) European credentials. It was a fundamental difference in perception for which Macmillan, in particular, was to pay a high price.[278]

3.4 The Strasbourg conference

The jointly called Anglo-French conference was duly held in Strasbourg from 30 January to 2 February 1961 with Thorneycroft in the chair. Invitations were sent to Austria, Belgium, Denmark, Germany, Italy, the Netherlands, Norway, Spain, Sweden and Switzerland. All of these countries were

274 See document headed *Rambouillet 3* on file PREM11/3513, PRO, London.

275 See Rhenter (1992).

276 See the minutes of the Cabinet Ministerial Committee on *Blue Streak* held 24 November 1961, document B.S. (61) 8th meeting, file CAB134/1428, PRO, London.

277 The seven members of EFTA were Britain, Norway, Sweden and Denmark, Austria and Switzerland, and Portugal.

278 For a concise account of the circumstances surrounding Macmillan's application for EEC membership, see Ward (1992). For the importance to the French of having access to UK technology, see e.g. Newhouse (1970).

represented at the conference bar Austria, who sent an observer. Australia did not attend. In anticipation of the meeting the British Minister of Aviation made a tour of European capitals. He stressed the importance of not allowing the USA and the USSR to have a monopoly in the launcher field, the "unrepeatable opportunity to take a decision to go into space" provided by the cancellation of *Blue Streak*, the possible television, navigational and aeronautical applications of satellites, and the "immense political advantages in Europe getting together on a project of this kind which would straddle the existing divisions between Six and Seven." [279]

Granted the complexity of the issues involved, and the short time which most delegations had had to prepare themselves, it was understood that the meeting would be essentially exploratory in character. After three days of deliberations the text of an Anglo-French memorandum summarised the main conclusions reached. It defined the initial programme of the envisaged organisation, should it be set up, as "to 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." The programme would also include the planning and construction of a first series of satellite test vehicles. The existing facilities already created would be put at the disposal of the Member States, who would only be asked to pay the additional capital expenditure and running costs arising from the programme. The contracts for carrying out this programme would be placed by the participating governments themselves and not by the executive of the organisation itself. However all technical information arising from the work already done on *Blue Streak* and the French second stage, as well as from the initial programme itself, would be freely available to the participating states. These arrangements were not necessarily binding on any subsequent programmes, nor would any member state be obliged to take part in any such programmes. At the request of delegates from Belgium, the Netherlands and Spain, the memorandum specifically allowed for the possibility of there being a merger between the launcher organisation and ESRO. [280]

The British faced two particular problems at the meeting. Firstly, there was the position of Australia. The Australians had agreed to put Woomera at the disposal of a European launcher "club," and would continue to pay their share of the costs of the range as agreed in the existing UK-Australia Joint Project (i.e. £9.5 million per annum). This, they felt, was to be regarded as a contribution in kind to any future European heavy launcher organisation which would entitle them to full membership rights. Britain agreed to stand by this position. And while it appears that most other delegates did not object to this idea, they were less convinced that Australia could continue to participate in any subsequent programmes on this basis. She too would have to begin to make direct financial contributions to the costs of the organisation.[281]

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279 See the record of Thorneycroft's talks on *Blue Streak* with German, Danish and Norwegian ministers presented to the Cabinet's Official Committee on Blue Streak, document B.S.(0)(61)4, 23 January 1961. The reference to straddling the divide between the Six and the Seven is, of course, to building a bridge between the EEC and EFTA member countries — see note 53.

280 For this paragraph see the final version of the memorandum by the French and British delegations dated 2 February 1961, and attached as Annex I to the report of the proceedings at Strasbourg prepared by the committee established to consider the administrative, organisational and financial aspects of the proposed joint venture, document B.S. (0) (61)7, 6 February 1961, PRO, London.

281 For this paragraph see the brief for the UK delegation cited in note 45, and the telegram sent to London from Strasbourg that was discussed at the Cabinet Ministerial Committee meeting on *Blue Streak* held on 1 January 1961, document B.S. (61) 2nd meeting, file CAB134/1428, PRO, London.

The second main area of difficulty concerned the basis for sharing the costs of the initial programme. The British estimated this at £70 million spread over five years.[282] The original UK proposal was that this amount should be shared in the same way as were contributions to CERN, i.e. proportionally to gross national income with a maximum of 25% for any one country. On this scheme the UK would have paid just under 25% of the overall cost, and France just over 20%.[283] It rapidly emerged that other countries did not like this idea. The small countries were not prepared to commit themselves to expenditures of this magnitude. France offered to share only 15% of the burden which, it claimed, would amount to less than half of the actual costs of developing the second stage of the launcher.[284] And the British delegation found themselves forced to telegram home for authority to pay up to 40% of the budget of any new organisation.[285] In the event Britain undertook to pay 33.33%, on the understanding that France, Germany and Italy should pay the same percentages as they were contributing to CERN for 1961/62, i.e. respectively 20.57%, 18.92% and 9.78%. The remaining 17.4% would be divided among the other eight participating countries proportionally to their gross national incomes. In effect this meant that the UK was willing to pass on its "excess" contribution of something over 8% to the smaller countries. It was agreed that if nevertheless any of these decided not to join the new organisation, the "big four" would negotiate among themselves as to how its percentage was to be made up.[286]

This was not the only concession that the UK had to make in order to tempt its European partners to join in the scheme. Before the Strasbourg conference British officials had thought, rather naively, that the ongoing costs of maintaining the *Blue Streak* programme should be shared by potential partners. These should be asked to begin payments two weeks after the conference, and to decide by the end of May whether they wanted to be full members or not. This was softened after the Strasbourg meeting, and a memorandum was drafted suggesting that other parties might be invited to share costs as from 1 April 1961. As far as we can establish, no one did so.[287]

The Strasbourg conference provided the first opportunity for a thorough exposé of the Anglo-French heavy launcher project among the dozen potential European partners. Too much could not be expected. The meeting was called in haste and, until the last minute, it was not clear on the UK side just what line Paris would take — they even allowed beforehand for the possibility that the French might try to "sabotage the Conference from within." [288] Certainly, after the meeting the British could be sure of French financial and political support up to a total of some 20% of the budget.[289] That was reassuring, but it was not enough. In fact, in a sense, it simply increased Britain's vulnerability. To cancel the *Blue Streak* programme now would involve a loss of face for Macmillan, who had personally prevailed on de Gaulle and who was preparing Britain's application for EEC membership.

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282 This figure was made up as follows. The original estimate for a rocket with all three stages built in the UK was £35m. With a 50% contingency and with £6m added for a satellite test vehicle, this brought the cost of an all-British project to £58m. It was thought not unreasonable to add £12m to this figure if the other stages were not British, though it was remarked that "we have no valid basis for estimating the additional cost of other than U.K developed 2nd and 3rd stages." See brief for the UK delegation referred to in note 45.

283 See Annex IV to the report dated 6 February 1961 cited in note 56.

284 For the French position see the first paragraphs of the annex to the final version of the joint Anglo-French memorandum dated 2 February 1961 which was cited in note 56.

285 See the telegram mentioned in note 57.

286 See the paper on financial contributions annexed to the final version of the joint Anglo-French memorandum dated 2 February 1961 and cited in note 56.

287 For this paragraph see the brief for the UK delegation to Strasbourg cited in note 45 and Annex V to the report of 6 February 1961 cited in note 56.

288 This is from the brief for the UK delegation cited in note 45.

289 In the minutes of the meeting of the *Comité consultatif de la recherche scientifique* held on 10 February 1961 we read that "la participation française, de l'ordre de 22%, paraît acquise.", file 28/CC, 2/D27 PV, AN810401 art 54 liasse 123, Archives Nationales, Paris.

On the other hand to continue the programme on a purely national basis for much longer while searching for additional partners was also likely to be embarrassing, both at home and abroad. The Labour opposition could be guaranteed to demand justifications for continuing to spend £350,000 a month on a militarily obsolete rocket. And, as Macmillan himself pointed out to Thorneycroft in April, there was "a point beyond which we cannot hawk this around Europe without becoming slightly ridiculous."[290] What British Ministers wanted above all was that matters came to a head quickly. They were to be disappointed.

3.5 German and Italian objections

The main parameters shaping Germany's position on the Anglo-French venture had been explained before the Strasbourg meeting to Thorneycroft. Foreign Minister von Brentano expressed his strong support, this being "dictated by the political advantages which would accrue from the joint project." Minister of Economics Erhard did not foresee any financial difficulties. It was on the technical aspects of the envisaged launcher that the Germans had their doubts. Though awaiting confirmation from their experts, they felt that "serious thought should be given to whether it might not be preferable to use American rockets." This line of argument subsequently gained ground. In March the Federal Republic informed the British government of its "willingness to participate in the consortium for building launchers and satellites." At the same time they suggested "that there should now be discussions on whether the consortium should construct a launcher based on Blue Streak or an American launcher under license."[291]

This move was most unwelcome for Britain. If the idea was widely accepted — and there were already signs that many European countries favoured the German line — it would completely sabotage the British project. It was therefore agreed that under no circumstances should the UK contemplate participating in a consortium to build American launchers under licence, nor in a second Strasbourg-like conference to discuss such a project. Instead Britain pointed out to Germany that the new US administration had just confirmed that the "mass of technical data" embodied in *Blue Streak*, much of it of American origin, could be disseminated to any new European organisation which used the rocket, and that there would be scope for further collaboration as regards the third stage and the satellite test vehicle. At the same time it was argued that the existing Anglo-French project would be better value for money than any alternative, as Britain was offering it the work already done on *Blue Streak* as a "free gift". [292]

As time dragged on so the pressure on Germany to take a favourable decision mounted. A meeting was arranged between Strauss and the UK Minister of Defence in May "to press the advantages of the project." It was suggested that Macmillan send a personal note to Kennedy "asking him to tell the other governments concerned, and in particular the Germans, that the United States administration was well disposed towards, or at least saw no objection to, the formation of the proposed consortium." Close contact was maintained with Adenauer, who had already told Macmillan that he supported the idea of a cooperative venture "with all his heart; Europe must play its part." [293] At the same time the British Cabinet, realising that cancellation would now be even more damaging than these seemingly interminable delays, pondered proposing again a joint venture to the French on a 50/50 basis in return for "certain information relating to guidance systems and to some aspects of the design of re-entry

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290 Personal minute from Macmillan to Thorneycroft, 24 April 1961, file AIR8/2255, PRO, London.

291 For this paragraph see the document cited in note 55, the record of a conversation between the Secretary of State (Home) and the German Ambassador on 20 February 1961 (file PREM11/3513, PRO, London), the record of a meeting between Macmillan and Adenauer on 23 February 1961 (*ibid.*) and the minutes of the Cabinet Ministerial Committee on *Blue Streak* held on 29 March 1961, document B.S. (61) 3rd meeting, file CAB134/1428, PRO, London.

292 For this paragraph see the minutes of the meeting on 29 March 1961 cited in the previous note.

293 See record of a meeting between Macmillan and Adenauer on 23 February 1961, file PREM11/3513, PRO, London.

heads, which was not of the highest secrecy [...]." [294] In the event this did not prove necessary. The high-level lobbying paid off. On 29 June Adenauer personally informed Macmillan that the Federal Government had approved German participation the day before provided, as a commission of experts had put it, "that German science and industry [were] given an adequate share of the work to be done." He hoped, Adenauer added, that this agreement would pave the way for the establishment of a European organisation "to secure for European science and technology a proper place in the field of space travel and space research." [295]

To encourage Germany's participation in the Anglo-French project they were promised the third stage of the launcher. That left Italy. And the Italians, like the Germans before them, were most unenthusiastic about the scheme: there was, as CERN and ESRO pioneer Edoardo Amaldi put it, "solid opposition" to it in the country. He explained the grounds for his opposition, and that of the majority in Italian scientific and technical circles, to an Anglo-French technical delegation who visited the Foreign Ministry in Rome on 21 September 1961. [296]

Amaldi had three main objections to the project. Firstly, he stressed that there was nothing of interest in it for Italian industry. Each stage of the envisaged "European" rocket would, in fact, be built in the country to which it had been attributed. This would effectively exclude not only Italy's industry from the most important parts of the project, but also her scientists and technologists. The situation, Amaldi went on, was to be contrasted with that at CERN. Here scientists and engineers from all the participating countries had been involved from the very start in defining the project, designing the machines, and bringing them to completion. Industrial contracts were awarded competitively on the basis of merit. In the Anglo-French proposal, by contrast, industrial contracts would be awarded "a priori, for either historical or political reasons, but not on the basis of scientific-technological arguments." [297]

Amaldi's second concern regarded the management scheme. Large projects of this kind were difficult to coordinate. These difficulties would surely be far greater in an arrangement which had stage one of the rocket built in the UK, stage two in France and stage three in Germany. "Any reasonable person", he wrote later, "sees the difficulty of matching three stages and the satellite made in 4 different countries and one can easily foresee the disputes that will arise if these do not fit well together." [298]

Finally, there was the projected rocket itself, which Amaldi judged as not being worth the money to be spent on it. Europe, he pointed out, was being asked to make a major investment in a rocket which would use a technology which was already available in other countries. Echoing the sentiments of Sir Solly Zuckerman, he stressed that this technology would undoubtedly be obsolete by the time the rocket was ready, in five, or more likely seven years. In sum, Amaldi concluded, the Anglo-French project would not contribute to "the scientific and technical development of Europe. For Italy it [was] essentially a form of friendly contribution to the development of U.K. (and French) industry in this

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294 For the information in this paragraph other than that just cited, see minutes of the Cabinet Ministerial Committee on *Blue Streak* held on 10 May 1961, document B.S. (61), 4th meeting, file CAB134/1428, PRO, London.

295 Letter Adenauer to Macmillan, 29 June 1961, file PREM11/3515, PRO, London.

296 Minutes of this meeting entitled *Verbale della riunione che ha avuto luogo al Ministero degli Esteri in data 21 corrente con la missione tecnica Anglo-Francese per il progetto Blue Streak*, as well as a report of Amaldi's personal contribution (*Intervento del Prof. E. Amaldi....*) to that meeting are in the Amaldi Archives, Box 210, Universita di Roma "La sapienza". The quotation is taken from a meeting of scientists held a few days later, *Verbale della riunone tenuta a Roma il 25 settembre 1961 presso l'Istituto di Fisica dell'Universita*, in the same box (cf. note 1).

297 See the personal intervention by Amaldi at the meeting on 21/9 cited in the previous note. De Maria (1993) has analyzed Amaldi's position on the European space effort in great detail.

298 See Amaldi's intervention in the meeting held on 21 September 1961 cited in note 71 and letter Amaldi to Adams, 15 December 1961, Amaldi Archives, Box 210, Università di Roma "La Sapienza."

field." If his authorities wanted to participate, he added, they should be clear that they were doing so purely for political reasons. [299]

Amaldi's statements were informed by the determination to protect an Italian national space programme which was being spearheaded by Luigi Broglio. Broglio was both the director of the Institute of Aeronautical Engineering at Amaldi's University of Rome 'La Sapienza', and a colonel in the Italian air force. [300] Already in July 1960 the Italians had succeeded in building an American *Nike* sounding rocket under licence. In August 1961 the government approved a three year space programme which included the construction, in collaboration with the USA, of the *San Marco* near-equatorial launching platform. And indeed, ten days after the meeting with the Anglo-French team in Rome, Broglio left for the United States to define the details of the *San Marco* 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.

The implications of Italy refusing to join the proposed organisation had serious consequences for Britain, from a financial and above all a political point of view.[301] By mid-September 1961 Austria, Norway and Switzerland had all let it be known that they were not interested in membership. If Italy followed suit the ensuing organisation "would not be truly European in scope [...]." What is more there might be other defectors. Both Germany and Denmark had accepted in principle, but on condition that the new organisation had "as broad a European base as possible, i.e. the participation as soon as possible [...] of all the states represented at the Strasbourg Conference." If they and other smaller countries dropped out, for reasons of cost and/or to protect their neutrality, Britain would find herself saddled with a project which had "most of the economic disadvantages of a multilateral enterprise conducting an expensive and complicated business" with none of the hoped for political benefits. In short, it was politically imperative in British eyes that Italy join in the launcher development project as soon as possible.

During the latter half of September "considerable pressure" was put on the Italians.[302] The British and French ambassadors in Rome made a joint approach to the government, German experts entered into direct contact with their Italian counterparts, and steps were taken to arouse the interest of Italian industry. A personal message from Macmillan to Italian Prime Minister Fanfani was delivered on 3 October. At the same time the cabinet ministerial committee responsible for *Blue Streak* considered alternative courses of action if Italy did not participate. All had serious disadvantages, particularly from a political point of view.

Cancellation, though the cheapest alternative, was out of the question, at least in Thorneycroft's eyes. "I regard Blue Streak as probably the most important technical project in my ministry," he said, reiterating the now standard arguments for continuation. *Blue Streak*, he insisted, was to be continued to avoid US dependency, particularly in telecommunications, to benefit industry, to enable Britain to be well placed to take advantage of possible military applications of space, and to avoid parliamentary criticism for not having cancelled earlier.[303] But if the UK proceeded without the Italians, what was the best basis on which to do so?[304] Britain could again consider going it alone, which would be more efficient and probably cheaper — but this would cast serious doubts over her claims to be interested in European collaboration and might have "an unfortunate effect on our negotiations with the European

299 See Amaldi's contribution on 21/9 cited in note 72 and his letter to Adams cited in the previous note. Amaldi's emphases have been suppressed.

300 For this paragraph see De Maria (1993), section 5.

301 This entire paragraph is based on a note by the secretaries of the Cabinet Ministerial Committee on *Blue Streak*, document B.S. (61)2, 21 September 1961, file CAB134/1428, PRO, London.

302 For this paragraph see the minutes of the meeting of the Cabinet Ministerial Committee on *Blue Streak* held on 2 October 1961, document B.S. (61) 5th meeting, in file CAB134/1428, PRO, London.

303 See the memorandum by the Minister of Aviation, document B.S. 61 (3) of 28 September 1961 on file CAB134/1428.

304 For what follows see document B.S. (61) 2 cited in note 77 and the minutes of the meeting held on 2 October 1961 cited in note 78.

Economic Community." She might seek a purely bilateral Anglo/French arrangement — but this might "reinforce pressure for the supply to France of purely military information [...]," and create difficulties in Washington. Or she might work for a tripartite Anglo/Franco/German consortium — but this might encourage the "smaller European countries to believe that we were now prepared to accept in other fields as well the idea of a tripartite directorate in Europe, to which they are strongly opposed." In addition if Germany built the third stage of the rocket on her own "Soviet propaganda against West German militarism, and allied encouragement of it, would be provided with a useful theme." In sum the most preferable alternative in Britain's eyes was to push for as wide a European participation as possible, encouraging the French and the Germans to share any ultimate shortfall in contributions, including that of the Italians (about 10%), on at least a pro rata base with the UK.

In an effort to bring matters to a head, the British and French governments called a meeting of all the European states represented at Strasbourg, plus Australia, for 30 October in London. Its aim was to discuss the draft of a convention establishing a European launcher development organisation. The week before Britain was still far from sure that a suitable basis for collaboration could be found. The Italians seemed to be insisting that *Blue Streak* be abandoned as a condition for their participation, though it was possible, said Thorneycroft, that their ministers "had agreed that it was for political reasons desirable for them to join ELDO, but felt constrained to take account of the fact that their technical advisers had reported unfavourably." The French, for their part, had refused to accept to share pro rata with the British (and the Germans) the shortfall in the ELDO budget if Italy should not participate, and had suggested cancelling the meeting if their Latin neighbour withdrew.[305] And there were continuing difficulties with the Australians, who persisted in their view that their contributions in kind to the development of *Blue Streak* should also entitle them to continuing rights, without further payment, in the subsequent period of satellite research and the commercial exploitation of telecommunication satellites. This line was sure to antagonise other potential European members of the consortium.

To deal with this situation there was little Thorneycroft could do, given his determination to press on, but to seek authority to offer even more generous financial incentives to the delegates to the London conference. To save the meeting from possible failure caused by a breach with Australia it was decided to offer to set aside £1million over five years from Canberra's contribution to the Joint Project to be used as an Australian financial contribution to possible post-*Blue Streak* ELDO programmes.[306] To make up the Italian shortfall should they not participate, Thorneycroft requested permission to pay up to 60% for a UK/France/German project, reducing to 50% as other countries were brought in.[307] The Minister of Aviation was then prepared to spend up to £42million on a "European" project — compared to the original £50 million estimate for a *Blue Streak—Black Knight* combination.

These moves were of course indicative of the increasing vulnerability of the UK and of the Minister of Aviation in particular. Britain had now been "hawking" this project around the continent for almost 18 months, and had spent some £6million on keeping the *Blue Streak* teams at work. The political repercussions of withdrawal, both at home and in terms of the Macmillan government's European aspirations, would be extremely serious. In addition Thorneycroft was under pressure from the European space industry. In September 1961 it established a supranational body called EUROSPACE, which included among its members all the leading European companies in aircraft and missile manufacture. Its aim, according to its constitution, was "to promote the development of aerospace activities in Western Europe," which included helping the embryonic European space organisations to carry out their programmes. More specifically, sectors of this industry, both in Britain and in France, were keen advocates of the *Blue Streak*-based European launcher. As F. Vinsonneau of the French

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305 See the minutes of the Cabinet Ministerial Committee on *Blue Streak* meeting on 23 October 1961 document B.S. (61) 6th meeting, file CAB134/1428, PRO, London.

306 For the Australian position see document B.S. (61) 2 cited in note 77. For the UK proposal as to how to assuage the Australians, see the minutes of the Cabinet Ministerial Committee on *Blue Streak* held on 27 October 1961, document B.S. (61) 7th meeting, file CAB134/1428, PRO, London.

307 For this proposal see document B.S. (61) 3 cited in note 79.

company SEREB put it, "What we did say, and repeat with conviction, was that the only solution in the [space] field was a united Europe [...] experiences 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." [308] There were undoubtedly strong technical and managerial arguments against going ahead with ELDO in the form being considered in 1961. But they seemed to be more than outweighed, at least in the eyes of the product champions, by the assumed industrial and above all political benefits of pressing ahead.

3.6 The Lancaster House conference

The UK duly convened a meeting of potential Member States to draft a final version of the ELDO convention at Lancaster House in London. It lasted from 30 October to 3 November 1961. Thorneycroft was in the chair, and representatives were sent by Belgium, Denmark, France, The Federal Republic of Germany, Italy, the Netherlands, and the UK. Australia also attended officially this time. Norway, Sweden and Switzerland, who were represented at Strasbourg, only sent observers.

After the opening plenary session, in which the Italians explained the doubts they had about the project, the conference broke down into an administrative and financial working party and a technical working party. These presented their results to plenary sessions where the main difficulties that had arisen were discussed. In general, according to an internal British document, "the representatives of other countries supported the formation of a European Launcher Development Organisation and were sympathetic towards the difficulties which the U.K. Government in particular was experiencing in its efforts to found the Organisation." At the end of the meeting an agreement was reached on the form of a suitable convention.[309]

Four main problems arose at the meeting. Firstly, of course, there was the question of Italy. According to one source, by the time the meeting took place, Italian engineers had come around to the view that, for all its limitations, ELDO had certain advantages for them. In particular the building of a test satellite for the launcher dovetailed neatly with their plans for the national space programme. Also they hoped, with the support of Germany, to push ELDO in the direction of studying advanced launcher technologies, particularly cryogenic propulsion. In the event they were unable to enter into formal commitments at Lancaster House. Apparently Prime Minister Fanfani, at the last minute, instructed the delegates to remain temporarily aloof since negotiations with the USA over the *San Marco* platform had reached a particularly important stage, and he wanted to do nothing which might hinder their successful conclusion. [310] Under these circumstances, the conference could do no more than strongly encourage Italian participation. To tempt them it was agreed that £2 million be set aside in the initial programme for a two-year study of future possibilities and the need for vehicles and ranges, preferably led by a suitably qualified Italian. The French delegation also suggested that Italy should take the lead in any advanced propulsion research which ELDO might undertake, a project that was close to Broglio's heart.

The second problem concerned the free exchange of information. Failure to agree on these rights would have imperilled the whole project, because the availability of information for use by other countries was fundamental to the British proposals. The German delegation had particular difficulties here because design and patent rights under German law belonged to the inventor. It was thus difficult for the government to get free access to this information for other Member States participating in ELDO. In the prevailing spirit of compromise a suitable way around the difficulty was devised.

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308 For more detail on the lobbying activities of the European space industry see De Maria and Krige (1993). The quotation can be found in *Aviation Week*, 3 July 1961, p. 31.

309 For this paragraph and the quotation see the Report on the Lancaster House Conference prepared for the Cabinet Ministerial Committee on *Blue Streak*, document B.S. (61) 6, 13 November 1961, in file CAB134/1428, PRO, London.

310 For this paragraph see the interview of C. Buongiorno with L. Sebesta, Rome, 23 June 1992, ESA archives, Florence. For additional information see also Sebesta's interview with L. Broglio, Rome, 22 June 1992.

Then there was the ongoing problem of Australia. The French, in particular, strongly objected to making commitments in the convention to future programmes, and Britain tended to sympathise with their position. The question was not resolved at the conference. Instead Britain accepted that Australia should circulate a note to other ELDO member countries repeating its offer to make the facilities available for the first programme also available as contributions in kind to any subsequent programmes. In return for this Australia would continue to have full membership rights in the organisation. Britain agreed to inform its ELDO partners that it was willing to go along with this arrangement. At the same time, in view of the attitudes expressed by other parties at the Lancaster House conference, she made it clear to Canberra that she would not put pressure on any country who was not prepared to accede to Australia's request.

The final important aspect discussed at the meeting was the financial one. Spain said that if it joined it could not afford to pay more than £1million to the organisation. The small countries, particularly the Netherlands and Denmark, wanted the absolute value of their contributions limited to their share of the £70 million estimate for the initial programme, i.e. they wanted this to be treated as a ceiling on expenditure. Britain and France would have none of it. They insisted that, while this was the best available estimate of the cost of ELDO, they could not guarantee that it would not be exceeded in a development project of the type being considered. The compromise found was to insert a clause in the financial protocol which stated that, if the £70 million limit should be exceeded, the Member States would discuss among themselves as to how to deal with the excess. The other financial problem dealt with at Lancaster House was how to share the shortfall should the Italians not join. France and Germany made it clear that they were most unlikely to help, despite considerable pressure put on them by the UK delegation. Instead, they suggested that, if Britain paid the Italian contribution of 9.78% they might be willing to share any outstanding shortfall due to the defection of smaller Member States. This was coupled with the demand by the big countries that the annual budget of the organisation be voted by a qualified two-thirds majority, the qualification being that it be accepted by those contributing 85% of the budget. This destroyed any hope that states like Belgium or the Netherlands might have had of restricting expenditure using formal voting mechanisms. [311]

In the light of these developments Thorneycroft's immediate problem was to persuade his colleagues that Britain should be prepared to pay Italy's contribution to a future ELDO. The matter was discussed by the Cabinet committee on 24 November 1961. It was badly received by the Chief Secretary to the Treasury and by the Minister for Science. Both insisted that further expenditure on ELDO would be at the cost of other more worthwhile scientific projects. There were certainly going to be sharply increasing demands for science and technology over the next five years from both the Research Councils, whose forward estimates increased by 10% per annum, and the universities. Why spend more money on a launcher with no guaranteed important civilian use? American launchers could be used to put scientific satellites into orbit. In telecommunications the Americans were far ahead, and had let it be known that there would be room for only one international system. Britain's contribution to ELDO would involve developing an already obsolete first stage, and her large stake in the organisation might well preclude her from having ESRO's satellite engineering laboratory, where the greatest technological advantages were to be obtained, on her soil. In sum, according Lord Hailsham, the science minister, if Britain took on the entire Italian share of the budget, it should be clear that this was being done "for reasons other than scientific", and the scientific effort in other fields should not be reduced to pay for it.[312]

The immediate purpose of the Cabinet meeting was to advise Macmillan on the line that he might take with de Gaulle in discussions which were due to begin that afternoon. There was general agreement

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311 All of the material in the preceding paragraphs dealing with the Lancaster House meeting is from the document cited in the previous note. See also ELDO (1965), pp. 8-10.

312 This paragraph is based on the minutes of the Cabinet Ministerial Committee on *Blue Streak* held on 24 November 1961, document B.S.(61) 8th meeting, and Hailsham's paper prepared for it, document B.S.(61)7, 16 November 1961, both in file CAB134/1428, PRO, London.

that he should ask the French President to join him in urging the Italian government to make a favourable response. If that happened Britain would be prepared to share the remaining shortfall equally with France and Germany. If Italy should stay out the question of whether or not Britain should itself make up the difference would have to be reconsidered, though Macmillan was told of the divided opinions at the meeting. The Prime Minister duly took up the issue the next day. de Gaulle said that France would be willing to bear more of the total cost of ELDO, but only to cover the deficit caused by non-participation of the smaller countries, not Italy. [313]

Our documents do not permit us to follow the subsequent evolution of the negotiations over Italian membership in any detail. When the ELDO convention was signed on 30 April 1962, though, Italy was among one of the seven participating states, the others being Britain, France and Germany, Belgium and the Netherlands, and Australia. In the agreed division of labour the Italians were given responsibility for the first series of satellite test vehicles, while Belgium would provide down range guidance stations and the Netherlands the long range telemetry links, including the requisite ground equipment. In 1963 negotiations were opened between Britain, France and Germany on how to share the shortfall of contributions to the budget, amounting to a little under 12%. It was agreed that this would be done pro rata according to the scale of contributions to the initial programme. In practice this meant that the UK absorbed almost half of the deficit, its final share rising to 38.79%. France, Germany and Italy were to pay respectively 23.93%, 18.92% and 9.78%. Belgium, at 2.85% and the Netherlands, at 2.64%, made up the balance. Australia's contribution was the provision, free of charge, of the range and rocket firing facilities at Woomera. The convention establishing ELDO came into force on 29 February 1964. [314]

3.7 Concluding remarks

The most striking feature about the birth of ELDO, and one that has been noted many times before, was the scepticism, and even opposition, to the project by many experts in the main participating countries. In the case of scientists this was mainly based on fears that the enormously costly rocket would be financed at the expense of their research programmes. Engineers stressed the obsolescence of the technology in the first stage, and the complex managerial problems that would be created by building bits and pieces of the system in different countries. These expert opinions were overruled in France, in Germany, and in Italy, along with the counter-suggestion that if Europe wanted to enter space rapidly it would be advised first to try to negotiate to build a heavy American launcher under licence.

ELDO then was a child of political, not technical parentage. [315] In particular, it was a child of the Macmillan government, which saw the rocket as at once enabling it to achieve a measure of independence from the United States and to draw closer to its continental partners, and indeed to the newly-fledged European Economic Community. There were other arguments of course for continuing with the project — to save costs, to boost industry, to preserve in-house skills — but it was these political concerns that dominated the thinking of Macmillan and Thorneycroft from the time the *Blue Streak* missile was cancelled.

It has been pointed out that Macmillan's decision to apply for Common Market membership in July 1961 was hopelessly ill-timed, that he placed far too encouraging an interpretation on the signals coming from the Elysée, and that if he had been more attentive the fiasco of de Gaulle's veto in

[313] See Aide memoire from Macmillan dated 26 November 1961 in file PREM11/3515, PRO, London.

[314] For this paragraph see ELDO (1965), pp. 11-15. For the position of the Italian ministers see the statement by Thorneycroft made at the Cabinet meeting on 24 November 1961, cf note 88.

[315] The phrase is a deliberate allusion to the remark made by ESA's then Director General in 1984, Erik Quistgaard, that ELDO was "a child of non-technical parentage, of blindness to technical reality" — see ESA (1984). De Maria and Krige (1993) survey a number of arguments in similar vein in the introduction and conclusion to their paper.

January 1963 might have been avoided.[316] While there is doubtless much truth in this, one can forgive Macmillan for feeling that de Gaulle was seriously interested in closer ties with Britain, at least in advanced technology. It was de Gaulle who, by all accounts, and against the opinion of all his experts, instructed his delegates at the last minute to take a cooperative line at the crucial Strasbourg meeting in January 1961. It was de Gaulle who accepted, in November 1961, that France share the shortfall of the contributions to the ELDO budget due to the non-participation of smaller countries. And it was while Britain's application to the EEC was pending that France and Britain agreed (in November 1962) to enter together another major, and financially disastrous project, the development of a supersonic airliner significantly labelled *Concorde*. In sum the negotiations over the setting up of ELDO took place in a context of a growing wish by Britain to become part of the European club, of an associated willingness on her part to make major compromises to achieve that objective, and of at least some positive signals from across the Channel that her membership would be welcomed. The difference, of course, was that whereas de Gaulle decoupled technological collaboration from the British application for membership of the EEC, Macmillan did just the opposite.

The possibilities inherent in this very specific political conjuncture, such as they were, were only exploited because of the determination of the British Prime Minister and of his Minister of Aviation. Thorneycroft never wavered in his conviction that it was essential for Britain to continue the development of *Blue Streak* as a civilian launcher. Macmillan never hesitated to contact now de Gaulle, now Adenauer, now Fanfani, and to ask them to intercede before their governments in favour of the British proposals. These personal ties were of crucial importance in bringing otherwise reluctant partners into line.

The British domestic political situation also played a key role in keeping *Blue Streak* alive. The moment it was decided to try to convert the missile into a civilian space launcher the Macmillan government exposed itself to charges that it was wasting money. As time passed, and hundreds of thousands of pounds a month were spent in anticipation of finding partners, so did these accusations become more difficult to rebut. What the Conservatives needed above all was a quick decision from other European governments. However the political symbolism was so great, the military interest so limited, and the technical aspects of the project so unsound, that this was just not possible. As the weeks and months dragged by so Britain's need to make ever more costly concessions to bring other partners on board increased. Each step forward, each partner acquired, was at once a sign of progress and a further impediment to the government extricating itself from the project. It gradually lost control over a process which steadily gathered its own momentum, and it paid a heavy price for it. By 1963 the UK not only found itself committed to paying almost 40% of the budget of the new organisation — far more than the 25% it had thought to pay when it initiated the scheme two years before. It also found itself brutally excluded from the Common Market by an uncompromising de Gaulle. Britain had failed to meet either its financial or its political objectives, and it was saddled with developing a technically obsolete rocket. It is hardly surprising that it very quickly began to reconsider its continuing membership of the very club that it had brought into being.

[316] Ward (1992).

Chapter 4: The Reorientation of ELDO's Programme and the First Steps Towards a Coordinated European Space Effort[317]

J. Krige & M. de Maria

4.1 The activities of the ELDO Preparatory Group

The governments represented at the Lancaster House conference in October-November 1961 realised that the signature and the ratification of the ELDO convention might take many months. Anxious to move ahead rapidly, they drew up a protocol, dated 9 May 1962, establishing an ELDO Preparatory Group (PG). This temporary body was instructed to make plans for the setting up of the organisation, pending the coming into force of the convention, and to co-ordinate the work already under way on ELDO's Initial Programme. In particular the PG was to invite the participating states to place the contracts in industry, at their own expense and risk, for those parts of the programme which were not yet started.

ELDO's Initial Programme (IP) involved developing a three stage launcher, labelled ELDO A (or sometimes Europa 1), and capable of putting 1000 kg into a near circular, low Earth orbit (300-500 km). This performance was, in fact, defined to meet the needs of ESRO's planned Large Astronomical Satellite (LAS -see chapter 6). The IP was initially scheduled to run for five years, and to cost £70 million (196 MAU, millions of monetary units, where 1MAU = $1). Following a proposal by the Italian delegation, those meeting at the Lancaster House conference also agreed to set aside £2 million to undertake, in parallel, the study of more advanced launchers and ranges. This was to be concluded by a report about the possible re-orientation and/or upgrading of the IP. The final distribution of the global budget between the participating states was Belgium 2.85%, France 23.93%, Germany 22.01%, Italy 9.78%, the Netherlands 2.64% and the United Kingdom 38.79%. Australia's contribution in kind consisted of making available range and supporting facilities in Woomera.

The Preparatory Group held its first meeting from 11-13 December 1961. It elected General E. Cigerza (Italy) as its chairman and set up a Technical Committee, chaired by W.H. Stephens (UK) and an Administrative Committee chaired by M. Depasse (Belgium). This structure was reconfigured over the next year. In October 1962, when the ELDO Secretary General, Ambassador R. Carrobio di Carrobio (Italy) attended the first meeting of the Preparatory Group, Cigerza handed over the chairmanship to D.W.G.L. de Havilland from Britain. Stephens was nominated Technical Director, H.L. Costa was appointed Administrative Director and G. Bock (FRG) took over Stephens' role as chairman of the Technical Committee.[318]

The Technical Committee's main task involved coordinating the Initial Programme, including setting up the launch facilities, the guidance system and the satellite test vehicle. It was also asked to study future programmes. While it existed it held twelve meetings and was assisted in its work by a Technical Planning Staff which was, in fact, the precursor of the ELDO Technical Directorate.The Administrative Committee, for its part, was required to draw up the diplomatic and legal texts regulating the activities of the Preparatory Group and, later, ELDO itself. It defined the structure of the organisation, and drew up the rules of procedure of the ELDO Council, as well as the ELDO financial

317 Parts 1 and 2 of this chapter are based on M. De Maria, *The History of ELDO. Part 1: 1961-1964,* ESA HSR-10. The remainder is based on original archival research by John Krige. All of the material cited is in the ESA archives based in Florence.

318 ELDO Preparatory Group, First Meeting (11-13 December 1961), ELDO/PG/1ère Réunion, 18 December 1961; ELDO Preparatory Group, *Report by the Technical Committee,* ELDO/PG/13 (Revised), 13 December 1961; ELDO Preparatory Group, ELDO/PG/PV 5, 12 July 1962; *Structure Provisoire jusqu'à mars 1963,* ELDO/PG/A/81, 14 September 1962; ELDO/PG/T(62), 6th Meeting, 29 October 1962; ELDO/PG(63), 21 February 1963.

rules, contracts and security regulations, including a patents protocol, and staff rules, including a protocol on privileges and immunities.[319]

In terms of the ELDO convention each member state was responsible for managing the part of the work on the Initial Programme which was assigned to it. This meant that the Preparatory Group, and ultimately the ELDO Secretariat itself, had very restricted powers of technical and financial control. Both were reduced to coordinating activities in the Member States' industries as best they could. The Preparatory Group was further hampered by its lack of legal personality, which prevented it from being able to make any financial commitments (like the signing of contracts for feasibility or development studies, staff recruitment etc.). All its decisions had to be taken unanimously and the Group relied "on the good will of Member States" to see that they were enforced. Staff were seconded by national governments, but somewhat reluctantly, so that by the end of 1962 only 53 people had been put at the PG's disposal, quite insufficient to guarantee even a minimum functioning of its structures. It also proved extremely difficult to vote its annual budgets. Notwithstanding all these difficulties, considerable progress was made in the period prior to the ratification of the ELDO convention.[320]

At the end of 1963 the launch pad developed by the Australian Department of Supply's Weapons' Research Establishment was ready. Blue Streak reached Woomera for its first full static firings by Christmas that year. The first full live firing was fixed for 25 May 1964. Bad weather delayed the test to 2 June, when there was another disappointment. The rocket's engines were stopped automatically just three seconds before the launch because of a "fault of an obscure nature" in the safety system of both the rocket and the ground installations. Three days, later, however, a "textbook launching" took place. On 5 June 1964, in a flight lasting 10 minutes Blue Streak rose to a height of 170km and a speed of 10,000 kph. Its trajectory was, however, prematurely curtailed six seconds before schedule. As the tanks containing propellants emptied, the remaining fuel began to slosh about. The rocket started rolling, and then cartwheeled spectacularly across the sky before the engines cut out and the rocket crashed into the desert. This setback notwithstanding, the British Minister of Aviation Julian Amory could justifiably claim that "Britain and Australia [could] meet their obligations under the first ELDO programme".[321] Indeed the second launch of Blue Streak, on 20 October 1964, was uneventful, as was the third test firing on 22 March 1965.[322]

Work in France also proceeded steadily. By the end of 1963 some twenty static trials had been made of the individual engines for the second stage, Coralie, at the LRBA's test bench at Vernon, near Paris. All were satisfactory. The French engineers still needed to test the ensemble of four engines together. The first test of the rocket itself was scheduled for spring 1965, and it was hoped to follow this up, during the same year, with two or three launchings with a dummy third stage and a satellite payload designed with the same aerodynamic configuration as foreseen for the whole launcher.

At the start of 1960 West Germany did not, of course, have any military medium or long-range ballistic missile or space programme. It thus started its space activities more or less from scratch and linked them closely with the development of an industrial capability. Up to 1961 the country had no government agency in a position to organise and control space activities in its firms, however. The government thus established a non-profit organisation, the GfW (Gesellschaft für Weltraumforschung) to supervise and administer its participation in ESRO and ELDO on behalf of the Ministry of Atomic Energy, to which responsibility for space matters was initially assigned. During the same year a new German aerospace consortium, ASAT (Arbeitsgemeinschaft Satelliten-trägersystem), was put together out of ERNO Raumfahrttechnik and Bölkow Entwicklungen KG. This organism began work on the third stage of the European rocket in 1961.

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319 See ELDO Council, 1st Session (5-6 May 1964), ELDO/C(64)PV/1, 22 June 1964, p.10.
320 ELDO(1966), pp. 11-13, 29-30.
321 *The Times,* 26/5, 3/6, 6 June 1964.
322 For details on the Blue Streak launches see Morton (1989), pp. 462-4.

At the end of 1962 responsibility for space research in Germany passed to the Space Research Department (SRD) of the newly formed Ministry of Scientific Research. The director of the SRD, Max Mayer insisted that a national programme should be developed in conjunction with the European programme. Germany's contributions to ESRO and ELDO, he said, "cannot be effective without a national programme in similar fields […]. We do not want to make purely financial contributions, but rather to contribute technically […]. What matters in our opinion," Mayer went on, "is to activate German science and technology through effective co-operation in space research in such a way that no one can later say that Germany has been eclipsed by other countries in relevant fields". In line with these sentiments, in 1963 the SRD, along with its engagements in ESRO and ELDO, began planning a national space programme which included the construction of test facilities, recoverable sounding rockets, a space transporter, a multipurpose satellite and a high-energy third stage for an eventual second-generation ELDO launcher. As for the first ELDO rocket, by the end of 1963 German engineers had built a structural dummy of their third stage and the main motor had run successfully in a number of static firings.[323]

Italy was to develop the Satellite Test Vehicle fitted with a variety of sensors to study the performance of its injection into orbit and the characteristics of its orbital test motion. The STV also had to probe the environmental conditions during launch and subsequent dynamic behaviour, data considered crucial to any future user of the rocket. The Italian component also allowed for a number of important experiments related to satellite technology, like satellite tracking, command transmission from the ground, tape recording and playback of measurements in orbit. Contributing firms included FIAT (firings), Aerfer (structure), Montecatini (pulse code modulation telemetry) and Selenia (check-out and telemetry equipment).

Belgium's task in the Initial Programme was the construction of a down range station which was to provide guidance, tracking and control of the third stage by accurate angular and distance measurements with a radio interferometry system. The development of the guidance station, built at the Gove Peninsula, Northern Australia, 1200 miles down range from the Woomera launch site, was assigned to three firms, ACE (Ateliers des Constructions Electriques de Charleroy), Bell Telephone and MBLME (Manufacture Belge des Lampes et de Matériel Electrique).

Finally the Netherlands was to develop an advanced design telemetry system, aimed at following the performance of the third stage and receiving telemetered signals from the satellite. This system, as well as the vehicle borne telemetry and the telemetry station at Woomera were entrusted to the Dutch firm Philips. An independent telemetry station, to be installed at Gove, was also in the hands of this company.[324]

In spite of the difficulties of starting a complex technological project in an international framework, and the weak powers of the ELDO Preparatory Group, we see then that between the signature and ratification of the ELDO convention work proceeded on the development of the launcher, on optimisation and control systems, on the satellite test vehicle, and on the guidance, telemetry and attitude reference systems. In April 1962 a new, and more realistic timescale was drawn up for the Initial Programme, which foresaw its completion by December 1966. Events would show just how optimistic that was.

4.2 The proposed re-orientation of ELDO's programme to meet the needs of telecommunications satellites

The ELDO convention entered into force on 29 February 1964 when five countries contributing 85% of the total financial contributions (Australia, France, Great Britain, the Netherlands and West

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323 Hochmuth (1974), p. 72, Wetmore (1963), pp. 67-77.
324 ELDO(1966), pp. 53-6.

Germany) had ratified it. Belgium followed suit on 2 April 1964, while Italy's signature was ratified on 4 March 1965.

The ELDO Council met for the first time on 5-6 May 1964 and was immediately obliged to reassess the whole situation. The United States was forging ahead with the development of communications satellites. On 10 July 1962 NASA launched Telstar which used ground stations in France (at Pleumeur-Bodou) and Britain (Goonhilly Downs) to transmit live television broadcasts across the Atlantic the very first day it reached orbit.[325] Plans for a telecom satellite in geostationary orbit were well under way.

The need to adapt the ELDO launcher to this new application dominated the opening address of the French minister in charge of scientific research and atomic and space problems, G. Palewsky. He listed the budgetary, technical and commercial issues which the organisation had to confront, problems aggravated by limited resources in which governments "must often solve economical and social problems of primary urgence" and so decide on the "priorities to be established". Palewsky was particularly concerned about the need to define a long-term programme which clarified whether it would be sufficient to modify the existing launcher or whether one needed to make a "more radical transformation" by changing the nature of the stages so as to develop a telecommunications satellite launcher. Finally he wondered whether a new equatorial launching site was needed to increase the useful payloads.[326]

The internal difficulties facing ELDO were also brought home by the British chairman of the Preparatory Group, de Havilland. ELDO's task, he said, was not only technically complicated by its very nature. It was aggravated by the way in which work had been distributed among Member States and by the Secretariat's lack of real powers. The total expenditure in the first three years had increased to 151.7 MAU out of a total ceiling of 196 MAU (=£70 million) initially foreseen for the Initial Programme. Insisting that further delays had to be avoided if costs were to be kept under control, and if ELDO was to have a rocket "within the time limit needed for its commercial exploitation", de Havilland went on to suggest that "if we want the ELDO launcher to be used in the frame of a world telecommunication satellite system, the performances of Europa 1 should be improved […]". The decision on these matters of principle, he suggested, should be left to an intergovernmental conference to be held later that year.[327]

Two matters preoccupied the ELDO Council in the months leading up to this conference: the cost and the re-orientation of the IP. The Secretariat proposed, on the basis of data supplied by the Member States, that the cost of the programme be increased to 329MAU, at April 1964 prices. It also suggested that a substantial contingency margin be allowed for, bringing the total cost of the programme up to some 400MAU, so more than double the figure adopted at the Lancaster House conference. The delegations to the ELDO Council were extremely concerned about the imprecision in these figures and the terms under which the contingency could be used. They ultimately agreed that the basic cost of the IP proposed to the conference of plenipotentiaries should be 339MAU, and that a contingency for technical factors be allowed for. Fearing that this would serve as little more than a pretext for uncontrolled overspending, the Council left the conference to lay down the "main principles" of its use.[328] The main objective of the revised programme was, as we have said, to develop a launcher capable of placing a telecommunications satellite in orbit. The European telecommunications organ, the CETS, let it be known that it hoped to launch experimental telecom satellites of an operational type

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325 Daniel R. Glover, "NASA Experimental Communications Satellites, 1958 - 1995", chapter 6 in Butrica (1997).

326 ELDO Council, 1st Session (5-6 May 1964), Minutes ELDO/C(64)PV/1, 22 June 1964, pp. 3-4.

327 Ibid., pp. 10-15.

328 ELDO Council, 4th Session (7-9 December 1964), ELDO/C(64)PV/4, 13 January 1965, ppp. 3, 6-9. See also *The Estimated Cost to Completion of the ELDO Initial Programme,* Note by Secretariat, ELDO/CG (Jan 65), 18 December 1964.

in 1970-71. CETS was a conference of European states created in 1963 as a forum for the discussion of European interests in the prospective world organisation of satellite communications (Intelsat), initially from the point of view of telecommunications traffic, but also with a view to European participation in the supply of equipment. To enter this field the Secretariat proposed a two-phase programme. In the first, the ELDO A/S launcher would be developed. This was based on ELDO A but had an extra apogee stage powered by a solid propellant motor. To make optimum use of the additional stage it would be necessary to modify Europa 1 slightly, and to include an inertial guidance system to ensure maximum flexibility in the choice of orbits, irrespective of the launching site. The Secretariat proposed that a first orbital launch of this rocket would be possible in 1968, that the programme would be completed a year later, and that its cost would be 50 MAU spread over five years (1965-69).

ELDO A/S was designed to put 110 kg into a polar orbit, and to carry about 40 kg of telecommunications equipment. It did not have a geostationary capability nor could it orbit an operational communications satellite. For this the Secretariat proposed the ELDO B launcher, also to be based on Blue Streak but having one or two high-energy upper stages using liquid oxygen and liquid hydrogen as propellants. More precisely the ELDO/B programme proposed by the Secretariat comprised two models, a two-stage (ELDO B1) and a three stage (ELDO B2) launcher, to be realised successively. To achieve ELDO B1 Blue Streak and the associated ground facilities needed to be modified to accommodate a liquid fuelled second stage having a maximum thrust of six tons, and fitted with the apogee stage developed for ELDO A/S. Completion of the rocket, which was designed to place up to 600kg in a polar orbit, or to orbit quite large geostationary satellites if launched from an equatorial launching site, was scheduled for the early 1970s. Its cost was estimated to be 140 MAU spread over seven years. ELDO B2 was designed to put up to 1000 kg in geostationary orbit. It would be derived from the ELDO B1 system, augmented by another more powerful hydrogen-oxygen stage. ELDO B2 called for significant changes in the Blue Streak first stage. The vehicle loading and first stage control problems were severe. What is more additional development work was required on the B1 high-energy stage and its engine if it was to be suitable as a third stage for B2, for high orbits and for deep space missions. If its development got under way by 1966, the Secretariat estimated that it would be operational by 1972-73 and at a cost of some 100MAU spread over seven years.[329]

Meeting in December 1964 the ELDO Council took a generally favourable approach to these proposals. Of course there were concerns about the reliability of the estimates, which would need to be firmed up on the basis of firmer estimates from the participating states. There was, however, general support for the French proposal, backed by Germany, that both programmes presented "the most desirable orientation" for the development work of ELDO in the period 1965-72. The Council invited the conference of plenipotentiaries to give its opinion on the reconfiguration of ELDO's programmes along these lines, and to indicate an "order of magnitude" of funding acceptable to governments. It also expressed the hope that the high-level meeting would work towards the definition of a European space policy bearing in mind both the needs of ESRO and CETS, and coordinating the activities of these bodies with those of ELDO.[330]

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329 This data from *Proposals for Future Activities of the Organisation,* Note by the Secretariat, ELDO/C(64) 38 rev., 2 December 1964 and *Proposals for Future Development Work of the Organisation,* Note by the Secretariat, ELDO/CG (Jan 65) 1 rev., 15 January 1965. See also ELDO/C(64) 12, 25 June 1964 and ELDO/T(64) 2, 2 September 1964.

330 ELDO Council, 4th Session, (7-9 December 1964), ELDO/C(64)PV/4, 13 January 1965.

4.3 1965/1966 The French and British attempts to reform ELDO

4.3.1 France's suggestion: why not leapfrog straight to ELDO B?

The intergovernmental conference foreseen by the ELDO Council was duly held from 19 to 21 January, 1965.[331] The Council laid before the delegates the revised cost estimates for the Initial Programme for the development of ELDO A, and its suggestions for improving its performance by developing ELDO A/S and ELDO B. This plan was immediately challenged by the French delegation, however. The French accepted that ideally it was preferable to advance to ELDO B through ELDO A and then ELDO A/S with the apogee stage. However, they felt that this programme was too expensive and would unnecessarily delay a useful operational launcher. They proposed instead that the whole of ELDO's activity should be directed at once to ELDO B. Work on the two upper stages of ELDO A was to be stopped, and the firings cancelled after F4. Only those parts of the Initial Programme which contributed directly to ELDO B should be maintained, and the apogee stage programme was to be discontinued. The French delegation insisted that the technical risks engaged in leaping over the intermediate stage of the technology were more than outweighed by the potential savings, and that only in this way could Europe hope to have an advanced launcher adapted to its requirements in the early 1970s.

The conference set up a Working Group under W.H. Stephens to consider these proposals. Its findings were ready two months later. While unanimous in agreeing with the French that ELDO B should be the ultimate objective in the early 1970s, the majority report rejected the French way of achieving this goal as detrimental to the organisation, as having unacceptable technical risks and as of minor financial significance. It proposed an alternative way of making savings which was, however, rejected by the French participants in the Group.

In the view of all representatives but those from Paris, the most drastic effect of the French suggestion would be that most current work would have to be stopped and contracts cancelled. Work would stop on the development of the first stage structure and its associated systems, and on the manufacture of engines. Nothing more would be done on the second or third stages or on the test vehicle and on their components. The result was that there would be a period of comparative inactivity ranging from three to five years in several Member States. Experienced personnel would have to be dismissed. The resulting loss of experience from the ELDO A programme, and the lack of adequate flight testing of the ELDO B engines, as well as adequate testing of inertial guidance, separation techniques and the apogee system would increase the technical risks, delay the programme and increase its cost. Confidence in ELDO would be undermined in government circles, among the remaining personnel and with the general public. Europe's ability to cooperate in space technology would be questioned. And the savings would be minimal. The Working Group estimated that it would cost about 245 MAU to terminate the IP and maintain the minimum infrastructure needed for ELDO B. 80 MAU more would be needed for testing and developing equipment which would otherwise have been produced in the ELDO A and A/S programmes. The total cost of the French proposal, 325 MAU, was thus only 130 MAU below the estimated cost of ELDO and ELDO A/S (455 MAU). And this difference was likely to be whittled away as new teams were recruited and trained for the ELDO B programme, and as schedules slipped due to their lack of experience. This was likely to substantially reduce the estimated maximum saving of 130 MAU.

This did not mean that the only technically and financially meaningful path to ELDO B was through ELDO A and ELDO A/S. The Working Group considered a number of other options. The best, the majority felt, was to build a two-stage launcher which omitted the French second stage Coralie altogether. "A detailed examination showed", said the Group, "that it was more advantageous to eliminate the second stage of ELDO A rather than the third stage because the orbital payload capability of the first and second stage alone is very small and it would be necessary to relocate the guidance and the telemetry equipment in the second stage with consequent problems of redesign."

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[331] For a survey of the meeting see *Report of the Working Group Set up by the Intergovernmental Conference in January 1965,* ELDO/CG(65)WG/13, 23 March 1965.

This solution would produce a rocket slightly superior to the immensely successful American Thor Delta for a net saving of about 50 MAU. It would keep most of the teams intact, and would enable the organisation to build up the requisite experience for ELDO B1 and to test much of the equipment needed for it. Of course, the Working Group noted in its report, this alternative "does not take advantage of the work already carried out on the second stage, and in consequence, 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".[332] The French members of the panel naturally refused to go along with this alternative.

The French initiative failed to win general support at the reconvened intergovernmental conference in April. Those present accepted that it was necessary to maintain the ELDO A programme as a basis for the development of a more powerful launcher. The ELDO Council meeting in December 1965 agreed that the cost of the Initial Programme indeed be increased to 335 MAU (£120 million). The United Kingdom delegation insisted that these commitments should not be entered into, and that expenditure should be limited to essential items pending a re-examination of policy and programmes at Ministerial level foreseen for March 1966. Overruled, the UK let it be known that its agreement to the 1966 budget was conditional on such a re-examination taking place. It was the start of a major reappraisal by Britain of the need for ELDO and of her role in the organisation which she had founded.

4.3.2 Britain's threat to withdraw from ELDO and the concessions made to her

In anticipation of the Ministerial meeting, on 16 February 1966 the United Kingdom circulated an Aide-Mémoire to its partners in ELDO. In it the government expressed grave doubts as to "whether the Organisation now is 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". The British case was amplified by Fred Mulley at the Ministerial meeting which opened in Paris on the afternoon of 26 April 1966.[333]

The British government's argument began by drawing attention to the cost increases in the Initial Programme and the slippage in its time schedule. Of course, said Mulley, it was "one of the facts of life that in the course of large scale development programmes, costs inevitably go up and the time scale is extended". Indeed the UK government had made provision for a contingency of 30% in the initial five-year programme from the inception of the scheme. This estimate had proved far too low. And understandably so. This was the first international development programme of its kind, and one in which three of the partners, Belgium, Germany and the Netherlands, had little or no experience in space activity when the business got under way. Costs had risen and delays had occurred for which no individual Member State could be blamed, said Mulley. But all the same one had to face the scale of the problem: the estimated cost of ELDO A had now more than doubled and it was expected to take seven and a half years rather than the original five. "When costs have increased substantially and there has been a considerable delay," said the British Minister, "we have had to ask ourselves whether the objectives which can still be achieved are worth the required expenditure of our limited resources of money, facilities and scientific effort, or whether it would be more sensible to bring the projects to an end and cut our losses". Nor should one think that European projects were immune to this kind of consideration, Mulley said. On the contrary, he believed that it would do "the cause of European unity a disservice" if they were isolated from the usual assessment applied to national programmes and allowed to "persist in expensive ventures which seem unlikely to prove viable."

The ELDO programme, Mulley went on, risked being just that. The original plan foresaw a launcher able to put 1000kg in circular orbit at 550 km which would also be suitable for ESRO's scientific payloads. However, the expected performance of the upper stages had fallen below expectations and their weight had increased, so diminishing the payload capability of ELDO A. What is more it had now emerged that telecommunications satellites would need to use the geostationary orbit and that

332 The quotations are from the Report just cited, at pp. 4-5.

333 The UK Aide-Mémoire is annex 1 to, while the minutes of the first session of the Ministerial conference are ELDO/CM(Apr. 65)PV/1, 26 April 1965.

ESRO's Large Astronomical Satellite would require a capability of 800 kg in 600-700 km orbit. ELDO A fired from Woomera could not meet either of these requirements. It would need to be fired from an equatorial launch base and upgraded using inertial guidance, adding another £20 million to the cost. All of this to provide ESRO with the two launchers it would need by 1972, launchers which could almost certainly be acquired more cheaply from the United States. Indeed, Mulley pointed out, ELDO A would not be competitive in performance or price with the American Titan IIIC launcher, which would be available in 1967, two years before the expected date of ELDO A's final test launching. As the Aide-Mémoire put it, "Her Majesty's Government accordingly have difficulty in escaping the conclusion that, even if present estimates are fulfilled, ELDO will produce in 1969 a vehicle which will be obsolescent and non-competitive in cost and performance with launchers produced by the United States".

Then of course there was ELDO B in its different variants. The increased capability was needed if Europe was to acquire independent access to the geostationary orbit. However, if developed, and making allowance for a 40% contingency, the cost of the programme would rise to £365 million or 1,022 MAU, said Mulley. Surveying the potential market for this launcher he was convinced that it would make far greater economic sense to rely on American launchers or to have European industry participate in consortia with American firms. Other arguments for continuing, like the acquisition of technological know-how, or the development of a European "capability" in space could be made, Mulley agreed, but insisted that they were of secondary importance. Summing up the British Minister repeated that the UK "doubted whether it was worthwhile going on with the ELDO Initial Programme or embarking on future programmes at much greater cost", though he did add that his government was willing to listen to the points of view of her partners "very carefully" before deciding what to do.

It is important not to lose sight of why the British adopted this position. Mulley's economically inspired cost-benefit analysis cannot simply be reduced to a narrow commercial logic. It was rather an immediate consequence of the uneven development of rocketry in the collaborating partners and its impact on the ELDO A programme. As Mulley pointed out to his colleagues, before the foundation of ELDO Britain had already spent about £87 million on the development of Blue Streak, of which about £65 million was relevant and necessary for the purposes of the ELDO. Of the £80 million subsequently spent on the organisation, £31 million had been contributed by the UK government. Thus Britain had spent almost £100 million on the development of the first stage already — double what all her partners together had spent on ELDO to date.[334] And with tangible results. The year before, in June, Blue Streak had been successfully commissioned. This meant that she could now develop a national heavy launcher of her own if she wanted to by combining Blue Streak with Black Knight, as the Minister responsible at the time, Julian Amory, was quick to point out.[335] But instead of doing so — though Mulley did not say this openly — she was financing a project whose original technological and political justification had evaporated, particularly after de Gaulle had vetoed the UK's application to join the Common Market in 1963. And she was financing it to the tune of almost 40%, most of which would now to be used to develop the French and German stages of the rocket. It was a difficult pill to swallow.

All the Ministers shared Britain's concerns about the rising costs and delays in the ELDO programme. All of them insisted, though, that this was only to be expected, granted the imprecise data used to estimate the cost of the Initial Programme, the lack of experience in the space sector in many countries, and the organisational novelty of the project. And no one was prepared to see the demise of ELDO. Reform not abolition was needed. Thus it was generally agreed that the powers of the ELDO Secretariat had to be strengthened, and that any additional programme should be carefully costed and controlled. More fundamentally, though the question of ELDO's existence and its future was seen by Britain's partners as one of policy and politics, not as one of immediate economic returns or of commercial viability.

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334 Minutes of the 4th meeting of the Ministerial Conference held on 28 April 1998, ELDO/CM(Apr.66)PV/4, 28 April 1966.

335 *The Times,* 6 June 1964.

Behind this determination lay the commercial and cultural importance of the telecommunications market. On 6 April 1965 the US launched the Early Bird satellite. Commercial service began on 1 June. Its 240 voice-channel capacity almost equalled the 317 channel capacity of all existing Atlantic telephone cables, and it cost much less. Of these 240 channels AT & T wanted to use 100; Canada, Britain, France and West Germany were also anxious to participate.[336]

It was obvious to Britain's partners that a European capability in this sector was imperative. They identified technological independence with national sovereignty and global power and would readily subscribe to NASA's claim made to the Congressional budget hearings in 1965 that "[…] knowledge, more than guns or butter, is the true power of modern states, and the technological balance of power is increasingly the major concern of the leaders of both weak and strong nations".[337] The delegates recognised that Europe started way behind the Superpowers and could not hope to compete with the United States or the Soviet Union. But nor was that the prime objective in establishing ELDO. What we are trying to do, said German Minister Stoltenberg, is not simply to develop a launcher, but to enable Europe to carry out space missions "out of its own resources, on the basis of its own knowledge and experience, at its own discretion, [and] for specifically European motives and requirements."

There were two aspects to this demand for autonomy. On the one hand there was the reluctance to rely on others to satisfy Europe's needs in the scientific or application satellites areas. To do so, said Stoltenberg, "would be tantamount to conceding to the supplier country from the outset a scientific, technological and economic monopoly". The effects of this were difficult to foresee, but potentially very damaging. As the Secretariat pointed out in its submission, the heavy demands made by the US programme on its launchers meant that there was no guarantee that NASA could launch European satellites at the appropriate time; already the American space agency had said that it could not ensure that its tracking services would be available on demand for the ELDO and ESRO programmes. Then of course there was the risk that when commercial systems like telecommunications were involved "the economic interests of the supplier country and Europe [would] cut across one another or fail [..] to coincide" (Stoltenberg), with negative consequences for Europe.

The reluctance of the Ministers to be hostage to US programme schedules and economic interests was coupled with the conviction that if they had their own, autonomous programme they could collaborate on better terms with the United States. What was wanted, said The Hague in its reply to the British Aide-Mémoire, was "equitable Atlantic cooperation", a "two-way traffic in know-how" as Brussels put it. Only in this way could "technological cooperation with the United States […] be economically as well as politically advantageous." The Belgian Minister of Foreign Affairs, Pierre Harmel, hammered the point home.[338] The European science ministers meeting in January 1966 under the auspices of the OECD, he said, were concerned by the "technological imbalance" between Europe and the US. They were convinced that a "dialogue with the United States would only again become fully fruitful when Europe had reduced its lag and so strengthened its partner's willingness to cooperate. […] How can we prove to the Americans that we should be worthwhile partners if by ourselves we have never achieved anything of significance?", he asked rhetorically. And he gave a concrete example of the implications of dependence. When in 1964 the Europeans had asked to be admitted as equal partners with equal rights to Intelsat, the US "took the view that there could be no possibility of discussing on equal footing with a partner who had nothing to add to their programmes." We need "an autonomous capability for launching spacecraft", Harmel concluded so as to have some control over the management of the world telephone and television satellite systems.

336 David J. Whalen, "Billion Dollar Technology: A Short Historical Overview of the Origins of Communications Satellite Technology, 1945 - 1965", chapter 9 in Butrica (1997).

337 Quoted in the ELDO Secretariat's response to the UK Aide-Mémoire, Annex II to ELDO/CM(Apr.66)5, p. 3.

338 For Harmel's contribution see ELDO/CM(Apr. 66)PV/2, Annex I, 27 April 1966.

Space policy was not simply a question of international policy though, but also of industrial policy. No one believed that there were direct ‘spin-offs’ from space. But many stressed the stimuli which advanced aerospace technologies provided to firms in key sectors, notably electronics, automation and special metallurgy. If Europe withdrew from space these benefits would be lost, and the technological gap widened even further.[339]

Space policy was also linked to European policy. Britain’s partners welcomed her participation and valued her role in European technological collaboration, and saw it as a way of strengthening her ties to the Common Market. As the Belgian government put it in its Aide-Mémoire, it “sets the highest value on maintaining and developing the technological collaboration that has brought together the United Kingdom and the countries of the European Economic Community in the space sector, and in so doing established a principle of far wider significance”. The point was elaborated by Foreign Minister Harmel. Science policies, he said, were becoming part and parcel of national and international economic policies in Europe. If Britain now loosened the ties binding it to the Six in ELDO its move “would inflict a serious blow on the efforts of those who are trying to achieve a wider union in Europe”. In short Britain’s willingness to collaborate technologically with her partners across the Channel was an important bargaining chip for those, including Belgium, who wanted to overcome French opposition to her membership of the EEC.

In the light of these considerations Mulley’s fellow ministers made it clear that it was essential in their view to keep ELDO in being. It made no economic sense to stop now, said Italian Minister Rubinacci. Many Member States had already invested heavily in the Initial Programme, industries had enlarged and modernised their facilities, and the suppression of ELDO A at this stage of its development was likely to cost as much as its completion.[340] There were political considerations to bear in mind too. As the German Aide-Mémoire put it, if ELDO was abandoned without achieving a tangible result, it would, “especially in the United States, result in a considerable loss of confidence in Europe’s technological potential, besides impairing Europe’s political image in general. Once cooperation within ELDO had been discontinued”, the document went on, “it could hardly be taken up again for similar purposes, and this would inevitably have damaging effects on European collaboration in other fields too”. In short, as the French Minister put it rather dramatically, “Verily, there is no more time for shilly-shallying and half-measures: we have our backs to the wall; we are condemned to agree, in other words, to succeed”.[341]

That granted it was clear that some basic policy decisions were needed. The Italians took the lead in insisting on the need for a coherent and integrated space policy. This would imply the use of ELDO launchers by ESRO and by CETS. It would imply the coordination of national policies with respect to these European organisations with, for example, the heads of delegations being the same in all three. It might also involve setting up a single organisation, though it was recognised that to integrate all activities into one body was a rather remote possibility at the time. One thing though that was stressed was that any such single body would need to be flexible, and that “not all Member States would need or wish to participate in all programmes” (Rubinacci). Indeed the Italian delegation even went as far as to propose a draft convention for such an organisation along these lines.[342]

Coming back to Britain, it is clear that her partners meeting in Paris recognised that her fears were well-grounded, and were most reluctant to see her withdraw from ELDO. A compromise had to be found. Indeed on the very first day the German Minister Stoltenberg made it clear that if a country did

339 See the Aide-Mémoires by the German, Belgian and Dutch governments, Annexes III, IV and VI to ELDO/CM(Apr 65)5.

340 In the minutes of the first meeting held on 26 April 1966, ELDO/CM(Apr. 66)PV/1, 26 April 1966, p. 14.

341 See the statement by the French representative, ELDO/CM(Apr 66)PV/2, Annex II.

342 The Italian position is in the Minutes of the meeting on the first day, ELDO/CM(Apr. 66)PV/1, 26 April 1966, and in their Aide Mémoires, ELDO/CM(Apr. 66)5, Annex V and ELDO/CM(Apr. 66)11, 22 April 1966. For support for the Italian position see, for example, the French reaction, ELDO/CM(Apr. 66)9, Annex III. The Italian draft convention is document ELDO/CM(Apr. 66)WP/5, 26 April 1966.

not want to carry on with the whole programme its wishes should be accommodated. His Dutch counterpart, Plate, conceded that "the United Kingdom's scale of contributions was large in relation to the initial programme and this would have to be reconsidered for future programmes".[343] Faced with this goodwill, and immense political pressure, the British could not but reconsider their position. And indeed Mulley's' speech on the last day, while maintaining a hard line by threatening to leave ELDO, also accepted to consider contributing to an improvement of the ELDO A rocket by the addition of apogee and perigee motors. But, he said, this had to be considered a new programme, i.e. the UK's financial contribution had to be reassessed. One point was made clear though: "to avoid any misunderstanding", said the Minister, "in any event my Government will not feel able to support the ELDO B programme or to agree to undertake any commitments in respect of them".[344]

While most delegations were keen to find a compromise with the British, the French took a harder line.[345] London may have made sacrifices for ELDO but so had Paris, said their representative. After to all it was thanks to de Gaulle that the Macmillan government was able to recycle Blue Streak as a satellite launcher. And if that decision was taken it was because France believed in the European programme, and believed in it enough "that she rejected at that time the possibility open to her of building her own national launcher". She was less certain now that the sacrifices were worth it, and she was sorely "tempted to go it alone with our national resources". Instead she was willing to take a new step forward in the ELDO framework. In particular she would consider buying two ELDO A launchers. But under certain conditions. Firstly, the participating states had to jointly enter into a delivery commitment, backed by well-defined penalty clauses for any defaulter. Secondly,. the new civilian equatorial launching base being developed at Kourou in French Guyana had to be used for the operational launches of the European rocket, Woomera's role being restricted to trials. This latter arrangement, said the French representative, was a "sine qua non" of France's continued commitment to ELDO.

The French attitude was doubtless deliberately intended to embarrass the British. The willingness to buy two launchers was an attempt to show the UK that there were users for the launcher. Tying that offer to the demand for a delivery commitment, however, forced London to face the consequences of its arguments. What the French wanted were "adequate guarantees that the common efforts deployed to date cannot be brought to naught by the failure of any one of us". This meant, the delegate went on, that the "obligations of each supplier would not lapse upon completion of that part of the programme with which he has been charged, but would continue for the greater benefit of the whole community". In short what the French were trying to do was to make the UK stand by her Continental partners, participating in all the ELDO programmes.

The insistence on the use of Guyana similarly put the British in a difficult position, this time with respect to their Commonwealth partner, Australia. Indeed the April 1966 conference had before it three offers for a new equatorial launch base, the Italian San Marco platform, which was to be anchored off the Seychelles, the new French base in Guyana, and Darwin in North Australia. And during the meeting the French did all they could to discredit the last. On the second afternoon of the conference, for example, an enraged Senator Henty remarked that the "French Delegation has seen fit to distribute this morning what claims to be a comparative study between the Australian and French proposals". This "so-called comparative document", the Australian Senator went on, "should not necessarily be accepted on its face value". "Better climate, better communications, better amenities […]" were just some of the factors in Australia's favour, he said, asking that the three proposals be considered together under conditions "conducive to sensible and practical conclusions".[346] But Paris had already made up its mind, Guyana was a sine qua non of her ongoing participation, and her partners, including Britain, would have to do what they could to pacify an Australia which was to be sacrificed in the interests of keeping France in ELDO.

343 ELDO/CM(Apr. 66) PV/1, 26 April 1966, pp. 12, 13.
344 ELDO/CM(Apr. 66) PV/4, 28 April 1966.
345 The French representative's statement is ELDO/CM(Apr. 66)PV/2, Annex II, 27 April 1966.
346 For Australian wrath see ELDO/CM(Apr. 66)PV/3, 27 April 1966.

The conference in April ended after an important exchange of views but without taking clear decisions. These were foreseen for a reconvened meeting scheduled for the 9 June.[347] A week before, on 3 June the British government circulated another Aide Mémoire which effectively re-iterated Britain's position and cast a pall of gloom over her partners. "The latest proposals" the document said, still did not "constitute a sufficient basis for continuing United Kingdom participation in ELDO". Her Majesty's Government had thus decided that "they cannot agree to participate in development of the apogee/perigee system", and that they "cannot continue to share in the financing of the ELDO Initial Programme beyond the extent to which they are already committed".[348]

The immediate result of the British initiative was a manifest hardening of attitudes among her partners. It was pointed out to Britain that she was legally obliged, in terms of the ELDO convention, to complete any programme which had been started. More fundamentally, though, it was stressed by the Dutch and the Italians that the United Kingdom had a "moral" responsibility to stay in ELDO. Both remarked that their governments had been initially very reluctant to join ELDO, but had been satisfied by the assurances and explanations given by Her Majesty's Government in the months after the Lancaster House conference. Now, said the Dutch delegate, ELDO "seemed in danger of being torpedoed by that same government". The "bitter disappointment" felt by The Hague, "who had always been a champion of the most extensive co-operation in Europe, including the United Kingdom" led Plate to go further. Britain, he stressed, was contemplating withdrawal now that its own launcher had been fully developed. It had reaped the full benefits from the Initial Programme, a programme from which The Netherlands had benefited very little to date. "By withdrawing now", Plate insisted, "the United Kingdom would not be giving her partners a reasonable deal".[349]

This was indeed an inopportune moment to withdraw. On 24 May 1966, just ten days before the UK circulated its Aide Mémoire, the F4 firing of Europa 1 took place at Woomera. It was the first time the entire rocket had been launched, with dummy second and third stages. Though the flight was aborted, probably unnecessarily, a little after two minutes, the relative success was most encouraging. Under these circumstances the Dutch accusations that Britain was "torpedoing" a potentially successful venture hit hard, and Mulley did not totally close the door to a compromise. In two restricted sessions the Ministers concentrated on ways to reduce Britain's percentage contribution to ELDO, and to come up with a preliminary redistribution of the financial load to submit to their cabinets. They agreed to meet again a month later to ratify this arrangement, to settle the question of the equatorial launch site, and to agree on measures for better financial control of ELDO's programme.[350]

4.4 The reform of ELDO and the pleas to coordinate the space effort

The ELDO Ministerial conference reconvened for the third and last time on 7 and 8 July, 1966. A number of extremely important decisions were taken, and were expressed in two major resolutions, one concerning ELDO's programmes and activities, the other concerning the co-ordination of European space activities.[351] The most important result of these negotiations was that the United Kingdom dropped its threat to withdraw and agreed to participate in the funding of both ELDO A and its upgrade. As a press release issued after the conference put it, all the Member States had agreed to undertake, as from 1 January 1967, a "reorientation" of the Initial Programme as well as

347 The Conference resolution is ELDO/CM(APR 66)17, 28 April 1966.

348 The Aide Mémoire is ELDO/CM(June 66) 12, 3 June 1966.

349 See the Minutes of the first meeting of the resumed Ministerial Conference, ELDO/CM(June 66)PV/1, 9 June 1966.

350 The minutes of these meetings are ELDO/CM(June 66)PV/2, 15 June 1966 and ELDO/CM(June 66) PV/3, 16 June 1966. The Confidential Resolution taken is ELDO/CM(June 66) 16, 10 June 1966.

351 The minutes of these meetings are ELDO/CM(July 66)PV/1 and PV/2 for the 7 July 1966, PV/3 and PV/4 for the 8 July 1966. The resolutions passed are documents ELDO/CM(July 66)16 and 17, 8 July 1966. Their contents are summarised in a Press Release, ELDO/CM(July 66)18, 8 July 1966.

"a supplementary programme" involving the development of ELDO A fitted with a perigee/apogee system (PAS) able to put 150 kg in a geostationary orbit, of inertial guidance and of an equatorial launch base. Two major concessions were made to Britain in return for this act of solidarity. Firstly, the scale of contributions was reorganised in her favour (see Table 4-1), Italy only accepting her increased burden on condition that she was given prime responsibility for the apogee stage. Secondly, to ensure better financial control over the programme, global and annual ceilings for 1967 to 1971 were imposed on the programme. The overall ceiling for expenditure from 1967 onwards was set at 331 MAU, which brought the total cost of the programme to 626 MAU. This was about £225 million or three times the original estimate made at Lancaster House in 1961. In an attempt to ensure suitable returns to the participants, the Ministers also agreed that each partner should receive industrial work corresponding to not less than 80% of its financial contribution.

Table 4-1. Redistribution of the ELDO financial load between its Member States agreed at the ELDO Ministerial Conference in July 1966

Country	Original %	% as from 1/67
FR Germany	22.01%	27%
France	23.93%	25%
Italy	9.78%	12%
U Kingdom	38.79%	27%
Belgium	2.85%	9% shared between B and NL
Netherlands	2.64%	
Australia	…	…

The decision to adopt Kourou as the European equatorial launch base was also confirmed. Italy was relatively reconciled to the rejection of its offer of the San Marco platform. The Australians, by contrast were extremely angry about the refusal to use Darwin. They went out of their way to make the offer technically and financially attractive and felt that they were not given a fair hearing. In June they made what the Secretariat deemed "a very fierce, somewhat bitter and […] unfair criticism" of its presentation of the three candidates, believing that the arguments against Darwin were biased. In July Senator Henty accepted the loss with dignity after a "most exhaustive and interesting discussion".[352] France, for its part, accepted prime responsibility for the construction of the base in Guyana, guaranteed free access to it, and proposed that the ELDO states contribute 25 MAU inclusive of contingencies to setting it up.[353] Woomera, as we mentioned earlier, would remain in use for development rather than operational launchings.

Britain's argument that there was no market for ELDO A, and its attempt to withdraw on those grounds, boomeranged. With France having agreed to buy two ELDO As and its insistence that there was an important market for ELDO's rockets, the Ministers agreed that from henceforth the organisation should not only develop and construct "prototype" launchers, but should also produce "ready-for-use vehicles and launch [..] them on behalf of users". This went along with a demand that ELDO's programme management methods and its organisation be reviewed and perfected. Of course measures were also taken to discourage a producer state from withdrawing and, in any event, to ensure that it continued to make available the facilities needed to build its part of the rocket. Britain thus found herself trapped into an ongoing commitment to build Blue Streak and to play a role in ELDO despite her doubts and hesitations about its viability. The Ministers were now also quite emphatic that steps had to be taken to coordinate the European space effort. The Belgian Prime Minister himself attended the meeting to draw attention to the importance he attached to this matter. He stressed

352 ELDO/CM(July 66)PV/2, 7 July 1966 for the quote by Henty and Annex II for the Secretariat's complaint.

353 There was an extremely unpleasant exchange six months later when the French delegation insisted that this figure did not include contingencies related to changes in economic conditions, ELDO/CM(December 66) PV/1, 14 December 1966.

the lack of coordination. The ELDO PAS launcher was being developed "without knowing whether a European communications satellite will be built and whether we [i.e. Belgium] will have a share in its construction". He pointed to the unnecessary duplication of work. Vital components of the experimental satellite designed to test the perigee/apogee system would not be reusable for a telecommunications satellite. ELDO and ESRO were building independent tracking stations. He remarked how difficult it was to distribute industrial contracts equitably between the partners when one had three independent instead of one overall space programme. And he made it clear that Belgium was not prepared to enter into further important financial commitments until the European space effort was put on to a rational, coordinated basis.[354] The Ministers meeting in July 1966 recognised that it would be difficult to set up a single European space organisation immediately. Instead they decided, first, that their conference, as then constituted, should take steps to transform itself into a standing body meeting at least once a year, and open to representatives from ESRO and CETS in particular. They also decided to establish a Committee of Alternates who would prepare their meetings and make recommendations to them for a coordinated space programme. The Alternates would be advised by a Study Committee whose task it would be to "examine the problem of amalgamating the existing European space institutions". The Ministers meeting in July also proposed that the Councils of ESRO, ELDO and CETS should set up a Coordinating Committee with representatives from each. It would meet at least every three months and its aim would be the "immediate coordination of the functioning of the three bodies […]".[355] To give effect to this resolution, the Ministers decided to meet again on 13 and 14 December 1966. The first steps along the path to the re-orientation of ELDO and the coordination of European space activities had been taken.

4.5 1966/1967: The European Space Conferences and the moves to coordinate programmes

The December Ministerial conference got under way in a buoyant atmosphere. One month before, on 15 November 1966, the fifth launch of Europa I with two dummy upper stages had been a complete success and plans were under way to commence the F6 firings with a live Coralie. The ELDO Secretary General confirmed that the powers of control of the Secretariat had been strengthened by appointing Project Management Directors for the ELDO A and ELDO PAS (i.e. Europa 1 and Europa 2) programmes. An international Industrial Integrating Group, as independent as possible of particular national and industrial interests was being constituted to watch over the implementation of the supplementary programme.[356] And there seemed a genuine willingness to coordinate activities. In fact the meeting on 13 December 1966 was attended by representatives of all the Member States of ELDO and ESRO, and 97.4% of the Member States (by percentage contribution of course) of CETS. The first day of the meeting thus inaugurated the European Space Conference. The second day was restricted to a meeting of the Ministers of the ELDO Member States.

The most important decision taken by the Ministers, on the initiative of the Belgian Prime Minister, was to set up an ad hoc group "to make a detailed inventory of the programmes, both international and national with full details, technical and financial", "and the policy behind them […]". All the Member States were to collaborate fully with this group, which was to put forward "broad proposals for a programme and the means to assure real co-ordination and integration". This idea was warmly received. Max Mayer from Germany, for example, agreed that national programmes, "had not been harmonised. There was a danger of parallel work and overlapping," he said, and it was necessary "to create a truly co-ordinated activity" in Europe. French Minister Peyrefitte was similarly positive. "It was essential to introduce homogeneity", he said, and "coherence into programmes having a certain tendency to expand each along its own lines without regard for the others. […] hence the need for jointly prepared and coordinated projects". A resolution calling for the stocktaking of programmes was

354 ELDO/CM(July 66)PV/2, Annex I, 7 July 1966.
355 The Resolution, we repeat, is ELDO/CM(July 66)17, 8 July 1966.
356 The Secretary General's report is ELDO/CM(Dec. 66)4, 6 December 1966.

thus duly passed by the European Space Conference on 13 December and confirmed by the ELDO Ministers the next day. Michel Bignier was asked to head the ad hoc group, and invited to submit his report in time for the next Ministerial meeting six months hence.[357]

Two sources of conflict were simmering just beneath these fine sentiments. Firstly, there was the balance to be struck between scientific research and applications within the coordinated European space effort. And things were looking bad for science. French Minister Peyrefitte was emphatic that space activities were important to his country by virtue of their “technological interest […] and by reason of their practical utility”. “Research must go on”, said Peyrefitte, “but the governments were forced to conclude that research was not the only interest possible, and they could not content themselves with that alone: as soon as an application emerged its use must be envisaged. The scientists must not be offended by this […]”, he added, in an attempt to reassure them.[358] But the debates then under way in ESRO gave one a foretaste of what this might mean. For the ESRO Executive and the scientific community, already struggling to develop a viable programme with restricted resources, had been dismayed to find that their Council refused to allow them to carry over 122 MFF of monies unspent between 1964 and 1966 and, in December 1966, and had refused to vote the ceiling of expenditure for the next three years. This was left to the ESRO Ministerial conference also scheduled for July 1967.[359] The second source of conflict was that of overlap between national and European programmes. On the one hand, the CETS was planning a communications programme at the European level. As A.E.K. Hartogh, the President of the CETS-Conference explained to Ministers, three months before their Technical Planning Staff had suggested the development of a series of communications satellites, which would include a television distribution satellite geared to European conditions and to be launched by Europa 2. A draft agreement had been drawn up with ESRO who was requested, in consultation with ELDO, to carry out a detailed study of a European experimental telecommunications satellite programme.[360]

In parallel, and notwithstanding their expressed wish for coordination and the avoidance of duplication, France, Germany and Italy all also wanted to develop a communications satellite of their own. France wanted one to meet the need for links with the francophone parts of Africa. Germany was developing a satellite for television transmissions from the Olympic Games scheduled in Munich in 1962. And Italy was insisting that the test satellite it was developing for the ELDO launcher should be able to “carry out communication functions”, and should be able to provide data for the ESRO/CETS studies on a European satellite. It was this situation that had led the Belgian Prime Minister to attend the meeting personally and to demand co-ordination, expressing the “hope that it would be possible to achieve a single communication satellite programme”. He was assured by France that there was “no incompatibility” between the French national satellite and the CETS satellite. He was told by Germany that “the fact of common activity did not exclude national programmes, equally the existence of national programmes in no way meant a lack of loyalty to the international programmes”. Italy argued that its aim was simply to ensure that “the technical content and possibilities of the European satellite [were] not sacrificed”. Faced with this determination the Belgian Prime Minister could not but agree, if only reluctantly, “that independence must be allowed to exist within European interdependence”, leaving the subject to be pursued further “on a later occasion”.[361] But the writing was on the wall.

When the Ministers next met in Rome from 11 to 13 July they took further steps towards coordinating the European space effort. The report of the Bignier ad hoc group was presented to them. It identified a number of gaps in the European programme. There was, for example, no launcher foreseen to put a

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357 The minutes of the first European Space Conference are CSE/CM(Dec. 66)PV 1, 13 December 1966, the two Resolutions are CSE/CM(Dec. 66)5, 13 December 1966 and ELDO/CM (Dec. 66)6, 14 December 1966

358 In CSE/CM(Dec. 66)PV 1, 13 December 1966.

359 See Krige and Russo (1994) chapter 4.

360 See the remarks in CSE/CM(Dec. 66)PV 1, 13 December 1966.

361 The debate is Item 4 in ELDO/CM(December 66)PV/1, 14 December 1966.

heavy payload for direct TV broadcasting in geostationary orbit, little progress had been made in the field of applications, and very little had been done in the area of component reliability, which was an essential requirement of the whole field of space technology. To overcome these deficiencies in the short term, the Bignier panel suggested that studies to improve or develop new launchers be undertaken, that all communications satellite programmes, including their ground station needs, be "carefully co-ordinated", and that special attention be given to an applied research programme for scientific and application satellites. Most fundamentally though the ad hoc group insisted that the European space effort lacked a long-term space plan and that the resources devoted to it were far too limited in comparison with what was spent by the Superpowers. They suggested that the Ministers thus consider a ten-year programme based on a main theme, e.g. the realisation of a direct television broadcasting satellite capability including a related applied research programme. They also proposed that the participating governments consider doubling their annual contributions to the space field from its then current level of 0.05% of the European GNP to 0.1% of the GNP (or about $600 million) by 1970.[362] To implement these proposals the Ministerial Conference set up a new Advisory Committee on Programmes. Its Chairman was J. P. Causse, who was the Director of France's Bretigny Space Centre at the time. The committee was to include economic and financial experts nominated by the Member States. Its task was to frame proposals and to establish priorities for a European space policy with special reference to the building of improved communications satellites and the elaboration of a "meaningful scientific programme concentrated on activities few in number but opening up new prospects in the research area". It was to come up with suggestions for a "balanced and co-ordinated programme", whose financial implications and economic impact were to be assessed. This was to be presented to the next meeting of Ministers to be held in Bonn in 1968. Here the Ministers hoped to use it to define the "medium and long term objectives of European space policy".[363]

The Ministers also took the necessary measures to formally stabilise their existence and to bestow their decisions with executive authority. They resolved that the European Space Conference would become a permanent body meeting at Ministerial level at least once a year, and open to all Member States of ESRO, ELDO and CETS. Its task would be "to elaborate a coordinated European space policy and supervise its execution". Decisions were to be taken unanimously and were to be binding on all participating governments. The Committee of Alternates would prepare the meetings of the ESC and the secretariat would be provided by the Coordinating Committee of the three space organisations.[364]

Notwithstanding the steps taken towards a coordinated space effort, difficulties persisted in all sectors, science, applications and launchers. Much to its disappointment, and in spite of pleas by the German and British delegations, ESRO's three-year ceiling was not voted, and it was not authorised to carry over the unspent money from the previous triennial exercise. As for applications, the paralysing effects of duplication in the key field of telecommunications were beginning to be felt. On 6 June 1967, a month before the conference, France and Germany had formally agreed to halt their independent communications satellites programmes and to build together Symphonie. This immediately impacted on the CETS plans. The day before, on 5 June, CETS had received ESRO's detailed proposals for a possible European satellite for television distribution. It had also received the results of a report by the European PTTs on the economic viability of European telecommunications satellites. It seemed clear to CETS President Hartogh that, in the light of these reports and events, a European programme now had to overcome a number of new hurdles. This was, firstly, for financial reasons. The economic study had indicated that "European communications satellites for telephony and telegraphy alone would not be conomically viable at present", while for television distribution "they are likely to become

362 For the Bignier report see CSE/CM(July 67)5, and CSE/CM(July 1967)16, 7 July 1967.

363 On the Causse Committee see CSE/CM(July 67)14, 13 July 1967, CSE/CM(July 67)13, Resolution No. 4, 13 July 1967, and the Press Release emitted after the conference, CSE/CM(July 67), 22 (rev.1), 13 July 1967.

364 See Resolution no 4, CSE/CM(July 67)13(Final), 13 July 1967.

profitable by the period 1970-1980". The dampening effects of this conclusion were reinforced by the "anxiety of some member countries to ensure that there shall be no duplication between the joint project and other projects, in particular the 'Symphonie' project". As a result CETS was likely to support a programme involving only one, and not two satellite models, as the ESRO study had proposed. It would also need to consider carefully the precise specification of the satellite to avoid duplication and to make the best possible allowance for all countries to participate in its technological development.[365]

The hesitations now plaguing the CETS distressed some of the delegations to the Rome Ministerial conference. It was becoming clear that, technically and politically, the joint European communications satellite risked being sabotaged by the centrifugal pull of national interests. The head of the Belgian delegation, J. Spaey was quite explicit about this. "We wish to state quite clearly", he said, "that our preference is for ESRO to carry through without delay the programme presented by CETS with the three principal European countries participating in all phases of the programme." Going on to remark that the design of Symphonie was very similar to the first phase of the CETS programme (CETS-A), he wanted to be "very clearly informed" as to whether France and Germany were "willing to commit themselves financially and industrially to the execution of the entire CETS programme in a framework of European co-operation concurrently with their bilateral programme […]". His fear was that Symphonie would replace CETS-A, which would not only delay decisions on the complete programme, but would also practically exclude a country like Belgium "from the very important first stage of development of application families, which would place their industry at a disadvantage for subsequent participation".[366]

Belgium's demands made little impact. German Minister Stoltenberg insisted that there was no need for the CETS to postpone its decisions until national or bilateral projects had been defined. He hoped rather that CETS would take the initiative and conclude its studies, so that other projects could be "harmonised" with it. The Italians, on the other hand, were less discrete and seemed ready to jettison the CETS programme altogether. Senator Rubinacci went on record as stating that his country was interested in contributing to a joint programme "either through some form of participation in the German/French bilateral programme or, which they would prefer, by further development of the PAS satellite, which they were preparing for ELDO, and which could be improved to become the European telecommunications satellite". His statement was subsequently amended and all reference to direct participation in the Symphonie project was removed.[367] But the implication was clear: France, Germany and Italy were not going to wait for the CETS to define jointly a European communications satellite; the commercial stakes were too high for them to delay any longer — or for their industries to remain spectators while the requisite technologies were developed across the Atlantic.

The launcher programme, for its part, was moving to a new crisis. Firstly, it had suffered another political setback. After a major Cabinet meeting on 2 May 1967 Prime Minister Harold Wilson announced that the British Labour government would apply for full membership of the European Community. On the 10 May the House of Commons endorsed this decision by an overwhelming majority of 488 votes to 62. A week later the whole project shuddered to a halt. On 16 May General de Gaulle vetoed the British application, announcing that the UK was not yet ready to join the Six.[368] To this political blow would soon be added a major technical setback. A few weeks after the Rome conference, on 4 August 1967, firing F6/1 of Europa I took place with live first and second stages and a dummy third stage. Coralie's engines failed to ignite after separation. F6/2 four months later was also a failure. This time Coralie failed to separate altogether from Blue Streak.[369] 1968 was to be dramatic year for the European space effort.

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365 Hartogh's report is CSE/CM(July 67)8, 6 July 1967.
366 CSE/CM(July 67)PV/2, Annex I, 11 July 1967.
367 CSE/CM(July 67)PV/2, 11 July 1967, and PV/2 add.2, Request for amendment, 27 December 1967 and PV/3, 12 July 1967.
368 Sked and Cook (1980), pp. 267-8.
369 Carlier and Gilli (1994), p. 109 and Morton (1989), p. 471.

Chapter 5: Implementing ESRO's First Scientific Programme

A. Russo

The scientists who, in 1959-60, set up the first initiatives to create a European organisation for space research had in mind the model of CERN. This was an example of a successful multinational organisation of European countries dedicated to fundamental research in a field of science (high energy elementary particle physics) where real progress could only be realised by big and expensive technical equipment (large particle accelerators and detectors) that no individual country could build by itself. Space research, however, is quite different from particle physics and if the CERN model could still provide evidence that European cooperation in a highly sophisticated scientific and technological domain could actually work, the institutional framework and the programme of the new organisation were to be significantly different. A rapid discussion of the main differences between these two examples of contemporary "big science" is useful to highlight the most significant aspects of the story we are about to tell in this chapter.

The first difference lies in the organisation of the research work. In the case of particle physics, this is arranged around a large accelerator and supported by the facilities of a large laboratory. The laboratory and its "big machine" represent an intrinsic, stable and permanent component of the research organisation, which sees different research groups sharing these facilities and alternating in performing experiments. Space research, on the contrary, is conducted by means of scientific instrumentation carried on board rockets or satellites and eventually destined to be lost with the spacecraft. Space missions can be more or less sophisticated and long lasting, from a simple sounding rocket to a complex space telescope, but each of them represents a definite and self-consistent element, involving at one and the same time the definition of a scientific aim, the building of the technical hardware, and the setting up of a specific managerial framework to link together scientific groups, technical teams, industrial firms, launching facilities, tracking and data handling facilities.

The second main difference between particle physics and space science regards their content. The former is a well defined research field, whose objectives and methods are continuously discussed and re-defined by a strongly homogeneous and influential sector of the scientific community. Space science, on the contrary, is defined by its technique rather than its objectives: it includes, in fact, any kind of scientific investigation conducted by the use of rockets, Earth-orbiting satellites, and deep-space probes. In terms of established scientific disciplines, it covers fields as different as atmospheric physics and chemistry, ionospheric physics, geophysics, plasma physics, cosmic-ray physics, the various branches of astronomy and astrophysics (solar, stellar and planetary; from radio wavelengths up to the gamma-ray region of the electromagnetic spectrum), and even material sciences, biology and medicine. Each of these disciplines and sub-disciplines is characterised by its own aims and methods, by its own intellectual and institutional framework, by its own approach to the opportunities offered by space technologies.

Finally, one must mention the different roles of particle physics and space science in the general framework of national and international policies for scientific and technological development. Particle physics is undoubtedly pure research, with very limited, if any, possibilities of practical applications. Its large-scale development in the post-war period was mainly due to the prestige and influence that this sector of the physics community enjoyed thanks to their wartime work. The fortunes of the field depend not on the promises of economic profits or better human welfare but rather on the leading influence this community exerts within scientific and political circles. It is quite different for space research. In fact, the techniques that render this research possible, rockets and satellites, have evident civil and military applications and their development largely depends on political choices based on extra-scientific considerations.

In two previous chapters, we have discussed the process which led to the definition of ESRO's first scientific satellite programme. This chapter will deal with the implementation of ESRO's programme in the "Auger years" (1964-1967). The scientists who contributed to this process, either in the capacity as national delegates in official bodies or as experts in advisory committees, were not members of one scientific community, with a well structured set of common cultural and professional values spread across national borders. Their task was not choosing the best instrument or the most promising experiment proposal within the framework of a shared disciplinary paradigm. They represented instead various scientific and national interests, and were called to establish priorities and to make choices between competing scientific disciplines and research programmes, between radically alternative technical options, and between different national policies. They were not members of an influential, international scientific elite who could confront the political decision-makers with the only arguments of their research goals. They were rather advocates of a variegated set of old and new scientific disciplines who had to negotiate among themselves and with national governments the place and fortunes of these disciplines in the wider framework of space activities.

5.1 Preparing for the implementation of the scientific programme

5.1.1 The interim period

The Meyrin Agreement which created the COPERS came into force on 27 February 1961 and was due to terminate one year later, when it was expected that the new ESRO Convention would have been ready for signature by the Organisation's Member States. As early as July 1961, at the 4th meeting of the STWG, it was decided to start an interim programme in order to lay the basis of the forthcoming Organisation, in terms of personnel and technical facilities.[370] In the event, due to delays in the preparation of the Convention, the Meyrin Agreement was duly prolonged and the interim period extended up to March 1964. In spring 1962, with the ending of the preliminary planning, the preparation of the launching programme became the most urgent task and it became clear that a new committee structure had to be defined for the interim period, modelled on that proposed for the permanent ESRO. The STWG then decided to dissolve the 4 sub-groups which had helped work out the *Blue Book* and to set up a Launching Programme Sub-Committee (LPSC) whose task was defined as follows:

> *To propose the programme of payloads for sounding rockets and satellites to be submitted to the Scientific and Technical Working Group (later to the Scientific Committee which is expected to be set up by the Council of ESRO) for final approval. The task of [the LPSC] will be to combine proposals for experiments into a programme of integrated payloads, with tentative dates of firings and an indication of the ranges from which the launchings will take place.*[371]

Reimar Lüst was chosen as the chairman of the LPSC, whose first membership included Robert Boyd and Odd Dahl, together with the Head of the Programmes and Facilities Division and the Finance Officer of COPERS. Subsequently, the French physicist Jacques E. Blamont joined the membership of the LPSC.[372] To advise the LPSC in the consideration of the experiment proposals presented by research groups, a number of ad hoc working groups was created, whose members were to be chosen among European scientists expert in the different fields of space science (Tables 5-1a and 5-1b).[373]

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370 STWG, 4th meeting (27-28 July 1961), COPERS/GTST/22, 17 May 1962. See also COPERS/33 (rev. 1), 29 November 1961.

371 STWG, 6th meeting (9 May 1962), COPERS/GTST/40, 17 May 1962, p. 2. See also COPERS/GTST/37, 30/40/62.

372 STWG, 7th meeting (29-30 October 1962), COPERS/GTST/61, 10 December 1962.

373 The membership of the ad hoc groups is given in the series of documents COPERS/LPSC/5, in particular COPERS/LPSC/5 (rev. 2), 7 January 1963 and COPERS/LPSC/5 (rev. 3), 15 February 1964. For the evolution of the working groups see: LPSC, 6th meeting (29 April 1963), COPERS/LPSC/84, 7 May 1963; STWG, 9th meeting (30-31 May 1963), COPERS/GTST/98, 20 June 1963; STWG, 10th meeting (3-4 October 1963), COPERS/GTST/126, 29 October 1963.

Finally, questionnaires concerning experiment proposals to be carried out with the first ESRO sounding rockets and satellites were sent out by the COPERS Secretariat.[374] The operational procedure to start the first European co-operative effort in space research was thus initiated. By the Spring of 1963, 71 proposals for satellite and space probe experiments had been received and discussed by the various working groups (Table 5-2). About 40 proposals were considered scientifically acceptable and classified in three groups: those requiring simple non-stabilised satellites, those requiring some kind of stabilisation of the spacecraft and those requiring a highly eccentric orbit satellite or a deep space probe.[375] By the same time, it was decided that the first Large Astronomical Satellites (LAS) of the long term programme should be devoted to high resolution (1 Å) stellar spectroscopy in the UV range, from the Lyman limit (912 Å) to about 3500 Å, on the basis of preliminary studies already performed in Great Britain.[376]

Following the discussions in the ad hoc working groups, the LPSC recommended that the first ESRO satellites should be two small non-stabilised satellites devoted to the study of the polar ionosphere and to solar astronomy and cosmic rays respectively. These satellites were eventually called ESRO I and ESRO II.[377] A simple glance at Table 5-2 explains this choice: it satisfied the interests of the largest fraction of the European space science community. The logic of numbers can be supplemented by the consideration that physicists involved in the study of ionospheric and auroral phenomena represented at that time the leading sector in the space science community, owing to their established experience in rocket experiments in the framework of national programmes. Moreover, most experiment proposals recommended by the ionospheric group did not require stabilisation and the group itself had suggested an integrated payload containing experiments "for measurement of the ionising agents, corpuscular and electromagnetic, as well as of the ionisations and excitations produced by those agents in the upper atmosphere".[378]

As to the experiment proposals requiring stabilised satellites, the LPSC limited itself to a classification according to the proposing group and to the kind of stabilisation required (i.e.: Earth pointing, Sun pointing and stabilisation with respect to celestial co-ordinates). Subsequently, it was agreed to devote the first stabilised satellite to non-solar astronomy experiments, thus satisfying the interests of the second large sector of the astronomical community.[379]

Finally, the LPSC considered the proposals for highly eccentric orbit satellites (HEOS) and space probes (SP). Both the group on interplanetary medium and the cosmic ray group had stressed the great desirability for ESRO to have a spacecraft journeying very far away from the Earth as soon as possible, and the LPSC invited the two groups to co-operate in order to define a good scientific mission for such a spacecraft. At the same time, the LPSC requested that a technical study be made on

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374 Letter of P. Auger, Executive Secretary of COPERS, 21 May 1962. The questionnaire for sounding rocket experiments is COPERS/39, that for satellite experiments is COPERS/96. New versions of these questionnaires were prepared in 1963 and 1964.

375 COPERS/LPSC/32, rev. 2, 7 May 1963. An earlier version of this document, COPERS/LPSC/32, rev. 1, dated 21 January 1963, lists 67 experiment proposals with no classification. The terms "highly eccentric orbit satellite" and "space probe" were used rather interchangeably in this phase. As a matter of fact, the former is a satellite whose orbit is a highly eccentric ellipse with apogee of more than 50,000 km; a space probe is a spacecraft injected into an escape orbit.

376 The story of the LAS will be discussed in detail in the following chapter and therefore will be dealt with here only when necessary.

377 LPSC, 5th meeting (6-7 March 1963), COPERS/LPSC/70, 2 April 1963. See also COPERS/LPSC/80, 26 April 1963 and COPERS/GTST/82, rev. 1, 14 June 1963. In view of difficulties which arose in the preparation of the payload for the polar ionospheric satellite, it was eventually agreed to launch first the solar and cosmic ray satellite: LPSC, 7th meeting (26 August 1963), COPERS/LPSC/95, 30 August 1963. ESRO II thus became the first satellite launched by ESRO.

378 Ad hoc group B, 5th meeting (14-15 February 1963), COPERS/LPSC/59, 8 March 1963, p. 9.

379 LPSC, 8th meeting (7-8 February 1964), COPERS/LPSC/123, 3 March 1964; first meeting of the Interim LPSC (23 April 1964), ESRO/ST/14, 4 June 1964; second meeting of the Interim LPSC (30 July 1964), ESRO/ST/60, 31 August 1964.

possible orbits and the associated tracking and telemetry problems.[380] Eventually, at its very last meeting, the LPSC agreed to recommend that the first ESRO highly eccentric orbit satellite (HEOS A) should be devoted to cosmic ray studies. It also recommended that a second HEOS or a space probe should be launched one year later and that primary consideration should be given to studies of the interplanetary medium.[381] If we consider these first decisions and the work in progress on the LAS, we see that, thanks to the work of the LPSC and its advisory groups, the first phase of ESRO's satellite programme was reasonably well defined when the Organisation came into being, with a fair balance among different scientific fields and technical options, and with about 20 research groups already involved in the preparation of the experiments. This was in line with the programme presented in the *Blue Book* and even though, owing to legal and financial reasons, the official life of ESRO was to start two years later than originally foreseen, scientists could feel confident that their optimistic plans could still be fulfilled.

5.1.2 ESRO's committees and advisory bodies

With the coming into force of the ESRO Convention, in March 1964, the STWG and the LPSC were dissolved and replaced by the Scientific and Technical Committee (STC) and its Launching Programme Advisory Committee (LPAC), respectively. The STC was made up of delegates from each Member State, preferably "competent scientists and technologists", with the task of advising the Council and ESRO's Director General on all scientific and technical matters affecting the work of the Organisation. Among its terms of reference there was in particular:

> *a To recommend to the Council the scientific and technical programme of the Organisation, having regard to the Organisation's financial and other resources, and to keep under review the progress made in carrying out this programme.*
>
> *b To examine proposals for space experiments and the composition of payloads, to approve where appropriate, and to make recommendations to the Council or the Director-General as appropriate regarding the timeliness and suitability of their inclusion in launching programmes.*[382]

R. Lüst and the Danish physicist B. Peters, from the Niels Bohr Institute in Copenhagen, were unanimously elected chairman and vice-chairman of the STC.[383]

As to the LPAC, its terms of reference were defined as follows:

> *The Launching Programme Advisory Committee (LPAC) shall prepare the scientific and technical programme of the Organisation for submission to the Scientific and Technical Committee. In particular, the Committee shall combine proposals for space experiments*

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380 LPSC, 6th meeting (29 April 1963), COPERS/LPSC/84, 7 May 1963; 8th meeting (7-8 February 1964), COPERS/LPSC/123, 3 March 1964.

381 Interim LPSC, 2nd meeting (20 July 1964), ESRO/ST/60, 31 August 1964.

382 Meeting of the Interim Scientific and Technical Working Group, 25-26 May 1964, ESRO/ST/32, 11 June 1964, p. 1-2. Document ESRO/ST/12, 6 May 1964, contains the terms of reference proposed by ESRO's Secretariat that were eventually amended at the meeting. The most important differences are that the initial proposal considered that the STC should be composed of one delegate per Member State and that it should advise only the Council and not the Director General. At the meeting there was some discussion as to whether one or two delegates would be preferable and the matter was put to the vote: Sweden, Belgium, Spain and the United Kingdom voted in favour of two delegates and the other delegations abstained. Eventually, the Council decided that the number of delegates should not be limited. Council, 2nd session (15-17 June 1964), ESRO/C/MIN/2, 8 July 1964. Other tasks of the STC included to advising on technical facilities and on the recruitment of staff, and advising on the Organisation's educational activities and co-operation with non-Member States.

383 STC, 1st meeting (10-11 September 1964), ESRO/ST/MIN/1, 14 October 1964.

into a programme of integrated payloads for sounding rockets, satellites and space probes. It shall also propose tentative dates of firings and indicate ranges from which the launchings will take place. In its work the LPAC shall take into account the financial, technical and scientific resources of the Organisation.[384]

The membership of the LPAC consisted of four (eventually five) scientists nominated by the STC who were to be elected for a period of two years and were eligible for re-election. The initial membership included Lüst (chairman), Boyd, Blamont and Cornelis de Jager (Table 5-3). Also carried over from the COPERS was the system of ad hoc working groups called to assist the LPAC in its consideration of the experiment proposals. The groups were identified by easily recognisable acronyms and their chairmen were appointed by the STC; their members were to be co-opted by the chairmen as experts (Table 5-4). The chairmen of the ad hoc groups were generally invited to the meetings of the LPAC, together with other persons such as the chairman and vice-chairman of the STC, the chairman of the Administrative and Finance Committee (AFC) and some members of the ESRO staff. Eventually, the LPAC decided that the number of members of a scientific working group should be between 9 and 12 and one third of the members should be replaced every year. The chairmen should act for a period of three years and they could not be members of the LPAC at the same time.[385]

5.1.3 Scientists and ESRO

The standard procedure to get an experiment included in one of ESRO's satellites provided that experiment proposals be presented by European scientific groups or individual scientists and discussed by the interested ad hoc group(s). If recommended from the scientific point of view, the proposal was then submitted to the LPAC for eventual inclusion in a satellite payload, according to the agreed scientific programme and scientific mission of the satellite. In this phase, ESTEC engineers, in consultation with the proponents, were called to assess the various experiment proposals and their compatibility with each other and with the spacecraft from the technical point of view. Finally, the LPAC combined the various experiments into integrated payloads which were presented to the STC and then to the Council for final approval. The system thus worked along two lines: on the one hand, the STC and the LPAC discussed and approved, at political and scientific level respectively, the overall programme of the Organisation and the scientific missions of its satellites, within the financial limits imposed by the Council; on the other hand, the scientific community at large suggested scientific objectives and specific experiments in the various fields of space research.

The LPAC represented the place where the two lines converged and where a suitable compromise had to be worked out between the expectations of the scientific community and the political and economic constraints of ESRO's agreed policy. The members of the LPAC were at one and the same time scientists and scientific policymakers: representatives of the interests of the scientific community and guarantors of the technical and financial feasibility of the proposed experiments within the framework of ESRO's programme; authoritative spokesmen of national scientific communities and research fields and persons responsible for making choices on behalf of purely scientific interests in a multi-national, multi-disciplinary organisation; strong personalities called to mediate between competing political, economic and scientific interests.

Above the LPAC, the STC was called to discuss and to recommend to the Council the overall scientific policy of the Organisation. This regarded the launching programme and other matters such

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384 STC, 1st meeting (10-11 September 1964), ESRO/ST/MIN/1, 14 October 1964, p. 2. Also ESRO/C/75, 13 November 1964. LPAC, 1st meeting (6 November 1964), ESRO/ST/80, 20 November 1964.

385 LPAC, 9th meeting (18 October 1965), ESRO/ST/154, 9 November 1965. The functions of the ad hoc working groups are described in ESRO/ST/40, 17 July 1964, with rev. 1 (26 August 1964) and rev. 2 (18 December 1964). The initial membership of the groups is in ESRO/ST/88, 9 December 1964. A partial renewal of the membership was approved at the 10th meeting of the LPAC (13 December 1965), ESRO/ST/168, 4 January 1966. In ESRO's annual General Reports one can find the membership of all ESRO's official bodies and advisory committees.

as the applied research programme; the technical facilities required for the integration, engineering and testing of rockets and satellites, for the launching operations and for tracking and data handling; the research programmes of ESLAB and ESRIN; the relationship of ESRO with national space agencies in the Member States and with NASA. In its membership, the essential tension between the members states' different interests, represented by the debates between national delegations, was interlaced with the several aspects of competition and cooperation between the different sectors of the space science community, expressed by the scientists present as delegates or advisers.

Under the LPAC, the discussions within the various ad hoc groups reflected the great variety of the scientific community interested in space research. For those scientists, the use of space technologies represented a new exciting frontier of experimental research. By sending instruments to the outer limit of the atmosphere and beyond it became possible to study a wide range of otherwise inaccessible phenomena such as the structure and properties of the ionosphere, the ultraviolet and X-ray components in the solar and stellar radiation, the structure of the Earth's magnetic field and its interaction with the interplanetary plasma, the primary cosmic radiation, the solar wind and the Sun-Earth relationship, the structure of the moon and of the other planets in the solar system.

In order to understand the evolving debates within ESRO's committees and advisory groups, it may be useful to discuss a few aspects of the internal dynamics of this variegated scientific community. A first dividing line can be drawn between the disciplines interested in the Earth's space environment and the Sun-Earth relationship and those interested in the study of celestial bodies (roughly speaking: geophysics and 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 the solar radiation. The introduction of rockets and satellites made it possible to study *in situ* these phenomena, thus changing dramatically the shape of this discipline which became the first research field to come of age in space science. The use of satellites in this field required relatively small and simple spacecraft and one can easily understand the important role played in ESRO by the ION ad hoc group and by its influential chairman (and then LPAC member) Bengt Hultqvist.

Another important group of research fields was the domain of astronomers, a far from homogeneous community, however, as their partition into three different ad hoc groups reveals. In this domain, the availability of space technology had opened up two new perspectives: the possibility to study the moon and the planets at close range (planetary science), and the possibility to study electromagnetic radiation from celestial bodies in spectral regions where it is prevented from reaching the Earth's surface by atmospheric absorption, in particular UV and X-radiation (solar physics and astrophysics). While it appeared quite difficult for Europe to compete in the former field, in view of the vigorous programmes pursued by the two superpowers, the possibility to enter the fascinating field of UV astronomy was an obvious call for European astronomers, both those interested in solar physics, among whom the chairman of the SUN group and (LPAC member) Cornelis (Kees) de Jager was a recognised world spokesman, and those interested in stars. On the other hand, owing to the kind of detectors involved, X-ray and gamma-ray astronomy fell more into the competence of cosmic ray physicists.

By the early 1960s, cosmic ray physics was at a turning point. For about three decades the study of cosmic ray phenomena had been the experimental ground for the investigation of high energy particle interactions. The building of large accelerators in the 1950s had now shifted particle physicists to the new laboratory facilities and the interest in cosmic rays developed more and more in relation with other celestial phenomena. Here too a significant transformation was taking place. At the beginning of the space age, in fact, cosmic ray physics could be included in the domain of space geophysics. Cosmic ray physicists investigated the solar wind and its interaction with the Earth's magnetic field and measured the composition and energy spectrum of non solar particles in the vicinity of the Earth. Being charged, these particles are affected by interstellar magnetic fields and reach our planet having lost any memory about the position of the source. The emergence of the new fields of X-ray and gamma-ray astronomy, which required detecting techniques drawn from experimental physics, opened the domain of astrophysical research to cosmic ray physicists (high energy astrophysics). X rays and gamma rays, in fact, propagate along straight lines from the sources and their investigation provides direct information on high energy processes in celestial bodies.[386] In this situation of rapid evolution of the discipline, which placed itself in a domain overlapping both geophysics and astrophysics, it is not surprising that the COS Group became one of the most dynamic and successful. Its first chairman was one of the most important pioneers of cosmic ray physicist in Europe, the Italian Giuseppe (Beppo) Occhialini, who eventually was co-opted in the LPAC.[387]

5.2 The sounding rocket programme[388]

A significant aspect of the scientific programme described in the *Blue Book*, is the important role played in it by the sounding rocket programme. Whatever doubts some may have had about their value, the fact remains that there was a strong demand for them in Europe. According the *Blue Book*, a survey undertaken early in 1960 revealed that there were about 55 groups comprising some 300 qualified scientists interested in doing space research. They proposed about 150 groups of experiments for ESRO's initial programme, no less than half of them with sounding rockets (and the remainder with satellites and probes).

Several factors accounted for this strong interest. First was the lack of homogeneity of the "discipline" of space science. As L. Hulthén, the chairman of the STWG, pointed out to the second session of the COPERS, "space research was not a well-defined discipline, like nuclear physics or organic chemistry. [...] In terms of well established sciences, it covered practically all astronomy and branches of physics and chemistry, e.g. geophysics, upper atmosphere physics and chemistry, cosmic radiation physics".[389] By launching a large number of sounding rockets one could hope to cover large sections of the field at relatively low cost, adding to rocket research already under development in several European countries.

Then there was the fact that the rockets provided a hedge against disappointments in the satellite programme, a programme in which competition was intense and lead times were long. Individual researchers, small groups or graduate students might have to wait years before actually getting a scientific experiment flown on a satellite. They were more or less assured results within one or a few years on a sounding rocket.[390] The relative inexperience of the European space science community was another argument in favour of sounding rockets. No less than 40 of the 55 groups surveyed had no flight experience, and were either already planning experiments or simply hoping to enter the field. Sounding rockets provided a useful means for novices to cut their teeth in the new, challenging domain. Finally, sounding rockets were of particular interest to groups in some of the smaller countries with relatively low budgets for space research. They enabled scientists in those countries to participate alongside their colleagues from Britain and France who had well developed national space programmes, and who had the experience and the resources required to fly also the (technically) more sophisticated and expensive satellite experiments.[391]

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

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386 For the origin and early evolution X-ray astronomy see Hirsch (1983).

387 On Occhialini see Russo (1996).

388 This section is essentially based on ESRO Annual Reports, and on Eaton (1989), Jaenschke (1971), and Rocket (1967).

389 COPERS, 2nd session (17-18 May 1961), 25 May 1961, p. 2.

390 This point was stressed in Hultqvist (1967).

391 Massey and Robins (1986), p. 121, have stressed the importance of sounding rockets for "small" countries during the negotiations for the definition of the scientific programme.

provided by researchers from the Institut d'Astrophysique in Liège and the Max-Planck-Institut für Extraterrestrische Physik in Garching. 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. 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. Other frequently used ranges were the Italian base in Sardinia and the Norwegian base in Andøya.

The number of launches carried out annually climbed gradually during the following years (Table 5-5). The figures for 1966 are somewhat misleading as they include nine launches made during a special solar eclipse campaign at Karystos on the Greek island of Euboea. Seven rockets, two *Centaures* and five (American) *Arcas* were launched within a narrow time window centred on the total eclipse of the Sun, while one *Centaure* and one *Arcas* were launched a few days earlier. The French *Centaure* and British *Skylark* rockets were the workhorses of the programme, supplemented by the American *Arcas* (Table 5-6). 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 in 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 there 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 2-1), 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 original figures in the *Blue Book*, it will 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. 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 on a site well beyond the Arctic Circle, the ionospheric and auroral phenomena studied there occurred seldom 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.

The sounding rocket programme, 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 know-how. 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 banqueting 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 of 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. Indeed as sounding rockets became increasingly sophisticated, as failure became more costly, scientifically, financially, and personally, so were the risks 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.

5.3 The revision of the 8-year satellite programme

The first problem the LPAC had to deal with was the revision of the eight-year programme in the light of information acquired since the writing of the *Blue Book*. This was a difficult exercise, which brought into evidence the several problems and contradictions which affected the early development of ESRO as regards both its financial conditions and its scientific constituency.

As discussed in a previous chapter, the programme approved by COPERS foresaw that most of ESRO's satellites were to be launched by Scout rockets (Table 2-1). Subsequent discussions among scientists, however, indicated an increasing interest in more sophisticated satellites than could be launched by the Scout vehicle. In particular, considerable interest was expressed in the use of the Thor Delta as a satellite launcher, capable of launching larger and stabilised spacecraft. As a consequence, in the Summer of 1963, the COPERS Secretariat was requested to make proposals for a possible programme based on a larger fraction of satellites and space probes of the Thor Delta (TD) type.[392] In the new proposal, the number of satellites to be launched was reduced to 14, namely 4 Scout-type satellites, 4 TD-type satellites, 4 highly eccentric orbit satellites or space probes, and 2 large satellites. The total expenditure, budgeted over ten years, was estimated at 852 MFF, i.e. about 16 % higher than in the *Blue Book*. The cost breakdown was radically different, however, as the costs for launchers and launch operations was now estimated at 317 MFF, including 11 backup launchings, while the expenditure on spacecraft development had risen to 535 MFF. A warning was added, however:

> *By their very nature the above estimates are inexact since so far no technical studies have been conducted which will give more reliable figures.* [393]

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392 STWG, 9th meeting (30-31 May 1963), COPERS/GTST/98, 20 June 1963. See also, for the financial implications of using different launch vehicles, COPERS/GTST/91, 15 May 1963.

393 COPERS/GTST/116, 3 September 1963, p. 6; COPERS/GTST/117, 27 September 191963.

Some COPERS delegations, however, considered that the new operational programme and its budgetary version were rather optimistic and therefore they agreed to the proposal only for the first year of ESRO (1964). This year's budget was to be prepared accordingly, while the budget proposals for the two following years were to be considered only as a planning exercise.[394]

5.3.1 The LPAC plays its role

It was now up to the LPAC to discuss a sound scientific programme fitting this operational programme and to make a recommendation to the STC.[395] A "lengthy discussion" on this topic started at the second meeting of the LPAC, in November 1964, and continued in the following three months. Eventually, definite conclusions were reached at an informal LPAC meeting, on 25 February 1965, and presented to the STC (Table 5-7).[396] The first decision regarded the Scout-type satellites: on the basis of new information about the cost of the Scout and Thor Delta launchers, it was recognised that the latter was definitely to be preferred because of the lower cost per kilogram of payload. Therefore it was agreed not to start any further project of this type after ESRO I and ESRO II, both scheduled for launching in 1967. This freed resources for the TD-type satellites and, in fact, it was recommended to increase their number to six, on the assumption that they should be based on a common basic structure and stabilisation system (the so-called "streetcar" concept). The scientific missions of the first four payloads were also agreed as follows:

- TD-1, stellar astronomy
- TD-2, solar astronomy
- TD-3, ionospheric studies
- TD-4, atmospheric studies

It was assumed that the solar satellite TD-2 and the ionospheric satellite TD-3 were to be launched in time for the solar maximum in 1968/69 in order to study the relation between solar activity and ionospheric phenomena.

The new policy in favour of the Thor Delta launcher also affected the programme of highly eccentric orbit satellites. In fact, it was recommended that they too should all be launched by Thor Delta rockets into orbits extending out to 200,000 km (i.e. outside the magnetosphere) and that the telemetry network would be worked out on this basis. As to the scientific missions of this kind of satellites, following the first HEOS devoted to cosmic ray studies, it was agreed to devote the second to experiment proposals from the PLA group and the third to ionospheric studies. No choice was yet made for the fourth.

Finally, regarding the major projects, three large astronomical satellites (LASs) were proposed, the last to be launched in the 9th year. Preliminary studies for the second major project were also under way, in particular on the feasibility of a fly-by mission to a comet and on a large solar satellite proposed by the SUN group. It was underlined, however, that "the necessary delays caused by the initial studies may

394 COPERS, 12th session (30-31 October 1963), COPERS/MIN/12, 15 November 1963.

395 In November 1964, the ESRO Council officially asked the LPAC to review the 8-year programme and to submit its proposal to the STC and the Council itself: Council, 5th session (25-26 November 1964), ESRO/C/MIN/5, 11 January 1965.

396 LPAC, 2nd meeting (24 November 1964), ESRO/ST/89, 18 December 1964. The February 1965 meeting was intended to be the fifth meeting of the LPAC, but as only two members of the Committee could attend (Lüst and Boyd), together with members of the ESRO Secretariat, it was not considered a formal LPAC meeting. The report on this meeting is in ESRO/ST/114, 16 March 1965. The conclusions were presented in the report of the LPAC chairman to the 4th meeting of the STC: ESRO/ST/109, 3 March 1965.

result in the launching of [the cometary] mission outside the 8-year period", while the solar satellite "might, if accepted, be able to use the same basic vehicle as the LAS series".[397]

The expenditure estimate for this satellite programme was at 455 MFF for spacecraft development and 225 MFF for launchings, both figures at 1962 prices. An additional amount of about 40 to 50 MF was to be added for the realisation of a deep space telemetry network. The total cost of the programme thus remained within the estimate in the *Blue Book*. It is remarkable, however, that in the three years since the writing of the *Blue Book*, the cost estimate for spacecraft development had doubled while the cost of launchings had been halved only because all backup launchings were dropped. On the one hand, this reflected the fact that now a larger number of more complex spacecraft were foreseen; on the other hand, the total number of satellites had also been reduced from 17 to 15 and industrial development work had actually started only for ESRO I and ESRO II, therefore any cost estimate for the other projects still suffered from a large margin of uncertainty.

5.3.2 The STC fails to reach agreement on the LPAC'S recommendations

When the LPAC's conclusions were presented to the STC, the chairman of the LPAC felt it necessary to put forward "a word of explanation [...] regarding the distribution of funds between the various projects":

> *The policy has been to maintain a fair distribution in the scientific programme between the various fields of activity in space science. [...] In these various fields the cost of making worth-while observations varies considerably.*[398]

Observations in the atmosphere and lower ionosphere could be made by relatively inexpensive rockets, Lüst argued, whereas a good astronomical programme required very expensive large satellites with high pointing accuracy and stability. Therefore, the attempt to keep a fair balance in scientific effort over the various fields of space science resulted in a disproportion in the distribution of money over the programme. He then concluded:

> *Any apparent excess in emphasis towards astronomy does not, in fact, mean that more astronomical observations are being done, but follows from the fact that astronomical observations require very expensive instruments if they are to be done at all.*

This argument, however, did not convince some members of the STC. Hultqvist, in particular, who was a Swedish delegate besides being the chairman of the ION group, argued that the balance of experiments was unfair since the proposed programme gave astronomers a much larger share in satellite space than what would be suggested on the basis of the interest of European scientists in the various disciplines of space science. According to him, satellite space appeared to be divided about fifty-fifty between astrophysical experiments and geophysical experiments, while:

> *Of the total number of satellite experiments proposed (about 83 at present), those disciplines represented by the SUN and STAR groups submitted 24 % of experiments, whereas those represented by the groups such as ION and COS submitted 66 %.*[399]

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397 ESRO/ST/109, cit., p. 4.

398 Report of the chairman of the LPAC to the 4th meeting of the STC, ESRO/ST/109, 3 March 1965, p. 2. Lüst, in fact, was the chairman of both the LPAC and the STC. However, he could not attend the STC meeting and the document was presented there by the Scientific Director of ESRO: STC, 4th meeting (10-11 March 1965), ESRO/ST/MIN/4, 3 May 1965.

399 STC, 4th meeting (10-11 March 1965), ESRO/ST/MIN/4, 3 May 1965, p. 2. Remark that cosmic ray studies were included by Hultqvist in the category of geophysical investigations because at that time they involved mainly the analysis of the solar wind and of the cosmic corpuscular radiation in the near Earth environment.

Hultqvist's arguments represented here more the opinions of the ION group than those of the Swedish Delegation. The former, in fact, had already claimed that "the proposed allocation [by the LPAC] of spacecraft to ionospheric and magnetospheric studies is totally inadequate to the needs". As an alternative, the ION group proposed a "minimum programme" consisting of no fewer than 11 spacecraft of different kind in order to deal with the various scientific problems in the field and to match the capacity of the scientific groups proposing experiments.[400] On the other hand, the other member of the Swedish Delegation, Y. Ohman, a veteran astrophysicist, underlined the need of pursuing most experiments in the astronomical field in order to gain experience before starting major projects. Astronomers, continued Ohman, "have been slow to see the advantages of space science", and they should not be discouraged, should the division of the programme be changed.[401]

Beyond the statistics, Hultqvist's arguments against the LPAC's proposed programme raised a question of scientific policy, namely whether to prefer a large number of small, non-stabilised multi-experiment satellites or a smaller number of large, stabilised observatory-like satellites. The first option was suitable for the study of the environment of the vehicle itself, i.e. the particles and fields present in the regions of space visited by spacecraft; the second was that of interest for astronomical and astrophysical studies, namely the study of distant objects. Connected to this question was the main controversial issue raised at the meeting, namely the idea of using streetcar-type satellites for the TD series. Several delegations, notably the French and the German, considered that a streetcar satellite would have serious scientific limitations which would not be counterbalanced by financial and technical advantages. The reasons were explained by the president of the French Centre National d'Etudes Spatiales (CNES), Jean Coulomb, in a document prepared for the following Council session:

> *There is no justification for the development of a "standard", or "omnibus" or "tramway" vehicle for the Thor Delta satellites. If that method can provide good results in the USA for OSO [Orbiting Solar Observatory], OGO [Orbiting Geophysical Observatory] and POGO [Polar Orbit Geophysical Observatory] satellites, it is essentially because the experiments grouped in each type of satellite are of the same character and the satellites therefore carry out fairly similar experimental programmes; there is justification in this case for planning a vehicle in which the various scientific experiments can easily be accommodated. On the contrary, the ESRO Thor Delta series will include one solar, one stellar, one ionospheric and one geodetic satellite, and the experiments will be very different. It is in fact planned to develop a vehicle having the combined capacities of OSO and OGO, with severe limitations in size and weight. It is difficult to see how that can be done without introducing considerable limitations in the vehicle experimental programmes. There would be such great problems of adaptation that the final cost of the four vehicles may well be greater than that of the four ad hoc vehicles.*[402]

Here again, behind the technical and financial uncertainties of the streetcar concept, an important issue of scientific policy was also involved, namely whether to base ESRO's programme mainly on the realisation of a number of specially designed satellites, in order to meet the requirements of very different scientific objectives, or to design a standard vehicle whose specifications (mechanical and electrical interfaces, attitude control, power, telemetry system, etc.) had to be met by the set of scientific experiments included in the payload. Obviously, these specifications were not "neutral" with respect to the kind of scientific mission the series of satellites was mainly called to accomplish: as the American case demonstrated, a geophysics standard satellite could be very different from an astrophysics standard satellite. Space scientists in the United States could benefit from the bonanza of

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400 SCI/WP/12, 25 January 1965, p.1. See also Hultqvist's remarks at the 4th meeting of the LPAC (1 February 1965), ESRO/ST/106, 17 February 1965, p. 5.

401 ESRO/ST/MIN/4, cit., p. 3, 4.

402 ESRO/C/114, 24 March 1965, p. 2. To Coulomb's list of American standard satellites one should add the OAO (Orbiting Astronomical Satellites) series. A technical proposal for "A multi-purpose Thor Delta satellite", offering "a reasonable compromise between the requirements made by the experiments for solar, ionospheric and cosmic ray research", was discussed in SCI/WP/27, 23 April 1965.

the Apollo programme and then have independent programmes for the three main domains of space science (solar astronomy, stellar astronomy and geophysics); in Europe they had to fit everything in one.

Finally, at the STC meeting, technical and financial questions were put forward by ESRO's Technical Director A.W. Lines. He stressed that the concentration of launchings to meet the solar maximum in 1968/69 would run the Organisation into a peak of expenditure and pose a severe stress on ESTEC's resources. A more rapid build-up of staff than planned was then required in order to successfully implement the envisaged programme. Lines also urged an immediate decision for endorsement of the programme and, in particular, an agreement on plans for the second year of the Organisation as soon as. In order to start investigating the possibilities of a basic design for a standard satellite, detailed information on at least two TD payloads was required while, at that moment, only the payload of TD-1 had been agreed on, the Technical Director stressed.

The meeting closed without reaching agreement, much to the regret of Boyd who complained that "the STC was unable to agree a programme on which the LPAC had spent a great deal of time, and which it genuinely believed was the best possible solution". The Committee, nevertheless, agreed on the reduction in the number of Scout-type satellites and on the increase in the number of TD satellites, with the proviso, however, that the use of stabilised satellites should not exclude experiments not requiring stabilisation from the launching programme. They also approved the LPAC's recommendation as to the scientific aims of TD-2 and TD-3, with the agreement that they should be known as solar maximum satellites and that the division of experiments between the various disciplines should remain flexible. Finally, after a long discussion, it was decided (with the abstention of Belgium and France who doubted the financial feasibility of the project) to recommend the payload already agreed on by the LPAC for the first highly eccentric orbit satellite. This decision, however, was subjected to the still controversial question of providing ESRO with a suitable deep space tracking and telemetry network (see below).[403] No agreement, on the contrary, was reached about the principle of using a multi-purpose vehicle for the TD satellites, thus leaving the core of the Organisation's operational programme pending.

Before the Council session, the LPAC held a meeting in order to consider the comments of the STC on the proposed programme. Here again it came out that the controversial parts of the programme were: (a) the feasibility and the advisability of a standard spacecraft; (b) the necessity of a deep space telemetry network; and (c) the possible underestimation of the costs for the LAS project. In the event, the LPAC agreed that the realisation of TD-3, TD-5 and of the second highly eccentric orbit satellite "would depend finally on a review in two or three years' time when a more precise idea of the costing would be available". Therefore, the TD-2 satellite had to be regarded as a "solar, ionospheric and geophysical satellite" and the scientific ad hoc groups were invited to submit new proposals for its payload accordingly. Meanwhile ESTEC could start working on this spacecraft according to "probable specifications [...] based on present knowledge of experiments available".[404]

That was a poor compromise. When the realisation of ionospheric satellite TD-3 actually proved impossible, the payload composition of TD-2 became a ground for harsh competition. It was bound to be a very hard job, in fact, to include in the same spacecraft experiments aimed at studying the Sun as a star that happens to be near the Earth (the way astronomers do) and experiments aimed at studying the influence of solar activity on the Earth's near space environment (the way geophysicists do).

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403 The results of a preliminary study on a possible ESRO's tracking and telemetry network for highly eccentric orbit satellites and space probes are in ESRO/ST/111, 4 March 1965. This paper was circulated at the meeting but not discussed because it had to be submitted first to the ad hoc groups. The French Delegation, however, expressed strong reservations about the opportunity of building a European deep space telemetry network.

404 LPAC, 5th meeting (19 March 1965), ESRO/ST/116, 2 April 1965, p. 6. The revised programme, with TD-3, TD-5 and the third HEOS listed in brackets and including new expenditure forecast, is presented in annex II to the minutes of the 6th Council session (24-25 March 1965) ESRO/C/MIN/6, 14 June 1965. See also ESRO/ST/128, 2 June 1965.

Moreover, this task had to be accomplished by a set of experiments and a satellite design compatible with the already agreed payload of TD-1.

5.3.3 No decision taken on the 8-year satellite programme

In the presence of these divisions within the scientific community and lacking definite recommendations from its advisory bodies, the Council could only agree on the most conservative attitude, thus leaving any decision on the 8-year programme pending. 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 Council also approved HEOS-A and its recommended payload, but it refused for the moment to endorse any extension of the existing ESRO tracking network (ESTRACK), in the hope that this, assisted by the French CNES stations, would make it possible "to obtain tracking and stored telemetry data sufficient for the proposed experiments". Finally, lack of understanding was still registered about the number of LASs to be included in the programme in order to save sufficient resources for starting a new major project (the so called SLEP: Second Large ESRO Project). Several Delegations felt that the costing of the major projects was unrealistic and it was agreed that the financial implications of the 8-year programme should be studied by the AFC before final proposals were submitted to the Council for approval.[405]

When the STC met again, in June 1965, only 5 projects plus the first LAS had been definitely approved (ESRO I and II, TD-1 and TD-2, and HEOS-A), and the whole operational programme was still under discussion. No step forward was taken at the meeting, given the persisting uncertainties about expenditure forecasts and the different opinions between delegations.[406] The French Delegation insisted that ESRO should keep financial estimates within the limits laid down in the Convention, which implied, according to their estimates, that TD-3 and TD-5 had to be definitely abandoned, as well as one HEOS (leaving only three) and one large satellite (leaving only two). The problem of the feasibility, scientific advisability, and cost of a single purpose vehicle for the TD series remained unsolved, because of the opposition of those who felt that this would impose too strict limitations to experiments aimed at different scientific objectives and advocated the use of small dedicated satellites instead of large spacecraft carrying many experiments with different scientific aims and technical requirements.

The following STC meeting had no better success in finding an agreement. The main issues regarded the expenditure forecast, in particular the fact that an expenditure peak was going to occur in 1967/68 and the budget exceeded the ceiling imposed by the Financial Protocol annex to the Convention. The STC agreed to maintain the earlier recommendation that only the spacecraft projects already agreed on should go ahead and no new projects should be started for the time being.[407]

The 7th meeting of the STC was not even able to discuss the matter of the revision of the 8-year programme, owing to the budget problems raised by the fact that the AFC had placed a limit on expenditure in 1967 at 230 MFF while, according to the Technical Director, 270 MFF would be needed in order to carry out the agreed programme. The French Delegations argued that should the 1967 budget be restricted to 230 MFF, cuts should be made not in the operational programme but rather in the internal expenditure (buildings and personnel), which they felt was excessive. Waiting for more light about the financial problems, the STC concluded with a discouraging resolution:

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405 Council, 6th session (24-25 March 1965), ESRO/ST/MIN/6, 14 June 1965, p. 7-9.

406 STC, 5th meeting (10-11 June 1965), ESRO/ST/MIN/5, 13 August 1965. The operational programme under discussion, with financial and budgetary implications, is in ESRO/ST/128, 2 June 1965 (with annex ESRO/AF/246). See also the comments of the French Delegations in ESRO/ST/128, add. 1, 14 June 1965.

407 STC, 6th meeting (5-6 October 1965), ESRO/ST/MIN/6, 26 October 1965.

> *The STC does not yet feel in a position to determine whether [...] it will be possible to complete the adopted programme within the time envisaged as regards [the approved projects] ESRO I, ESRO II, TD-1, TD-2, HEOS and LAS.*[408]

In fact, by the end of 1965, contracts had been signed and industrial development work started only for the construction of ESRO I and II (in April 1965 and December 1964, respectively). Tender action had been concluded for HEOS-A and development work started in January 1966, but only on the basis of a preliminary letter of intent while the contract itself was signed only in November that year. As to the TD-1/TD-2 project, the payload composition of the two satellites was approved by the Council in November 1965, but tender action was delayed and no definite information about the cost of the project was available. Finally, the LAS was still in the phase of design studies.

In conclusion, by the end of its second year (not considering the COPERS period), ESRO was still lacking a definite operational programme for its first 8-year lifetime, its management was still unable to make long-term plans on the basis of definite cost estimates and budgets, and European scientists had not even certainty about the actual possibility of launching all satellites under development. The final blow to the optimistic hopes expressed in the *Blue Book* came when the Member States refused to revise the ceilings which in 1961 the scientists had considered sufficient for an ambitious programme and which now proved dramatically insufficient to support even a much reduced programme.

5.3.4 The 1966 crisis and the abandonment of LAS

The year 1966 was the last of ESRO's first 3-year period (1964-1966), a period which was controlled by a financial ceiling of 385 MFF at 1962 prices, established by the Financial Protocol annex to the ESRO Convention. The Protocol also established a ceiling of 602 MFF for the second 3-year period (1967-1969), which left MFF 523 for the last two years of the initial 8-year programme to bring the total up to the ceiling of MFF 1510 set for that period.

During 1966 it became evident that the Organisation was unable to implement during the first three years all the capital investment and construction work for which the budget provided and in fact, after adjustment to 1965 prices, an underspending of 122 MFF was foreseen. In the spring of 1966, in view of the forthcoming Council session called to decide on the budget for the second 3-year period, the STC discussed again the revised 8-year programme and endorsed the proposal of the ESRO Executive that unspent funds allocated to the first 3-year period should be carried forward to the second. On this basis, a budget of 808 MFF (at 1965 prices) for the second 3-year period could be assumed, which implied that work could be begun on a pair of TD satellites roughly every 1.5 to 2 years and on a space probe at intervals of 2 years. The programme would be extended up to 1974 to complete all launchings.[409] The Council, however, did not endorse this position and reaffirmed that the ceiling for the second 3-year period should be kept at 602 MFF at 1962 prices, i.e. 686 MFF at 1965 prices. The budget for 1967 was fixed at 230 MFF at 1965 prices as against the 260 MFF requested by ESRO.[410]

Facing this situation, a severe revision of the programme was required on the basis on the new figures about available resources. Assuming that work on the projects already started (ESRO I, ESRO II and HEOS-A) proceeded as planned, it was clear that "funds are not available to proceed with work on

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408 STC, 7th meeting (5 November 1965), ESRO/ST/MIN/7, 16 December 1965. See ESRO/ST/161, 2 November 1965, with attached FIN/WP/40, rev. 1, 29 October 1965.

409 STC, 9th meeting (2-3 May 1966), ESRO/ST/MIN/9, 7 June 1966, and 11th meeting (15 July 1966), ESRO/ST/MIN/11, 24 August 1966. See also ESRO/ST/201, 27 April 1966. The financial situation and the budget proposal from the ESRO management are in ESRO/AF/476, 20 June 1966.

410 Council, 12th session (18-20 July 1966), ESRO/C/MIN/12, 1 September 1966. The Council went even beyond the recommendation of its AFC, which had proposed to carry forward about half of the unspent money and to set the budget level for the second 3-year period at 750 MFF: see ESRO/AF/549, 7 July 1966, and rev.1, 8 July 1966.

TD-1 and TD-2 and the LAS, even if no new satellites (TD 3/4 and HEOS-B) are started before about 1970". The conclusion:

> *The launching of the LAS during the first 8-year period could therefore only be made possible by either abandoning the TD-1 and TD-2, or reducing the LAS aims and devoting only 160 MFF to the spacecraft and 35-40 to the scientific package.*[411]

Should neither of these alternatives be accepted, the launch the LAS would probably result impossible in 1971, within the 8-year period, and no new satellite project apart from TD-1 and TD-2 could be started before this date. In addition, owing to the approved budget for 1967, it was impossible to maintain the launching schedule for the TD satellites and therefore "some reduction of the aims of these satellites, or some delay, [was] necessary". This was not easy to do, however, for two main reasons: firstly, TD-2 was closely linked to the occurrence of the solar maximum and therefore any delay implied that its payload had to be dramatically reconsidered; secondly, a tender for both TD satellites had been requested and any phasing out of them required a new tender action. Again, two alternative options were presented, both of which foresaw the launching of the LAS outside the 8-year period. In the first, the two TD satellites would be slightly simplified and the LAS programme would be slowed down in such a way as to launch it in 1973-74; in the second, one of the TD satellites would be cancelled from the programme, and the LAS would go ahead more rapidly, with an anticipated launch in 1972-73.

A dramatic discussion took place in the LPAC when they were called to give their advice; all aspects of ESRO's financial matters were analysed in order to avoid any reduction in the operational programme and keep "the viability of ESRO as a reputable scientific organisation". In the event, the LPAC recommended to reduce as much as possible the programme for capital investment, going as far as to propose the elimination of applied research contracts, the moving of ESRO's headquarters and ESDAC to ESTEC and the elimination of ESRIN. Even the abandonment of the sounding rocket programme was considered. As to the main issue, the LPAC strongly affirmed the highest priority of the TD-1/TD-2 programme and recommended that a ceiling of 300 MFF should be imposed on the LAS, of which no more than 200 MFF in the 8-year period. This would leave some money for starting new projects and the LPAC stressed that:

> *ESRO should undertake medium satellites and space probe projects at such level as to ensure that two launchings take place on the average every year. This is considered a minimum programme.*[412]

The LPAC's recommendations were endorsed by the STC after a long discussion that again dealt with all aspects of ESRO's activity and management.[413]

By the end of 1966, the situation of ESRO was dramatic, with the budgetary difficulties seeming to jeopardise even the programmes already approved. In the operational programme the Executive presented to the STC in November, no funds were available for the LAS in 1967 and only 1 MFF could be allocated to the TD-1/TD-2 programme, with the possibility of allocating some 6 MFF from the contingency fund. This programme, however, was due to start in early 1967 and the cost development plans submitted in the tenders foresaw payments of about 20 MFF for that year. This was to be maintained if they wanted to launch TD-2 in the first half of 1970, in time for the solar maximum, and TD-1 six months later. Two alternatives existed in order to keep an acceptable launch

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411 SCI/WP/66, 19 August 1966, p. 4. Also in ESRO/ST/215, 9 September 1966.

412 LPAC, 13th meeting (27 August 1966), ESRO/ST/218, rev. 1, 28 September 1966, p. 6. The conclusions are also reported in ESRO/ST/215, 9 September 1966. The draft budget for 1967 and the forecast estimate for the 1967-69 period based on this recommendation is presented in ESRO/AF/561, 7 September 1966; also in ESRO/ST/216, 9 September 1966.

413 STC, 12th meeting (22-23 September 1966), ESRO/ST/MIN/12, 2 November 1966.

date for TD-2, namely either to get at least 250 MFF available for 1967 from the Council or to reach an agreement with the successful tenderer on a payment plan for 1967 with payments of about 5 MF.[414]

A long and nervous discussion took place in the STC about the whole of ESRO's grim situation. The key issue was again the LAS, the large project which had been thought to be the main rationale for ESRO coming into existence but whose eventual realisation also hampered any other project. Again, the STC agreed (with the only abstention of the United Kingdom) to accord absolute priority to the TD-1/TD-2 project while, by a few painful votes, it was substantially decided to halt the LAS until the Ministerial conference scheduled for the next year examined the new cost estimate and decide on the future of the project.[415]

The Council meeting in December could not find unanimous agreement (as required by the Convention) on the level of resources for the second 3-year period, thus preventing the Organisation from planning ahead on a secure basis. It agreed however on a 1967 budget of 240 MFF and, endorsing the priorities established by the STC, requested the Secretariat to make proposals for savings in order to allow additional expenditure in the order of 4 to 7 MFF for TD-1 and TD-2.[416] Thus, by the end of January 1967, a contract for the construction of TD-1 and TD-2 could finally be awarded.

This set of decisions probably represented the decisive blow to the LAS and, in fact, they showed the prevailing interest among European space scientists in a programme largely based on medium sized satellites, meeting the various scientific objectives and managerial capabilities of several groups, against a programme largely based on large and sophisticated spacecraft.[417]

* * *

By the end of ESRO's first 3-year period, and 5 years after the *Blue Book*, the comparison between the present situation and the original plans was not exciting. Only five small and medium size satellites were under development and could be launched within the 8-year period covered by the Convention; no other project of this kind had been approved yet; the large astronomical satellite was definitely jeopardised and with it any hope to develop large space projects from which ESRO had mainly derived its raison d'être; scientific competition, technical and financial difficulties, and lack of confidence from Member States made any long-term planning almost impossible.

Four main reasons can be given for this resounding set-back. The first regards the multinational character of ESRO and its institutional framework. The Convention had designed an organisation on which tight control was to be kept by member state delegation. This applied to the scope of its scientific programme, the extent of its facilities, and above all its budget, which was fixed over eight years and with fixed ceilings on expenditures at regular intervals. Painful negotiations at several levels were required for most decisions and the executive branch of the Organisation suffered from weakness and lack of autonomy. This was the malaise that J.H. Bannier so vividly described in March 1967, presenting his report on the structure and procedures of ESRO and on the changes deemed necessary.[418]

The second reason derives from the high fragmentation of space science, which implies a wide diversity of interests within the scientific community. The course chosen by the ESRO pioneers to respect this diversity in order to keep a united front in the early development of space research in Europe now collided inevitably with financial realities. When it started to become clear that not all research fields could be pursued and priorities had to be established, the competition among scientists

414 ESRO/ST/229, 28 October 1966.

415 STC, 13th meeting (8-9 November 1966), ESRO/ST/MIN/13, 27 December 1966.

416 Council, 14th session (1-2 December 1966), ESRO/C/MIN/14, 20 January 1967.

417 More details on the LAS story in the following chapter.

418 See chapter 2:

became so fierce as to paralyse ESRO's advisory bodies. At the end of this phase one can already recognise one loser, namely the community of astronomers. Those interested in stars had lost the Large Astronomical Satellite and those interested in the Sun were to fight for the TD-2 payload and eventually lost. When, by the end of 1966, the LPAC started to discuss ESRO's new satellite projects, it was evident that the decision making process would not be painless.

Thirdly, one must mention the dramatic underestimation of the financial resources necessary to support the space research programme anticipated in the *Blue Book* and the glaring inability of ESRO to arrive at definite evaluation of the costs of projects. The lack of experience among engineers and industrialists in Europe about the requirements of space activities was certainly the main reason for this inability. To this one can add the illusory belief in the so-called "transatlantic factor", namely the idea that costs could be significantly lower in Europe than in the United States.

Finally, Member States were not ready to support ESRO by itself. This Organisation, in fact, was but an element in a complex framework which also included several others: the Member States' national space programmes; the European launcher to be developed by ESRO's sister organisation ELDO; the rising interest in application satellites and the commercial implication of space activities; the complex relationship of cooperation-competition between Europe and the United States; the ongoing process of European economic integration. It was in this framework that ESRO's crisis reached its peak. Precisely in December 1966, following one year of negotiations among ESRO, ELDO and CETS (Conference Européenne des Télécommunications par Satellites), the first European Space Conference (ESC) was convened in Paris, with the aim of defining a co-ordinated space policy in Europe. The task could not be accomplished easily, however, and it was only in November 1968 that the third session of the ESC was able to find a tentative solution, thus smoothing the way for the ESRO Council to agree finally on a level of resources for a new 3-year period (1969-71). Only then was ESRO allowed to make plans again.

5.4 Choosing ESRO's first satellites

Within the general framework discussed in the first part of this chapter, we shall now analyse the choice of the scientific payloads of ESRO's first generation of satellites. These were the two small, non-stabilised satellites ESRO I and ESRO II, launched in 1968 and renamed after launch *Aurorae* and *Iris* respectively; the two small highly eccentric orbit satellites HEOS-A and HEOS-A2, launched in 1968 and 1972 and then renamed HEOS-1 and HEOS-2; the medium size, stabilised satellite TD-1, launched in 1972; and the small satellite ESRO IV, also launched in 1972, which replaced the second satellite of the TD series (TD-2). All these were multi-experiment satellites, i.e. the spacecraft carried a payload comprising several instruments provided by different research groups, according to the agreed scientific mission of the satellite and to its technical specifications.

At every level, the selection of a satellite mission and of a specific experiment in its payload involved several intertwined scientific and political aspects. A quick list, in a rather arbitrary order, should include: the proper assessment of the scientific importance of the various research fields in a long term perspective; the financial constraints which limited the range of good projects that could actually be implemented; the scientific and technical assessment of the various experiment proposals, both by themselves and with regards to their compatibility with other experiments in the same satellite payload; the unavoidable competition within the multi-national and multi-disciplinary space science community; the need to comply with the principle of just return in the geographical distribution of industrial contracts; the consideration of the scientific programmes of national space agencies in Europe and of the American NASA; the different views of ESRO's Member States about the place of space research in the general framework of national space policies; and also the feelings, ambitions, expectations, idiosyncrasies and mutual relationships of the rather restricted number of scientists involved in ESRO's advisory bodies.

In the following pages, we will concentrate on those aspects that involved more directly the scientific community and emerged as major issues in the discussions in the LPAC. The main theme will be, as to be expected, the growing competition between the various fields of space science within the progressive retrenching of the satellite programme because of the constraints of the Organisation's financial resources. After a general overview of the status of the programme by the end of 1966, the section is divided into two main parts. The first deals with the choice of the first small satellites' payloads (ESRO I and II, and HEOS-A) and with the difficult definition of the TD satellite programme. This part covers a time span going from early 1963, still in the COPERS period, when the scientific missions of ESRO I and II were defined, to the spring of 1966, when the payload composition of TD-2 was finally approved by the STC and Council. In the second part, the narrative starts from the spring of 1967, when the decision to recommend a second HEOS-type satellite was taken, and then analyses the complex situation determined by the crisis of the TD programme in 1968, and the debates which eventually led to the abandonment of TD-2 and the start of the far less ambitious ESRO IV project.

5.4.1 The status of the scientific satellite programme in 1966

By mid-1966, more than two years after the official inception of ESRO and more than four years after the creation of COPERS, only six satellite projects had been approved by the ESRO Council, of the fifteen included in the revised 8-year programme of the Organisation. These were grouped in four separate families with different technical and orbital characteristics (Table 5-8).[419] The first family included the two small non-stabilised satellites ESRO I and ESRO II: these spacecraft had been designed for launching by Scout rockets into low polar orbit and were devoted to the study of the polar ionosphere, and to solar astronomy and cosmic ray studies respectively. The second family consisted of small, highly eccentric orbit satellites with apogees of about 200,000 km, to be launched launching by means of a Thor Delta rocket. Three to four satellites of this type were included in ESRO's programme and the first member of the family, the 105-kg spin stabilised spacecraft HEOS-A, was devoted to the study of plasma, magnetic fields and cosmic rays inside and outside the magnetosphere.

The third family consisted of heavier, stabilised satellites whose weights, dimensions and characteristics had been designed with a view to their launching by means of a Thor Delta rocket into near Earth orbits. The satellites in this family were planned to be built according to a standard design ("streetcar" concept) and, in fact, it was hoped that the TD-type spacecraft might be a sort of workhorse for the development of the main part of ESRO's satellite programme. Only the first two satellites had been approved, out of the four to six included in the programme, and they were being studied jointly. The first, named TD-1, was devoted to non-solar astronomy; the second, TD-2, carried experiments aimed at investigating the electromagnetic and particle radiation from the Sun and their influence on the ionosphere during the period of maximum solar activity in 1968-69. Finally, the last family included three large satellites for astronomical studies, the first of which was the Large Astronomical Satellite (LAS) to be devoted to high resolution stellar spectroscopy in the UV range. They were to be launched either by the rocket being developed by ELDO or, failing that, by an Atlas Agena launch vehicle.

The scientific missions and the payload composition of these satellites had been agreed on in 1964-65 by the STC, on the basis of the recommendations of the LPAC, and then approved by the Council. Of the 110 proposals for satellite experiments received by ESRO by the end of 1965 (Table 5-9) and numbered from S-1 to S-110, 70 had been recommended by the ad hoc working groups and more than half had been allocated room in the payloads of the satellites under development.[420]

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419 ESRO, General Report, 1964-65.

420 The list of experiment proposals, with proper classification, is reported in the series of documents COPERS/LPSC/32, rev. 1-3, from 21 January 1963 to 12 November 1963, and ESRO/ST/87, plus rev. 1-2, from 25 November 1964 to 7 March 1967. See also ESRO's General Report, 1964-1965.

5.4.2 The small non-stabilised satellites ESRO I and ESRO II

The scientific mission and the payload composition of ESRO's first two satellites was recommended by the COPERS Launching Programme Sub-Committee (LPSC) in the spring of 1963 and then approved by its Scientific and Technical Working Group (STWG) (Tables 5-10 and 5-11).[421] These satellites were also proposed to NASA as a co-operative effort, and eventually NASA offered to provide free launchings of both satellites by Scout rockets.[422]

While keeping their original scientific missions, the payloads of the two satellites underwent a few important changes before final approval by the ESRO Council. In fact, by early 1964, experiment S-31, aimed at measuring micrometeorites, was withdrawn from ESRO II, while the LPSC agreed that experiment S-42 should not be included in ESRO I. It was also agreed to extend the aims of experiment S-71 in ESRO I and to include in ESRO II experiment S-72, proposed by J. Labeyrie and L. Koch of the Centre d'Etudes Nucléaires de Saclay and aimed at measuring solar protons.[423] Subsequently, preliminary design studies showed that the weight of the scientific payload was too high. This posed a question of priorities which, as was pointed out, "affect[ed] the whole philosophy of the satellites".[424] It was decided to ask the ad hoc Working Groups to discuss a "negative priority" list for the experiments already included in both satellites. This was not an easy operation, however. On the one hand, K. Rawer, from the Ionosphären Institut in Breisach, who had joined E. Vassy in the preparation of experiment S-70, strongly objected to the ION Group's recommendation to drop this experiment from ESRO I. On the other hand, R. Boyd preferred to withdraw his experiments S-42 and S-48 when he discovered that both were on the negative priority list for ESRO II. Eventually, the STC confirmed the exclusion of these three experiments in spite of the objections of the German Delegation in defence of Rawer's arguments (Tables 5-12 and 5-13).[425]

Two considerations are suggested by inspection of Tables 5-10 to 5-13. The first is the clear leadership of British groups in European space research, in particular those at University College (Boyd) and Imperial College (Elliot). As the German delegation in the STWG put it: "These two satellites seemed more national than international in character".[426] British space science had certainly a leadership role in Europe: it had started as early as in 1953 a rocket programme for ionospheric studies, with launchings going on since 1957, and was involved since 1959 in the Ariel satellite programme in collaboration with NASA. The British scientists, among whom Boyd and Elliot were authoritative spokesmen, had been enthusiastic about the perspective of European collaboration in space research and contributed significantly to the definition of the institutional framework and the scientific programme of the new Organisation.[427]

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421 LPSC, 5th meeting (6-7 March 1963), COPERS/LPSC/70, 2 April 1963; 6th meeting (29 April 1963), COPERS/LPSC/84, 7 May 1963. STWG, 9th meeting (30-31 May 1963), COPERS/GTST/98, 20 June 1963. Also COPERS/GTST/82, rev. 1, 14 June 1963.

422 In December 1963 and in January 1964, discussions took place in Washington and in Paris, respectively, between ESA and NASA about eventual co-operation in scientific satellite projects, in particular about the proposed payloads of ESRO I and II. The content and outcome of these discussions are presented in COPERS/GTST/139, 11 February 196. See also Krige & Sebesta (1994).

423 LPSC, 8th meeting (7-8 February 1964), COPERS/LPSC/123, 3 March 1964.

424 Interim LPSC, 1st meeting (23 April 1964), ESRO/ST/14, 4 June 1964, p. 3. See also the meeting of the Interim Scientific and Technical Working Group (25-26 May 1964), ESRO/ST/32, 11 June 1964, p. 4.

425 The decisions of the ad hoc working groups (with Rawer's objections) are in ESRO/ST/44, 20 July 1964 and ESRO/ST/45, 29 July 1964 for ESRO I and ESRO II respectively. Discussions and decisions were taken at the second meeting of the Interim LPSC (30 July 1964), ESRO/ST/60, 31 August 1964, p. 4-6, and at the first meeting of the STC (10-11 September 1964), ESRO/ST/MIN/1, 14 October 1964, p. 3-4. The new payloads recommended for ESRO I and ESRO II are presented in ESRO/C/73, 13 November 1964 and were approved by the Council at its 5th session (25-26 November 1964), ESRO/C/MIN/6, 11 January 1965, p. 3. Experiment S-70 was rather heavy (4 kg), with a high power consumption and mechanically complicated.

426 STWG, 9th meeting (30-31 May 1963), COPERS/GTST/98, 20 June 1963, p. 5.

427 Massey and Robins (1986).

The second consideration regards the scientific aims of the two satellites. These were small, non-stabilised spacecraft, carrying very simple experiments designed to measure the radiation environment around the spacecraft, either ionospheric particles or solar radiation or cosmic rays. This kind of experiment represented a direct extrapolation to satellite projects of the experience matured with sounding rocket experiments, and met the scientific interests of a substantial part of the young but already well established European space science community. ESRO I, in particular, followed the well established tradition of rocket-borne experiments to investigate auroral phenomena and the polar ionosphere.

5.4.3 HEOS-A and the problem of ESRO's deep space telemetry network

Among the experiment proposals recommended by the ad hoc Working Groups in the spring of 1963, six required highly eccentric orbit satellites (HEOS). Three of these had been proposed by the PLA group for studies of the interplanetary medium, and three by the COS Group for the study of the relation between the fluctuations in the geomagnetic field and the acceleration and dumping of Van Allen particles. The latter group had also recommended a space probe (SP) to measure cosmic rays, magnetic fields and interplanetary plasmas at considerable distance from the Earth's magnetic fields. The LPSC invited the two groups to co-operate in order to find a good scientific mission for a spacecraft journey very far away from the Earth and, at the same time, requested ESTEC to start studying possible orbits and associated tracking and telemetry problems.[428]

A meeting was arranged between the chairman of the PLA group and representatives of the COS Group, followed by a meeting of the COS Group which produced a proposal of an integrated payload with a set of experiments for simultaneous measurements of plasma, magnetic field and cosmic ray particles. The payload was eventually approved by the LPSC, with the further recommendation that a second HEOS or SP should be launched a year later and that for this, "consideration should be given in the first instance to the proposals from the PLA ad hoc working group".[429] When the matter arrived at the STC, however, the French Delegation expressed their anxiety about the costs of the space probes, owing to the requirement of a deep space telemetry network. In fact, the network which ESRO was building for low orbit satellites (ESTRACK) was not suitable for spacecraft in highly eccentric or escape orbits. The problem regarded not only the first such spacecraft but the whole satellite programme of ESRO, in particular if the cometary mission under study should be chosen as the second large project after the LAS.[430]

A short technical digression may be useful at this point, with regards to four aspects of the difference between a network for low orbit satellites and a deep space network.[431] The first is the geographical requirement. For low orbits, the satellite motion is predominant as compared with the Earth's rotation and therefore, in order to observe all orbits at least once per revolution, about 8 to 10 stations are required along great circles oriented broadly in the direction North-South. For a satellite on a highly eccentric orbit or for a space probe, the situation is entirely different because it is the Earth's motion which is predominant. In other words, when the spacecraft is far away from Earth, namely for most of its revolution time, it can be considered to stay motionless while the Earth rotates below it. In this case, a continuous observation can be achieved by a network consisting of three stations located almost at the same latitude (preferably lower than 30 degrees) but evenly spaced from one another in longitude.

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428 Ad hoc group G [COS Group], 3rd meeting (19 March 1963), COPERS/LPSC/78, 24 April 1963, with appendices 1 and 2. LPSC, 6th meeting (29 April 1963), COPERS/LPSC/84, 7 May 1963; 8th meeting (7-8 February 1964), COPERS/LPSC/123, 3 March 1964. See also COPERS/LPSC/80, 26 April 1963 and COPERS/GTST/82, rev. 1, 14 June 1963.

429 COS Group, 6th meeting (13 March 1964), ESRO/ST/10, 21 April 1964. Interim LPSC, 2nd meeting (20 July 1964), ESRO/ST/60, 31 August 1964, p. 7-8. All relevant documents are grouped in ESRO/ST/6, 15 April 1964 and in ESRO/ST/33, 20 July 1964.

430 STC, 1st meeting (10-11 September 1964), ESRO/ST/MIN/1, 14 October 1964.

431 ESRO/ST/6, 15 April 1964, appendix 3. More technical aspects are presented in ESRO/ST/92, 12 January 1965.

The second aspect regards the visibility time from a station. Low orbit satellites can be observed from one station for a short time, usually less than 20 minutes, and it is therefore necessary to record at low speed the instrument readings during most of the orbital period, and to play back the information rapidly when the satellite passes over a station. For satellites on highly eccentric orbits, the time during which it is visible from one station is of the order of hours (except if the station sees the satellite when it is near the perigee, in which case the observation time is of the order of 3 minutes). The information can be transmitted to Earth all along the orbit, either in real time, with a three-station network, or by playing back stored data if only two stations are available.

The third aspect regards the telemetry frequency. The ESRO network being built for low altitude satellites operated on 136/137 MHz, a frequency which is not very attractive for long distance space communication, due to galactic noise. Both for this reason and to increase the bit rate, it is preferable to use a higher frequency (400 or 1700 MHz) and then larger antenna dishes, with corresponding cost increase.

Finally, the fourth aspect regards the tracking of satellites. For tracking purposes it is not necessary to make position measurements evenly distributed over the orbit but it is imperative to make at least a minimum number of relatively accurate measurements during each orbit. Here again, ESRO's low orbit network drastically limited the possibility of making reliable measurements and it appeared inevitable to consider the realisation of a system better suited for long distance tracking. This also had important implications in so far as time-scale and budget were concerned.

Facing these problems and the French objections, the STC decided not to take a decision on the recommended payload before having investigated better the implications of the project as regards the setting-up of a deep space facility. In particular, it was also recognised that considerable differences in costs and technical requirements occurred between a network suitable for highly eccentric orbit satellites only and a network for deep space probes. The LPAC did not push the matter further for the moment but it agreed that a highly eccentric orbit with apogee of 200,000 km ought to be sufficient for the first highly eccentric orbit satellite (HEOS-A), as this would take the spacecraft outside the magnetosphere.[432] A study was then realised in ESTEC about a network suitable for such an orbit where two alternatives were presented:

1. A three-station network based on stations almost identical with ESTRACK-type stations and located in, say, Australia, southern Europe and Mexico (or southern USA).

2. A two-station network using higher frequency and larger antenna dishes (about 25 m diameter).[433]

The first option would be satisfactory for HEOS-A and could also be used for near Earth satellites in conjunction with the other stations in the ESTRACK network. The bit rate obtainable at 200,000 km was estimated 10 per sec. However, in order to convert it to a real deep space network, it would require replacement of the antennae and change of the frequency of operation. The two-station network would allow a bit rate about three times higher and could be converted to deep space use by the relatively simple modification of changing the frequency of operation. On the other hand, the absence of a third station would produce a gap of about 6 hours in operation every 24 hours. The cost of the two networks was estimated as roughly the same, in the bracket of 40 to 50 million French Francs (MFF). It was also estimated that both the addition of a third station to the two-station network and the conversion of the three-station network to large dishes would require about 20 MFF.

On this basis the matter was discussed again by the STC, where the scientific value of the payload recommended by the LPAC for HEOS-A was strongly advocated by the Italian, Swedish and German delegations. It was finally agreed, with the abstentions of France and Belgium, to recommend to the

432 LPAC, 4th meeting (1 February 1965), ESRO/ST/106, 17 February 1965.
433 ESRO/ST/111, 4 March 1965. Other and more technical aspects are presented in ESRO/ST/92, 12 January 1965.

Council the inclusion of this payload in the ESRO programme.[434] The Council eventually approved the payload, but, following the arguments of the French delegation, it did not endorse any extension of the tracking and telemetry network in addition to the new ESTRACK station already planned in the Falkland Islands, and requested a further study before coming to a decision.[435] The study was eventually performed and it showed that, besides the available ESTRACK and CNES stations, one additional station was required in order to meet the minimum scientific requirements for HEOS-A. This additional coverage could be provided by a station planned by ELDO for its programme in Australia, at a cost of less than 1 MFF for additional equipment.[436] The Council approved this solution and, after a further recommendation of the COS Group to include experiment S-79 to measure cosmic ray electrons, it approved the final payload of HEOS-A in the form given in Table 5-14.[437]

5.4.4 The TD programme and the definition of the TD-1 payload

Since the very beginning many experiment proposals had been recommended by the ad hoc Working Groups for inclusion in the payload of a stabilised satellite and a design study for such a satellite was being performed by the Royal Aircraft Establishment.[438] The use of a stabilised platform made this spacecraft suitable for astronomical observations and in fact, in April 1964, the LPSC recommended to carry out two feasibility studies, one combining solar and stellar astronomy experiments and the other with only non-solar astronomy experiments.[439] Subsequently, at the very beginning of ESRO's official life, it was decided to devote the first stabilised satellite to stellar astronomy and the second to solar astronomy.[440] Only the payload of the former was approved (Table 5-15a), however, pending the revision of ESRO's 8-year programme. When the advantage was recognised of using the Thor Delta (TD) rocket as a medium launching vehicle, the LPAC recommended a programme of six TD-type standard spacecraft, the first two of which (TD-1 and TD-2) were to be the already agreed satellites for stellar and solar astronomy, respectively. A third TD satellite was to be devoted to ionospheric studies, with the assumption that the solar satellite TD-2 and the ionospheric satellite TD-3 would be launched in time for the solar maximum in 1968-69, in order to study the correlation between solar activity and ionospheric phenomena.[441] Before any discussion about the payload composition of these two satellites could take place, however, financial difficulties and the opposition of a few member state delegations to the "streetcar" concept led to the abandonment of TD-3 and therefore it was decided to ask the ad hoc scientific groups to submit fresh proposals for TD-2, now to be considered as "a solar, ionospheric and geophysical satellite".[442] This was but a compromise, based on the idea that it could be possible to combine in a single spacecraft scientific objectives which pertained to very different scientific fields, namely the study of the Sun, of the ionosphere of the solar-terrestrial relations. Hardly surprisingly, it revealed itself a bad compromise which led to harsh competition and eventually to the abandonment of TD-2.

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434 STC, 4th meeting (10-11 March 1965), ESRO/ST/MIN/4, 3 May 1965.

435 Council, 6th session (24-25 March 1965), ESRO/C/MIN/6, 14 June 1965, p. 8. The French position is in ESRO/C/114, 24 March 1965. The status and planning of ESTRACK by early 1965 is presented in ESRO/ST/94, 8 January 1965.

436 ESRO/C/119, 18 May 1965.

437 Council, 7th session (27-28 July 1965), ESRO/C/MIN/7, 23 September 1965; 9th session (24-26 November 1965), ESRO/C/MIN/9, 31 January 1966. See ESRO/C/149, 12 November 1965. An electron detector in the payload of HEOS-A had been recommended by the COS Group at the beginning but no proposal was available at that time. The choice of S-79 was made by the COS Group at its 10th meeting (14 April 1965), COS/10, 17 May 1965.

438 ESRO/ST/5, 17 April 1964.

439 Interim LPSC, 1st meeting (23 April 1964), ESRO/ST/14, 4 June 1964. A third payload, also including experiments devoted to solar and stellar astronomy but with more emphasis on the former was proposed by the SUN group. The different options are discussed in ESRO/ST/39, 17 July 1964.

440 Interim LPSC, 2nd meeting (30 July 1964), ESRO/ST/60, 31 August 1964; STC, 1st meeting (10-11 September 1964), ESRO/ST/MIN/1, 14 October 1964.

441 LPAC, 2nd meeting (24 November 1964), ESRO/ST/89.

442 LPAC, 5th meeting (19 March 1965), ESRO/ST/116, 2 April 1965, p. 6.

The problem of the payload composition of the two TD satellites was discussed by the LPAC in July 1965, after new information on the performance of the augmented Thor Delta launcher had shown that larger satellites of this series were possible and new payload space was thus available. Here the competition between scientists interested in the various field of space research showed itself a difficult issue to cope with. On the one hand, B. Hultqvist, on behalf of the ION group, strongly argued in favour of experiment S-17, proposed by W. Dieminger, from the Max-Planck-Institut für Aeronomie in Lindau/Harz, and aimed at studying the topside of the ionosphere by a special sounder (the so-called "topside sounder"). This experiment had been originally suggested as the main experiment in the "ionospheric satellite" TD-3; now the ION group gave it the highest priority and insisted that it should be included in TD-2. On the other hand, C. de Jager, on behalf of the SUN group, argued that the two satellites should include a solar spectrograph covering the range from Lyman-alpha (1216 Å) up to 300 MeV and realised by the combination of 8 experiments.[443] A long discussion followed, in particular about the scientific merits of the topside sounder in comparison with other kinds of measurement and in consideration of the vigorous programme of topside sounder satellites was already being pursued in Canada (*Alouette* satellite programme). It was also realised that the inclusion of the topside sounder would considerably affect the design of the satellite, making it significantly different from TD-1 and thus jeopardising the streetcar concept. In the event, the LPAC confirmed that TD-1 and TD-2 should be based on the same design, with the possibility of stabilisation of the order of 1 minute of arc. The topside sounder in its present design could therefore not be included in the TD-2 payload. The LPAC recommended the addition of three more experiments to TD-1 (Table 5-15b) and composed a tentative payload for TD-2, with the proviso that a study should be made on the possible modification of the topside experiment in such a way that it could also be included. This was again a compromise, of course, and the conflict was to explode soon.

5.4.5 The TD-2 payload and the topside sounder controversy [444]

The discussion on the TD-2 satellite was resumed, in an atmosphere of growing tension, at the following meeting of the LPAC. Further studies had demonstrated in fact that, if one wanted a common design for the two satellites, the inclusion of the topside sounder experiment, even after reduction of weight, power and size, was scientifically and technologically incompatible with the probe experiments already approved for inclusion in the payload.[445] A choice had to be made which could not be painless, considering that the LPAC had to confront "the opinions of the ION group and of other scientists and of letters which the chairman had received on this subject". After long discussions the LPAC concluded that:

> *At this stage the LPAC should concern itself solely with giving its unbiased scientific judgement to the STC, taking into account, of course, the technical and financial resources available. [...] Considering all these factors, the LPAC felt that a higher scientific priority should be given to the probe experiments compared to the topside sounder.*[446]

The main reason for the LPAC's decision was certainly the willingness to keep the design of TD-2 as much as possible similar to that of TD-1, both for financial reasons and because they wished to base the core of ESRO's satellite programme on a highly stabilised spacecraft, suitable for astrophysical investigation. The inclusion of the topside sounder would have required major changes in the design,

443 LPAC, 7th meeting (9 July 1965), ESRO/ST/134, 5 August 1965. On the augmented Thor Delta launcher see SCI/WP/32, 3 May 1965 and SCI/WP/36, 6 July 1965. The weight of the scientific package could be increased from 54 to 80 Kg. The recommendations of the three interested scientific ad hoc groups SUN, ION and COS are presented in SUN/12, 30 June 1965; ION/18, 8 July 1965 and COS/12, 8 July 1965, respectively.

444 A list of documents relevant for the story of the topside sounder proposal is in GEN/WP/74, 23 September 1966.

445 SCI/WP/40, 6 September 1965.

446 LPAC, 8th meeting (10 September 1965), ESRO/ST/136, 5 October 1965, p. 3-4. See also ESRO/ST/145, 24 September 1965 and ESRO/C/131, 13 July 1965.

particularly in the stabilisation system, and would have significantly shifted the satellite's scientific mission towards the field of ionospheric research. The latter was certainly respectable and it had been the first to take full advantage of the advent of space technologies; it was also true, however, that a lot of good work had been done already in this field and the future of space science seemed not being there but rather in more complex satellite technologies, aimed at investigating distant celestial objects or the Earth's space environment far beyond the atmosphere.

The reaction of the ION group could not have been harsher. The group approved two resolutions in which the whole scientific policy of the LPAC was challenged and an alternative proposal for the TD-2 payload recommended.[447] In the first resolution, a strong case was made against the alleged unfair distribution of the experiments allocated in the five approved satellites (excluding the LAS) between the astronomical disciplines (covered by the SUN and STAR groups) and the disciplines covered by the other groups. In this context, the penalisation of experiments of interest for the ION group was particularly underlined: they represented 35 % of proposals but only 23 % of allocated experiments. The document then claimed in crescendo:

> *The ad hoc Working Group for the Ionosphere and Auroral Phenomena represents a larger number of groups actively interested in European space research than any of the other ad hoc working groups. The international reputation of the European work in these fields is very high. The total number of scientists engaged in ionospheric and auroral studies represents an important fraction of all scientists involved in ESRO activity.*[448]

Blaming the LPAC for not having adequately taken into consideration the opinions and the expectations of the majority of scientists working in the ionospheric and auroral field, the ION group went as far as to recommend that the LPAC should include a full member with special interest in the ionosphere, in order "to remedy the present unsatisfactory situation [and] to ensure a more reasonable distribution of ESRO's limited resources".[449]

With regards to the LPAC's decision on the TD-2 payload, the ION group's judgement was that "[it] is scientifically not sound and that it presents a deep deception of the justified expectations of European scientists engaged in geophysical research". They argued that the present design for TD-2, which required a very expensive stabilisation, should be replaced by a new design for a geophysical satellite with no or inexpensive stabilisation, carrying a payload based on the topside sounder (S-17) and a few other experiments.[450]

Lüst could not accept this criticism of legitimacy to his LPAC and prepared a statement which he submitted to the following Committee meeting. In this statement, the chairman reaffirmed that the LPAC composed payloads only on the basis of the agreed scientific mission of a given spacecraft, taking into account the scientific merits of the experiment proposals and their technical and financial implications. As to the distribution of experiments among the various disciplines, Lüst insisted that "the LPAC achieved this distribution surprisingly well since the percentage of the allocated experiments seems to be balanced very well". In any case, he continued, "it must also be the task of the LPAC to stimulate research in those fields where the activity is not yet high enough". Finally, Lüst

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447 ION group, 13th meeting (14 September 1965), ION/24, 5 October 1965. The resolutions approved are ION/22, 22 September 1965 (on the LPAC policy) and ION/23, 22 September 1965 (on the TD-2 payload). The latter was also sent to the STC with the code number ESRO/ST/141, 28 September 1965. Recall the dissatisfaction of the ION group towards the LPAC's scientific policy expressed by Hultqvist a few months earlier, when the STC discussed the revision of ESRO's 8-year programme.

448 ION/22, cit., appendix, p. 1. A table in this appendix presents the distribution of experiment proposals and allocated experiments among the various ad hoc groups.

449 ION/22, cit., p. 1.

450 ION/23, cit., p. 1.

felt obliged to remark that two of the four members of the LPAC were involved in ionospheric research more or less directly and none of them was interested only in stellar astronomy.[451]

After a long discussion, on which, unfortunately, the minutes do not give us any information, the meeting agreed to Lüst's statement and only accepted the ION group's request that in the future, if the LPAC did not follow the recommendations of an ad hoc group, detailed explanations should be reported to the group itself.

Then it was up to the STC to deal with the matter and to make a final recommendation to the Council. Here again scientific and technical aspects intertwined with the still controversial question of the opportunity of making the spacecraft for TD-1 and TD-2 as far as possible identical. During the discussion, Lüst asked the vice-chairman B. Peters to take the chair in order to allow him greater freedom to express his views in his capacity as chairman of the LPAC. In the event, the delegations were called to vote: Belgium, Denmark, France, Germany, Spain and Sweden voted for the inclusion of the topside sounder in the payload of TD-2; Italy, the Netherlands and the United Kingdom voted against; the Swiss delegation was absent. Therefore, upsetting the recommendation of the LPAC, the STC recommended that the probe experiments be replaced by the topside sounder.[452] The Council endorsed this decision and authorised the STC to make any changes that might prove necessary in order to fit the topside sounder in the payload.[453]

Some information on the composition of the STC at this meeting may be useful to understand the outcome of the discussion. Three influential scientists were delegates of the countries voting against the topside sounder, namely G. Occhialini (I), H. van de Hulst (NL) and R. Boyd (UK), the latter being also a member of the LPAC. Their vote was certainly determined by their scientific interests and by their preference for the streetcar concept for the TD series. The Netherlands delegation, for example, was explicit in the statement that "much of the information on the ionosphere is being constantly collected by other topside sounder experiments and therefore the topside sounder was less important than the other experiments". The United Kingdom delegation, for their part, said that "they had always believed that TD-1 and TD-2 should be as similar as possible". Finally, ESRO's scientific director B. Bolin recalled that the ION group's suggestion to design a spacecraft with a much simpler stabilisation system would have excluded experiments aimed at direct solar observation, what was hardly acceptable for a satellite aimed at studying solar-terrestrial phenomena related to the solar maximum.

The most influential countries voting in favour of the topside sounder were Sweden, France and Germany. Sweden was represented by B. Hultqvist, the chairman of the ION group and an obvious advocate of the topside sounder. He reaffirmed that "the topside sounder was the most powerful ionospheric equipment that existed", and that the ION group had proposed unanimously that it should be the key experiment in TD-2. France was notoriously against the streetcar concept (recall the opposition of the CNES's president, J. Coulomb), and the French delegation in the STC did not include any scientist, but two top officials from the CNES (M. Bignier and A. Lebeau).[454] Germany was also critical of the streetcar concept and it was officially represented in the STC not by Lüst, the chairman of both the STC and the LPAC, but by a ministerial top official (Regula) and by W. Priester, a scientist involved in atmospheric research, while the proposer of the topside sounder, W. Dieminger, acted as an adviser. We have no hints about the reasons for the vote of the other delegations except, perhaps, the lukewarm attitude of Belgium towards the streetcar concept.

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451 LPAC, 9th meeting (18 October 1965), ESRO/ST/154, 9 November 1965, p. 3. Only Lüst and Boyd of the LPAC participated in the meeting. This was also attended by the President of the Council, A. Hocker, by the chairmen of all ad hoc groups except for de Jager, and by a numerous group from the Executive, including the Director General P. Auger and the Technical Director A.W. Lines.

452 STC, 6th meeting (5-6 October 1965), ESRO/ST/MIN/6, 26 October 1965. The discussion on the to side sounder is on p. 4-6. The new payload composition is in ESRO/C/148, 12 November 1965.

453 Council, 9th session (24-26 November 1965), ESRO/C/MIN/9, 31 January 1966.

454 to the streetcar concept.

After the STC meeting, ESTEC's engineers put themselves to work with the S-17 experimenters in order to solve the technical difficulties connected with the inclusion of the topside sounder in the TD-2 payload. It was recognised that a modification of the antenna was possible so that it would not disturb the stabilisation of the satellite but, on the other hand, a serious problem arose regarding the telemetry requirements. In fact, 60,000 bits per second were required to telemeter the complete output and it was not possible to store such an amount of information on the onboard tape recorder. Therefore, data could only be transmitted in real time during each pass of the satellite over a telemetry station, what required at least half of the time of contact with the station. This significantly limited the amount of information available from the topside sounder and, at the same time, it implied that half of the total telemetry capacity of the satellite had to be allocated to this experiment.[455]

According to W. Dieminger, the proposer of S-17, the topside sounder experiment remained scientifically valuable even in the worst condition, but the LPAC wanted to reaffirm their reservations. They could not upset the policy established by the STC, of course, but the message they sent to the Committee was clear enough. In fact, the decision to confirm the topside sounder in the TD-2 payload was agreed with the abstentions of two of the three members of the LPAC attending the meeting (Blamont and de Jager) and of four of the six chairmen of ad hoc groups (Frith, de Jager, Occhialini and Swings). The third LPAC member, chairman Lüst, who was also the chairman of the STC, could not but vote in favour while the fourth member, Boyd, an opponent of the topside sounder, was absent. The chairmen of ad hoc groups voting in favour were Hultqvist (of course) and L. Biermann, a German theoretical astrophysicist interested in solar wind phenomena. The LPAC also agreed to present the STC with the following statement:

> *The LPAC expresses concern about the technical difficulties which will probably be encountered in the development of TD-2. The experimenters involved should be kept informed on the status of the project and, particularly, on possible interference problems. The development costs of TD-2 should be thoroughly assessed.*[456]

In the event, a preliminary assessment of costs performed in ESTEC reopened the whole question. As the engineers vividly put it, it was not possible to deal cheaply with the technical difficulty caused "by attempting to put an experiment into a satellite with which it is not compatible".[457] Taking together both TD satellites the figures were: 80 MFF for two different scientific payloads integrated into a standard spacecraft (streetcar concept); 100 to 125 MF for two different spacecraft but with common components; 160 to 275 for TD-1 and TD-2 as now proposed. A wise alternative was then suggested, i.e. to build two similar TD spacecraft, as originally suggested by the LPAC, and to carry out the topside sounder experiment in a separate Scout-type satellite.

On the basis of the new information, the discussion on the topside sounder experiment was resumed in the STC and a new vote was called. Only the Swedish delegation (i.e. Hultqvist) was now in favour. Belgium, Denmark, Germany, the Netherlands and the United Kingdom voted against; France, Italy and Spain abstained.[458] Then the question came of to what should be done with the topside sounder. The Danish delegation stressed that it had voted for its omission from TD-2 only on the understanding that it would be flown somehow or other. France and Italy called for further information. The German delegation pointed out that Dieminger's group had been working on this experiment for a long time. The British urged proper consideration of the scientific aspects, as "there would be many launchings of topside sounders on the other side of the Atlantic". In the event, it was agreed to request ESTEC to

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455 SCI/WP/51, 9 December 1965.
456 LPAC, 10th meeting (13 December 1965), ESRO/ST/168, 4 January 1966, p. 6.
457 ESRO/ST/177, 27 January 1966, p. 3.
458 STC, 8th meeting (14-15 February 1966), ESRO/ST/MIN/8. The Swiss delegation was absent.

study the technical and financial implications of the Scout-satellite option, while the scientific merits of the project would be discussed by the ION group and by the LPAC.[459]

Not surprisingly the ION group expressed a strong recommendation to launch S-17 by Scout.[460] They again recalled the outstanding contribution of European scientists to ionospheric physics and stressed that "the proposed experiment would involve an exceptional number of scientific groups". Five groups had indicated their wish to receive and process data from the topside sounder and Dieminger offered to waive the normal experimenters' priority for receiving his data and to enable other groups to participate fully in the analysis of the results. It is fair to say that the whole scientific community interested in ionospheric research was advocating that ESRO should launch the topside sounder experiment in one of its satellites.

They did not succeed. The LPAC, in fact, "taking into account the estimate of cost of 30 MFF, in view of the severe financial limitations of ESRO", decided not to recommend this expenditure which, in their opinion, was not "entirely justified on scientific grounds". The LPAC recognised, however, that:

> *The sequence of events leading to this proposal, involving considerations other than scientific, may be taken into account when the Council makes its final decision.*[461]

The chairman of the LPAC explained to the STC that this last sentence, which opened the door to a political decision in favour of the topside sounder, had been included in the approved statement because his committee felt that ESRO had certain responsibilities towards the experimenter who had been working on this experiment for some time. Furthermore, Lüst recalled that "several delegations [in the STC] had agreed to the elimination of the topside sounder from the TD-2 payload on the understanding that some other solution would be found for this experiment". The STC finally agreed to endorse the LPAC decision not to recommend to the Council the approval of the topside sounder experiment on a separate Scout vehicle and, by a majority vote, decided to delete the last sentence in the LPAC resolution.[462]

When the matter came to the Council, the German delegation stressed that "the future of Prof. Dieminger's group was at stake [as] it had been working on the topside sounder experiment for about a year on the understanding that it would be flown by ESRO". In the event, the Council approved the STC's recommendation which definitely ruled out the topside sounder experiment, but also asked the STC's chairman to assist Dieminger's group in his search for collaboration with NASA.[463]

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The approved payloads of both TD-1 and TD-2 underwent small changes in the following months. In late 1966, experiments S-30 and S-96 were withdrawn from TD-1 and TD-2 respectively, and the ad hoc groups were called to submit recommendations for replacement. The LPAC eventually agreed to

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459 *Ibidem*, p. 5. The feasibility of a Scout-type satellite for launching the topside sounder is discussed in ION/30, 4 March 1965. The STC also requested the Council for authorisation to take a final decision on this matter but it did not obtain the necessary delegation of power: Council, 10th session (24-25 March 1966), ESRO/C/MIN/10, 10 June 1966, p. 3-4. See ESRO/C/174, 9 March 1966.

460 ION group, 15th meeting (15 March 1966), ION/31, 17 March 1966. The arguments in favour of the topside sounder are presented in detail in ION/32, 26 March 1966, from which the follwing quotation is taken (p. 2).

461 LPAC, 12th meeting (5 April 1966), ESRO/ST/207, p. 4. The new chairman of the ION group, A.P. Willmore, abstained. The resolution of the LPAC is also reported in ESRO/ST/195, 13 April 1966, with attached ION/32 and ESTEC's report SCI/WP/59, 25 March 1966.

462 STC, 9th meeting (2-3 May 1966), ESRO/ST/MIN/9, 7 June 1966, p. 15. Italy, Netherlands, Spain, Sweden and the United Kingdom voted in favour of the deletion; France and Germany against; Belgium, Denmark and Switzerland abstained.

463 Council, 11th session (22-24 June 1966), ESRO/C/MIN/11, 15 July 1966, p. 6.

recommend experiment S-125/S-133 for TD-1 and experiments S-118 and S-126 for TD-2.[464] Finally, in early 1970, experiment S-1 was withdrawn from TD-1. The final configuration of the two payloads is reported in Tables 5-16 and 5-17.

One consideration is suggested by inspection of these tables, which touch the resulting hybrid composition of the two TD payloads. TD-1 had originally been devoted to non-solar astronomy. Subsequently, when the new capability of the Thor Delta launcher allowed an increase of the payload weight, two experiments on solar physics had been added and one for cosmic ray studies. TD-2 was to be devoted to solar astronomy but, when financial and institutional difficulties led to the abandonment of TD-3, its mission was redefined in order to include other research fields. This resulted in very complex payloads, including various uncorrelated experiments in both branches of astrophysics (solar and stellar), in atmospheric and ionospheric physics, and in cosmic ray physics. Again this puts into evidence the fluid condition of the European space science community in 1965, still unable (and also unwilling, we should say) to use ESRO's limited resources to implement a satellite programme based on a few well defined scientific missions, supported by technically sophisticated instrumentation. On the contrary, in a context characterised by great uncertainty regarding the technical and financial conditions of the satellite programme, any research group and any sector of the scientific community could lobby for a share in ESRO's spacecraft. The lack of an authoritative scientific staff in ESRO and the weakness of its management *vis-à-vis* member state delegations are the main reasons for this unhealthy situation. In 1966 this was still compensated by the ongoing LAS project, but after the abandonment of ESRO's most ambitious project and the drastic retrenchment of the financial resources available to the Organisation, the need of establishing scientific guidelines and priorities became inescapable.

5.4.6 The second highly eccentric orbit satellite and the ESLAB controversy

In 1967, within the framework of discussions about future satellite projects, the LPAC recommended that the HEOS-A spacecraft should be used for a second highly eccentric orbit satellite (HEOS-A2). The scientific mission of this satellite was to be defined by the chairman of the LPAC together with the chairmen of the ION, PLA and COS Groups. The recommendation was endorsed by the STC who invited scientific groups in Europe to submit experiment proposals that, in their words, "could include either new experiments, repeats of experiments of HEOS-A1, or modified versions of these".[465]

Seventeen proposals were received by March 1968 and examined by the three interested Working Groups. They agreed that HEOS-A2 should be injected into an orbit of high latitude apogee and its mission should include "a study of propagation of cosmic rays in the solar system in correlation with direct measurements of interplanetary fields and particles and of the properties of the boundary between the magnetosphere and interplanetary space". On this basis, the chairmen of the groups proposed a payload composition to the LPAC.[466]

The LPAC had no difficulty in approving the proposed payload, but for one experiment for which two almost identical proposals existed: S-204, proposed by D.E. Page, from ESRO's scientific laboratory (ESLAB), and S-217, proposed by J. Labeyrie, from the Centre d'Etudes Nucléaires in Saclay.[467] Both experiments aimed at measuring intermediate energy particles and, according to the COS Group, "although S-204 was technically the better experiment, S-217 should have priority because of the

464 LPAC, 16th meeting (8-9 February 1967), ESRO/ST/245, 8 March 1967. The recommendation was accepted by the STC at its 14th meeting (21 February 1967), ESRO/ST/MIN/14, 10 April 1967. Both S-125 and S-133 aimed at measuring celestial gamma rays, the former being proposed by Lüst and the latter by Occhialini and Labeyrie. The two groups decided to collaborate and the experiment was eventually known as S-133. See also ESRO/ST/213, 9 September 1966 and SCI/WP/75, 30 January 1967.

465 LPAC, 17th meeting (11 April 1967), ESRO/ST/253, 30 April 1967; 18th meeting (28 September 1967), ESRO/ST/271, 9 October 1967. STC, 16th meeting (9-10 October 1967), ESRO/ST/MIN/16, 29 November 1967, p. 5. See also SCI/WP/94, 22 September 1967.

466 ESRO/ST/290, 27 June 1968, p. 1.

467 LPAC, 22nd meeting (3 May 1968), LPAC/6, 17 June 1968.

wider energy ranges covered".[468] When reporting to the LPAC, however, the chairwoman of the COS Group, C. Dilworth, said that both experiments had been modified since and now they resembled each other more than before so that, in her opinion, the matter should be referred back to the COS Group for further discussion.

As a matter of fact, the choice between these two experiments involved considerations other than of purely scientific value. The real issue was that S-204 was the first experiment proposal coming from within ESRO which was a serious candidate for inclusion in an satellite payload, and it was in direct competition with a similar experiment proposed by a French group which usually enjoyed a large share in ESRO spacecraft. The establishment of a research laboratory within ESRO had been one of the main controversial issues in the COPERS period, when the institutional framework of the Organisation was discussed, and ESLAB was the outcome of a compromise which implied that ESRO's scientists were not to compete with research groups in Member States.[469] This non-scientific consideration, more than the wider energy range covered, had possibly influenced the COS Group's original choice of Labeyrie's experiment, "although S-204 was technically the better experiment". What had happened since exposed the real question, however, as the ESLAB group had shown that they could extend their energy range by a simple modification of their experiment and the Saclay group had taken over a part of the design of their competitor in order to improve the performance of their own.[470] After a long discussion, which touched several issues well beyond the problem of just choosing one experiment for a small satellite, the LPAC agreed to seek a way out from the slippery ground in which aspects "apart from scientific value" had to be taken into consideration. Both proposals were referred back to the COS Group for further consideration "on scientific and technical grounds", on the basis of the judgement of an external referee. If the group arrived at the opinion that really no differences existed on these grounds between the two proposals, the question had to be discussed again by the LPAC. The German cosmic ray physicist G. Pfotzer, assisted by COS Group's members G. Pizzella and P. Rothwell, was invited to report on S-204 and S-217. In the event, following their recommendation, the COS Group reversed their former judgement and approved S-204.[471] The payload composition of HEOS-A2 was thus submitted to the approval of the STC and Council as in Table 5-18.

No problems arose in the former, which did not even convene to discuss on the HEOS-A2 payload and the delegations voted *ad referendum*.[472] But it was quite different in the Council, where the controversy exploded openly when the French delegation "strongly protested against the manner in which the payload composition had been decided". There was no question, they argued, about ESLAB's right to submit proposals for experiments, but "they must be of an original nature and not compete with the proposals submitted by national scientific groups". The delegation went as far as to add a statement that sounded like a menace:

> *The decision taken had created a feeling of uneasiness within the French group whose proposal has been set aside. [...] The situation that had thus arisen was extremely unfortunate. [...] If the only French group of scientists concerned with the work of ESRO were led to have a negative attitude, it would be difficult for the French Delegation to defend the Organisation.*[473]

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468 COS Group, 18th meeting (25-26 March 1968), COS/37, 8 July 1968, p. 3.

469 See chapter 2.

470 C. Dilworth, private communication to the author. Among extra-scientific considerations one could add the fact that Page and the ESLAB group were somewhat outsiders in the European "space science club" while Labeyrie was a long-time friend and collaborator of Dilworth and Occhialini.

471 COS Group, 19th meeting (5 June 1968), COS/39, 18 October 1968. The report of the referees is appended as annex I.

472 ESRO/ST/290, 27 June 1968. ESRO/ST/290, add. 1, 14 August 1968.

473 Council, 25th session (8-9 October 1968), ESRO/C/MIN/25, 6 November 1968, p. 13 and 14. The French delegation also blamed the Director General because, when requesting the vote of the STC ad referendum, he had not officially informed them of the change in the payload composition: ESRO/C/370, 8 October 1968.

A rather nervous discussion followed, in which the chairman of the LPAC, rather desperately, stressed that "the experiments were considered solely on the basis of their scientific value and the LPAC did not take account of political aspects". This was particularly true for the case under discussion, he added with plain naivety as the point raised by the French was in fact a matter of policy. The Director General, on his own part, recalled that the ESLAB programme, which included the experiment under discussion, had been approved more than a year and a half before: He could not accept that experiments proposed by ESLAB should not be allowed to compete on an equal footing with national groups:

> *ESLAB had an extremely important task to carry out and it would be impossible to retain highly qualified scientists in ESLAB if they had the impression that there was no hope of seeing a practical application of their work.*[474]

In the event, science prevailed over politics, and the payload of HEOS-A2 was approved as proposed by the LPAC, with the abstentions of the Belgian and French delegations and a generic recommendation to the STC for an improvement in the selection procedure of experiments.

5.4.7 The TD-1/TD-2 crisis and the abandonment of TD-2

By early 1968 it appeared evident that the financial costs of the joint TD-1/TD-2 project had been greatly underestimated by the industrial consortium with which a preliminary contract had been signed one year earlier. A detailed revision resulted in a real cost escalation, from the original estimate of 109 MFF to twice this figure. By the time the TD programme was finished, the ESRO Directorate warned, the actual sum spent might well be in the region of 320 MFF, including capital facilities and launchings.[475] The ESRO Council was thus confronted with a difficult choice. On the one hand, it could decide to cancel the TD programme, the only important project left for the Organisation in the first phase of its 8-year period. This implied devastating effects, such as the waste of the money, capital investment and human resources already invested; a great blow to the prestige of European industry; a traumatic effect on the experimenters and the definitive loss of confidence of the scientific community in ESRO. Going on with the TD programme, on the other hand, would severely squeeze and limit the funds available for the future scientific programme and would render more difficult the task of balancing the geographical distribution of contracts.

The bad news about the TD programme dropped like a bomb-shell in the dramatic financial and institutional crisis ESRO was living in early 1968. The Organisation, in fact, was feeling the consequence of the Member States' failure to reach agreement on the ceiling for the second three-year period (1967-1969), and therefore any budget decision required unanimous approval in the Council. All problems and difficulties accumulating in the seven years since the start of the European joint effort in space were showing up in all crudeness. In the words of the new Director General, Hermann Bondi, "the future of ESRO looked bleak indeed".[476]

A dramatic discussion on the TD programme took place at the Council session of 28-29 March 1968 but it came to nothing. The Council, in fact, did express an indication in favour of the continuation of the programme and authorised the extension of the preliminary contract for 4 months, but, on the other hand, it could not find unanimous agreement to approve the inclusion in the 1968 budget of the contract authority required by the Director General to sign the final contract. The main opposition came from the Italian delegation, because of their deep dissatisfaction towards the geographical

474 *Ibidem*, p. 13.
475 ESRO/C/342, 14 March 1968, with add. 1 (21 March 1968) and add. 2 (27 March 1968).
476 Bondi (1984), p. 22. Bondi had taken over from Auger in November 1967.

distribution of ESRO's industrial contracts which penalised Italy.[477] An extraordinary Council session was then called one week later, on the occasion of the official inauguration of ESTEC, in the hope that a suitable solution could be found. This was not to be, however. The Italian delegation, in fact, subjected its approval to the continuation of the programme to the condition that Italy's participation in the programme be limited to 11.72 % of the original cost estimate (109 MFF for the construction of the satellites and 40 MFF for launchings). This, of course, was hardly acceptable by other Member States and ESRO's Legal Adviser warned that there was no possibility in the Convention of meeting the Italian delegation's request. As a consequence, Italy's one vote against the inclusion in the 1968 budget of the contract authority necessary for the placing of the TD contract resulted in a veto that blocked the project against the wishes of all other delegations. The Organisation, the Director General stressed, found itself "virtually without a programme", while the German and French delegations, for their part, cautioned that "the decision now made would have very serious consequences [...] as regards the Member States' future attitude towards ESRO".[478]

Following the Council decision, ESRO found itself in the necessity to cancel the TD programme outright. This meant the complete loss of 72 MFF already committed to the programme and the wastage of the facilities of ESTEC and ESTRACK installed to cater for the two satellites and destined to remain idle pending a new programme. Moreover, from the scientific point of view, European scientists had lost the possibility of studying the solar maximum from space. In this situation, which left the Organisation "at the mercy of a single delegation's veto", Bondi felt that a solution had to be worked out anyway, in order to enable ESRO "to meet its obligation to the scientists who had experiments on the TD satellites". He suggested cancelling only one of the TD satellites, while the other could be continued as a special project under article VIII of the Convention, which allowed ESRO to develop projects on behalf of a group of Member States, after approval by a two-thirds majority in the Council. The cancelled satellite would be replaced by a new, small satellite carrying only the experiments remaining scientifically valid.[479]

The STC endorsed Bondi's proposal with the proviso that first priority on future flight opportunities should be given to experiments from the cancelled TD satellite, and the proposal was then approved by the Council.[480] It was now the LPAC's task to advise as to which of the TD satellites should be cancelled and, eventually, on which of its experiments should be retained in the new satellite. A first discussion on this question took place at the restricted LPAC meeting held during the COSPAR

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477 Council, 22nd session (28-29 March 1968), ESRO/C/MIN/22, 22 April 1968, p. 15. The resolution was approved by 6 votes in favour; Italy voted against, Switzerland and Denmark abstained, Belgium did note take part in the vote. From ESRO's General Report for 1967 (p. 114) we learn that, by the end of that year, Italy's financial contributions to ESRO was 11.41 per cent of total member state contributions while the percentage value of contracts placed in the country was 7.50. The ratio of contract percentage to contribution percentage was 0.657. This figure was significantly higher than for Denmark (0.358) and Spain (0.249); significantly lower than for France (1.954), Belgium (1.602), Switzerland (1.325), Netherlands (1.154), and Sweden (1.130); and comparable with that of Germany (0.612) and the United Kingdom (0.713). The latter two countries, however, were by far the most important contributors to ESRO (23.32 and 24.19ÿ%, respectively) and therefore the absolute value of contracts was high.

478 Council, 23th session (4 April 1968), ESRO/C/MIN/23, 3 May 1968, p. 7.

479 Bondi's proposal is presented in ESRO/C/349, 17 May 1968, from which the first of the previous quotation is taken. Its legal and financial aspects are discussed in ESRO/C/350 and ESRO/C/351 respectively, both dated 17 May 1968. See also ESRO/C/356, 21 May 1968. The second quotation is from Bondi's presentation at the 1st meeting of the STC (6 May 1968), ESRO/ST/MIN/18, 26 June 1968, p. 2.

480 STC, 19th meeting (29 May 1968), ESRO/ST/MIN/19, 28 June 1968. Council, 24th session (30 May 1968), ESRO/C/MIN/24, 7 June 1968. At this session the Council approved to cancel one TD satellite and to pursue the other either as an ESRO project or as a special project. In the event, as unanimity was not reached, the TD-1 project was approved as a special project financed by all Member States bar Italy: Council,
25th session (8-8 October 1968), ESRO/C/MIN/25, 6 November 1968. The complex legal and financial aspects of the
TD special project are presented in ESRO/C/360 with several addenda and revisions.

Symposium in Tokyo, on 14 May 1968, but no firm recommendation was issued in that occasion.[481] In the event, as it appeared that there was no clear priority on scientific grounds as to which of the TD satellite projects should continue, the STC agreed to authorise the Director General, in consultation with the Bureau, to take the decision, after carrying out a technical and financial assessment.[482] This showed that, in order to enable significant simplification of the project, the spacecraft design had to be modified so that it could keep its stabilisation only if shone upon by the Sun but not during eclipses. This implied that the satellite should be injected into an helio-synchronous orbit. Proper consideration of the experiments included in the two payloads showed that the scientific mission of TD-1 could still be fulfilled satisfactorily after this modification while that of TD-2 would be seriously jeopardised. Therefore the former was kept in the programme as a "special project" funded by all Member States bar Italy, while a "TD-2 rescue operation" was undertaken in order to save as many as possible of the TD-2 experiments.[483]

5.4.8 The TD-2 rescue operation and the approval of ESRO IV

The problem of rescuing the still scientifically valid experiments of TD-2 was not easy, as it required "a solution [...] that was fast, compatible with the industrial policy of the Organisation, and did not consume so much of the available funds that it would prevent new projects being started".[484] Of the 11 experiments included in the satellite payload (Table 5-17), 4 required solar pointing (S-39, S-106, S-118, S-126), while the others could be flown in non-stabilised satellites. From the viewpoint of research fields involved, three experiments regarded solar physics (S-39, S-106, S-126); three regarded atmospheric physics (S-80, S-97 and S-118); three regarded ionospheric and auroral phenomena (S-45, S-85, and S-94); and two regarded solar wind (S-99 and S-103). It was thus evident that any solution of the rescue operation involved a complex decision on how to take into account various scientific interests and technical constraints.

In September 1968, three options were presented to the LPAC and the STC by the ESRO Directorate for Programmes and Planning. The first was to rescue some of the experiments not requiring solar pointing by using an non-stabilised spacecraft like ESRO I or ESRO II. In particular, the ESRO I spacecraft structure could be used to make a so-called ESRO III satellite carrying the ionospheric experiments S-45, S-85 and S-94; otherwise, by using the ESRO II spacecraft with improved solar cells, the so-called ESRO IV satellite could be realised, which would carry the atmospheric experiment S-80 and the solar wind experiments S-99 and S-103 (the other non solar-pointing atmospheric experiment S-97 had been withdrawn). The cost estimate of the spacecraft was 25 MFF and 20 MFF respectively, with an additional 7.5 MFF for the Scout launcher. ESRO III would be ready for flight in September 1971; ESRO IV by the end of 1971. The second option was to use a NASA OSO (Orbiting Solar Observatory) spacecraft for flying three of the four solar pointing TD-2 experiments, namely S-39, S-106 and S-118. In this case ESRO would purchase a flight unit of a standard OSO spacecraft from NASA at a cost of around 40 MFF and would place these experiments in the pointing section of the satellite. The remaining payload capacity would be put at NASA disposal for American experimenters in order to obtain in exchange the provision of a Thor Delta launcher without charge (the cost of such a launcher was about 20 MFF). The launch of such a satellite was possible before the end of 1972, still in time to cover the solar maximum.

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481 LPAC, 23rd meeting (14 May 1968), LPAC/7, 26 June 1968. The meeting was attended by LPAC members Lüst,
De Jager, Hultqvist and Occhialini (Blamont being unable to attend), by the director of ESLAB (E.A. Trendelenburg) and by J. Ortner of ESRO's Directorate of Programmes and Planning.

482 STC, 19th meeting (29 May 1968), ESRO/ST/MIN/19, 28 June 1968.

483 ESRO, *General Report 1968*. The TD-1 special project is described in ESRO/C/362, 23 September 1968, and add. 1, 27 September 1968. A general account of the TD-2 rescue operation is in ESRO/ST/303, 19 February 1969.

484 STC, 20th meeting, 7 October 1968, ESRO/ST/MIN/20, 18 November 1968, p. 7. Also LPAC, 24th meeting
(first session, 23 September 1968), LPAC/15, 13 November 1968.

Finally, the third option foresaw the development in Europe of a new spacecraft with good solar stabilisation capability. In fact, the ESRO's Secretariat had received "an unofficial proposal from a European firm to develop a stabilised satellite with a higher degree of stabilisation than the OSO, at a lower cost, and with a faster delivery schedule and under more satisfactory contract conditions than had hitherto been thought possible". This solution, however, could not be realised before the end of 1974 and was more expensive than the others. It actually envisaged the development of a real new solar satellite project.[485]

The LPAC did not feel able to give preference to one of these different possibilities or to establish priorities between them. Looking at the matter from a purely scientific point of view, the Committee seemed less interested in rescuing the TD-2 experiments than in starting a vigorous programme in solar physics in collaboration with NASA.[486] The latter had suggested in fact a joint ESRO/NASA project for building two improved OSO spacecraft, carrying experiments provided in equal number by the two agencies, and the LPAC felt that ESRO should not miss this opportunity. The STC, on their side, avoided taking a decision at this stage, limiting themselves to entrust the LPAC with the responsibility of "examining and recommending whether the experiments were of sufficient value to merit their being given priority over newer proposals".[487] Thus the issue went back to the LPAC. As a matter of fact, the problem of the TD-2 replacement had important political and scientific implications that made any decision difficult and painful. First of all, from the scientific point of view, it was necessary to assess the scientific worthiness of the TD-2 experiments at the time when they could be flown *vis-à-vis* new experiment proposals. As the Danish delegation in the STC put it: "There was a risk of conflict between the moral obligation of the Organisation to fly the displaced TD-2 experiments and the interests of the future projects". Moreover, as it was evident that the rescue operation could not save all TD-2 experiments, a selection had to be made and this involved a major issue of scientific policy, namely the role of solar physics in ESRO's programme. Among the political aspects, there was the need to place a certain number of sub-contracts to firms other than those that had been responsible for the construction of ESRO I and II so as to comply with the requirements of fair geographical distribution of contracts. Another important political issue, connected with the OSO option, regarded the hostility of several Member States to any choice involving "buying American".

Three dramatic meetings of the LPAC were held between November 1968 and March 1969 to discuss the whole matter. At the first, all TD-2 experimenters presented their work in progress and called strongly on the moral obligation ESRO had towards them.[488] This was particularly stressed by those proposing solar pointing experiments. Speaking on behalf of the Leicester University group preparing experiment S-39, K. Pounds said that they had already spent 70 % of the total contract sum for their spectrograph, adding that "it would be essential that ESRO did not delay further a decision on whether or not experiment S 39 would be flown before the end of 1972". The Munich group proposing S-118 claimed that this experiment represented a new technique for the study of the oxygen content of the upper atmosphere and "no other experiment of its kind had been designed so far by any other group". They had already invested 800,000 DM in the development of the instrument and Lüst added that "[this] group would probably be disbanded were this experiment to be suppressed". De Jager, while advocating the scientific merit of experiment S-126 ("the best existing for scanning the solar disk in soft X-rays"), recognised that it could not be included in a standard OSO spacecraft and volunteered to withdraw the experiment if ESRO decided to rescue the solar pointing experiments by using such a satellite. He added, however, that:

> *It was his sincere hope that, in the event of the experiment being withdrawn for the reasons stated, ESRO would take into consideration the efforts so far made in the*

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485 STC, 20th meeting (7 October 1968), ESRO/ST/MIN/20, 18 November 1968, p. 7.

486 LPAC, 24th meeting (first session, 23 September 1968), LPAC/15, 13 November 1968.

487 STC, 20th meeting (7 October 1968), ESRO/ST/MIN/20, 18 November 1968, p. 7-8.

488 LPAC, 25th meeting (19 November 1968), LPAC/19, 8 January 1969. Following quotations from p. 4-6. Technical information on the various TD-2 experiments were presented in LPAC/14, 11 November 1968.

realisation of the instrument and examine the possibility of flying an improved version some time in the future on a solar satellite with highly improved scanning capabilities.

As a matter of fact, for most European space scientists as well as for the LPAC, the rescue of the solar pointing experiments, and thus the involvement of ESRO in the rapidly evolving discipline of solar physics, was certainly more appealing than the ESRO III or ESRO IV solution. The time factor was essential in this case since significant results could be obtained by the proposed experiments only if the satellite were launched not later than 1972, what excluded the possibility of building a new satellite in Europe. In the event, the LPAC recommended the second option, namely to buy an OSO spacecraft to fly the solar pointing experiments S-39, S-106 and S-118 in its pointing section, leaving the non pointing section to American experiments in exchange for free launching by Thor Delta.

At the following meeting of the LPAC, in January 1969, the framework had radically changed.[489] ESRO's Director for Programmes and Plans, J.-A. Dinkespiler, informed that NASA was not interested in the proposed arrangement and consequently, if ESRO wanted to use an OSO spacecraft to rescue its solar pointing experiments, it would have to pay for both the satellite and the launcher. In this case, however, it would be possible to accommodate in the spacecraft also the non-pointing experiments, thus rescuing most of the TD-2 experiments. But this solution implied paying some 65 to 105 MF to NASA and it seemed hardly feasible to persuade ESRO's Member States to spend their money across the Atlantic. Only very strong scientific arguments could justify the effort. In Bondi's words:

The Director General would only consider the OSO solution as a possibility if the LPAC were to state categorically that this was the only possible solution. If any other possibility existed and it was a question of preference on the part of the LPAC, he could not, for political reasons, undertake to recommend this solution to the STC and Council.

Another possibility did exist, as a study made by ESRO showed that it was possible to design and build in Europe a small solar-pointing, Scout-type satellite to fly the three experiments already approved for the OSO solution (EUROSOL project).[490] The main drawback laid in the time scale, as it would not be possible to launch this satellite before the second half of 1973. In conclusion, Dinkespiler listed the costs (including launchers) and schedules of the various solutions for the TD-2 rescue operation as they could be estimated at that stage:

European pointing satellite	*100*	*MFF*	*second half of 1973*
OSO-a (without prototype)	*65*	*MFF*	*Spring 1972*
OSO-b (with prototype)	*105*	*MFF*	*end 1972*
ESRO III or IV	*35 - 40*	*MFF*	*end 1971*

Facing this situation, the LPAC could only choose the line of least resistance, if only from the political and not from the scientific and financial viewpoint:

The LPAC felt it desirable to have a European solar satellite developed and flown by 1973 on condition that all three experimenters concerned would agree to this solution, particularly with regard to the time scale. [...] In the event of any one answer being negative, ESRO would be left with the choice of pursuing the OSO solution or abandoning the rescue operation for the pointing experiments.

In other words, the members of the LPAC and the chairmen of the ad hoc groups, who acted on behalf of the European space science community, did not feel strong enough to advocate the purchase of an American spacecraft on the basis of purely scientific arguments, i.e. the possibility of rescuing most of

489 LPAC, 26th meeting (8 January 1969), LPAC/25, 13 February 1969. Following quotations from p. 4-6 and 8.

490 This project is described in annex 1 to ESRO/ST/303, 19 February 1969.

the TD-2 experiments at good price and according to the best timing. They rather hoped that the experimenters could accept the postponement of one year so as to save a solar physics programme in ESRO. At the same time, they did not express any interest in the ESRO III and ESRO IV options.
At this stage, following a question from the chairman of the COS Group, C. Dilworth, the Director for Satellite and Sounding Rocket Programmes in ESTEC, P. Blassel, specified that the schedule presented was correct only if ESRO accorded the highest priority to the solar satellite, i.e. in preference to HEOS-A2. In fact, as the TD-1 project was already occupying almost the entire technical staff, and because of the difficulty of recruiting competent staff at short notice, only one new project could be started and a priority had to be established. This information radically changed the situation. For the LPAC, in fact, any delay in the development and launch of HEOS-A2 was not acceptable, as this "would amount to ESRO's disappointing the experimenters involved in this satellite". Therefore, assuming the HEOS-A2 project to take first priority, starting in Spring 1969 as planned, the realistic time scale had to be changed as follows:

European pointing satellite	*Spring 1974*
OSO - a (without prototype)	*Autumn 1972*
OSO - b (with prototype)	*mid 1973*
ESRO III or IV	*mid 1972*

The new time scale affected the position of the LPAC and led its members to assume a more resolute line *vis-à-vis* the STC and the Council:

> *The LPAC as well as the solar experimenters themselves regard 1972 as the latest possible launch date for the rescue of the TD-2 solar pointing experiments. This condition cannot be achieved using a European solar satellite due to the time factor imposed. Therefore, the LPAC recommends the rescue of the experiments on board an OSO satellite without prototype, being the only possible solution within the required time scale. If Council were not to support this recommendation, the rescue operation for the solar pointing experiments could not be realised.*

In other words, facing the prospects of a delay of almost 2 years compared to the most acceptable launch date, the LPAC felt they had good enough scientific arguments to overcome political opposition. They knew this would not be easy, however, and called the community to a lobbying initiative:

> *The scientists themselves should brief their delegations so that they had a full understanding of the implications for the European scientific community should they reject the OSO proposal for political reasons.*

They did not succeed, however. On the eve of the STC meeting called to issue its final recommendation to the Council, the LPAC met again and it was clear at that moment that there was no hope of getting the OSO solution approved. On the one hand, this solution was certainly attractive from the financial point of view and by far the most interesting one from the scientific point of view. On the other hand, it was of no technical interest to Europe and thus contrary to ESRO's industrial policy. Unless this policy was modified for this purpose, the rescue of the TD-2 pointing experiments had to be abandoned. In conclusion, while the OSO solution was still listed among possible options, the LPAC agreed to recommend the launching of ESRO IV, for which the possibility of allocating in its payload, after slight modification, five non-pointing experiments had been demonstrated (Table 5-19).[491]

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491 LPAC, 27th meeting (5 March 1969), LPAC/27, 26 March 1969. See ESRO/ST/302, 19 February 1969, with add. 1, 5 March 1969, and ESRO/ST/303, 19 February 1969. For the ESRO IV payload see LPAC/21, 23 December 1968.

It is quite probable that, by that time, European solar physicists had decided to abandon the controversial OSO solution for launching obsolete experiments and to set a more promising attack front, i.e. lobbying to get ESRO to embark on an advanced solar satellite project at a later stage. In fact, at the STC meeting on the following day, the main spokesman of this community in Europe, the LPAC member and Dutch delegate C. De Jager declared that:

> *Although [the delegation] had no objections in principle against buying an OSO in the United States, they did not think this was the desirable solution for the solar physicists: their requirements went beyond launching simply one or two solar experiments on an OSO and would be far better satisfied with a more advanced solar project later in the programme.*[492]

In the event, the STC endorsed (with the abstention of France and Belgium) the LPAC's recommendation to develop the ESRO IV project and adopted a recommendation, put forward by Lüst, by which ESRO was urged to initiate, as soon as possible a feasibility study for "a sophisticated solar satellite, which should be included among the proposals for a major project from which a choice would be made in 1970/1971".[493] The solar physics community did not have its feasibility study, nor did it have a chance to advocate its satellite against other project proposals. In fact, in 1969, after the decision to build the two new satellites COS-B and GEOS, the LPAC was called to discuss ESRO's long-term scientific policy, in order to enable the Organisation to make "a careful selection of new feasibility studies to be initiated on future projects".[494] The outcome was a policy definition which definitely excluded stellar astronomy and high resolution solar astronomy from ESRO's future satellite programme, confining these fields to rocket experiments. According to the LPAC's scientific policy on ESRO satellite programme for the late 1970s, primary consideration had to be given to a very limited number of research fields, including fundamental physics (like the investigation of the general theory of gravitation), high energy astrophysics (X- and gamma-ray astronomy), cosmic ray studies, and plasma physics investigations in the magnetosphere. As a consequence, the structure of ESRO's scientific advisory groups was reorganised in 1971, the existing six ad hoc groups being replaced by an Astrophysics Working Group, a Solar System Working Group, and a Fundamental Physics Panel. By 1969 the first phase of ESRO's life came to an end. The Organisation's first generation of satellites were in orbit (ESRO I and II, HEOS-1) or under development and scheduled for launch in 1972 (HEOS-2, TD-1 and ESRO IV): this was the actual outcome of the ambitious programme which the ESRO pioneers had written in the *Blue Book* for COPERS in 1961. With the approval of two new satellite projects (COS-B and GEOS) and the policy definition of early 1970 a new phase started: it was definitely recognised that ESRO could not support all fields of space science in a viable way but it had to select a few, well-phased major projects according to agreed scientific guidelines. Choices had to be made in order to establish priorities and concentrate efforts in those fields where: (a) interesting new scientific results could be expected; (b) technical complexity and financial needs fell within the limits of ESRO's capabilities; and (c) a safe niche for original results existed between the programmes of the two space superpowers.

At this turning point there were winners and losers, of course. Among the former we can easily identify the cosmic ray physicists, who firmly occupied both the ground of magnetospheric investigation and that of high energy astrophysics: both COS-B and GEOS were recommended and strongly advocated by the COS Group, while the following X-ray mission of the EXOSAT satellite was also an achievement of the same sector of the space science community. The most illustrious losers were, needless to say, the astronomers. Those interested in stellar astronomy first lost the Large

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492 STC, 21st meeting (6 March 1969), ESRO/ST/MIN/21, 24 March 1969, p. 4.

493 *Ibidem*. It appears from the minutes that only Sweden considered that "the policy of not buying American" should be slackened in this case and the OSO solution adopted. ESRO IV was approved by the Council, together with HEOS-A2, at its 27th session (25-26 March 1969), ESRO/C/MIN/27, 4 April 1969. See also ESRO/C/397, 14 March 1969.

494 ESRO/ST/330, 10 October 1969, p. 1. The selection of COS-B and GEOS will be discussed in chapter 7. The definition of ESRO's scientific policy will be dealt with in detail in chapter 8.

Astronomical Satellite (LAS) and then did not succeed in getting the less ambitious UVAS (Ultra Violet Astronomy Satellite) project approved against COS-B and GEOS. Solar astronomers, on their side, lost TD-2 and did not even have a second chance.

At the beginning of the new decade ESRO was reaching maturity. Something of the muddled enthusiasm of its early period had faded away and a new awareness of the role and limits of the Organisation had emerged from the hard times of the crisis. Important changes in the organisational structure gave more flexibility and autonomy to the Organisation and ESRO's Member States reaffirmed their confidence in it by agreeing on its extension beyond the 8-year period covered by the original Convention. The scientific programme could be planned on a more secure basis and, moreover, Member States entrusted to ESRO the task of studying and eventually implementing a new programme on application satellites. In the difficult and controversial situation of European cooperation in space, ESRO represented the most solid element.

Table 5-1a
Ad hoc Working Groups and their chairmen in 1962-63

A	Atmospheric Structure	G.V. Groves (UK) [495]
B	Ionosphere and Auroral Phenomena	B. Hultqvist (S)
C	Meteorology	A. Nyberg (S)
D	Solar Astronomy and General Astronomy	J.-C. Pecker (F)
E	Interplanetary Medium	C. De Jager (NL)
F	Lunar and Planetary Astronomy	P. Swings (B)
G	Cosmic Rays and Trapped Radiation	G. Occhialini (I)
H	Geodetics, Relativity and Gravitation	W. Kertz (D) [496]

Table 5-1b
New distribution of atmospheric and astronomical groups

A, C	Atmospheric structure	R. Frith (UK)
D	Sun	C. De Jager (NL)
E	Moon, planets, comets and interplanetary space	L.F. Biermann (D)
F	Stars and stellar systems	P. Swings (B)

Table 5-2
Satellite experiment proposal by early 1963

A - Atmospheric Structure	3
B - Ionosphere and Auroral Phenomena	20
C - Meteorology	2
D - Solar Astronomy and General Astronomy	20
E - Interplanetary Medium	7
F - Lunar and Planetary Astronomy	--
G - Cosmic Rays and Trapped Radiation	18
H - Geodetics, Relativity and Gravitation	1
TOTAL	71

From: COPERS/LPSC/32, rev. 2, 7 May 1963.

[495] M. Nicolet (B) had been initially proposed for the chairmanship of this group but he could not accept.
[496] J. Bartels (D) had been initially proposed for the chairmanship of this group but he could not accept. This group was eventually dissolved.

Table 5-3
Membership of the Launching Programme Advisory Committee (LPAC)

1964-67	1968-69	1969-70
R. Lüst (chairman) J. Blamont R. Boyd C. de Jager	R. Lüst (chairman) J. Blamont B. Hultqvist C. de Jager G. Occhialini	R. Lüst (chairman) J. Geiss B. Hultqvist G. Occhialini B. Strömgren

Table 5-4
Chairmen of ad hoc Working Groups

	1964-65	**1966**	**1967-68**
ATM Atmospheric structure	R. Frith	R. Frith	F. Möller
ION Ionospheric and auroral phenomena	B. Hultqvist	A. Willmore	A. Willmore
SUN Solar astronomy	C. de Jager	R. Michard	R. Michard
PLA Moon, planets, comets and inter-planetary medium	L. Biermann	L. Biermann	J. Geiss
STAR Stellar astronomy	P. Swings	P. Swings	L. Gratton
COS Cosmic rays and trapped radiation	G. Occhialini	B. Peters	C. Dilworth

Table 5-5
ESRO sounding rockets launches

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

N.B: The 1966 figures include ESRO's participation in the solar-eclipse campaign on the island of Karystos, Greece, in May 1966, when ESRO launched seven rockets within a 3-hour windows centred on the time of the eclipse, plus two other rockets some days earlier.

Table 5-6
Rocket types used by ESRO

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

Table 5-7
Launching programme proposed by the LPAC in February 1965

Year	Small satellite (Scout type)	TD satellites (stabilised)	HEOS or space probes	Major projects
1967	S-1 S-2			
1968				
1969		TD-1 TD-2	SP-1	
1970		TD-3 TD-4	SP-2	
1971		TD-5 TD-6	SP-3 SP-4	A-1
1972				A-2

It was assumed that Thor Delta rockets would be used for all TD- and SP-type satellites. For major projects the ELDO launcher was assumed.

From ESRO/ST/109, 3 March 1965. p. 6. Also ESRO/ST/114, 16 March 1965, p. 6.

Table 5-8
ESRO's satellite projects by the end of 1965

Spacecraft families	Names of satellites	Total weight (kg)	Scientific payload (kg)	Initial apogee (km)	Initial perigee (km)	Orbital inclination	Launch date
Small satellites	1. ESRO I 2. ESRO II	81 80	19 20	1500 1100	275 350	90 ° 98 °	1967 1967
Highly eccentric orbit satellites	1. HEOS-A 2. (3) 4.	105	25	240,000	200	33 °	1968 1970 (1971) 1971
Medium-size stabilised satellites	1. TD-1 2. TD-2 (3) 4. (5) 6.	400 400	80 63	500 1200	500 350	98 ° 90 °	1969 1969 (1970) 1970/71 (1971/72) 1971/72
Large astronomical satellites	1. LAS 2. 3.	800	225	650	650	0 or 90 °	1970 1971 1972

From ESRO, General Report, 1964-65, fig. 2.9 and 2.10.

Only the names of the projects actually approved are indicated. Notice that two TD satellites and one HEOS satellite are in brackets because their actual realisation seemed already jeopardised by lack of financial resources.

Table 5-9
Satellite experiments proposals by the end of 1965

ATM	Atmospheric Structure and Meteorology	8
ION	Ionospheric and Auroral Phenomena	39
SUN	Solar Astronomy	16
STAR	Stellar Astronomy	7
PLA	Study of the Moon, Planets and Interplanetary Medium	14
COS	Cosmic Rays and Trapped Radiation	25
---	Space Biology	1
	TOTAL	110

From ESRO General Report, 1964-65, p. 26-27.

Table 5-10
The payload of ESRO I approved in 1963
(polar ionosphere)

S-32	Auroral photometry	D.R. Bates Queen's University, Belfast
S-42	Helium lines He II (304 Å) and He I (584 Å)	R. Boyd University College London
S-44	Ionospheric electron temperature and density	R. Boyd University College London
S-45	Ionospheric composition and ion temperature	R. Boyd University College London
S-70	Ionospheric sounding	E. Vassy Lab. Phys. de l'Atmosphère, Paris
S-71	Flux and energy spectrum of electrons and protons	J. Rybner Technical University, Copenhagen J.A. Ratcliffe Radio and Space Res. Station, Slough B. Hultqvist Kiruna Geophysical Observatory

From: COPERS/GTST/82, rev. 1, 14 June 1963, p. 2.

Table 5-11

The payload of ESRO II approved in Spring 1963
(solar astronomy and cosmic rays)

S-25	Trapped radiation	H. Elliot Imperial College, London
S-27	Solar and Van Allen belt protons	H. Elliot Imperial College, London
S-28	Protons and alpha particles in cosmic rays	H. Elliot Imperial College, London
S-29	High energy cosmic ray electrons	J.G. Wilson University of Leeds
S-31	Measurements of micrometeorites	D.R. Bates Queen's University, Belfast
S-36/37	Solar X rays	E.A. Stewardson University of Leicester R.L.F. Boyd University College, London
S-42	Helium lines He II (304 Å) and He I (584 Å)	R.L.F. Boyd University College, London
S-48	Measurement of Lyman alpha	R.L.F. Boyd University College, London

From: COPERT/STWG/82, rev. 1, 14 June 1963.

Table 5-12
The final configuration of the ESRO I payload
(polar ionosphere)

S-32	Auroral photometry	D.R. Bates Queen's University, Belfast A. Omholt, A. Egeland Oslo University
S-44	Ionospheric electron temperature and density	R. Boyd, A.P. Willmore University College London
S-45	Ionospheric composition and ion temperature	R. Boyd, A.P. Willmore University College London
S-71A	Flux and energy spectrum of electrons, 40-400 keV	R. Daziel and D.E. Page Radio and Space Res. Station, Slough
S-71B	Electron and proton density	B. Hultqvist, W. Riedler Kiruna Geophysical Observatory
S-71C	Energy spectrum of auroral protons	M.F. Soras Bergen University O.E. Petersen Technical University, Copenhagen
S-71D	Angular distribution of particles	B. Landmark and G. Skovli Norwegian Space Committee O.E. Petersen Technical University, Copenhagen
S-71E	Energy spectrum of protons, 1-30 MeV, 40-400 keV	R. Daziel and D.E. Page Radio and Space Res. Station, Slough

From: ESRO, General Report, 1964-1965.

Table 5-13

The final configuration of the ESRO II payload (solar astronomy and cosmic rays)

S-25	Trapped radiation	H. Elliot, J.J. Quenby Imperial College, London
S-27	Solar and Van Allen belt protons	H. Elliot, J.J. Quenby Imperial College, London
S-28	Protons and alpha particles in cosmic rays	H. Elliot, J.J. Quenby Imperial College, London
S-29	High energy cosmic ray electrons	P.L. Marsden University of Leeds
S-36	Solar X rays, 1-20 Å	E.A. Stewardson, K. Pounds University of Leicester R.L.F. Boyd University College, London
S-37	Solar X rays, 44-70 Å	C. De Jager, W. De Graaf Utrecht Observatory
S-72	Flux and energy spectrum of solar protons, 35-1000 MeV	J. Labeyrie, L. Koch Centre d'Etudes Nucléaires, Saclay

From: ESRO, General Report, 1964-1965.

Table 5-14

The payload of HEOS-A approved in Autumn 1965

S-58/ S-73	Flux, energy spectrum and angular distribution of interplanetary plasma	C. De Jager Utrecht Observatory R. Coutrez Université de Bruxelles A. Bonetti University of Bari G. Pizzella University of Rome
S-24A	Interplanetary magnetic field	H. Elliot, P.C. Edgecock Imperial College, London
S-24B	High energy cosmic ray protons	H. Elliot, A.R Engel Imperial College, London
S-24C	Solar protons, 1-20 MeV	H. Elliot, R.J. Hynds Imperial College, London
S-16	Interaction between interplanetary plasma and magnetic fields	R. Lüst Max-Planck-Institut, Garching
S-72	Solar and cosmic ray protons	J. Labeyrie, L. Koch Centre d'Etudes Nucléaires, Saclay
S-79	Cosmic ray electrons, 50-600 MeV	C. Dilworth University of Milan J. Labeyrie Centre d'Etudes Nucléaires, Saclay

N.B.: The complex experiment S-24 was made up of the original proposals S-24 and S-27, both presented by Elliot.

N.B.: The collaboration S-58/S-73 was made up from experiment proposals originally presented by the Brussels group (S-58) and by the Rome/Bari group (S-73).

From: ESRO/ST/109, 3 March 1965 and ESRO, General Report 1964-1965.

Table 5-15a

The payload of TD-1 approved in Summer 1964

S-1/ S-2/ S-68	Scanning of the sky in the ultraviolet and infrared	P. Swings Université, de Liège R.E. Butler Royal Observatory, Edinburgh
S-30	Celestial gamma rays	G.W. Hutchinson, D. Ramsden University of Southampton
S-59	Stellar spectrography in the UV	C. De Jager, A.B. Underhill Utrecht Observatory
S-77	Celestial X rays, 3-30 keV	J. Labeyrie, L. Koch Centre d'Etudes Nucléaires, Saclay

N.B.: Experiment S-1 (IR scanning) and S-2 (UV scanning) were originally presented by Swings; experiment S-68 (IR scanning) was originally presented by Swings and Butler.

Table 5-15b

Addition to the payload of TD-1 in 1965

S-67A	Primary cosmic ray particles	J. Labeyrie, L. Koch Centre d'Etudes Nucléaires, Saclay
S-88	Solar gamma rays, 50-300 MeV	J. Bland, G. Occhialini University of Milan
S-100	Solar X rays, 40-300 keV	C. De Jager, J.N. Van Gils Utrecht Observatory

From: ESRO/ST/145, 24 September 1965 and ESRO General Report 1964-1965.

Table 5-16

The final configuration of the TD-1 payload

S-2/ S-68	Scanning of the sky in the ultraviolet and infrared (1000 -3000 Å)	P. Swings Université, de Liège H.E. Butler Royal Observatory, Edinburgh
S-59	Stellar spectrography in the UV	C. De Jager, A.B. Underhill Utrecht Observatory
S-67A	Primary cosmic ray particles	J. Labeyrie, L. Koch Centre d'Etudes Nucléaires, Saclay
S-77	Celestial X rays, 3-30 keV	J. Labeyrie, L. Koch Centre d'Etudes Nucléaires, Saclay
S-30	Celestial gamma rays	G.W. Hutchinson, D. Ramsden University of Southampton
S-88	Solar gamma rays, 50-300 MeV	J. Bland, G. Occhialini University of Milan
S-100	Solar X rays, 40-300 keV	C. De Jager, J.N. Van Gils Utrecht Observatory
S-133	Celestial gamma rays, 70-300 MeV	J. Labeyrie, Y. Koechlin Centre d'Etudes Nucléaires, Saclay G. Occhialini, L. Scarsi University of Milan R. Lüst Max-Planck-Institut, Garching

From: ESRO, General Report, 1967.

Table 5-17

The final configuration of the TD-2 payload

S-39	Solar X-ray spectrometry	E.A. Stewardson, K.A.Pounds University of Leicester
S-45	Ionospheric composition and ion temperature probe	R.L.F. Boyd, A.P. Willmore University College, London
S-80	Neutral particle composition of the upper atmosphere	W. Priester, U. Von Zahn University of Bonn
S-85	Low energy auroral electrons	R. Dalziel, T. Briant Radio and Space Research Station, Slough
S-94	Auroral particles	B. Hultqvist, W. Riedler Kiruna Geophysical Observatory
S-97	Light emission from oxygen and ionised nitrogen	J.E. Blamont Service d'Aéronomie, CNES, Verrières
S-99	Solar protons, 13-160 MeV	C. De Jager, H.F. van Beck Utrecht Observatory
S-103	Solar protons, 0.6-28 MeV	R. Lüst, D. Hovestadt Max Plank Institut, Garching
S-106	Solar UV spectrography	R.L.F. Boyd, M. Timothy University College London
S-118	Optical determination of thermospheric O_2 concentration	F. Möller University of München
S-126	Scanning of the solar corona in the range 15-35 Å	C. De Jager Utrecht Observatory

N.B.: Besides S-45, two more probe experiments had been originally included in the payload: S-11 (by K. Rawer, from the Ionosphären Institut, Breisach) and S-93 (by J. Sayers, from the University of Birmingham). Subsequently, for technical reason, only one could be kept and the ION group recommended S-45 at its 14th meeting (19 November 1965), ION/27, 7 December 1965.

From: ESRO, General Report, 1966.

Table 5-18

The final configuration of the HEOS-A2 payload

S-201	Magnetic field measurement	H. Elliot Imperial College, London
S-202	Plasma measurement	G. Pizzella University of Rome
S-203	ELF radiation in solar wind and magnetosphere	B. Peters Danish Space Res. Inst., Copenhagen
S-204	Intermediate energy particles	D.E. Page Space Science Department, ESTEC
S-209	High energy cosmic ray electrons	C. Dilworth University of Milan J. Labeyrie Centre d'Etudes Nucléaires, Saclay
S-210	Measurement of solar wind	Rosenbauer Max-Planck-Institut, Garching
S-215	Measurement of micrometeorites	J. Zähringer Max-Planck-Institut, Heidelberg

From: ESRO General Report, 1968.

Table 5-19

The final configuration of the ESRO IV payload

S-45	Density, temperature and composition of positive ions	R.L.F. Boyd, A.P. Willmore University College, London
S-80	Mass spectrometer of neutral gases	W. Priester, U. Von Zahn University of Bonn
S-94	Auroral particles	B. Hultqvist, W. Riedler Kiruna Geophysical Observatory
S-99	Galactic and solar particles, 2.5 -320 MeV	C. De Jager, H.F. Van Beck Utrecht Observatory
S-103	Galactic and solar particles, 2.5 -360 MeV	R. Lüst, D. Hovestadt Max-Planck-Institut, Garching

From: ESRO, General Report, 1969.

Chapter 6:
The Rise and Fall of ESRO's First Major Scientific Project: the Large Astronomical Satellite (LAS)[497]

J. Krige

The Large Astronomical Satellite (LAS) was a planned orbiting observatory whose primary objective was to gain basic knowledge about celestial objects using a high-resolution ultraviolet spectrometer. For several reasons – scientific, technical, political – it seemed to be an ideal project for the fledgling European Space Research Organisation (ESRO) which officially came into being in 1964. Yet it was never flown. This chapter tells its story, the story of a technological device which was born in the late 1950s, which became increasingly controversial, and which finally passed away in 1968 for lack of financial and political support.

For many years astronomers had speculated about the scientific advantages of placing an observatory beyond the interfering influence of the Earth's atmosphere. For example, about 99 % of the radiation emitted by celestial bodies in the far ultraviolet (10^2 - 10^3 Ångström) are already absorbed 100 km above the Earth's surface. However, hopes of researching such regions of the electromagnetic spectrum were doomed to remain in the realm of science fiction until sufficiently powerful rockets were available. The success of the V2s, developed in Nazi Germany during World War II, "made it all seem possible", to quote Lyman Spitzer, a longstanding champion of space telescopes.[498] The bulk of these rockets, along with the best German engineers, were captured and transferred to the United States after the war.[499] Encouraged by what they had achieved, as early as 1946 Spitzer described the "Astronomical Advantages of an Extra-terrestrial Observatory". This early, classified report identified the scientific interest of a satellite without a telescope, of a satellite with a small ten-inch telescope, and finally of a satellite carrying a giant 200-600 inch telescope. This device, surmised Spitzer, would break new ground, would "uncover new phenomena not yet imagined, and perhaps [...] modify profoundly our basic concepts of space and time".[500] The claims may have been exaggerated but the underlying sentiments were genuine. After the war astronomers and astrophysicists were increasingly determined to study the sky from space.

Apart from its scientific interest, the Large Astronomical Satellite was a technical challenge. The observatory had to be stabilised in space, i.e. the tumbling motion acquired during its injection into orbit had to be sensed and counteracted, after which it had to be locked into an inertial reference frame. It then had to be slewed within this frame so as to point successively at stars and other celestial bodies of varying degrees of brightness. Finally, the satellite had to be locked on to a star long enough to collect useful data (fine guidance). This information then had to be relayed back to one or more ground stations on Earth.[501] All of these operations called for highly sophisticated engineering solutions. The design of the spacecraft that would carry the LAS was just the kind of project that would attract engineers to ESRO's new technical research centre in Noordwijk, Netherlands (ESTEC). It would also provide a stimulus to European industries who were being called on to build up quickly the in-house expertise needed for them to compete successfully in the space sector.

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497 This chapter is essentially based on Krige ed. (1993). We wish to thank Harwood Academic Publishers for the permission to use this paper here.

498 Quoted in Smith (1989), p. 29.

499 For a history of the V2 and the Nazi war effort, see Neufeld (1995). The rounding up of the German rocket scientists and their material and their transfer to the US are described in Lasby (1971). For the early exploitation of these resources in the US see DeVorkin (1992).

500 See Smith (1989), p. 30.

501 For a general technical description of the spacecraft needed for this kind of device, see Rogerson (1963), especially section 3.

Finally, the LAS was of great 'political' interest. One of the most important rationales for launching a collaborative European space effort – indeed for joint international ventures in any field of big science – was that several nations could achieve together what none of them could achieve alone. This was a key argument for setting up CERN in the early 1950s, and it was used again by scientists, in fact by some of the same scientists, for setting up ESRO in the late 1950s.[502] In the words of Alexander Hocker, ESRO's second Council Chairman, "[...] the real 'raison d'être' of the Organisation [was] to carry out projects of a scale and technical complexity beyond what the European countries could achieve within the framework of their individual national programmes". And, he went on immediately to say, "this was the reason why, right at the outset, consideration was given to the project for a Large Astronomical Satellite".[503] From the point of view of many of those who set up ESRO in the early 1960s, the LAS was seen to justify the creation of ESRO as the construction of its big accelerators was seen to justify the creation of CERN.

This chapter describes and analyses the evolution of this major technological project from its inception in the late 1950s to its demise roughly a decade later. The treatment is essentially chronological, and is divided into three main phases. During the first, which lasted until 1964, the broad scientific objectives of Europe's first astronomical observatory were defined. This was a period when the space science community was flush with optimism, and in which its members collaborated enthusiastically in anticipation of the new opportunities and resources which 'their' envisaged space organisation would bring. The second phase, lasting for the next two years, was the one in which the scientific aims had to be translated into a technically feasible design. Three different groups made proposals at this stage, one of them so radically different from the other two that no compromise between it and them was possible. Its rejection sparked off a painful and sometimes angry conflict, which was exacerbated by disagreements over how best to organise the LAS project. The concluding phase is that which covered 1967 and 1968. This was the phase in which the final design characteristics and costing of the LAS's scientific payload and the spacecraft to carry it aloft were firmed up in consultation with industry. Costs rose, and ESRO simultaneously entered a financial crisis which was coupled with a major re-evaluation of its basic objectives. The LAS did not survive the shock.[504]

Methodologically speaking we describe the sequence of events whereby a technological artifact comes into being – or fails to do so, as in this case. It shows how, in different stages of the evolution of a technological project, decisions are taken about what device to build (or whether to build it all) which involve a mix of various kinds of factors – scientific, technical, institutional, financial, political. The weights attributed to these factors differ depending on what stage the decision making process has reached and on the context. These decisions sometimes involve making choices, sometimes not. Sophisticated 'technologies' are not 'chosen' like consumer goods off a supermarket shelf. They are the result of a lengthy, messy process, the outcome of battles won and lost, and of compromises struck, between interest groups with very different, and sometimes conflicting, priorities.[505]

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502 For the launching of CERN see Hermann et al. (1987), especially Part II by D. Pestre. The role of some of the 'founding fathers' of CERN (in particular E. Amaldi and P. Auger) in the setting up of ESRO is discussed in chapter 1.

503 Foreword by A. Hocker to *ESRO General Report 1966*.

504 For an account of the LAS from a UK point of view, see Massey and Robins (1986), chapter 6.

505 The approach followed here resonates with that of the so-called 'social constructivists' and with closely-allied critiques of the 'rational model of decisionmaking'. For the former see particularly Bijker et al (1987) and Hughes (1983). For its application in the space sector see Mack (1990). The classic critique of the rational model is Allison (1971). For a study on decisionmaking in science which exposes the limitations of this model see Pestre in Hermann et al. (1990), chapter 12.

6.1 Defining the scientific objectives of LAS (1960-64). The time of optimism and of cohesion in the scientific community

6.1.1 The first set of specifications of the LAS

The seeds of ESRO's LAS project were sown at the very first meeting of the COPERS Interim Scientific and Technical Working Group (STWG). Held in Stockholm on 4 and 5 April 1961, one of its main tasks was to draft proposals for a European space science programme. The scientists present broke the programme down into two broad categories, short term and long term projects. The latter were dealt with first. Robert Boyd, who was a member of the UK's National Committee for Space Research, proposed two: Earth-orbiting astronomical observatories and lunar satellites. He identified ten possible objectives for the Earth-orbiting observatories, including ultraviolet stellar spectroscopy, soft X-ray spectroscopy, the search for special UV and X-ray sources, and the study of the directional intensity of cosmic rays. "The British proposal", the minutes of the meeting tell us, "was generally considered a very suitable basis for the cooperative European Space Research". In fact it was taken over almost unchanged in the final report (the so-called "Blue Book") prepared by the Group for the third session of the COPERS held in Munich on 24 and 25 October 1961.[506]

The next steps towards defining the specifications of an orbiting observatory were taken in March 1963. A Working Group, chaired by R.E. Butler from the Royal Observatory in Edinburgh, was set up and met for the first time on 22 April. Butler had prepared a paper for the meeting in which he explained the possible research that could be done with a large astronomical satellite, and gave his views on the most suitable instruments to be flown on ESRO's first LAS.[507] The LAS Working Group (LASWG) rapidly converged on the desirable characteristics of the satellite. Many options – notably investigations of the moon, the Sun, and the planets – were discarded on the grounds that they were being done already, or could best be done by other means. Similarly the making of sky scans in wavelength regions not observable on the surface of the Earth, while being judged the "most urgent" task, was discarded on the grounds that they would probably be done before LAS was ready by the American 'Project Celescope' (see below) and by one of the first medium-sized ESRO satellites (later labelled TD-1). Accordingly, the Working Group proposed "that the primary instrument for the first large ESRO astronomical satellite should be designed to make spectrophotometric observations in the spectral range extending from the Lyman limit (912 Å) to about 3500 Å". A resolution of 1 Å, "or better if instrumentally possible", was to be aimed at. In order to observe faint stars, it was thought "essential to be able to degrade this to 10 Å and even to 100 Å at will by ground control". The instrument was to be flown on a spacecraft which could be pointed to a succession of positions in the sky to an accuracy of "a few minutes of an arc". If directed at a star or star-like object, it was then to 'lock-on' to the body "to a greater accuracy and [to] remain locked on for a period of minutes or hours". Finally the Group recommended that, alongside the primary instrument, there should be a smaller instrument to make broad-band X-ray observations.[508]

The Chairman of the LAS Working Group was enthusiastic about the potential of this device. A large satellite meeting the specifications, Butler wrote in July 1963, "[would] have exciting possibilities". Scientists could obtain "high resolution ultra-violet spectra of very many early type stars, [...] medium and low resolution spectra of many less bright stars of all types, of nebulae, and of other interesting objects", as well as new information on the "chemical composition, age and surface gravity of stars, on stellar coronae, on stellar and interstellar hydrogen". These data would not only be useful in their own

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506 The minutes of the Stockholm meeting are in HAEC, Box 1688. Boyd's detailed proposal is Appendix 3 to the minutes. For a more detailed discussion of the Stockholm meeting and of the "Blue Book" see chapter 2.

507 It was decided to set up the Working Group at a joint meeting of the ad hoc advisory groups on Solar and General Astronomy and of Lunar and Planetary Astronomy in March 1963 (COPERS/LPSC/86, rev. 1, 3 July 1963). Butler's paper prepared for its first meeting, and dated 29 March 1963, is COPERS/LPSC/71, 4 April 1963.

508 The material in this paragraph is from COPERS/LPSC/71, cit., from the *Draft Recommendations* of the first LASWG meeting (Golay archive, file "Correspondance"), and from Butler's report to the LPSC, COPERS/LPSC/86, rev. 1, 3 July 1963.

right. They were also "likely to stimulate many different branches of astronomy particularly stellar physics, star clusters, galactic structure and interstellar matter".[509]

The Working Group recognised "that the majority of astronomers concerned with the satellite, although possessing considerable enthusiasm, were ignorant of many space research techniques and limitations". Accordingly, at the end of 1963 the COPERS commissioned preliminary design studies of the spacecraft with the Royal Aircraft Establishment (RAE) in Britain, with the Centre National d'Études Spatiales (CNES) in France, and with the Deutsche Versuchsanstalt für Luft- und Raumfahrt (DVLR) in Germany. Their task was to assess, by April the following year, "the feasibility of carrying out this project with the required degrees of precision and stability".[510]

Butler's leading role in drawing up the specifications of the LAS, and the Working Group's rapid agreement on a "reasonable scientific outline" for the satellite, are not surprising. In fact some of its basic features were already specified around 1958 by a Working Group (Chairman H.E. Butler) of the newly-established British National Committee for Space Research (BNCSR). Discussing what the most suitable astronomical payload would be for the UK's *Blue Streak* satellite launcher they concluded that "the highest priority should be given to flying an ultra-violet spectrometer operating in the wavelength range 3300 to 1200 Å with a spectral resolution as high as 1 Å". As for the spacecraft, the RAE at Farnborough undertook "to work out the technical requirements and possibilities for an astronomical satellite stabilised to a few minutes of an arc".[511] There were certainly strong scientific and technical arguments for building the LAS proposed in the Blue Book and refined by the LASWG. But the envisaged satellite was also the 'Europeanisation' of a British project which was born in the UK well before ESRO or even COPERS came into being. And it never lost its birthmark.

6.1.2 Tightening up the specifications: the determination to compete

From its inception the LAS Working Group wanted the final design of the satellite to take account, as far as possible, of the "opinions of the majority of European astronomers". To this end they organised a meeting in Paris in April 1964 which was attended by 18 European astronomers and several American visitors. The delegates were presented with a 230–page report reviewing the kinds of studies that could be done with the LAS. After the meeting, and having considered the findings of the three commissioned technical studies, the Working Group tightened up its specifications for the satellite.[512] These specifications were approved at the meeting of the Group held on 9 July 1964.[513] They were intended to serve as a basic point of reference for any proposed designs of the LAS.

The specifications arrived at differed in one important detail from those agreed on the year before: the resolution of the ultraviolet spectrometer. In April 1963, it will be remembered, it was agreed that this should be 1 Å (or better, if technically feasible), degradable to 10 Å or even 100 Å to observe faints stars. The new specifications mentioned a few tenths of an Ångström as a "reasonable target", degradable by factors of 2.5 or thereabouts. The pointing accuracy of the spacecraft was upgraded correspondingly. In April 1963 it was assumed that this would be a "few minutes of an arc". The July

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509 COPERS/LPSC/86, rev. 1, cit.

510 The first remark is by Butler and is from his "Review" cited in note 15 below. The centres were assisted, respectively, by the British Aircraft Corporation, by Nord Aviation, and by Bolkow Entwicklungen – see *ESRO General Report 1964-65*, p. 41, from which the final quotation is also taken. The invitations to firms in the Member States to apply for this work is COPERS/249, 19 August 1963. The design study made by the RAE is in Box P(Z)6, 003, that of the Guided Weapons Division of the BAC in Box P(Z)6, 004 HAEC.

511 Massey and Robins (1986), p. 152. Butler was the Chairman of the BNCSR's Solar and Stellar Astronomy Working Group.

512 For this information see Butler's "Review of the Work and General Recommendations", chapter 1 of ESRO, Scientific Report No 1: *Report of the Working Group on the Large Astronomical Satellite, Review of the Scientific Objectives*, Paris: COPERS, March 1964 (quotation from p. 3), Golay archives. See also *ESRO General Report 1964-65*, p. 41.

513 See *Revised Preliminary Scientific Specification as Approved by the LAS Working Group at the Meeting in Paris on 1st October, 1964*, LAS/22, 2 October 1964.

1964 specifications called for an accuracy of the order of one minute of an arc.[514] In short the 'new' LAS was both scientifically more refined (in the restricted sense that it aimed at higher resolutions) and technically more complex (in calling for an increased degree of stabilisation of the spacecraft) than its predecessor.

This change in the specifications was not uncontested both inside the Working Group and in the wider community at large. Some members of the Group considered the new target resolution of a few tenths of an Ångström to be "too severe". Similarly, in a letter to the Group dated 14 June 1964, G. Courtès, a senior French astronomer who was not a member of the LASWG, wanted it put on record that he considered the spectral resolution now proposed to be "too stringent".[515] Behind these objections were fears, which were later to burst violently into the open, that the increased technical complexity of the satellite would unduly limit its scientific scope, push European industry to, if not beyond its limits, and send costs soaring. Against that, there seems to have been one crucial argument which carried the day in 1964: that a LAS that did not meet the new specifications would be a LAS devoid of scientific interest, a LAS rendered obsolete before it was flown by the parallel American Orbiting Astronomical Observatory (OAO) project.

A comprehensive description of the OAO plans was written up by one of the main protagonists of the programme, John B. Rogerson, in summer 1963. It was summarised in a review which was released around spring 1964.[516] The OAO project was to be a series of satellites equipped with a precisely stabilised platform on which astronomical observing equipment could be mounted. These were to be launched at yearly intervals beginning in 1965, the scientific package becoming successively more sophisticated. The first OAO was to carry instruments for the Smithsonian Astrophysical Observatory and for Wisconsin University. Labelled "Project Celescope", its primary aim was to measure the brightness of every star that was above its equipment threshold in each of four wavelength regions. This was to be followed by a satellite carrying an experiment provided by NASA's Goddard Space Flight Center, designed to obtain absolute spectrophotometric measurements of selected stars, nebulae, and galaxies. Finally, there was the most complex payload of all, Princeton University's Flying Telescope Project. Devised by Spitzer and Rogerson, it was a "telescope-ultraviolet spectrometer system which [would] permit the study of O and B spectral type stars as faint as sixth visual magnitude with high spectral resolution in the range of 700 to 3200 Ångströms". [517]

When the LASWG first met in April 1963, they realised that Project Celescope (later labelled OAO-1) would probably provide a map of the sky before the LAS was launched. At the time this did not seem to matter very much. Of course the European group did "not want completely to copy any US (or possibly USSR) satellite". At the same time, Butler felt that "we should not give too much attention to the remark '...but the Americans (or Russians) will have done that long before we do...'. Even if by accident or otherwise two nearly identical satellites were in orbit", he went on, "in most cases there

514 The information is from the source just cited. It should be added that the specifications required that the scientific instrumentation was not to occupy a space greater than one metre in diameter and 2.5 metres in length, and its weight was to be around 200 kg. It was foreseen that the payload would be launched into a polar orbit from the Woomera range in Australia using an ELDO A rocket. This, it was claimed, could place 800 kg into a 600 km circular polar orbit, leaving 220 kg for scientific instrumentation. The stated performance of the ELDO A launcher is in document entitled "Situation arising over the ELDO A launcher", SCI/WP/30, 29 April 1965 (Golay archve, file "Groupe d'Études Spatiales - Correspondance").

515 Massey and Robins (1986) at p. 153. Courtès's letter (Institut d'Astronomie Spatiale, Marseille) is referred to in the Minutes of the 8th Meeting of the LASWG, LAS/17, 11 August 1964 (Golay archive, file "Groupe d'Etudes Spatiales - Correspondance").

516 Rogerson (1963). The review was *Review of astronomical observations from outside the Earth's atmosphere*, and it was made by an International Astronomical Union Commission, President L. Goldberg: see paper laid before the British National Committee for Space Research, document NCSP/20 (64), 1964 (Golay archive, file "Projet LAS Geneve").

517 Rogerson (1963), at p. 645. The rest of the paragraph is essentially based on Goldberg's Report cited in the previous note. For more information on the OAOs see Smith (1989) pp. 37 et seq.

[was] an adequate number of heavenly bodies to justify such duplication".[518] By March 1964 Butler seemed a little more anxious. "The U.S. programme [had] visibly clarified", he noted, and there were a number of "superficial similarities between the ESRO design and that of the US Goddard Space Flight Center component aboard OAO-2".[519] At this stage, and before the April meeting with astronomers, the original design specifications were still intact. Three months later, however, they had been tightened up to bring the LAS more in line with the Flying Telescope Project (OAO-3), which had a planned resolution of 0.1 Å and 0.4 Å. The performance of the LAS was upgraded so that it could compete with the best the Americans could offer. It was a choice which was to have major influence on the subsequent trajectory of the technology.

6.2 Choosing the scientific payload (1965-66). The collapse of consensus and the ongoing debate over project management

6.2.1 The debate over project management: at home or in-house?

In parallel with the firming up of the specifications on the LAS there were lengthy discussions in 1964 on how best to manage the project. The point at issue was a longstanding and divisive one inside the space science community. It concerned the degree of control which national groups should be given over the scientific package, and the nature of their interface with ESTEC.

Early in 1964 the ESRO Executive opened the discussion on how best to manage the LAS project.[520] It was understood that ESRO, which was funding the LAS, had overall responsibility for the satellite. ESTEC would build the spacecraft and it would place contracts with groups in the Member States for the scientific payload. One possible management scenario was that one of these groups, reporting periodically to ESRO's Scientific Director, would be responsible for the scientific planning, programme and coordination. This group could then be joined by scientists from other Member States, so preserving the international flavour of the project. The alternative favoured by the Executive was to establish a permanent scientific group of about 20 people near ESTEC, perhaps in ESLAB, the small associated scientific laboratory. This group "would be actively engaged on some of the scientific work" associated with the LAS (i.e. experimental laboratory work and instrument design), and would act "as a co-ordinator of the other work being undertaken on contract". The in-house knowledge built up inside ESLAB would enable the Scientific Directorate to exercise the "scientific control of contracts with external scientific groups" and to coordinate their designs with those of the spacecraft engineers at ESTEC.

This scheme was received lukewarmly, particularly by the British and the French delegates to the ESRO Council's Scientific and Technical Committee (STC), who did not like the idea of ESRO exercising this degree of control over national scientific groups.[521] In August 1964 the UK delegation put forward a counterproposal. It suggested that "the overall responsibility for the design, development, testing and data assimilation" of the LAS's scientific payload should be vested in an appropriate institute in an ESRO Member State, under contract to ESRO. At the same time, to ensure that the project was "broadly spread throughout the ESRO countries", the UK delegation proposed that the LAS, like the American OAO project, "should not be conceived as a single project, but as a continuing project with a series of launchings". Instead of having back-up launches for a single design, as originally proposed, the money would be spent on flying "two, three, or even four" different scientific payloads using a "basic standard satellite" designed by ESTEC. The British confirmed the usefulness of having a group of project scientists near ESTEC. However, their main task would not be to do scientific research, nor to exercise scientific control over the national groups, as the Executive had proposed. It would be to coordinate "the scientific payload design done by national teams with the

518 COPERS/LPSC/71, cit (fn. 10).
519 Butler's "Review" cit. (fn. 15).
520 COPERS/GTST/144, 13 February 1964, COPERS/GTST/143, 10 March 1964, and ESRO/ST/21, 15 May 1964, from which the following quotations are taken.
521 ESRO/ST/32, 11 June 1964.

work of ESTEC on the standard satellite". At some later date it may of course design its own payload for the LAS, but that would only be after it had built up "the necessary capacity".[522]

The UK's proposal had several advantages. Firstly, the scientific groups to undertake the LAS would be based on existing national teams and could draw on their strengths. Secondly, unlike the Executive's proposal, this would also enable work on the LAS to get started quickly, and without having first to build up a senior core of scientists at ESTEC, which might prove difficult anyway. Thirdly, it represented something of a compromise between those who felt that ESLAB should have a strong core of in-house scientists and those who felt that this would be dangerous, draining the best personnel from national projects and creating a privileged elite who would rapidly seek to monopolise the most interesting scientific work.[523] The UK proposal straddled the fence, leaving the major responsibility for the scientific payload with national groups, all the while holding out the possibility that in some distant future ESLAB may have its own important scientific teams. Despite some minor misgivings, the British recommendations were thus accepted almost intact by the ESRO Council and its committees in the autumn of 1964. And national groups were invited to submit proposals for the scientific package of the LAS by the end of the year.[524]

6.2.2 The scientific groups submit their designs: the first signs of tension

Three distinct scientific groups submitted definite proposals for the LAS's scientific payload. These were:

- a Belgian-French-Swiss group, which had constituted itself as the Groupe d'Études Spatiales, and which we shall label the BFS group. It was based at the Institut d'Astrophysique de Liège (Director P. Swings), the Institut d'Astronomie Spatiale in Marseille (Director G. Courtès, who was also the project leader) and the Observatoire de Genève (Director M. Golay);

- a German–Dutch group, called the Gernelas group, and based at the Max Planck Institut für Extraterrestrische Physik in Garching (Director R. Lüst), the Max Planck Institut für Astrophysik in Munich (Director L. Biermann), the Space Research Laboratory of the University of Utrecht (Director C. de Jager) and the Kapteyn Observatory of the University of Groningen (Director J. Borgman). The project leader was J.G. Emming (Utrecht);

- a British consortium made of groups based at the UK Atomic Energy Authority's Culham Laboratory (led by R. Wilson, who was also the project leader), at its Atomic Weapons Research Establishment at Aldermaston (L. Maddock), at University College London (R. Boyd), and at the Royal Aircraft Establishment at Farnborough.

There was a fourth proposal from a Swedish group which was not, however, strong enough to undertake the project on its own, and which was hoping to collaborate with the British team.[525]

The most striking feature about these proposals was that the BFS Group had decided to deviate from the specifications drawn up by the LAS Working Group in October 1964. As we have seen, the previous summer Courtès (BFS Project Leader) had strongly objected to the increase in the resolution of the spectrometer from 1 Å to 0.1 Å. Consistent with this objection, and refusing to be bound by the

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522 This paragraph is based on the British *Note...* (ESRO/ST/57, 27 August 1964) and on the subsequent debate in the 1st STC meeting (10-11 September 1964), ESRO/ST/MIN/1, 14 October 1964.

523 For this important debate see see chapter 2.

524 ESRO/ST/MIN/1, cit.; ESRO/ST/76, 10 November 1964 (for the LPAC's view); ESRO/C/76, 13 November 1964 (for the recommendation submitted by the STC to the Council); and ESRO/C/MIN/5, 11 January 1965 (for the Council debate).

525 The details of the three groups are from paper ESRO/ST/193, 12 April 1966, and they may have changed in membership between this date and January 1965. The willingness of the Swedes to join with the UK group was stated at the 3rd STC meeting (10-11 June 1965), ESRO/ST/MIN/3, 13 August 1965.

'agreed' specifications, the BFS Group proposed a LAS scientific payload which had a maximum resolution of about 1 Å.

The STC met in January 1965 to discuss these proposals. It was obviously desirable that the groups try to agree on a set of scientific objectives and payload specifications. But it was also obviously impossible. A suggestion by the Belgian delegation that the three teams should meet to discuss the scientific merits of their proposals before design studies were started was roundly rejected by the British. The UK delegation "did not see the use of such a meeting", the STC minutes tell us, "the differences of opinion between the various groups being very large". More specifically, the British, supported by the Dutch, raised two objections to the BFS proposal. It deviated from the specifications drawn up "after long and careful study by a group consisting of many of the most competent astronomers in Europe". It also risked simply duplicating work that the Americans would already have done with their early OAOs. Against them, the French delegation, supported by the Belgians, insisted that the specifications of the LAS Working Group were to be regarded as a guide and not as an obligation. They recognised that the proposal deviated from the recommendations of the LASWG, but "felt very strongly that it was impossible at the present time to meet the very ambitious requirements laid down by this group". Consequently they had preferred to submit "a more modest proposal, the reliable functioning of which was much more certain and which", in their view, "could produce results of great scientific interest". The STC, unwilling at this stage to make painful choice, agreed to place design contracts with all three of the main groups. At the same time it recommended that representatives of these groups meet with ESTEC staff as soon as possible to discuss the design of the spacecraft. The Committee suggested that at this meeting "the possibility of combining the proposals might be considered" adding, realistically, "in particular the question of combining the Swedish proposal with one of the others".[526]

At one level, the STC's action was simply the classic approach of a decision maker faced with a difficult and divisive choice: decide without choosing and hope that a 'choice' can be made at a later date which, in the light of new circumstances, does not offend anyone.[527] Perhaps it also reflected a wish to hedge bets by keeping several options open for as long as possible so as to be in a better position later to capitalise on new scientific, technological and political developments. Behind these strategies though there were also the pressures to dilute LAS's international character which had been building up around the project throughout 1964. The consensus over the LAS had been broken in the summer of 1964 when the target resolution of its UV spectrometer had been increased tenfold. This difference of opinion became institutionalised with the decision to give national teams a large measure of control over the development of their preferred scientific payload. And it was clear that the divisions would be exacerbated by giving contracts to all three teams. As the Dutch delegation pointed out, once the designs of the different payloads were frozen, there would be even less hope of getting the groups to collaborate. A bruising and damaging conflict within Europe's young space science community was looming.

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526 STC, 3rd meeting (20-21 January 1965), ESRO/ST/MIN/3, 17 February 1965. It should be pointed out that the STC was following the recommendations of the LPAC which, meeting the day before, had decided that all three main groups should be given design contracts: ESRO/ST/102, 17 February 1965.

527 Schilling (1961).

6.2.3 LAS's scientific payload is chosen: incipient tension turns to open conflict

Design contracts for the three scientific groups were duly authorised. The contracts stipulated that the final designs had to be submitted by 31 January 1966.[528] To assess them, ESRO set up a board of consultants comprising three astronomers, two spectroscopists, and one expert on electronics and data handling. Their conclusions were then submitted to a panel of experts comprising L. Goldberg, Director of Harvard University Laboratory, USA, L. Gratton, Director of the Laboratory of Astrophysics in Frascati, Italy, and H.C. van de Hulst, Professor of Theoretical Astronomy at the University of Leiden, Netherlands. This panel submitted its recommendations to the Director General at a meeting held at ESTEC on 4 and 5 April 1966.[529]

To assess the design studies the board of consultants broke down the project into nine main categories (e.g. design, telescope, electronics, management). These features were then further subdivided into a total of 63 subheadings. Each subheading was marked on a scale from 3 (very good) to zero (unacceptable). The points were then summed to give a final score for each proposal. The result was 145 points for the UK team, 132 points for the Gernelas group, and 120 points for the BFS group. More concretely, the board found that the British team was ahead as far as overall management, overall design, and technical facilities were concerned. The Gernelas proposal, they added, was technically comparable but managerially weaker than that of the UK group. As for the BFS proposal, wrote the board, it was "the weakest of all".[530]

The ESRO Directorate and the panel of three experts considered this report in the knowledge that there would only be enough money in the first eight-year plan for just one major scientific payload on the LAS. They made two main recommendations. Firstly, they proposed that only one high-resolution instrument should be built, and that it should be based on the UK design. A back-up unit incorporating any new technological developments would also be built in parallel to cover the risk of the first LAS failing. Secondly, returning to the Executive's original proposal, and hoping to internationalise the project, they recommended that a highly competent scientific project manager should be appointed at ESLAB and given "full executive responsibility for the scientific payload".[531]

The Belgian-French-Swiss Group fought back immediately. The consultants and the expert panel, they insisted, had treated them unjustly.[532] They had concentrated on the technical aspects of the designs at the expense of wider considerations. The BFS team, said the paper, were being "penalised" for having "the courage to rethink the problem", and to come up with a design that was "realistic in its concept, original in its mechanical and optical solutions, [and] logical in its scientific programme". In defence

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528 The process of drawing up these contracts was complicated by sudden doubts over the suitability of the ELDO A launcher. At its meeting in March 1965 the STC was informed that it now looked as though this rocket could not place more than about 400 kg into a 600 km polar orbit, half the overall weight initially announced. If this were confirmed it would mean that the British or Gernelas scientific packages would be too heavy for the European rocket (document SCI/WP/30, 29 April 1965, Golay archive). The possibility of using an American launcher was immediately explored (ESRO/ST/130, 4 June 1965). The problem was resolved in the light of new information from ELDO (ESRO/ST/126, 28 May 1965). In May ESRO was informed that it was "estimated" that ELDO A could put a payload of 800 kg into an equatorial orbit of at least 700 km. Launching would take place from a range that France proposed to set up in French Guyana, and which would be ready in 1968-69. This proposal was accepted by the STC in June on condition that, if there was any substantial degradation in the announced performance of ELDO A, or any important delays in its development which affected the LAS schedules, a US launcher would be used "to avoid any substantial changes in the spacecraft design" (ESRO/ST/MIN/5, 13 August 1965).

529 The three volumes of the Gernelas study and one volume of the UK study are in box P(Z)6, 003; four of the seven volumes of the BFS study are in box P(Z)6, 004, HAEC. For details on the panel of experts see ESRO/ST/191, 15 April 1966 and ESRO/ST/193, 12 April 1966.

530 ESRO/ST/193, 12 April 1966.

531 ESRO/ST/191, 15 April 1966.

532 The BFS Group's paper is ESRO/ST/208, 29 April 1966.

of their position, the BFS group put forward three types of arguments: scientific, technical, and financial. They were to echo down the later history of the LAS.[533]

On the scientific side, the group did not deny that the British and Gernelas instruments would produce results of interest. They simply insisted that their device would also do so, and in fact would break new ground. The advantage of a high-resolution spectrometer, they said, was that it could make a detailed study of a few already comparatively well-known objects. The advantage of their payload, by contrast, was "the satellite's power of exploration". It could be used to study galactic structure as a whole, to explore highly unusual celestial objects or those having a violent evolution, and to observe extra-galactic sources which radiated strongly in the low wavelength region. In sum, according to the BFS group, whereas the British and Gernelas packages were well suited to refining what was already known, their instrument had the possibility of making exciting new discoveries.[534]

A second important advantage of their device claimed by the BFS team was that it was technically feasible and avoided unnecessary risks. Take for example the mirrors in the British and the BFS designs. The former was to be of quartz and had to be of perfect optical quality. "The technical hazards in construction (very small tolerances), in survival at launch (behaviour under vibration), and in operation in space" were considerable. The BFS mirror, on the other hand, could be of beryllium or of a synthetic substance with "very large" optical tolerances. Consider too the required pointing accuracy of the spacecraft. The high-resolution spectrometer called for a satellite capable of fine pointing with a precision better than 1 arc sec. The low-resolution instrument, required a primary stabilisation to the nearest minute of an arc. In short, unlike the British proposal, the BFS design adopted "mechanical and optical solutions which [were] elegant without being acrobatic or ruinous".

Finally, there was the question of costs. It was clear that the more sophisticated satellite and scientific payload called for by the British group would be more expensive than those required for a low-resolution instrument. Here the BFS remarked that "an analysis of project economy" showed that if ESRO went ahead with the British design it would amount "to attempting to reach the performances of NASA's OAO III, while spending much less and practically without any preliminary experience". A paper prepared by the ESRO Executive in June 1965, after a visit to NASA headquarters, confirmed this line of argument. Here it was reported that NASA's estimate of the OAO programme costs was "about four times as great as the ESRO estimates" for the LAS. The Executive admitted that the American programme was more ambitious and complex. But their paper insisted that all the same the LAS could probably only be built within the budget "provided no attempt [was] made to introduce very new developments or to push to extremes mechanical, electronic or control problems of the spacecraft".[535] In the eyes of the BFS team, the British proposal did just that. As they put it to the STC, "it would seem rather odd that Europe should wish to adopt at the outset a stellar programme closely similar to that in the United States, using one satellite – and one only! – weighing half as much and built with much smaller funds [than] that in the United States".

The STC met early in May 1966 to discuss the experts' reports and the BFS Group's paper.[536] As one might imagine the ensuing debate was lengthy – Massey and Robins, who were the British delegates, remember that it lasted more than five hours – and very divisive – unsurprising, since many of those

533 ESRO/ST/208, 29 April 1966, and ESRO/ST/204, 25 July 1966. The subsequent quotations are from this document.

534 We are not able to assess the validity of this contrast. It should however be noted that in subsequent discussions of the Star and Stellar Systems (STAR) Working Group of the LPAC, it was agreed that, while both low and high resolution experiments were useful, they could be not be done using a single instrument. Accordingly, in October 1966 the STAR group "strongly" recommended that "LAS design should not be changed to aim at wide field ['low resolution'] spectrophotometry": STAR/23, 5 October 1966, STAR/25, 13 October 1966 and STAR/30, 14 November 1966 (Golay archive, file "STAR").

535 ESRO/ST/129, 4 June 1965.

536 STC, 9th meeting (2-3 May 1966), ESRO/ST/MIN/9, 7 June 1966.

who had proposed payloads were also national delegates.[537] In the event, it was 'agreed' that the UK's design be adopted. In a concession to the BFS group, it was added that, if it was technically and financially possible, low resolution experiments would be combined with high resolution experiments in the same payload. The question of management was not settled unambiguously. The French and Belgian delegations insisted that "the management of the project should be confided to the British group, whose capabilities had been proved. ESLAB", they went on, "did not have the facilities and should not 'cut its teeth' on a project of such magnitude and importance". The Director General (P. Auger), along with the Danish, Dutch and Swiss delegations, on the other hand, were not keen to give a single national group overall responsibility for the project. To resolve the difficulty it was decided to discuss the matter with the Project Manager of the British team, and to hold a special meeting of the STC before the next Council session to try and reach agreement on the management aspects. The debate ended on a tense note. The Belgian delegation asked that the minutes record its reservation concerning all the decisions taken by the meeting on the LAS. The French delegation added that, "for the Organisation's sake, it regretted the conclusions reached by the Committee".[538]

This debate calls for two comments. Firstly it was a debate between two sectors of the space science community with very different disciplinary histories, very different professional backgrounds, and very different ways of defining the aims of research. Loosely speaking it was a conflict between physicists and stellar astronomers, the former recently attracted to space, the latter seeing their work as part of a tradition of celestial studies going back for centuries. As Marcel Golay, one of the members of the latter group and a team leader in the BFS consortium has put it, for the physicists "a star was a laboratory, for us [i.e. the astronomers] a star was a member of a vast population itself part of a vast structure".[539] The former preferred to study a single phenomenon, to concentrate on a single event or process. The latter, on the other hand, the stellar astronomers, preferred making surveys of collections of objects. They were not interested in the properties of an object 'for itself', but for the light it threw on how a population of such objects behaved. And they lost out. They lost out because their approach, according to Golay, had a 19th Century flavour to it. They also lost out because, compared to the 'physicists', they were relatively indifferent to space research, particularly in the early 1960s - after all they had a considerable amount of ground-based equipment that they could use.[540] Finally, they were defeated because stellar astronomers lacked the social weight and impressive organisational acumen of a physics community that had become increasingly powerful since the war.

The second point to note is that the contrasting positions adopted by the British/Gernelas teams and the BFS group are indicative of the dilemmas faced by a scientific community which was at least a decade behind its American counterpart and which, at the same time, had to try to compete with it. In this situation there were two opposed ways of situating oneself *vis-à-vis* the leader. One philosophy took a medium- to long-term view. It held that one should try to approach parity gradually, first building up the experience and know-how with scientifically interesting but technically and financially 'realistic' projects. This was the approach favoured by the BFS Group. They agreed, as one of their members, P. Swings, put it as early as 1962, that "what we wish most is to have at our disposal the expensive, heavy, stabilised orbiting satellites". However, Swings went on, before trying to build something equivalent to the most sophisticated device planned in the USA, "much experience with more modest instruments must be gained".[541] Against that there was the view, insisted on by the British

537 In particular P. Swings (B), M. Golay (CH), R. Lüst (G), and C. de Jager (NL). H. Massey (UK) was intimately involved with the British proposal - see Massey and Robins (1986), p. 155.

538 The amended version of the Belgian comment is to be found in ESRO/ST/MIN/10, 6 July 1966. It differs from the briefer version in the draft minutes (ESRO/ST/MIN/9) by stressing that several delegations had raised doubts about the scientific, technical and financial aspects of the UK project.

539 M. Golay, private communication, 30 September 1991, 1 October 1991.

540 Let us not forget that ESO, the European Southern Observatory, was established in 1962 to operate an astronomical observatory in Chile and to promote and organise cooperation in astronomical research in Europe. At present it has no less than fourteen optical telescopes in operation.

541 Swings, "Report on the Scientific Interest and Problems", in J. Ortner's Report on the *COPERS Colloquium concerning astronomical experiments to be accommodated in ESRO rockets and satellites*, COPERS/LPSC/14, 4 September 1962.

from mid-1964 onwards, that one should try to catch up in one leap. If one did otherwise, if one took a stepwise approach, one would always be behind, building devices which were obsolete, and lacking in any kind of scientific or technical challenge. As one participant who assessed the proposals remembered afterwards, "we had to choose between (A) something that might be by later commentators called 'again the same thing, a student's exercise' or (B) an ambitious project that might turn out to be difficult or too expensive for us".[542] They decided to take the risk.

6.2.4 The BFS Group strikes back, in vain

Despite its setback in May 1966 the BFS Group was not beaten yet. A meeting to take stock of the situation was held in Paris in July. It was attended by some members of the Group and a number of senior Belgian, French and Swiss ESRO Council and STC delegates.[543] They realised that the Council, which was to meet a week later, would surely ratify the STC's recommendation to fly the UK's LAS. At the same time, they thought it might just be possible for them to have a simplified version of their package flown. There were certainly formidable obstacles to be overcome. But there was one glimmer of light. The month before another attempt to work out a management scheme for the LAS had failed. The Executive had again put forward a proposal which gave considerable scientific responsibility to a project manager and his team at ESLAB, and the British had again insisted that the project be based at Culham under the scientific control of their Project Leader.[544] That granted, was it not possible that "the Franco-Belgian-Swiss project might find an ally in the ESRO Directorate if it appeared as a way of getting out of this impasse and if it provided a means by which ESLAB could be consolidated"? Would a low-resolution experiment, by virtue of its dimensions and its relative simplicity, not enable "ESLAB along with international help, to organise itself and to acquire experience which would be extremely useful for controlling LAS"?[545] Put differently, granted that the LAS was not a suitable project on which the newly-born ESLAB could cut its teeth, why not have its scientists start on something related but less complex, and which would be built first, moving later on to the LAS? In short, the BFS hoped to exploit the resentment felt in some ESRO circles about the UK's determination to control the LAS by having a version of their payload built in-house, and flown before the Culham group's experiment.

With these considerations in mind the BFS submitted a new paper to the STC meeting held just before the July 1966 Council session. It asked the committee to recommend to the Council that a ceiling of 50 MFF be imposed on the high-resolution experiment. It also requested that the 25 MFF set aside in the ESRO budget for a second large project be used for a low-resolution experiment. And it suggested that a top-level Astronomic Programmes Department with its own Director be set up inside ESRO for the management of both projects, its task being "to ensure that these projects [were] of an international character".[546]

542 H. van de Hulst, private communication, 5 September 1991. There was an analogous debate at CERN over its bubble chambers as described by Krige & Pestre (1986), and by Krige in Hermann et al (1990), chap. 9.3. On the difficulties of Europe catching up with the USA see particularly Pestre in Hermann et al (1990),
chapter 13. See also Collette's paper later in this volume where he speaks of the need for Europe to leapfrog the USA if it was to remain competitive in the commercial field of telecommmunications by satellite.

543 Those present were Coulomb (ESRO Council and STC Chairman), General Aubinière (DG, CNES), Bignier (Council, STC and CNES), Cruvelier (Marseille), de Boisgelin (Foreign Affairs and Council), for France; Dubois (Council Adviser and STC), Monfils, and Housiaux (Liège University and STC) for Belgium; and Chavaz (Swiss Embassy, Paris and Adviser. STC). See letter from Chavaz to Golay, 12 July 1966 (Golay archive, file "Groupe d'Etudes Spatiales, Correspondance").

544 For the debate over the management problem in June see the ESRO Executive's paper, ESRO/ST/209, 15 June 1966, the UK addendum, ESRO/ST/209, add. 1, 17 June 1966, and the minutes of the 10th STC meeting (21 June 1966), ESRO/ST/MIN/10, 6 July 1966.

545 The quotations are from Chavez's letter cited in note 46. Our translation from the French.

546 ESRO/ST/204, 25 July 1966.

This counterattack bore little fruit. The only residue it left in the decisions taken by the Council in mid-July was that ceilings should be imposed on the costs of the spacecraft and its scientific payload in November, when more data would be available.[547] Apart from that, the Council, by six votes to four (Belgium, France, Spain and Switzerland), confirmed that there should be only one basic design for the LAS scientific package. It also agreed that it be based on the UK design, that there be one back-up unit, and that a contract for the primary scientific package be negotiated with Culham laboratory. The management structure of the project was fudged. The Council agreed that there should be an overall LAS systems manager, and instructed the Director General "to make proposals as soon as possible concerning the structure for the internal management of the project within the Organisation". At the same session, the Council discussed ESROs next three-year budget. And it took a decision which dramatically changed the terms of the debate about the LAS.

6.3 Settling the final design and operational needs (1967-68). Rising costs, shrinking budgets and the withering away of LAS

6.3.1 The financial crisis of July 1966 and the dangers it posed to LAS

When the ESRO Convention was signed in 1962, the meeting of government representatives also signed an associated protocol making financial provision for the Organisation. It stipulated an overall eight-year ceiling of expenditure of 1509 MFF. It also set ceilings for the first and second three-year periods. The Organisation was to spend no more than 384 MFF in 1964-66 and the limit for 1967-69 was set at 602 MFF. All of these figures were in 1962 prices. At its meeting in July 1966, the ESRO Council's Administrative and Finance Committee (AFC) was presented with a draft budget for the next three years which called for 808 MFF in 1965 prices.[548] This figure was composed of three elements. There was 602 MFF, the sum provided for under the financial protocol. Then there was an additional 84 MFF, being an adjustment of 13.9 % to update the 602 MFF to 1965 prices. Finally there was a new item: 122 MFF. This was money which had not been used during the first three-year period and which the ESRO Executive wished to carry forward to the second. There had been an underspending, said the Executive, because the build up of the Organisation had gone ahead more slowly than anticipated.

In the ensuing debate in the AFC it was provisionally decided to allow ESRO to carry forward about half of the unspent monies, and the budget level for 1967-1969 was set at 750 MFF (602 + 84 + 61 MFF, rounded up) in 1965 prices.[549] The Council, meeting a week later, was not prepared to do even that. The Belgian and French delegations "criticised the Organisation's lack of financial discipline, its too heavy investment and [its] staff plans" - including the decision to go ahead with the LAS project, "which was the most difficult to carry out".[550] The British delegation made it clear that it would not support a budget of more than 686 MFF (602 + 84 MFF) for the next three years. The Italian delegation went further, refused to accept the adjustment for inflation, and asked for a budget level of 602 MFF in 1965 prices. In the event, the Council invited the Executive to prepare a budget for the next three years for 686 MFF, rounded up to 690 MFF.[551] The Executive's hope of carrying forward the unspent funds from the first three-year period was dashed.

In the light of this situation, a new expenditure profile was prepared for consideration by the STC.[552] New costing of the LAS indicated that the spacecraft plus two flight models would cost

547 Council, 12th meeting (24-25 July 1966) ESRO/C/MIN/12, 1 September 1966. The resolutions taken on the LAS are ESRO/C/XII/Res. 5, 25 July 1966.

548 ESRO/AF/476, 20 June 1966.

549 The AFC recommendations are spelt out in ESRO/AF/549, 7 July 1966. The French and Italian delegations did not support these figures at the meeting.

550 ESRO/C/MIN/12, cit. The comment about the LAS is in a French note: ESRO/C/218, 15 July 1966.

551 The resolution is in document ESRO/C/DP/12, 28 July 1966. It included the stipulation by the Italian delegation that their government was not prepared to pay more than 602 MFF for 1967-69.

552 SCI/WP/66, 19 August 1966, attached to a summary of the LPAC recommendations for the STC, ESRO/ST/215, 9 September 1966.

210 – 250 MFF, while UK figures for the scientific package with its back-up indicated that these would cost 50 MFF. On the basis of this data, and the need to cut 55 MFF from the satellite programme, two alternative scenarios were proposed. Both allowed for minimal expenditure on the LAS and its instruments in 1967, when a large slice of the anticipated ESRO budget would be needed for commitments already entered into. Both put the launching of the spacecraft outside the initial eight-year life of ESRO. On hypothesis A, the two envisaged TD satellites would be slightly simplified, the take-off of LAS expenditure would be slowed down, and its anticipated launch would be in 1973-74. On hypothesis B, one of the TD satellites would be dropped from the programme, and the LAS programme would go ahead more rapidly, with an anticipated launch in 1972-73.

The Launching Programme Advisory Committee (LPAC) considered these recommendations at its meeting on 27 August 1966.[553] After a lengthy discussion, it adopted hypothesis A. The TD-1 and TD-2 satellites, it said, should be "pursued with the highest priority". A ceiling of 300 MFF should be imposed on the LAS for the spacecraft and the scientific package, and not more than 200 MFF of this was to be spent by the end of the first eight-year period of ESRO's life, i.e. 1971.[554] These recommendations were accepted by the STC at its meeting on 22 and 23 September 1966, the Italian delegation abstaining.[555]

What considerations informed the decision to give the two TD satellites top priority? One reason seems to be purely practical. Tenders for the two satellites had already been called for, and the offers opened the month before.[556] It would be difficult to cancel one or either of these projects now, with design work already so well advanced. Then it must also be remembered that these were multi-experiment satellites. TD-1 carried seven experiments, TD-2 no less than ten at this time. These instruments had been built by national groups in many Member States. The two satellites could thus count on widespread scientific and political support. Finally, some of the experiments to be flown would be useful for later ESRO projects. One of TD-1's main tasks was the study of stellar astronomy, and in some eyes it could be seen as part of the overall LAS programme.

All the same this set of priorities, far from securing the future of the LAS, in fact tended to endanger it. Firstly, the viability of the Culham group was threatened. It was not simply that there was little or no money to fund them during 1967. There was also the problem of what they were to do. The UK had said that they needed five years to develop their scientific package. Since the work on the spacecraft and the package had to proceed in parallel, and the anticipated launch was seven years hence, it was clear that Culham had to slow down its activities for one or two years. This would surely be at the cost of the group's morale and its interest in the project.

Secondly, there was the danger that the project costs may escalate above the ceiling. The estimate for the scientific payload seemed accurate enough. There was far more uncertainty surrounding the costs of the spacecraft. "It should be recalled", wrote the Executive in October, "that the figures for the spacecraft are based on an assumption that such development costs in Europe only would be about 2/3 of the corresponding ones in the US". If further studies showed that assumption to be unrealistic, "some modifications of the scientific aims might become necessary in the course of working out the final design during 1967 and 1968".[557]

Finally, there was the danger that the LAS fall victim to changes in ESRO's long-term policy, which was due to be discussed at a Ministerial Conference in 1967. It was becoming clear that at this

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553 LPAC, 13th meeting (27 August 1966), ESRO/ST/218, rev. 1, 28 September 1965. See also chapter 5.

554 The full programme implied by this decision "provided for the launching of ESRO I and II in 1967, HEOS-A in 1968, TD-2 in 1969, and also geared towards the launching of TD-1 in 1970, LAS in 1973-74 and towards the starting of another project in 1968-69": ESRO/AF/561, 7 September 1966, and ESRO/AF/561, corr. 1, 19 September 1966.

555 STC, 12th meeting (22-23 September 1966), ESRO/ST/MIN/12, 2 November 1966.

556 This information is from document SCI/WP/66, cit.. As the spacecraft were tendered for as a unit pair, it would also have been difficult to cancel just one of them.

557 ESRO/ST/229, 28 October 1966.

conference the Member States would be looking for a de-emphasis of the science programme. As the Belgian delegate to the STC put it, "governments would have more confidence in ESRO if the Organisation's research programme was coordinated with other European space activities, like the development of a launcher and of telecommunications satellites. A coordinated programme of this type", the Belgian delegate went on, "would enable Europe, if not to catch up with the United States, then at least to ensure that it was not left even further behind".[558] About one third of the LAS's costs, or 100 MFF, were to be borne outside the first eight-year period foreseen in the ESRO Convention. If the future ESRO was to include a strong applications satellites programme, the prospects for an expensive and prestigious scientific project like the LAS were bleak indeed.

6.3.2 The UK's attempts to save the Culham group

Alarmed by developments the UK Atomic Energy Authority and the Science Research Council made two proposals intended to secure the viability of the LAS and of the Culham group. Firstly, they offered to pay for the work at Culham during 1967, the money only being refunded by ESRO in 1968, when there was more breathing space in the budget. Secondly, they proposed that the Culham Group be authorised to develop a half-scale model of the LAS. This would be flown on a star-stabilised rocket then being developed in the UK. The experiment, said the Culham Group Leader, in addition to ensuring that his team would remain fully employed, "would increase the know-how available on the technological aspects of the development and might well have an impact on the final design of the payload".[559]

The British suggestion was rejected by the STC at its meeting on 8 and 9 November. The German and Dutch delegations were strongly in favour of continuing the LAS, believing that large, advanced projects had a fundamental place in a European space effort. Other delegations were less convinced, fearing that it would unbalance the programme. And when the British offers of support for the Culham group were put to the vote, to the bitter disappointment and anger of the Group Leader, they were refused by five votes (Belgium, Denmark, France, Italy and Spain) to three (Germany, Netherlands, and UK). Sweden and Switzerland abstained.[560] In the light of this decision, the STC agreed, after another painful vote, that work on the scientific package should be temporarily halted, and that tender action be initiated for the spacecraft on the basis of the Culham group's design. The Ministerial conference to be held the next year would examine the new cost estimates and decide on the future of the LAS. These recommendations were endorsed by the Council a few weeks later with one important change. On the insistence of ESRO's Technical Director it was agreed to provide minimal finance for the nucleus of the Culham Group until the Ministerial Conference was held, hopefully in summer 1967. This was because the help of the group was said to be essential for the assessment of tenders.[561]

Two brief comments are apposite here. Firstly, the votes in the STC were indicative of the deep divisions now created by the LAS inside the European space science community. On the one hand, they reflected the ongoing animosity of the Belgian and French delegations to the high-resolution instrument favoured by the German, Dutch and British teams, and their determination to try to kill the project at every opportunity. The financial situation brought them additional allies: Italy and Spain, who were becoming increasingly apprehensive about the costs of ESRO, and Denmark. The Danish position was spelt out in a long statement made to the STC in November, and (what was most unusual) reproduced verbatim in its minutes. The LAS, said the Danish delegation, was taking resources away from projects of interest to the smaller Member States, like sounding rockets and the scholarship

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558 This is from the minutes of the 13th STC meeting (8-9 November 1966), ESRO/ST/MIN/13, 27 December 1966. Our translation from the French version. On the 1967 European Space Conference see chapter 9.

559 This paragraph is based on ESRO/ST/229, 28 October 1966, and the explanations by the head of the Culham group in ESRO/ST/MIN/13, cit.

560 ESRO/ST/MIN/13, cit.

561 Council, 14th meeting (30/11-2/1266), ESRO/C/MIN/14, 20 January 1967. The contract with the Culham Group was subsequently extended until the end of February 1967 and finally terminated on 31 July 1968 (see *ESRO General Report 1967*, p. 54, and *1968*, p. 25).

programme. It was also forcing cuts in the applied research programme which was essential if Europe was to be less dependent on American material and know-how. The costs, they concluded, were not worth the benefits, and the Large Astronomical Satellite should be given a very low priority in the ESRO programme. The second point to note about this debate is the support for the British LAS by ESRO's Technical Directorate. This had been guaranteed from the start. Indeed early in 1966 the Technical Director had proposed calling for tenders for the LAS spacecraft using the UK design of the payload as a guide even before the technical studies submitted by the three scientific groups had been assessed by the ESRO consultants.[562] At one level this reflected the longstanding relationship between the Technical Director, Alfred (Freddy) Lines and the British team. Lines had been at the Royal Aircraft Establishment before joining ESRO. Here he had directed a programme, in consultation with British astronomers, aimed at working out the technical requirements and possibilities for an astronomical satellite stabilised to a few minutes of an arc. In 1962 he had presented a paper to a COPERS Colloquium describing his main findings.[563] The RAE subsequently provided one of the first early feasibility studies of the spacecraft for COPERS. Lines had thus been personally and emotionally involved with the UK group and their project from the very beginning. In addition, at a more general level, there was the interest of producing a spacecraft of the complexity demanded by the British (and Gernelas) LASs. Here was a project worthy of the engineers at ESTEC, a project which would stimulate them personally, challenge them professionally, and ensure that the centre in Noordwijk would become a lynchpin in the development of ESRO and of Europe's space effort.

6.3.3 Enter new cost assessments, exit the LAS

A call for tenders for the LAS spacecraft was duly issued in January 1967. A consultant from NASA, W.G. Stroud, was employed for six months to assist with the tender evaluation and to help establish realistic cost estimates for the project. In doing this, Stroud and his teams from ESRO, ELDO and Culham actually redefined the project - in fact he even proposed changing its name to the European Space Observatory. The LAS was once again to be "a continuing programme comprising a series of flights of the same spacecraft with different scientific packages". The basic specifications remained unchanged, but the technology was upgraded (e.g. by the inclusion of an onboard computer) - and costs soared. Stroud's estimates in June 1967 for the scientific payload were 55-60 MFF (compared to 50 MFF a few months before), those for the spacecraft were now 400-500 MFF (double the earlier estimate). The NASA consultant also included for the first time estimates of the cost of ground support facilities and equipment, including data acquisition and handling, which added another 180-230 MFF on to the bill. On top of that there was the launcher to be paid for, at 120 MFF. In short the total cost of the LAS was now about 900 MFF in 1967 prices - to be compared with a ceiling of 300 MFF for spacecraft and payload agreed only a few months before.[564]

We shall end our story here. The Council, said Stroud sanguinely in presenting his report, ought "not to be alarmed by the apparently high cost. [...] LAS was designed for an extremely advanced and challenging task and no other project that existed or was planned was capable of carrying out such a task".[565] The Council, predictably, baulked at Stroud's cost figures, but agreed that the LAS could be submitted to the Ministerial Conference, "as an example of the type of project that should be

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562 The proposal to call for tenders is ESRO/ST/180, 2 February 1966. The criticism that Lines was 'jumping the gun' was made particularly forcefully by the French and Belgian delegations at the 8th STC meeting (14-15 February 1966), ESRO/ST/MIN/8, 4 April 1966.

563 For the information on Lines' past links in the UK see Massey and Robins (1986), 152. His paper at the COPERS Colloquium is in the document compiled by J. Ortner and cited in note 44.

564 For information in this paragraph see *ESRO General Report 1967*, pp. 52-5 and ESRO/ST/254, 5 June 1967 (for the cost estimates).

565 ESRO/ST/253, 30 April 1967 (for Stroud's presentation to the LPAC), ESRO/ST/MIN/15, 5 September 1967 (for his presentation to the STC on 5 June), and ESRO/C/MIN/17, 6 July 1967, (for his presentation to the Council, from which the quotation is taken). He backed up his intervention with a paper giving "A Justification for the European Space Observatory (LAS)", ESRO/C/MIN/17, Annex II, 5 July 1967.

undertaken by ESRO".[566] The Ministerial Conference, meeting in Rome from 11-13 July 1967, decided to set up an Advisory Committee on Programmes, chaired by J-P. Causse, whose task it was to "elaborate proposals for a joint space policy and programmes".[567] The Causse Report, published six months later, found that the LAS "[could] be undertaken, but that it [was] at the limit of Europe's present technical and financial resources".[568]

When was a decision taken to abandon the LAS? Apparently in mid-1968. The ESRO "Bureau" discussed the future of the project at a meeting on 9 May 1968 and resolved "to discontinue the contract [with Culham], unless the next Council meeting should wish otherwise".[569] In the event, the next Council meeting, held on 30 May 1968, was dominated by difficulties surrounding the TD project. To judge from its minutes, it never even considered the LAS.[570] And according to ESRO's 1968 General Report, "the contract with the Culham Group for the [LAS] experimental package was terminated as of 31 July 1968, because of the high cost of the whole project".[571] After eight or more years of work, and thousands of pages of technical reports, ESRO's Large Astronomical Satellite had quietly disappeared from its scientific programme.

A footnote. In 1968 the UK team started redesigning their scientific package and had carried out a feasibility study for another high-resolution UV spectrometer with "somewhat relaxed" specifications. Its wavelength range was restricted to 1000–2000Å. And the pointing accuracy of the spacecraft was reduced to 2 arc sec, as compared to 0.1 arc sec for the LAS.[572] This became the UVAS, which was also unsuccessfully put forward as a candidate for an ESRO satellite. UVAS in turn evolved into the International Ultraviolet Explorer (IUE), a joint ESA/NASA/UK Science Research Council satellite and a close cousin of the LAS.[573] The IUE was successfully launched into geostationary orbit on 26 January 1978 - twenty years after the first plans for the LAS were drawn up.

6.4 Post-mortem

Why was the LAS never realised as an ESRO project? The answer is apparently simple: it was too expensive. And indeed the costs soared. In 1961 the Blue Book gave a figure of 84 MFF for the cost of an astronomical satellite, using UK estimates of what industry would charge to build one. By end-1966, when the specifications had been firmed up and the first serious designs and costing completed, it looked as though the scientific payload would cost about 50 MFF and the satellite about 250 MFF. A year later, Stroud and his team, after upgrading the scientific package and tendering for the spacecraft, came up with figures of 55 - 60 MFF and 400 - 500 MFF, respectively. In fact the Causse Report estimated that the LAS programme and its launchers would cost about $180 million, equivalent to the cost of about five or six medium-sized scientific or applications satellites.

We cannot leave matters at that, though. Indeed it is meaningless to speak of the LAS as too expensive. From a technical point of view it was in fact cheaper, and allegedly better, than the American OAO programme which, according to the Causse Report, had already cost about $250 million by December 1967. If the LAS was too expensive, it was too expensive given the amount

566 The Council minutes are ESRO/C/MIN/17, 6 July 1967.

567 The minutes of the European Space Conference are CSE/CM(July 1967)/PV/..., with various dates.

568 The Report of the Advisory Committee on Programmes, chaired by J-P. Causse, is document CSE/CCP(67)5, December 1967. The quotation is from p. 15. The Causse Report is discussed in detail in chapter 9.

569 H. van de Hulst (private communication), 5 September 1991.

570 The minutes are ESRO/C/MIN/24, 7 June 1968.

571 *ESRO General Report 1968*, p. 25.

572 See *ESRO General Report 1968*, at pp. 25 and 87 for this information.

573 On the decisions regarding UVAS and IUE see chapters 7 and 8 in this book. The IUE was designed to give high-resolution (approx. 0.1 Å) spectra of bright objects and low-resolution (approx. 6 Å) spectra of fainter objects. The spectral range covered was 1150 Å to 3200 Å. Fine guidance to an accuracy of 1 arc sec was provided. The total weight of the IUE spacecraft and scientific payload was 668 kg. See Massey and Robins (1986), chapter 15, and Macchetto & Penston (1978).

of money European governments were prepared to spend on ESRO and the scientists' insistence that the organisation had to have a balanced programme.

From the very start it was clear that European governments were not prepared to pump anything like the amount of money into ESRO that the USA was spending on its civilian space science programme in NASA. One important reason for this so-called 'lack of political will' was that, granted the commercial and military interest of space, some major European powers also wanted to build up an independent launch capability and substantial national space programmes. They were prepared to invest in joint scientific research in parallel, but only under tightly controlled financial conditions. Even this was rapidly judged by some to be a luxury. The pressure in the mid-1960s to broaden ESRO's brief to include application satellites, and a number of major funding crises in ELDO, effectively meant that there could be no major upturn in the funding for scientific satellites, as the LAS required.

The LAS also suffered from a growing loss of support in the space science community. It must be remembered that space science is a fragmented discipline. The LPAC had no less than six different ad hoc Working Groups proposing rocket and satellite experiments in diverse fields. To maintain some 'balance' between them it had to ensure that no one field was granted too large a share of the available resources. This counted heavily against the LAS, which increasingly threatened to skew the whole research programme in favour of stellar astronomy. The lack of widespread scientific support for the LAS in 1965-6 was also undoubtedly due to the so-called 'management problem'. There may have been all sorts of good reasons why the UK blocked every initiative by the ESRO Executive to build up a strong in-house group of space scientists who would share in the work on the LAS's scientific package. But this was a move which was particularly resented by some of the smaller countries. They saw front-line research in an international centre like ESTEC as the only way in which their scientists and engineers could build up the necessary know-how in the space sector. By consistently refusing to take meaningful steps to 'internationalise' the work on the LAS - a project paid for by ESRO, after all - British scientists undoubtedly lost the goodwill of important sections of the ESRO management and of at least some of their professional colleagues in other countries.[574]

Another reason why the LAS was abandoned was that it was seen to be technically too ambitious for ESRO. The Causse Report made much of this. Many of the components called for in the designs proposed by Stroud and his team had performance specifications which were more demanding than those currently being achieved in the USA. It was not sure that European industries were yet in a position to undertake a venture of this size and complexity, said the Report. Linked to the question of technical risk was, of course, the fear of further cost escalation. It is thus not surprising that when the LAS was abandoned, the Culham group designed a technologically simpler payload. In particular they dramatically reduced the pointing accuracy of the spacecraft which was one of the main factors pushing up its cost.

Surveying these arguments it is of course striking that the difficulties faced by the LAS were precisely those predicted by the Belgian-French-Swiss group who proposed building a low-resolution instrument in 1965. From the start they had objected to increasing the target resolution to 0.1 Å, and they had warned against the implications of the corresponding increases called for in pointing accuracy. They had also objected that the satellite demanded sophisticated technology (e.g. a finely-polished and delicate quartz mirror) which would make it technically risky and highly costly. The scientists in these groups cannot have been pleased at the demise of the LAS. But they must have felt a certain grim satisfaction at seeing their early predictions, which had been swept so brusquely aside, confirmed by later events.

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574 According to one of the protagonists, R. Lüst, "the so-called 'management problem' was one of the major reasons that the project lost wide-spread scientific support. In my opinion, this could be stated more strongly as being the killer". As confirmation, Lüst remarks that projects like COS-B, EXOSAT and particularly *Hipparcos* would never have been accepted if they had been arranged in line with the UK management scheme. (Letter from R. Lüst to the author, 5 September 1991

Does this mean that the BFS design should have been chosen at the start? That would be too hasty. Everyone realised the scientific, technical and political importance of ESRO having large, expensive and challenging projects in its programme. The LAS not only fulfilled these objectives. It also held out the promise that European astronomers and astrophysicists could compete on an equal footing with their American colleagues. This was why most European stellar astronomers consistently supported the British design for the LAS. This was a dream which most space scientists felt the BFS payload could never fulfil. It was a dream which was inevitably shattered. If you want to compete in a race you need comparable resources, and these Europe did not have. Causse's committee drew the sobering conclusions. It was essential for ESRO to have ambitious projects, but preferably "in a field where competition [was] not too lively already" and in which the Organisation could "collaborat[e] with the other great space Powers".[575]

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575 Causse Report, *cit.,* pp. 19-20.

Chapter 7: The COS-B Satellite: A Case Study in ESRO's Selection Procedures[576]

A. Russo

COS-B is the name of a successful space mission aimed at studying celestial gamma rays. It was carried out by a team of European scientists within the framework of the scientific programme of the European Space Research Organisation (ESRO) first and of the European Space Agency (ESA) later. First proposed in the mid-1960s, the project was approved by the ESRO Council in 1969 and the satellite was launched in August 1975 (Figure 7-1). It provided a continuous flow of useful data until April 1982, when the instruments on board were switched off because of the irreversible deterioration of the main detector. Stored in several hundreds of magnetic tapes, these data are still available for further processing by the scientific community at large.

The historical interest of the COS-B mission can be considered from at least three points of view. Scientifically speaking, it made a fundamental contribution to the field of gamma-ray astronomy, dramatically improving the available data base from about 8000 events to more than 200,000 in the energy range from 50 to 5000 million electron-volts (50 MeV - 5 GeV). The mission produced the first gamma-ray map of the sky in three different energy bands and the first catalogue of discrete sources at energies higher than 100 MeV (Figure 7-2). The new information on celestial gamma rays provided by COS-B added significantly to the scientific knowledge of the so-called "turbulent universe" which was being explored simultaneously through the study of pulsars and by X-ray astronomy.[577]

COS-B is also historically interesting for the light it throws on the early development of ESRO. ESRO was conceived in the early 1960s as an international scientific organisation to foster European cooperation in space research. From the mid-1960s onwards it had to come to terms with the rapid development of space activities in the field of applications. National policies differed sharply and a variety of political options and organisational strategies were brought forward, causing considerable stress in the institutional context where the COS-B project was discussed and eventually approved. This was also ESRO's first observatory-like (single-experiment) satellite and the first major scientific mission of the Organisation. Before COS-B, the discontinued LAS apart, ESRO's satellite programme was based on spacecraft carrying several experiments provided by laboratories in its Member States. Even if one or more of the experiments failed, the others could still collect good scientific data. The scientific payload of COS-B, on the contrary, comprised one experiment only, i.e. a gamma-ray telescope whose parts were provided by different laboratories. This meant that the decision-making process leading to the approval of the project was particularly complex, that the scientists who built the payload had to be sure that it worked reliably, and that a new management structure had to be evolved.

Finally, from the sociological point of view, COS-B can be viewed as an example of the establishment of "big science" in space research. Three aspects are relevant here. Firstly, there were the people. The many scientists involved in the construction of the scientific payload of COS-B and in the analysis of its data were widely distributed in space and time, spread as they were over six laboratories in four countries and over three scientific generations. They had to deal with problems arising from their different institutional settings and scientific cultures, as well as with tensions and conflicts about the meaning and the aims of such a long "experiment". Secondly, there was the problem of management. COS-B was a complex scientific and technological enterprise, whose success depended on a careful division of labour and on the ability to integrate into a single project competence and expertise in

[576] This chapter is essentially based on Russo (1993c). We wish to thank Harwood Academic Publishers for the permission to use this paper here.

[577] The experiment is described in Bignami et al. (1975). Among the many papers reporting on its results one must cite Swanenburg et al. (1981), Mayer-Hasselwander et al. (1982), Clear et al. (1987). See also, *ESA Bulletin*, 2 (*COS-B Special*), August 1975.

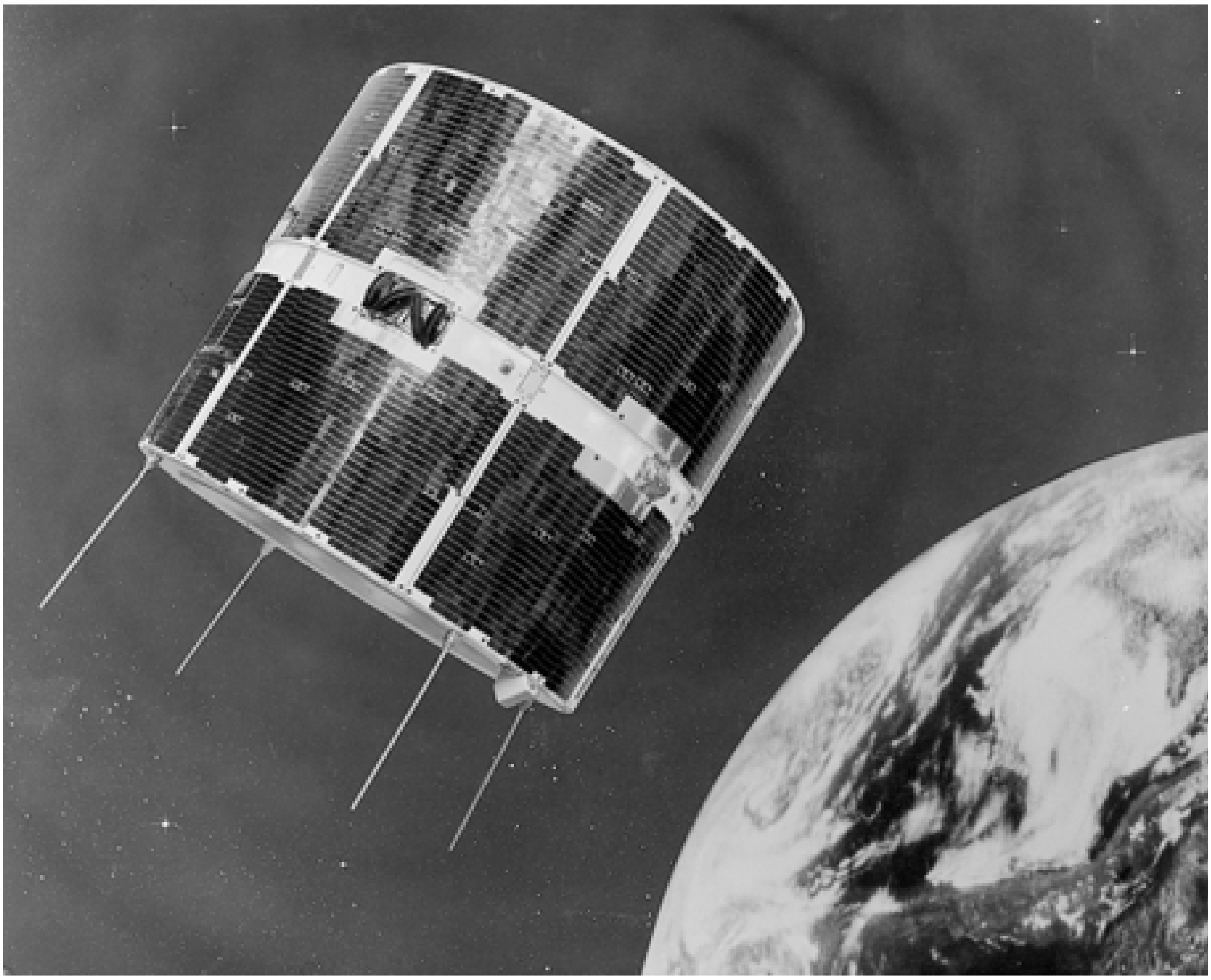

Figure 7-1: The COS-B satellite

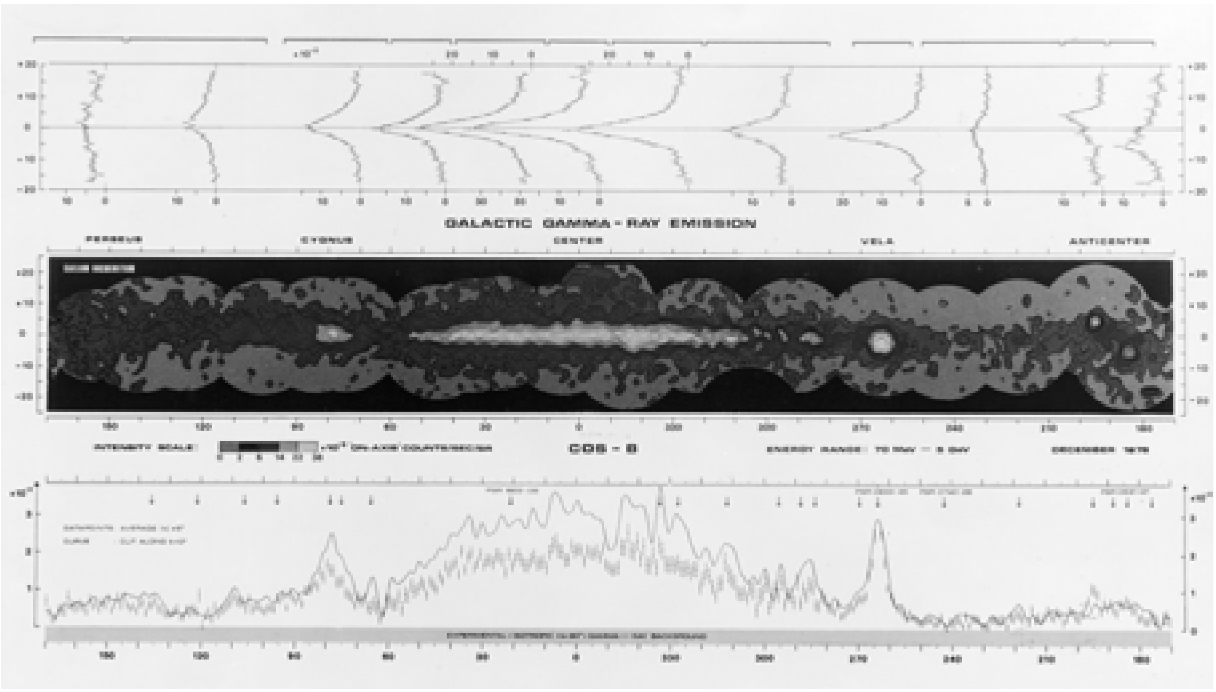

Figure 7-2: The gamma-ray map of the Milky Way as observed by COS-B

several fields. The fact that the construction of the scientific payload and its integration in the spacecraft were split among different laboratories, with different leaders who were funded from different sources, pushed the art of management to the limits of what was possible. Finally, there was the role of computer analysis in obtaining meaningful results from the huge flow of data coming from the satellite. This is an obvious aspect in contemporary "big science" experiments, but was less apparent when COS-B was first conceived. In fact, its development intertwined with the dramatic growth of information science and of its influence on the design of space experiments. Indeed COS-B served as a test-bed for new software (e.g. pattern recognition), and this too affected the actual implementation of the project, both from the scientific and from the organisational point of view.

In this chapter we shall analyse the first phase of the history of COS-B, concentrating on the decision-making process which transformed an ingenious scientific idea into a project undertaken by a big multinational organisation. The aim is to present it as a case study of the many factors that played a role in a major scientific and technological choice of this kind. Three levels, in particular, can be identified in the chain of events that brought COS-B into ESRO's programme. The first is the scientific context, where the Organisation's several advisory committees discussed the project's merit and its feasibility in comparison with other competing projects. The second regards the institutional dynamics of the bodies called on to take the decision. Finally, there is the set of political and financial factors that affected the decision-making process itself.

Our narrative will extend over the three and a half years that were necessary for ESRO to arrive at a definite decision about a scientific programme which included COS-B as its major component. Three main phases can be identified in this story. The first, lasting from early 1966 to spring 1967, was the period when ESRO's scientific advisory bodies discussed the satellite proposals put forward by the scientific community. Among these, a project for a cosmic ray satellite devoted to gamma-ray astronomy was taken into consideration and given some priority. The severe crisis inside ESRO in the years 1967-68 characterised the second phase. No project could actually be taken beyond the stage of a feasibility study. In addition, it was now suggested that an X-ray experiment be added to the gamma-ray experiment considered before. The third phase, from late 1968 to June 1969, was the time when decisions were taken. The idea of having a satellite solely devoted to gamma-ray astronomy (COS-B) was again strongly advocated, and it eventually triumphed over a joint X- and gamma-ray satellite (COS-A). Political and financial considerations, as well as scientific arguments, led to ESRO adopting a programme in which top priority was given to the COS-B project and a geostationary satellite (GEOS), against an alternative programme involving a satellite for astronomy in the ultraviolet.

7.1 Gamma-ray astronomy and the S-111 proposal

The first record in the files of what was to become the COS-B mission is a "proposal for experiment" presented in November 1965 to ESRO under the title "A multipurpose detector for the study of electromagnetic and nuclear events". It received the code number S-111, namely the 111th in the series of proposals for an experiment to be flown on an ESRO satellite.[578] The S-111 proposal was presented by three scientists of great prestige in the European space research community, Giuseppe Occhialini, Reimar Lüst, and Jacques Labeyrie, on behalf of the research groups which they directed respectively at the Istituto di Scienze Fisiche of the University of Milan (Italy), the Max-Plank-Institut für Extraterrestrische Physik in Munich (Germany) and the Centre d'Etudes Nucléaires in Saclay (France). The main purpose of the proposed experiment was to measure the flux, energy spectrum and degree of anisotropy of the diffuse gamma radiation having an energy greater than 100 MeV, and to search for and study discrete gamma-ray sources. Moreover, different triggering conditions of the main detector

578 ESRO, Proposal for experiment S-111, 25 November 191965, *COS-B papers*, Palermo.

allowed the measurement of the absolute flux, energy spectrum and negative-positive ratio of primary cosmic electrons of energy greater than 1 GeV.[579]

To analyse the complex decision-making process by which this original proposal eventually became a definite project approved by ESRO we must consider the scientific aims of the proposed experiment, the characteristics of its protagonists, and the institutional setting in which it was proposed. By the mid-1960s, gamma-ray astronomy was a very new field of research from which much was expected. Measurements of celestial gamma rays, in fact, could provide direct information on physical processes which played a crucial role throughout astronomy, both as a source of energy in stars and in interactions of cosmic ray particles with the interstellar medium. As P. Morrison put it in 1958:

> *[This] is a form of radiation which is more directly related to high-energy and nuclear processes than is optical or radio emission, and yet does not share with high-energy charged particles the complete loss of information about the position of the source.*[580]

Morrison's paper, often considered as the birth of gamma-ray astronomy, provided the stimulus for the first surge of experimental work.[581] In fact, after discussing several processes which could give rise to cosmic gamma rays and the possibilities of experimental measurements, Morrison concluded:

> *All experience suggests that such speculative estimates of what is present in a novel field of enquiry rarely prove reliable; but it suggests no less strongly that the extension of observations to such a new domain will in the end repay considerable effort. This note is intended mainly to attract to this problem the attention of those experimenters skilled in the required arts.*

The challenge was first accepted by a research group at the Massachusetts Institute of Technology (MIT) directed by W.L. Kraushaar, who designed an instrument to be flown on board the satellite *Explorer XI*. The experiment was successful and, in 1962, the possible detection of "gamma rays of non-terrestrial origin" was announced, thus giving birth to experimental gamma-ray astronomy.[582] By the time S-111 was proposed to ESRO, however, the scanty data available from this and a few other experiments indicated the great difficulty of obtaining reliable and unambiguous results, due both to the low fluxes observed and to the high background radiation created in and around the detectors.[583] Concluding a long review on the subject in 1967, G.C. Fazio renewed the challenge:

> *Future experiments in gamma-ray astronomy are not going to be performed easily. However, the knowledge of the universe to be gained by the detection of a flux of gamma rays is so important that more sensitive experiments are essential.*[584]

This ambitious and difficult task inspired S-111. Its proponents were physicists with longstanding experience in fields such as cosmic rays, nuclear and particle physics and plasma physics, and had been involved in space research from the earliest days of ESRO. Of the three, Occhialini was the senior member and the scientific driving force. His involvement in cosmic-ray physics dated back to the early 1930s and he had important results to his credit, such as the discovery of electron-positron

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579 The original design also included a detector for measuring heavy cosmic-ray nuclei. The Danish physicist B. Peters showed an interest in this part of the S-111 project and a possible collaboration between him and a senior member of Labeyrie's group, L. Koch, was discussed. The heavy nuclei experiment was eventually discarded.

580 Morrison (1958), p. 859. The following quotation is from p. 864. Being neutral, gamma rays are not affected, like charged cosmic ray particles, by interstellar magnetic fields and propagate along straight lines.

581 See for example Hillier (1984).

582 Kraushaar & Clark (1962). Also, Kraushaar et al. (1965).

583 Contemporary reviews are Ginzburg & Syrovatskii (1965); Greisen (1966); Fazio (1967). Also Lüst (1966); Hutchinson (1966).

584 Fazio (1967), p. 524.

showers (with P. Blackett) and the discovery of the π-meson (with C. Powell). By the mid-1960s, the cosmic-ray group of the University of Milan, directed by "Beppo" Occhialini and by his wife Constance (Connie) Dilworth, was heavily involved in space research, and building experiments for ESRO rockets and satellites.[585]

The scientific collaboration between Milan and Saclay had originated a few years before, when the two groups jointly realised several balloon-borne experiments to study primary cosmic ray electrons.[586] At the large laboratory of the French Commissariat à l'Energie Atomique, Labeyrie directed the Service d'Electronique Physique, where his group had developed a solid-state detector for high-energy particles.[587] Occhialini led him to cosmic rays and space research, and eventually a Section d'astrophysique was established in Saclay in the early 1970's.[588] Lüst's main scientific interest was in plasma physics and in the role of plasmas in space physics and astrophysics. After spending some time at MIT, he had established at Garching b. Munich the Max-Plank-Institut für Extraterrestrische Physik in the early 1960s. He had been one of the founding fathers of ESRO and his group was also among the first users of ESRO rockets and satellites.[589]

The joint proposal S-111 derived from the three groups' common experience and scientific interests. On the one hand, it was a natural follow up of the French-Italian collaboration; on the other, it drew from the three laboratories' experience with the spark chamber technique. The rapid development of this device in the early 1960s had made the spark chamber particularly suited for space research.[590] A visual spark chamber associated with plastic scintillation counters was the detector used in the Milan-Saclay balloon experiments, while a wire spark chamber had been developed at the Max-Plank-Institut by M. Sommer and Klaus Pinkau, the latter being a brilliant physicist who had just arrived in Garching from the University of Kiel and who soon became Lüst's principal collaborator. A spark chamber was the central element in the detecting system of S-111. The same groups, calling themselves the MiMoSa (Milano-Monaco-Saclay) collaboration, also used a spark chamber built at Saclay for a small gamma ray experiment proposed in 1967 for the TD-1 satellite (proposal S-133).[591]

The detecting system of S-111 included two spark chambers triggered by a telescope made of two Cerenkov counters and a set of plastic scintillator counters. The upper spark chamber was for the conversion of gamma rays and the identification of the direction of arrival. The lower chamber served for energy measurement. Different triggering conditions could be remote-controlled for gamma rays and electrons respectively. The total weight of the experiment was estimated at about 60 kg. The satellite was required to have a circular, near polar orbit with altitude of 700 km and a minimum lifetime of twelve months. It had to be pointed at different regions of the sky in order to detect and study possible discrete sources of gamma rays. A significant feature of the proposed experiment was that it would use most of the facilities available on the satellite for the scientific payload. S-111 was thus essentially a proposal for a single-purpose space mission and was in fact intended for a second generation ESRO satellite.

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585 Two satellite experiments were being developed in Milan to be flown on board of ESRO spacecrafts HEOS-A and TD-1 respectively: S-79, in collaboration with Labeyrie's group, to investigate cosmic ray electrons, and S-88 to study solar gamma rays. ESRO, *General Report 1964-65*. On Occhialini see Russo (1996).

586 Bland et al (1968).

587 Labeyrie (1963).

588 By 1965, Labeyrie and his co-workers were building four satellite experiments for ESRO. These were S-79, with the Milan group; S-72, to measure solar protons, to be flown on both ESRO-II and HEOS-A; S-67-A, to investigate the spectrometry of primary cosmic rays, to be flown on TD-1; and S-77, also for TD-1, for X-ray spectrometry. ESRO, *General Report 1964-65*.

589 Two satellite experiments were in construction in Munich, to be included in the payloads of HEOS-A and TD-2 respectively: S-16, to study the interaction of interplanetary plasma with magnetic fields, and S-103/104, to investigate solar protons. ESRO, *General Report 1964-1965*.

590 Roberts (1964); Wenzel (1964).

591 Experiment S-133 derived from two different proposals, from Milan-Saclay and Munich respectively: ESRO, *General Report 1967*.

7.2 ESRO in the mid 1960s

The European Space Research Organisation (ESRO) was officially born on 20 March 1964, after four year of laborious preparations. Its statutory purpose was "to provide for, and to promote, collaboration among European States in space research and technology, exclusively for peaceful purposes".[592] To accomplish its tasks, the ESRO Council and the Director General were advised by two special committees, the Scientific and Technical Committee (STC) and the Administrative and Financial Committee (AFC). Both the Council and the STC and AFC were made of delegations from the Member States. As for the definition of the Organisation's scientific programmes, the most important body was the Launching Programme Advisory Committee (LPAC). The latter was composed of five eminent scientists whose task it was to evaluate the experiment proposals coming from the scientific community and to suggest integrated scientific payloads for rockets and satellites.[593] The LPAC was supported by six working groups of scientists expert in the different fields of space science, identified by easily intelligible acronyms: ATM (atmospheric structure), COS (cosmic rays and trapped radiation), ION (ionosphere and auroral phenomena), PLA (moon, planets, comets and interplanetary medium), STAR (stars and stellar systems) and SUN (solar astronomy). Of the 110 satellite experiments proposed to ESRO by the end of 1965, 70 had been recommended by the expert groups and more than half of them had been arranged in the payloads of the Organisation's five planned satellites. These were two small satellites, ESRO-I and ESRO-II, to be launched in 1967, a highly eccentric orbit satellite (HEOS-A), scheduled for 1968, and two medium sized satellites, TD-1 and TD-2, planned for 1969. Besides these, a project for a large astronomical satellite (LAS) for stellar astronomy in the ultra-violet region was also studied.

When S-111 was presented, a new phase was opening in European space research. More and more groups were entering the field and competing for space on satellite payloads, and there was a growing awareness of the need for more ambitious scientific programmes. On this highly competitive terrain, a choice among different projects was not simply based on scientific merit. It was necessarily the result of a decision-making process in which various aspects had to be taken into consideration: scientific value, of course, but also technical and financial feasibility, fair distribution among different sectors of the scientific community and among different Member States, research programmes of other space agencies, fair return in industrial contracts, and so on. In competing on this terrain, Occhialini, Lüst and Labeyrie had the advantage of being at one and the same time proponents of a specific project and involved at the highest level in the definition of the Organisation's scientific policy. Lüst was one of the founding fathers of ESRO and, in the late 1960s, he was a German delegate in the Council (vice-president from 1969), the vice-chairman of the STC and the chairman of the LPAC. Occhialini was an Italian delegate in the STC, the scientific adviser to the Italian delegation in the Council and, from May 1968, a member of the LPAC. Labeyrie was a member of the COS Group, of which C. Dilworth became the chairman in 1967. Their game was to be played on different tables. As scientists, they had to work out a well-defined scientific mission, good enough to compete successfully with many others in the several fields of space science. As group leaders, they had to get a technically feasible design ready for when ESRO would have been in the position to decide about its new scientific programme. As ESRO policy-makers, they had to do their best to ensure that their project was chosen.

7.2.1 Two competing projects for ESRO's second generation of satellites

Early in 1966, the LPAC started to discuss ESRO's future satellite programme. By that time, the type of mission and the payload composition of the first generation of spacecraft had been established, and it was possible to arrive at "quiet and thorough deliberations on what satellites ESRO might launch in the years 1970 to 1972".[594] Three aspects were to be considered, i.e. the desires and intentions of the scientists, the technical feasibility of the proposed projects and the economic resources of the Organisation. Moreover, there was the possibility of co-operating with NASA for realising very large

592 *Convention for the Establishment of a European Space Research Organisation* (signed on 14 June 1962 and entered into force on 20 March 1964).

593 The membership of the LPAC in this period is reported in table 3 of chapter 5.

594 LPAC, 11th meeting (17 January 1966), ESRO/ST/173, 14 February 1966, p. 3.

projects. The LPAC decided to ask the ad hoc working groups to discuss the matter and to inform them about the suggestions coming from the scientific community at large.

When the LPAC met again, in April, it was evident that another large project comparable to the LAS could not be completed with the funds available for the eight-year period covered by the ESRO Convention. Any such satellite could thus only be undertaken, if at all, in co-operation with NASA. Attention was thus focussed on the desirable scientific objectives of ESRO's own programme of medium-sized satellites. In tackling this problem, the ad hoc working groups generally did not attempt to compose payloads on the basis of proposals for satellite experiments already available in the ESRO files. Instead they put forward their suggestions about the kind of scientific missions from which the most interesting results could be obtained. The result was some 16 mission projects covering topics as different as the study of ionospheric irregularities, the study of solar flares, the study of interplanetary plasma, and the investigation of cosmic gamma rays and electrons. The latter project, requiring a satellite in a circular, low orbit, was among those recommended by the COS Group, who also presented proposal S-111 as an example of the payload for such a satellite.[595]

After discussing the findings of the groups, the LPAC concluded that it was too early to submit specific recommendations to the STC, and recommended to start studies on a few satellite projects, looking for compatibility with other spacecraft already under development and considering the possibility of combining different proposals. While these studies were under way in ESTEC, a severe financial crisis arose in ESRO, which jeopardised the whole of the operational programme and rendered any future planning almost impossible. The rapid escalation of costs, the difficulties connected with the fair distribution and management of industrial contracts, the different political views on the role and tasks of ESRO in the general context of European space activities, these and other factors made it impossible to reach unanimous agreement in the Council (as demanded by the Convention) on the level of resources to be granted to ESRO for its second three-year period (1967-69). For two years, as Director General Herman Bondi later recalled, the Organisation had to live "from hand to mouth, and 'extra-legally'".[596]

An immediate consequence of the crisis was the uncertainty surrounding the future of the Large Astronomical Satellite (LAS), by far the most expensive and most demanding ESRO project. A decision about LAS was to be taken at a Ministerial Conference planned in mid-1967 and, in fact, the whole of the Organisation's future satellite programme hinged to a great extent on the outcome. In this difficult situation, the LPAC could only underline that:

> *It is of the greatest importance to the viability of ESRO as a reputable scientific organisation that no reduction be made in the operational programme. [...] ESRO should undertake medium satellites and space probe projects at such a level as to ensure that two launchings take place on the average every year. This is considered as a minimum programme.*[597]

Even a minimum programme, however, implied that difficult choices already had to be taken in this early, and somewhat uncertain phase of the decision-making process. Thus, a large fraction of the

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595 The proposals of the scientific working groups, including the large projects involving ESRO/NASA co-operation, are in document SCI/WP/55, 25 March 1966. The ION group was the most prolific, proposing 6 projects plus one involving four satellites. For the recommendations of the COS Group, see the report of its 13th meeting (17 March 1966), COS/24, 6 April 1966. All projects were discussed at the 12th meeting of the LPAC (5 April 1966), ESRO/ST/207, 3 May 1966, and the conclusions were presented in documents ESRO/ST/199, 21 April 1966 (medium-sized spacecraft) and ESRO/ST/200, 21 April 1966 (large projects and ESRO/NASA co-operation). See also SCI/WP/61 and SCI/WP/62, 30 March 1966.

596 Bondi (1984), p. 22. The ESRO crisis in 1966, which eventually led to the abandonment of the LAS, is discussed in the previous chapter.

597 LPAC, 13th meeting (27 August 1966), ESRO/ST/218, rev. 1, 28 September 1966, pp. 5, 6. Also in ESRO/ST/215, 9 September 1966. Different options for a revision of the satellite programme in the new financial situation are presented in SCI/WP/66, 19 August 1966.

LPAC's meeting in December 1966 was devoted to a discussion of ESRO's future satellite programme and to a critical consideration of the several projects on the table. All the main elements of the scientific and political equation to be solved were exposed and extensively reviewed. In particular: whether to concentrate on one specific field of space research or to offer an equal share of the total spacecraft programme to each scientific group; whether to aim at having as many scientists as possible participating in the programme or to favour projects which promised to yield the most important scientific results; whether to favour outstanding original research or rather to stimulate space research in many laboratories; whether to advocate a rapid implementation of the LAS project and then to accept a limited number of medium-sized satellites or to propose that the LAS be abandoned in order to release more resources for a larger number of less ambitious projects. Some boundary conditions were also discussed: what to expect from the eventual co-operation with NASA; how to arrive at definite cost evaluations of the various projects; how to get a clear assessment on performance, reliability, availability and likely future developments of the different American and European launchers.[598]

After further discussions, both in the scientific groups and in the LPAC, the latter recommended, early in 1967, that two alternative programmes should be studied in more detail, each of them including several options.[599] The first was a joint ION/COS/PLA project consisting of three satellites operating simultaneously in different orbits and providing correlated data. This project included a highly eccentric orbit satellite to study the solar wind plasma (HEOS-B proposed by the PLA group), an intermediate orbit satellite to measure high-energy particles in the magnetosphere (COS Group), and a low orbit satellite to make measurements of several atmospheric and ionospheric parameters (ION group).[600] The alternative programme which interested the LPAC foresaw the launching of a number of independent satellites to be chosen from those proposed by the various groups. These were:

1. a cosmic ray satellite whose scientific mission was to be decided by the COS Group (and for which S-111 was considered as the most interesting proposal);

2. a satellite with orbit adjustable from 400 to 1000 km altitude to study small-scale ionospheric irregularities (ION group);

3. a solar satellite for high resolution studies of the Sun in the ultraviolet (SUN group);

4. a geostationary satellite for studies of the magnetosphere (strongly recommended by the COS Group).[601]

The LPAC requested feasibility studies on all these projects and, although it did not explicitly indicate preferences at this stage, it did hint at some priority scale:

> *The Joint [ION/COS/PLA] Project would offer an opportunity to many scientists to carry out experiments. On the other hand, the [LPAC] was aware of the originality of some of the cosmic ray experiments proposed by the COS Group.*[602]

At this stage of the decision-making process, Occhialini, Lüst and Labeyrie's gamma-ray project thus had to compete at several levels. Firstly, at the core of ESRO's scientific activity, there was the competition between the LAS project and the rest of the ESRO programme - a conflict in which a

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598 LPAC, 15th meeting (13-14 December 1966), ESRO/ST/237, 6 January 1967.

599 LPAC, 16th meeting (8-9 February 1967), ESRO/ST/245, 8 March 1967. The groups' opinions are reviewed in SCI/WP/76, 30 January 1967.

600 The joint satellite project is described in SCI/WP/71, 21 October 1966.

601 The geostationary satellite was supposed to use the spacecraft being studied by ESRO for the experimental communication satellite requested by the European Conference on Satellite Communications (CETS, from French initials). See chapter 11 in this book.

602 LPAC, 15th meeting (13-14 December 1966), ESRO/ST/237, 6 January 1967, p. 8.

well-defined sector of the space science community (the astronomers) and one of the Organisation's most influential Member States (the UK), were opposed by another sector of the community (the physicists) and by another influential Member State (France, supported by Belgium and Switzerland).[603] The second decision level involved the choice between the joint three-satellite project and the alternative programme of independent satellites. The former involved a large fraction of the physics community interested in space research and would provide a coordinated set of data on the Earth's space environment. It was supported by an influential member of COS Group, the English scientist H. Elliot who had elaborated the scientific mission of one of the three satellites. Thirdly, the cosmic ray satellite had to compete with the others in the alternative programme, proposed by groups interested in other fields of space research. ESRO's resources did not allow for more than one or two projects to be started in the near future and even if the joint project were dropped, a choice had to made among the equally interesting scientific objectives of the alternative programme. Finally, within the COS Group itself, besides Elliot's interest in the joint project, Occhialini, Lüst and Labeyrie's gamma-ray experiment S-111 was not the only candidate for the cosmic ray satellite. In fact, when calls were made for defining its scientific mission, two other experiments were also proposed (Be^{10} isotope abundance in the primary cosmic radiation and solar neutrons). These posed no real danger to S-111 though, and the COS Group soon recommended that the feasibility study of the cosmic ray satellite should be made "taking proposal S-111 as an example".[604] More important was the fact that a new scientific objective was soon to emerge in the cosmic ray field: to defeat it would require all the resources that the S-111 collaboration could master.

7.2.2 The LPAC makes its choice - to the satisfaction of the COS Group

The feasibility study of the cosmic ray satellite was realised in ESTEC in collaboration with M. Sommer from Lüst's laboratory and with L. Scarsi, a former student of Occhialini's.[605] It presented two possible alternatives. The first was essentially the same as S-111: a heavy (700 kg) low orbit satellite with command pointing capability, carrying a 160 kg scientific payload consisting of two spark chambers with associated scintillation and Cerenkov counters. The second was a highly eccentric orbit satellite, which had the advantage that it avoided interference from the Earth's shadow, from celestial radiation rediffused by the Earth (the albedo), and from trapped (van Allen) radiation. In the latter case, however, due to restrictions on weight and telemetry, one had to exclude the second spark chamber for energy measurements. The COS Group eventually recommended the first project.[606]

In May 1967 this feasibility study was presented to the LPAC, together with the others requested by the Committee.[607] The Chairman of the COS Group, B. Peters, informed the LPAC that "the majority of the COS Group had concluded that the proposed three-satellite project was not acceptable and would, therefore, *not be endorsed* by the Group".[608] The feasibility study, in fact, had shown that the project could not fulfil its main scientific objective, since it failed to allow for the desired distinction between temporal and spatial variations. The LPAC accordingly agreed to drop the joint three-satellite programme as a unitary complex, but to retain one component, the highly eccentric orbit satellite (HEOS-B). This was to satisfy the request of the PLA group for independent studies of the interplanetary medium. This choice made, the LPAC drew up a tentative launching table which gave priority to the cosmic ray satellite and the geostationary satellite, both to be flown in 1972. HEOS-B

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603 See previous chapter.

604 COS Group, 15th meeting (23-24 January 1967), COS/30, 6 February 1967, p. 10. Also LPAC, 16th meeting (8-9 February 1967), ESRO/ST/245, 8 March 1967, p. 6.

605 L. Scarsi, M. Sommer, H. Martin, R. Pacault, J. van Boeckel, J. Ortner, *Feasibility study of a cosmic ray satellite*, ESRO SP-23, August 1967.

606 COS Group, 16th meeting (24 April 1967), COS/32, 8 May 1967. The study also presented the "economy solution" of a smaller experiment, using a TD-type spacecraft without command pointing, which was not studied in detail and was rapidly discarded by the COS-Group.

607 All these feasibility studies are reviewed in ESRO/ST/251, 23 May 1967.

608 LPAC, 17th meeting (11 May 191967), ESRO/ST/253, p. 3 (emphasis in the original). Elliot had dissented from this conclusion. See also the report of the 16th meeting of the COS Group (24 April 1967), COS/32, 8 May 1967.

and the ionospheric satellite were scheduled for 1973 and the solar satellite for 1974. This programme was eventually approved by the STC.[609] Another step forward had been taken for S-111, whose position was further strengthened by the decision of the LPAC, following Peters' suggestion, to nominate C. Dilworth, as the chairperson of the COS Group. Everything was still uncertain, however, pending a final decision on the LAS and on the role of ESRO in the context of a European space policy.

7.3 The growing importance of X-ray astronomy

The European Space Conference held in Rome on 11-13 July 1967 did not reach any definite conclusion on the many controversial issues concerning European cooperation in space. Instead it decided to create an Advisory Committee on Programmes, chaired by J.-P. Causse, to elaborate a coherent space policy covering science, application and launchers. The Conference did express confidence in ESRO's activity but left the Organisation in a state of uncertainty as regards funding, and the extent of its involvement in application satellites. No decision was taken on the LAS. In this situation, the LPAC decided to continue work on the feasibility studies of the cosmic ray satellite and of the geostationary satellite, which were the first on its preferred launch schedule. At the same time, there were signs that a new confrontation was brewing in the STC, as we read in the minutes of its October 1967 meeting:

> *The United Kingdom Delegation [M.O. Robins, W.D.B. Greening and A.P. Willmore] wondered whether the cosmic ray satellite, estimated to cost MF 130 [million French francs], represented a good investment since only a few scientific experiments would be in the satellite. The Chairman of the LPAC [Lüst] said his committee attached great importance to this project which was of great scientific interest, and pointed out that certain vital studies could only be carried with large experiments. The Italian Delegation [Occhialini and E. Cigerza] said that the successful execution of this project would be a major advance for European space science.*[610]

The British delegation was concerned for two main reasons. Firstly, the increasing possibility that the LAS would be cancelled disturbed the astronomers, who feared that stellar astronomy would ultimately not be included in ESRO's scientific programme. In this perspective, the STAR group had already prepared a proposal for a wide-field ultra-violet astronomy satellite, and the UK group who had designed the LAS had worked out a simplified version of the same payload to be proposed in the event that the LAS was dropped.[611] Secondly, a new field of space research, X-ray astronomy, was seeking recognition among the community of cosmic-ray physicists. The LPAC and the STC, in fact, requested that the feasibility study of the cosmic-ray satellite be revised in order to consider the inclusion of an X-ray experiment in the scientific payload.[612] This point deserves a short digression.

The interest in X-ray astronomy within the space science community grew rapidly after the epochal, first rocket observation of a celestial (non solar) X-ray source in 1962 (Scorpio X-1). A significant

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609 STC, 15th meeting (5 June 1967), ESRO/ST/MIN/15, 5 September 1967. Also: ESRO/ST/249, 19 May 1967, and add. 1, 25 May 1967; ESRO/ST/262, 26 September 1967.

610 STC, 16th meeting (9-10 October 1967), ESRO/ST/MIN/16, 29 November 1967, p. 6.

611 For the wide field astronomy satellite (eventually called WIFAS) see the reports of the 9th (31 May 1967), the 10th (27 September 1967) and the 11th (14 December 1967) meetings of the STAR group: STAR/42, 25 July 1967; STAR/46, 23 November 1967; STAR/49, 12 January 1968. The study is in STAR/52, 20 June 1968. See also STAR/47, 27 November 1967. The study for the simplified LAS (eventually called UVAS) is STAR/54, 18 June 1968.

612 It is interesting to remark that, against the LPAC's decision, C. Dilworth reported that "the association of X-ray studies had been discussed in the COS Group, although agreement between members had not been reached". LPAC, 18th meeting (28 September 1967), corrigendum, ESRO/ST/271, corr. 1, 13 October 1967.

migration of scientists from other fields ensued.[613] By 1967 more than a dozen groups, most of them in the USA, were working in X-ray astronomy and a large mass of data had been collected by balloon and rocket experiments. Moreover, rapidly varying X-ray stars had been reported, posing puzzling problems for experimenters and theoreticians. In this context, it became clear that satellite experiments, which could observe X-ray sources over an extended period of time, were essential if further important progress was to be made.[614]

Two groups in Europe were active in X-astronomy, both of them in the United Kingdom. The first was at University College London, under the direction of R.L.F. Boyd and A.P. Willmore, who had extended their earlier involvement in solar X-ray studies into the new field. The second had been established in 1960 at the University of Leicester by K. Pounds, a former student of Boyd's. The two groups had jointly designed an X-ray telescope to be flown in NASA's OAO-3 satellite. A similar design had been used for the X-ray telescope which had been included as a subsidiary instrument in the UK project for the LAS payload alongside the primary UV telescope.[615] With the LAS looking less and less likely and with X-ray astronomy in full expansion, British scientists naturally thought of proposing an X-ray experiment for the coming cosmic ray satellite. They could count on the influence of Boyd in all important boards of ESRO (Boyd was in the LPAC up to April 1968, in the Council and the STC in 1969). Accordingly, as soon as the LPAC called for a new feasibility study of the cosmic ray satellite, including an X-ray instrument, Pounds presented a design based on the combination of a high-resolution telescope (employing a grazing incidence parabolic mirror and operating in the 0.4 to 2 keV energy range), and a conventional geometrically collimated proportional counter (operating in the 2 to 20 keV energy range).The new feasibility study for the cosmic-ray satellite, completed in January 1968, included Pounds' design for an X-ray instrument. It clearly reflected a compromise between the two scientific interests. On the one hand, it was stressed that:

> *The primary scientific mission of the cosmic ray satellite should remain the study of the gamma ray flux and energy spectrum, both from diffuse and discrete sources. [...] The X-ray experiment [...] is given as* an example *of an additional experiment which could fly along with the main gamma-ray telescope.*[616]

On the other hand, the study was made more general and not immediately connected with the former S-111 proposal. The breakdown by weight of the 170 kg experimental payload was 130 kg for the gamma-ray experiment (including 40 kg was for the energy measuring device) and 40 kg for the X-ray experiment. The report was discussed by the LPAC in January 1968. Behind the usually impersonal language of the minutes of the meeting, one can grasp a rather nervous debate:

> *Professor Boyd thought that the outcome of the feasibility study looked to be fairly satisfactory. He felt that, when the letters inviting the submission of experiments were sent out, it should be made clear that there was a certain flexibility in the scientific proposals made and that the experiments described in the feasibility study should be regarded as examples. It was then for the LPAC to assess the value of the proposals made. Professor Occhialini-Dilworth considered that the ESRO scientific working groups, as consultants to the LPAC on scientific matters, should be asked their opinion on the proposals received for experiments.*[617]

Both Boyd and Dilworth probably felt that the inclusion of two such different experiments in the satellite was not scientifically sound and a decision about which scientific objective should be

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613 Hirsch (1983). The pioneer work had been made by a scientific team using a rocket developed by the private company American Science & Engineering: Giacconi et al., (1962).
614 Morrison (1967); Friedman (1969).
615 Massey and Robins (1986), p. 366-387.
616 M. Sommer, K.A. Pounds, J. van Boeckel, H. Marin, R. Pacault, *Revised Feasibility Study Cosmic Ray Satellite*, ESLAB/27, 17 January 191968, p. 3 and 14 (emphasis in the text).
617 LPAC, 19th meeting (23 January 1968), ESRO/ST/280, 21 February 1968, p. 3.

privileged in the final design was still pending. Boyd, an obvious supporter of X-ray astronomy and of Pounds' proposal, wanted to disassociate the cosmic ray mission from the S-111 option as much as possible and to shift the major responsibility for the choice to the LPAC. Dilworth, on the other hand, wanted to stress the role of the COS Group, of which she was chairperson and where she knew that a strong interest existed in the gamma-ray option.

The main difficulty raised at the meeting, however, was the lack of a clear and definite assessment of the cost of the satellite, in particular after the incorporation of the X-ray experiment. As a result, following a suggestion made by Lüst, it was decided to prepare a cost estimate of the whole operation, including a comparison with previous ESRO projects and covering both the option of a single gamma-ray experiment and the option of two experiments.

7.4 The Caravane Collaboration

The decision to postpone the decision on the cosmic-ray satellite was received with some relief by the proponents of the gamma-ray experiment. As Dilworth wrote, "this means we have at least one month more breathing time, to solve the numerous technical problems involved in the project".[618] The main issues were the kind of spark chamber to be used and the technique for energy measurement. By this time, the three groups had adopted the evocative term Caravane Collaboration, suggested by Occhialini since they always seemed to meet in airport lounges, on the move. An important question for them was the possible extension of the collaboration to other groups. This was both a scientific requirement, namely to take advantage of a larger technical expertise, and a financial one, in order to share the cost on a wider basis. It was also a political move, intended to strengthen the Caravane's position in ESRO and to facilitate the passage of the gamma-ray proposal through the Organisation's decision-making structure. We must recall that, in March 1968, Occhialini had been elected by the STC in the membership of the LPAC, together with B. Hultqvist. The other candidates were Elliot and Peters. At the same time, Boyd had retired from the membership of the Committee.[619]

Two steps were taken in this respect by the leaders of Caravane. The first was to accept the proposal made by the British physicist and COS Group member G. Hutchinson that there be an international collaboration aimed at the realisation of the cosmic-ray satellite project. Hutchinson and his group at the University of Southampton had developed a gamma-ray experiment for the payload of the NASA OGO-5 spacecraft and wanted to increase their involvement in the field.[620] Having examined the first feasibility study for a pure gamma-ray satellite, Hutchinson invited a number of European laboratories to discuss the formulation of a joint proposal in which his group would provide a spark chamber based on the acoustic system of spark location which they had developed some years before.[621] The Southampton group was easily added to the Caravane.

Lengthier negotiations were required for the next important addition to the Collaboration, namely the cosmic-ray group at the Kamerlingh Onnes Laboratorium in Leiden. This group was directed by Hendrik (Henk) van de Hulst, an eminent radioastronomer and astrophysicist who had secured his place in the history of astronomy thanks to his suggestion that the spectral line of interstellar neutral hydrogen at a wavelength of 21 cm be used for studying the large scale structure of our Galaxy.[622] One of the founding fathers of ESRO, van de Hulst was a Dutch delegate in the Council (chairman in

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618 Dilworth, letter to L. Scarsi (and others), 1 February 1968, *COS-B papers*, Palermo.

619 LPAC, 20th meeting (15 February 1968), LPAC/1, 14 March 1968, and STC, 17th meeting (27 March 1968), ESRO/ST/MIN/17, 4 April 1968.

620 Hutchinson et al. (1970). This experiment was unsucessful due to high background triggering rate.

621 G. Hutchinson, letter to L. Scarsi (and others), undated, with annexed "Outline proposal for a combined cosmic ray satellite project", November 1967, *COS-B papers*, Palermo.

622 Van de Hulst's prediction that the 21 cm line might be detectable astronomically was made in 1944; the line was actually detected in 1951 by H.I. Ewen and A.M. Purcell at Harvard College observatory and promtly confirmed by Van de Hulst, L.Muller and J.H. Oort.

1968-70) and in the STC (chairman in 1967). The Leiden group had also entered the field of gamma-ray astronomy through building a detector for the payload of OGO-5.[623]

At a meeting of the Caravane held in Paris in January 1968, a solid group from Southampton attended, including Hutchinson. The meeting was also attended by an observer from Leiden, A. Scheepmaker. Pinkau introduced Caravane to him in these terms:

> *We collaborate on equal terms, there are no more or less important contributions from the various groups. All scientific data are available to any member of the collaboration. All publications should be seen and be given permission to publish by the editorial board.*[624]

Important decisions about the final configuration of the experiment were taken at this meeting. The first concerned the technique of spark detection in the spark chamber. Three options were up for discussion: Saclay's vidicon, Southampton's acoustic spark chamber and Munich's wire spark chamber. After lengthy discussions and a careful comparison of the three techniques, it was decided that "the experiment should be done with the wire spark chamber of wire spacing about 0.7 mm on the assurance of the Munich group that such a wire spacing can be achieved." A letter from Pinkau three weeks later confirmed that the "007 chamber" worked satisfactorily.[625] As to the energy measuring device, it was decided to use a calorimeter based on plastic scintillators. It was then decided that Munich should build the spark chamber, Southampton the scintillation and Cerenkov counters for the triggering telescope and that Saclay, Milan and possibly Leiden should share the construction of the other parts of the payload.[626] Each group was to take technical and financial responsibility for its own part.

The design was discussed and specified further at a meeting held at the end of March. This was the first Caravane meeting attended by Van de Hulst who, on behalf of the Leiden group, accepted to participate in the study phase of the project but reserved a final decision regarding collaboration for another two weeks.[627]

While these negotiations were going on inside the Caravane, bad news arrived from ESRO. The cost of the cosmic-ray satellite had risen to some 200 MFF. Considering this figure, "the LPAC did not feel that it could make a recommendation to the STC regarding this project at the present time".[628] In fact, in the spring 1968, the financial situation at ESRO was critical and, as Bondi recalled later, "the future of ESRO looked bleak indeed".[629] The glaring failure to estimate costs correctly and the ongoing controversies among Member States over basic issues of policy had brought the Organisation to a deadlock, and it was clear that its ambitious initial programme could not be realised. The LAS project had to be abandoned and the medium-sized (so-called TD) satellite programme had to be drastically reduced. In this difficult situation, ESRO could not decide to undertake a new major project without a radical redefinition of its role and its programmes.

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623 Bleeker et al. (1970).

624 *Minutes of the meeting of the Caravane collaboration*, Paris, 16-18 January 1968, *COS-B papers*, Palermo. The Caravane's editorial board was never created; its role was eventually taken by the COS-B Steering Committee, made of the heads of the laboratories involved in the experiment.

625 K. Pinkau, letter to members of the Caravane, 12 March 1968, *COS-B papers*, Palermo.

626 Eventually, Saclay took charge of the anticoincidence counter, Milan of the experiment electronics and Leiden of the energy calorimeter.

627 *Minutes of the Meeting of the Caravane Collaboration*, Paris, 26-27 March 1968, *COS-B papers*, Palermo.

628 STC 18th meeting (6 May 1968), ESRO/ST/MIN/18, 26 June 1968, p. 6. LPAC, 21st meeting (3 April 1968), LPAC/4, 10 May 1968. About the new criteria on cost estimation, which also affected the LAS project, see the previous chapter. After the cosmic-ray satellite, the STC decided to re-evaluate the costs of the other projects under study as well.

629 Bondi (1984), p. 22.

Faced with this situation, the leaders of the Caravane decided to try elsewhere. NASA had called for proposals for satellite payloads, including experiments in the field of gamma-ray astronomy. Seizing the opportunity, the Caravane rushed a proposal to NASA to beat the deadline of April 15.[630] This initiative came to nought. NASA Headquarters also received a proposal to fly a gamma-ray experiment from a group at its Goddard Space Flight Center. It was obviously difficult for a European team to beat a competitor that was a part of NASA itself.[631] More worrying for the Caravane Collaboration was the fact that Goddard's project was essentially the same as their own. The NASA team had already used the wire spark chamber technique in balloon-borne experiments and was now implementing this technique for larger payloads to be used both in balloons and in satellites.[632] Goddard's project was eventually adopted by NASA and included in the payload of the satellite SAS-2, scheduled for launch in late 1972.[633] If the Caravane experiment was ultimately going to be accepted by ESRO, it was essential that the collaboration improve their instrument to ensure that it was not scientifically obsolete if, or when, it was flown.

7.5 COS-A and COS-B

By the end of 1968 ESRO was recovering from its crisis. Three satellites (ESRO I, ESRO II and HEOS-A) had been successfully put into orbit and were functioning very well. A special arrangement had been reached regarding the TD satellite programme, by which TD-1 was retained in the programme as a special project while TD-2 was abandoned, some of its experiments being incorporated in the payload of a smaller satellite (ESRO-IV).[634] Finally, the European Space Conference held in Bad Godesberg in November had found a tentative way out of the aged and controversial question of the role of Europe in the three domains of space, i.e. scientific satellites, applications satellites and launchers. ESRO Member States participating in the Conference agreed to an expenditure of 860 MFF for the scientific programme in the three-year period 1969-71 and, what is more important, they authorised the necessary commitments for individual scientific projects that would extend beyond the eight-year period covered by the 1964 Convention. ESRO had returned to legality and its future seemed assured.[635]

ESRO's Committees could start to make plans again. The LPAC resumed the projects under study in ESTEC, deciding as well "to retain in the long term programme provision for at least one stellar astronomy project and one other major project (as, for example, the cosmic ray satellite)".[636] In fact, as mentioned above, even before the LAS programme was definitely jeopardised, there was pressure building up within the astronomy community to have a new, less ambitious project approved by ESRO. Two candidates were on the table. The first was a satellite for high-resolution (0.1 Å) ultra violet spectroscopy of single stars (UVAS). Its scientific aims were essentially those of the LAS, but with somewhat relaxed specifications, and it was proposed by the former LAS group at the UK Atomic Energy Authority's Culham laboratory. The second project was a wide-field astronomy satellite (WIFAS) aimed at obtaining a sky map of stars in the UV region using low resolution spectroscopy (1 Å). WIFAS was supported by that part of the astronomy community that had always

630 *Minutes of the Meeting of the Caravane Collaboration*, Paris, 26-27 March 1968, *COS-B papers*, Palermo. The Caravane Collaboration proposal to NASA is *Investigation of extraterrestrial gamma radiation in the energy range 25-500 Mev* (April 1968), *COS-B papers*, Palermo. At this stage the collaboration included Southampton but not yet Leiden.

631 Pinkau to Scarsi (and others), 7 May 1968, with annexed letter of intent by Goddard's C.E. Fichtel, D.A. Kniffen, H. Ogelman; *COS-B papers*, Palermo.

632 Fichtel et al. (1970).

633 Tucker & Tucker (1986), p. 106-123. SAS-2 had a successful but short flight, from November 1972 until June 1973, when a capacitor failed.

634 See chapter 5 in this volume.

635 ESRO, *General Report 1968*. A detailed discussion of these events is in Chapter 11.

636 LPAC, 24th meeting (first session, 23 September 1968), LPAC/15, 13 November 1968, p. 3. See also STC, 20th meeting (7 October 1968), ESRO/ST/MIN/20, 18 November 1968. Relevant documents are: LPAC/10, 18 September 1968 and ESRO/ST/295, 26 September 1968.

considered low-resolution, wide-field investigations a more interesting scientific mission than that adopted for the LAS.[637]

As for the reassessment of the cosmic-ray project, the main problem was to accommodate the design to the new weight constraints imposed by the use of an American Delta launcher instead of the ELDO launcher previously considered. While the latter could place a scientific payload of 170 kg into orbit, the maximum allowed by the American vehicle was 130 kg. A study group was convened and it was decided to reduce the weight of the gamma-ray experiment from 130 kg to 90 kg by eliminating the energy measuring device. The remaining 40 kg would be for the X-ray experiment. Sommer and Pounds were asked to revise the gamma- and X-ray instruments, respectively, while the French firm Sud-Aviation was charged with preparing a detailed feasibility study for the whole satellite.[638]

Needless to say the Caravane's leaders did not like the envisaged solution. Pounds' new design of the X-ray detector, based on a modulation collimator with moveable shutters, was very large and heavy. Moreover, they felt that the need to compete with Goddard's SAS-2 meant that the energy-measuring device had to be kept in the European gamma-ray experiment. Pinkau hurried to Milan to discuss the situation with Occhialini and Dilworth. They decided not to change their original design and to use all their influence in ESRO's committees to get the feasibility study to 'match' their own project. At a meeting of the study group held in late February 1969 at ESRO Headquarters in Paris, which Pinkau attended as a representative of the chairman of the COS Group, he stressed that the mass breakdown 90-40 kg should not be considered as final, and that a decision about the inclusion of the energy measuring device was up to the COS Group. Sud-Aviation was invited to study the implications of having a scientific payload composed of a pure gamma ray experiment weighing 130 kg.[639]

The full offensive was taken at the meeting of the COS Group held in Milan on 18 March.[640] After Sommer's and Pounds' presentations of the gamma- and X-ray experiments respectively, Pinkau presented an alternative proposal which, as he said, had been "cooked up in two days" by the Caravane collaboration just before the meeting.[641] They stressed that, following SAS-2 (mainly devoted to a survey of gamma ray sources), the main purpose of the ESRO satellite should be the measurement of the energy spectrum of identified sources with the highest possible resolution, in order to understand physical processes occurring in them. Referring to Sommer's proposal they argued:

> *What is left optional there (namely the additional calorimeter counters) is considered a necessity. In our view, the gamma-experiment should be the primary aim of the mission and should define the boundary conditions for the satellite.*

Starting from the design elaborated in their NASA proposal of April 1968, the Caravane then presented the modifications that could be envisaged in order to remain within the weight limit of 130 kg. They also proposed, as a possible alternative, a satellite having a moderately eccentric orbit. Since the observation time was increased by a factor two on such a satellite, the sensitive area and so the weight of the experiment could be reduced. This alternative had been originally suggested and advocated by C. Dilworth and, in fact, now appeared to the Caravane as the most promising design.

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637 The STAR group had recommended to start feasibility studies and cost evaluation of both projects at its 12th meeting (5 July 1968), STAR/58, 2 October 1968. For the debates about the specifications of the envisaged ESRO astronomical satellite see chapter 6.

638 "Minutes of the meeting held at ESRO headquarters on 4 February 1969", ESRO MS/16, 17 February 1969.
M. Sommer, letter to C. Dilworth (chairman of the COS-Group) and to R. Lüst (chairman of the LPAC), 13 February 1969; *Sommer papers*. M. Sommer, *The gamma-ray experiment for the COS-A satellite*, ESRO MS/25, 28 March 1969; K. Pounds, *The X-ray experiment for the COS-A satellite*, ESRO MS/26, 28 March 1969; V*van de Hulst papers*.

639 "Minutes of meeting held on 27 February 1969", ESRO MS/22; *Sommer papers*.

640 COS Group, 21st meeting (18 March 1969), ESRO COS/42, 27 March 1969.

641 A. Dean, Y. Koechlin, K. Pinkau, L. Scarsi, R.D. Wills, undated, untitled handwritten draft; Van de Hulst's personal notes on the meeting; V*an de Hulst papers*.

A lively discussion followed Pinkau's presentation, and chairperson Dilworth finally presented a systematic analysis of the four possible options discussed. The first was Sommer's and Pounds' design for a joint X- and gamma-ray mission in a circular orbit satellite. The second was a sort of compromise, with 50 % of the energy calorimeter and a reduced weight of the X-ray experiment. The third and the fourth were the two alternatives (circular orbit and eccentric orbit satellite) presented by Pinkau on behalf of the Caravane collaboration for a purely gamma-ray mission. In the event, it was unanimously decided that the pure gamma ray, eccentric orbit satellite deserved a feasibility study which was also entrusted to Sud-Aviation. This project was called COS-B which, as matters now stood, was in competition with the Pounds-Sommer project labelled COS-A.[642]

On 5 and 6 May, 1969, a special symposium was convened by ESRO to prepare for the selection of projects to be included in ESRO's future scientific programme. This was the occasion for European space scientists to learn about and discuss the results of the feasibility studies on possible satellite missions made in the previous months. These included COS-A and COS-B, a satellite for ionosphere research, a geostationary satellite for magnetospheric studies (GEOS), an atmospheric research satellite (EARS), a Mercury fly-by mission, and the two ultraviolet astronomy projects UVAS and WIFAS.[643] Following the symposium, the ad hoc working groups met in order to recommend priorities. The COS Group met in Frascati on 12 May and settled its own priorities:

> *[The COS Group] came reluctantly to the conclusion that, whereas the gamma and X-ray experiments proposed (both of high scientific interest) are scientifically compatible, they are technically only compatible on the same satellite at increased cost and considerable concession in the scientific aims. The COS Group concluded that the maximum scientific value could be obtained by separate missions. It therefore recommends the COS-B version. At the same time the COS Group strongly urges ESRO to include in its programme as soon as possible a satellite suited to high precision X-ray investigations.*[644]

The Caravane Collaboration had succeeded in the first and most direct confrontation, i.e. within their own sector of the space science community. They had 'persuaded' the COS Group to prefer a more ambitious, single mission rather than a hybrid experiment whose results would not have been competitive with other projects under development. However, it must be stressed that, had there been at the time a strong interest in, and influential supporters of, X-ray astronomy in the COS Group, a parallel study of a pure X-ray satellite (COS-C?) could have been requested. This was not the case, and the COS-B mission remained the only, well-studied project in the field of high-energy astrophysics. The Caravane Collaboration now had to win first in the LPAC against the proposals supported by the other groups and then in the higher (political) levels of ESRO's decision-making structure.

7.5.1 The LPAC makes its choice - to the satisfaction of the Caravane

In anticipation of the LPAC meeting, the five leaders of the Caravane Collaboration sent a letter of intent to Director General H. Bondi, informing him of their "intention to submit a detailed proposal on

642 *Cosmic Ray Satellite B*, ESRO FS/6, 29 April 1969; *Cosmic Ray Satellite A*, ESRO FS/5, 29 April 1969; HAEC, folder 646.

643 "Preparations for ESRO's future scientific programme", *ESRO/ELDO Bulletin*, 5, May 1969, 14-18. These projects are presented in a series of reports, coded FS/1 to FS/8 that can be found, with the exception of FS/7 and FS/8 (UVAS and WIFAS), in folder 646, HAEC. The programme of the symposium is in LPAC/28 (rev. 1), 2 May 1969. It is interesting to remark that in this programme, the presentation of the two cosmic-ray satellites includes an introductory lecture by Pinkau (who is also presenting COS-B) on "Scientific mission of gamma-ray experiments" which is not present in an earlier version of the same programme: LPAC/28, 14 April 1969.

644 COS Group, 22nd meeting (12 May 1969), COS/44, 20 October 1969, p. 4-5. This resolution was adopted with the dissention of the British scientist J.J. Quenby. Quenby was not directly interested in X-ray astronomy
(his research field was the magnetosphere).

a gamma ray astronomy experiment [....] if ESRO should decide to go ahead with a satellite project suitable for such an experiment". The proposal, they added, "is similar to the gamma ray experiment now studied in connection with the COS-B project".[645] The circle was thus closed. Caravane's experiment proposal perfectly fitted ESRO's COS-B project - hardly surprising since the people who acted as ESRO's principal scientific advisers for the definition of its programme were the same scientists who submitted a proposal correspondingly perfectly to one of the projects considered for inclusion in the programme itself. Moreover, as there were no other proposals besides the Caravane's for a gamma-ray mission, the COS-B project, if approved, could go ahead without the delay caused by a call for experiment proposals and selection. This was certainly an aspect which the LPAC and the STC could not avoid considering when making their choice.

Together with COS-B, four other projects had passed the expert groups' examination and were submitted to the LPAC. These were the atmospheric satellite (EARS) recommended by the ATM group, the Mercury fly-by mission recommended by the PLA group, the geostationary satellite (GEOS) recommended by the ION and the COS Groups, and the ultraviolet project UVAS, that the STAR group had preferred to WIFAS.[646] All the chairmen of the working groups (barring the SUN Group), the president of the STC, P.A Sheppard, and a large group of ESRO staff and officials (including the Director General Bondi, the Director of ESTEC W. Kleen and the Director for Programmes and Planning J.A. Dinkespiler) attended the crucial 28th meeting of the LPAC held in June 1969. Here the scientific, technical and financial aspects of the projects presented were widely discussed in order to define a sound launching programme.[647]

The atmospheric research satellite was rapidly discarded, pending further definition of the scientific objectives of the mission in the light of ESRO's envisaged involvement in a meteorological satellite programme. The Mercury mission was eliminated as too expensive, "in spite of the desirability of Europe entering the increasingly important field of planetary exploration". It would absorb too much of ESRO's limited budget. Three projects remained and the choice between them was left to a restricted meeting of the four members of LPAC who were present, namely Lüst, Occhialini, J.A. Blamont, and B. Hultqvist (the fifth, the Dutch astrophysicist C. de Jager was unable to attend), assisted by Bondi and Dinkespiler.

The three projects under discussion, namely COS-B, GEOS and UVAS, were very different in their characteristics and scientific objectives, and served the needs of the three most important sectors of the space science community: physicists interested in high energy cosmic phenomena, scientists studying the magnetosphere, and astronomers. COS-B involved a single, well defined experiment, to be realised by an international group of laboratories. According to the LPAC, "it had an essentially new exploratory character in which there were possibilities of far-reaching discoveries but some risk also of disappointment". The geostationary satellite, on the contrary, was a multi-experiment mission, which could only be flown after the scientific community had chosen among different experiment proposals. The LPAC's judgement on GEOS was that "[it] was unlikely to yield far-reaching discoveries in terrestrial plasma but it could have very important possibilities in regard to future extraterrestrial and cosmic plasma physics". Finally, UVAS was a very ambitious project, "of great scientific significance in the long run, [which] would provide an assured return in scientific information with the possibility also of a scientific break-through". Observation time would be shared by European astronomy groups, sixteen of which had expressed an interest. The major point against UVAS was that its cost was on the borderline of ESRO's budget for satellite projects.

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645 Van de Hulst, Occhialini, Lüst, Labeyrie, Hutchinson, letter to Bondi, 16 May 1969. This letter was in response to a letter of Bondi (25 April 1969) to the scientific community at large, aimed at getting information about possible proposals in view of the discussions in the LPAC and the STC on ESRO's future programme. Both letters are reported in ESRO/ST/316, 6 June 1969.

646 The recommendations of the ad hoc working groups groups are in LPAC/38, 14 May 1969.

647 LPAC, the 28th meeting (22-23 May 1969), LPAC/39, 26 June 1969. Following quotations are from p. 6 and 11.

This latter point needs elaboration. The estimated costs to ESRO of the three projects were 223 MFF for UVAS, 141 MFF for COS-B and 129 MFF for GEOS. In the case of UVAS being selected, it was intended that ESRO pay for both the satellite (estimated cost at 160 MFF) and for the scientific payload (estimated cost at 73 MFF).[648] This was the policy that had been followed for the LAS, in which the Organisation was expected to bear the entire cost of the project. In the case of COS-B and of GEOS, on the contrary, ESRO would only bear the cost of the satellite. The experiments were to be funded by the scientific groups building them (as for all previous ESRO satellites). Behind the financial arguments there was again the question of choosing between different scientific policies and different research fields. The decision to be taken by the LPAC was whether to recommend that all of ESRO's resources be invested in one big astronomical project or to give priority to less ambitious projects in a wider range of disciplines, with the implication that "this somewhat handicaps the astronomers and planetarians, for whom any worthwhile project is likely to be a more costly one".[649] The LPAC opted for the latter policy. It recommended a priority list for the projects to be included in ESRO's programme which put both COS-B and GEOS at the top of the list, COS-B alone in second place and UVAS in third.[650]

7.6 The final choice

The Caravane collaboration had succeeded in the second important step. It was not the last, however. It was now up to the STC to make a recommendation on the programme from the general scientific and policy point of view, and then for the Council to give its approval. In both bodies the Caravane had to face stiff opposition to COS-B, notably from the representatives of the British scientists interested in X-ray astronomy and stellar astronomy, led by H. Massey and R. Boyd. Already annoyed by the preference accorded to COS-B over COS-A, they could hardly accept the rejection of UVAS, a project in which the British scientific community, as well as the British industry, had invested much and from which much was expected. It was no compensation to them that Hutchinson's group from Southampton was likely to participate in COS-B, Hutchinson being isolated and somewhat at odds with the UK scientific establishment. Nor was it enough that a group from Imperial College, London, including the physicist J.J. Quenby, was interested in magnetospheric research and then in GEOS. As far as Massey and Boyd were concerned, an entire and an extremely influential sector of the British space science community risked being excluded from ESRO's future programme. And this, in their view, was intolerable.

The discussion at the STC meeting on the LPAC recommendation was impassioned and dramatic, according to the recollections of some protagonists. Scientific and financial considerations became intertwined with personal feelings, rivalries and expectations.[651] The main argument put forward by the British delegation (Boyd and Greening) was that "the decision in favour of COS-B had been taken by the LPAC, not on the ground of strictly scientific interest, but mainly for financial reasons". But, they went on, this argument was no longer valid since several groups had recently expressed a willingness to form a consortium for the construction of the UVAS payload and to fund it. The new situation, they concluded, called for a re-examination of the LPAC's resolution. In the British delegation's view, "not only would the UVAS experiment satisfy more scientific groups than would the COS-B, but the development of the spacecraft would be technologically more exciting". The STC did not accept the UK's argument, however. It agreed by 7 votes in favour, 2 against (UK and Belgium) and 1 abstention

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648 This figure for the scientific package of UVAS was given by the Director General at the 28th Council session.

649 "ESRO's future satellite programme", *ESRO/ELDO Bulletin*, 6 (July 1969), 16-17, on p. 17. This article presented a review of ESRO's general financial position by mid-1969.

650 The LPAC's recommendation is also reported in ESRO/ST/310, 2 June 1969 and ESRO/ST/314, 6 June 1969.
The possibility of funding both COS-B and GEOS derived from the fact that the two projects could be conveniently phased.

651 STC, 22nd meeting (19-20 June 1969), ESRO/ST/MIN/22, 29 July 1969. The following quotations are from p. 3-4.

(Germany) that the new information on the financial aspect should not bear on the discussion at that meeting. The reason given was that the setting up of such a consortium would certainly take a long time and that a choice could not be postponed any longer. In conclusion, with only Belgium abstaining, the STC confirmed the recommendation of the LPAC to adopt COS-B and GEOS in ESRO's programme. It also reaffirmed its interest in stellar astronomy, however, and expressed its hope to "receiv[e] for consideration in 1970 a fully worked out proposal for an ultra-violet astronomical satellite with an experiment jointly financed and executed by an international European team of scientific groups". The question of the financial aspect of the three projects was raised again by the UK Delegation, with added vigour, a few days later at the Council session:

The experiments to be flown in COS-B and GEOS [...] were to be financed by the scientific groups, but these groups were subsidised by the governments and it must be borne in mind that each government agency had a certain total envelope with which the space effort in its country was financed. Therefore some Member States might have difficulties in financing the participation of their scientific groups for both satellites. [...] As twenty-two groups had shown great interest in [the UVAS project], it should not take too long to form a Consortium for the financing of its scientific package, thus allowing it to be considered on an equal footing with the other two projects.[652]

According to the British delegates, a negative decision on UVAS "would close the doors on ultra-violet astronomy for a long time" so that it was wiser "to keep the option open for all three satellites until the November session [of the Council]".

The British position was sympathetically received by some delegations. The Belgians, in particular, felt that any firm commitment to extend the scientific programme beyond 1971 should be postponed, pending the conclusions of the Causse Committee and the decisions of the European Space Conference. The Dutch, for their part, felt that "the United Kingdom Delegation's suggestion to put the three projects on an equal footing should be studied". The French and the Swedish delegations, on the contrary, believed that, even without a firm long-term commitment, a clear-cut decision had to be taken. Some delegations stressed that the Bad Godesberg Conference in November 1968 had authorised the Council to approve projects that would extend beyond 1971 and thought, as the German delegation put it, that "the Council should now avail itself of this authorisation and by adopting these two projects in ESRO's programme give a clear indication [...] of what was judged to be scientifically valuable and feasible at this time". The Director General, for his part, stressed that ESRO had certain 'moral obligations' *vis-à-vis* the scientists:

This decision must be taken in order to convince the scientific community that ESRO had the firm intention to carry out these projects. It was evident that this commitment could only be good if decisions were taken at a higher level, to continue a space programme in Europe and to make the necessary resources available to this end.

The Council ultimately approved the adoption of the COS-B and GEOS satellites in the ESRO's programme. It added the proviso that before any contractual obligations were undertaken for the development phases, the Council had to confirm that this programme were compatible with decisions on European space policy taken within the framework of the European Space Conference. The Council also authorised the STC to approve the composition and scheme of management of the international team of scientific groups which were to provide the scientific payload for COS-B. Three and a half years after the S-111 proposal had first been put forward, the Caravane was on the way to achieving its main objective: new data on cosmic gamma rays, and that using a satellite exclusively dedicated to their experiment. They could not afford to fail.

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652 Council, 28th session (1-2 July 1969), ESRO/C/MIN/28, 18 July 1969. This and the following quotations are from
p. 5-7.

It is up to the historian to add a final comment. Scientific and technical considerations played certainly the major role in the process that led COS-B to the last stage of decisions. The final choice was not just a matter of scientific rationality, however. In fact, from the scientific and technical point of view, UVAS was certainly as good as COS-B, or even better. The project had been worked out and was to be implemented by the experienced laboratory that had worked on the LAS since long time. It was an observatory-type satellite whose scientific mission was of great interest for a large fraction of the astronomical community and promised an assured scientific return. From the institutional point of view, it represented, as the heir of LAS, the kind of large space project from which ESRO had mainly derived its raison d'être. The COS-B project, on the contrary, while aiming at investigating a certainly interesting new cosmic phenomenon, had an exploratory character with all the risks associated with this kind of mission. Its scientific payload was to be realised by an international collaboration whose managerial capability had never been tested before. Finally, as regards COS-B and GEOS, ESRO placed itself again in the position of an organisation called to provide technical and managerial services for scientific projects whose responsibility was outside. UVAS was certainly much expensive. However, from the financial point of view, as it presented itself in spring 1969, UVAS was not so much more challenging than COS-B and GEOS. As a matter of fact, the possibility of having the scientific payload of UVAS funded by groups outside ESRO was discarded without, at the same time, having firm assurance that COS-B would have been. We shall see in a moment how this risked to jeopardise the project after its approval.

In a wider perspective, one can look at the success of COS-B and GEOS against UVAS (and, before this, the abandonment of LAS) as a consequence of the weakness and disunity of European astronomers with regard to space research as compared to physicists.[653] In general, it was in the interest of the former that ESRO produced a few stabilised high-performance satellites (LAS and UVAS were examples of this kind) while the latter, spread among many disciplines, preferred a programme based on a large number of medium-sized satellites. But it is worth to recall that astronomers were not unanimous in preferring UVAS to the wide-field satellite (WIFAS). In fact, of the 16 groups expressing interest in UV stellar astronomy, 7 were in favour of UVAS, 5 preferred WIFAS and 4 would have been satisfied of any of them.[654] On the contrary, a programme including both COS-B and GEOS represented an optimum for the physicists involved in space research as it involved several groups of two influent sectors of this community. Finally, if we look more closely at the internal dynamics of ESRO's committees and advisory groups, one cannot avoid considering the role played by the prestige, far-sightedness and scientific skill of people like Occhialini, Lüst and Dilworth. They were able to play with great passion and intellectual integrity their role of scientists interested in a specific research field as well as that of scientific advisors concerned with the future of European co-operation in space.

To conclude, at the question "Why was COS-B eventually chosen as an ESRO project?" answers can be given at several levels and involve many different factors - scientific, technical, institutional, financial, political, personal. These factors weighted differently at different times in the sequence of events which led to the decision to include COS-B in ESRO's scientific programme: the result looks not so much as a "wholly rational" choice among clearly defined alternatives but rather as the outcome of battles and compromises between interest groups. In this case, the result was a very considerable scientific and technical success, such as an official history can refer to it as "a reward for the courage of its proposers who met some opposition from those who felt the mission was too risky".[655] On balance, one must recognise that an outstanding success was also IUE, the UV space astronomy mission that the NASA and the UK Science Research Council jointly derived from the LAS and UVAS, and which was eventually realised with the contribution of the European Space Agency. Of

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653 Golay (1984).

654 ESRO/ST/316, 6 June 1969. STAR Group, 14th meeting (12-13 May 1969), STAR/61, 2 June 1969.

655 *Twenty years of European cooperation in space, 1964-1984*, ESA Report, Noordwijk, 1984, p. 45.

course, no one would dare to say that it is a blame for ESRO's advisory bodies not to have recommended UVAS in 1969!

7.7 Epilogue

The Council resolution of July 1969 ended the long decision-making process, thus establishing the second phase of ESRO's scientific programme, under discussion since 1966. This was an essentially political decision and it had political consequences. Two of them must be mentioned here. The first regarded the participation of Hutchinson's group in the COS-B programme. The UK's Space Policy and Grants Committee, following a recommendation of its Astrophysics Working Group (chairman Boyd), did not recommend that the British Science Research Council support the Southampton group.[656] Informing ESRO's Director General of the decision not to provide financial support to Hutchinson, J.F. Hosie, on behalf of the United Kingdom Delegation, went even further:

> *The specific issue under our consideration was, of course, that of support for UK participation in the payload. However, it followed that doubts as to scientific timeliness and promise in relation to cost applied equally to the whole project. It was therefore agreed that we should express the hope that there will be a re-examination in ESRO of the desirability of devoting so large a share of ESRO's limited resources to this particular project.*[657]

An informal meeting was held at ESRO's headquarters in response to this threat to re-open the debate on the scientific programme adopted by the Council. It was attended by Bondi and Dinkespiler, by the chairmen of the Council (van de Hulst) and of the STC (P.A. Sheppard), by Lüst, in his capacity of chairman of the COS-B Steering Committee, and by the Director of ESTEC's Space Science Department (SSD, formerly ESLAB), E.A. Trendelenburg.[658] Two important decisions were taken here. The first was to organise as soon as possible a colloquium to discuss the scientific mission of COS-B within the general framework of gamma-ray astronomy, in order to assess and possibly remove the existing doubts of British scientists. The second was to suggest that SSD took over Southampton's part of the project, both technically and financially. The Caravane accepted this suggestion after a careful examination of other possibilities, and recommended that ESTEC recruit Southampton scientist R. Wills in order to take advantage of the large amount of research that had already been done in Hutchinson's laboratory.[659]

This new scheme was not uncontroversial, as it meant that ESRO would have to pay for a share in a project that one of the leading Member States had refused to support. Moreover, several delegations (the French in particular) worried that the large scale of the participation of SSD in the COS-B project would strengthen the position of ESTEC's scientific laboratory as a competitor with national groups. The future of COS-B (and indirectly of ESRO's scientific programme) thus depended on the result of the planned colloquium. This was eventually held in ESTEC on 1-2 June, 1970. Both European and American scientists were present, and H. Massey, certainly not sympathetic to the Caravane's project, was invited to take the chair. After a day and a half of scientific reports and informal discussions, the members of the Caravane apparently succeeded in convincing the British scientists of the scientific

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656 *Report of the second meeting of the Steering Committee of the COS-B Collaboration*, 2 February 1970, Annex "Report of discussion of financial matters", *Van de Hulst papers*. See also Massey and Robins (1986),
p. 389.

657 J.F. Hosie, letter to Bondi, 10 March 1970, ESRO/C/449. Bondi's reply (18 March 1970) is *ibidem*.

658 Report on COS-B meeting held in Paris on Thursday, March 26, 1970, Van de Hulst papers.

659 *Minutes of the third meeting of the Steering Committee of the COS-B collaboration*, 14 April 1970, with attached letter from van de Hulst to Bondi, V*van de Hulst papers*. Also ESRO/ST/347, 20 May 1970. For an account of SSD's activities in that period see Trendelenburg et al. (1970).

value of COS-B.[660] Following further recommendations by the STC and by the Administrative and Finance Committee, the Council finally approved the full participation of the SSD in the project with the other partners of the Caravane (Figure 7-3 and Table 8-1, p. 246).[661]

The second implication of the COS-B decision regarded the functioning of ESRO's planning procedures and its overall scientific policy. The protracted and complex process which ultimately led to the choice of ESRO's second generation satellites had revealed that new procedures were needed for defining the Organisation's long-term scientific policy. The time when any scientific group interested in space science could expect to get an experiment on one of ESRO's satellites was definitely over. The Organisation had to develop mechanisms for selecting a few, well-phased major projects according to previously defined scientific guidelines. On the one hand, it was evident that ESRO's budgetary limitations would not permit it to support all fields of space science in a viable way. On the other hand, the definition of future projects required a large amount of coordination with national policies. No less important was the consideration that, as the French delegation to the STC had put it, "the difficulties were aggravated by the fact that the Committee charged with making the selection from among the various proposals was composed of scientists who might be personally involved in the preparation of the proposals".[662] We shall discuss in the following chapter the initiatives undertaken by the LPAC in order to outline a well defined scientific policy for the new phase of ESRO's life.

To conclude, one cannot but give a short account of what happened with COS-B. Following 5 years of laborious implementation of the project, the satellite was successfully launched by a NASA Delta 2913 rocket from Western Test Range, California, on 9 August 1975. It was the first satellite bearing the flag of the newly created European Space Agency (ESA) which had taken over from ESRO and ELDO earlier that year. Three days later, a telex from ESOC, ESA's satellite operation centre in Darmstadt, Germany, informed the COS-B people that everything was operating correctly. Soon thereafter the first gamma ray event, "awaited with bated breath", showed up on the quick-look display screen (Figure 7-4). It was definitive evidence that the instrument that so many scientists and engineers had conceived, designed and built had performed well in the space environment and that it could fulfil its aims.[663]

It is difficult to overestimate the importance of COS-B in the historical evolution, first of ESRO and later of ESA. The management of such a complex undertaking involved the planning, coordination and integration of dozens of scientists, engineers and technicians at scientific laboratories and industrial plants spread in several countries. The direct involvement of ESTEC's Space Science Department in the construction of the experiment and in the data analysis contributed significantly to make ESA's scientific laboratory a highly qualified research centre, The great scientific value of the results obtained by a well designed space mission in a leading field of space science added considerably to the Agency's self-confidence and prestige. COS-B is probably less well known than the Ariane rocket, and its digitised data are certainly less spectacular than Giotto's pictures. Nevertheless the project remains one of the single most important steps in the process that finally brought European space science to the level that ESRO's founding fathers had envisaged.

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660 ESRO, *Gamma-Ray Astrophysics Colloquium*, ESRO SP-58, November 1970. The good impact on the British scientists of the "excellent presentations and discussions at the Colloquium", was reported by V. Manno, letter to Pinkau et al., 12 June 1970, *Van de Hulst papers*. See also STC, 25th meeting (8 June 1970), ESRO/ST/MIN/25, 29 June 1970.

661 ESRO/ST/MIN/25, cit., AFC, 63rd meeting (9-10 June 1970), ESRO/AF/MIN/63, 25 June 1970; Council, 32nd session (30/6-1 July 1979), ESRO/C/MIN/32, 10 July 1970.

662 STC, 22nd meeting (19-20 June 1969), ESRO/ST/MIN/22, 29 July 1969, p. 4.

663 Taylor (1975), p.44.

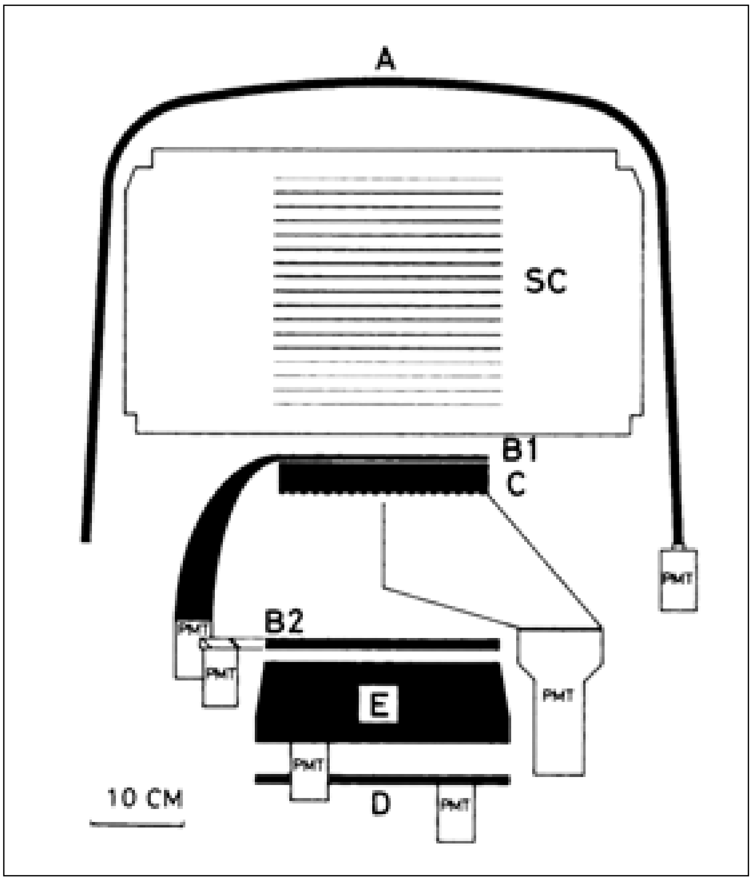

Figure 7-3: Sectional view of the experimental package

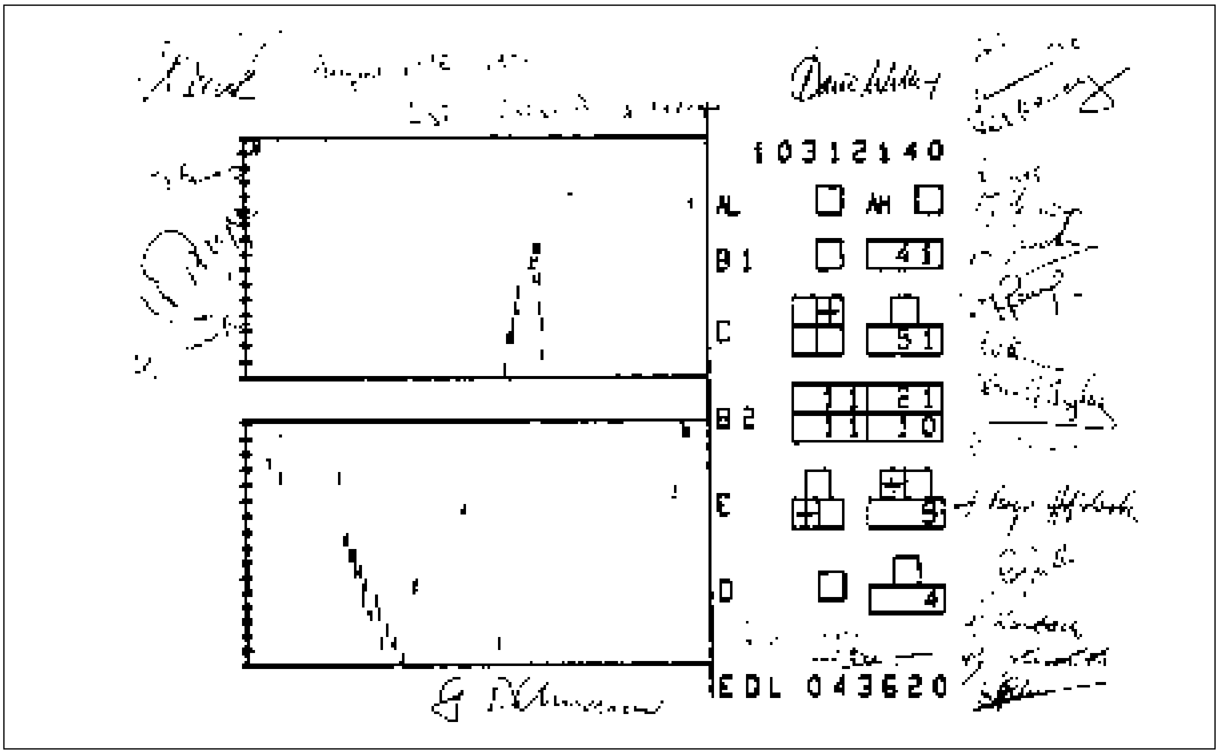

Figure 7-4: The first gamma ray detected by COS-B

How is a large project chosen in a big science organisation? From the case study we have discussed in this paper a few aspects of general interest can be drawn.[664] The first regards the main role played by the financial constraints, both with respect of the total amount of resources and for the expenditure planning over several years. This is a boundary condition where scientific considerations are very poorly represented, it depends rather on general political factors, economic conditions at national and international level, industrial interests and so on. In the case of COS-B, this aspect affected significantly the length of the decision making process and was the most stringent argument against UVAS and the Mercury fly-by mission.

A second aspect regards politics. Both at national and at international levels, a proper compromise between different and conflicting interest groups must be searched for, according to political guidelines whose dimension goes well beyond the scientific ground. LAS, UVAS, COS-B, had not only scientific and financial significance but they also represented political objects which provided ESRO with different characterisations. While scientists were discussing in the LPAC and in the expert groups, government officials, diplomats and ministers confronted themselves in the STC, in the Council, at the European Space Conferences. The issues were whether European satellites were to be launched by European or American rockets; whether science or application should represent the future main engagement of ESRO; whether the balance of space activities in Europe had to be shifted more towards national programmes or towards international cooperation; whether space activities were more a scientific luxury, a commercial interest or a technological need for advanced industrial societies. Behind all this, there were governments discussing of benefits and drawbacks of European economic and political integration.

Finally, one must not forget the role of personalities. Choosing a big scientific project is also a matter of confrontation among scientists involved in the decision making process: members of advisory committees or national delegations, government advisers, policymakers at various levels. At each stage of this process, the traditional ties of cooperation, fellowship and solidarity that characterise the scientific community are strained by the emergence of national interests, disciplinary competitions, personal ambitions, career expectations, personal relationships and so on. When only one or two big projects can be started every three or four years, the stake is high and scientific objectivity is often a luxury. When making a choice entails some kind of painful discrimination, personal prestige, diplomatic talent, personal or professional links can play a decisive role.

We will not forget mentioning the scientific merits of competing proposals, of course. We do maintain, however, that this is not the main factor in choosing big science projects. It is peculiar of big science, in fact, that any proposal arriving at the very decision making level has already passed through a sifting which vouch for its scientific worthiness. The choice is always between projects that are all excellent and scientifically valid and then it is always a matter of hard politics, not of scientific rationality.

[664] It must be underlined, however, that big differences exist between the case of space research and the classical "big science" example of particle physics. The former is multi-disciplinary and each satellite represents a unique piece of experimentation; the latter is a well defined scientific discipline organised around big equipments in large laboratories (accelerators, detectors). It must also be recalled that the case of ESRO/ESA is different from that of NASA, the latter having in-house large research laboratories which the former has not. Finally, it is important to recall the multi-national structure of ESRO/ESA, which is also the case for CERN but not for NASA or Fermilab. For particle physics at CERN see Hermann et al. (1990); for NASA, see Newell (1980).

Chapter 8:
ESRO's Satellite Programme in 1969-1973:
The Definition of a Scientific Policy and the "First Package Deal"

A. Russo

The year 1968, the fifth of ESRO's official life, was very important: "The most momentous in the Organisation's five years of existence", ESRO's General Report heralded, while the chairman of its Scientific and Technical Committee (STC) declared that 1968 was "ESRO's first glorious year [...] against the background of the growing pains of ESRO's formative years".[665] Three main reasons can be given for these optimistic claims. Firstly, ESRO could finally boast the successful launchings of its first three satellites: ESRO II in May, renamed *Iris* after launch; ESRO I in October, renamed *Aurorae*; HEOS-A in December, renamed HEOS-1. All were performing well and scientists were drawing good scientific results from their data. Secondly, ESRO's organisational structure had been significantly changed, following the recommendations of the group of experts chaired by J.H. Bannier, who had analysed in detail the Organisation's structure, procedures and internal working methods.[666] Finally, the third meeting of the European Space Conference, held in Bad Godesberg in November, put an end to a long institutional and financial crisis by drafting a tentative space policy for Europe which included ESRO's eventual involvement in application satellite projects. At the same conference, ESRO Member States agreed to a level of resources for the scientific programme in the period 1969-1971 for the amount requested (860 MFF = 172 MAU) and authorised necessary commitments for individual projects that would extend beyond 1971, namely beyond the 8-year period covered by the original ESRO Convention.[667]

For the ESRO management this represented the way out a long period of uncertainty, and planning the future of the Organisation became again "a rational and fruitful exercise". By the end of 1968, in fact, only one project had already been approved, namely the TD-1 satellite, scheduled for launch in 1972, and it appeared absolutely urgent to limit the large fluctuation in workload resulting from the protracted absence of decisions. The time was ripe for ESRO to choose new projects and to define more efficient long-term planning instruments: "Only with a real and challenging programme", they concluded, "can we keep and recruit staff of the necessary calibre and make proper use of our facilities".[668] And in fact several new projects were approved in 1969.

A first set of decisions was taken in March, when the ESRO Council approved three small satellite projects: ESRO IB (*Boreas*), a follow-up of ESRO I carrying the same payload, eventually launched in October 1969; HEOS-A2 (HEOS-2), launched at the end of January 1972; and ESRO IV, the result of the TD-2 rescue operation, launched in November 1972. By these decisions, an acceptable continuity in the short term programme was achieved and the first phase of ESRO's satellite programme was concluded. Subsequently, as discussed in the previous chapter, in July ESRO was able to bring to conclusion the long decision-making process leading to the approval of two satellite projects for the second phase. These were the COS-B satellite, to investigate celestial gamma rays, and the geostationary satellite GEOS for studies of the magnetosphere.

In this chapter, we will analyse the development of ESRO's scientific satellite programme in the period 1969-1973, namely between the decision on COS-B and GEOS and the selection of the next satellite projects: the ISEE-2 spacecraft in an ESRO/NASA three-satellite project devoted to magnetospheric and solar wind studies, and the X-ray astronomy observatory *Exosat*. These four years were the most

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665 ESRO, *General Report 1968*, p. 7; P.A. Sheppard's "Foreword" to *ESRO/ELDO Bulletin*, Supplement, August 1969 (*HEOS-1 Special*), p. 4.

666 See chapter 2.

667 MFF stands for Million French Francs and MAU stands for Million Accounting Units, ESRO's conventional monetary unit defined on the basis of the set of Member States' national currencies.

668 ESRO/ST/302, 19 February 1969, p. 1.

important in the history of European cooperation in space. They marked the end of the illusion that ESRO's sister organisation ELDO could ever build an all European satellite launcher and the transformation of ESRO itself from an organisation solely devoted to scientific research to one mainly engaged in the domain of application satellites. Facing the growing political and economic importance of space activities, European governments were involved in long and painful discussions about the possible definition of a coherent space policy for the Old Continent, trying to find a compromise between conflicting national interests. In 1973 this compromise was finally agreed on, starting a process which led in 1975 to the birth of the European Space Agency (ESA), out of the ashes of ELDO and the wealth of ESRO.

In this context it was hardly possible for ESRO to approve new satellite projects in this period, in spite of the several mission definition and feasibility studies which were performed after suggestions from the European space science community. The time was not wasted, however, and we can consider these four years a period of maturation of ESRO's scientific programme. Three elements contributed to this maturation process. Firstly, with the successful launching of three satellites and the development of six new spacecraft, four of which launched within the period we are considering, ESRO acquired invaluable experience and proved to be a reliable organisation. This was not of minor importance in the positive outcome of discussions on European space policy. The second element regards the place of the scientific programme within ESRO's new engagement in the application field. While the budget for the scientific programme was dramatically reduced in the period we are considering, this programme was made mandatory in the new institutional setting and the money finally started to flow from Member States continuously and predictably. Long-term planning became "a rational exercise" as it had never been before. Finally, the third element of the maturation process, the one that will constitute the main thread of this paper, regards the definition of a scientific policy. ESRO's policy-makers definitely abandoned the illusion that the Organisation could actually pursue the "book of dreams" that the European space scientists had written in the *Blue Book*, and made an important effort to discuss guidelines and priorities, on the basis of the financial and technical resources available, and taking into account the parallel development of national space programmes in Europe and the United States.[669]

Following this thread, the chapter is organised in three main parts. In the first we will review the main features of the two satellite projects approved by the ESRO Council in July 1969, namely COS-B and GEOS. These were the last to be approved in the institutional framework established by ESRO's founding fathers and represented a cornerstone for the following evolution of the Organisation's scientific programme. In the second part, we will analyse the discussions within the European space science community which led to the important policy statement issued by ESRO's Launching Programme Advisory Committee (LPAC) in early 1970. The relevant aspect of this policy definition was the recognition that only a limited number of scientific fields could be included in ESRO's scientific programme and a choice had to be made: magnetospheric physics and high energy astrophysics were included in this number with high priority, while UV stellar astronomy, solar physics, and planetary science were definitely ruled out. As a consequence of this decision, the X-ray satellite project HELOS was recommended in 1971 by the LPAC but, pending the outcome of the political discussions among ESRO's Member States, its eventual inclusion in the Organisation's programme was not even discussed by the Organisation's governing bodies. The latter, however, did approve LPAC's other recommendation that ESRO should cooperate in the NASA/UK project International Ultraviolet Explorer (IUE). In the third part we will report on the important "Package Deal" agreed on by the ESRO Council in December 1971, which formally established application satellite programmes, and then we will discuss the choice of ISEE-2 and Exosat, the coherent conclusion of four years of scientific discussions and feasibility studies.[670]

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669 The so-called "Blue Book" is the original programme of ESRO as approved by the European Preparatory Commission for Space Research (COPERS) in October 1961: see chapter 2.

670 The 1971 package deal will be discussed here from the point of view of ESRO's scientific programme. Other viewpoints on this important event in ESRO's life are in chapter 10 and 13.

8.1 COS-B and GEOS

In the previous chapter, we have discussed in detail the decision-making process leading to the adoption of COS-B and GEOS in ESRO's satellite programme.[671] It must be recalled here that this choice implied the rejection of the UVAS project, a space observatory for ultraviolet astronomy strongly advocated by the same groups which had been involved in the ill-fated Large Astronomical Satellite (LAS). This decision, therefore, represented a new blow to the expectations of European astronomers interested in space research and, at the same time, it set the stage for the eventual emergence of magnetospheric science and high energy astrophysics as the leading fields in ESRO's scientific satellite programme.

COS-B was an observatory-type satellite whose mission was the study of the extraterrestrial gamma radiation with energy above about 30 MeV. The scientific payload was provided by a group of laboratories, calling themselves the *Caravane Collaboration*, who built the different parts of the instrument (Table 8-1). The heads of the groups providing the payload constituted the Steering Committee responsible for the scientific direction of the project and for the publication of its results. An important aspect of this project is that ESTEC's Space Science Department (SSD, formerly ESLAB) was a member of the collaboration and had the responsibility for integration and management. This was the first time that ESRO's in-house research laboratory was significantly involved in a major satellite project; this affected the further evolution of the laboratory, making it a recognised scientific institution. The satellite was successfully launched in August 1975 and it provided a continuous flow of useful data until April 1982, when the instruments on board were switched off because of the definitive deterioration of the main detector.

GEOS was a geostationary satellite whose scientific mission was the study of physical phenomena in the magnetosphere by integrated measurements of particles, fields and plasma. Unlike COS-B, GEOS was a multi-experiment satellite: its scientific payload was made up of 7 different instruments provided by 10 European laboratories. Because of its unique orbit and the sophistication of its payload, GEOS was selected as the reference spacecraft in the world-wide "International Magnetospheric Study" (IMS). The satellite 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 in December 1977 and successfully executed in July 1978. The satellite's operations were terminated in June 1982.

COS-B and GEOS were ESRO's second generation satellites, after the greatly curtailed ESRO, HEOS and TD programmes, and they were quite different from each other, both in their scientific mission and in their overall conception. COS-B was the first ESRO/ESA single-experiment, observatory-type satellite and this implied that the success of the mission depended on a close coordination between the different people and institutions responsible for the development of the spacecraft and the payload. While in multi-experiment satellites the failure of one experiment did not jeopardise the success of the mission, in the case of COS-B a good performance of all the different parts of the satellite and its payload was the *sine qua non* condition for the fulfilment of the scientific aims. The actual implementation of the project, however, was based on ESRO's standard practice that the scientific payload should be provided by external laboratories which depended on separate funding, expressed different scientific cultures and worked in different institutional contexts. The *Caravane Collaboration* kept scientific responsibility for the mission and the property of the data, which represented the standard for an "experiment" rather than for an "observatory". While not a particularly sophisticated spacecraft from the technical point of view, COS-B was, for all these reasons, very challenging from the point of view of the management. This was complicated by the fact that ESTEC's SSD was at one and the same time responsible for building a part of the instrument and for the integration of the whole payload. Thus the problem of how to share responsibility for the scientific supervision over the experiment between the collaboration as a whole and SSD's scientists became a matter of continuous

671 The scientific aims and technical specifications of the two satellites by the time of their launch are described in *ESA Bulletin*, 2 (August 1975) and 9 (May 1977), respectively.

negotiation. The organisation and management of COS-B in the different phases of development of the project was a matter of experimenting and testing by itself, the results of which significantly affected the further evolution of scientific satellite management in ESA. In the words of Roy Gibson, ESA's Director General when COS-B was launched:

> *[It was not] always easy to develop a management scheme for the payload which had to be established by mutual and voluntary agreement between ESRO and the members of the payload collaboration, particularly as ESRO was not financing the payload. [...] The Organisation has also drawn certain conclusions from this experience, such as that for observatory satellites ESA hardware financing is a must. This philosophy has been adopted for the EXOSAT payload.*[672]

GEOS, on the contrary, was conceived like ESRO's first generation satellites, namely as a broad scientific mission to be accomplished by a set of experiments chosen among proposals coming from the scientific community and integrated into the payload. In this case, however, owing to the peculiarity of the satellite's scientific mission, the problem of close cooperation among the different experimenters, as well as between them and the scientific community at large, presented itself in more urgent terms than previously. While the experiments in previous ESRO satellites were relatively independent from one another and each group dealt with its own data autonomously, the GEOS experimenters from the very beginning discussed ways to achieve the maximum scientific value from the satellite and defined common modes of payload operation and data handling. They also established contacts with other scientists through a Committee for Co-ordination of Observers associated with GEOS (CCOG), created in 1972 on the initiative of a number of eminent European scientists.[673]

8.1.1 The choice of the payload composition for GEOS

In order to organise in the best possible way the scientific programme of the newly approved geostationary satellite, ESRO organised a 3-day colloquium in Lyngby, near Copenhagen, in mid-October 1969. Here it was stressed the opportunity of achieving an integrated scientific programme, with related experiments being carried out by ground-based, balloon-borne or rocket-borne instruments. Immediately following the colloquium, the three interested Working Groups ION, COS and PLA held a joint meeting in order to define the mission objectives and to draft a letter of invitation for experiment proposals.[674]

This was a very delicate passage. After the long and controversial decision-making process regarding COS-B and GEOS itself, it was clear that the time when any scientific group interested in space research could hope to get a share in one of ESRO's scientific satellites was over and GEOS appeared to many as the last chance. At the same time, the peculiarity of the orbit made GEOS a spacecraft of great scientific interest for many research fields, and much attention had to be devoted to obtain the best results from it. In fact, the study of the magnetosphere and its phenomena was typically a scientific domain created by the advent of space technologies, and it spread over several sectors of the space science community. By probing this "little backyard universe", as the magnetosphere came to be called, geophysicists wanted to pursue further their investigation of the structure of the Earth's magnetic field; for ionosphere physicists it was of great interest to study how particles and waves travelling along the magnetic lines determined ionospheric phenomena; cosmic ray physics was also

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672 R. Gibson's Introduction to *COS-B Special*, *ESA Bulletin*, 2 (August 1975), p. 4.

673 ESRO, *General Reports 1972* and *1973*, and *Annual Report 1974*.

674 The report on the meeting (17 October 1969) is in LPAC/55, 10 November 1969, and the conclusions are presented in LPAC/57, 28 October 1969. The meeting followed separate meetings of the three groups held earlier on the same day, whose reports are ION/80, 19 December 1969; COS/46, 20 February 1970; and PLA/62, 4 December 1969 respectively. The three groups were responsible for advising the LPAC on ionospheric research (ION), cosmic rays (COS) and planetary science (PLA). Three other groups existed, responsible for atmospheric research (ATM), stellar astronomy (STAR) and solar astronomy (SUN). The structure and functions of the LPAC and its scientific advisory groups are discussed in chapter 5.

involved, as the shape and structure of the magnetosphere is strongly affected by energetic particles from the Sun; finally, the magnetosphere was a sort of natural laboratory for plasma physics studies.[675]

After long discussions, the purpose of this mission was carefully defined as follows:

> *To make integrated scientific studies of the distribution of thermal plasma, energetic particles, fields and waves, by means of a satellite in a geosynchronous or geostationary orbit. All types of experiment, however, for which this type of orbit is appropriate will be considered for inclusion in the spacecraft.*[676]

Through careful wording the LPAC then specified that magnetospheric and interplanetary studies would be considered on the same basis; that priority should be given to experiments for which a geostationary orbit was advantageous, but other types of experiment would be considered for inclusion in the payload, "if they are of exceptional value or significance"; that the study of energetic particles was included in the mission but with the exclusion of galactic cosmic rays; that the orbit should be defined as "geostationary" but that "experimenters who would prefer a geosynchronous orbit would have to justify their requirements, taking into account the penalties which might result".[677]

Two important points were stressed by the LPAC, that represented a novelty with respect to previous ESRO's practice. Firstly, the experimenters were advised that they would be actively engaged in managing and funding data processing, and that each experimenter would be required to communicate his processed data to the others. GEOS, in fact, would provide an enormous potential output of data, about 200 times as much as current ESRO satellites, and it was desirable to reduce the Organisation's workload in this field.[678] Secondly, the LPAC endorsed a solicitation from the Danish physicist B. Peters, aimed at fostering cooperation among groups participating in the project.[679] A two-stage procedure was then defined for the submission of experiment proposals. In the first stage, groups wishing to participate either in the hardware or in the data analysis for a specific experiment were to write a letter of intent, to be circulated in order to enable other groups to become acquainted with the existing possibilities and to stimulate the start of cooperative programmes. After this preliminary step, definite experiment proposals had to be submitted.

By mid-January 1970, 28 letters of intent had been received, including 35 experiment proposals. Moreover, several groups expressed an interest in participating in the scientific programme of GEOS by rocket, balloon and ground-based experiments. Further negotiations among all interested groups led to the submission, by the end of March, of 31 experiment proposals that were classified into 10 fields: low-, medium-, and high-energy particles, ion composition, plasma experiments, DC electric fields, DC magnetic fields, electric and magnetic wave fields, Lyman-α emission, beacon experiment. Two

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675 For an overview on the discovery and early studies of the magnetosphere, see Newell (1980), pp. 172-186. The definition "little backyard universe" is in Knott (1977), p. 12.

676 LPAC/57, 28 October 1969, p. 1.

677 LPAC, 29th meeting (13 November 1969), LPAC/63, 12 January 1970, pp. 7 and 11. Possible orbits are discussed in MS/64, rev. 1, 11 November 1969.

678 It is interesting to remark that the Director General H. Bondi stressed the fact that "European experimental groups, to date, did not have sufficient experience to handle the flood of data that would be derived from this satellite". LPAC, 32nd meeting (15-16 June 1970), LPAC/88, 24 August 1970, p. 4.

679 Peters, on behalf of the Danish delegation, had submitted a written statement on this subject to the STC at its 23rd meeting (22 October 1969), ESRO/ST/MIN/23, 22 January 1969. The matter had been widely discussed by the COS Group at its 23rd meeting (17 October 1969), COS/46, 20 February 1970.

experts for each field were appointed as referees and their reports were then discussed by a panel of experts, chaired by the British physicist H. Elliot, that finally submitted its conclusions to the LPAC.[680]

It required a long discussion in the LPAC in order to analyse the panel's recommendations as well as the referees' reports when any inconsistency was present. As a result, the recommendations of the panel were generally accepted and an integrated payload was defined, including 9 experiments in 7 fields of study (Table 8-2). The LPAC, in particular, endorsed the panel's suggestion to exclude the beacon experiment and the study of high-energy particles and Lyman-α emission. It decided, on the contrary, to include experiment S-303 to measure ion composition, a field that the panel had not recommended for the GEOS mission.[681] This payload composition was eventually endorsed by the STC even though, regarding experiment S-328, the French delegation wanted to reaffirm its opposition to development of payloads by ESLAB.[682]

8.2 Working out a scientific policy

Just after the decision on COS-B and GEOS, the LPAC's membership was partially renewed by the STC. Jacques Blamont and Cornelis (Kees) de Jager were replaced by the Swiss physicist Johannes Geiss and the Danish astrophysicist B. Strömgren, who joined Bengt Hultqvist, Reimar Lüst and Giuseppe (Beppo) Occhialini in the Committee (Table 8-3).[683] The new LPAC was asked by the Director General Hermann Bondi "to consider the problem of ESRO's long-term scientific policy in order to enable ESRO to make a careful selection of new feasibility studies to be initiated on future projects".[684]

As a matter of fact, the complex affair of the selection of the satellite projects for the second phase of the programme had shown that the problem of the ESRO's long-term scientific policy deserved fresh consideration. Several factors had to be considered before undertaking any feasibility study on projects to be realised in the second half of the 1970s. Firstly, it was obvious that budgetary limitations would not allow ESRO to carry out satellite projects in all fields of space science: the Organisation had to make choices about the research fields in which it wanted to concentrate its efforts. Secondly, ESRO's satellite programme had to be based on a few, well-phased projects with a well-defined scientific mission and an integrated payload. This implied the definition for each project of a clear scientific leadership to deal with the building of the payload, the observation programme and the data handling. Thirdly, the definition of ESRO's scientific programme required a large amount of coordination with the Member States' national space programmes and with NASA, both in the light of eventual collaboration and to avoid wasteful overlapping. Fourthly, as ESRO was going to be involved in application satellite programmes, some kind of coordination had to be defined, from the technological and managerial viewpoint, between this new field of activity and the scientific programme. The case of GEOS was an example of a scientific satellite whose technological implications (platform, telemetry, tracking stations, and so on) were relevant for the telecommunication satellite programme, also based on the realisation of a geostationary satellite. Finally, no less important was the problem of

680 The procedure for the selection of the GEOS payload was agreed at the 31st meeting of the LPAC (27-28 February 1970), LPAC/73, 3 April 1970. The initial 35 proposals were presented in LPAC/66, 26 January 1970, and add. 1, 28 January 1970. The following 31 proposals were presented in GEOS/4, 27 May 1970. Reports of the referees are in the series of documents GEOS/7-38. The panel of experts consisted of H. Elliot (chairman), R. Gendrin, G. Haerendel, N. Herlofson, J.W. King, G. Pfotzer, J.J. Quenby, J. Sayers. The panel held two meetings, on 20 April and 30 April - 2 May 1970, whose reports are GEOS/1, 14 May 1970, and GEOS/2, part I-III, 27 May 1970 - 5 June 1970. The panel's final report is GEOS/3, 28 May 1970. Both the conclusions of the Panel and those of the referees are summarised in LPAC/83, 11 June 1970.

681 LPAC, 32nd meeting (15-16 June 1970), LPAC/88, 24 August 1970. LPAC's recommendations are in LPAC/86, 17 June 1970.

682 STC, 26th meeting (14-15 October 1970), ESRO/ST/MIN/26, rev. 1, 23 November 1970, p. 4.

683 STC, 22nd meeting (19-20 June 1969), ESRO/ST/MIN/22, 29 July 1969, p. 6. The list of candidates presented by ESRO's Director General also included H. Elliot and B. Gregory.

684 ESRO/ST/330, 10 October 1969, p. 1.

defining selection procedures which avoided what the French delegation at the STC called "an unhealthy situation", namely that "the Committee charged with making the selection from amongst the various proposals was composed of scientists who might be personally involved in preparation of the proposals".[685]

Following the Director General's request, the LPAC set up two panels: a Geophysics Panel, chaired by A.P. Willmore, and an Astrophysics Panel, under the chairmanship of C. Dilworth (Tables 8-4a and 8-4b). The former was to cover research in geophysics and planetary science, including studies of the neutral atmosphere, the ionosphere, the magnetosphere and the solar wind, as well as studies of the planets and interplanetary matter. The latter was to cover research in solar and stellar astronomy, cosmic rays and cosmology. These two panels held several meetings between August and December 1969, with the participation of several invited experts, and their reports were presented to the LPAC in January 1970. We will discuss them separately.[686]

8.2.1 The Geophysics Panel

The first point made clear by the Geophysics Panel was that ESRO should exclude planetary missions and missions aimed at studying the solar wind and the interplanetary medium at great distance from the Earth:

> *They are necessarily expensive missions partly because of the large launcher cost and partly because of stringent demands on the spacecraft which result from the long mission duration, large transmission distance and variations in the solar constant of the spacecraft.*[687]

It was impossible for ESRO, the Panel argued, to sustain a healthy scientific programme in these fields with the limited financial and technical resources available. Moreover, as American activity was rather strong and was expected to undergo substantial expansion in the future, "ESRO would experience strong competition with unequal resources". The Panel, however, did not exclude planetary studies if these could be pursued by a small Earth-orbiting optical telescope specially devoted to the observation of planets. If the regions far away from the Earth were excluded for financial reasons, those nearest the Earth's surface were excluded for lack of real scientific interest. The Panel recognised that studies of the neutral atmosphere and of the ionosphere at mid-latitudes should be omitted from the ESRO programme: the former could be pursued by national sounding rocket programmes or in the framework of the forthcoming ESRO's meteorological satellite programme, the latter could not receive significant improvement by additional future satellites.

There remained the wide domain of magnetospheric studies, for which ESRO's resources were sufficient to establish a viable programme and whose scientific interest was worth such an effort. Even though it was recognised that the exploratory content of this field of study was not so great, given the results obtained over the previous decade in the US and the Soviet Union on the structure and properties of the magnetosphere, it was nevertheless possible to carry out studies in plasma physics under extreme conditions, a branch of physical research of great interest and wide applicability both on the Earth and in the skies. In the words of the Panel's scientists:

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685 STC, 22nd meeting (19-20 June 1969), ESRO/ST/MIN/22, 29 July 1969, p. 4. The comment was on the choice of COS-B and GEOS.

686 The terms of reference of the two panels are in the annex to ESRO/ST/330, 10 October 1969, and also in LPAC/41, 8 September 1969. The membership is *ibidem*. The Geophysics Panel met three times, their summary reports being LPAC/42, 22 August 1969; LPAC/44, 4 November 1969; and LPAC/53, 2 December 1969. The Astrophysics Panel met 4 times, their summary reports being LPAC/46, 22 October 1969; LPAC/52, 9 January 1970; LPAC/54, undated; and LPAC/64, 13 January 1970. The two panels' final reports to the LPAC are LPAC/68, 27 January 1970, and LPAC/69, 9 January 1970, respectively.

687 LPAC/68, cit., p. 5.

> *In addition to being interesting, in itself, as an unusually rich branch of physics, the physics of collisionless plasma has the added attraction of being a key subject in thermonuclear research. This circumstance has, in recent years, led to remarkable progress in plasma technology, that has greatly improved the basis for laboratory simulation of cosmic phenomena. Far from making space plasma experiments unnecessary, such improvements (which can be expected to continue) will make it increasingly fruitful to combine laboratory experiments and space observations in the effort toward better understanding of the physics of collisionless plasma.*[688]

In conclusion, as regards the fields included in its terms of reference, the Geophysics Panel recommended that ESRO should concentrate its scientific satellite programme on plasma physics studies in the magnetosphere and on astronomical observations of the planets. Studies of the polar ionosphere and nearby interplanetary space by small satellites could be undertaken only if in support of the magnetospheric programme. It was agreed not to explicitly award priority to either of the two recommended research fields, but a wide majority in the Panel thought that higher priority should be given to magnetospheric studies.

8.2.2 The Astrophysics Panel

The Astrophysics Panel had a more difficult task. The difficulty arose from at least two factors. Firstly, the research fields in the Panel's terms of reference included three broad research fields: cosmic rays (including also celestial X- and gamma-rays but excluding solar radiation), stellar astronomy (including visible, infrared and ultraviolet radiation), and solar physics (including all corpuscular and electromagnetic radiation from the Sun). A survey among the European scientific community had shown that there was roughly an equal number of groups interested in each of these fields, and important results were expected from the use of satellite instrumentation of ever increasing sophistication. Moreover, the very possibility of definite discipline classification was made difficult in a phase which saw the emergence of a new discipline, high energy space astrophysics, based on the use of physical techniques to investigate astronomical objects. In this situation, the possibility of excluding some research field, as had been done by the Geophysics Panel, or even to establish priorities, was definitely out of the question.[689]

The second difficulty derived from the consideration of NASA's post-Apollo programmes of manned space stations (expected to be in orbit by the end of the 1970s), for which Europe's collaboration was urged by the American space agency. These stations would provide splendid opportunities for scientific research in the fields covered by the Panel and therefore the various scientific objectives had to be assessed and scheduled in the light of the facilities eventually available on the space stations. In this context, a new question arose, i.e. ESRO's role and responsibility in the building and management of instrumentation to be placed in NASA's spacecraft and space stations in the framework of ESRO/NASA cooperation.

In the event, the Astrophysics Panel decided to follow a different path from that of the other panel: it agreed not to make selections or to establish priorities, but rather to discuss the scientific interest of the various research fields, stressing that it was up to the scientific community, through ESRO's advisory Working Groups, to give advice about the choice of future projects.

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688 *Ibidem*, p. 11. It should be recalled that one of the member of the Panel, the Chairman of the ATM Group U. von Zahn, protested against the priority given to magnetospheric studies, arguing that "while the main emphasis should be placed in ESRO on the exploration of space, a choice was being made of a field or research of non exploratory character". LPAC/53, 2 December 1969, p. 4.

689 Updated statistics of European groups interested in ESRO's programmes were presented at the 2nd meeting of the Astrophysics Panel (20-21 October 1969), LPAC/52, 9 January 1970. Slightly different figures had been presented earlier at the second meeting of the Geophysics panel (1-2 September 1969), LPAC/44, 4 November 1969. Besides the three fields cited above two others were considered by the Astrophysics panel: radio astronomy and fundamental physics. About the growing role of physicists in the traditional domain of astronomers,see Hirsch (1983), in particular chapter 6.

Underlying the discussions in the Astrophysics Panel there was the ongoing competition between astronomers and cosmic ray physicists, the former advocating large and sophisticated space telescopes for high resolution studies of the Sun and other stars in the UV region, the latter being more and more interested in developing satellites devoted to high energy astrophysics (i.e. X- and gamma-ray astronomy).[690] In this competition, astronomers had the advantage of being in the position to claim their turn in using ESRO resources, after the misgivings felt by the astronomical community in relation to the abandonment of the LAS, UVAS and TD-2 projects. On the other hand, they suffered a weakness deriving from three factors. Firstly, their projects were on the borderline of ESRO's financial resources, often requiring collaboration with NASA or even the use of NASA's spacecraft. Secondly, their scientific objectives were in an area well covered by the American OAO (Orbiting Astronomical Observatory) and OSO (Orbiting Solar Observatories) programmes, which were to be followed up by more powerful missions, including manned stations. Finally, such projects were in competition with the interests and expectations of astronomers relying on ground based telescopes, who also advocated ever more powerful instruments.[691]

As to the high energy astrophysics community, they certainly had the advantage that their projects could fit well into ESRO's medium-satellite programme, but suffered from one serious drawback. They had already obtained the gamma-ray satellite COS-B while, in the X-ray astronomy field, they lacked a project that could successfully compete with the vigorous American programme: NASA's first Small Astronomy Satellite (SAS-A), scheduled for launch in late 1970, was entirely devoted to X-ray astronomy, and an ambitious programme of large High Energy Astronomy Observatories (HEAO) was soon to be approved.[692]

Concluding its discussions, the Panel suggested a programme for the 1970s articulated in three phases. In the first half of the decade, when no new satellite launches would be available, the programme was to consist of stabilised sounding rockets, essentially devoted to ultra-violet and X-ray astronomy. After 1975, a small- and medium-size satellite programme was to be defined whose scientific objectives did not require the facilities of the space stations. The third component of the programme was the preparation of experiments to be carried out from the space stations, for which "ESRO should offer to European experimenters not only coordination and management, but also basic facilities".

With respect to the various research fields, the Panel's report pointed out that, after the negative outcome of the UVAS and the TD-2 affairs, a large expectation existed among the European astronomical community for satellite projects devoted to stellar astronomy and solar physics. "The need for ultraviolet observations has been stressed by European stellar optical astronomers for many years", the Panel remarked, "particularly in the design studies carried out for the LAS and the UVAS". It then continued:

> *If it appears that such a facility is outside of ESRO's financial possibilities, it might be quite appropriate to make use, on a cooperative basis, of the OAO vehicle developed by NASA. Scientific aims and basic instrumentation may remain identical to what has been proposed for the UVAS, thus making use of the feasibility study work already carried out by ESRO on the subject.*[693]

The Panel also recommended that ESRO should propose to NASA a joint project for a space astronomical observatory filling the gap between the OAO series and the facilities aboard the manned space stations. When more information on the latter would be available, ESRO was to provide

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690 This point has been discussed by Dilworth (1992).

691 In this period, the European astronomical community was involved in plans and discussions on the envisaged European Southern Observatory (ESO), a large facility to be built in Chile. See Golay (1992).

692 SAS-A was renamed *Uhuru* after launch and provided the first catalogue of celestial X-ray sources: Hirsch (1983).

693 LPAC/69, cit., p. 5-6.

facilities to enable European astronomers "to put auxiliary equipment at the focus of large, stabilised, light collecting devices".

As regards solar research, two types of projects were presented, which seemed of particular interest for European scientists. The first was a satellite to study high energy plasma phenomena (flares) in the solar atmosphere by simultaneous measurements in a wide spectral range, from extreme ultraviolet to sub-millimetre, with good angular, spectral and temporal resolution. This kind of project, in the Panel's opinion, seemed to be "within the reach of European technology and the European scientific interest and capacity". The second project, on the contrary, envisaged cooperation with NASA to build a solar space observatory to study the solar atmosphere with angular resolution better than 0.2".[694]

Against these major astronomical projects, cosmic rays and high energy astrophysics (the physicists' domain) appeared with a low profile in the Panel's report. About cosmic ray studies, it was recalled that much could be done by balloons, "satellites being necessary for particular experiments requiring either long and continuous observation times, or complete freedom from the Earth's magnetic field". Two such lines of investigation were indicated: the search for anti-nuclei and a detailed investigation of the chemical and isotopic composition of the cosmic radiation. As to X-ray astronomy, the report limited itself to surveying the projects under development and then concluded:

> *However, it is certain that X-ray studies will, in the future, require instrumentation of ever increasing power and complexity and the Panel felt that European experimenters might profitably concentrate on developing, over the next few years, sophisticated X-ray detection systems so that they are available to take advantage of the facilities provided by the manned space stations.*[695]

No less generic was the presentation of gamma-ray astronomy: in the field of high energies (above 30 MeV) ESRO was developing the COS-B satellite while, in the low-energy range (0.3 to 10 MeV), much more sophisticated experimental techniques were required.

Besides these "classical" research fields, others were discussed as eventual new terrains for space experiments. A field "adopted enthusiastically by the Panel" was that of fundamental physics, namely the application of space technology to the study of phenomena involving fundamental laws and principles of physics. Two examples were put forward in particular, both aiming at testing gravitation theories. One was an experiment on the space-time metric, involving the timing of the passage of a laser signal to the Earth from a satellite in orbit beyond the Sun. The other concerned the detection of gravitational waves in the quiet conditions afforded by satellites.[696] Other research fields were put in a more distant future, such as infrared astronomy (for which a programme of technological research was recommended); optical astronomy (for which a long focal telescope on a manned space station was suggested, with the aim of measuring accurately the orbit of a large number of binary stars and then obtaining a much better knowledge of stellar masses); and radio astronomy (for which the possibility was envisaged of a long wavelength radio telescope on the moon, or an extension to long-baseline interferometry using a geostationary satellite).

8.2.3 The LPAC's policy statement of February 1970

The reports of the Geophysics Panel and the Astrophysics Panel were submitted to the LPAC in January 1970, but the Committee agreed that, before arriving at a definite statement on ESRO's future scientific policy, the two reports should be further discussed by the six ad hoc Working Groups.[697] The outcome of these discussions did not make the LPAC's task easier, however. Commenting on the Geophysics Panel's report, the ION group objected to the principle of establishing a negative priority

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694 *Ibidem*, p. 8.

695 *Ibidem*, p. 5.

696 *Ibidem*, p. 9. A preliminary mission definition study for a space experiment on the geometry of space-time had already been performed, following a proposal of J. Blamont: LPAC/48, 15 October 1969.

697 LPAC, 30th meeting (14 January 1970), LPAC/70, 3 February 1970.

list and argued that the Panel's guidelines should be used only for the major projects and should not cover areas in which important missions could be carried out by the use of small satellites. The PLA group stressed that new information from the United States showed that inexpensive planetary missions were indeed possible and suggested studying the feasibility of a Venus orbiter. The STAR group expressed its concern for the fact that so much emphasis was placed on the space stations, whose availability in the near future was still uncertain, and recommended a satellite flying instrumentation similar to the UVAS type to carry high resolution studies. The COS Group stressed the importance of high energy astrophysics and of studies on the isotopic and chemical composition of cosmic rays. This group also gave top priority to the study of neutrons and charged particles from the Sun, a research area not included in the Astrophysics Panel's report, and placed the study of the magnetosphere rather low in its list of priorities, contrary to the recommendations of the Geophysics Panel. Finally, the COS Group recommended overriding priority to the field of fundamental physics, should a mission in this domain prove feasible. The SUN group stressed the importance of having an ESRO solar satellite to bridge the gap between the end of NASA's OSO programme and the space station projects. The ATM group strongly complained against the elimination of atmospheric research.[698]

In the event, the LPAC finally arrived at a definite statement about ESRO's future scientific policy after two days of lively discussions. The chairman of the Council, H. van de Hulst, also attended the meeting, together with an important delegation of ESRO's directorate (the Director General H. Bondi, the Director of Programmes and Planning J.A. Dinkespiler, and the Director of ESTEC's Space Science Department E.A. Trendelenburg), and with C. Dilworth and J.W. Dungey representing the Astrophysics Panel and the Geophysics Panel respectively. The main issue was again UV stellar astronomy and the pressure from the astronomical community to have a serious involvement of ESRO in the field. B. Strömgren informed the LPAC of a letter he had received from the chairman of the STAR group about "the concern felt by astronomers at the scarcity of optical astronomy in ESRO's programme". The group advocated better communication between the LPAC and the astronomical community and urged that investigations should be started, "for the use of an orbital observatory to take advantage of the work already undertaken [for UVAS]". Strömgren himself, however, acknowledged that "this was an area in which competition was involved", and that the opportunity of a UVAS-type project should be assessed taking into consideration the American programme. According to the LPAC chairman Lüst the problem presented itself in the following terms:

> *The LPAC should demonstrate: a) whether it felt ESRO should have, besides a sounding rocket programme, satellite activity in the UV wavelength range, which would mean that a substantial percentage of the budget should be allocated for this purpose in the future; and b) whether such activity would involve ESRO's starting a medium-sized satellite like UVAS with later modifications. On the other hand, consideration should be given as to whether it would be better to link this type of programme to the space station on the lines that ESRO might build certain equipment, e.g. a telescope, for use on the station.*[699]

That was a matter of scientific policy, of course, which had to confront the financial reality. The latter was presented by Dinkespiler, who provided the meeting with a tentative launching programme of scientific satellites for the second half of the 1970s, on the basis of an envisaged budget of 30-33 MAU per year (Table 8-5). Dinkespiler's table was obviously ecumenical: it showed how it was

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698 The the two Panels' reports were discussed at the following meetings of the ad hoc Working Groups: ION, 28th meeting (26-27 January 1970), ION/84, 17 February 1970; PLA, 16th meeting (6 February 1970), PLA/65, rev. 1, 23 March 1970; STAR, 15th meeting (11 February 1970), STAR/65, 25 February 1970; COS, 24th meeting (19 February 1970), COS/50 [missing in the files]; SUN, 14th meeting (4 February 1970), SUN/40, 23 February 1970; ATM, 16th meeting (12 February 1970), ATM/49, 8 April 1970. The comments of the various groups are reported in ION/83, 23 February 1970; PLA/64, 19 February 1970; STAR/64, 23 February 1970; COS/48, 23 February 1970; SUN/38, 16 February 1970; ATM/48, 19 February 1970.

699 LPAC, 31st meeting (27-28 February 1970), LPAC/73, 3 April 1970, pp. 10 and 11.

possible to include in ESRO's satellite programme all technical options, namely one large satellite project (50 MAU in 5 years), 2 medium sized projects (32 MAU in 4 years), 3 small near-Earth orbiting satellites (9 MAU in 3 years), and 1 highly eccentric orbit satellite (16 MAU in 3 years).

The LPAC's decision went into another direction. Concluding the discussion, in fact, the Committee definitely excluded large satellite projects from the ESRO programme and stated that, "with the presently foreseen budget for scientific spacecraft [...], it would be possible to perform in the five-year period 1975-80 three medium-sized satellite projects and three to five small satellite projects". As regards the contents of the programme, four research fields were to be given primary consideration according to the LPAC, namely:

a. fundamental physics, with some priority given to experiments to test gravitational theories;

b. plasma physics investigations in the magnetosphere and coordinated studies in the surrounding interplanetary medium and in the polar ionosphere by means of GEOS-type, HEOS-type and small near-Earth satellites;

c. high energy astrophysics projects in the X-ray and low energy gamma-ray regions;

d. special cosmic ray studies such as the determination of elemental and isotopic abundance and the measurement of solar neutrons and charged particles.

The LPAC's policy statement, as we see, was consistent with the recommendations of the Geophysics Panel while, regarding the other Panel's controversial issues, it definitely endorsed the arguments of the advocates of high energy astrophysics and cosmic rays. In fact, the most important element in the LPAC's policy statement was that it explicitly excluded stellar UV astronomy and solar high resolution astronomy from ESRO's satellite programme, confining these fields to rocket experiments. In the opinion of the LPAC, "it would be inopportune to launch unmanned satellites at dates so close to those when the [space] station begins to work". Preparation for eventual participation in the NASA manned space station programme was recommended, but the LPAC made it clear that "the funds for a major European participation in the development of the manned space station programme will be provided in addition to the currently foreseen ESRO space science budget". Finally, as regards planetary missions, the LPAC agreed with the Geophysics Panel that ESRO could not compete in this field with the programmes pursued in the USA and USSR. Even in this case, it specified that any eventual participation in a cooperative programme with NASA would require additional resources.[700]

The LPAC decided that its report should not be submitted to the approval of the STC and the Council. It was agreed, however, that the policy statement contained in it should provide, on the one hand, the LPAC with definite guidelines for future discussions and recommendations and, on the other hand, ESRO's Directorate of Programmes and Planning with a general framework for future feasibility studies. These same guidelines, the LPAC stressed, "could be of help to European experimenters in defining the direction of their space activities and might assist in the definition of scientific policies in national space programmes and in particular in the orientation of the work of institutes".[701]

Ten years after the Blue Book, this was the first time that the representatives of the scientific community involved in ESRO programmes had tried to define a clear scientific policy, based on a set of priorities and on the exclusion of some scientific areas and technical options. Even though not

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700 LPAC/80, 22 May 1970, pp. 2 and 4. This is the first draft of the LPAC's Report on future policy for the scientific space programme of ESRO. The first two chapters of this document report on the activity of the Geophysics Panel and the Astrophysics Panel and on the final recommendations of the LPAC. The various research fields are then reviewed in the following chapters. The draft was slightly amended at the 32nd LPAC meeting (15-16 June 1970), LPAC/88, 24 August 1970, and the final report was eventually circulated in June in the form of a booklet.

701 *Ibidem*, p. 3.

formally endorsed by ESRO's governing bodies, this policy did aim at shaping the further development of the scientific programme of the Organisation, with the ambition of establishing guidelines for the whole of European space science. In this respect it is important to remark that in the new organisational framework established after the Bannier Report, the LPAC became an advisory body of the Director General, who eventually reported to the STC. In fact, the LPAC's policy definition made explicit reference to the activity of ESRO's new Directorate for Programmes and Planning (DPP), created in 1968 after the recommendations of the Bannier Report, whose task it was that of "elaborating a long term-policy, and initiating its execution, on the basis of thorough analysis of the past and a sound and wide-ranging knowledge of space activities, programmes and capabilities in Europe and throughout the world". In this capacity, the DPP was the office responsible for the execution of mission definition and feasibility studies and for providing the European space science community with all information about the status and perspectives of the space programmes in the world. It represented the LPAC's immediate interlocutor within ESRO's top management.[702]

Reaching maturity, ESRO could no longer remain a service organisation for any kind of project emerging from competing interests within the scientific community. Thirteen years after the beginning of the space era, the general framework of world-wide space research appeared clearly defined; the European space science community had definitely got over its infancy; and ESRO could now rely on a more predictable, though limited, set of financial, technical and human resources. It was possible and necessary for the Organisation to plan its long-term programme on a more secure base, and the LPAC felt it had to play its part.

If we look at the LPAC's policy statement of February 1970 a few considerations are called for about its most important aspect, i.e. the exclusion of solar and stellar astronomy from the ESRO satellite programme. This was not an obvious or a painless choice. In fact, it mortified one of the most important sectors of the space science community and excluded research fields in which the use of space technology had stimulated a dramatic breakthrough in scientific knowledge. The decision to limit solar and stellar astronomy in the ultraviolet to the sounding rocket programme was actually a political as well as a scientific choice, whose rationality derived from at least three main factors. The first was the consideration of the American effort in these fields. In spite of their great scientific importance, the LPAC felt that a major effort of ESRO in any of them could not be justified since the knowledge obtained would probably not be unique.[703] Rather than committing a substantial fraction of ESRO's limited resources to such fields, the LPAC felt that it was better to foster collaboration with NASA in the space station programme.

The second factor regards the weakness of the astronomical community *vis à vis* the space programmes, what prevented them from working out good projects and lobbying efficiently through ESRO's policymakers. Even considering NASA's activities, in fact, European astronomers could still claim their past experience in designing the LAS and UVAS projects and could certainly advocate the expediency of a European undertaking in stellar astronomy or solar physics. The NASA's space station programme was far from being established on a firm financial and institutional frame and the field was wide enough to allow a niche where important original results could be obtained by a European satellite. ESRO's financial resources did not in fact exclude this possibility while still leaving enough money for other projects, as Dinkespiler's table showed. Most stellar astronomers and solar physicists, however, were mainly interested in the development of ground based facilities and they lacked the scientific culture and technical expertise required for developing important space projects. The few groups interested in space research which had contributed to the first ESRO satellite payloads were

702 The quotation is from ESRO, *General Report 1967*, p. 5. Among the terms of reference of the Director for Programmes and Planning, there was that of providing the secretaries of the STC and the LPAC.

703 This point was made clear in the LPAC's report LPAC/80, 22 May 1970, pp. 17-18.

also engaged in national or multinational projects outside ESRO's programmes and could not viably support a new major undertaking.[704]

Finally, if we are to understand the reasons for a political defeat, we must also look at the winners. These were the two main physicists' communities involved in space research: those interested in the Earth's space environment and those interested in high energy astrophysics, i.e. those who had advocated and benefited from the choice of GEOS and COS-B. The former looked at the magnetosphere as the new frontier of geophysical research, with a large variety of experimental possibilities; the latter were colonising a new and promising field, where experimental techniques borrowed from physical research could be successfully implemented for studies of high energy phenomena in astronomical objects. The COS-B project had provided them with an instrument devoted to high energy gamma rays. Now, just at the time when the LPAC was discussing its policy statement, they worked out a valid suggestion for an X-ray satellite project. It was too late for discussing it in the Astrophysics Panel and the COS Group meetings but still in time to affect the LPAC's decisions. In fact, reporting to the LPAC on the results obtained by the X-ray Mission Definition Group set up in ESRO a few months earlier, the Executive informed the Committee that it seemed possible to carry out localisation of X-ray sources in the arc second range by using the lunar occultation method with an HEOS-A2 type satellite, to be compared with the arc minute accuracy attainable with SAS-A. There was finally a project that could compete on equal footing with the American important programme. Indeed, as soon as she heard this statement, C. Dilworth was ready to underline that "the Astrophysics Panel and COS Group reports would be modified by this information". It is quite evident that the information did affect the LPAC policy statement, as the field of X-ray astronomy was given high priority in spite of the low profile it appeared in the Astrophysics Panel's report. The competition was starting again and the various scientific interests were ready to take sides.[705]

8.3 LPAC's first recommendation on future missions: HELOS and SAS-D (IUE)

In June 1970 the LPAC started to discuss the choice of ESRO's future satellite projects, to follow COS-B and GEOS in the second half of the 1970s. Three mission definition studies had been completed, all fitting within the LPAC's policy statement and devoted respectively to: (a) a space experiment on gravitation theories; (b) an X-ray astronomy satellite; and (c) a series of small standard magnetospheric satellites.[706]

The X-ray astronomy satellite appeared the most promising project. A Mission Definition Group (K. Pounds from Leicester University, R. Rocchia from Saclay, P. Sanford from Imperial College, and J. Collet and R. Pacault from ESRO) had studied the matter, considering only projects not involving very advanced technology such as highly accurate stabilisation, and remaining within the general range of small- or medium-sized projects. After considering the X-ray experiments already envisaged on four other satellites to be launched in the near future (the American SAS-A, the European TD-1, the British UK-5, and the Japanese COSRA), the group concluded that the main aim of a future ESRO mission should be the precise determination of the position and geometric shape of X-ray sources, with an accuracy of a few arc sec. This could be achieved by a lunar occultation method with a spacecraft in a highly eccentric orbit. They envisaged a detector sensitive to photons within the energy

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704 This point has been discussed by Golay (1992) with regards to stellar astronomy and by de Jager (1992) with regards to solar physics.

705 LPAC, 31st meeting (27-28 February 1970), LPAC/73, 3 April 1970, p. 9. This was the first reference to what was to become first the HELOS (High Energy Lunar Occultation Project) project and later on *Exosat*. See also Dilworth (1992).

706 LPAC, 32nd meeting (15-16 June 1970), LPAC/88, 24 August 1970. These studies were presented in LPAC/75, 8 April 1970; LPAC/76, rev. 1, 23 July 1970; and LPAC/77, 25 May 1970; respectively. At the meeting, a study on the possible launching of a second GEOS was also discussed. This option was discarded at the following LPAC meeting, where the three main projects were discussed in detail: LPAC, 33rd meeting (1-2 October 1970), LPAC/92, 23 November 1970.

range 0.3 to 20 keV as the main component of the scientific payload of this satellite, whose orbit would allow the scanning of approximately 30 % of the sky, covering about 40 % of X-ray sources presumably known at the time of launch.

The COS Group had endorsed this project, C. Dilworth reported, and the LPAC also showed considerable interest in it, recommending that a feasibility study should be carried out "with all possible speed". The LPAC also urged that a note on this project should appear in *Nature* and that a survey should be made in order to identify the scientific groups in Europe potentially interested in it. Finally, two other members were recommended in the membership of the Mission Definition Group: J. Bleeker from Leiden University and J. Trumper from the Max-Planck-Institut in Garching. The group could also take advantage of the advice of C. Dilworth.[707] A well-defined and properly timed project, a widespread interest among an influent sector of the scientific community, and a dedicated group of scientists were thus established for the X-ray satellite project, which eventually came to be called HELOS, an acronym for Highly Eccentric Lunar Occultation Satellite. The COS Group, and its chairperson C. Dilworth in particular, felt a sort of moral obligation for supporting the X-ray satellite, after their recommendation of the pure gamma-ray satellite COS-B against the alternative project COS-A, which included both a gamma-ray and an X-ray experiment.[708] As regards the two other studies, the space experiment on gravitation theories and the small magnetospheric satellites, the former was certainly the more interesting from the scientific point of view (it aimed at testing a fundamental physical law) and the more challenging from the technical point of view (it required the development of a heliocentric probe, with an extremely accurate clock and a very sensitive accelerometer on board). It was clear, however, that the realisation of such a mission required a good deal of advanced scientific and technical studies, and the LPAC recommended keeping on this studying and looking into NASA's possible interest in collaborating on such a project.

Finally, as could be expected, the launching of small standardised satellites for magnetospheric studies was advocated by the ION Group, which stressed the widespread interest in this project among European scientific groups, as well as the possibility of relating the small satellite programme to the GEOS mission.[709] Two types of mission were considered, one based on the use of highly eccentric orbit satellites and the other on satellites in circular orbits in the altitude region between 300 and 3000 km. In the first case, three groups of scientific objectives were suggested: studies of the polar region at high altitude, studies of magnetospheric dynamics, and studies of plasma physics. In the second case, two satellites should operate at the same time, with experiments aiming at high latitude studies of the coupling between the magnetosphere and the ionosphere.

In the event, the LPAC was called to discuss one more project, namely the offer by NASA to have ESRO's collaboration in the development of SAS-D, a space telescope for UV astronomy scheduled for launching in 1974/75. This was an adaptation of the UVAS package to an Explorer-type satellite injected into a geosynchronous orbit. The project, in fact, was to be realised by a collaboration between NASA and the UK group which had designed both the LAS and UVAS. Possible participation of ESRO was envisaged in the provision of a ground station to monitor the satellite on this side of the Atlantic and/or in the development of some sub-system of the satellite. For a total cost of no more than 2 to 4 MAU, the European astronomical community would have been offered observational time of the order of one third of the total observational time. This possibility, LPAC member B. Strömgren reported, generated "enthusiasm (...) among scientists who are worried about the future of UV astronomy in Europe". In their opinion, Strömgren added, "the proposed astronomical rocket experiments would not be sufficient if one wanted to prepare for the phase when European

707 Collet et al. (1970). COS Group, 25th meeting (5 June 1970), COS/53 [missing in the files].

708 See chapter 7. When recommending COS-B against COS-A, in March 1969, the COS Group had urged that a satellite project devoted solely to X-ray astronomy should be studied by ESRO.

709 ION Group, 28th meeting, (26/27/70), ION/84, 17 February 1970; 29th meeting (5 June 1970), ION/90, 26 October 1970. The interest of the scientific community was documented in ION/81, 9 January 1970 and add. 1, 13 January 1970.

experimenters would have access to the post-Apollo Programme", and the participation in the SAS-D programme would satisfy just such a need. The LPAC accepted the plea: it expressed its great interest in the project and urged ESRO to further investigate the possibility of cooperating with NASA in the SAS-D project. The Committee was aware, of course, that this could appear to be in contradiction with its own policy statement; therefore it stressed that this policy did not exclude but rather hoped for a financially feasible involvement in UV astronomy in preparation for eventual participation in the manned space station programme.[710]

The time of decision came at the end of April 1971, when the feasibility studies for the various projects were available to the LAPC. The main question regarded the choice between the magnetospheric project and the X-ray astronomy project HELOS. Whatever the choice made between them, it was possible in addition to undertake a smaller project to be selected between participation in the SAS-D project and the establishment of a study and laboratory programme to prepare a space experiment on gravitation theories.[711]

Three different options had been studied for the magnetospheric project: a highly eccentric magnetospheric satellite (HEMS), to be launched by the ELDO *Europa II* rocket or the NASA *Thor Delta* vehicle, and two near Earth magnetospheric satellites (NEMS), to be launched by the French *Diamant-C* and the British *Black Arrow* respectively. Reporting on the recommendations of the ION group, its chairman J.W. King explained that a series of satellites would not be necessary to achieve the scientific aims and emphasise rather the need to have correlated measurements from another satellite at the time of GEOS as part of the International Magnetospheric Study. According to the ION Group, first priority had to be given to the HEMS project while the NEMS projects should be considered as second choice.[712]

The ION group's support to the magnetospheric project was not coupled with that of the COS Group. On the contrary, the latter criticised the lack of clear scientific aims in the proposed magnetospheric missions. Not surprisingly, the group strongly recommended the X-ray mission, which they considered "an important and advanced tool in X-ray astronomy, with possible future application in the low energy gamma ray field".[713]

The strength of HELOS derived from two main factors, one scientific and one institutional. From the scientific point of view, the project had the advantage of the lunar occultation method, which allowed the precise determination of the position of X-ray sources and the measurement of their fine structure and angular dimensions with high accuracy. This was a very important characteristic, since the launching of the satellite was planned after that of SAS-A, which was to produce the first large scale survey of the X-ray sky, and before the launching of the first High Energy Astrophysics Observatory (HEAO), a family of second generation satellites for X-ray astronomy whose pointing accuracy, however, was expected to be one order of magnitude lower than that of HELOS.

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710 LPAC, 33rd meeting (1-2 October 1970), LPAC/92, 23 November 1970, p. 10. Information on the possible ESRO participation in the SAS-D programme was presented in ESRO/C/480, 23 November 1970.

711 LPAC, 36th meeting (28-29 April 1971), LPAC/110, 30 August 1971. This document is divided into two parts with different page numbering., The first reports on the open meeting, attended by the chairmen of the working groups; the second reports on the restricted meeting, with only LPAC members, the chairman of the STC (Lüst) and a limited ESRO staff. The result of feasibility studies were presented in LPAC/103, 16 April 1971 (near Earth magnetospheric satellites), LPAC/104, 16 April 1971 (highly eccentric magnetospheric satellites), LPAC/105, 2 April 1971 (HELOS), LPAC/108, 26 April 1971 (SAS-D), and LPAC/109, 21 April 1971 (gravitation theories).

712 ION Group, 31st meeting (29 March 1971), ION/103, 6 April 1971. In addition to these three projects, a feasiblity study had also been carried out on a smaller near Earth satellite to be launched by the less powerful Diamant B launcher. The ION group, however, considered that this option would not be able to fulfil the envisaged scientific objectives.

713 COS Group, 28th meeting (26-27 April 1971), COS/60, 11 June 1971, p. 13.

As regards the institutional aspects, HELOS was an observatory-type satellite like COS-B but with one significant difference with respect to the latter, i.e. that ESRO would be responsible for funding both the spacecraft and the scientific package. HELOS was thus to be the first ESRO project for which the Organisation would bear the financial cost of the experiment. The satellite would become a real observatory-like facility, which meant that the whole European scientific community working in X-ray astronomy would be interested in its performance, would be involved in its scientific management, and would have access to its data. If HELOS was approved, ESRO's J. Ortner pointed out, "it was intended to expand the Mission Definition Group to include representatives of all institutes actively engaged in X-ray astronomy, in order to define the scientific payload in the best possible way".[714] In conclusion, while the magnetospheric project still placed itself in the early tradition of ESRO's satellites - a loose scientific mission in a well-established research field, to be fulfilled by a collection of experiments provided by different laboratories - HELOS was definitely in the new tradition inaugurated by COS-B - a space observatory in a new and dynamic exploratory field, requiring the unitary effort of an important sector of the space science community.

Last but not least, it must be recalled that behind HELOS there was the support of the same coalition which had determined the success of COS-B (Occhialini's Milan group with Dilworth, Lüst's Munich group with Trumper, van de Hulst's Leiden group with Bleeker), with two important additions: ESTEC's Space Science Department, where the involvement in COS-B had produced the establishment of a lively research programme in high energy astrophysics, and the British X-ray group at Leicester University (K. Pounds), which had lost the possibility of flying its X-ray instrument in COS-A and now wanted to seize the new opportunity.

If the alternative between the magnetospheric project and the HELOS project required the most important choice, another decision had to be taken by the LPAC, i.e. whether to recommend ESRO's cooperation in the NASA/UK SAS-D project or to recommend a laboratory research programme to prepare a space experiment on gravitation theories. Regarding the former, the suggested form of cooperation was the development by ESRO of a ground station in Europe, including a set of antennae and a dedicated computer, at an estimated cost of around 3 MAU. This solution would give European astronomers full scientific control of the observational time allocated to them, namely some 40 per cent of the total equally shared between ESRO and the UK. As regards the space experiment on gravitation theories, studies carried out in industry and scientific institutes had confirmed "the real gain one could expect from a complex space experiment entirely and exclusively devoted to tests of gravitation theories".[715] The proposed mission foresaw the use of a spacecraft in heliocentric orbit to measure the coefficients of the space-time tensor with the highest accuracy possible. Owing to the great technical complexity of the project, a vigorous programme of laboratory research was required in order to demonstrate its feasibility and to permit assessment of its cost.

ESRO's involvement in the SAS-D project was strongly recommended by the STAR group, represented at the LPAC meeting by its chairman, L. Houziaux, who was also ESRO's representative in the SAS-D Working Group. According to the STAR Group, ESRO's participation in the SAS-D project represented "a unique opportunity to satisfy the European UV community at a very attractive cost". The group's resolution then concluded on a note of victimisation:

> *Rejection of the offer by NASA would deprive the European astronomical community of the immeasurable benefits from the large capabilities offered by SAS-D. With the TD-1 instruments being the only sources of astrophysical information from satellites, the European community would be placed at a major disadvantage with regard to its*

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714 LPAC/110, cit., p. 7. This aspect of the HELOS mission was emphasised at the COS Group meeting which recommended it. The LPAC had discussed at length the financing of scientific experiments for ESRO satellites at its 33rd meeting (1-2 October 1970), LPAC/92, 23 November 1970, and it had agreed that, for large projects, consisting of one or two large experiments, there would be a great advantage if ESRO funded the scientific payload.

715 LPAC/109, cit., 21 April 1971, p. 3.

American counterpart. [...] It is felt that the expenditure required for participation in the SAS-D project is not excessive in respect of what has been requested for, and given to, astronomy.[716]

It was eventually the task of the restricted meeting of the LPAC to issue a final recommendation about the selection of ESRO's next scientific satellite projects. Not surprisingly these were HELOS and SAS-D. Even though the minutes of the meeting do not report any explicit reason for the choice of HELOS, these can be easily inferred from what has been said before. We can just recall four main aspects: (a) it was a well designed project, with a clear scientific objective and with strong support from an influential sector of the scientific community involved in ESRO's programmes; (b) it allowed European scientists to play a significant role in the promising field of X-ray astronomy even in the face of NASA's important effort; (c) following COS-B, it gave coherence to ESRO's scientific programme in the field of high energy astrophysics; (d) it would be the first truly ESRO satellite.

The choice of HELOS excluded, for financial reasons, the possibility of adopting the magnetospheric project recommended by the ION group, but it did allow ESRO's participation in the SAS-D programme. The LPAC recognised the great rewards in observation time for European astronomers that would be obtained by this participation and strongly recommended it. No decision, on the contrary, was taken on the laboratory programme for the space experiment on the gravitation theories, pending the views to be expressed by the newly established Fundamental Physics Panel.

8.3.1 IUE adopted in the ESRO programme

In the event, owing to the political difficulties described in the following section, only the possible participation in the SAS-D project was put forward to the STC. It was easily approved and the STC also recommended that, besides providing a ground station at a cost of about 3 MAU, ESRO should also contribute to the spacecraft hardware up to a maximum of 1 MAU.[717] In July 1971 the Council finally approved this recommendation and the project was then called International Ultraviolet Explorer (IUE). We can notice a sort of irony in the circumstance that the first new ESRO project approved after the LPAC's policy statement was in fact in a field that had been excluded in that very statement.[718] The IUE satellite was launched in January 1978 into a geosynchronous orbit and, after commissioning, it was operated for 8 hours each day from ESA's Villafranca station, near Madrid, from which European astronomers could carry out their observations just as in the case of a ground observatory.

8.4 The 1971 crisis and the "first package deal"

Notwithstanding the LPAC's discussions and recommendations there was no question for ESRO deciding on the start of a new major satellite project in the spring of 1971. In November 1970, in fact, the latent crisis which afflicted European cooperation in space had erupted dramatically at the fourth session of the European Space Conference (ESC). On that occasion, ESRO's *General Report* informs us, "the disunity between the countries favouring a 'coherent policy' including an independent European launcher effort and the others reached such a magnitude that the meeting broke up".[719] As a consequence, all plans for a unified European space organisation that for two years had dominated

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716 LPAC/110, cit., p. 10. STAR, 27th meeting (27 April 1971), STAR/72 [missing in the files].

717 STC, 28th meeting (18 May 1971), ESRO/ST/MIN/28, 30 June 1971. See also ESRO/ST(71)9, 12 May 1971 and ESRO/ST(71)10, 7 May 1971. The STC's endorsement was taken with the sole abstention of Spain, who pressed to have the ESRO tracking station for GEOS and SAS-D in her territory. Eventually, the ground station was built at Villafranca, near Madrid, and ESA also contributed the deployable solar-cell array of the spacecraft.

718 Council, 43rd session (13-14 July 1971), ESRO/C/MIN/43, 14 December 1972. Information to the Council was provided in ESRO/C(71)34, 2 July 1971. The IUE project is described in *ESRO/ELDO Bulletin*, 18 (May 1972), pp. 13-17.

719 ESRO, *General Report 1970*, p. 9. More on the ESC crisis in chapter 10.

discussions receded dramatically and the very future of Europe collaboration in space appeared rather grim. Denmark and France went as far as to denounce the ESRO Convention in order not to incur financial obligations extending beyond the first eight-year period. Given this situation, it was impossible for the Organisation to embark on a new programme and even the projects under development had to be delayed.

Facing the failure of the ESC meeting, ESRO Member States agreed that their delegations to the Council should negotiate further among themselves, leaving aside the problems which had led the ESC to deadlock. In spite of some difficulties and setbacks, ESRO had proved to be sufficiently reliable and successful in its work; it had acquired maturity and competence in managing industrial contracts; and it had established a firm basis for the development of application satellites, which increasingly appeared to be the true political and economic rationale for European co-operation in space.[720] The new Chairman of the ESRO Council, the Italian physicist Giampiero Puppi, former Chairman of the ESC's Committee of Senior Officials, was given the task of negotiating a proper compromise in order to drive the Organisation, as smoothly as possible, to its new role in the application field and, at the same time, to offer European space policymakers a new ground for negotiations. After one full year of intense negotiations, the compromise was worked out and it became known as the "First Package Deal".[721] The main aspect of the 1971 package deal is that ESRO definitely abandoned its role as an Organisation solely devoted to scientific research and undertook application satellite programmes on telecommunications, aeronautical communications, and meteorology. The dramatic rise of importance of these application programmes can be appreciated if one considers that for the years 1972, 1973 and 1974 they were to be provided for at an overall cost of 22.8 MAU, 48.5 MAU and 63.4 MAU respectively, eventually reaching an annual level of resources of not less than 70 MAU in the period 1975-1980. In comparison, the budget for the scientific satellite programme for 1972, 1973 and 1974 was fixed at 41.7 MAU, 36.0 MAU, and 31.7 MAU respectively, eventually reaching a minimum level of 27 MAU in the years 1975-1977 (Figure 8-1).[722] As a consequence of this re-orientation, the Council decided to eliminate the sounding rocket programme and to terminate the scientific activities in ESRIN by 1973. The Kiruna launching range (ESRANGE) was taken over by Sweden under an appropriate protocol while, in order to smooth Italian protests, it was eventually decided that ESRIN should become the new seat of the Documentation Service.[723] Further economies were effected in the scientific programme by postponing the start of the development contracts for the COS-B and GEOS projects, by deferring new projects, and by limiting future scientific satellites launchings to one about every two years.

The 1971 package deal marked "the beginning of a new period in the life of ESRO".[724] The Organisation was definitely transformed into a space agency mainly devoted to application satellites with only a minor fraction of its jobs and funds devoted to science. During the laborious negotiations which led to the compromise, "the whole scientific programme was put in some doubt", the chairman of the STC reported.[725] In the first draft of Puppi's package deal, in fact, it was suggested that the scientific programme should be made optional from 1974, a position strongly supported by France, and only with a drastic reduction of funds had it been finally agreed to keep it mandatory. The sum of 27 MAU, however, fell quite short of scientists' expectations. In fact, in the hottest phase of negotiations, both the STC and the LPAC had approved a statement in which, on the basis of some

720 "Statement by the Director General" at the 35th session of Council (22 December 1970), ESRO/C/483, 18 December 1970.

721 Council, 44th session (20 December 1971), ESRO/C/MIN/44, 6 January 1972. The Council resolution with the agreed on "package deal" is reported in *ESRO General Report 1971*, p. 129-132, and in *ESRO/ELDO Bulletin*, 17, (February 1972), p. 6-11.

722 The figures are taken from G. Puppi's and A. Hocker's comments to the Council resolution of December 1971, *ESRO/ELDO Bulletin*, 17 (February 1972), pp. 11-14 and 14-19. The institutional aspects of the first package deal will be discussed in detail in Chapter 11.

723 ESRIN, the ESRO Space Research Institute, was located in Frascati, near Rome (see chapter 2).

724 *ESRO General Report 1971*, p. 9.

725 STC, 28th meeting (18 May 1971), ESRO/ST/MIN/28, 30 June 1971, p. 2.

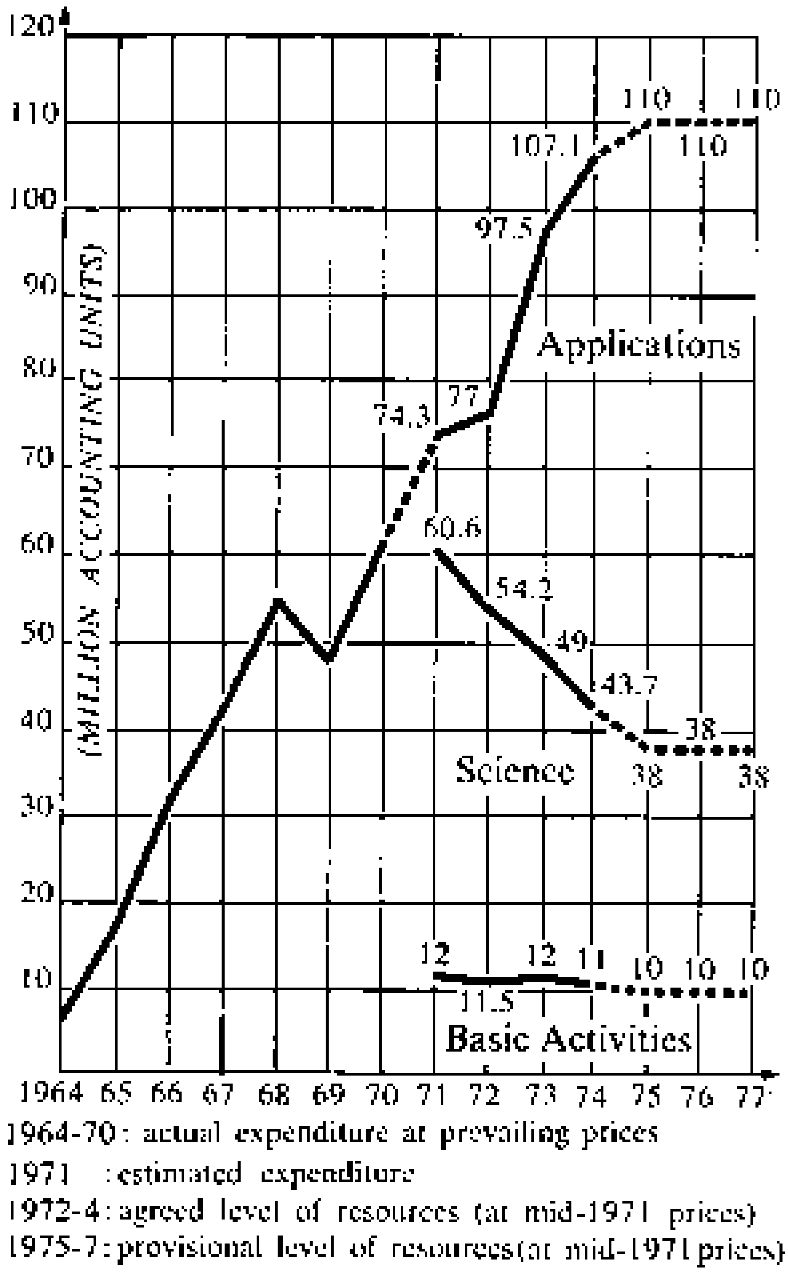

Figure 8-1: Distribution of Financial Resources between Science, Applications and Basic Activities agreed by the ESRO Council in December 1972
(ESRO/ELDO Bulletin, No 17, February 1972, p. 15)

statistics on the number of scientific groups active in space research in Europe, they argued that ESRO should launch one medium-sized satellite per year. The statement concluded that "the minimum level of funding required for a truly viable scientific satellite programme lies between 43 and 47 MAU".[726] It is against this background that we shall consider the further evolution of discussions and decisions about ESRO's scientific satellite programme.

8.5 Choosing ESRO's new satellite projects

8.5.1 The new structure of the expert Working Groups

Following the policy statement of February 1970, the LPAC considered whether the structure of the existing ad hoc Working Groups should not streamlined towards the research fields recommended for the future ESRO satellite programme.[727] Three aspects had to be considered. The first regarded the evolution of the scientific fields involved in space research. The existing ION group, for example, was no longer interested only in "ionospheric and auroral phenomena" but had in fact taken over responsibility for a much wider domain, covering the whole of solar-terrestrial phenomena (magnetosphere, solar wind and interplanetary medium). Similarly, the COS Group, whose original terms of reference included "cosmic rays and trapped radiation", no longer had members representing radiation belt physics and its main interest was now not in cosmic rays but in high energy astrophysics. The second aspect regarded the evolution of ESRO's scientific policy, after the LPAC's policy statement. It appeared, for example, that the work load of the PLA and ATM groups would not be very large in the future, while some merging of the SUN and STAR groups seemed advisable to cover the field of astronomy and low energy astrophysics. At the same time, because of the emphasis laid on the importance of fundamental physics studies, a new Working Group on this subject was recommended. The third aspect regarded the delicate issue of the relationship between ESRO and its customers, i.e. the European space scientists. A reduction in the number of scientific groups implied in fact that fewer scientists would be involved in discussions about ESRO's scientific programme, thus reducing goodwill and support for ESRO in the Member States. In other words, the role of the Working Groups was to be viewed from two different angles: (a) obtaining the best advice on scientific matters within the framework of ESRO's overall policy; (b) keeping the European space science community together.

The LPAC eventually decided to postpone a decision on the change in the structure of the existing Working Groups, pending the conclusion of Puppi's negotiations on the first package deal. The Committee, however, did agree to set up a Fundamental Physics Panel (FFP) under the chairmanship of H. Bondi.[728] The issue was taken over again by the LPAC in September 1971, following a solicitation by the STC.[729] By that time fresh information was available about the proposed reduction in the budget of the scientific satellite programme and the elimination of the sounding rocket programme. As a consequence, the Committee agreed that the FFP should remain as an advisory body of the LPAC and that two new Working Groups should replace the existing six: a Solar System Working Group (SSWG) to cover solar physics, geophysics, solar-terrestrial relations and planetary science; and an Astrophysics Working Groups (AWG) to cover stellar astronomy, X- and gamma-ray astronomy and cosmic rays. Each Working Group would have approximately 15 members, to be elected by the LPAC with a gradual build-up and serving for a period of 3 years. All fields of space research were thus formally maintained in the working group structure; this however was made much more coarse-grained and the number of scientists involved was reduced by roughly 50 %. It is important to remark that solar physics was included in the terms of reference of the Solar System

[726] LPAC, 36th meeting (28-29 April 1971), LPAC/110, cit., p. 2-3 of the restricted session; STC, 28th meeting (18 May 1971), ESRO/ST/MIN/28, 30 June 1971, Annex 1; also in ESRO/ST(71)10, 7 May 1971, p. 2-3.

[727] LPAC, 33rd meeting (1-2 October 1970), LPAC/92, 23 November 1970. Relevant documents on this issue are LPAC/95, 25 November 1970, and ESRO/ST(72)8, 11 January 1972.

[728] LPAC, 34th meeting (10-11 December 1970), LPAC/96, 15 January 1971; 36th meeting (28-29 April 1971), LPAC/110, 30 August 1971.

[729] LPAC, 37th meeting (28-29 September 1971), LPAC/119, 15 November 1971; STC, 28th meeting (18 May 1971), ESRO/ST/MIN/28, 30 June 1971.

Working Group, thus stressing its relevance to solar wind phenomena in the interplanetary space and to solar-terrestrial relations rather than to astrophysics.

The chairmen and vice-chairmen of the groups were to be approved by the STC after nomination by the LPAC. Eventually, G. Haerendel, from the Max-Plank-Institut für Extraterrestrische Physik in Garching, was nominated Chairman of the SSWG, and C. de Jager, from the Utrecht Observatory, was nominated Chairman of the AWG. A. Dollfus (Paris-Meudon Observatory) and L. Scarsi (University of Palermo) were their respective deputies. The new structure came into effect on 1 February 1972, at which time the existing Working Groups were disbanded (Table 8-6).[730]

8.5.2 The selection of ISEE-2 and Exosat

The agreement reached in the ESRO Council at the time of the first package deal foresaw that the development contract for the next scientific satellite project should start not later than January 1975, which implied that a decision had to be taken in 1973. In the course of 1972, three projects were studied in detail by the Directorate of Programmes and Planning. The first was the HELOS project, under study since two years and already recommended by the LPAC. Further studies demonstrated that the spacecraft's pointing system, designed to achieve good lunar occultation of sources, also assured the possibility of making observations in any celestial direction. Moreover, the satellite's design made it possible to study temporal variations in the intensity of X-ray emissions from discrete sources in a range between a few tens of microseconds and a few tens of hours. The conception and objectives of the HELOS mission were discussed in a colloquium organised at ESRIN in May 1972 and by the end of the year the scientific objectives and model payload of the satellite had been fully defined.[731]

The two other projects involved cooperation with NASA, more and more a necessity for ESRO after the reduction of the scientific programme budget. The first project envisaged the launch of two satellites into adjacent orbits for the study of small scale spatial and temporal variation in magnetospheric plasma and solar wind. This project, originally called IMP-K/K' and then renamed IMP-M/D (Ionospheric and Magnetospheric Physics - Mother/Daughter), had been discussed for the first time during a joint ESRO/NASA programme review meeting held in Washington in early February 1971.[732] Subsequently, following further discussions between ESRO and NASA and a preliminary study of an ESRO Mission Definition Group, the COS and the ION groups jointly agreed to recommend that ESRO should undertake the project with NASA by supplying the "daughter" satellite, and the LPAC requested a feasibility study.[733] The two space organisations eventually defined a selection procedure for the payloads of both satellites, which foresaw the possibility that American experiments might be included in the European satellite and *vice versa.* This was an important innovation for ESRO, whose satellite payloads had been reserved till then to European scientists. Another important aspect of the agreement was that, following the usual NASA procedure but contrary to ESRO's standard procedure, an announcement of flight opportunity, based on the mission definition, would be sent out and experiment proposals discussed *before* the mission was actually approved.[734] The IMP-M/D project was then discussed in May 1972 at a colloquium in ESRIN and, by

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730 LPAC, 38th meeting (9 November 1971), LPAC/122, 20 December 1971; STC, 30th meeting (25 January 1972), ESRO/ST/MIN/30, 17 February 1972.

731 *ESRO General Report 1972*, pp. 106-107. The proceedings of the symposium are in ESRO (1972).

732 The report of this meeting (1-2 February 1971) is LPAC/107, 17 March 1971.

733 LPAC, 37th meeting (28-29 September 1971), LPAC/119, 15 November 1971. The report of the joint COS/ION meeting (14 September 1971) is ION/108, 2 November 1971 and the resolution passed at the meeting is in ION/106-COS/62, 15 September 1971. In this resolution, it was made clear that the inclusion of the project in the ESRO programme was recommended with the provision that " the missions already approved by the LPAC are not jeopardised". This reflected the COS Group's concern that the IMP-M/D project might compete with HELOS: COS Group, 29th meeting (14 September 1971), COS/63, 3 November 1971. Document MS/282, 15 September 1971, is a presentation of the project at this stage.

734 LPAC, 38th meeting (9 November 1971), LPAC/122, 20 December 1971; STC, 30th meeting (25 January 1972), ESRO/ST/MIN/30, 17 February 1972. The terms of the agreement are described in LPAC/120, 2 November 1971 and in ESRO/ST(25), 29 November 1971.

the end of the year, the selection procedure had been completed and the payloads of both satellites definitely approved.[735]

The last project was a spacecraft to be injected into an orbit around the planet Venus. Preliminary studies on a possible low-cost mission to Venus had already been made by ESRO in 1971, compatibly with the LPAC policy statement which excluded planetary exploration for budgetary reasons, but did allow for re-consideration of this issue should a significant cost reduction prove possible.[736] The envisaged solution was a Venus orbiter based on a spacecraft whose size and cost would be of the order of that of GEOS. Subsequently, following a joint ESRO/NASA meeting on future co-operation in space science, held in Washington on 18 April 1972, it was decided to link this project to NASA's Pioneer Venus programme. The project foresaw that NASA should provide the basic spacecraft (the so-called "space bus"); ESRO would then transform it into an orbiter by the addition of a suitable motor and would be responsible for the integration of the scientific payload and the testing of the satellite; finally, the spacecraft would be delivered to NASA for launching on a Thor Delta vehicle. A joint ESRO/NASA committee eventually worked out the scientific objectives of the mission and defined a model payload.[737]

When the LPAC was finally called to issue its recommendation on the choice of ESRO's new satellite projects, the scientific importance of the event could not be underestimated. It came as much as four years after the choice of COS-B and GEOS, and from that time onwards the aims and scopes of the Organisation in the wider context of European space activities had undergone significant changes, of which the dramatic reduction of the scientific budget was certainly not the least important. It was clear that the new decision would have a major impact on the overall development of space research in Europe, on the relationship between ESRO and NASA, and on the public image of ESRO's undertakings. In fact, the event was given all the official prominence it deserved. The three projects were first discussed in a two-day symposium, held at ESRIN on 26-27 February 1973, attended by about a hundred scientists from all over Europe. The symposium was then followed, on 28 February, by meetings of the Astrophysics and Solar System Working Groups and of the Fundamental Physics Panel, whose conclusions were reported to the LPAC. Finally, on 28 February and 1-2 March, the LPAC itself held its meeting and, in a restricted session, issued its final recommendation to the Scientific Programme Board (SPB), the body that had replaced the STC in the new organisational structure of ESRO which took into account its involvement in application satellite programmes.[738]

As usual in the case of major LPAC's decisions, the choice involved scientific, financial and political aspects. Each of the three projects under discussion was recognised as being "fully worthy of adoption

735 The agreed payload composition of both satellites was presented in LPAC/147 + addendum, 13 December 1972, and it was approved by the LPAC at its 44th meeting (15 December 1972), LPAC(73)2, 23 January 1973. Besides the two IMP-M/D satellites, a third ("heliocentric") NASA-built spacecraft was contemplated, with correlated experiments on the solar wind undisturbed by the presence of the Earth. Some of the instruments of this spacecraft were also to be provided by European scientific groups.

736 A mission definition study for a low cost Venus orbiter was requested by the PLA group after the LPAC's policy statement: PLA, 18th meeting (2 July 1970), PLA/69, 18 August 1970; 19th meeting (25 September 1970), PLA/71, 20 November 1970.

737 The report on the ESRO/NASA meeting, prepared by LPAC's chairman J. Geiss, is in LPAC/127, 9 May 1972. The project was then discussed at the second meeting of the Solar System Working Group (15 May 1972), SOL/4, 21 August 1972, and a feasibility study was requested by the LPAC at its 40th meeting (16 May 1972), LPAC/128, 23 June 1972.

738 LPAC, 46th meeting (28/2-2 March 1973), LPAC(73)11, 21 March 1973. The three projects were described in ESRO/PB-S(73)2, 13 March 1973 (Venus Orbiter); ESRO/PB-S(73)3, 9 March 1973 (HELOS); and ESRO/PB-S(73)4, 9 March 1973 (IMP-M/D). The programme of the Frascati symposium is in LPAC(73)8, 24 January 1973, and its attendance is in MS(73)10, 14 March 1973. The conclusions of the AWG, SSWG and FPP are attached to the minutes of the LPAC meeting, together with the LPAC's recommendation to the SPB. The latter was eventually presented to the SPB in ESRO/PB-S(73)1, 8 March 1973. It must be remarked that the minutes of the LPAC meeting do not report at all on the discussion which led to the conclusion presented in this document.

by ESRO". Financial limitations, however, made it impossible to recommend simultaneous adoption of all three because this would have unduly delayed the date of the next decision for another four years. By appropriate phasing, however, it was possible for ESRO to realise two projects, the first to be started in 1974 and the second in a later year. Therefore, the first problem the LPAC had to confront was whether to recommend simultaneous adoption of both or to choose one now and delay the decision on the second project to some later time. The issue was debated at length and eventually it was agreed that two projects ought to be adopted contextually, the main reason being that ESRO should remove all uncertainty about its future plans and "leave no doubt in the minds of national authorities and of the scientific community of its determination to carry out a good scientific programme". Moreover, by adopting two projects the interest of potential experimenters in the second project would be fully retained, giving them ample preparation time to optimise the scientific package. In the opinion of the LPAC, all these aspects compensated the disadvantage deriving from the frustration of many other scientists who would be "painfully aware that three years will elapse before they get another chance on a European space vehicle".[739]

Then came the problem of which two projects out of the three on the table should be recommended for adoption, a choice that involved at least three different considerations. The first regarded of course a comparison between the three projects from the viewpoint of their scientific interest and the degree of support they received from the scientific community. From this point of view HELOS was certainly the best placed. This was in fact a satellite based on an original concept proposed by European teams, whose scientific mission pertained to a new and dynamic research field, and that had been under study since a long time. The project had been already recommended by the LPAC two years earlier and had been strongly recommended now by the Astrophysics Working Group. The Fundamental Physics Panel had also given it top priority, on the motivation that "it will help to answer questions of fundamental significance in gravitation and cosmology as well as many problems of astrophysical importance".[740]

The other two projects pertained to the interests of the Solar System Working Group. This had concluded that they were both scientifically valuable and that "a grouping together of the two projects would constitute a balanced programme and serve a wide section of the scientific community".[741] The Group carefully avoided to award priority to either of them. This was in fact a very delicate issue. On the one hand, participation in the IMP-M/D project was consistent with the LPAC's policy statement and would usefully complement the GEOS mission, thus meeting the interests of a sector of the European space science community that had a leading role in the development of ESRO's scientific programme. On the other hand, the Venus Orbiter would provide ESRO and European scientists with a unique opportunity to enter the fascinating field of planetary exploration at low cost. According to the Working Group, the number of scientific groups eventually involved in the project was estimated to be no less than 25 and the Venus mission would foster new lines of research by bringing diverse disciplines together.

The second consideration regarded ESRO's relationship with NASA, a complex relationship that involved both partnership in joint projects and "friendly competition".[742] While HELOS was a pure ESRO project, both the Venus Orbiter and the IMP-M/D mission were cooperative projects and, in fact, this was the first time the two agencies were due to be involved in such an important collaboration. The status of the two projects on the other side of the Atlantic was different, however. The IMP-M/D mission had already been approved by the top NASA management and by the President's Office for Management and Budget, and it was on the way to obtaining congressional approval for starting in 1975. Moreover, payloads for both satellites and for the associated NASA's

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739 ESRO/PB-S(73)1, cit., pp. 2-3. This document (as well as the minutes of the LPAC meeting) inform us that this was a "majority opinion" in the LPAC but it is silent about the actual position of individual LPAC members.

740 LPAC(73)11, cit., Annex V.

741 LPAC(73)11, cit., p. 4.

742 ESRO/PB-S(73)1, cit., p. 5.

heliocentric spacecraft had already been decided by a joint ESRO/NASA screening procedure. Therefore, if ESRO approved its part of the project (i.e. the "daughter" satellite), there was very little risk that it might be cancelled by U.S. authorities at a later date. The situation was different for the Venus Probe. ESRO, in fact, had received word from NASA that, because of its tight budget situation, this project could not start in 1974 and it was still uncertain whether it could be included as a new start in 1975. A positive decision by ESRO could affect the eventual course of action in the US, but the risk was not negligible that the project might be cancelled in the future, as a consequence of negative decisions in the United States.

Finally, the third consideration involved the question of timing, as ESRO was due to start its new satellite project in 1974. The Venus Orbiter, even if adopted, could not start so soon, pending NASA's final decision, and therefore the first project had to be either HELOS or the daughter satellite in the IMP-M/D project. If the former was adopted, its cost development would prevent the start of a second project before 1976 and, as a consequence, ESRO participation in the IMP-M/D project would become incompatible with NASA's timetable. If, on the contrary, the latter was adopted, it would still be possible to undertake the second project (HELOS or the Venus Orbiter) one year later.

In this situation, the LPAC decided to recommend the programme which appeared less risky from the point of view of its actual feasibility and the more consistent with its three-year-old policy statement. It agreed to recommend that ESRO should adopt the IMP-daughter spacecraft and HELOS, the former starting in 1974 and scheduled for launch in 1977, the latter starting in 1975 and scheduled for launch in 1979. The LPAC's recommendation, endorsed by ESRO's Director General, was approved by the SPB and finally, in April, the Council approved the adoption of the two projects in the ESRO programme.[743] They were eventually renamed ISEE-2 and Exosat.[744]

Two considerations are called for regarding this conclusion. The first concerns the LPAC's decision to recommend the contextual adoption of two projects, although only one could actually start in the near future. Considering what we have said about the timing and the status of ESRO/NASA collaboration, this decision was not innocent as regards the choice of which projects had to be selected. If, in fact, only one project had been adopted, this could have been either HELOS or the IMP-daughter satellite, and in both case the Venus Orbiter would have been in a more favourable condition at the time of decision on the second project. We can venture to say that the wish of the majority of the European space science community to realise both its pet projects played an important role in a decision which took advantage of the weakness of the Venus Orbiter in early 1973 and bound the long-term ESRO programme. This circumstance emerged when the LPAC's recommendation was submitted to the SPB for approval. Here the French delegation, supported by the Belgian, expressed reservations on HELOS and strongly advocated the Venus Orbiter. They insisted that there was no need to take an immediate decision on HELOS and proposed instead that, after the adoption of the IMP-daughter satellite, tender actions should be carried out among the scientific community, in order to assess the real degree of interest in HELOS and the Venus Orbiter in Europe before the choice of the second project. A vote was then taken on the French proposal to postpone a decision on HELOS and it was rejected by 5

743 SPB, 3rd meeting (27 March 1973), ESRO/PB-S/MIN/3, 11 April 1973; Council, 56th session (11-12 April 1973), ESRO/C/MIN/56, 3 May 1973. The financial implications of this decision were presented in ESRO/PB-S(73)7, 14 March 1973. According to the revised ESRO Convention, the SPB would have the power to take final decisions on the scientific programme. As the new Convention was not yet in force, however, the decision taken by the Board was eventually submitted to Council for confirmation: ESRO/C(73)18, 29 March 1973. At the Council meeting, the funding by ESRO of the HELOS payload was a matter of some controversy. Eventually, on this specific aspect, Belgium and Spain voted against and France abstained.

744 The acronym ISEE stands for *International Sun-Earth Explorer*. ISEE-1 and ISEE-2 (the former IMP "mother" and "daughter" satellites) were launched in tandem in October 1977; ISEE-3 (the IMP "heliocentric" satellite) was launched in August 1978. The launch of Exosat had to be delayed until as late as June 1983. A description of the ISEE mission at the time of its launch is in Durney (1978) and Eaton (1978). For Exosat, see Altmann et al. (1982) and Taylor et al. (1982).

votes against (Germany, Italy, Netherlands, Switzerland, United Kingdom) and four votes in favour (Belgium, France, Spain, Sweden), with the abstention of Denmark. In the final vote on the LPAC's recommendation, Sweden joined the majority. We can only offer a suggestion about the positions expressed by SPB delegations, as no clear reasons emerge from the minutes of the meeting. On the one hand, no important research group was active in France in X-ray astronomy while French planetologists did certainly have an interest in the Venus Orbiter; Exosat, on the other hand, enjoyed full support from the influential scientific circles interested in X-ray astronomy in the UK, Netherlands and Italy, besides being supported by the ESRO scientific and technical staff.

The second consideration is of a more general character. It regards the development of ESRO's scientific planning since 1969. In the context of the difficult times European cooperation in space was suffering in those years, the LPAC and the Directorate of Programmes and Planning made every effort to define a long-term scientific policy based on clear priority choices, accurate mission definition and feasibility studies, and intelligent cooperation with NASA. The choice of IMP-M/D and HELOS after COS-B and GEOS was in fact the logical outcome of this effort. With the painful decision to close the rocket programme and the recognition that ESRO could not sustain a viable satellite programme in all research fields nor undertake alone large and technically sophisticated projects, the forthcoming European Space Agency had to find its own ground for scientific activity by selecting a limited number of original projects in well-selected research fields, and by fostering participation in cooperative projects with NASA.

8.6 Epilogue

In July 1973, a few months after the adoption of ESRO's new scientific satellite projects, an important session of the European Space Conference marked the decisive turning point in the history of ESRO and, more generally, of Europe in space. A new "package deal" negotiated within the framework of the European Space Conference gave ESRO the overall responsibility for the new Ariane launcher programme, whose management was entrusted to the French Centre National d'Etudes Spatiales. This, in the words of the new Council chairman Maurice Lévy, "transform[ed] ESRO for the first time in effect into a space organisation with a complete and balanced programme".[745] The same agreement, continued Lévy, foresaw for the European space organisation "the start of a great adventure", namely co-operation with NASA in the Space Shuttle programme by the construction of a space laboratory (Spacelab) to be integrated in the Shuttle. Finally, a new application programme, a satellite programme for the control of maritime navigation (MAROTS), was also decided on and entrusted to ESRO.

From the institutional point of view, the implementation of the new "à la carte" method of programme financing and the fact that each of the three new programmes was sponsored by one of the main Member States - Ariane by France, Spacelab by Germany and MAROTS by the UK - gave strength and stability to ESRO's activity. Quoting again from Lévy:

> *It can therefore be said that the Organisation now has an almost completely charted programme until 1980, and that this programme is particularly rich and diversified. The ESRO budget, which was practically doubled after the first package deal in 1971, has again been doubled following the new package deal of July 1973.*

As a matter of fact, with the final liquidation of ELDO, it was evident that the forthcoming European Space Agency would actually be based on ESRO's structure and on-going programme.

Space science was no longer the only component of this programme, nor the most important. It was however the one which was already providing useful results as well as the one upon which the very existence of a joint European effort in space could be based. By mid 1973 four ESRO satellites were

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745 Lévy's foreword to the *ESRO General Report 1973*, p. 7. For the second package deal see chapter 11.

orbiting around the Earth (HEOS-1 and 2, ESRO IV and TD-1), one was scheduled for launch in 1975 (COS-B) and two were under development for launching in 1977 (GEOS and ISEE-2). Moreover, ESRO was actively involved in the co-operative IUE project which promised an important scientific return to European scientists. At the same time, what was most important, the Organisation had finally succeeded in defining a scientific policy which gave coherence to the selection procedure of future programmes. And the procedure in fact went into motion again in the second half of 1973. In September that year the Director General asked the LPAC to discuss ESRO scientific policy for the period following ISEE-2 and Exosat in the early 1980s. The Astrophysics and the Solar System working groups were called to produce reports on this matter, according to their respective areas of interests, and new "Guidelines for ESRO scientific mission studies" were issued by the LPAC in January 1974. Within these guidelines, eleven missions were recommended for immediate studies in view of the selection of the new project(s) foreseen in 1976.[746] The European participation in the Space Telescope programme and the Out-of-Ecliptic (later *Ulysses*) mission were the outcome of the new selection process.

The most significant aspect of the maturation process which we have analysed in the previous pages can be recognised in the growing awareness among ESRO's scientific policymakers of the limits imposed on the Organisation by its specific charter: that of a multinational organisation whose aims and programmes had to be continuously negotiated by its Member States on the basis of different, and sometimes conflicting, political and economic interests. In this negotiation, science, i.e. scientists' thirst for new knowledge about celestial phenomena, was not an independent variable, but rather a component of a complex network dominated by more mundane affairs. ESRO's overall policy certainly kept science in its very foundation but its actual definition and development largely derived from forces other than scientific dreams. The *Blue Book* had envisaged the launching of a large scientific satellite each year, plus a good number of smaller satellites; now European space scientists had accepted that ESRO could launch no more than one scientific mission every two or three years and they had learned how to make the best choice out of their best ideas. The eventual development of ESRO's scientific programme in the following years maybe disappointed the hopes and expectations of a few European scientific groups but one can safely say that it was also a matter of pride for the European space community as a whole.

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746 The LPAC's report is coded LPAC(74)4, January 1974. The two working groups' reports are ASTRO(73)15, 18 January 1974 and SOL(73)16, December 1973.

Table 8-1
The Caravane Collaboration for the COS-B satellite

Laboratory	Group leader	Hardware
Centre d'Etudes Nucléaires, Saclay, France	J. Labeyrie	Anti-coincidence counter
Max-Planck-Institut für Extra-terrestrische Physik, Garching, Germany	R. Lüst	Spark chamber
Space Science Department, ESTEC, Noordwijk, Netherlands	E. Trendelenburg	Triggering telescope
Huygens Laboratory, University of Leiden, Netherlands	H. van de Hulst	Energy calorimeter
Istituto di Fisica, Università di Milano, Italy	G. Occhialini	Experiment electronics
Istituto di Fisica, Università di Palermo, Italy	L. Scarsi	Pulsar synchroniser

Table 8-2
The GEOS payload recommended by the LPAC in June 1970

S-301	Study of thermal plasma	Centre National d'Etudes des Télécomm., Issy-les-Moulineaux (F)
S-302b	Study of thermal plasma	Mullard Space Science Laboratory Dorking (UK)
S-303	Composition, energy spectra and angular distribution of ions	Universität Bern, Switzerland Max-Planck-Institut, Garching (D)
S-310	Pitch-angle distribution of electrons and protons (0.2 - 20 keV)	Kiruna Geophysical Observatory (S)
S-321	Pitch-angle distribution of electrons (30 - 200 keV) and protons (40 keV - 1.4 MeV)	Max-Planck-Institut, Lindau (D)
S-325	Electromagnetic wave fields in the magnetosphere (0.1 - 10,000 Hz)	Centre National d'Etudes des Télécomm., Issy-les-Moulineaux (F) Danish Space Research Institute Lyngby (DK)
S-328	DC, ELF and VLF electric fields in the magnetosphere	ESTEC, Noordwijk (NL)
S-329	DC electric field	Max-Planck-Institut, Garching (D)
S-331	DC and ULF magnetic fields	Laboratorio di Ricerche Spaziali, Frascati (I)

Experiment S-331 was chosen against the similar experiment S-332, from the Technisches Universität, Braunschweig (D), on the basis of consideration to fair geographical distribution.

It was agreed that, in the event of weight problems arising during the project definition phase, experiment S-302b should be excluded.

Subsequently, experiments S-301, S-325 and S-328 were combined in one experiment, coded as S-300.

Source: LPAC/86, 17 June 1970.

Table 8-3
Membership of the Launching Programme Advisory Committee (LPAC)

1969-70	1970-1971	1971-1972	1973
R. Lüst (chair)	J. Geiss (chair)	J. Geiss (chair)	H.C. van de Hulst (chair)
J. Geiss	H. Elliot	H. Elliot	H. Elliot
B. Hultqvist	B. Hultqvist	B. Hultqvist	G. Haerendel
G. Occhialini	G. Occhialini	H.C. van de Hulst	G. Pizzella
B. Strömgren	B. Strömgren	J.L. Steinberg	J.L. Steinberg

Table 8-4a
The Geophysics Panel

A.P. Willmore (chair)	University College London
J. Blamont	Service d'Aéronomie, Verrières-l.-B.
A. Dollfus	Observatoire de Paris, Meudon
J.W. Dungey	Imperial College, London
C.-G. Fälthammar	Royal Institute of Technology, Stockholm
G. Haerendel	Max-Planck-Institut, Garching
J.A. Ratcliffe	Radio and Space Research Station, Slough
P. Rothwell	University of Southampton
U. von Zahn	Universität Bonn

Table 8-4b
The Astrophysics Panel

C. Dilworth (chair)	Università di Milano
G. Cocconi	CERN, Geneva
H. Elliot	Imperial College, London
A. Hewish	Cambridge University
L. Houziaux	Université de Liège
K.O. Kiepenheuer	Fraunhofer Institut, Fribourg
E. Schatzmann	Institut d'Astrophysique, Paris

Source: LPAC/41, 8 September 1969.

Table 8-5
Tentative satellite programme presented by J.A. Dinkespiler at the 31st LPAC meeting (27-28 February 1970)

	1970	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**
ESRO IV	3	3	3							
TD-1	10	10	10							
COS-B		3	9	9	9					
GEOS		1	6	8	8	7				
Small satell.	*		3	3	3					
Large satell.		*		10	10	10	10	10		
Small satell.			*		33	3				
Medium satell.				*		8	8	8	8	
HEO satell.				*		5	5	6		
Medium satell.					*		8	8	8	8
Small satell.						*		3	3	3

An asterisk indicates the time the project is approved.
Figures in the table are in MAU (Million Accounting Units).

Source: LPAC/73, 3 April 1970, p. 14

Table 8-6
Initial membership of LPAC's Working Groups (1972-1973)

Fundamental Physics Panel	Solar System Working Group	Astrophysics Working Group
H. Bondi (chairman)	G. Haerendel (chairman)	C. de Jager (chairman)
I. Roxburgh (deputy)	A. Dollfus (deputy)	L. Scarsi (deputy)
J. Blamont	M. Ackerman	M. Golay
G. Cocconi	H. Bolle	L. Houziaux
G. Colombo	C. Fälthammar	P. Léna
B. Laurent	K. Fregda	J. Lequeux
R. Lüst	E. Gérard	P. Mezger
G. Occhialini	J. King	B. Peters
E. Schatzman	G. Pfotzer	K. Pinkau
D. Sciama	M. Pick	K. Pounds
	G. Pizzella	M. Rees
	J. Quenby	
	F. Sanchez	
	L. Storey	

Chapter 9: The Beginning of the Telecommunications Satellite Programme in ESRO

A. Russo

The European Space Research Organisation (ESRO) was created in the early 1960s as an organisation solely devoted to space science. Its Convention, in fact, made no reference to the possibility of carrying out work on application satellites such as for telecommunications, meteorology, navigation, etc. At the end of 1966, however, after a request from the European Conference on Satellite Communications (known by its French initials CETS), the ESRO Council accepted to undertake "a six-month study to evaluate the technical and financial implications involved in the development and launching of a few experimental communications satellites and to indicate other developments of interest in the field of application satellites".[747] This event marked the beginning of ESRO's involvement in the field of application satellites, in particular in what appeared as the most promising sector from the commercial point of view, namely telecommunications satellites. Today the telecommunications programme demands about 9.1 per cent of the budget of the European Space Agency (ESA), the Organisation which succeeded ESRO and ELDO (the European Launcher Development Organisation) in 1975. The percentage rises to 27.8 per cent with the inclusion of the other main application programme, Earth observation, to be compared to the 12.8 per cent devoted to the scientific satellite programme.[748] The major satellites developed within these two application programmes, the communications satellite Olympus, launched in 1989, and the Earth Resources Satellite ERS-1, launched in 1991, are by far the most expensive in the ESA satellite family. Their cost is over 700 MAU, i.e. twice the cost of Hipparcos, ESA's space telescope for astrometric measurements, and 4.5 times the cost of ESA's scientific space probes Giotto and Ulysses.[749]

At the time when ESRO undertook its studies on behalf of the CETS, the first experimental phase of satellite telecommunications was at its end. The American satellites Telstar (1962) and Early Bird (1965) had well demonstrated the technical feasibility and economic profitability of space links for long distance telephony; and the first television transmissions across the oceans and continents had dramatically shown the social relevance of live TV on a planetary scale. Plans were under development to build a satellite system for global coverage of the Earth. It took several years, however, for the European space organisation to go from those preliminary studies to the start of the first development programme. It was only at the end of 1971 that the ESRO Member States definitely approved that the organisation be formally engaged in a telecommunications satellite programme and provided the necessary funding. The analysis of this difficult beginning of ESRO's telecommunications programme is the subject of this chapter. In the following, we will discuss the actual implementation of this programme up to 1978, when the first experimental satellite (OTS-2) was successfully launched.[750]

The transformation of ESRO from an organisation solely devoted to scientific research into one mainly involved in application programmes was not the main reason for this long delay. On the contrary, the ESRO staff was much interested in the new undertaking and was soon ready to integrate

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747 ESRO, General Report 1966, p. 12.

748 ESA, Annual Report 1997. Other high highest percentages of the ESA budget are demanded by the space transportation programme (28.3 %) and the manned space flight programme (13 %).

749 The acronym MAU stands for Million Accounting Unit, ESA's conventional monetary unit based on a gold standard. In the period covered by this chapter, its value was about 1 US dollar. Giotto is the name of the well-known space mission to Halley's comet in 1986 and Ulysses is the name of the spacecraft launched in 1990 into an orbit extending outside the ecliptic plane to observe the solar poles.

750 The first OTS satellite was lost in September 1977 due to the failure of the Thor-Delta rocket. ESRO's first application satellite successfully in orbit was thus the meteorological satellite Meteosat, launched in November 1977.

the new tasks into the managerial and technical framework of the Organisation. Nor were the national delegations in the ESRO Council worried about this sort of "genetic change": by the mid-1960s it was evident that pure research alone was not the only good reason for launching satellites (leaving apart military interests), but important economic and commercial aspects were also involved. And it made no sense to create a new organisation to cover these aspects when one existed already that had proved its capability and reliability. Space scientists did express concern and even opposition, fearing that work on applications would jeopardise the scientific programme, but they could hardly resist the drift.

The reason why it took five years to start a telecommunications programme in ESRO lies rather in the political and institutional framework in which such a programme had to be defined and agreed on, namely the need for a coherent space policy for Western European countries. Defining a strategy in satellite telecommunications implied important choices regarding international relations, industrial policy, defence of economic and commercial interests, control of areas of cultural influence. Does Europe need a space policy defined at continental level? How is coherency defined at this level? What is the place of telecommunications in this frame? Answers to these questions were different in different countries, both because governments had different visions of Europe's role in a USA-USSR dominated world and because various interest groups held conflicting views about the importance and mutual relationship of the various sectors of space activities - science, telecommunications and other application fields, and launchers.

The long and controversial process which led to the adoption of the telecommunications programme in ESRO, the story we are telling in this chapter, is but one aspect of the emergence of such a European space policy out of the experience of ESRO and ELDO. The compromise reached at the end of 1971, which we discuss in the last section, cleared the situation regarding ESRO and finally gave a start to the telecommunications programme. It did not resolve the main controversial issue, however, namely whether Europe should develop and use its own rockets to launch its application satellites or rely on American launchers. To answer this question required two more years of difficult negotiations whose outcome marked the origin of the European Space Agency.

9.1 The beginning of the space telecommunications era

9.1.1 The prophet

In the ideal portrait gallery of satellite telecommunications, the first place would be occupied by one of the world's best-known and best-selling popular science writers: Arthur C. Clarke, the author of 2001: A Space Odyssey. A prophet of the space age and an amateur communications scientist, Clarke suggested for the first time, in an article published in 1945, the idea of geo-synchronous communications satellites. In that article, Clarke noted that a satellite in an orbit with a radius of 42,000 km (i.e. 36,000 km above the Earth's surface) has a period of exactly 24 hours:

> *A body in such an orbit, if its plane coincided with that of the Earth's equator, would revolve with the Earth and would thus be stationary above the same spot on the planet. It would remain fixed in the sky of a whole hemisphere and unlike all other heavenly bodies would neither rise not set.*[751]

If a space station were built in this orbit, continued Clarke, and were equipped with suitable receiving and transmitting equipment, it could act as a repeater to relay transmissions between any two points in the hemisphere beneath. Moreover, a transmission originating from any point on the hemisphere could be broadcast to the whole of the hemisphere itself, "and thus the requirements of all possible services would be met". Three satellite stations would ensure complete coverage of the globe (Figure 9-1).

Clarke wrote his article twelve years before the first artificial satellite of any kind was actually launched, and space stations appeared to most people not far from science fiction. At that time, the

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751 Clarke (1945), as reprinted in Pierce (1968), p. 38

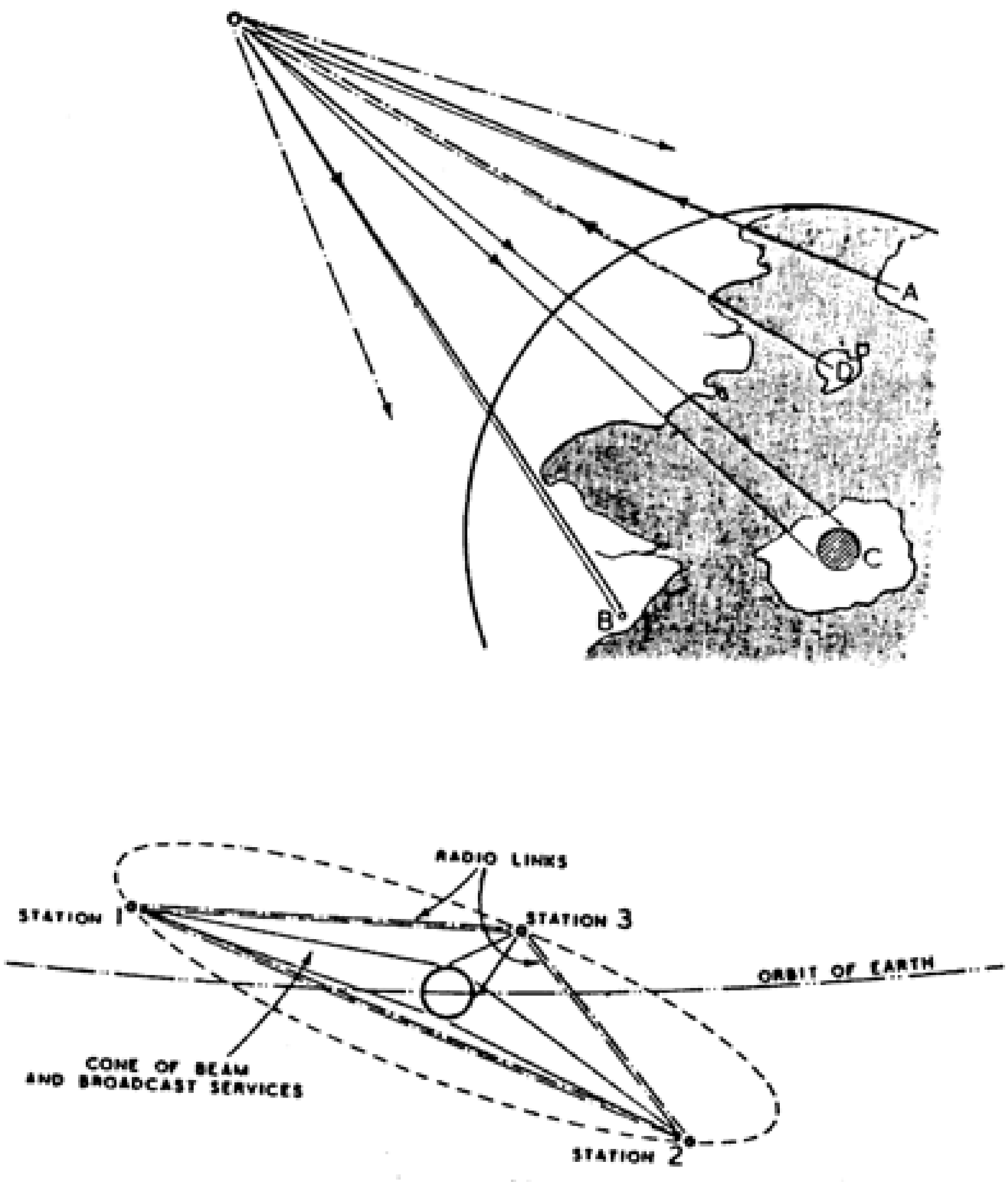

Figure 9-1: A.C. Clarke's original figures (1945) of geostationary telecommunications satellites

only way to provide long distance telephone communications was by high-frequency radio waves. Long submarine cables, established since 1858 for telegraphic communications across the Atlantic, could transmit the dot and dashes of telegraph messages but were unsuitable to handle the high-frequency signals required to transmit the fine modulations of the human voice.[752] Fortunately, radio waves are reflected by the ionospheric layers of the upper atmosphere and by the Earth's surface, thus allowing the transmission of signals along the curved surface of our planet by a series of successive reflections. The transmission, however, suffered from the irregular behaviour of the ionosphere and its quality depended on such phenomena as weather conditions, solar flares and magnetic storms. Establishing a voice circuit always required the great skill of operators, and often was much disturbed.

Unsatisfactory though long-distance telephony was in 1945, the position of the new-born television was far worse, as Clarke stressed in his article. In order to transmit images, in fact, much higher frequencies are required than to transmit sound, and the corresponding waves are not reflected by the ionosphere. A complex network of VHF repeaters in sight of one another was thus required to provide television coverage over a large area, while coverage of a whole continent appeared prohibitively expensive and transoceanic links impossible.

In the second half of the 1950s, the situation of long-distance telephony changed significantly, thanks to the great technical advances in electronics stimulated by World War II. The first transatlantic telephone cable (TAT-1) went into service in 1956, and it was soon followed by a succession of transoceanic cables of ever-increasing capacity. Then, in the following two decades, transistors replaced the vacuum tubes and it became possible to handle several thousand voice circuits in a single telephone cable.[753] Cable television came later but it is still limited to limited land regions.

The laying of the first transoceanic telephone cables happened just when the launch of the first satellites made Clarke's vision appear to be a real possibility. In fact, the competition between these two communication systems started from the very beginning. Satellites have three obvious advantages over cables. Firstly, they allow multiple access from several ground stations (fixed or, eventually, mobile) while cables can only provide point-to-point circuits; secondly, the cost of satellite circuits is independent of the distance of the earth stations while the cost of cable circuits increases with their length; finally, satellite transmissions can leap over physical and political barriers that can hardly be passed by cables. On the other hand, the advocates of cables argued that the technology of satellite telecommunications was still in its infancy while cables had a century-old history behind them. Live world-wide television, direct calling service to and from any place on Earth, and the need to transmit huge amounts of data in real time were still in an uncertain future, while the high costs, technical difficulties and not rare failures of satellites and launchers were in the actual present. Any forecast about the future demand of long-distance telephone circuits and TV channels was unreliable and no guarantee existed that the enormous investment required to realise an operational system could be profitable from the commercial point of view.[754] And if satellite telecommunications could overpass geographical and political barriers, their massive use implied nevertheless a strong dependence on those very few countries which had the technical and financial means to build such satellites and, principally, to launch them into the suitable orbit. Finally, one must not forget that big investments had

[752] For a popular account of the wiring of the Oceans for communications purposes see Clarke (1992).

[753] The TAT-1 cable had an initial capacity of 36 voice circuits and it was thought that this would be enough to carry all the transatlantic telephone traffic for some years ahead. In fact, the demand for calls grew very rapidly and the cable was fully loaded almost from the day it went into service. By the time of the launch of Early Bird (1965), the new, high-performance TAT-4 cable had a capacity of 408 voice circuits. In 1982 the individual submarine cable capacity was 4000 circuits. These data are respectively from Dalgleish (1989), p. 6; Smith (1976), p. 152; and Astrain (1984), p. 3.

[754] As an example of the difficulty of foreseeing future trends, we can note that, according to Galloway (1972), there were only 550 overseas telephone circuits in 1961 and the projected global need for 1980 was about 8000 circuits. As a matter of fact, a single Intelsat V satellite, the first of which was just launched in 1980, had a traffic capacity of 12,000 circuits plus two TV channels. And in 1982, the total world transoceanic telephony service amounted to 40,000 circuits: Astrain (1984), p. 3.

been made in the communications business and therefore the competition between cables and satellites also involved important economic and commercial interests.[755]

9.1.2 The first experimental communications satellites: Echo, Telstar, Syncom

The importance of satellites for military communications was recognised from the very beginning of the space age. The first programmes were started by the US Department of Defense as early as 1958 and in December that year an Atlas rocket launched the first communications satellite, SCORE (Signal Communications by Orbiting Relay Equipment). It recorded a transmission at a frequency of 150 MHz while passing over one earth station and then played it back at 132 MHz when requested by another station. The maximum message length was 4 minutes, and the spacecraft capacity was either one voice channel or seven teletype channels. The satellite was used to broadcast a tape recording of a Christmas message from the US President D. Eisenhower and this first "voice from space" dramatically demonstrated the potential of communication satellites.[756]

SCORE was followed in 1960 by another military satellite, Courier, an improved version of the delayed repeater SCORE-type satellite. NASA, for its part, developed a satellite telecommunication programme based on a passive satellite called Echo, an orbiting balloon 30 m in diameter, made of plastic coated with aluminium and used as a passive reflector of telephone and television signals at a height of about 1500 km. The first Echo satellite was launched in August 1960 and a second one, somewhat larger and more rigid, followed in January 1964. Echo I provided the first real-time satellite transmission of a transatlantic signal between America and Western Europe; Echo II performed communications experiments between the United States and the Soviet Union.[757]

For the general public, the era of space communications was actually opened on 10 July 1962, when a Thor-Delta rocket launched Telstar I, the first real-time transponder, designed and built for NASA by the American Telephone and Telegraph Company (ATT). Two weeks after launch this satellite provided the first live broadcast of television images across the Atlantic, and less than one year later, in May 1963, Telstar II established an analogous connection over the Pacific between the USA and Japan.[758] The Telstar satellite weighed 80 kg and presented itself as a sphere with a diameter of about 1 m. It was launched into a low elliptical orbit inclined at approximately 45° to the equator, with perigee at about 1000 km and apogee at about 6000 km. The period of the orbit was 158 minutes. The communications equipment was based on frequency modulation (FM) of the radio-frequency (RF) carrier: a frequency of 6.39 GHz was used for ground-satellite (uplink) transmissions and 4.17 GHz for satellite-ground (downlink) transmissions. This choice of frequencies, which set the precedent of the 6/4 GHz operation, derived from the fact that they were widely used by terrestrial microwave

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755 Kinsley (1976) has analysed how interest groups linked to the common carriers in the United States have endeavoured to control innovation in the field of satellite telecommunications in order to protect investments in traditional cable facilities. See also Galloway (1972), p. 148.

756 Smith (1976), pp. 49-50.

757 On NASA's passive satellite experimentation see Smith (1976), pp. 51-55.

758 NASA was also involved in another active communications satellite project, Relay, in collaboration with the Radio Corporation of America (RCA). The first satellite of this project, Relay I, was launched in December 1962, followed in January 1964 by Relay II. Although overshadowed by publicity surrounding the Telstar satellite, Relay was NASA's most advanced communications satellite before adoption of the entirely new Syncom design. Smith (1976), pp. 80-83.

systems (microwave radio communications, radar) and therefore much of the technical hardware required was already well developed.[759]

NASA's Telstar and Relay projects were research and development projects whose aim it was to demonstrate the technical feasibility of satellite telecommunications and to provide information for the eventual design of operational systems. All these satellites were placed in near-Earth orbits and each of them was therefore visible simultaneously to widely-separated earth stations for only a few relatively short periods each day. As a consequence, a large number of such satellites were needed in order to have at least one in the sky at any given time and thus to provide full-time service. Moreover, earth stations had to be equipped with two separate steerable antennas, in order to receive signals from one satellite and to relay them to another. On the contrary, a single geostationary satellite like that envisaged by Clarke could be seen 24 hours a day from about 40 % of the Earth's surface, and this made it possible to provide direct and continuous communications between a large number of widely separated stations, each equipped with one fixed antenna. Two main problems presented themselves, however, to those who advocated a telecommunications system based on geostationary satellites. The first was the availability of powerful enough rockets to lift heavy payloads to the required altitude of 36,000 km. The second was the foreseeable difficulty in telephone conversations caused by the time delay (about half a second) in the transmission of signals from an earth station to another and back again via such a distant satellite. To these technical problems one should add the then complete ignorance about the environment of the geostationary orbit and the concern that the satellite could not survive long enough to be useful.

The launch by NASA of Syncom II, on 26 July 1963, proved that the first problem had a solution even with the then existing rockets. The solution in fact came from two young engineers of Hughes Aircraft Company, H. Rosen and D. Williams, and consisted in launching the satellite into a low-altitude circular orbit in preparation for two major boosts in velocity. The first was provided by the last stage of the rocket and injected the spacecraft into an elliptical "transfer orbit," with the apogee at the geostationary altitude of 36,000 km. From the transfer orbit apogee the satellite could then be injected into a circular orbit at the requested distance from the Earth by firing a solid rocket motor ("apogee motor") on board the spacecraft. Small liquid mono-propellant rockets were used to adjust the position and orientation of the spacecraft in the orbit, and a controlled spin system kept the satellite antennas pointed at the Earth at all times.[760]

Syncom II was the first experimental geosynchronous communications satellite (actually the first geosynchronous satellite of any kind) but its orbit had an inclination of 32°, which caused a daily north-south excursion of the satellite. Its mass was only 39 kg, which was the maximum capacity of the Thor Delta rocket at that time, and it was able to relay several voice circuits or one television channel between earth stations provided with large antennas. This satellite had the tragic distinction of carrying across the Atlantic, on 22 November 1963, the television images of the assassination of President J. Kennedy. The next satellite in this series, Syncom III, was launched in July 1964 and the

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759 An RF carrier is an electromagnetic wave used to transmit some kind of information (voice, video pictures, or data) through free space. The information is recorded by modulating either the amplitude of the carrier wave (AM) or its frequency (FM). In the latter case, that used for satellite communications, the frequency modulation is operated within a bandwidth centred at the carrier frequency and lying within the particular frequency band assigned to the transmission. Frequency bands are allocated for various purposes by the International Telecommunication Union (ITU), a United Nations Agency located in Geneva, Switzerland. The 6/4 GHz uplink/downlink operation is within the so-called C band, a band that has the great advantage of having the minimum combination of natural and man-made noice sources. Useful textbooks on satellite communication technology are Pratt & Bostian (1984), Elbert (1987), Dalgleish (1989) and Maral & Bousquest (1998). An historical account of the technical development of communications satellites is in Fordyce (1986).

760 Podraczky (1979), p. 39; Smith (1976), p. 58-60 and 83-87; Fordyce (1986), pp. 202-203. The Syncom project was a joint project of NASA and the Department of Defence; the technical design and the construction of the satellite were realised by Hughes Aircraft Company. The first Syncom satellite was launched on 14 February 1963 but it was unsuccessful.

orbit inclination was now reduced to zero, so that the satellite was in the Earth's equatorial plane and was truly geostationary. The satellite was used to transmit television pictures from the Tokyo Olympic Games in August that year.

The Syncom project demonstrated the feasibility of placing satellites into geostationary orbits and maintaining precise station-keeping and attitude control. These two simple, lightweight, spin-stabilised satellites dramatically added new evidence of the political and social importance of world-wide telecommunications, and showed the great economic value of satellite technology for telephony and television. By the end of 1964, the first demonstration phase of satellite telecommunications was coming to an end and the time was ripe for starting commercial ventures.

9.1.3 Comsat, Intelsat and the beginning of commercial satellite telecommunications

While the engineers were experimenting, the future of satellite telecommunications was also discussed at the political level in the United States. In 1962, after a long period of difficult negotiations involving NASA, industrial lobbies, the Congress and the White House, Congress passed the Communications Satellite Act. By this act, the realisation and exploitation of commercial systems for international satellite telecommunications was entrusted exclusively to the newly created Communications Satellite Corporation (Comsat), whose ownership was shared in equal parts between the main American communications companies (ATT, ITT, RCA, etc.) and private investors (among which the aerospace industries). While formally a private corporation, Comsat had been created in pursuance of the US national policy in the field of satellite telecommunications and this was reflected in its statute: three members of the Board of Directors were nominated by the US president, and controls and regulatory powers were entrusted to the Federal Communications Commission (FCC) and the State Department.[761]

The task of Comsat was twofold. Firstly, it had to determine the feasibility of a commercially valuable communications satellite system, and eventually to develop such a system. Secondly, as the system could only be international, it was mandatory for Comsat to involve as many countries as possible in the project and to work out a suitable institutional framework. In order to fulfil the first task, Comsat placed an order with Hughes, the builder of the Syncom satellites, for a geostationary satellite to be used as a demonstration system of such a technology from the commercial point of view. As to its second task, Comsat undertook an important effort to encourage international participation in the new venture.[762] The result of this effort was the formal signing, on 20 August 1964, of the Interim Agreements that established the International Telecommunications Satellite Consortium (Intelsat), whose task it was "to design, develop, construct, establish, maintain, and operate the space segment of a single global commercial communications satellite system".[763]

The Intelsat agreements were signed by 13 nations plus the Vatican City, but the membership grew rapidly, reaching 48 by the end of 1965, 63 in 1968, and 83 in 1972.[764] The agreements consisted in fact of two different documents: an intergovernmental treaty covering organisational principles and arrangements for an international communications satellite system; and a Special Agreement signed by national entities responsible for telecommunications, dealing with the operating aspects of the new

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761 The political process leading to the approval of the Communications Satellite Act and the creation of Comsat is discussed by Galloway (1972), pp. 47-73, and Smith (1976), pp. 93-120. See also Kinsley (1976), pp. 1-25.

762 International cooperation in satellite telecommunications had already been established by NASA and ATT in the framework of the Echo, Relay and Telstar projects, in order to build and operate ground stations in a few western European countries.

763 Colino (1984), p. 61. The negotiations leading to the Intelsat agreements are extensively discussed in Galloway (1972), pp. 75-104, and Smith (1976), pp. 121-141. The term "space segment" refers to the satellites, their launching, and their tracking and operation in orbit. The parallel term "ground segment" refers to the earth station network used to access to the satellite communications system in order to assure the requested services (telephony and telegraphy, television, data transmission, etc.).

764 The list is given in Galloway (1972), appendix B, pp. 193-198.

organisation. Intelsat's ownership shares were assigned to these entities according to the proportional use of the system, on the basis of ITU's projections for the year 1968. This gave Comsat, which represented the US, 61 per cent of quotas, while the British Post Office (BPO) was a weak second with about 8 per cent of the share. The combined European share was 30.5 per cent and the total Canadian, Japanese and Australian was 8.5 per cent. It was assumed that new members would acquire their quotas from the shares of existing members on a pro rata basis, with the proviso that Comsat's share would not be reduced under 50.6 per cent.[765]

The governing body of Intelsat was an Interim Communications Satellite Committee (ICSC), whose members were drawn from the signatories of the Special Agreement and represented countries or group of countries with at least 1.5 per cent of the projected 1968 Intelsat traffic level. The voting procedure was based on a complex decision-making formula which gave non-American members some degree of control on the most important decisions. Comsat, however, was by far the dominant member in the new organisation, with more than 50 per cent of the voting power, while several smaller countries had to share a single vote (the USSR, had it joined Intelsat as Western countries hoped, would have less than a fraction of vote). Moreover, Comsat's position was strengthened by the fact that the American company was appointed as the operating manager of Intelsat.

The Intelsat agreements of 1964 reflected the dominant position of the United States in the technology of satellites and launchers. The other signatories obtained, however, that these agreements should be temporary and that a new accord should be re-negotiated after five years, in order to arrive at a definitive institutional structure more respectful of the interests of other Intelsat members. An international conference was to be called in 1969 to discuss proposals for the new arrangement. By that time, it was expected that much more information would be available about the technical, financial and commercial aspects of satellite telecommunications, and that other countries would possess the level of technology required to enter the field competitively.

9.1.4 Early Bird and beyond

In the capacity of Intelsat's operating manager, Comsat had responsibility for the design, development and operation of the space segment of the system, while the ground segment was to be provided by the appropriate bodies in the countries in which they were situated. Comsat's satellite under development at Hughes, then known as HS 303, was thus designated as the first operational satellite for use by Intelsat. Renamed Early Bird and then Intelsat I, it was launched on 6 April 1965. On 28 June, twenty years after Clarke's forecast, it successfully inaugurated a commercial communications service between Europe and the United States. What was more important, Early Bird definitely demonstrated the acceptability and good quality of telephone communications by geostationary satellites: it was proved in fact that the communication delays associated with such satellites were acceptable as long as any echoes along the communication path were adequately controlled, which could be achieved by the use of suitable electronic devices.

Early Bird (Figure 9-2) was very small and involved crude technology. It was a spin stabilised cylindrical spacecraft, 72 cm in diameter and 60 cm long, weighing 38.5 kg. The communications payload included two transponders which received transmissions in the 6 GHz band and re-transmitted in the 4 GHz band. One transponder relayed signals from Europe to North America and the other operated in the backward path. The power capability was 240 telephone circuits or one TV channel and multiple access was not possible: this meant, firstly, that when television was transmitted, telephone traffic had to be switched to cables; secondly, that only point-to-point communications were

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765 In 1966, Comsat held 55 per cent of Intelsat quotas while 17 European countries held 27.5 per cent (Britain 7.4 per cent and France 5.5 per cent). By the end of 1970, Comsat's share was 52.6 per cent and European countries' 26.6 per cent (Britain 7.2 per cent, France and Germany 5.3 per cent): Voge (1966), p. 33; Galloway (1972), appendix B, pp. 193-198.

Figure 9-2: Early Bird

allowed and each earth station on both sides of the Atlantic had to take it in turns to work with the satellite.[766]

Even though designed "almost as it were a submarine cable in the sky", Early Bird dramatically demonstrated the potential of communications satellites from the commercial point of view. Its capacity of 240 voice circuits was comparable with the capacity of ATT's brand new, high performance TAT-4 cable, which held 408 telephone channels, and above all it allowed live television transmission, whose impact on the general public was revolutionising the world system of information and entertainment. Unfortunately for Early Bird, however, the simultaneous going into service of TAT-4 made it impossible to demonstrate the economic competitiveness of satellites over submarine cables for transoceanic telephony. In fact, as Nature informed its readers, "communications companies on both sides of the Atlantic wanted to recoup some of their investment first, and the satellite rates were in any case set far too high".[767] This situation would change before the end of the decade.

The success of Early Bird led the ICSC to decide, in February 1966, that the Intelsat commercial system should be based on the use of geostationary satellites. Hughes was contracted for a new generation of such spacecraft and in 1967 Intelsat I was joined in orbit by three Intelsat II satellites. The first provided service to the Pacific Ocean region, the second provided additional trans-Atlantic service, between Europe and South America, and the third became a spare in orbit for the Pacific Ocean satellite. These satellites took advantage of the increased capabilities of the Thor-Delta rocket and each of them weighed about 87 kg. The telephone capacity was the same as Intelsat I but the communications payload was now designed to allow multiple access, i.e. to carry signals from several earth stations simultaneously. Twenty-five countries in two ocean regions were thus connected by the Intelsat system and this determined both a substantial increase in international telephone traffic and a significant lowering of rates charged by cable carriers. Even though the possibility of launch failures made the economics of satellites still uncertain, it became clear, as Nature put it, that "new cables can only add to existing capacity, while satellites can almost multiply it". And in fact, in the last quarter of 1967, Intelsat realised its first net operating profit.[768]

Finally, in May 1969, the third generation of Intelsat satellites, Intelsat III, established the global coverage and world-wide service that Arthur Clarke had envisaged, with one satellite over each of the Earth's oceans and many earth stations spread all over the world. It was estimated that 500 million people saw the television pictures, relayed by the Intelsat III satellites, of the first landing on the moon in July 1969. Eight Intelsat III were launched between September 1968 and July 1970, but three failed to reach the geostationary orbit. And the number of hours for television transmission and reception increased from 1372 in 1968 to 6792 in 1972.[769]

The Intelsat III satellites, built by TRW and weighing 152 kg, had significant advantages compared to their predecessors. Their two transponders allowed 1200 telephone circuits or up to four television channels, or 700 telephone circuits and one TV channel handled simultaneously. Like the previous Intelsat satellites, it received transmissions at about 6 GHz and converted them to about 4 GHz for transmission down to Earth. An important improvement was the new type of communications antenna,

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766 Description of Early Bird and its operation can be found in Podraczky & Pelton (1984), pp. 95-100. This paper describes all generations of Intelsat satellites up to the early 1980s. In the initial period, four stations operated in Europe, at Pleumeur-Bodou (F), Goonhilly Downs (UK), Raisting (G), and Fucino (I); and one in the United States, at Andover, Me. Subsequently a new station was added at Mill Village, Canada. The European traffic was rotated from station to station on a weekly basis, with the smaller station at Fucino carrying traffic on weekends.

767 "World wide satellites", Nature, 212, 554-555 (5 November 1966), on p. 554.

768 "Double or nothing", Nature, 216, 4-5 (7 October 1967), on p. 4; Smith (1976), p. 152.
See also Astrain (1984), p. 4. The Intelsat II satellites were realised by Comsat for use by NASA for the Apollo missions to the moon, but about half of channels remained free for commercial use. The first satellite, launched in October 1966, failed to reach synchronous orbit because of a malfunction of its apogee motor. This was followed by three successful launches in January, March and September 1967.

769 Smith (1976), p. 153.

provided with a despun motor which kept it fixed in the direction of the Earth while the spacecraft was spinning. In this way, all the power was radiated towards the Earth while in previous satellites, whose antenna rotated with the satellite, most of the power was radiated into space.[770]

The enormous increase in demand for communications satellite service called for new generations of satellites, with much higher capacity and improved performance. Thus, even during the construction phase of the Intelsat III satellites, a new series of Intelsat IV satellites was contracted with Hughes, to take advantage of a larger launch vehicle, the Atlas-Centaur, capable of placing some 700 kg into geostationary orbit. The first Intelsat IV went into service in early 1971 over the Atlantic region, and six others followed between 1971 and 1975. These satellites had a mass of about 730 kg and they were provided both with a global-beam antenna oriented towards the Earth, like their predecessors, and with two high-gain "spot-beam" antennas, steerable in orbit under ground command towards a restricted area on the Earth's surface. The satellite's twelve transponders allowed a capacity of about 4000 telephone circuits plus two TV channels.[771]

New generation of Intelsat satellites followed in the 1970s and 1980s (Intelsat IV-A, V and VI), together with several experimental and commercial communications satellites developed and launched by other national and international organisations. We are not going to pursue this historical account further, as it would go beyond the time span covered in this chapter. It is fair to recall, however, that in the same period 1965-1975, the USSR also developed her communications satellite system, based on the Molniya satellites, the first of which was launched in 1965. In November 1971 the Intersputnik organisation was created, on the initiative of the Soviet Union and other countries under USSR influence.[772]

9.2 The first steps in satellite telecommunications in Europe (1964-1966)

Europe was a latecomer in the communications satellite field. While development work was actively pursued in the US, the European space effort was in fact insignificant: ESRO and ELDO existed only in embryo, the very few national programmes were still in their early stages and no plan existed specifically directed towards communications satellites. Early involvement of European countries in the field was limited to the realisation of two ground stations to participate in the experimental programme of Telstar and Relay, the first built by the British Post Office at Goonhilly Downs and the second by the French PTT at Pleumeur-Bodou. Subsequently, a large station was built at Raisting in Germany and a smaller one at Fucino in Italy, both used to receive signals from Early Bird.

First plans for independent European activity in the space sector started only in 1963, when the results obtained in the U.S. had already shown the technical feasibility and economic interest of communications satellites, and when Comsat started its actions to promote an international arrangement for a world-wide system. The growing disparity between the USA and Europe, in fact, gave rise to considerable concern since it would have caused a substantial weakness of Europe both in the control of whatever arrangements might be made and in the industrial competition for the construction of the necessary hardware.

In March, the British Minister of Aviation announced a joint UK-Commonwealth programme for a civilian-military satellite communications system based on geostationary satellites. One month later the consortium of European aerospace industries Eurospace presented a comprehensive space programme which gave high priority to the development of an all-European communications satellite system, based on a set of satellites in equatorial orbit. Finally, a European Conference for Satellite Communications (ECSC, better known as CETS from its French initials) was established in May, with

770 Podraczky & Pelton (1984), pp. 103-109; Dalgleish (1989), pp. 9-12.
771 Podraczky & Pelton (1984), pp. 109-113; Dalgleish (1989), pp. 12-15.
772 For the USA-USSR relations concerning satellite telecommunications and the creation of Intersputnik see Galloway (1972), pp. 121-136. We will not deal with this development as it has little or no importance for the history of ESRO in this period.

the twofold aim of co-ordinating the positions of European countries in the forthcoming negotiations for the Intelsat agreements, and to promote the development of a European programme in satellite telecommunications.

The CETS had been called after the conclusions of a meeting of the Conference of European Postal and Telecommunications Administrations (CEPT, from its French initials), held in Cologne in December 1962. Participants in this meeting had discussed the American proposal of establishing a single global system and had agreed that Europe would take a regional approach to this initiative rather than negotiate a series of bilateral arrangements, as proposed by Comsat. The CETS was thus intended to be the instrument for Europe to speak with one voice in the negotiations.[773] The first institutional organisation of Intelsat defined in the 1964 Interim Agreements could only reflect the position of strength of the United States and of Comsat. The problem for Europe was now to develop its own telecommunication satellite programme in order to arrive in a better position at the re-negotiations for the definitive arrangement. This was the CETS's second aim.

Two main reasons pushed CETS Member States to get actively involved in the space sector of satellite telecommunications. The first was the economic interest of European industries in participating in the Intelsat development and procurement contracts at a level consistent with Europe's financial contribution to the consortium. By 1966, in fact, it was evident that European companies were unable to compete successfully with their American counterparts, and Comsat was thus awarding most of the Intelsat money to American firms. In 1967, for example, the British Parliament's Estimates Committee lamented that "the US share of contracts was overwhelmingly high", and stressed that in the contracts allotted for six Intelsat III satellites worth 32 million dollars, the value of contracts allotted in the UK was only 500,000 dollars, i.e. less than 1.6 per cent, well below Britain's 7.41 per cent share of Intelsat quotas.[774] One year later, Nature recalled that the share of contracts placed by Intelsat in Europe was only 4 per cent, and commented:

> *It is precisely in the field of satellite construction, satellite sub-systems, onboard power supplies and such things that European tenders have done badly, in part, of course, because they lack the experience of their American competitors. It is a cogent argument of CETS advisers that the inequality will not be rectified without more direct European participation in the launching and designing of satellites.*[775]

The second reason in favour of an autonomous European involvement in communications satellites was political. By the mid-1960s, when the cold war had overcome its hottest phase, a good deal of international competition took place on the ground of scientific and technical achievements, commercial success, and cultural influence. This kind of competition existed not only between the two sides of the iron curtain but also on the western side of it. With the Americans heading to the moon and the Soviets lifting heavier and heavier payload beyond the atmosphere, space no longer appeared as merely a new frontier for esoteric scientific investigation. It was definitely a key element for technological innovation, for industrial development and for national prestige. And with Japan, China and Canada already on their way to space, Europe could not remain sitting on its very limited programmes in space research and launcher development. Satellite communications rather than basic science appeared more and more as the privileged area of application of space technology, with a potential market as large as the world and with a political interest as important as free communications in the so-called "global village". As Le Monde would eventually comment: "The transmission of radio

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773 Bignier (1966); Galloway (1972), pp. 93-94; Smith (1976), pp. 135-136. The CETS met for the first time in May 1963 in Paris and following meetings were held in July 1963 (London), October 1963, March and June 1964 (Rome), and October 1964 (Bonn).

774 Estimates Committee (1967), p. xi. See also ibidem, p. 64.

775 "More negotiation for Intelsat", Nature, 218, 714 (25 May 1968).

and television programmes is one of the most supple and diversified means to assure a presence and influence abroad".[776]

Three main difficulties presented themselves regarding the achievement of an independent European capability in space communication. The first derived from the fact that two multinational space organisations already existed in Europe, one to develop launchers and another to build scientific satellites, but none had been created for building and operating applications satellites. While the creation of a third organisation appeared unwise, any eventual involvement of those existing in the new field implied changing their charter and operational programme. This problem was made more difficult by the fact that, both at national level and in international negotiations, the different aspects of space activities were dealt with by bodies as different as Ministries of Industry, Ministries of Aviation, Ministries of Science and Technology, Ministries of Foreign Affairs, Research Councils, Space Committees, PTT administrations and so on. The CETS itself did not have an official statute as an independent organisation but was rather a series of meetings of governmental and PTT representatives, with a small secretariat serving ad interim. This rendered the task of defining a coherent space policy a hard task not only at European level but very often at the level of individual countries.[777]

The second difficulty lay in the situation created by the Intelsat agreements. As this international consortium was to provide for a global space communications network, its members were committed not to build systems that could compete with such a network on the commercial ground. This left them two possible policies in space telecommunications: to compete in the international market for supplying satellites and/or important technical hardware to Intelsat, or to develop communications satellites for national use. But European space industries were not in a position to tender successfully against American ones, and European countries were not large enough to require the use of satellites for domestic telecommunications. A third way did exist, in fact, for Europe to foster an industrial policy in the communications satellite field, but its political implications were rather delicate. This was the development of a space communication system at regional level, namely covering a large part of the European continent and the Mediterranean area, whose geographical extent would be comparable with that included within the national borders of the United States or Canada. The limitation of such a policy was twofold. Firstly, this regional system could take over some of the Intelsat traffic and thus undermine the commercial interests of this organisation. Secondly, it had to win approval and support from its potential users, i.e. the national PTT administrations, whose attitude, in fact, was very cautious. On the one hand, these considered that satellite links within the European continent would not be economical compared with the ground network, in which they had invested so much and which was rapidly expanding. On the other hand, they were reluctant to get involved in matters where political negotiations between foreign offices were more important than the usual technical agreements between telecommunications administrations.[778]

The third difficulty was the lack of a European launcher capable of putting a satellite into the geostationary orbit. The Europa rocket (or ELDO A), under development in ELDO, was not qualified for this, therefore any independent European programme in space telecommunications by geostationary satellites implied either the use of American rockets or an important change in ELDO's programme. The availability of launching facilities for scientific satellites had been assured by the American authorities but it was not evident that this would be granted even when commercial interests

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776 Le Monde, 29 January 1967, quoted in Hochmuth (1974), p. 158. ESRO's deputy Director General stressed that the first decade of the space age had been "the era of scientific satellites"; now a new phase was opening, "the era of application satellites", and telecommunications represented the most important sector of application satellites: Bertrand (1966), p. 26. See also Giarini (1968), pp. 95-107.

777 As an example, in the UK the different bodies responsible for space were the Ministry of Defence (military satellites), the Ministry of Aviation (space technologies and launchers), the Department of Education and Science through the Science Research Council (scientific satellites), the General Post Office (telecommunications): *Estimates Committee (1967)*, p. 1.

778 This last aspect was noted by the US representative during the early negotiations with the CEPT in 1964: Galloway (1972), p. 93.

were at stake. As to ELDO, we have seen in the previous chapters how this organisation was suffering from serious financial and technical difficulties.

The definition of a suitable institutional framework, the emergence of an important and reliable customer, and the building of a European launcher with geostationary capability were thus the necessary preconditions for the success of a communications satellite programme in the Old Continent.

9.2.1 The first definition of the CETS programme

In July 1963, at its second meeting, the CETS decided to create two subordinate bodies, a Committee on Organisation (CO), to cover juridical, administrative and financial matters, and a Space Technology Committee (STC), with the aim of defining a programme capable of qualifying the European industry to participate in the Intelsat procurement contracts. The STC worked out a five-year plan which foresaw two phases: a three-year phase of research and development starting in January 1965, financed on a national basis and co-ordinated by the STC itself; and a phase with multinational funding starting by the end of 1966. The plan was discussed at the CETS meeting held in Bonn in October 1964, the first after the signature of the Intelsat agreements. Here it was agreed to recommend to the Member States the start of the first phase, and to undertake a detailed study on the scientific, technical, economical and financial aspects of the proposed second phase. The Conference also set up a Technical Planning Staff (TPS), composed of experts from industry and governmental bodies under the direction of N. Simmons, from the British Ministry of Aviation, whose task it was to review the work on space technology in Europe and to propose a joint development programme for a European experimental communications satellite capable of meeting the requirements of the Intelsat global system.[779]

The TPS report was issued in December 1965. After surveying the current and potential European capability in space and communications technologies, the TPS summarised its views:

> *Europe has the potential capability necessary for development of communication satellites, but to realise this potential will require the purposeful execution of a well-planned co-operative programme.*[780]

The proposed programme was to be developed in five years at a cost of 370 million French francs (MFF). It consisted of three stages:

1. The use of the ELDO A test launchings F9 (planned in October 1968) and F10 (planned in mid-1969) for testing telecommunication components;

2. The realisation of an all-European experimental communications satellite;

3. The study of other application satellites such as for television broadcasting, navigation, and meteorology.

Three or four experimental satellites were foreseen, to be launched into a low inclination orbit at an altitude of 14,000 km (8-hour period) by the use of an improved ELDO launcher (ELDO A/S) or an American launcher. The realisation of such satellites, together with the development of a more advanced launching vehicle (ELDO B), was considered by the TPS a necessary step in order to put

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779 Bignier (1966); Blassel & Collette (1968). The terms of reference, the composition and the organisation of work of the TPS are reported in the notes on the first TPS meeting (12-14 January 1965), SCL/TPS/6E, 15 January 1965; HAEC, folder 1240.

780 TPS Report on European Potential and Recommended Development Plan, SCL/TPS/116E, 15 December 1965, p. 20; HAEC, folder 401.

Europe "in a position to participate fully in any competition to supply equipment for the global system, or any sub-system required, from 1970 onwards".[781]

The TPS objectives were more ambitious, however, than securing European industry a share of Intelsat procurement business. They recommended that, besides long-distance telephony, other important applications, such as satellites for direct television broadcast, navigation assistance to ship and aircraft, and meteorology. The TPS went as far as to consider that developing one of these alternative application satellites should be the real primary objective of the recommended telecommunications programme. The reason:

> *Since these other functions are ones which in general have a specifically regional interest, as opposed to the world-wide application of long-distance telephony, and since they are not at present the subject of international agreements giving a single organisation a monopoly of their exploitation, they may be particularly appropriate for European development effort.*[782]

9.2.2 CETS, ESRO and ELDO

While the TPS was working out its plan for a joint European communications satellite programme, a CO/STC working group discussed the institutional and financial aspects of such a programme, and in particular the possible use of the existing space organisations for its implementation.[783] In fact, both ESRO and ELDO had been invited to the various CETS meetings and had participated in the work of the STC. In September 1964, the chairman and vice-chairman of the STC, W. Stephens and M. Bignier, had visited ESTEC to discuss with ESRO's Technical Director A. Lines the prospects for possible collaboration.[784] The definition of a formal arrangement was not an easy task, however, for three main reasons. The first regarded the institutional aims of the two organisations. The ELDO Convention defined as the sole objective of the Organisation: "the development and construction of space vehicle launchers and their equipment suitable for practical applications and for supply to eventual users". In the view of the CO, this excluded the possibility of ELDO developing a communications satellite programme, unless important changes were made in its statute and organisation. No difficulty existed, of course, for ELDO to provide the vehicles for launching the satellites themselves.

A somewhat better situation presented itself in the case of ESRO. Article II of its Convention stipulated in fact that "the purpose of the Organisation shall be to provide for, and to promote, collaboration among European States in space research and technology [our emphasis]". This formulation could be interpreted as allowing the realisation of an experimental communications satellite. This, however, required a special approval from the Council and the proper integration of such an undertaking in the organisational, financial and technical framework of the Organisation. In any case, the ESRO Convention definitely excluded the eventual continuation of the programme towards commercialisation.

The second difficulty derived from the different membership of the various organisations involved. Only six European countries, plus Australia, were members of ELDO; ten were in ESRO; nineteen participated more or less regularly in the CETS meetings; and twenty-three belonged to the CEPT, five of which, however, had not signed the Intelsat agreements (Table 9-1). It was still unclear whether all

781 TPS Report, cit., p. 22. The ELDO A/S project consisted in the addition of a fourth stage (apogee) motor to the ELDO A launcher under development, in order to achieve orbits at higher altitudes. ELDO B was a project for a completely new rocket with geostationary capability.

782 TPS Report, cir., p. 31.

783 Reports on two meetings (1 April 1965 and 6-7 September 1965) of this working group are available: SCL/JWG/3F, undated, and SCL/JWG/10E, 20 September 1965. A CO working group charged to study the conventions of ESRO and ELDO was also set up and met on 20-21 May 1965, SCL/CO.13/3F, undated. All these documents are in folder 1240 of HAEC.

784 ESRO/36, 14 October 1964, p. 2.

ESRO Member States would be willing to participate in the communications satellite programme while, at the same time, some non-ESRO countries would certainly do so. This circumstance implied difficult problems regarding the legal arrangement of the collaboration, the management and financing of the programme, and the definition of the industrial policy.

Finally, there was the problem of the financing of the programme, i.e. whether only governments should contribute or whether private investments should also be considered, in particular for the operational phase of the programme, when profits might be produced by commercial activities. In this case, the CO/STC working group argued, one could envisage the formation of a Comsat-like European company, capable of challenging the American exclusive role in the management of the global system. This implied, however, the loss of governmental control over the telecommunications system, a prospect not as easily acceptable in Europe as it was in the US. Moreover, doubts were expressed as to "whether such financing would be practicable since such operation would require considerable investments and could derive only long-term profits, and perhaps, in the early stage, funds invested might be lost".[785]

Concluding this phase of its work, the working group recommended that governments and industries should be requested to give their views on the method of financing the European communications satellite programme and on the kind of institutional framework to be established for the experimental and the operational phase of such a programme. It was also agreed that the ESRO and ELDO Councils should be formally approached in order to know their opinions on the TPS report, now near completion, and on how the programme described there could be carried out.[786]

The answer of ESRO was immediate and positive: two weeks after the CETS's letter the Executive had already elaborated plans for the technical and financial management of the CETS programme. Ten days later the Council agreed that "an encouraging reply should be sent to the CETS, declaring the Organisation's interest in close co-operation".[787] As a consequence, at the following meeting of the CO/STC working group, held in February 1966 with the participation of delegations from ESRO and ELDO, a large majority emerged in favour of appointing ESRO in the role of manager of the telecommunications programme.[788] Four reasons were explicitly given for this choice: (a) the requirements for a communications satellite would determine the design and the requirement of the launching vehicle and not the opposite; (b) the facilities available to ESRO were more apt to deal with telecommunication problems; (c) the membership of ESRO included all countries likely to be interested in participating in the execution of the programme; (d) it appeared easier to have the cooperation of the other organisation as sub-contractor than if ELDO were chosen.[789]

ELDO, however, was the main problem in the path towards an autonomous European communications satellite programme. In fact, in spite of the conclusions of the TPS report, no telecommunication programme could start before bringing to solution the crisis that ESRO's sister organisation was living in 1965-66.

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785 SCL/JWG2/10E, cit., p. 3.

786 ESRO/C/145, 8 November 1965, with attached copy of a letter, dated 28 October 1965, sent by the chairmen of the CETS Committees on Organisation and on Space Technology to the chairman of the ESRO Council and to the President of the ELDO Council.

787 ESRO Council, 9th session (24-26 November 1965), ESRO/C/MIN/9, 31 January 1966, p. 25. The document of the Executive is ESRO/C/150, 13 November 1965.

788 Three reports on this meeting (10-11 February 1966) are available: the "Conclusions of the Chairman", SCL/JWG4/1E, 14 February 1966; a "Summary report" dated 25 February 1966; and the ELDO document ELDO/C(66)14, 21 February 1966. The first two documents are in folder 1240, HAEC. See also Bignier's report at the 21st AFC meeting (8-11 March 1966), ESRO/AF/MIN/21, 16 May 1966, pp. 9-10. It must be noted that the possible use of the ELDO launchings F9 and F10 for telecommunications experiments was to be negotiated directly by ELDO and CETS.

789 With respect to the last point, ESRO Director General P. Auger had made it clear to CETS that ESRO would not accept a position of sub-contractor of ELDO.

9.2.3 The ELDO crisis of 1965-1966 and the start of the ELDO-PAS project [790]

The problem of the European launcher was hotly debated in 1965-1966, both in the ELDO Council and in the wider political circles involved in discussions on the European space policy. ELDO's initial programme called for the development of a three-stage rocket, called Europa (or ELDO A), with the capability of launching a large satellite into a near-Earth circular orbit (e.g. 800 kg payload at 550 km). The construction of this rocket was entrusted to the Organisation's Member States: the first stage was based on the British former military rocket Blue Streak, the second stage (Coralie) was to be built in France, and the third stage (Astris) in Germany. Italy was given the task of building a series of test satellites, Belgium was to provide down-range ground guidance stations, and the Netherlands the long-range telemetry links. In addition to these European countries, Australia had also joined ELDO, making its launching base of Woomera available to the Organisation.

By the beginning of 1965, however, it was recognised that much of ELDO's initial programme needed to be revised. Firstly, the cost of completing the programme had risen up to more than twice the original estimate (£ 143 million as compared to £ 70 million). Secondly, the objective of the initial programme appeared obsolete *vis-à-vis* the recent development of space activities: the Europa rocket, in fact, was not powerful enough to launch into a geostationary orbit the payload necessary for a telecommunications mission. The crisis burst in January 1965, when the French delegation in the ELDO Council called for the abandonment of the initial programme and the start of a new programme for a more powerful rocket (ELDO B), aimed at providing Western Europe with launching capability into the geostationary orbit.

A Working Group was set up with the task of formulating proposals for a reorientation of ELDO activities, and in the course of 1965 plans for the realisation of the ELDO B vehicle were elaborated at technical level. The political aspects were far from being resolved, however, and negotiations lasted a year and a half. France, on the one hand, strongly advocated an independent European launcher capability, following President de Gaulle's policy of national independence in strategically important areas of science and technology. Britain, on the other hand, felt that its heavy investment in ELDO was not worth the results to be expected and cast doubt both on the validity of the initial programme and on the possibility of successfully developing any future programme like ELDO B. In June 1966, the new (Labour) British government went as far as to anticipate the withdrawal of the United Kingdom from ELDO.

A compromise was eventually reached at a Ministerial Conference of ELDO Member States held in July. Here, in return for a dramatic reduction of Britain's financial contribution to the budget of ELDO (from 38.8 to 27 per cent), it was agreed to undertake a new launcher project, called ELDO-PAS or Europa II, designed to launch a 150 kg satellite into geostationary orbit when fired eastwards from the equatorial base of Kourou, in French Guyana. Europa II was not a really new rocket, as ELDO B was intended to be, but rather a modification of the Europa launcher (now called Europa I) in order to make it capable of injecting a satellite into geostationary orbit. Its design in fact consisted of the addition of the so-called "perigee-apogee stages" (PAS) to Europa I, namely a fourth stage (perigee motor) capable of injecting the satellite into a transfer orbit, and an apogee motor in the satellite itself to fire it into geostationary orbit (Figure 9-3). The ELDO-PAS programme thus allowed ELDO to take advantage of the work already done on the initial Europa programme, whose continuation up to

790 We synthesise in this section the contents of chapters 3 and 4 in order to make this chapter self-consistent. See also Pfaltzgraff & Deghand (1968); Hochmuth (1974), 59-98; and Schwarz (1979).

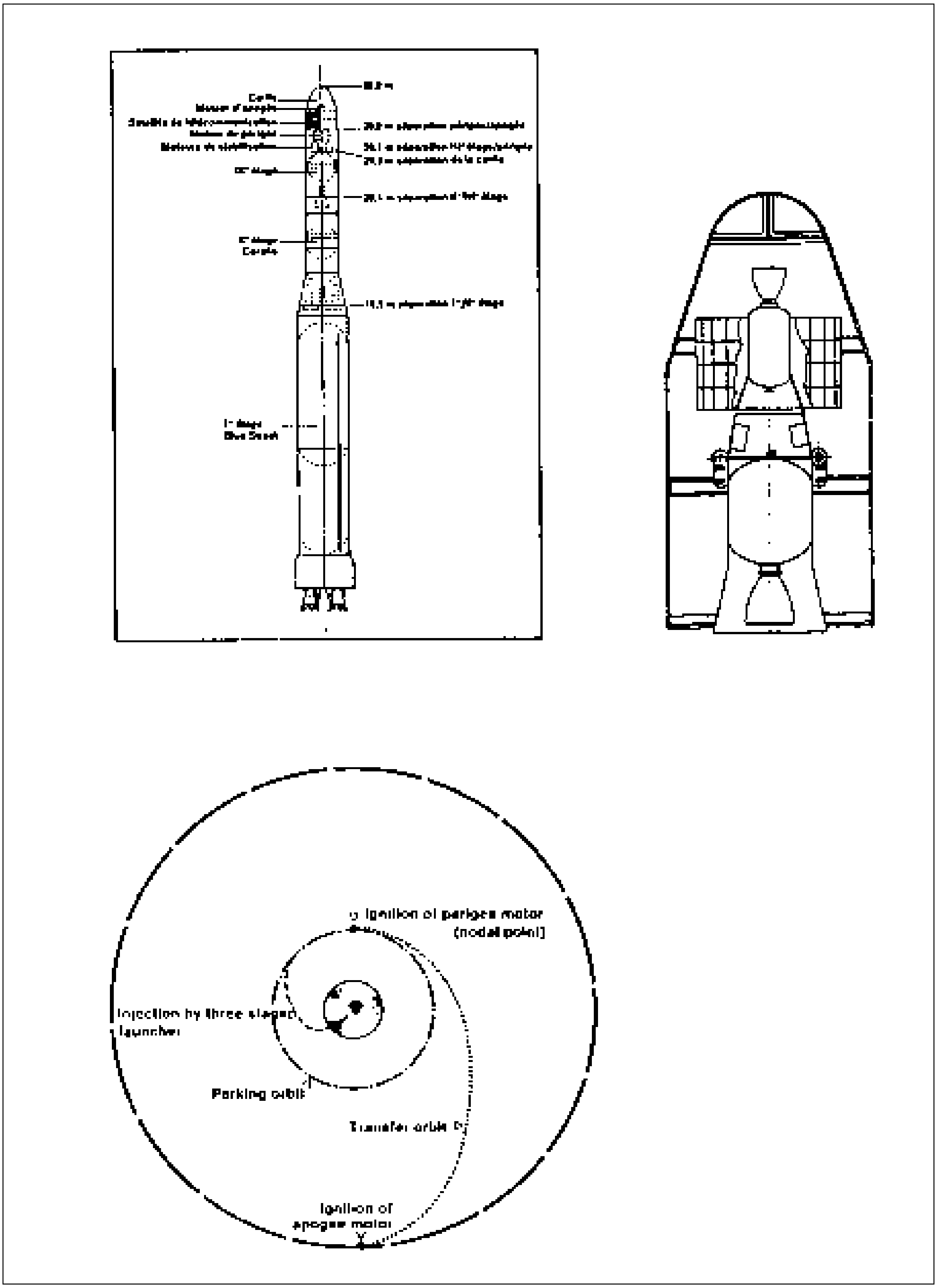

Figure 9-3: The ELDO-PAS concept

completion was also approved. A new management scheme was also defined, in order to solve some of the problems which had beset the Organisation since its beginning.[791]

9.2.4 ESRO's first studies of communications satellites: CETS A and B

The compromise worked out for ELDO promised to provide Europe by 1970 with a launcher capable of putting a communications satellite into geostationary orbit. This element, as well as the most recent developments of Intelsat, changed the framework of the TPS plan. The TPS therefore prepared a supplementary report in which the new possibilities were assessed in the light of the success of Early Bird and the growing political and social importance of real time television distribution.[792]

The first important aspect put into evidence was the decision of Intelsat to base its system on geostationary satellites. Plans for the new generation of Intelsat III satellites were already under development, noted the TPS, with a view to establishing a world-wide service of satellite communications by the end of the decade. The European share in the procurement contracts for such a system would be only 4.5 per cent of the total cost. In this perspective the place of Europe could only be very limited:

> *The yield to Europe in communication satellite technology from Intelsat III procurement is limited in both quality and quantity, e.g. it involves mainly repetitive work and little of the creative element. It falls short by an order of magnitude of the minimum programme recommended in [the original report] and cannot, by itself, generate the required capability, nor the envisaged European potential.*[793]

At the same time, the TPS concluded, it was difficult to forecast the specification for an eventual successor to Intelsat III and it could not confidently be predicted that the payload capability of the ELDO-PAS launcher would be adequate for this purpose.

Against this background, a re-definition of the CETS objectives was called for, leaving aside the field of transoceanic telephonic communications, where so little room existed to compete successfully, and taking into account the specific needs and interests of Europe. After discussing the most recent developments and trends in the various fields of application satellites (aeronautical and maritime communications, television distribution and broadcasting, navigation, meteorology, regional telephonic communications), the TPS experts indicated television distribution and broadcasting as the most promising field of activity for Europe and urged the CETS to start an experimental programme in this field.

At the 6th meeting of the CETS, on 22-24 November 1966 in The Hague, the TPS proposal was finally accepted by the Conference as the basis of a joint European programme in communications satellites. A tentative institutional framework was also agreed for the implementation of this programme, which

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791 ELDO, Report to the Council of Europe for 1966. A technical description of the ELDO-PAS system is in Blanc (1966) and Nouaille (1968). The launch eastwards from an equatorial base made it possible to take advantage of the rotation of the Earth. The ELDO-PAS project was approved by ELDO Member States as a "supplementary programme", in addition to the "initial programme" described in the ELDO Convention. The project also included the installation of an inertial guidance system in the third stage of the Europa rocket, the establishment of an operational firing range in Kourou suitable for equatorial launchings and the development of a suitable ground network. The reduction of the British financial contribution was balanced by the other Member States: France (from 23.9 to 25 %), Germany (from 22 to 27 %), Italy (from 9.8 to 12 %), Belgium and the Netherlands (from 2.85 and 2.64 % respectively to 9 % jointly).

792 This supplementary report (SCL/TPS/116/Supplement, 6 September 1966) is attached as Appendix 3 to ESRO/C/225, 14 September 1966.

793 TPS/116/Supplement, cit., p. 4, emphasis in the original.

foresaw that ESRO be entrusted with its management in close co-operation with ELDO.[794] The Conference then decided to commission ESRO to undertake a feasibility study of the programme described in the TPS reports and, on this basis, a formal agreement between the two organisations was defined and duly approved by the ESRO Council.[795]

The agreement with the CETS foresaw that ESRO should prepare a feasibility study of a European communications satellite programme aiming at the development of an experimental satellite for telephony and television distribution, comparable to the Intelsat III satellite then under development. Three satellites were to be built and launched into geostationary orbit by Europa 2, the first launching being scheduled for 1971. The study was also to include development plans, financial estimates and proposals for the organisation of work. Finally, the study was to provide indications about further developments on second generation telecommunications systems and other application fields. The total cost of the programme was not to exceed 435 MFF, i.e. 280 MFF for the experimental satellites (including 135 MFF for the provision of the launchers), 55 MFF for the associated programmes of research and development, and 100 MFF for studies of other applications. The sum of 1.5 MFF was made available to ESRO by CETS Member States for the realisation of the feasibility study, and a report was expected by the end of May 1967.

Thanks to the work of a team of about 30 engineers under the direction of P. Blassel, the study was completed in due time and the final report was sent to the CETS delegations.[796] Two types of experimental satellites meeting the mission specification defined by the TPS were presented. The first satellite (CETS-A) could be developed in four years, taking advantage of the industrial capabilities existing in Europe. The second (CETS-B) involved more advanced technological developments and thus belonged to a later stage in the series of future objectives.[797]

9.3 Technical optimism and political setbacks (1967)

ESTEC's study was discussed in the various CETS committees and arrived on the tables of the second meeting of the European Space Conference (ESC), convened in Rome on 11-13 July 1967 to discuss the prospects of a coherent space policy for Europe.[798] As a matter of fact, the prospects for such a policy could hardly be considered with optimism at that time. ESRO was virtually without a programme and was living a dramatic institutional and financial crisis. Its Member States, in fact, could not agree unanimously (as demanded by the Convention) on the level of resources for the second three-year period (1967-69) and the Organisation was thus prevented from making any long-term plan. Its most important and ambitious project, the Large Astronomical Satellite (LAS) seemed definitely jeopardised and a drastic reduction of its initial programme was inevitable.

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794 CETS, 6th Plenary Meeting (22-24 November 1966): "Summary of conference decisions", SCH(66)21E, (Revised), 28 November 1966; "Provisional summary record", SCH(66)23E, 30 November 1966; folder 1240, HAEC. It must be noted that the meeting decided to enlarge the terms of reference of the CETS, in order to include other application fields besides conventional telecommunications. The meeting was attended by representatives of Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Monaco, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, Vatican City. Observers attended from Greece, Australia, ELDO (the deputy Secretary General W. Stephens), ESRO (the Director General P. Auger) and the CEPT.

795 ESRO Council, 14th session (30/11-2 December 1966), ESRO/C/MIN/14, 20 January 1967, p. 45-46. The development of ESRO/CETS negotiations, including correspondence, draft agreements, technical specifications and the CETS' November resolution, are reported in ESRO/C/221, 27 July 1966 (with add. 1, 16 September 1966; add. 2, 13 September 1966; add. 1, rev.1, 21 September 1966); ESRO/C/225, 14 September 1966 (with 3 appendixes); ESRO/C/245, 29 November 1966 (with 3 appendixes). On ELDO side, see ELDO/C(66)57, 6 October 1966, and ELDO/C(66)62, 29 November 1966. For ESRO/ELDO negotiations, see ELDO/C(67)24, 31 March 1967, ESRO/C/279, 24 April 1967, and the correspondence in folder 402 (HAEC).

796 Letter, P. Auger to A. Hartog (President of the CETS), 30 May 1967: HAEC, folder 401.

797 Blassel & Collette (1968), Collette (1993).

798 The setting up of the European Space Conference is discussed in chapter 9.

With regards to ELDO, the approval of the Europa II programme had not removed the reasons for conflicts between the various national interests. While giving Europe an adequate degree of independence in the capability of launching application satellites, the ELDO-PAS system could not be considered the last word in the path towards real European autonomy. Foreseeable developments in space communications technology and other application fields called for much heavier satellites and more powerful rockets. And here the disagreement sharpened between the countries sceptical about the prospects of a launcher development programme and those firmly committed to achieving European autonomy in this field. Britain and France, as expected, led the opposite camps. For the British Estimates Committee, the ELDO programmes had no future: the only firm prospective buyer of Europa II was the French Government (two launchers), while Intelsat would hardly have used a rocket costing about two and half times an equivalent American launcher. As to Europa I, the likely abandonment of the LAS by ESRO implied the loss of the only foreseeable client for this launcher. In conclusion, the Committee recommended that Britain should oppose any proposal to further develop the ELDO-PAS programme, let alone undertake more advanced projects, and should rather invest mostly on the all-British light satellite launcher Black Arrow.[799] France, on the contrary, insisted that Europe could not sustain a credible space policy in commercially interesting application fields without the availability of its own launchers.

This disagreement over launchers paralleled that regarding the prospects of the joint European communications satellite programme. While agreeing on the financing of ESRO's feasibility study, CETS Member States were far from being equally convinced of the opportunity of undertaking the programme itself, due to the great uncertainty about the economic aspects.

According to the TPS, which had been requested by the CETS meeting in The Hague to make a study of the economic aspects of application satellites, the investment required for the development of the experimental communications satellites would not be amortised in the period 1970-75. They stressed, however, that in the long-term period (i.e. in 10-15 years) the whole foreseeable field of satellite applications would cover important economic sectors and would lead ultimately to benefits many times the investment involved. Besides the eventual direct economic benefits, the TPS also underlined that it was important for Europe to control the technological development of application satellites instead of relying exclusively on U.S. technology.[800]

Against the TPS's optimistic vision, however, an economic study made by the CEPT concluded that a European communications satellite system would be more expensive than the conventional ground links and, moreover, would not be competitive in comparison with the cost of using the Intelsat system. In contrast, the Eurospace consortium found that an operational system for telephony and television transmission would be profitable *vis-à-vis* conventional systems already in the second half of the 1970s.[801]

The doubtful arguments about the economic and financial aspects, as well as the lack of a unifying political and institutional framework, made the CETS incapable of establishing clear guidelines. And the distance between its principal members was becoming wider and wider. In the United Kingdom, the Post Office was adamantly against any direct involvement in communications satellites, considering that the best way the country could secure its interests in the future of space

799 Estimates Committee (1967), pp. xxvi-xxvii. The Black Arrow project for a three-stage satellite launcher had been started in 1964 but the decision to proceed with this programme was taken by the British government only in 1966. The programme was to be completed within three or four years. The programme, in fact, was cancelled even before the first and last operational launch of the rocket in October 1971: "Britain will cancel Black Arrow space programme", The Times, 30 July 1971; "Choosing Britain's place in the space race", ibidem, 29 October 1971.

800 TPS, Economic Potential for Europe of Application Satellites, SCL/TPS/217E, 30 May 1967: HAEC, folder 401 bis.

801 The CEPT study had also been requested by the CETS at its The Hague meeting. Both this study and that of Eurospace are referred to in the TPS study. A comparative analysis of the three studies is in the Causse Report (fn. 65). See also Müller (1991), pp. 110-112.

telecommunications was by building and commercialising ground stations within the Intelsat system. For the Estimates Committee, the CETS was "not an organisation but a continuing conference [whose] continued existence in its present form would appear unlikely to achieve any useful purpose". The Committee then recommended that Britain should not take part in the CETS programme for a television distribution satellite but should rather undertake a project to build an all-British satellite in the framework of the Anglo-American military space communications system Skynet.[802]

France and Germany, on the contrary, were the most active among the advocates of European autonomy in space. Both countries in fact managed to come down to business without waiting for the outcome of pan-European ventures. France announced at The Hague conference the decision of its government to undertake a national programme for a 3-axis stabilised communications satellite, called Saros II, designed for launching by ELDO-PAS. The mission of this satellite was very similar to that of the CETS project, i.e. to provide telephone circuits and television distribution over an area covering Europe and North Africa, and this caused a great deal of worry to some delegations which feared that the French project would jeopardise the joint European project. [803] Germany, for its part, started a national project for a spin-stabilised satellite, called Olympia, designed to relay television pictures of the Munich Olympic Games in 1972. Eventually, the two countries combined their efforts and reached agreement on a bilateral project which they called Symphonie. Italy too decided in 1968 to develop its own national programme in satellite telecommunications, project Sirio, based on the work made on the experimental satellite originally designed for ELDO-PAS.[804]

The discussions about launchers and communications satellites naturally involved important political aspects of the relationship with the United States and the role of European countries in the Intelsat framework. Facing the strong American position in satellite telecommunications and heavy satellite launchers, France was determined to prevent a US monopoly of communications satellites and to develop regional systems covering the area of French (and European) cultural influence. They pressed for the development of a vigorous European programme in satellite telecommunications, which could not leave out the development of suitable launching vehicles. This insistence on European independence in space was consistent with President de Gaulle's policy of political, economic, military and technological independence from the superpower beyond the Atlantic, and the French government was able to co-ordinate the actions of all its bodies within the framework of this policy.[805]

Britain, instead, moved within the Anglo-American "special relationship," reinforced by de Gaulle's veto against Britain's membership in the European Community in May 1967. They thought that very few possibilities existed for an autonomous European action in the space sector of space communications, both because of the strength of the American presence and because of the foreseeable small commercial demand for the kinds of communications satellites that Europe could build and launch. Europe, according to the British, should concentrate all effort on obtaining more favourable conditions for its industrial interests in the Intelsat framework.

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802 Estimates Committee (1967), pp. xix and xxvi-xxvii. The definition of the CETS as a "continuing conference" was suggested to the Committee by the Head of the Foreign Office's Scientific Relations Department, E.G. Willan, on p. 103. The BPO's position is presented in a memorandum, pp. 48-51, and in the witness of two top officials, pp. 52-74. The Skynet programme started in 1965 and a satellite was launched in 1969 over the Indian Ocean, mainly for maintaining communications with British forces east of Suez. The satellite had been manufactured in the United States while Britain provided the ground stations. The programme contemplated the launch of two satellites of an improved type in 1973: Select Committee (1971), pp. xxv-xxvi and 164-165.

803 SCH(66)23E, 30 November 1966, c5t., pp. 21-23. Such worries were expressed with particular vigour by Belgium and were repeated at the STC meeting on 12-13 January 1967. A report on this meeting was prepared by A. Dattner for Auger, 17 January 1967, HAEC, folder 1240.

804 On Symphonie, see Hochmuth (1974), pp. 157-171. On Sirio, Ragno & Amatucci (1978), pp. 63-122, and Sirio (1978).

805 McDougall (1985b).

In conclusion, looking at the main European countries, France regarded space as a key element in its political strategy; Germany as an important element for the country's technical development, especially in key fields where its industry was highly competent, like communications electronics; Britain as a business to be pursued as long as it produced an economic return.[806] As H. Bondi plainly put it, for the benefit of the British Select Committee on Science and Technology:

> *As usual, the two opposite poles were France and the U.K. The French motivation was very strongly a European presence in space, a European independence of America, never mind what the cost benefit analysis shows, and the British attitude was if you could not show - if I may exaggerate a little - that it was the sort of project that the bank would be happy to finance, then it should not be done anyway.*[807]

At the Rome ESC meeting, the ESRO study of the CETS satellites found itself in the framework of this complete lack of agreement about European space policy and, moreover, it had to confront the challenge of Symphonie.[808] The German delegation stressed that this project was "not an alternative, but a complement to the CETS project, aiming towards the advanced satellite which is the objective of the European nations".[809] The French, for their part, stressed the importance of solidarity amongst the European states engaged in space activities and insisted that they should give priority to the development of technologically advanced communications satellites. The other delegations' opinions regarding the Franco-German project were much variegated: open hostility was expressed by Belgium, which advocated a European joint project and feared that Symphonie would undermine the CETS undertaking; the Italian argued that further development of the PAS satellite that they were preparing for ELDO might be proposed as an element of the European communications satellite programme; the British insisted that any such programme should be assessed from the economic and commercial point of view.[810]

In the event, as is usual the case when big controversial issues are on the table, the Conference decided not to decide. It agreed instead to create an Advisory Committee on Programmes, with the task of elaborating a coherent space policy in Europe and proposing programmes in the framework of such a policy. The head of the French CNES centre at Brétigny, J-P. Causse, was appointed as the chairman of the Committee, whose work produced a report by the end of the year.[811] Before discussing it, however, we must report on an important development which happened just after the closing of the Rome conference.

9.3.1 The European Broadcasting Union (EBU) and the Eurafrica project.

While Symphonie was being developed and ESRO was studying its communications satellite projects for Europe, the need arose of finding a client, i.e. a user able to transform an experimental device into an operational system and a commercial article. Most PTTs, as we have seen, had a more than lukewarm attitude towards satellite telecommunications for Europe. But a "frustrated customer of the PTTs" offered ESRO a possible alternative.[812] This was the European Broadcasting Union (EBU), the association of television companies which operated the Eurovision system. The transmission of Eurovision programmes was realised by the EBU through a network of wide-band cables provided by the PTT administrations on a commercial basis. The establishment of such a network, however, required several hours, the cost of the service was considered too high, and the distribution was limited to the countries connected to the existing network. The use of a satellite relay system could provide the EBU with its own distribution network, which could be operated in real time at short notice, and

806 Schwarz (1979).
807 Select Committee (1971), p. 186.
808 ESC, Rome meeting (11-13 July 1967), CSE/CM/(July 67)PV/1-6, 11-13 July 1967.
809 CSE/CM/(July 67)PV/2, p. 2.
810 CSE/CM/(July 67)PV/2, pp. 2, 6-7, and Annex I; CSE/CM/(July 67)PV/3, pp. 2-5.
811 Report of the Advisory on Programmes (hereafter Causse Report), CSE/CCP(67)5, December 1967.
812 Collette (1993), p. 89. Also Blassel & Collette (1968).

capable of reaching all countries from which the satellite was visible, in particular African Near East countries in the European cultural area.

As early as January 1967, when ESRO was starting its study of the CETS programme, the President of the EBU, J.B. Broeksz, had expressed to Auger the great interest of his organisation for this work and specified the requirements of a possible satellite for the Eurovision system.[813] Then, at the CETS meeting held immediately after the Rome conference, the EBU Director General officially confirmed the interest in ESRO's work and requested that it should be pursued with consideration of the EBU requirements. As a consequence, the CETS agreed to grant ESRO 1 MFF to continue the studies already executed, and to design an experimental communications satellite programme, distinct from Symphonie and meeting the needs of the Eurovision system. The cost of such a programme had to be limited to 450 MFF.[814]

The opportunity offered by the EBU presented several advantages to the European organisations involved in space. Firstly, it allowed ESRO to keep its technical team united and working on the communications satellite project instead of dispersing it pending the decision on its actual development.[815] Secondly, it offered the CETS a way out the embarrassing situation of having a "European" project too similar to that developed by two of the most important European countries. Finally, it provided ESC delegations with the example of a communications satellite more oriented towards operational activity than towards experimentation.

The CETS request was duly approved by the ESRO Council and work was resumed in ESTEC by Blassel's team.[816] Two projects were studied in particular. The first was a system satisfying the requirements of the EBU (satellite CETS-C or Eurafrica), namely the replacement of ground circuits with space links to provide simultaneous distribution of two Eurovision-type television programmes within Europe and North Africa. The second was an experimental system for semi-direct television broadcast (satellite CETS-D or Geovision). Both projects required development time scales of about five years, but only the first satellite fell within the financial limits of 450 MFF fixed by the CETS and was within the launching capability of the Europa launcher.[817]

In December 1967 the ESTEC study was sent to the CETS delegations and to the Causse Committee. The latter, in its report, strongly recommended the Eurafrica project as the application satellite project to be initiated in the immediate future. In the words of the report:

> *The problem set by the EBU has, in fact, considerable attraction. It sets a target for technological studies that is sufficiently ambitious while at the same time being almost capable of attainment; it makes it immediately possible to acquire very valuable operational experience in both the space sector and the ground sector; it can lead rapidly, if desired, to operational activity on what appears to be a good economic basis; and in any event it will provide useful data for the study of the future economic aspects of television satellites.*[818]

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813 Broeksz to Auger, 20 January 1967, HAEC, folder 1240. Auger's reply, 6 February 1967, is also ibidem.

814 Letter from the CETS President A. Hartogh, to ESRO Director General P. Auger, 19 July 1967, HAEC, folder 402. Also in ESRO/C/302, 26 July 1967, Annex 1.

815 The worry about "breaking brutally" the work of the technical team was expressed in a letter from Auger to Hartogh, 21 March 1967, HAEC, folder 1240.

816 ESRO Council, 18th session (27 July 1967), ESRO/C/MIN/18, 14 August 1967, p. 8. Auger to Hartogh, 28 July 1967, HAEC, folder 402.

817 Letter from ESRO's new Director General, H. Bondi to Hartogh, 30 November 1967, HAEC, folder 402. A satellite for television distribution has the same role as a normal TV repeater, namely its signals are collected in the normal TV network and re-transmitted by standard UHF waves. A satellite for semi-direct television broadcast sends signals that can be collected by an antenna and redistributed by cables within a small community. Direct television broadcast by satellite means that signals from the spacecraft can be collected by individual users by means of a small antenna.

818 Causse Report, p. 24.

As to the commercial point of view, the Causse Committee had performed a comparative analysis of the three studies prepared respectively by the TPS, the CEPT and Eurospace, with the conclusion that "the proposal for a television relay satellite system comes closest, among the European space projects under discussion, to having a prospect of financial viability in the foreseeable future". As to the other projects, they concluded that a European satellite used exclusively for telephony, telegraphy and data transmission did not appear financially justified in the short term but could become viable in the period 1975 to 1980. No definite conclusion could be arrived at on the economic validity of semi-direct and direct TV broadcast, and on other application fields.[819]

From the technical point of view, the Eurafrica satellite (Figure 9-4) represented an important step forward in relation to previous American satellites as well as to Symphonie. The former, in fact, were based on spinning technology to assure the stabilisation of the spacecraft. As to Symphonie, its design did foresee the more sophisticated three-axis stabilisation to keep the satellite firmly oriented towards the Earth, but its solar cell array was not designed to track the Sun. The Eurafrica design, on the contrary, adopted "four-axis" stabilisation, namely three-axis stabilisation of the body of the satellite and Sun-pointing solar array.[820] Other characteristics, like a longer operational life (5 years), a higher power output, and a less expensive earth station, made Eurafrica a kind of prototype of an operational satellite designed to meet the requirements of a well defined client, while the Franco-German project still belonged to the experimental stage. The EBU in fact reaffirmed its interest in the project and, in July 1968, its General Assembly officially approved the use of an operational satellite system for Eurovision based on Eurafrica. The EBU specified that they were ready to bear the cost of the operational satellites following the experimental one, provided that it should not bear any development costs of the latter and that the annual average expenditure of the operational system did not exceed that of terrestrial circuits or other means of television distribution that might be available at the time of launching.[821]

9.3.2 The Causse Report and its "wholehearted" reception in ESRO

The immediate start of the Eurafrica project was an important aspect of the "balanced programme" suggested in the Causse Report, which included the development of scientific and applications satellites and a European launcher to follow Europa 2.[822] The programme was articulated in four phases, each requiring definite decisions to be taken at different times of its development. The first phase, whose start was to be decided as soon as possible, foresaw the continuation of the Europa 1 and Europa 2 programmes, the start of the Eurovision satellite programme and the development of a scientific programme according to one of three possible options. The first foresaw the continuation of the LAS project which, however, was "at the limit of Europe's present technical and financial resources".[823] The second option considered the abandonment of the LAS and the realisation of some two scientific satellites per year, which was considered a "minimal programme". The third option foresaw the start of an experimental meteorological satellite programme, with a corresponding reduction of the scientific programme.

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819 Ibidem, p. 75. The comparative analysis of the three studies is presented in Annex 6.

820 A description of the Eurafrica satellite and its mission is in Blassel & Collette (1968). See also Collette (1993). Two industrial offers had been presented for Simphonie, one from the Aérospatiale-MBB consortium, the other from Matra. The latter did foresee sun pointing of the solar array but it was the former, which did not, that won the contract. It must be noted that three-axis stabilisation was a rather advanced technology, under development at that time in the framework of NASA's ATS (Applications Technology Satellite) programme. The launching of ATS-6, the first three-axis stabilised satellite, was in 1974, only months before the launching of Symphonie: Giget (1993).

821 Broeksz to Hartogh, 1 December 1967, reported in Annex 3 to the Causse Report. See Davidson (1970), p. 11.

822 For a more detailed discussion of the Causse Report see chapter 9. Here we limit ourselves to those aspects which are relevant to our presentation of ESRO's early activity in communications satellites.

823 Causse Report, p. 15.

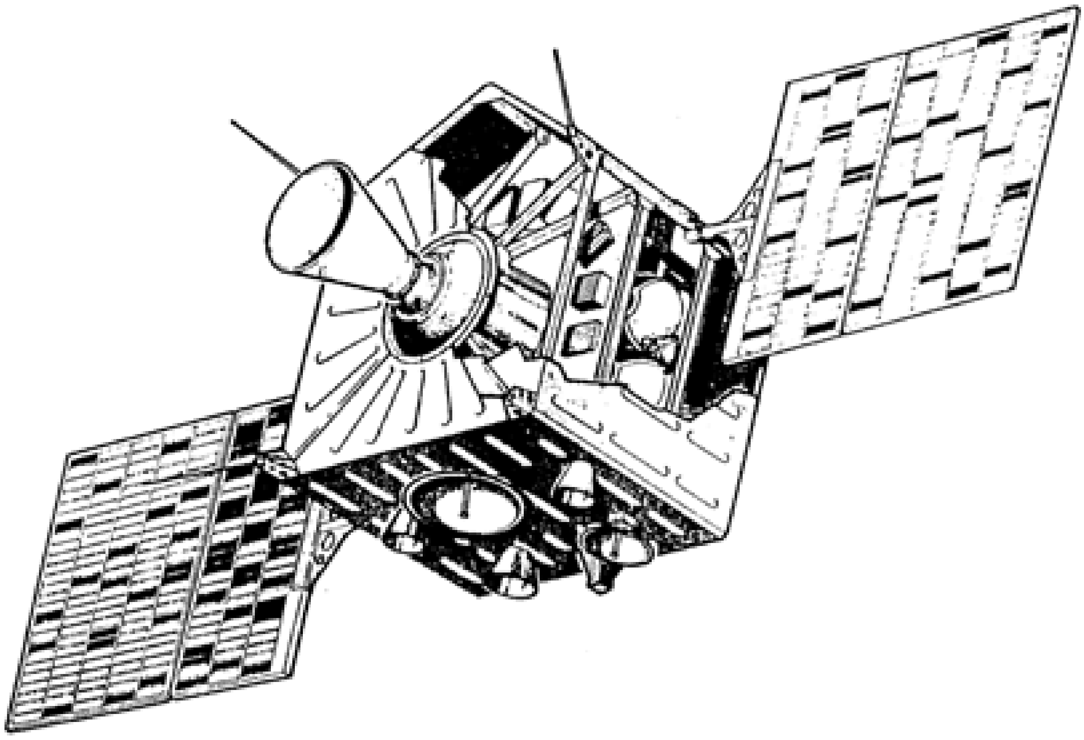

Figure 9-4: The Eurafrica satellite

The second phase was to start with the decision, to be taken by 1969, to embark on a launcher project with greater capability than Europa II, together with a programme for a second generation communications satellite. The Europa III rocket, as it was called, was to become operational in 1975-76 and would have the capability of putting into geostationary orbit a 500-kg satellite for semi-direct TV broadcasting. The following phases three and four were only roughly described, featuring the development of a vehicle for launching a 2-ton payload into geostationary orbit and the start of "a project of major importance in science or a field of application, that would not be a mere repetition of projects already carried out in the US or the USSR".[824]

All decisions about the actual implementation of the programme described in the Causse Report were deferred to the forthcoming meeting of the European Space Conference, planned in Bonn in spring 1968. No major technical or political impediment seemed to exist, however, for the eventual realisation of the television relay satellite project. The ESRO staff, in fact, welcomed "enthusiastically" the Causse Report and its suggestion that ESRO should be entrusted with a development programme of application satellites. With the likely abandonment of the LAS and the growing difficulties in obtaining from Member States important resources to develop pure science, the involvement in application programmes appeared as the new rationale for ESRO continuing its very existence and the only way to provide ESTEC engineers with challenging enough projects. In the words of the Executive:

> *A decision to this effect would enable better advantage to be taken of past and future investments in installations, technical research, and the training of specialist staff.*[825]

The message that ESRO's founding father and first Director General P. Auger wrote at the moment he left the Organisation echoed the general optimism:

> *Les programmes opérationnels devront être partagés de façon judicieuse entre les missions à caractère purement scientifique et les missions ayant pour but des applications, telles que télécommunications, météorologie ou navigation. Ce partage tiendra compte des besoins des groupes scientifiques dans les Etats Membres comme des besoins technologiques résultant des applications projetées, mais aussi des influences réciproques de ces deux types d'entreprises. Les efforts dans les domaines de la science pure et des applications, loin de se contrarier, devront être harmonisés entre eux, et conduire ainsi à une plus grande efficacité.*[826]

Auger's successor, the British scientist Hermann Bondi, expressed his confidence that the Organisation would carry out the communications satellite programme "with the full and enthusiastic support of the whole organisation from the management down"[827] The new Director General saw several advantages in the development of a large balanced programme involving scientific and applications projects. The first was a more efficient use of existing capital resources and of new capital investment. Secondly, such a programme would facilitate the attainment of more equitable geographical distribution of contracts, "which is in the forefront of the new ESRO Directorate's preoccupations".[828] Finally, a large and challenging programme would require a substantial increase in ESRO's staff and would make the Organisation's technical establishments more attractive in recruiting the best engineers. Bondi knew however that ESRO owed its very existence to the European scientific community and that their support was more than ever necessary in this delicate passage:

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824 Ibidem, p. 63.
825 ESRO/C/347, 24 April 1968, annex, p. 3.
826 Auger (1967), p. 32.
827 ESRO/C/325, 25 January 1968, p. 2. This is Bondi's statement at the meeting of the Committee of Deputies of the CETS (22-23 January 1968).
828 Ibidem, p. 1.

> *The integration of [the CETS] project in ESRO's scientific activity constitutes one of the most important issues that ever faced ESRO's Council. For a positive decision we require the support of the scientific community which we have gone a long way (but have not succeeded completely) in convincing that the application work is a beneficial complement to our scientific programme and not a dangerous competitor.*[829]

Bondi in fact undertook the very delicate task of convincing his scientific colleagues that "ESRO could not survive on a very narrow base of pure scientific research". As he recalled later, "There was really not much of a choice".[830]

9.4 The worries of the scientists

It was not obvious to ESRO, whose raison d'être was the pursuit of pure research, that it should undertake the development of application satellites. At least, it was not so obvious to the scientists as it was to the other direct protagonists of ESRO's activities. We have seen already the enthusiasm of the ESRO staff. No major problems existed in the eyes of the Council's Administrative and Finance Committee (AFC) either. The Committee recognised in fact that, from the legal point of view, articles II and XIII of the Convention provided a sufficient basis for engaging ESRO in the work requested by the CETS: the former mentioned the promotion of both space research and space technology as the aims of the Organisation; the latter stated that, by a unanimous decision of the Council, ESRO could cooperate with other international organisations.[831]

The scientists' perspective was different, however. As soon as the ESRO Council gave its first "encouraging reply" to the CETS in November 1965, the vice-chairman of the Scientific and Technical Committee (STC), the Danish physicist B. Peters, sent a long letter to chairman R. Lüst to express his opinions about a question that, in his opinion, "will no doubt have a profound influence on the future evolution of European space research".[832]

Peters recalled that ESRO had been funded as an organisation solely devoted to pure research and stressed that its policy had to be dictated by scientific considerations only. He indicated the serious disadvantages for scientific research which, in his opinion, could arise out of a merger of scientific, technological and commercial activities. The first regarded the budget: in the long run, argued Peters, the part of the ESRO budget devoted to the application programme would certainly become predominant with respect to that devoted to scientific research. A second disadvantage regarded institutional aspects: important policy decisions, he said, would depend on elements other than scientific interest. As Peters vividly put it:

> *The rate of build up, the future launching programme, the relative scale of efforts going into different ESRO establishments etc. will no longer be governed exclusively by dates such as the solar maximum, an eclipse or the arrival of a comet but may often be*

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829 Ibidem, p. 2.

830 The first quotation is from Bondi's interview with M.S. Hochmuth, reported in Hochmuth (1974), p. 90. The second is from his interview with J. Krige, on 5 November 1992, in the framework of the ESA History Project (HAEC). In the latter interview, Bondi recalled in particular a long discussion on this matter with the influential Dutch scientist H. van de Hulst, at that time the Chairman of ESRO's Scientific and Technical Committee (STC). Typewritten notes on this meeting (24 October 1967) and Van de Hulst's "Private notes on CETS" (dated 7 November 1967) are in fact in HAEC, folder 397.

831 AFC, 21st meeting (8-11 March 1966), ESRO/AF/MIN/21, 16 May 1966, p. 9-12. At this meeting only the Italian delegation expressed concern and aversion towards ESRO's involvement in application satellite work.

832 The letter, dated 1 December 1965, is reported in ESRO/ST/172, 3 January 1966. A copy of the original is among the documents that Professor M. Golay has provided for the ESA History Project, HAEC.

overruled by dates such as those of the Washington meeting [for Intelsat negotiations] in early 1969.[833]

ESRO's executive staff would have to be elected taking into account the dual purpose of the organisation, Peters continued, and "substantial commercial interests [would] have a more or less direct influence on priorities in the execution of contracts which ESRO places with industry". An important part of the objectives pursued in setting up the ESRO organisation might be lost, and "one can even envisage that the scientific effort may become only an appendix". Peters concluded that ESRO should remain a completely independent scientific organisation and that the best way to strengthen Europe's position in the Intelsat negotiations was to demonstrate its space capability by launching the Large Astronomical Satellite on schedule by an ELDO rocket.

At that time, Peters' views were probably shared by a significant fraction of the scientific community.[834] His drastic position, however, could hardly be defended in front of the clear political drive towards commercial space activities. Scientists had to choose either to defend a rigid position against ESRO's involvement in application satellites, which could only be defeated, or to state as strongly as possible the necessary conditions to safeguard the scientific programme in the new framework. Lüst circulated Peters' letter among several scientists active in ESRO, and the question of the possible co-operation with the CETS was then discussed at an informal meeting held in Paris in January 1966. The participants chose the second alternative:

The scientists who participated in the discussion expressed deep concern about the fact that, whatever collaboration agreements ESRO may enter into with other organisations, the scientific purpose of ESRO, its programme and the management of the programme by ESRO, must be fully safeguarded. It was suggested that ESRO express its willingness to consider, in principle, entering into arrangements on a contractual basis with CETS, for the purpose of constructing communication satellites, provided that all necessary steps are taken to ensure that such assistance can be rendered without jeopardising the extent and time schedule of ESRO's programme.[835]

In a more formal setting, the matter was discussed again in February at the 8th meeting of the STC.[836] The French delegate M. Bignier, speaking in the capacity of chairman of the CETS' Space Technology Committee, stressed that "everything would be done to ensure that the programmes of CETS and ESRO did not hinder one another or upset the execution of ESRO's scientific programme in any way". He underlined that the CETS programme, at that stage, did not imply a commercial application for the satellite. His arguments, however, did not completely convince the scientists. The Danish Delegation (B. Peters and O. Petersen) expressed their fear that "the size of the CETS project would overwhelm ESRO". The Italians (G. Occhialini and E. Cigerza) said that co-operation with the CETS was outside ESRO's mandate. The British delegation (H. Massey and M.O. Robins) declared that they were in favour of co-operation with the CETS, but felt that "this was not an inevitable decision for ESRO to take but rather a special move on ESRO part to assist in the early, exploratory stages of a new European project". Finally, ESRO's Scientific Director, B. Bolin, listed a few points which had to be taken into account, "should co-operation with CETS be seriously envisaged". These were:

833 We should stress that Peters' argument here is typical of scientists' standard ideology. We have shown in the previous chapters that the development of the ESRO scientific programme was hardly dependent only on such "natural" events but always involved many non-scientific factors.

834 A similar opinion was expressed for example by Golay in a letter to Lüst, 17 January 1966, Golay papers (HAEC).

835 ESRO/ST/178, 27 January 1966. The scientists present were: L. Biermann, J.E. Blamont, R. Boyd, J. Coulomb,
R. Frith, B. Hultquist, C. de Jager, R. Lüst, R. Michard, G. Occhialini, B. Peters, P. Swings, A.P. Willmore. Several letters from other scientists involved in space research but not active in ESRO were also available at the time of the discussion.

836 STC, 8th meeting (14-15 February 1966), ESRO/ST/MIN/8, 4 April 1966, p. 19-22.

The budgets must be absolutely separate; the programmes must be well defined, with detailed planning to safeguard the priorities of the scientific programme; any commercial aspects must be completely separate from the development phase of the programme; and there must be a clear definition of the body with which ESRO would have to deal and its responsibilities vis-à-vis the ESRO Council.[837]

In the event, the STC, with the Italian delegation voting against and the Belgian and Spanish delegations abstaining, adopted a recommendation to the Council essentially identical to the statement issued by the group of scientists one month before.

The subsequent development of discussions about the European space policy made it clear that very little room existed for the scientists' arguments within the framework of the strong political and economic interests in conflict. Just a few months after the STC meeting cited above, the outburst of ESRO's financial crisis and the start of negotiations in view of the planned ESC meeting of July 1967 virtually blocked the decision-making process on ESRO's future scientific satellite programme and cast a shadow on the very implementation of the programme already defined (the TD programme and the LAS project). Nor did the Rome conference clear the situation, as we have seen, pending the conclusions of the Causse Committee. It became clear to scientists that their hopes and expectations could only be satisfied within a framework defined at political level, in which all aspects of space activities found a proper place. Within this framework, science could only be one, and certainly not the most important, aspect. For national governments and policymakers, space research alone could not justify the enormous technological, industrial and financial stress that the construction and launching of spacecraft demanded. And for the space science community the only possibility to foster their disciplines was to profit as much as possible from the political, economical, and industrial machinery set in motion by the rapid development of applications satellites. "In the real world an isolated scientific programme will not be viable itself", the ESRO General Report commented, and the European space scientists realised that the control over the organisation they had created 6 years before was definitely slipping out their hands.[838]

9.5 More political negotiations and new technical studies (1968-1970)

In spite of their enthusiastic reading of the Causse report in December 1967, Bondi's and the ESRO staff's optimism was not justified. The first negative signs had already manifested themselves in the course of that year: in May de Gaulle's veto against the British application for full membership of the European Community had nullified the main political rationale for Britain to continue supporting ELDO; two launch failures of Europa I in August and September, due to malfunction in the French second stage Coralie, called the design of the whole project into question; and in the United Kingdom, important political circles insisted that Britain should oppose any further investment in ELDO-PAS and should not take part in the television system proposed by the CETS, arguing that European countries should relinquish their programmes in communications satellites in exchange for a reduction of Comsat's dominant position in Intelsat.[839] Then, in early 1968, the UK and the Netherlands firmly opposed a request from the ESRO Directorate, supported by Causse and by the majority of the CETS and ESC delegations, to authorise a new expenditure of 0.8 MFF in order to enable ESRO to retain the team of engineers that had carried out the studies of the CETS project and to prepare the pertinent tender documents, pending the ESC Bonn meeting.[840] Finally, called to give its opinion on the Causse Report, the British government announced in April 1968 that the United Kingdom would not

837 Ibidem, p. 20. The very same conditions had been expressed by Bolin just a few days before at the meeting of the CO/STC working group: see "Summary Report", cit., p. 2-3).

838 ESRO, General Report, 1968, p. 11.

839 Estimates Committee (1967).

840 ESRO/C/311, 30 November 1967, and add. 1, 27 March 1968; ESRO/C/327, 5 February 1968. Documents and correspondence related to this episode are in folders 397 and 402, HAEC.

undertake further financial commitments to ELDO and would not participate in the CETS project for the Eurovision satellite.[841]

The announcement came as a political bombshell that struck all those who kept advocating a European "balanced space programme". Three meetings of the ELDO ministerial conference were held in four months in order to keep the Europa programmes going on, in spite of the expected overspend above the ceilings fixed in July 1966, and to determine the conditions for keeping the Organisation alive.[842] As to the CETS, its Committee of Deputies held a meeting in London on 16-17 May to overcome the British position and to define a joint policy document in view of the forthcoming Intelsat negotiations. All efforts aborted, however, and the very legitimacy of CETS' role was put in question. In the words of ESRO's legal adviser, H. Kaltenecker:

> *This example shows clearly the inefficiency of the CETS body as such and the need to establish in Europe a strong guidance in this respect. [...] I think that the time is ripe for the ESRO Secretariat to make its position clear. We have the obligation to make clear to Member States, with a view to our future planned activities in the application satellite sector, what legal, administrative, political and technical consequences might arise if the European position with regard to the establishment of regional systems is not strongly safeguarded in future Intelsat arrangements.*[843]

For ESRO (and ELDO) top management a possible way out was that the Intelsat question be discussed within the framework of the ESC, "even if that means that the CETS loses its last reason of being". The situation was not better there, however, given the tight political interlinking between communications satellites and launchers. In this disarray there was no foundation for convening the new meeting of the ESC to discuss the Causse Report, and the ESRO telecommunications programme could certainly not start. If we consider that, in the same period, ESRO was still without an agreed level of resources for its second three-year period and, moreover, it was suffering from the dramatic failure of the TD programme, we can fully appreciate Bondi's comment one year later: "In the early summer of 1968, it was hard not to despair of a European space future".[844]

9.5.1 The Bad Godesberg Conference

By the end of the year a possible compromise had been worked out and the third meeting of the European Space Conference could finally be called, on 12-14 November 1968 in Bad Godesberg, near Bonn.[845] This compromise was based on three main elements. Firstly, it was decided that one European space organisation should be created out of the existing ESRO, ELDO and CETS, and a Committee of Senior Officials was set up to work out the procedures for the amalgamation. Secondly, it was agreed that the programme of the new organisation should consist in a minimum programme, mandatory for all Member States, and a number of optional programmes, in which only interested states would

841 "Space cutback by Britain puts ELDO future in doubt" and "ELDO: the booster we can well do without", The Times, 17 April 1968. See also Krige (1992b).

842 The three sessions of the ELDO ministerial conference were held on 11-12 July, 1-2 October, and 11 November 1968, and are reported on respectively in ESRO/ELDO Bulletin, no. 2 (August 1968) 24-29;
no. 3 (November 1968) 21-32; no. 4 (January 1969) 39-41.

843 ESRO, Memorandum from Kaltenecker to Bondi, 10 July 1968, HAEC, folder 1143. A note from the ELDO Executive expressing similar concern was attached to the memorandum. See also "More negotiation for Intelsat", Nature, 218, 714 (25 May 1968). The inability of CETS to reach consensus *vis-à-vis* the Intelsat negotiations is again registered by Kaltenecker six month later, in a memorandum dated 24 January 1969, commenting on the meeting of the CETS-Committee of Deputies of 22 January 1969; and again by ELDO's M. Bourély in a report dated 3 November 1969, on the meeting of the same body of 29-30 October 1969: both in HAEC, folder 1143.

844 Bondi (1969), p. 4. See also Bondi (1984).

845 ESC, Bad Godesberg meeting (12-14 November 1968), CSE/CM(November 68)PV/1-4, 12-26 November 1968. The resolutions adopted at the Bad Godesberg conference are in ESRO/ELDO Bulletin, n. 4 (January 1969), p. 8-13.

participate. While it was clear that launcher development was to be considered as an optional programme, the actual content of the minimum programme was left open, pending the definition of the new Convention.[846] Finally, the third element regarded the controversial issue of launchers. It was agreed that the interested Member States could continue developing the programme for a European launcher, on the basis of a revision of the ELDO-PAS project made necessary to keep it within the foreseen budget. It was assumed that the European countries should undertake on average two launches per year but, in order to protect the interests of non-launcher states, it was agreed that these states should not pay for any price difference higher than 25 per cent of the price of comparable non-European launchings.[847]

Two important decisions were taken by the Bad Godesberg conference regarding ESRO: the first was the authorisation to the ESRO Council to approve a level of resources for the scientific programme in the three-year period 1969-71 in the amount requested (860 MFF); the second was the authorisation of financial commitments for individual scientific projects extending beyond 1971, i.e. beyond the period covered by the original ESRO Convention. The Conference, however, frustrated ESRO's plans in the application satellite field. It granted in fact the sum of 1 MAU (or 5 MFF) per year to pursue preliminary studies on various application programmes, but it did not authorise the start of development work on the Eurovision satellite. The interested Governments were rather requested to express their opinion as to their participation by 1 March 1969. Subsequently, a governmental conference would be called "in order to reach a decision on the execution of the project on the basis of the economic and technical information available".[848] This further delay was considered with some disappointment in ESRO: "[It] is bound to have ill effects in industry and to lower their confidence in us", Bondi commented in this respect.[849]

9.5.2 More ELDO problems

The lack of decision derived again from the unsolved problems in ELDO. The Bad Godesberg compromise, in fact, was based on a sort of "confidence trick" which would be put to the test at the following ELDO Council meeting.[850] By a striking volte-face on its space policy, in fact, the UK government, represented at the conference by the Minister of Technology Anthony W. Benn, announced that it would support application satellite programmes in ESRO, including the CETS relay satellite. Britain however conditioned her financial participation in such programmes on her release from commitments to ELDO under the existing arrangements.[851] This condition was not accepted by other ELDO partners in Bad Godesberg and all decisions were thus deferred to the next ELDO Council meeting which, in turn, was postponed in order to see the outcome of the key F7 test flight of Europa 1, the first orbital test with all three stages operational.

The test, on 29 November, was a failure, due to a malfunction in the German third stage Astris, and the Council meetings held on that same day and then on 19-20 December could not go better.[852] The

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846 An anticipation of optional programmes was the agreement on the TD-1 satellite project, approved by the ESRO Council in October 1968 as a "special project" funded by all Member States bar Italy.

847 A crude analysis of the conflicting feelings and interests regarding the launcher problem is offered in Bondi's comment on the Bad Godesberg conference: Bondi (1969).

848 ESRO/ELDO Bulletin, n. 4 (January 1969), p. 9. The sum of 5 MFF is reported in ESRO, General Report 1968, p. 12. The figure in the conference resolution is 1 MAU. Besides continuing studies on the television satellite, the Conference recommended the start of studies on other application projects such as meteorological satellites, satellites for air and maritime traffic control, semi-direct TV broadcasting, and Earth resources.

849 Bondi (1969), p. 6. The frustration of the ESRO staff regarding the progress of the communications satellite programme is also evident in ESRO, General Report, 1968, pp. 89-92.

850 "A key to European future", Nature, 220, 730-731 (23 November 1968). See also, ibidem, the pessimistic editorial on the conclusions of the Bad Godesberg Conference: "Europe leaps into the dark", pp. 727-728.

851 CSE/CM(November 68)PV/1, Annex 3.

852 The F7 test flight is described in ESRO/ELDO Bulletin, n. 4 (January 1969), 14-19. A very short report on the Council meetings is ibidem, 40-41. The dramatic development of discussions can be appreciated from the minutes: ELDO/C(68)PV/7, 12 December 1968, and ELDO/C(68)PV/8, 17 January 1969.

British and Italian governments formally announced that they were unwilling to pay their full share for the completion of current programmes and were not interested in participating in the future programmes. As a consequence, the 1969 budget could not be voted by the Council and a new ministerial conference of ELDO Member States was called.[853] The conference took place on 15 April 1969 and a solution was found to the Organisation's new budgetary crisis, with France, Germany, Belgium and the Netherlands agreeing to make up the difference resulting from the reduction of the British and Italian contribution. At the same time, in adherence to the programme described in the Causse Report, these four countries, together with Australia and Italy, decided to start studies on a new rocket, the two-stage Europa 3, capable of launching geostationary satellites with a mass up to 700 kg, the size of the communications satellites foreseen in the 1970s. Finally, the Conference authorised ELDO to study the conditions for producing not only prototype rockets but ready-for-use Europa launchers on behalf of commercial users. This "production programme" was much sought after by France and Germany, in view of their eventual order for two Europa 2 rockets to launch Symphonie.[854]

9.5.3 Dragging on

The uncertainty over ELDO affected negatively the progress of the Eurovision project in ESRO, and the compromise on the ELDO budget reached in April did not ease the situation. In fact, the governments interested in the CETS/EBU experimental satellite were unable to decide on participation in the project by 1 March 1969, as requested by the Bad Godesberg conference, and an attempt by Bondi to convene a governmental conference on the CETS-C project in June or early July aborted because of the ongoing uncertainties.[855] Although the attitudes of most governments appeared favourable, the time was not ripe yet for a governmental conference to approve the project for at least three reasons. The first regarded of course the launcher problem: even considering the new compromise reached on ELDO, the PAS satellite project had to be considerably modified in order to be adapted to the requirements of the CETS-C satellite and, moreover, most of the development costs of the system (e.g. ground facilities and the apogee motor) were now to be borne by the CETS programme. In this situation, ESRO engineers were requested to study the possibility of launching the CETS/EBU satellites by means of a Thor-Delta rocket instead of Europa 2 and to compare the two options. The study showed that the use of the American launcher was technically feasible and possibly cheaper.[856] As a matter of fact, the ESRO staff wanted to de-couple the satellite project from the controversial question of the choice of the launcher, but this, of course, was opposed by the French delegation at the CETS. It was then agreed to keep the satellite associate with the ELDO launcher but to consider the possibility of using a Thor-Delta in two years' time after the start of the project. As a consequence, the industrial studies for the definition phase of the project were requested to consider both options as to the launching vehicle. However, given the complete uncertainty about the launching system to be eventually adopted, no reliable information could be obtained on how much money would be tied up in the expensive launcher business and the financing of the programme remained uncertain.[857]

The second reason for uncertainty regarded the selection of prime contractorship for the programme management. ESRO's study foresaw that this should be entrusted to ESRO itself but CETS Member

853 Italy's disillusion with ELDO derived from the fact that, in order to keep the project within the 1966 budget, the Europa programme had been scaled back by cancelling the apogee motor and the PAS test satellite, both contracted with the Italian industry.

854 The resolutions approved at the ELDO ministerial conference are reported in ESRO/ELDO Bulletin, n. 5, (May 1969), pp. 19-30. The growing importance of Germany in ELDO is testified by the fact that the Conference agreed that German should become the third official language of the Organisation, "enjoying equal status with English and French".

855 Information for this paragraph derives from correspondence and other documents in folder 1143, HAEC.

856 Telex from P. Blassel to J. Dinkespiler, 14 October 1968, in folders 402 and 1143, HAEC.

857 Simmons to Bignier, 20 December 191968 (reporting on a joint TPS/ESRO/EBU meeting on 18 December 1968); ESRO's L.T. Trollope, notes on the CETS STC meeting of 8 January 1969: both in folder 1143, HAEC. CETS STC, meeting of 30 September 1969, SCL/ST.35/Report, 20 October 1969, folder 397, HAEC.

States insisted that it should be entrusted to industry. A first compromise was worked out by the ESRO Directorate in May 1968, which was approved by the CETS. It foresaw a rather muddled procedure which involved complex sharing of responsibility between CETS, ESRO, an industrial prime contractor, and several subcontractors. Eventually, ESRO's usual method of placing a contract for the whole project with one industrial consortium was adopted, but with some modification in order to have a prolonged competitive phase. This involved a first phase where two or three consortia were contracted to prepare design studies of the project, and then a competitive evaluation to select the consortium to carry out full development.[858] The formation of industrial consortia in the field of satellite telecommunication and the definition of appropriate tender actions were thus necessary pre-conditions for further actions in the ESRO/CETS programme. This was not plain, however, "since the Member States did not all have a common industrial policy in this respect", as the ESRO staff remarked disconsolately.[859] In fact, the competition regarding industrial leadership to be gained in this new field was added in this case to the ever present problem of fair geographical distribution of contracts. The problem was further complicated by the presence of the already established consortium working on Symphonie.

The foreseeable competition with Symphonie was in fact the third reason for uncertainty. It was evident that the European market for regional communications satellites could not sustain two competing products and therefore only one project could survive for operational activity after the experimental phase. Delicate technical, industrial, and political issues were thus involved in any decision regarding the "European" project. After the Bad Godesberg conference, the ESRO engineers prepared two documents to confirm the validity of the Eurafrica satellite for the Eurovision needs, and to stress the superiority of its design with respect both to the Franco-German project and to the Intelsat III satellite.[860] At the same time, however, the Symphonie industrial consortium and the executive committee of the project started studying new versions of the satellite, Symphonie B and C, which satisfied the EBU specifications and involved a wider range of European industry.[861]

The problem then was whether and how to correlate the Symphonie programme and the ESRO/CETS programme, and this involved technical issues (i.e. compatibility between the two designs), industrial competition (i.e. the relationship between the Symphonie industrial consortium and other European aerospace and communications industries), and political questions related to the further development of the European space telecommunications programme (from TV relay to semi-direct and direct TV distribution) and of the ELDO launcher programme (from Europa II to Europa III).[862] In this respect the position of the CETS remained a very difficult one, as it officially sponsored one project (the Eurafrica satellite) but its two most influent members were engaged in a competing project.[863] Nor was ESRO's position easier, for the very same reason.

858 Information for this paragraph is from documents in folder 402, HAEC.

859 ESRO, General Report 1968, p. 90.

860 "The distribution of Eurovision by satellite: the interest of the pre-operational CETS-C project", 31 December 1968; and "Comparaison des satellites CETS-C, Symphonie, Intelsat III et Intelsat IV au point de vue de l'Eurovision", 3 January 1969: both in folder 1143, HAEC.

861 Davidson (1970), p. 12. Symphonie and CETS-C were the object of careful comparison by the EBU representative at the 35th meeting of the CETS Space Technology Committee (30 September 1969), SCL/ST.35/Report, 20 October 1969. See also Collette (1993).

862 These aspects are presented in an unsigned and undated handwritten note with the title "The problem of Europe's telecommunications satellite", in folder 1143, HAEC. The author is most probably Bondi and it appears that the note was written in spring 1969.

863 An example of this difficulty is given by the discussions at the meeting of the Committee of Deputy of the CETS of 29-30 October 1969, as reported by ELDO's M. Bourély to ESRO's and ELDO's Directorates, 3 November 1969, folder 1143, HAEC.

9.5.4 The PTTs step in

At the end of June, the EBU made an official request to the ESC, "asking to be told the Conference's intentions with regard to the development of a space system for television distribution".[864] Following this move, the ESC's Committee of Senior Officials asked ESRO to start an industrial consultation in order to obtain definite proposals for the realisation of the Eurafrica project. It also recommended that a governmental conference should be called by mid-November in order to finally take a decision on the execution of the television satellite programme and to inform accordingly the EBU Administrative Council, whose meeting was scheduled for 20 November.[865] Three large industrial consortia responded to the request of consultation and submitted their proposals which, after proper evaluation, were presented to the Committee of Senior Officials on 3-4 November.[866] Here, however, a *bad news* and a *good news* were announced that put everything under discussion again. The bad news was the EBU report on their pessimistic conclusions about the costs of the 1975-1985 operational phase: after new evaluation, a television relay satellite system embracing Europe and North Africa would be more expensive than the terrestrial Eurovision network it sought to replace. The good news was the CEPT announcement that they wished to be involved in the definition of a European communications satellite on behalf of PTT administrations. Such a satellite, of course, was to provide allowance not only for television but also for other classes of traffic of interest for the PTTs, such as intra-European telephony, telegraphy and telex traffic, and data transmission.

Two main reasons can be identified for this change of attitude by the PTTs. The first was the now demonstrated technical and commercial reliability of communications satellites, and the growth in demand of telephony services they had determined. We should recall in this respect that the PTT move happened just after the new Intelsat III satellites started providing world coverage for telephonic traffic and TV links with the moon. The peculiar role of satellites *vis-à-vis* cables (i.e. not only competition but also complementarity) in a world-wide telecommunications system was now evident. Satellites orbiting above oceans and continents, rather than cables laid across mountains and seas, provided easier and less expensive links with underdeveloped countries in large regions of the Earth, and allowed greater flexibility in handling large fluctuations in the demand (e.g. when important events like the Olympic Games or the outbreak of a local war called for much more capacity). The second reason was more political and regarded the on-going negotiations for the definitive Intelsat agreements, started in February 1969. We shall not deal with this matter here but a short comment may be useful.[867] European countries wanted to remove Comsat from its dominant position and advocated the right to establish regional systems of satellite telecommunications besides Intelsat's global network. The European space industry, represented by Eurospace, was very active in supporting these concepts but it was also necessary that the PTT administrations play their part. Thus, a political pressure likely existed on them to adopt a more sanguine approach to satellite telecommunications. We can recall in this respect that in the autumn of 1969 the United States finally agreed to the

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864 ESRO, General Report 1969, p. 124. See also "The European Space Conference", ESRO/ELDO Bulletin, n. 6 (July 1969), p.15.

865 Resolution adopted by the ESC's Committee of Senior Officials at its meetings of 3-4 July 1969 and 28-29 July 1969: CSE/HF/(69)28, 29 July 1969.

866 The three consortia were led respectively by Hawker Siddeley Dynamics (with Matra, Erno, Saab, Fiat, and LCT), Thomson-CSF (with Fokker, Dornier, Elliot, Fiar, and GEC-AEI), and MBB and British Aircraft (with Nord and Sud Aviation (eventually merging in Aérospatiale), ETCA, Selenia, Siemens and AEG-Telefunken). The latter consortium was essentially that of Symphonie. ESRO, General Report 1969, pp. 124-127.

867 The Intelsat negotiations started on 24 February 1969, in the presence of delegations from 63 Intelsat Member States (they had become 77 by the time of the closing of the conference, in May 1971) as well as from the United Nations, the International Telecommunication Union (ITU), and ITU Member States not Intelsat members. The Conference held three sessions at plenipotentiary level: in February-March 1969, February-March 1970, and May 1971. The final vote for the definitive agreements took place on 21 May and then, after the necessary ratifications, the permanent structure entered into force on 12 February 1973. Alegrett (1979); Galloway (1972), pp. 155-164; Smith (1976), pp. 141-155.

establishment of regional systems, provided that a two-thirds vote of the Intelsat Assembly recognised there would be no economic or technical incompatibility between the two systems.[868]

Facing the new situation, the Committee of Senior Officials decided to submit the ESRO/CETS mission to fresh study and set up a joint working group of representatives of ECS, CEPT, EBU, ESRO and ELDO. The terms of reference of the Working Group were to study the possibility of carrying out an economically viable European communications satellite programme that could satisfy the requirements of the CEPT and EBU for the period 1975-1985. In the first phase, the satellite was to be compatible with the capability of the Europa 2 launcher.[869] By April 1970, the study on the new mission was completed and a report issued. It recommended a two-phase approach: an initial (ca. 200 kg) experimental satellite carrying about 1000 telephony circuits and one television channel, suitable for launch by Europa 2 in 1975, followed by a major (400 to 500 kg) satellite carrying up to 4000 telephony circuits and two television channels for launch around 1980. The Ministers of Posts and Telecommunications of the CEPT countries, convened in Brussels on 28 April 1970, endorsed the project.[870]

Again ESRO was ready for the new meeting of the ESC, scheduled on 22-24 July 1970 in Brussels.[871] Three years had elapsed since the Organisation's first studies on a communications satellite for CETS, and almost two years since the previous ESC session, in Bad Godesberg, which had approved the principle that ESRO be involved in application satellite programmes. In the words of the Organisation's Director General:

> *During this period, although considerable progress has been made in the studies, ESRO has been rather 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.*[872]

ESRO, however, felt confident that a reliable partner had now been found and a politically appropriate framework created: the PTT administrations in fact not only held legal monopolies on telecommunications but also were part of the governments of the countries which were to be involved in the programme. In spite of the difficulties and delays in the actual implementation of the Bad Godesberg compromise, the ESRO staff could sound a note of optimism once again:

> *In these conditions, it is not unreasonable to expect the first half of 1970 to lead to our governments' eagerly awaited full approval of the development of a telecommunication satellite and to hope for the approval of a second line of applications before the end of the year. [...] Applications stand at the very hinge of Europe's future in space. Without a true involvement in applications, there can be no united political will, no increasing industrial involvement, and no comprehensive or indeed comprehensible direction to the space effort.*[873]

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868 Galloway (1972), pp. 155-164; Smith (1976), pp. 141-151. Eurospace's position was expressed in Eurospace (1969).

869 "The European Space Conference", ESRO/ELDO Bulletin, n. 8 (January 1970), pp. 10-11; "Studies on application satellites", Ibidem, n. 9 (April 1970), pp. 18-19; ESRO, General Report 1969, p. 124.

870 Davidson (1970). A summary of the Joint Working Group's report and of ESRO's comments on it are in Select Committee (1971), pp. 242-244.

871 Together with the developments on the communications satellite programme described above, we should mention that, in accordance with the Bad Godesberg resolutions, first studies were pursued in 1969 and early 1970 on two other kinds of application missions, namely on an air traffic control satellite for the North Atlantic (in co-operation with NASA) and on a meteorological satellite (in consultation with the meteorological offices of member countries): "Studies on application satellites", ESRO/ELDO Bulletin, 9 (April 1970), 18-19.

872 Bondi (1970).

873 ESRO, General Report 1969, p. 9.

9.6 The crisis of the ESC and the ESRO "package deal" (1970-1971)

Once again, the optimism was not justified. Two sessions of the fourth meeting of the European Space Conference, on 22-24 July and 4 November 1970, did not succeed in reaching an agreement on the critical issues of launcher development and relationship with the United States.[874] The latent crisis that had for some years characterised the European space activities burst out at the second meeting, where "the disunity between the countries favouring a 'coherent policy' including an independent European launcher effort and the others reached such a magnitude that the meeting broke up".[875] By the end of the year, all plans for a unified European organisation receded and the future itself of Europe in space appeared rather grim. Denmark and France went as far as to denounce the ESRO Convention in order not to incur financial obligations extending beyond the first eight year period.

Given this situation, progress in the field of application satellites could only be very slow, in spite of the fact that, at the first session of the Conference, "there was unanimous recognition of the fact that applications satellites - in particular television satellites - must form the central element of any space program worthy of Europe".[876] In July, in fact, the ESC did finally decide to undertake a programme aimed at developing the CEPT/EBU satellite, but the Conference authorised and funded only the very first stage of the programme. Of the total cost of the project, estimated at 450 MAU, only a sum of 5 MAU was made available to ESRO up to mid-1971. This was certainly "a considerable step forward from the 1 MAU per annum previously available for the whole application programme", Bondi commented, but not yet a definite green light to programme development. The persisting uncertainty about the future of Europe in space did not allow the participants in the ESC July meeting to enter into a more resolute commitment. It was decided that decisions to proceed to the next stages of the application programmes would be taken later by a "double qualified majority", namely a positive vote of two-thirds of the states and two-thirds of the contributions. This was enough to justify Bondi's prudent optimism in September; the dramatic conclusion of the November meeting showed that much still had to be done.[877]

9.6.1 The ESRO "package deal" of 1971

Commenting on the grim events of 1970, the Chairman of the ESRO Council, the Dutch scientist H. van de Hulst, wrote:

874 ESC, Brussel meetings (22-24 July 1970 and 4 November 1970), CSE/CM(July 70)PV/1-3 rev., 30 July 1970; CSE/CM(November 70)PV/1-2, 4 November 1970 and 19 November 1970. It must be recalled that the July meeting of the ESC was held about one month after the F9 (and actually last) launch of Europa I, which failed again because of the accidental disconnection of a plug during the powered flight of the first stage. The nose fairings were not jettisoned and, moreover, a deficiency of third-stage thrust occurred in its flight. As a result, "the planned orbit was not achieved [and] the combined third stage and nose fairings enclosing the satellite flew over the North Pole zone and came down in the Caribbean north of Guyana". The satellite carried a communications experiment built by a number of CETS Member States. ESRO/ELDO Bulletin, n. 10 (June 1970), 10-11, on p. 11.

875 ESRO, General Report 1970, p. 9. The November meeting concluded with a press release because the participants could not agree on a formal resolution: ESRO/ELDO Bulletin, n. 12 (November 1970), pp. 6-7. A contemporary account of the crisis, as seen by an advocate of a joint European effort in space between the July and the November ESC meetings, is given in Tassin (1970).

876 Foreword of T. Lefèvre, President of the ECS, to ESRO/ELDO Bulletin, n. 11, September 1970, p. 4. This issue of the Bulletin was entirely devoted to the July meeting and reports the resolutions approved.

877 The quotation is from Bondi (1970), p. 28. Positive decisions were also taken in July regarding two other application programmes, i.e. an aeronautical satellite programme, in cooperation with NASA, and an meteorological satellite programme, in consultation with the European meteorological authorities. The sums of 5 MAU and 2.5 MAU were allocated for these programmes, respectively, up to end 1971. Studies of other application satellites (Earth resources, and direct and semi-direct television broadcasting) were also authorised within the budget allocated to the meteorological programme. For a description of progress work in these application satellite programmes by the end of 1970, see ESRO General Report 1970, 9-17.

If the metaphor is correct, that the European Space Conference is the roof covering the various space activities and organisations in Europe, then ESRO has in 1970 been working under a leaky roof. This had no immediate effects on the quality or quantity of the work done internally but by the end of the year staff and delegations were making ready to push the furniture around once it became clear where the drip would come through the ceiling.

Facing the failure of the European Space Conference, ESRO Member States agreed that their delegations to the Council should negotiate further, leaving aside the problems which had led the ECS to deadlock. In spite of the difficulties and setbacks in the definition of a global space policy for Europe, and against the failure of ELDO and CETS, ESRO had proved to be sufficiently reliable and successful in its work, acquired maturity and competence in managing industrial contracts, and already established a firm basis for the development of applications satellites, which appeared to be the true political and economic rationale for European co-operation in space.[878]

The new Chairman of the Council, the Italian physicist G. Puppi, former Chairman of the ESC's Committee of Senior Officials, was given the task of negotiating a suitable compromise in order to drive the Organisation, as smoothly as possible, to its new institutional obligations in the application field and, at the same time, to offer European space policymakers new ground for negotiations. After one full year of intense negotiations and several Council meetings, the compromise was worked out and it became known as the "first package deal".[879] From the point of view of this chapter, the main aspect of the deal is the decision that ESRO should finally cease to be an organisation solely devoted to scientific research and undertake three application satellite programmes with different sets of Member States involved (optional programmes), namely:

a. An aeronautical satellite programme, with the participation of Belgium, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom, in co-operation with the U.S. Federal Aviation Administration. The maximum level of resources made available by European states for this programme was not to exceed 100 MAU.[880]

b. A meteorological satellite programme, with the participation of Belgium, France, Germany, Italy, the Netherlands, Sweden, Switzerland and the United Kingdom. The maximum level of resources made available by these States was fixed at 115 MAU.[881]

c. A communications satellite programme, with the participation of Belgium, France, Germany, Italy, Sweden, Switzerland and the United Kingdom, according to plans already established for the CEPT/EBU mission.[882]

These three programmes were to be executed simultaneously and, at the same time, ESRO would also carry out exploratory studies in other application fields. In particular these studies regarded satellites for Earth resource survey, for maritime navigation, and for semi-direct and direct TV broadcasting.[883]

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878 "Statement by the Director General" at the 35th session of Council (22 December 1970), ESRO/C/483, 18 December 1970. See also van de Hulst's letter to the ESRO Council delegations (5 December 1970), ESRO/C/473, 10 November 1970.

879 ESRO Council, 44th session, (20 December 1971), ESRO/C/MIN/44, 6 January 1972. The Council resolution is reported in ESRO, General Report 1971, p. 129-132, and in ESRO/ELDO Bulletin, n. 17, (February 1972), p. 6-11.

880 Canada was also involved in the programme and eventually Denmark joined the other ESRO Member States. All figures are at mid-1971 prices.

881 The agreement to proceed with the Meteosat Programme was eventually signed in 1972 by Belgium, Denmark, France, Germany, Italy, Sweden, Switzerland, and the United Kingdom.

882 Eventually Denmark joined the programme.

883 Studies on such missions had already started in 1971 and are described in ESRO, General Report 1971, pp. 53-56.

To appreciate the growing importance of application programmes in the work of the Organisation, one can considers that for the years 1972, 1973 and 1974 these were to be provided for by the participating Member States at 22.8 MAU, 48.5 MAU and 63.4 MAU respectively, eventually reaching an annual level of resources of 72 MAU in the period 1975-1977. ESRO's four major countries (France, Germany, the United Kingdom and Italy) agreed in principle to contribute to a minimum total level of resources of 70 MAU per year from 1974 to 1980 for the application programmes. In comparison, the budget for the scientific satellite programme for 1972, 1973 and 1974 was fixed at 42.7 MAU, 37.0 MAU and 32.7 MAU respectively, eventually reaching the level of 28 MAU in the years 1975-1977 (Tables 9-2 and 9-3, and Figure 8-1).[884]

The 1971 package deal was made possible by essentially two key elements: the implementation of the optional programme system announced at the Bad Godesberg conference of November 1968, and the exclusion of the controversial launcher problem from the negotiations. It was agreed that only the scientific programme and the basic activities should be included in the mandatory programme, to which all Member States had to contribute according to their gross national product.[885] This mandatory programme was significantly reduced, as we have seen, in order to release funds for application programmes. Participation in the optional programmes was based on a scale of contributions derived from the mandatory budget, with the only modification that shortfalls due to the non-participation of some Member States were distributed between the participating states pro rata to their normal share. As to the hot question of launchers, the ESRO Council re-affirmed the Bad Godesberg agreement that the Organisation would give priority to European launchers, "on the condition that the cost of a launching does not exceed 125 % of the cost of the relevant non-European launching". It also stated, however, that if an appropriate launcher for a specific mission were denied from outside Europe, ESRO would procure the necessary launcher for this mission in Europe, contributing to its development costs if necessary. The guidelines to be followed in this eventuality were carefully defined in the Council resolution.

The 1971 package deal marked "the beginning of a new period in the life of ESRO".[886] The Organisation was definitely transformed into a space agency mainly devoted to applications satellites with just a minor fraction of its activity and its funds devoted to science. Within this framework, the telecommunications satellite programme could finally enter the development phase, after 5 years of discussions and mission definition studies, and almost ten years after Telstar. The package deal also represented the most important positive element in the ongoing discussions over the European space policy which were to lead to the (second) package deal of 1973 and eventually to the creation of the European Space Agency (ESA) in 1975. With the spectacular failure of the first - and actually the last - launch of the Europa II rocket, on 5 November 1971, and the eventual cancellation of ELDO's Europa programme in early 1973, ESRO became the very core and model of the new agency.

9.7 Concluding remarks

The difficult start of satellite telecommunications in Europe which we have discussed in this chapter calls for a few considerations. The first is about the importance of the political dimension in the whole story. From the technical point of view, designing and developing a communications satellite programme was an interesting and stimulating job for ESTEC engineers and an important opportunity for the European industry. The challenge was accepted and good results obtained. The economics of a

884 All figures given above are at mid-1971 prizes and include contingency. Information for this paragraph is taken from G. Puppi's and A. Hocker's comments to the Council resolution of December 1971, ESRO/ELDO Bulletin, n. 17 (February 1972), p. 11-14 and 14-19.

885 The basic activities included technological studies, technical information and education programmes, and common costs that could not be allocated to individual scientific and application programmes.
The inclusion of technological studies in the basic activities was a matter of controversy, as reported in Hocker's comment on the council decisions: ESRO/ELDO Bulletin, n. 17 (February 1972), 14-19, on p. 18.

886 ESRO, General Report 1971, p. 9.

European communications satellite system was quite a different matter, however, and the lack of enthusiasm among those responsible for telecommunications derived not only from their generally conservative attitude but also from the great uncertainty about the actual possibility that such a system might become more economical in comparison with the expanding ground network. As late as 1970, the estimates of the total number of telephone circuits in Europe to be routed via satellite varied from 3000 to 5000 for 1980, from 5000 to 10000 for 1985, and from 8000 to 20000 for 1990. And the satellite system was expected to become more economical than the terrestrial network not before 1989 according to the pessimists, and by 1982-83 according to the optimists. The UK Ministry of Posts and Telecommunications, for its part, insisted that satellites could never be cheaper than cables for intra-European links.[887]

Here is how one of the protagonists, who was to become the Secretary General of Eutelsat, saw the situation in his recollections:

> *The size of the European continent, and the relations within the countries in its western part, meant that a satellite system would only be able to involve links carrying low-density traffic. The distribution of television programmes seemed more promising, but the EBU in its turn regarded the project as far too expensive, and rejected it. In 1967, then, it was still madness to talk in terms of a satellite system within Europe. Unlike INTELSAT, which was meeting a real need in improving communications between continents, a telecommunications satellite for Europe seemed on the evidence available to be a 'luxury' which Europe did not need and the telecommunications administrations could not afford.*[888]

In the event, it was politics that provided the necessary impulse, and the long negotiating process that eventually led to the start of the programme was a matter of policy. The decision not to rely on the US-dominated Intelsat system within the area of European cultural influence, the decision not to be dependent on American launchers, and the decision to qualify the European industry for prime contractorship in the promising market of satellite telecommunications were all aspects of a wider political initiative which involved foreign policy, technological and industrial policy, and general economic interests. The French government was the most convinced advocate of such decisions, with the important support of Germany and Belgium; the United Kingdom was their main opponent, backed by Switzerland and the Scandinavian countries; a way out could only be found on the political ground and had to cover not just telecommunications but all aspects of space policy.

The second consideration regards "the pendulum swinging between cooperation at a European level and selfishness at the national level".[889] Here again the issue was mainly political. Facing the American initiative in the early 1960s, the European countries felt they had to define a united position and created the CETS. This, however, was a rather hybrid forum, involving foreign ministries, PTT agencies, ministries of industry, etc. Thus, after the conclusion of the 1964 Intelsat Interim Agreements, the conflict between different interests and concerns made discussions frustrating and decisions useless. Both CETS's tasks could not be fulfilled, namely the definition of a common European position *vis-à-vis* the negotiation for the definitive Intelsat arrangement and the realisation of a joint European communications satellite project. With the crisis of ELDO and the successes of the first Intelsat satellites, in 1967-1970, the pendulum swung towards national or bi-national projects. France and Germany started Symphonie and Italy Sirio; Britain got involved in the Anglo-American defence system Skynet. But Symphonie needed a launcher, and France and Germany needed Britain to

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887 The figures are from Davidson (1970), p. 13. The pessimistic view was that of the joint working group set up by the ESC at the end of 1969; the optimists were in ESRO. See Select Committee (1971), pp. 242-244. The forecasts varied according to different estimates about the growth rate in total telephone traffic, the minimum distance between centres to be linked by satellite circuits, and the proportion of total traffic to be routed via the satellite.

888 Caruso (1984), p. 107.

889 Collette (1993), p. 83.

get it. The pendulum had therefore to stay in the "European" field. In this field, the ESRO Directorate and ESRO's smaller Member States (Belgium in particular) could play their best cards. Politics demanded that both European ventures and national programmes be protected. Finding a compromise required a long time and laborious negotiations but it had to be reached for Europe to keep a decent role in space. The 1971 package deal was an important step forward for the joint European effort, and it paved the way for the more important compromise of 1973. ESRO's project, however, still had to fight on the commercial terrain against the Franco-German project. In the event, two industrial consortia in the space telecommunications field emerged in Europe, one which was building Symphonie and one which was eventually contracted to build ESRO's Orbiting Test Satellite (OTS).[890]

Finally, a last consideration regards the "genetic change" in ESRO. The transition from a scientifically oriented programme to one primarily directed towards applications raised concern among scientists but eventually gave them the assurance that scientific investigation in space was firmly anchored to wider political and economic interests. The fact that the scientific programme was made mandatory within the framework of strong institutional and financial commitments freed the development of scientific projects from the uncertainties that had plagued the first phase of ESRO's history. Less money was available, unfortunately, but long-term planning was finally possible. From the organisational point of view, pending the outcome of ESC negotiations and the birth of the new space agency, ESRO Member States had to define a new institutional framework, with new bodies delegated to deal with application matters, and the ESRO management had to re-arrange its internal organisation to confront the new tasks.

Many important questions about the role of Europe in space remained open after the 1971 package deal, the most important being of course the ever-present problem of the launcher policy and the relationship with the United States. But the decision of the ESRO Council that the Organisation should assume a multiple role was a real turning point for the history of the European space effort. The path was now open for the establishment of an organisation responsible for the execution of scientific and applications satellite programmes and related industrial policy on the continental scale. Much still had to be done, but it was now impossible to go back.

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890 Collette (1993). Details on the OTS story in the following chapter. Both satellites and their follow-ups were highly successful and confirmed Europe's technological catch-up in spite of its ten-year lag: Giget (1993).

Table 9-1
Membership of European organisations in 1965

Countries	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		

* Signatories of the Intelsat Interim Agreements

Table 9-2
Level of resources 1972-77 approved by the ESRO Council in December 1971

	1972	**1973**	**1974**	**1975**	**1976**	**1977**
Scientific programme and basic activities	54.2	49.0	43.7	38.0	38.0	38.0
Scientific satellites	35.0	33.8	30.6	25.8	26.5	26.6
SAS-D	---	0.5	1.1	1.2	0.5	0.4
ESRIN and ESRANGE	6.7	1.7	---	---	---	---
Basic activities	11.5	12.0	11.0	10.0	10.0	10.0
Contingency	1.0	1.0	1.0	1.0	1.0	1.0
Application programmes	22.8	48.5	63.4	72.0	72.0	72.0
Aeronautical	4.0	17.9	20.5	18.0	18.8	6.2
Meteorological	2.1	7.9	16.3	26.8	25.8	25.0
Telecommunications	15.7	20.7	24.6	25.2	25.4	29.0
Other applications	---	---	---	---	---	9.8
Contingencies	1.0	2.0	2.0	2.0	2.0	2.0
Total expenditures	**77.0**	**97.5**	**107.1**	**110.0**	**110.0**	**110.0**

Source: ESRO/ELDO Bulletin, 17 (February 1972), p. 15.

Table 9-3
Breakdown of ESRO staff in 1971 and 1972

	End 1971	**End 1972**
Scientific satellites	181	116
Space science	53	45
Applications satellites		
Telecom	35	73
Aerosat	26	49
Meteosat	3	20
Sounding rockets & ESRANGE	137	8
ESRIN	75	60
Basic activities *	339	323
Common costs (non fixed part)	272	280
Support **	230	221
Total	**1351**	**1195**

* Includes studies, space technology, technical information, education and the fixed part of common costs.

** Includes workshops and design office, testing, data acquisition and data processing.

Source: ESRO/ELDO Bulletin, 17 (February 1972), p. 19.

Chapter 10:
The Early Development of ESRO's Telecom Programme and the OTS Project[891]

A. Russo

In the previous chapter we have discussed the first steps of ESRO's involvement in telecommunications satellites. First studies on the technical feasibility and economic viability of a joint European communications satellite system were undertaken by the Organisation in early 1967, on behalf of the European Conference on Satellite Communications (CETS). It took almost five years of technical studies and laborious negotiations before the ESRO Council could finally approve the start of a research and development programme aiming at establishing such a system in the 1980s, in collaboration with the Conference of European Postal and Telecommunications Administrations (CEPT). The main reasons for this difficult beginning can be summarised in the following elements. Firstly, the European start in space telecommunications occurred much later than the developments in this field realised in the United States. The first commercial service of satellite communications was inaugurated in the summer of 1965 by the American satellite Early Bird, after several years of experimentation with satellites like Echo, Telstar, and Syncom. 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 world. At the beginning of the 1970s, the U.S. still controlled the technology of communications satellites and dominated the international consortium Intelsat, created in 1964 with the task of establishing and operating a global commercial system. Any European undertaking in this rapidly expanding field meant leapfrogging the technological gap and finding a viable niche within the Intelsat system.

Secondly, it was necessary to establish a proper institutional framework in which a European initiative in this field could be undertaken. ESRO had been formally established by ten European countries in 1964 as an organisation solely devoted to space research. Its programme included the launching of sounding rockets and spacecraft to investigate physical phenomena in the Earth's space environment and to observe celestial bodies from outside the atmosphere. The Organisation's charter did not consider the building of application satellites, and even though its Directorate and its technical staff looked with interest upon the involvement in this field, this required the definition of a new Convention and of new financial arrangements from Member States. This was not the only problem, however. More important by far was the question of launching the spacecraft that ESRO was to build. A second multinational organisation did exist in Europe to develop launchers, the European Launcher Development Organisation (ELDO), which included six of ESRO's Member States, plus Australia. ELDO, however, was hampered by severe technical and managerial problems and the cost of its programmes escalated dramatically. A strong disagreement then arose between countries sceptical about the prospects of a European launcher development programme and those firmly committed to achieving European autonomy in launching capability. Britain and France led the opposite camps, the former stressing the high cost of the envisaged European launchers in comparison with the American vehicles, and the latter insisting that Europe could not sustain a credible space policy without the availability of its own launchers.

This brings us to the third element of the background, namely the discussions and negotiations about a coherent space policy to be pursued by Europe. Ten years after the first Sputnik's historic launch, space no longer appeared as merely a new frontier for esoteric scientific investigation or a spectacular stage for the ongoing political and military confrontation between the two superpowers. Social and economic objectives were more and more among the principal aims of space programmes, and space appeared as an important ground for technological innovation in all industrialised countries. Whence a challenge for the Old Continent. Which space policy for Europe? How to set European aerospace and electronic industry to

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891 This chapter is essentially based on Russo (1994).

compete successfully with their American counterparts? How to cope with the economic and cultural challenges that communications satellites posed on a planetary scale? How to take advantage of Western Europe's position in the "free market area" without suffering from the economic and military supremacy of the United States? To these and other questions the European countries gave different and even conflicting answers, according to their respective interests and policies. Finding a compromise, or a "package deal" as it was eventually called, was not easy, nevertheless it was a necessary condition before agreeing on the start of ESRO's telecommunications programme.

Finally, the fourth element we must recall here is the question of users. Developing a communications satellite system for Europe implied in fact some commitment from the post, telephone and telegraph (PTT) administrations and from television companies to use such a system to provide services to their customers. But such a commitment could only be granted if satellites proved more economical than the ground network, and this was by no means obvious. On the contrary, the potential users' economic studies showed that the satellite system would hardly be viable and its operating cost could not be charged on telephone bills.

When, in December 1971, the ESRO Council approved the start of the telecommunications programme, the problems referred to above had found a first solution. The new Intelsat agreements provided for the possibility of establishing regional communications satellite systems, and ESRO engineers, in collaboration with industry, had designed a programme foreseeing the development of advanced spacecraft and communications technologies. With regards to the institutional aspects, ESRO Member States had agreed on a package deal that definitely transformed the Organisation into one mainly devoted to the implementation of application satellite programmes. And if the problem of launchers was still under discussion, a compromise was agreed on by which ESRO would give priority to European rockets, if available, on the condition that the cost of launching did not exceed 125 % of the cost of using a non European vehicle. Finally, the question of users had also been settled, at least partially. While not committing themselves yet to using the envisaged satellite system, both the CEPT and the European Broadcasting Union (EBU) had agreed to be involved in the design of ESRO's telecommunications programme, on the basis of their forecasts about telecommunications traffic and Eurovision distribution in the 1980s.

In this chapter we will discuss the first development phase of ESRO's telecommunications programme, including the implementation of the OTS (Orbital Test Satellite) project. Two main questions were debated in this period which posed a serious challenge to the ESRO Executive's negotiating capability. The first is again the question of users, i.e. the economic viability of the system. While expressing their interest in being involved in the experimental phase of the programme, the PTT administrations reserved their position about the use of the eventual operational system until the real economic advantage of such a system was demonstrated. The second question regarded the essential tension between the national interests of ESRO Member States and their cooperative undertaking in the Organisation. The telecommunication programme, in fact, involved a large scale technological effort in key industrial sectors, with important financial investments and promising returns on the commercial level. ESRO's scientific programme, adding to important national space programmes in some Member States, had made possible the formation of a significant industrial capability in Europe. The consolidation and success of national industries and individual companies now strongly depended on the much more important communications satellite programmes of the 1970s and 1980s. ESRO's Member States entrusted to the Organisation not only the task of building and launching application satellites but also that of achieving this objective in the framework of an industrial policy whose main element was the so-called "just return" principle, namely that each member state should receive a share of the Organisation's high-technology industrial contracts equal to the share of its financial contribution to it. And it was not easy, of course, to implement such a principle against strong conflicting interests in a rapidly expanding new field.[892]

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[892] For a thorough analysis of the industrial policy aspects of ESRO's telecommunications programme see Müller (1990).

The narrative is divided into three main parts. The first deals with the definition of the programme in the months preceding its actual approval by the ESRO Council. This process involved negotiations with the CEPT and intertwined with the discussions that eventually led to the ESRO's package deal. The programme, as it was approved in December 1971, consisted of two phases: the first aiming at developing and launching an experimental satellite; the second at developing and launching the final operational unit. The start of the experimental phase until the approval of the OTS project and the associated technological research programme will be the object of the second part of the chapter. The main issue in this analysis will be the conflict between national interests, i.e. the conflict between those ESRO Member States which supported national communications satellite programmes and those which did not. In this framework, the OTS solution represented the result of a successful initiative of the ESRO Executive, supported by the expertise of the Organisation's technical staff. The third part will present the early implementation of the OTS project, with special emphasis on the industrial policy aspects involved in the choice of the contractors for building the satellite and its Earth control station.

10.1 The definition of ESRO's Telecom Programme (1970-1971)

The fourth session of the European Space Conference (ESC), held in Brussels in July 1970, agreed that ESRO should undertake a programme aimed at establishing by 1978-1980 an operational European telecommunications satellite system (hereafter Telecom Programme). The objective of the programme was to provide in the 1980s a satellite system capable of handling a certain percentage of the total telecommunication traffic between CEPT member countries, and capable of distributing real-time television programmes in the EBU Eurovision area. The programme was also intended to fulfil a technological objective, i.e. the qualification of the European industry in the satellite telecommunication field, in order to make it capable of participating competitively in the development of future communications systems such as the Intelsat V system. The total cost of the programme was estimated at 450 MAU. The ESC decision came after several years of technical and economic studies. The Conference, however, authorised and funded only the very first phase of the programme, i.e. "parametric studies on all aspects of the operational system in cooperation with the telecommunication and television administrations and agencies concerned [and] the development of the first experimental ground and orbital elements of this satellite programme". 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 stage 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.[893]

The caution expressed by the participants in the Brussels meeting towards full commitment in the telecommunications programme derived from three main reasons. Firstly, the still uncertain situation regarding the overall European space policy, in particular about the controversial question of the Europe launcher. Secondly, the uncertainty about the economic aspects of the programme, in particular whether a European communications satellite system would be more economical compared with the expanding ground network. Finally, the telecommunications programme represented an important technological challenge for ESRO and for the European industry, which suffered from a ten-year delay with respect to their American counterpart. In order to reach a competitive position in this rapidly expanding industrial and commercial field Europe had to develop second generation communications satellites, and for all the optimism of ESRO engineers success could not be assured.

The preparatory study programme for a European communications satellite system agreed at the July 1970 session of the ESC survived the dramatic crisis of the following November session of the same conference, again in Brussels. Here, the deep disunity between countries favouring a "coherent space policy" that would include the development of a European heavy satellite launcher, on the one hand, and

[893] ESRO/ELDO Bulletin, 11 (September 1970), p. 12 (Resolution n. 1 of the Conference). MAU stands for Million Accounting Units, ESRO's conventional monetary unit based on a gold standard. One AU was roughly equivalent to one US dollar.

those that considered that this was a wasteful use of limited resources, on the other, reached such a magnitude that a compromise could not be agreed on and the conference collapsed after the first day. A door was left open for further negotiation, however, as the Conference did agree on a resolution which invited ESRO to take the appropriate budget decisions for 1971. In fact, the ESRO Council succeeded in keeping alive the telecommunication and other application programmes, as well as the very idea of a European joint effort in space.[894] The Telecom Programme budget for 1971 was approved as outlined in the resolution of the July ESC meeting (i.e. 5 MAU until mid-1971), and the Council authorised to undertake hardware development. An Interim Application Programme Committee (IAPC) was also created, with the task of supervising the implementation of these programmes and making recommendations to the Council.[895] The positive vote on the Telecom budget was not important from the political point of view, as it concerned only the completion of the preliminary phase decided on in July by the ministers. But in the delicate political situation following the ESC crisis it was by no means obvious that the ESRO Member States would be willing to make a further commitment to a programme alien to the Organisation's charter and whose future was so uncertain. In fact, this vote was made possible by one important element, namely the decision to start negotiations for a revision of the ESRO Convention in order to include application programmes and to provide for optional participation of Member States to the various programmes instead of mandatory participation to all. Thanks to the negotiating capability of the new chairman of the Council, the Italian physicist G. Puppi, a compromise was reached after one year of intense negotiations, becoming known as the "first package deal". In this same period, the preliminary study phase (or Phase 1) of the Telecom Programme was brought to an end and negotiations started for the definition of the second phase.

10.1.1 Designing a European communications satellite system

Soon after the July 1970 session of the ESC, ESRO started studying a satellite system meeting the instructions of the Conference, in collaboration with a special working group on telecommunication satellites (SET Working Group, from the French initials) established by the CEPT's Coordinating Committee on Satellite Communications (CCTS)[896]. The operational objective of the system was to handle a significant fraction of intra-European traffic in the 1980s at a cost comparable with that of land-based systems. The system was to provide two types of services: (a) public telecommunication services (telephony, telegraphy and telex, with the possible addition of wideband data transmission), and (b) television distribution of Eurovision programmes.

A key element in the design of the system was the estimate of the number of telecommunication circuits to be routed through the space system in the decade 1980-1990. This depended on three main parameters, i.e. the growth rate of traffic, the minimum distance between centres to be linked by satellite, and the distribution of total traffic between the ground and the space networks. On the basis of the growth rate calculated by the PTT administrations, and assuming that satellite circuits would be convenient over distances of 800 km or more, the ESRO study adopted the figures reported in the table below for the number of circuits to be routed by satellite.

Fraction of traffic routed by satellite	**1980**	**1985**	**1990**
one third	4600	8400	16000
one half	6900	12600	24000
two thirds	9200	16800	32000

894 ESRO Council, 35th meeting (25-26 November 1970), ESRO/C/MIN/35, 21 December 1970. See also: the letter of the Council chairman to delegations (5 November 1970) reported in ESRO/C/473, 10 November 1970; the statement by the Director General in ESRO/C/483, 18 November 1970; and the note by the Directorate in ESRO/C/482, 8 December 1970.

895 ESRO Council, 36th meeting (22 December 1970), ESRO/C/MIN/36, 5 March 1971. See also ESRO/C(71)6, 4 February 1971, and add. 1, 9 February 1971.

896 ESRO/ST/372, 2 October 191970. A description of these studies is in Contzen (1971). See also Davidson (1970).

The requirements for the television distribution service had been defined by the EBU. In this case, the purpose of the system would be to replace all the terrestrial circuits used for transmitting television programmes between European countries and between Europe and North Africa. Moreover, it had to extend the Eurovision geographical coverage to those EBU member countries (Iceland, Cyprus, Lebanon, etc.) where it was not possible to distribute programmes in real time. It was estimated that, after 1975, Eurovision needs would be met by the provision of two permanent television channels capable of transmitting colour TV programmes and high quality sound. An operational satellite with a mass in geostationary orbit of 700 to 800 kg was assumed as the basic element of the space segment of the system. It was eventually named ECS (European Communications Satellite). One or two such satellites would be operated simultaneously by some 30 to 35 earth stations in Europe, North Africa and the Near East, twenty of which for both telephony and television, a few for telephony alone and fewer than ten (essentially the North African and Near Eastern ones) reserved to television.

As regards the technical characteristics of the communication system, the most important aspect was the adoption of carrier frequencies above 10 GHz, i.e. in the so-called Ku-band. In particular, the 14.0-14.5 GHz band was adopted for uplink (ground-to-satellite) transmissions and three 250 MHz bands between 10.95 and 12.75 GHz were adopted for downlink (satellite-to-ground) transmissions.[897] This was a novelty in satellite telecommunications, for which the use of frequencies in the C-band (around 6 GHz for uplink transmissions and 4 GHz for downlink transmissions) was a standard because of the minimum combination of natural and man-made noise sources. But the use of such a frequency band suffered from being shared with terrestrial radio services, and this limited the choice of earth station sites and imposed limitations in the power flux from the satellite in order to eliminate possible interference. The choice of frequencies in the Ku band significantly reduced the overlapping and, as the lower frequencies were becoming overcrowded, it was expected that future communications satellites would mostly operate in this frequency band. At that time, however, there was little or no experience in satellite communication technology above 10 GHz, and the use of such frequencies presented several difficulties for the design of space communication systems.[898]

The first difficulty was that radio signals at frequencies around 12 GHz may be subject to heavy attenuation in the atmosphere, mainly due to rain. Measurements of this phenomenon were rare, particularly in Europe, and this implied a large margin of uncertainty in planning for satellite-Earth links. An experimental programme was therefore required in order to get statistically reliable data from measurements at different geographical locations, and extending over a sufficiently long period of time and in different climatic conditions. Such a measurement programme could be carried out using either the sky as a natural source of radiation or a satellite specially designed for this purpose.

The second difficulty derived from the limitation of the frequency bandwidth available for transmissions (500 MHz for uplink and 250 MHz for downlink). This limited the capacity of the satellite and therefore, in order to meet the expected demand for telephone circuits in the 1980s, it was necessary to study and implement sophisticated transmission techniques. These included:

a. the use of spot-beam antennae to concentrate the radiated power around areas of highest traffic density;

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897 The problem of which frequency to adopt in the European communications satellite system was much debated in that period within the CEPT's political and technical bodies. In the event it was agreed to adopt the Ku band and the CEPT applied to the International Telecommunication Union's World Administrative Radio Conference for Space Telecommunications held in Geneva in 1971 for use of the 12.75-13.25 GHz band for uplink transmissions and 11.45-11.95 GHz band for downlink transmissions. This request was not accepted, however, and the plan eventually adopted provided for the bands specified in the text. ESRO, General Report 1970, p. 12, and 1971, p. 46.

898 The following presentation is derived from Contzen (1971), pp. 292-295. The practicability of the Ku band (at 14/12 GHz) was under study at that time in the joint NASA-Canada CTS (Communications Technology Satellite) programme and in the Italian Sirio programme. The CTS was launched in January 1976, Sirio was launched in August 1977. The first commercial use of the Ku band was on Canada's ANIK-B satellite, launched in December 1978: Fordyce (1986), p. 206.

b. the re-utilisation of frequencies within the allowed bandwidth, i.e., transmitting two different signals on the same frequencies but with different polarisations;

c. the use of the speech interpolation technique, which enables the most efficient utilisation of the telephone channels by assigning them to users only when they are actually talking;

d. the assignment of communication channels on demand rather than permanently.

Other difficulties derived from three technical requirements imposed by the use of such a technology. The first was the need to develop new on-board repeater equipment including several microwave components, notably a travelling wave tube amplifier (TWTA). The second was the need to achieve high pointing accuracy, of the order of 0.1 degrees, and then to design a sophisticated three-axis stabilised spacecraft instead of using the standard spin-stabilisation technique. Finally, a power as large as 1000 Watt was required, which implied the development of a complex Sun-tracking solar array.

In conclusion, the telecommunication programme designed by ESRO's engineers envisaged a major technological push, which they hoped would put Europe on an equal footing with the USA in communications satellite technology. Thanks to the important financial effort by governments in the R&D phase, channelled to industry through ESRO's managerial and technical expertise, the technological leapfrogging that European industry needed in order to compete successfully on the world market would be made possible. And the user organisations in the telecommunication field, on their part, would be granted a reliable satellite system, technologically up to date and economically competitive.[899]

10.1.2 The search for a programme strategy

With the approval of the 1971 budget ESRO could keep implementing the preparatory activities of the Telecom Programme, as defined by the ESC in July 1970. The aim was twofold: (a) to define the overall programme development strategy, including phasing and costing, and (b) to initiate the industrial development of important technical equipment, notably the TWTA and the repeater. At the end of this preparatory phase, and on the basis of its results, it was expected that the CEPT and the EBU would commit themselves to using the system. ESRO Member States could therefore decide on the continuation of the programme and the start of the development phase.

In the first half of 1971 the three European industrial consortia COSMOS, MESH and STAR were contracted to carry out studies on the complete system (satellites and launching, ground stations, communication techniques) and study contracts were awarded for the TWTA and the modular repeater.[900] The Executive then worked out an overall programme concept to be submitted to the IAPC.[901] The most important aspect of the proposed strategy was the definition of an intermediate phase between the preparatory study activities (Phase 1) now near to completion, and the development of the operational ECS satellite meeting the users' requirements (now called Phase 3). The intermediate phase (Phase 2) was essentially devoted to technological development and to the qualification of critical equipment on board an experimental satellite to be launched before the ECS satellite. Two motivations justified this experimental phase: firstly, the need to test and qualify in the space environment the subsystems to be used in the final system; secondly, the need to provide the users (PTT administrations and TV companies) with some pre-operational capability, in order to enable them to gradually gain experience with satellite telecommunications and to progressively integrate the space system in the existing terrestrial network.

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899 Collette (1993).

900 ESRO, General report 1971, pp. 45-48; Müller (1990), pp. 138-143. The three consortia had been established in the late 1960s in order to associate European industries with the twofold aim of sharing know-how and management effort, and meeting just return requirements. On the formation and evolution of consortia, see Beattie & De la Cruz (1967) and Dondi (1980b).

901 ESRO/IAPC(71)9, 24 May 1971.

The experimental phase also included R&D work not involving tests in orbit and the ESRO participation in the 12 GHz propagation experiments on the Sirio A satellite developed under the Italian national programme.[902] As regards the experimental satellite for the orbital tests, two options were presented (Table 10-1). The first foresaw the use of a 200-kg satellite, mainly devoted to the testing of communication techniques: this satellite could be either specially designed or derived from satellites under development in national or multilateral programmes, namely the Italian Sirio and the Franco-German Symphonie.[903] The second option involved the development of a satellite of the 500 kg class, able to test most of the spacecraft technology intended for use aboard the future ECS and to offer users some kind of pre-operational communication capability. The total cost of the programme varied between 360 MAU and 436 MAU depending on the option, the least costly being Option Ib (Sirio-B) and the most expensive Option II (Table 10-2). The latter, in particular, involved greater spending in the experimental phase than in the operational one, because most of the development work for the test satellite would be directly transferable to the operational unit.

The overall timetable of the programme depended on the option selected for the intermediate phase. If the first option was approved, the test satellite could be developed in a relatively short time and launched in the second half of 1975 or in mid-1976. In this case, however, in order to make up for the large technical difference between the 200 kg test satellite and the large operational satellite to be launched in 1980, it was necessary to develop a prototype flight models of the latter, to be launched in 1977. The true operational satellite would be launched one year later. A different pattern presented itself for the programme development in the second option. In this case, the development work for the 500 kg experimental satellite and the 800 kg operational satellite would largely overlap, the former being considered a technological prototype of the latter and the same industrial group being entrusted with the task of building both. The experimental satellite would be launched by end-1976 or early 1977, with a second one available for launching at the end of 1977 if necessary. No prototype for the operational satellite was foreseen, two flight units of which would be developed and supplied to the users, as required by the CEPT, one of them to be launched by the end of 1979 at ESRO's expense.

The programme elaborated by the Executive was submitted in June 1971 to the IAPC, called to issue a recommendation to the July session of the Council where a final decision was to be taken.[904] Here, not surprisingly, France and Germany strongly supported Option Ic (also preferred by Belgium), and Italy Option Ib. The ESRO programme, these delegations argued, should take advantage of the technology and expertise already available as a consequence of national efforts, and the development of an experimental satellite could be accomplished at a minimum cost by starting from an existing programme. In actual fact, by supporting the integration of their national satellites into ESRO's Telecom Programme, these countries wanted to guarantee their home industry the most favourable conditions in the future competitive tenders for the most important ESRO contracts. The structure of the whole European industrial capability in the field of communications satellites would thus be based around the core already established by the national programmes. But for exactly the same reasons the United Kingdom, the Netherlands and Spain gave preference to Option II. As the UK delegation put it:

> *Option I was almost exclusively based on national satellite proposals and inherently led to a bad geographical distribution [of ESRO's contracts], something which probably could not be corrected by any reasonable industrial measure and which was likely to be perpetuated throughout the programme.*

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902 Sirio (Satellite Italiano per la Ricerca Industriale Operativa) was a 200 kg spin stabilised satellite designed for propagation experiments at frequencies above 10 GHz. It had originated from the PAS vehicle foreseen on top of ELDO's Europa 2 rocket. On the Sirio programme see: *Sirio (1978*) and *Ragno & Amatucci (1978*), pp. 63-122.

903 The Symphonie programme had been established by France and Germany in 1967 and it aimed at launching a 250 kg three-axis-stabilised satellite for telecommunications experiments in the 4-6 GHz band. The primary objective of the programme was to gain technical knowledge and experience in the development of communications satellites.

904 IAPC, 3rd meeting (8 June 1971), ESRO/IAPC/MIN/3, 30 June 1971.

The Dutch delegate, for his part, argued that "the Netherlands participation in the programme would depend on a fair return to its industry, which seemed very difficult to achieve in the case of Option I".[905]

While ESRO's Member States tried to shape the joint programme as far as possible according to their national interests, the CEPT, which attended the IAPC meeting as an observer, wanted to include as much as possible of the R&D work in the ESRO programme, in order to limit the cost of the operational system which the users would have to pay for. The CEPT representatives, in fact, emphasised that both carrying out the communications experiments at an early stage, as foreseen in Option I, and testing the components and subsystems intended for the operational unit on board a technological satellite, as foreseen in Option II, were necessary. They stressed how important it was, on the one hand, to obtain reliable information about the possibility of frequency re-use as soon as possible, because this had important implications for the design of earth stations, and, on the other hand, to have maximum assurance on the good performance of the final system, thanks to orbital tests of the most critical communications and spacecraft technologies. The CEPT also made it clear that they were not particularly interested in pre-operational capability on board prototypes before 1980. They rather expected two flight units of the ECS to be supplied to them by that time - one of which in orbit. These were to be completely free of any prototype aspect and built in conformity with the final configuration of the satellites that the PTT administrations would subsequently procure and launch in order to maintain the system in operation.

Unable to reach an agreement and facing the CEPT requirements, the IAPC found itself in a deadlock and a new meeting had to be called before the Council meeting. ESRO then worked out a third option which combined the two basic elements expressed in the previous ones, namely the early launch of a 200 kg satellite for telecommunications experiments and the development of a pre-operational satellite.[906] Option III foresaw a two-stage experimental phase: in the first, two satellites in the 200 kg class (i.e. Sirio-B or Symphonie-B) would be placed in orbit in 1975, to be used primarily for radio propagation experiments at 11 and 13 MHz, for frequency re-use experiments, and for space qualification of critical communications equipment. Subsequently, a 700 to 800 kg prototype of the operational satellite would be launched by 1977, to be used as a technological test bed for the final product and, possibly, for some pre-operational activity of experimental character. Two flight units of the operational satellite would finally be supplied to the users, one of them to be launched by the end of 1979 at ESRO's expense, as required by the CEPT. The estimated cost of such a programme was 448 MAU, i.e. higher than in the case of option I but of the same order of magnitude as in the case of Option II (Table 10-3). Most of the money would be spent in the experimental phase, owing to the fact that the development and launching of both the 200 kg satellites and the pre-operational satellite were included in this phase. In spite of the Executive's effort to find an acceptable compromise, the national delegations in the IAPC were again unable to find an agreement. The countries without a national programme in satellite telecommunications (Netherlands, Spain, Sweden and the UK) continued to oppose any national bias in the joint programme and maintained their support for Option II. France, Germany, Italy and Belgium, on the contrary, supported Option III. Switzerland also expressed some inclination towards the latter, while Denmark abstained as it had not yet decided to participate in application programmes. For the British delegation, Option II represented a single line of development, whereas the new option "appeared to consist of two quite distinct and separable parts". The first of these lines, they argued, satisfied the industrial interests of some Member States but "would be carried out at the expense of development of the large satellite, certain aspects of which would be deleted for want of money". The French, on the contrary, stressed that Option II was not acceptable, "because it involved the successive and costly development of two different large satellites, of 500 and 700 kg". Moreover, under this option, it would require six years before the first technological tests in orbit could be conducted, while the use of a 200 kg satellite would permit them very quickly.[907]

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905 ESRO/IAPC/MIN/3, cit., pp. 5 and 8. The British position was spelled out in detail after the meeting in ESRO/IAPC(71)14, 29 June 1971.

906 ESRO/IAPC(71)9, add. 1, 18 June 1971.

907 IAPC, 4th meeting (9 July 1971), ESRO/IAPC/MIN/4, 20 August 1971, p. 7.

Good technical reasons existed for both arguments, of course, but the issue was clearly not only technical and involved important industrial policy considerations. Two main aspects were discussed by the advocates of the two options under discussion. The first concerned the need to perform experiments on frequency re-use at an early stage in order to test the possibility of implementing such a technology. The CEPT stressed that, from the point of view of the construction of earth stations, this verification should be effected at least two years before the start of the operational phase. It added however that, "for the purposes of designing and developing these stations, it will be necessary to have the results of the verification much sooner". But how much sooner remained unspecified, and the conclusion was that, "as regards the potential user requirements, there is not sufficient difference between Options II and III for CEPT to be able to recommend one in preference of the other"[908]. This position of CEPT's left the field open to confrontation between divergent opinions. For the British delegation, frequency re-use experiments could be done at considerably less expense by means of point-to-point ground links or using an aircraft equipped with a stabilised platform. They also pointed out that a Canadian satellite scheduled for launch in 1975 would conduct this type of experiment and it would be possible to use the results provided by this satellite. France and Germany, for their part, insisted that the need to conduct the technological tests in orbit very quickly could only be satisfied by using the 200 kg satellites and underlined that Option III would permit advantage to be taken of development work already done in Europe.[909]

The second aspect regarded the ever-present issue of just return. For the UK, Option III had the "unacceptable disadvantage [...] of a geographical distribution of contracts that distinctly favoured certain Member States from the outset".[910] An ESRO study had shown, in fact, that the choice of this option implied that 31 per cent of the extra-mural programme expenditure, excluding launchers, involved constraints in the geographical distribution, i.e. it was likely to be allocated to companies of certain Member States because of their unique competence in the programme. This percentage was only 17 per cent in Option II.[911] For the Executive, a fair geographical distribution of about 70 per cent of extra-mural expenditure was still equitable, as it corresponded to what had been achieved in the scientific programme. It was not so for the British delegation, who thought that in the new application programmes, which involved much more important economic and technological aspects than in the scientific programme, an unfavourable situation should not develop from the beginning.

The long discussion again came to nothing and the meeting ended with a resolution which registered the disagreement among the delegations and left the Council with the task of choosing between Options II and III. As the IAPC chairman, M. Bignier, explained to Council delegates: "There was no certainty that the IAPC would be able to take a final decision, because political considerations might prevail over the technical aspects".[912] The Council, however, was not in a better position to take a decision.

10.1.3 Working out a "package deal"

In July 1971, the ESRO Council was actively engaged in the negotiations on the reform of the Organisation that were to lead to the so-called "first package deal". While agreeing in principle that ESRO should devote its main effort to application satellite programmes, Member States were still a long

908 ESRO/IAPC(71)15, 9 July 1971, pp. 1-2. See also ESRO/IAPC/MIN/4, cit., pp. 3-4.

909 ESRO's engineers did not like the British suggestions. They argued in fact that the use of an aircraft would provide only data on local phenomena and of little statistical value while, as regards the Canadian satellite, it was doubtful whether its position in orbit would be compatible with the measurements that needed to be made in Europe. They also stressed that both Sirio-B and Symphonie-B had been designed to enable the requisite verification to be made under truly representative conditions.

910 ESRO/IAPC/MIN/4, cit., p. 7.

911 ESRO/IAPC(71)9, add.1, cit., p. 8 (table III).

912 Council, 39th meeting (13-14 July 1971), ESRO/C/MIN/39, 3 August 1971, p. 23.

way from the definition of a suitable framework for such undertakings. Divergences existed about the financing and management of programmes which not all Member States were to be involved in; about the relationship between the scientific programme and the application programmes; about the future of ESRIN, the research institute near Rome whose activity was to be stopped, and ESRANGE, the shooting-range near Kiruna no longer necessary after the winding up of the sounding rocket programme. And finally, by far the most important issue, disagreement and uncertainty existed on the critical question of the European launcher. No application satellite programme could be undertaken, in fact, without a guarantee that it would actually be possible to launch such satellites. On this question the Council was in a deadlock. The UK argued that American launchers would certainly be made available for European communications satellites, as they always had been for scientific satellites, while ELDO's experience had shown that it made no sense to embark on uncertain and expensive programmes to achieve European independence. France, on the contrary, did not believe that the US would launch European satellites that were potentially harmful for their commercial interests and insisted that Europe should build its own launchers as a part of a coherent space policy. The position of the American authorities, in fact, was ambiguous, and it seemed that it would depend on the outcome of the negotiations about the possible European participation in NASA's post-Apollo programme. Informal negotiations were being pursued at the U.S. embassy in Brussels by the ESC President T. Lefèvre in order to have a clarification of this mostly important issue.

In the event, the Council adopted a proposal worked out by its chairman G. Puppi and generally accepted as a basis for further negotiations.[913] It recognised the need for Europe to undertake a substantial telecommunications programme and stated that the countries willing to participate in such a programme should eventually choose one of the proposed options. The four largest contributors to the ESRO budget (France, Germany, Italy and the UK) committed themselves to participating in this as well as in other approved application programmes and to contributing to a minimum total level of resources of 70 MAU per year from 1974 to 1980 for their execution.[914] The decision about which strategy should be adopted for the Telecom Programme - indeed about the actual start of the programme - was postponed to when the final package deal would be agreed on. The programme in fact was an element of a general agreement in which all aspects of the European space policy were to find their own place. At the July meeting of the Council an important step was actually achieved, i.e. the definite adoption of the principle of optional programmes and the commitment of ESRO's "big four" to participate in all application programmes with an assured minimum level of resources. It still depended on the negotiating ability of chairman Puppi to bring the process to a successful outcome.

10.1.4 The CEPT report on the viability of the system

There was a second important reason for the Council to suspend the decision, namely that several PTT administrations were not ready yet to commit themselves to using a satellite system for their telecommunications needs. A few days before the Council meeting, the CEPT had issued a report on the technical, financial and operational aspects of such a system from the user's perspective: a document whose conclusions were discouraging.[915]

The report had been prepared by the CEPT's Coordinating Committee on Satellite Communications (CCTS) and its SET Working Group with the aim of assisting the PTT administrations and the ministers "in deciding under what terms [they] might take part in the [ECS] project". Starting from the already defined mission requirements and from the available information on the technical and financial aspects of the programme, several scenarios were discussed. These involved the following elements:

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913 ESRO/C/MIN/39, cit., pp. 17-19. The approved resolution is reported in ESRO/C/XXXIX/Res. 4, with attached ESRO/C/XXXIX/Res. 3, rev. 2 (draft), 14 July 1971. See also ESRO/ELDO Bulletin, n. 15 (August 1971), pp. 24-26.

914 An aeronautical and a meteorological satellite programme were also under study, and the expenditure for all application programmes in 1972 and 1973 was established at 27 and 53 MAU, respectively.

915 CEPT, Study on a European telecommunication satellite system, Doc T/CCTS(71)24E, July 1971. Also attached to ESRO/IAPC(71)18, 26 July 1971.

a. two hypotheses on the fraction of circuits to be routed via satellite: one third and one half;

b. two values for the launch success probability: 0.75 and 0.9;

c. two confidence levels (i. e. the probability of not needing more than the stated number of satellites): 50 % and 90 %;

d. two different system configurations: with and without frequency re-use.

Having excluded the cost of the first operational satellite in orbit and a second spacecraft available on the ground, both to be provided by ESRO, the total investments by the users for the decade 1980-1990 were estimated at 139.1 to 271.2 MAU, depending on the hypotheses chosen. This amount included the procurement and launch of subsequent satellites, the establishment of about 30 earth stations, and the operating costs of the system. Most of the investments regarded the ground segment (i.e. the earth stations and associated facilities), whose cost was estimated at 102.6 to 120.1, with an additional 5.7 to 5.9 MAU if the Atlantic islands Madeira, Azores and Canaries were to be covered.[916]

The above figures had to be compared with the savings in the terrestrial network achievable as a consequence of the transfer to the satellite system of part of the total telecommunication traffic. And the comparison could not be more depressing. The total savings were estimated at 84 MAU if one third of the traffic was shifted to the satellite system, and 113 if the fraction was one half. The possible inclusion of the Atlantic islands added 6 and 10 MAU, respectively. In conclusion, the cost of operating the ECS satellite system resulted in excess of the corresponding savings by some 65 to 175 % if the former was to carry one third of the traffic, and 39 to 140 % if the fraction was one half. The lower figures, of course, implied the most optimistic assumptions about the launch success probability and the performance of the satellites in orbit.

The report acknowledged that this economic comparison did not take into account certain factors which could not be evaluated in financial terms, such as the fact that the satellite system would provide the EBU with a significantly more extensive coverage than that of their existing networks (and with two channels instead of a single one), or the diversification and flexibility that satellites provided to the global telecommunication system. It was also noted that the method employed for the economic evaluation meant comparing the costs of establishing a new system with the costs of extending a system already in existence. All the same, from the point of view of the CEPT no doubt could exist that, in one way or another, the governments had to make themselves responsible for the difference between the actual costs of the satellite system and those which the users would normally have to bear. The development of the European aerospace and communications industry could not be financed by telephone subscribers, and the financing of a European satellite telecommunication system required a political decision involving both the ministers responsible for space activities and those responsible for telecommunications. The commitment of the potential users to the Telecom Programme was of course a sine qua non condition for the implementation of the programme itself, and therefore the CEPT report raised great concern. It appeared once again that space was not a matter of crude economics but of political strategy on a continental level. As the British delegation at the Council put it (with the Italians concurring):

> *Had the project under discussion been a United Kingdom national project it would certainly have been turned down in view of the CEPT report and in view of the fact that it would probably be necessary to subsidise the programme during its operational phase. However, the case under discussion was not a national project but an international undertaking which formed part of the package deal and with which [the UK delegation] could go along.*[917]

916 In order to give an idea of how the cost was shared between the different elements of the system, we can note that the study estimated the cost of the satellite at 9 to 11 MAU, depending on the configuration, and the launching cost at 18 MAU if the Atlas Centaur rocket was used and at 22.5 if Europa 3 was used. These figures were taken as a basis for calculation in the different scenarios.

917 Council, 42nd meeting (23-24 November 1971), ESRO/C/MIN/42, 3 December 1971, p. 14.

In fact, it was only when such a political agreement was eventually reached, in December 1971, that the start of the Telecom Programme could finally be approved.

10.1.5 A new option is worked out

As we have seen, the ESRO Council had decided in July 1971 that the three application programmes (telecommunications, meteorological and aeronautical) should be executed simultaneously, and had fixed an overall financial envelope for them, i.e. 27 MAU for 1972, 53 MAU for 1973, and 70 MAU per year as of 1974. The Telecom Programme, under either Option II or III, could not be accommodated within these limits and therefore the Executive was instructed to study a new programme strategy, compatible with the stated budgetary constraints, as well as with the new situation emerging from the CEPT report. One month later the new option had been worked out, which differed from the previous ones in two main aspects.[918] Firstly, Phase 2 was now essentially characterised by a technological programme, while the orbital tests would be based on the utilisation of one experimental satellite to be realised within a cooperative effort and therefore with some financial contributions from outside ESRO. Secondly, the decision to proceed with Phase 3 would be required only by mid-1975, on the basis of the results of the experimental phase as well as of the financial, technical and operational conditions prevailing in the mid-1970s. The programme was thus broken into two clearly different ones, each requiring a specific decision to start: the first aiming at launching an experimental satellite by the end of 1975, the second aiming at developing the operational satellite as defined by the users' requirements.

Two possible alternatives for the realisation of the experimental satellite were discussed. The first was cooperation with the on-going Symphonie programme, aiming at launching one Symphonie B spacecraft by the end of 1975. This had been preferred to Sirio B because the latter did not allow the testing of either three-axis stabilisation techniques (because Sirio was spin stabilised) or frequency re-use (because of on-board antenna problems). The second alternative involved a collaboration with the American company COMSAT within the framework of the Intelsat programme. As Intelsat's operating manager COMSAT was in fact studying an experimental satellite as a technological step in the development of the new Intelsat V spacecraft, and its project corresponded closely to that of the ESRO programme: it aimed at launching in 1975 a 350 to 400 kg, three-axis stabilised satellite, with orienting solar panels, high gain antennas, Ku band frequencies, and active thermal control.

Exploratory contacts had already been established between ESRO and COMSAT and collaboration appeared possible along four main lines: (i) the satellite would be designed by a mixed ESRO/COMSAT team; (ii) ESRO participation would be of the order of 30-40 % of expenditure; (iii) the satellite and its subsystems would be developed by both European and American industry under ESRO and COMSAT contracts, respectively; (iv) integration and testing would be conducted by the COMSAT Laboratories at Clarksburg with the participation of an ESTEC team and representatives of European industry.[919]

As regards the content of the operational phase, no specific proposal was presented at this stage. It was suggested that a prototype satellite might be developed and launched by 1979-1980, followed by the production of two flight models of the final operational unit and the launch of one of them in early 1982. The latter could be either a 700 to 800 kg spacecraft, as previously envisaged, or a spacecraft of the order of 400 kg, in the event that a review of the mission, the communications system and the technologies used

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[918] ESRO/IAPC(71)28, 9 November 1971.

[919] ESRO/IAPC(71)28, cit., p. 9. The possible ESRO/COMSAT collaboration is reviewed in ESRO/IAPC(72)7, 21 February 1972.

showed such a mass to be adequate. In this latter case, an optimistic possibility was that this spacecraft might be a direct follow-up of the experimental satellite, if the ESRO/COMSAT option was chosen, thus making the prototype and the operational unit one and the same. In any case, no decision about the operational phase was required before 1975, thus leaving enough time for clarifying the political and economic aspects and obtaining the commitment of the potential users. This was much appreciated by those delegations which were less enthusiastic about the European communications satellite programme. The British, as usual, gave voice to them:

> *The United Kingdom delegation, recalling that it had laid down two conditions to be met before it could vote in favour of proceeding to the second phase [i.e. the viability of the programme and the commitment of the potential users], pointed out that this meant that when the time came it would not be influenced by arguments of a political nature which might, in the view of some countries, militate in favour of continuing the programme.*[920]

The new programme strategy was presented to the IAPC in November 1971 together with the financial implications of the different possibilities (Table 10-4). The CEPT, represented at the meeting by the chairman of the SET Working Group, took a critical approach towards the new version of the programme and expressed some resentment at not having being consulted by ESRO when the new option was being elaborated. Two aspects in particular were criticised. The first regarded the envisaged collaboration with COMSAT. Intelsat, in fact, had not as yet taken any decision on the execution of an experimental programme in preparation of the Intelsat V series, and no guarantee existed that Comsat's plans would actually be approved by the governing body of the international consortium. The second aspect was that under the new approach a decision on the operational system was not to come before 1975. This might discourage certain users, e.g. the EBU, and might lead them to route their traffic differently.[921] Regarding the foreseen launch of the first operational satellite in 1982, the CEPT representative recognised that it was difficult to assess the exact date at which a European system was actually required to be operational and that CEPT had adopted 1980 as a working hypothesis. He added however:

> *If this was now to be postponed, the effects resulting from such a slippage would have to be studied in detail. In this context, it could not be denied that a European system might run certain risks if it became operational only after Intelsat V, because the history of international telecommunications showed that the carrier who enters the market first is usually the best placed competitor.*[922]

Despite CEPT's reservations, the IAPC considered with great interest the envisaged ESRO/COMSAT collaboration for an experimental communications satellite. Pending the Intelsat decision, however, France and Germany insisted that the possibility of using Symphonie, at conditions still to be defined, be maintained "as a veritable programme alternative".[923] In the event, "after a lengthy discussion", no choice between the various programme alternatives was clearly recommended: The IAPC simply recognised that collaboration with COMSAT "might offer certain advantages" and recommended the Council to base its examination of the Telecom Programme on the main principles set out by the new option, namely the implementation of a cooperative experimental satellite programme and the procedure of staggered decisions for the funding of successive phases.[924]

10.1.6 The 1971 package deal and the approval of the Telecom Programme

In the one-month period between 20 November and 20 December 1971, the ESRO Council held three busy meetings. These achieved bringing to conclusion the long negotiating process started one year

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920 ESRO/C/MIN/42, cit., p. 14.

921 As early as mid-1969 the EBU had in fact received an offer to use the Intelsat system for the needs of Eurovision: CSE/HF(69)22, 16 July 1969.

922 IAPC, 9th meeting (9-10 November 1971), ESRO/IAPC/MIN/9, 22 December 1971, p. 23.

923 ESRO/IAPC/MIN/9, cit., p.24.

924 ESRO/IAPC/IX/Res. 5, 12 November 1971.

before and destined to radically change the Organisation's role and aims. With the final approval of the resolution on the "Reform of the Organisation", ESRO Member States agreed on a package deal which definitely transformed the former space research organisation into an organisation mainly devoted to space applications. While in the old framework all Member States were called to finance the Organisation's programme according to the GNP (gross national product) formula, now this condition applied only to the basic activities and the scientific programme. The application satellite programmes, on the contrary, were considered optional, and each of them was financed only by the participating countries. As a consequence of this agreement, the three programmes whose definition studies had been under development for a few years were finally approved: the Telecom Programme we have been dealing with in this and the previous chapter; an aeronautical satellite programme in collaboration with the US Federal Aviation Administration and Canada; and a meteorological satellite programme deriving from a project already studied by the French space agency. These programmes were to be executed simultaneously, with the "big four" confirming the decision taken in July to participate in all three with a minimum total level of resources of 70 MAU per year. At the same time, ESRO would also carry out exploratory studies in other application fields such as satellites for Earth resource survey, maritime navigation, and semi-direct and direct television broadcasting.[925]

After five years of technical studies and political negotiations, a decisive step was thus taken regarding the Telecom Programme, which was supported by eight of ESRO's ten Member States: Belgium, Denmark, France, Germany, Italy, Sweden, Switzerland, and the UK.[926] According to the plan elaborated by the Executive and recommended by the IAPC, these participating countries decided to undertake Phase 2 (experimental) of the programme from 1972 to 1976, at a maximum cost of 100 MAU, and agreed that a decision about the succeeding phase would be taken in 1975 by a double qualified majority.

10.2 The start of Phase 2 and the approval of the OTS project (1972-1973)

10.2.1 The content of the experimental phase programme

With the approval of Phase 2 of the Telecom Programme, real development work could finally start. The programme for this phase was divided into four main parts (Table 10-5).[927] The first regarded the communication system and included studies on the satellite, the earth stations, the communication techniques, and the propagation problems at 14/11 GHz. The latter, in particular, required an extensive experimental programme which involved the building and installation of radiometers at five different locations in Europe, the execution of propagation experiments on terrestrial links, and ESRO participation in the Italian Sirio project.

The second part of the programme was the so-called Supporting Technology Programme (STP), consisting in the development of the new technologies required by the advanced design of the envisaged system. The most important elements in the STP programme were the travelling wave tube amplifier (TWTA) and the modular repeater at 14/11 GHz, i.e. the basic components of the communication payload. Preliminary industrial studies of these components had already started in 1971; in 1972 contracts were awarded to the French firm Thomson-CSE for the development and qualification of the TWTA, and to the German AEG-Telefunken for the development and qualification of the modular repeater. Most of the critical equipment under the STP programme was contracted to industry during 1972.[928]

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925 The final Council resolution, adopted at its 44th meeting (20 December 1971), is reported in ESRO/ELDO Bulletin, 17 (February 1971), pp. 6-11.

926 Denmark's participation was actually decided at a later stage because Denmark had first to officially withdraw its denunciation of the ESRO Convention pronounced by the Danish government at the end of 1970.

927 ESRO/IAPC(72)6, 23 February 1976.

928 ESRO/PB-TEL(72)1, 25 August 1972; Müller (1990), pp. 139-148 and 170-181.

The third and by far the most important part of the programme consisted in the development and launching of an experimental satellite by the end of 1975. This satellite would enable orbital tests of the communications techniques foreseen, of the 14/11 GHz communications equipment and of the three-axis-stabilised platform. As said above, the financial limitations on the programme imposed either the use of a spacecraft modified from that employed in another programme (the Symphonie B option) or, alternatively, the development of a new spacecraft in collaboration with another organisation (the ESRO/COMSAT option). The Executive, however, recommended the latter for two main reasons. Firstly, the Symphonie option was not compatible with the budgetary constraints unless France and Germany undertook to cover part of the satellite cost and, secondly, the three-axis stabilisation techniques required to be tested were in many cases different from the Symphonie configuration. This part of the programme also included ESRO participation in the Canadian Communication Technology Satellite (CTS), by which some key hardware developed under the STP programme could be tested on board the CTS, whose launch was expected in March 1975, i.e. some eight months before the launching of the ESRO satellite.[929]

The fourth part of the programme consisted of preliminary studies of the operational ECS satellite, in preparation of the subsequent Phase 3. These studies were to be performed in two steps. The first, in 1972, regarded the definition of the operational satellite configuration (Phase A study), in order to detail the necessary supporting technology and flight experimentation. The second, whose aim was to prepare a more definite design of the satellite (phase B study), would start after a two-year lapse, in order to take advantage of the results of the other parts of the programme. In January 1972, six-month contracts for phase A studies were placed with the three industrial consortia COSMOS, MESH and STAR, which independently studied three possible configurations, namely:

a. a dual satellite system consisting of two 400 kg satellites separated by about 3 degrees and not implementing frequency re-use technology (COSMOS);

b. a system using a single 680 kg satellite with frequency re-use (MESH);

c. the so-called "baseline system", involving the use of a single 800 kg satellite with frequency re-use (STAR).[930]

Before closing this section we have to note that, with the start of the Phase 2 of the Telecom Programme, contacts between ESRO and CEPT were resumed on a formal basis, after a period of cooling off in their relations subsequent to the presentation of the CEPT report. Technical collaboration was thus re-established with the SET Working Group, while some PTT administrations expressed their interest in the developing and setting up of some earth stations already during the experimental phase of the programme.[931]

10.2.2 The failure of the envisaged ESRO/COMSAT cooperation and the OTS proposal

The prospects of ESRO/COMSAT collaboration in the framework of the Intelsat programme were short-lived. Comsat’s experimental satellite project in preparation of the new Intelsat V satellite generation was in fact strongly opposed within Intelsat. The American company had a strong interest in developing this programme in its laboratories in order to gain the expertise needed to compete in the U.S. domestic satellite communications market. Most Intelsat signatories, however, felt that the international consortium should not pay for Comsat’s apprenticeship in satellite design and construction. The issue, which coupled with the fierce competition for the choice of the satellite destined to bridge the gap between Intelsat IV and Intelsat V, was hotly debated between late 1971 and early 1972 by the Interim Communications

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929 ESRO/IAPC(72)8, 21 February 1972; IAPC, 10th meeting (2-3 March 1972), ESRO/IAPC/MIN/10, 14 March 1972, p. 18. The hardware to be tested on board the CTS included the TWTA, the parametric amplifier and the solar array blanket.

930 ESRO/PB-TEL(72)2, 11 August 1972.

931 Exchange of correspondence between the chairman of the CCTS and ESRO's Director General, in ESRO/PB-TEL(72)4, 21 August 1972; also IAPC, 10th meeting (2-3 March 1971), ESRO/IAPC/MIN/10, 14 March 1972.

Satellite Committee (ICSC), Intelsat's governing body.[932] On 3 March, the CEPT representative informed the IAPC that the ICSC had decided to suspend discussions with ESRO until its June meeting, by which time its technical sub-committee would have produced a report on whether or not Intelsat needed an experimental satellite. But it was clear that Comsat's plans could hardly win approval of two-thirds of Intelsat members, as required under the new Intelsat agreements.[933]

The new situation re-opened the key question of the choice of the spacecraft for the orbital tests. This in fact had never been completely settled, as France and Germany had always insisted that the Symphonie option should be considered in parallel with the ESRO/COMSAT project. Now, however, the issue presented itself in a much more controversial way. Against Symphonie B, Italy re-proposed its Sirio B and, more important, the UK announced its intention to develop a national communications satellite, named UKATS (United Kingdom Application Technology Satellite), and demanded that this satellite should be used within the European programme. All three national options were unsatisfactory: Sirio B was technically outdated, UKATS was still on the drawing board and the programme had not even been approved yet, France and Germany had not made any firm offer of financing the use of Symphonie B within the ESRO experimental programme. It was evident, however, that no major country would have agreed to go along with another nationally-based project, and a deadlock seemed inevitable.

In these circumstances, the Executive decided to by-pass the IAPC and to re-examine the needs of a test satellite in the framework of the ongoing configuration definition studies of the ECS system. Three new independent study contracts were thus placed with COSMOS, MESH and STAR, "to give to industry an opportunity to express their view freely on all aspects of the problem". These studies, conducted in the summer 1972 in close relation with the ECS phase A studies, analysed separately, "on an open basis", a range of satellite options from the 40 kg Franco-Russian SRET vehicle to a dedicated 400 kg ESRO spacecraft, including of course Sirio B, Symphonie B and UKATS. The conclusions of these studies paved the way for coming out of the impasse:

> *The common view is held by the consortia that there is no substitute for a dedicated orbital test satellite with a configuration approaching as nearly as reasonable that of the proposed operational vehicle. All three consortia, while using sometimes very different criteria, placed such an experimental satellite well ahead of any other option.*[934]

In order to understand this conclusion and its implications we have to analyse the results of the ECS configuration definition studies and their relevance for the experimental satellite programme. As discussed above, the three consortia had independently studied three different system configurations. These studies, however, had resulted in a remarkable degree of similarity in the definition of the sub-systems: identical modular repeater elements, same power conditioning, similar telemetry, tracking and command (TT&C) subsystems, etc. All three approaches foresaw the use of advanced technologies and recommended a comprehensive development, qualification and flight test programme, in order to meet the planned schedule for the ECS deployment and to increase confidence in its ultimate successful operation. It is in this framework that the three consortia assessed the different options for the experimental satellite, i.e. each of them independently considered which option would allow the most profitable orbital test programme from the point of view of the operational system defined by its own phase A study. The result was unequivocally the same for all three: a dedicated 350 to 400 kg satellite

932 The competition was mainly between Hughes Aircraft, supported by COMSAT, which proposed a modified version of Intelsat IV (Intelsat IVA), and Lockheed Aircraft, supported by most other Intelsat signatories, which proposed a completely new design (early Intelsat V programme). Both Hughes' and Lockheed's satellite projects were also intended for US domestic services. Eventually, Hughes won the contract, thanks to COMSAT's dominant position as the US representative in Intelsat. See Kinsley (1976), p. 125-126; Müller (1990), p. 182; Podraczky & Pelton (1984), p. 111.

933 IAPC, 10th meeting (2-3 March 1972), ESRO/IAPC/MIN/10, 14 March 1972, p. 17.

934 ESRO/PB-TEL(72)2, 11 August 1972, pp. 2-3.

whose configuration and critical technological content should be as close as possible to that of the ECS. This satellite was eventually named OTS (Orbital Test Satellite).

Important technical and financial implications derived from the OTS proposal. The use of such a dedicated satellite, in fact, required an integrated Phase 2/Phase 3 approach and a new programme development. The launch of the experimental satellite was postponed to the end of 1976, the prototype unit was no longer necessary, and the launch of the operational satellite was definitely planned in 1980 for any ECS configuration. The deletion of the prototype and the close technical similarities of the OTS and ECS spacecraft resulted in significant savings of the programme costs. In comparison with the current programme (ESRO/COMSAT test satellite plus 800 kg ECS with prototype) the total saving was 19 MAU in the case of an 800 kg ECS, and 112 MAU in the case of a 400 kg ECS.[935] These savings, however, could only be achieved at the expense of exceeding the overall ceiling of 100 MAU for the experimental phase approved by the ESRO Council in December 1971, as a consequence of the effort for the development and building of the OTS (Table 10-6).
The OTS proposal was presented at the first meeting of the newly created Telecommunication Satellite Programme Board (PB-TEL), the Council's delegated body in charge of supervising the Telecom Programme.[936] Here, as to be expected, the initiative of the Executive was strongly criticised by the German, French and British delegations. The Germans stressed that:

> *The procedure of the Secretariat was incorrect in approaching the consortia before all the possibilities of [...] external collaboration had been definitely eliminated. It was evident that the consortia would naturally prefer a new project to one in which they did not participate.*

The French, for their part, proposed that "the possibility of passing from Symphonie B to an operational satellite should also be studied". The British pointed out that the UKATS project (now renamed GTS, Geostationary Technological Satellite) had been approved recently and that "the possibility of in-orbit testing of equipment on this satellite should now be studied in detail by the Secretariat".

After a lengthy discussion of the technical and financial aspects of the OTS proposal, it was clear that no decision could be reached at the meeting. It was finally agreed that ESRO should further study the alternative approaches to experimentation in orbit, and that the CEPT's CCTS should be asked to express their opinion, as potential users of the system, on which approach would give the greatest confidence in the programme. In the event, the CCTS refrained from expressing any preference for the different options, but it pointed out that the availability of a significant pre-operational communication capacity during the experimental phase would be very useful. Such a capacity, the CCTS argued, could be used free of charge for routing some telecommunication traffic via satellite, and it was "very desirable to permit the progressive installation of a network of earth stations before the commencement of the operational phase". For some national PTT administrations, they concluded, this was a prior condition to the construction of an earth station.[937] This emphasis on the need for pre-operational capability in fact supported the OTS option, as this satellite could be designed to provide such a capability within the remaining mission objectives of the test satellite.

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935 The comparison is with option IV (iv) in Table 4.

936 PB-TEL, 1st meeting (6 October 1972), ESRO/PB-TEL/MIN/1, 2 November 1972; following quotations from pp. 4-5. It must be noted that until the formal approval of the Telecom Programme, the PB-TEL acted on a provisional basis and its decisions had to be endorsed by the Council.

937 ESRO/PB-TEL(72)8, 14 November 1972, annex II.

The case for OTS was presented by the ESRO Directorate at the second meeting of the PB-TEL, on the basis of a thorough comparative analysis of the various options under discussion.[938] Their reasons for selecting the OTS programme against others based on Symphonie or GTS can be summarised as follows:

a. Greater technical merit, i.e. relative fulfilment of the orbital test programme objectives;

b. Minimum overall programme cost;

c. Best solution from the point of view of industrial policy (i.e. geographical distribution of contracts and return of investments in ESRO's Supporting Technology Programme);

d. Possibility of re-using the modular-designed OTS platform in support of other geostationary missions;

e. Significant pre-operational activity in the experimental phase and start of operational activity by 1980;

f. Greater flexibility in the definition of the content of the operational phase.

Flexibility and industrial policy considerations were the two decisive factors that the Executive particularly pointed out at the meeting. They stressed that the OTS "had been designed very much more as a prototype than as a test bench" and that the communication capability offered by this satellite in 1977 would be 5000 telephone channels and 2 television channels, namely of the same order as that of an Intelsat IV satellite.[939] The discussion at the meeting made the strength of the Executive's proposal quite evident against the national-biased alternatives. Despite the doubts and criticisms expressed by the French, German and British delegations, the OTS option was strongly supported by the smaller Member States, which also pressed for a decision to be taken very soon. The Belgian delegation, in its statement, fully interpreted their opinions:

> *[All other options] involve one or several national industries having a preponderant position and pose the issue of Europeanisation of the project [...] This issue of Europeanisation was the stumbling block in all previous attempt to reach agreement on a telecommunications programme. The Delegation considers that those industries in the Member States that are engaged on national studies are thereby already placed in a sufficiently privileged position and that there is no need to strengthen their position further through the medium of a European budget.*[940]

In the event, despite the reservations expressed by the British delegation, the Programme Board recommended the Council to approve the Executive's proposal and to adopt the OTS project.[941]

10.2.3 The approval of the Telecom Programme Arrangement

After the PB-TEL approval of the OTS concept for the Telecom Programme's Phase 2, it still remained to define the financial plan of the programme and the legal framework within which ESRO would

938 ESRO/PB-TEL(72)6, 7 November 1972; PB-TEL, 2nd meeting (17 November 1972), ESRO/PB-TEL/MIN/2, 11 December 1972. See also Müller (1990), p. 186.

939 ESRO/PB-TEL/MIN/2, cit., pp. 5-6.

940 ESRO/PB-TEL/MIN/2, cit., annex II.

941 ESRO/C(72)73, 4 December 1972. The precise objectives of the OTS programme were eventually discussed by a group of experts consisting of ESRO staff, CEPT's Permanent Nucleus, and representatives appointed by the delegations. The group held two meetings (on 8 December 1972 and 11 January 1973, respectively), reported on in ESRO/PB-TEL/EXP/MIN/1, 18 December 1972, and ESRO/PB-TEL/EXP/MIN/2, 25 January 1973. Their final report, ESRO/PB-TEL(73)1, was discussed and amended at the 3rd meeting of the PB-TEL (30 January 1973), ESRO/PB-TEL/MIN/3, 22 February 1973, and the conclusions are in ESRO/PB-TEL(73)6, 13 February 1973.

implement it. These elements were to be included in the formal arrangement between ESRO and the governments of the participating Member States.[942]

The main controversial issue regarded the financial aspects, as the estimated cost of the experimental phase now exceeded the upper limit of 100 MAU fixed by the Council in December 1971. The Executive estimated the direct cost of this phase at 121.7 MAU, at mid-1972 prices, plus 28.8 MAU for the programme share of ESRO's common and support costs (distributed pro rata among all programmes). The payment schedule had also been changed, extending beyond the originally envisaged period of this phase (1972-1976) up to 1978.[943] Apart from inflation, the reasons for the increase were to be found, according to the ESRO Director of Programmes and Planning, "in the decision [...] to develop an experimental satellite on a purely European basis [as well as] in the objectives which the delegations had fixed in respect of this satellite, with particular reference to the wish to have a certain pre-operational capacity".[944] The argument did not convince all PB-TEL delegations, however. Belgium, France and the UK said that if such cost estimates should be confirmed their participation in the programme would be called into question. They noted in particular that the budget presented by ESRO included some elements in the Supporting Technology Programme which seemed no longer necessary. The Board then decided to set up a small group of experts with the task of reviewing the programme and suggesting possible cuts.
After a two-day meeting, the expert group could do no better than identify a few programme elements that either could be started during the following operational phase or were not strictly indispensable for the OTS or ECS. This allowed a possible reduction by 6.6 MAU.[945] This gave rise to a hard confrontation in the following PB-TEL meeting between the French delegation and the Executive. The former made it clear that they would not subscribe to the programme if the budget for the experimental phase were not reduced of 6.6 MAU, according to the findings of the expert group. Against this position, the Director of ESTEC, O. Hammarström, "insisted on the speed with which the experts had had to carry out their work and on the numerous doubts that still persisted regarding the possibility of actually cutting out certain studies without seriously jeopardising the programme as a whole". The head of the Telecom Programme, R. Collette, spoke out recalling that:

> *One of the basic aspects of the programme was the development of technologies that would enable Europe to catch up with the United States in a number of fields. This was why ESRO had preferred a three-axis-stabilised spacecraft to the conventional type of spin-stabilised satellite and had also defined "advanced" telecommunications systems. A programme of this kind therefore necessarily comprised a certain number of unknowns and risks, and if funds were drastically curtailed it was to be feared that it would not be possible to overcome the difficulties that were to arise. [...] It would not be realistic to maintain the technical specifications and timetable of the programme, and at the same time to cut down the expenditure considered indispensable to meet the specifications in question.*[946]

Both Hammarström and Collette stressed that "very important decisions would soon need to be taken in collaboration with industry" and that any further delay would endanger the normal progress of the work which had been under way for two years. Just in those days, in fact, ESRO was evaluating the tenders for the important phase B OTS contract, as we shall soon be considering.

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942 The first draft of this Arrangement is ESRO/PB-TEL(72)7, 14 November 1972, and the laborious elaboration of the final text is recorded in its various revisions and addenda. The final text is ESRO/PB-TEL(72)7, rev. 4, 7 May 1973, but the scale of contribution of participating countries was subsequently changed as in ESRO/C(73)64, 8 October 1973.

943 ESRO/PB-TEL(73)4, 20 February 1973; PB-TEL(72)7, rev. 2, 13 February 1973.

944 PB-TEL, 4th meeting (27 February 1973), ESRO/PB-TEL/MIN/4, 15 March 1973, p. 5.

945 ESRO/PB-TEL(73)9, 28 March 1973. The precise figures were 2.8 MAU for expenditures that could be deferred to the following phase and 3.8 MAU for not indispensable expenditures.

946 PB-TEL, 5th meeting (21 March 1973), ESRO/PB-TEL/MIN/5, 17 April 1973, pp. 3, 4 and 5-6.

A tentative compromise was suggested by the Executive and supported by the British delegation, namely that the original amount of 121.7 MAU should be retained but that the sum of 6.6 MAU would remain blocked subject to subsequent decisions by the Board. But the French delegation "stated categorically" that it was opposed to this proposal and the Board had to yield. It was agreed to remove that sum from the budget and to fix the financial envelope for Phase 2 at 115.1 MAU, plus 28 MAU for common and support costs. The work corresponding to the 6.6 MAU was placed in a so-called sub-phase 2 bis whose execution would be decided, as in the case of the operational Phase 3, by a double-qualified majority (Table 10-7). In this form the Telecom Arrangement was finally approved by the Board, with the French delegation expressing its reservation, and then submitted to the Council for final approval.[947]

Why was the French delegation to the PB-TEL so critical of the technological work proposed by the Executive as to risk jeopardising the whole experimental programme to defend savings of the order of 5 % of the estimated cost? And so unhappy about the solution eventually agreed on that it was unable to approve even the text of the Arrangement that the Committee was to submit to the Council? Three reasons were given by the delegation for its negative vote: (a) the uncertainty in the exact content of the programme after the revision of the group of experts; (b) the fact that a substantial amount of the basic technology in the programme was of general interest and yet was funded solely by the telecommunications programme; and (c) the lack of coherence between the industrial policy pursued for the technology programme and that followed for the development of the satellite. All this can hardly be taken at face value. As to the first point, in fact, the group of experts had considered "satisfactory" the technical content of the Supporting Technology Programme (STP) and had accepted the ESTEC analysis of the OTS. Moreover, most of the industrial contracts under the STP had already been placed and it was not desirable to interrupt work in progress. Finally, their revision had produced possible savings for 6.6 MAU over 121.7 MAU, certainly not a conclusion that could make the content of the programme uncertain.

The second reason had some justification. The director of ESTEC, in fact, had recognised that "it was very often extremely difficult to fix the dividing line" between studies of general interests and those connected to a specific programme, a statement strongly criticised by the French delegation.[948] Nevertheless, here again the amount of money involved was negligible: the group of experts had concluded that studies worth only 3.8 MAU were not strictly indispensable for the OTS or ECS and therefore had to be considered of general interest. Certainly not enough to justify a negative vote even after these studies had been moved to Phase 2 bis and subject to approval by double-qualified majority.

The last point regarded the lack of coherence in the industrial policy. This term, in the ESRO framework, meant essentially fair geographic distribution of industrial contracts or, more explicitly, the pressure from Member States to get a share of technologically important contracts for their national industry that was not less than their financial contribution to the Organisation (the "just return" concept). In this respect, a difference did exist between the policy followed for the STP and that followed for the development of OTS. In the latter case, owing to the importance of the contract, a procedure now standard for ESRO procurement contracts was being used, i.e. tenders for detailed design studies of the satellite configuration (Phase B studies) had been requested from the industrial consortia COSMOS, MESH and STAR.[949] In the case of the high-technology, small-value contracts under the STP, on the contrary, ESRO tended to award these contracts more freely, on the basis of the technical experience and capability of bidding companies.

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947 ESRO/PB-TEL/MIN/5, cit. p. 8. See also the report of the chairman of the PB-TEL to the Council: ESRO/C(73)23, 6 April 1973. The text submitted to the Council (with the cover ESRO/C(73)11, add. 1, 26 March 1973) is ESRO/PB-TEL(72)7, rev. 3, Annex I, rev. 1 [21 March 1973]. The work to be performed in Phase 2 and that shifted to Phase 2 bis were eventually detailed by the Executive in ESRO/PB-TEL(73)12, 6 July 1973.

948 ESRO/PB-TEL/MIN/5, cit., p. 3.

949 The selection process for the OTS contractor will be discussed in the following section.

This of course resulted in a rather unbalanced distribution of contracts among the countries participating in the telecommunications programme, with expenditures concentrated in those countries which supported national communications satellite programmes: France, Germany and Italy.[950] This situation had been criticised at the PB-TEL by the Belgian delegation, which complained that "such scattering of contracts might [...] distort the geographical distribution of work within the consortia"[951]. But while the French delegation could rightly claim that a certain "lack of coherence" in industrial policy did exist between these two parts of the programme, it is less clear why they felt unhappy about a situation in which France was certainly not penalised, and which could in any case be justified and did not involve a large fraction of the programme budget.

A more general answer should therefore be given to the question posed above. French space policymakers, as we have seen, did not like the OTS project. They had to come to terms with it when it became clear that Symphonie had no chance of being incorporated in the ESRO programme, but they wanted to prevent ESRO from implementing a fully-fledged R&D technological programme in space telecommunications which might lead to duplicating national activities. Such a concern about the relationship between the technological research activity within ESRO's Telecom Programme and national efforts in similar fields had already been expressed by France (and Germany as well) two years earlier, and a whole IAPC meeting had been devoted to discussing this issue. The respective positions were clearly expressed here. The French delegation argued that the ESRO programme should be used "in complement of national efforts"; the German stressed "the importance of coordination with national programmes"; and ESRO's Director of Programmes and Planning J.A. Dinkespiler advocated the need of a certain degree of duplication appealing to the interest of all Member States of the Organisation:

> *When an action is carried out within the ESRO programme, the hardware or the software which results from it becomes the property of the Organisation and the use of the know-how which has been acquired is made available both to the Organisation and to each one of its Member States. When a similar action is undertaken in one of the national programmes, the know-how which results from it is made available to the Member State in question, not to the Organisation as such or to the other Member States. It is therefore not a matter of indifference to each one of the Member States to see an action undertaken in one of the national programmes, rather than in the international programme. This means that all Member States [i.e. not only those having national space programmes] must participate in the decisions regarding coordination. It also means that this coordination would be greatly facilitated and encouraged if some measure of symmetry was restored between national programmes and the ESRO programme as regards access to technical know-how.*[952]

The quotation is long but it makes it clear that what ESRO meant by coordination was just the opposite of what France and Germany did. For these countries European space activities had to be considered as a whole and therefore the international programme had to be used to increase the effectiveness of national programmes and not to compete with them: coordination meant complementarity, integration and rationalisation. For the ESRO Directorate, on the contrary, the Organisation had to develop its own programmes on behalf of its whole membership and the relationship with the stronger Member States had to be on equal footing. "Coordination does not necessarily mean that all duplication should be avoided",

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950 Müller (1990), 145-146.

951 ESRO/PB-TEL/MIN/5, cit., p. 6.

952 IAPC, 6th meeting (3 September 1971), ESRO/IAPC/MIN/6, 17 September 1971, p. 10 and 11-12. The issue had been raised at the 4th meeting of the IAPC (9 July 1971), ESRO/IAPC/MIN/4, 20 August 1971. ESRO's technology programme was presented in ESRO/IAPC(71)17, 31 August 1971.

Dinkespiler argued, "some competition may be desirable; coordination efforts should aim at avoiding haphazard duplications and at filling gaps"[953]. After further discussion in a round table organised by the ESRO Applied Research Advisory Committee (ARAC) and in other IAPC meetings, the issue did not resulted in major modifications in the STP plan for 1971-72.[954] We have seen how the same issue was still outstanding in spring 1973.

After this digression about the French aversion towards ESRO's technology programme, we can resume our narrative. After the PB-TEL's approval of the Telecom Arrangement, the final decisions on the programme had to take the practical form of: (a) a declaration by the Member States which had supported the programme in December 1971 regarding their intention to participate in the programme as now proposed; (b) the approval of the Telecom Arrangement by the Council; and (c) a Council resolution authorising the Director General to sign the Arrangement in the name of ESRO. The Arrangement would then enter into force after being signed by the governments of the participating states and by ESRO.

At the Council meeting in April 1973, the delegations from Belgium, Denmark, France, Germany, Sweden, Switzerland and the UK confirmed the commitments of their governments to participate in the Telecom Programme. The Italian delegation, however, pointed out that it could not take any position because its government had not yet approved the new plans and budget for Phase 2 of the programme. Hence all decisions were taken subject to the condition that by 1 June Italy confirmed its participation in the programme.[955] That date passed, however, without Italy having taken a decision because of a government crisis (indeed an often recurring event in this country). Nor did a subsequent deferment of the deadline by two weeks produce a decision. On the contrary, the Italian delegation declared that, pending government endorsement of the modified programme, it was not even in a position to repeat its commitment within the limits of the December 1971 agreement (i.e. within a total budget of 100 MAU for Phase 2).[956] This position created "a very serious situation". The 1971 package deal, in fact, was "the legal basis for all undertakings of the Organisation since its adoption, [it] was equivalent to a promise to participate in the programme and permitted the programmes to be modified on the basis of consultations among Member States concerned". The Council then adopted a firm resolution expressing its "acute disappointment" regarding the Italian government's attitude, "which threatens the very existence of this important programme". The package deal could not be called into question, they stated.[957] In the event, after three months of negotiations, the Italian government did approve the programme as now defined and the Telecom Arrangement could finally be signed.[958]

10.3 The Telecom Arrangement and the start of the OTS project (1973-1974)

The Telecom Arrangement formally entered into force on 21 September 1973, after being signed by the governments of the eight Member States which had originally supported the programme in December 1971 (Belgium, Denmark, France, Germany, Italy, Sweden, Switzerland and the U.K.) and by the Director General of ESRO. Subsequently, the Netherlands decided to join the programme too, with a fixed contribution share of 2.5 % instead of 4.8 % as resulted from the GNP formula. The balance was covered by the other participating countries on the basis of a GNP scale of contribution (Table 10-8).[959]

953 ESRO/IAPC/MIN/6, cit., p. 12. Müller (1990), pp. 171-175 and 208-214, presents the cases of the development contracts for the TWTA and for the momentum wheels as interesting examples of the relationship between ESRO's technology policy and national industrial interests.

954 The ARAC discussion is reported in ESRO/IAPC(71)26, 29 October 1971.

955 Council, 56th meeting (11-12 April 1973), ESRO/C/MIN/56, 3 May 1973.

956 Council, 57th meeting (1 June 1973), ESRO/C/MIN/57, 20 June 1973; 58th (extraordinary) meeting (29 June 1973), ESRO/C/MIN/58, 13 July 1973.

957 ESRO/C/MIN/58, cit., p. 3. The quotations are from the French and the German delegations, respectively, and from the Council resolution reported in ESRO/C/LVIII/Res. 1 (Final), 29 June 1973.

958 Council, 60th meeting (21 September 1973), ESRO/C/MIN/60, 3 October 1973. The final text of the Arrangement is ESRO/PB-TEL(72)7, rev. 4, 7 May 1973.

959 ESRO/C(73)64, 8 October 1973.

Spain thus remained the only ESRO member state not supporting the Telecom Programme.

10.3.1 The content of the Telecom Arrangement

The Telecom Arrangement consisted in a formal agreement between ESRO and the governments of the states participating in ESRO's Telecom Programme. The Telecommunications Programme Board, composed of representatives of the participating states, was made fully responsible for the programme and delegated to take decisions related to it. The objectives of the programme were defined as follows:

> *To design, develop, construct and set up the experimental and pre-operational space segment of a space communications system matching the objectives of the users, and to make reliable operational satellites available to the users on completion of the programme.*[960]

The programme, as discussed above, was broken down into two phases. The first phase (or Phase 2, as it was called because it followed the preparatory study phase of 1970-71) was a technological and experimental phase which the governments agreed to finance on the basis of a firm financial envelope of 115.1 MAU (at mid-1972 prices), with the addition of 28 MAU as the programme's share of ESRO's common and support costs. This phase would run from 1972 to 1978, with the launch of the OTS at the end of 1976. A possible sub-phase 2 bis was foreseen, covering further work on advanced technologies at a cost of 6.6 MAU, plus a contingency allowance of 4.4 MAU. The decision to start such a sub-phase was to be decided by a double-qualified majority.

The second phase of the programme (Phase 3) would be devoted to the development of two operational flight units (ECS) to be made available to the users, one in orbit and the other on the ground, on terms still to be defined. The launch of the first ECS was foreseen in 1980, but the possible launching of a prototype model was also foreseen, if necessary. The indicative financial envelope of this phase, including common and support costs and contingencies, was estimated at 160 to 283 MAU, depending on the configuration of the satellite (i.e. 400 or 800 kg) and on the possible additional launching of a prototype. Decisions on the start and precise content of this phase would be taken in 1975 by a double-qualified majority, and its completion was foreseen for 1980, with the launch of the first ECS.

The Arrangement gave the participating states firm financial control over the programme but, at the same time, it bound them to its execution up to completion. On the one hand, any change of the firm financial envelope established in the Arrangement was subject to the approval by a two-thirds majority and the same majority was required for approving the annual budgets relating to the programme. On the other hand, no participant could withdraw from the programme unless the cumulative overruns of estimated cost to completion exceeded 20 % of the amount of the firm financial envelope for reasons other than changes in the price levels. Should this be the case, those participants wishing to continue the programme would determine the arrangement for such continuation and report to the Council for any necessary decision. The participating countries authorised ESRO to conclude the necessary contracts for the execution of the programme in conformity with the Organisation's rules and procedures. The Arrangement, however, stated explicitly that:

> *In placing contracts and sub-contracts for the execution of this programme, preference shall be given, wherever possible, to execution of the work in the territories of the participants, taking into consideration the Council's decisions in the matter of industrial policy and distribution of work.*[961]

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[960] ESRO/PB-TEL(72)7, rev. 4, cit., p. 3.
[961] Ibidem, p. 7.

We shall see in the following two sections how this statement, which touched the ever present question of just return, became a hot issue when ESRO had to award the most important contracts in this phase, namely for the construction of the OTS and for the satellite control and test station.

10.3.2 Selection of the OTS contractor

Two months after the approval of the Telecom Arrangement, ESRO brought to an end the selection process for awarding the contract for the development and building of the OTS.[962] This process had started in October 1972, on the basis of the standard phase procedure adopted by ESRO for the development of its satellite projects.[963] This foresaw four main phases defined as follows:

> Phase A: Definition of the mission, preliminary analysis of the satellite, identification of the various possible design concepts.
>
> Phase B: Detailed definition of the satellite and start of critical activities, especially as regards the schedule.
>
> Phase C: Final development of the subsystems, with production of mock-ups, test models and engineering model of the satellite.
>
> Phase D: Fabrication, integration and testing of the qualification and flight units of the satellite followed by the launch.

Phase A studies had been performed by the COSMOS, MESH and STAR consortia between October 1972 and January 1973. The same consortia were then invited to tender for the more important phase-B studies, for which only two parallel contracts were to be awarded. According to the technical specification defined by ESRO, the final OTS had to incorporate three critical elements developed under the STP programme, namely the repeater from AEG-Telefunken (D), the TWTA from Thomson-FIAR (F/I) and the antenna from Selenia (I). As France, Germany and Italy had obtained such important contracts for their national industries, a British company was the obvious choice for prime contractorship, in order to achieve a balanced distribution of contracts within the overall programme. In fact, in their tenders all consortia were led by British companies: COSMOS by Marconi, MESH by Hawker Siddeley Dynamics (HSD) and STAR by British Aircraft Company (BAC).[964] After proper evaluation, the Executive recommended and the Administrative and Finance Committee (AFC) approved the awarding of phase B contracts to MESH and STAR.[965] The exclusion of the COSMOS consortium definitely left out of the OTS development (and eventually of ESRO's Telecom Programme) the industries involved in the Symphonie project, namely Aérospatiale (SNIAS) and Messerschmitt-Bölkow-Blohm (MBB), thus predetermining the emergence of two major European industrial groupings for communications satellites, one from the COSMOS consortium and the Symphonie experience and the other from the OTS/ECS experience.[966]

At the end of September 1973, the MESH and STAR consortia had completed their competitive phase B studies and submitted proposals for phase C/D, i.e. for the actual development of the OTS flight model.

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962 This process has been described in detail by Müller (1990), pp. 195-214, and we recapitulate the story here, after independent checking with the relevant documents.

963 ESRO/PB-TEL(72)10, 22 December 1972.

964 The other most important members of the consortia were: in COSMOS: SNIAS (F), SAT (F), MBB (D), Selenia (I), ETCA (B); in MESH: MATRA (F), ERNO (D), SAAB (S), Aeritalia (I); in STAR: Thomson-CSF (F), Dornier (D), FIAR (I), Fokker (NL), Contraves (CH), Ericsson (S).

965 ESRO/AF(73)35, 28 March 1973; AFC, 89th meeting (11 April 1973), ESRO/AF/MIN/89, 18 April 1973. The value of the contract was 1.5 MAU for a 24-week period.

966 From the COSMOS consortium and the Symphonie experience emerged the Eurosatellite group. The other was Satcom International, essentially deriving from the MESH consortium, the winner in the competition for the OTS main contract. See Müller (1990), 302-337, and also Collette (1993). A comprehensive survey of the European space industry in the late 1970s and early 1980s is in Dondi (1981).

The selection of the final contractor was of vital importance:

> *The OTS contract was not only the largest single contract to be awarded, but since OTS was basically a scaled-down model of the operational ECS, the industrial consortium which was awarded the OTS contract would also be selected to develop and produce the subsequent ECS satellites [...]. Because of its advanced nature and the financial resources involved, the OTS contract was expected to hold importance beyond the Telecom Programme, shaping the future technological competence of European industry in the area of communication satellites.*[967]

The two tenders were evaluated from the point of view of price and quality, and the result of the evaluation was definitely in favour of the STAR proposal.[968] The Executive then recommended the AFC to award the contract to this consortium. When, however, the Committee discussed the question, only the British, Dutch and Swiss delegations supported this recommendation. The other delegations, while recognising the superior quality of the STAR tender, argued in favour of the MESH proposal on the basis of industrial policy considerations.[969] Awarding the OTS contract to STAR, they argued, could jeopardise the future of the MESH consortium, since the two last major ESRO contracts, for the COS-B and GEOS satellites, had been awarded to COSMOS and STAR, respectively, and the Meteosat contract was also being awarded to COSMOS.[970] This would endanger the conditions for real industrial competition in Europe and would also raise serious problems of unemployment in some countries.

Against these arguments, the Executive defended the validity of its technical and financial evaluation. They drew the delegations' attention to the real shortcomings of the MESH tender, "which were to be found at the levels of project management and system engineering". And the Director General went as far as to emphasise that:

> *If the AFC was to base its judgement merely on considerations of industrial policy, independently of the Secretariat's technical and financial evaluation, the latter would become meaningless.*[971]

In the event, the Executive's proposal was put to the vote and rejected by six votes (Belgium, Denmark, France, Germany, Italy and Sweden) to three (Netherlands, Switzerland and the UK). The AFC then approved the awarding of the OTS contract to MESH with the negative vote of Switzerland and the abstention of the UK.[972] As we have intimated, this decision had important consequences on the shape of the European aerospace industry, contributing to giving MATRA and ERNO the leading role they would eventually have in France and Germany, alongside SNIAS and MBB respectively.

10.3.3 The OTS control and test station

The exploitation of OTS as an experimental satellite required the establishment of a dedicated earth station to provide for the functions of telemetry, tracking and telecommand (TTC), and to carry out the

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967 Müller (1990), p. 201.

968 ESRO/AF(73)127, 14 November 1973.

969 AFC, 95th meeting (29-30 November 1973), ESRO/AF/MIN/95, 13 December 1973.

970 MBB was the prime contractor for COS-B and BAC for GEOS; the Meteosat contract was awarded to SNIAS as prime contractor for the COSMOS consortium. Müller (1990), p. 204, wrongly ascribed the COS-B contract to STAR; this satellite was in fact being developed by the CESAR consortium, the forerunner of COSMOS.

971 ESRO/AF/MIN/95, cit., p. 5.

972 The Spanish delegation did not take part in either vote because Spain did not participate in the Telecom Programme. The contract was awarded on the condition that acceptable solutions would be found in respect of those aspects of the tender which ESRO had considered poor, with no increase of the tender price and no major change in the timetable for the programme.

required experiments of the communications payload. It was envisaged that such a station should be linked by high-quality data transmission link to ESRO's Operational Center (ESOC) in Darmstadt, Germany. Two questions were involved in the discussions about the OTS control station: the first regarded the choice of the site where the station had to be built, the second regarded the choice of the contractor for its design and manufacture.[973]

With regard to the choice of the site, the starting point was the Council decision, taken in November 1972, that all ESRO's geostationary satellites should be operated by one control station located in Odenwald, near Darmstadt. Should it prove impossible to operate any particular satellite from this station, a second possibility was offered by installing the necessary facilities at the station ESRO had established in Villafranca del Castillo, near Madrid, to operate the IUE satellite.[974] On this basis, and having received assurance from the German authorities that the 11 and 14 GHz frequency bands could be used at the Odenwald site, the Council decided in April 1974 that the OTS control station should be located there.[975]

Meanwhile, a tender action was started for the choice of the contractor, and in June 1974 ESRO received two offers, one from a consortium led by AEG-Telefunken and another from a consortium led by Siemens. Neither of them was entirely satisfactory from the technical point of view, but the Executive recommended the former, subject to the condition that the deficiencies found in the offer were overcome. It was also expected that the British company Marconi would be included among the sub-contractors, in order to achieve a more balanced geographical distribution of work. Pending this revision of the tender proposal, and because the question of the location had been re-opened, only 0.750 MAU out of the 5.325 MAU contract value was committed for a 10-week design phase and for critical long-lead items.[976]

The question of the location was again on the table because in July the German authorities had informed ESRO that the availability of the OTS frequencies could only be guaranteed in Odenwald until 1980. Given this situation, the Executive considered it unreasonable to build the station there, both because the OTS was likely to have a lifetime extending beyond 1980 and because the same station was also to be used for the ECS, which would operate on the same frequency bands as OTS. On the other hand, the Villafranca site also had to be excluded because the eccentric location of the station in relation to the coverage area of the satellite antenna beams prevented the possibility of properly conducting the required experiments on the OTS communications system.[977]

After the elimination of Odenwald and Villafranca, three other alternatives were analysed by ESRO, only two of which, however, deserved consideration.[978] The first was the offer by the German authorities to build the OTS control station at the Usingen site, 30 km north-west of Frankfurt, where the Deutsche Bundespost had its overseas transmitting station and where they planned to build the German station for pre-operational use of OTS. The main problem with Usingen was the existence there of high-power HF transmitters, with a risk of interference with the ESRO station. This problem was discussed with representatives of the German PTT administration but could not be solved satisfactorily. The second

973 As noted above, the national PTT administrations would set up, at their own expenses, the earth stations required for the operational use of the ECS system. In addition, some administrations were willing to set up facilities for the experimental programme and pre-operational use of the OTS. For ESRO/CEPT negotiations on the future OTS operation see ESRO/PB-TEL(74)22, 21 August 1974, and ESRO/PB-TEL(74)26, 16 September 1974.

974 Council, 51st meeting (23-24 November 1972), ESRO/C/MIN/51, 5 December 1972. The Odenwald station was already destined to operate the ESRO satellites GEOS and METEOSAT. The Villafranca station was ESRO's main contribution to the joint NASA/UK/ESRO IUE space telescope in geostationary orbit.

975 Council, 64th meeting (29 April 1974), ESRO/C/MIN/64th, 10 May 1974. The Council decision was based on ESRO/C(74)15, 25 March 1974, with add. 1 and 2, 29 April 1974. See also ESRO/PB-TEL(74)3, 1 February 1974.

976 ESRO/AF(74)82, 12 July 1974; AFC, 101st meeting (25 July 1974), ESRO/AF/MIN/101, 8 August 1974.

977 PB-TEL, 10th meeting (3 July 1974), ESRO/PB-TEL/MIN/10, 22 August 1974. About the problems at the Villafranca site, see ESRO/C(74)15 and ESRO/PB-TEL(74)3, cit.

978 ESRO/C(74)50, 17 September 1974.

alternative foresaw the building of the OTS control station at the Redu site, in Belgium, where one of the stations of ESRO's satellite control network (ESTRACK) had been established since the beginning of the Organisation's life. The choice of Redu did not present any major technical problems: all services and facilities existed on the site, reliable data link to ESOC was quite feasible, and no objections existed to the use of the required frequencies on the part of the Belgian authorities. In fact, the latter had already advocated the choice of Redu for the OTS station even against Odenwald, in order to give more prominence to "the Organisation's only facility located in Belgium".[979] The third alternative was offered by the Italian authorities. It consisted of having the OTS controlled under ESRO contract by the Italian company Telespazio, which operated the PTT station at Fucino, near Rome. The OTS control station at Fucino would be partly financed by Telespazio and used both for the ESRO experimental programme and for OTS pre-operational use by the Italian company. Eventually, the station would become the Italian earth station in the operational ECS system.[980]

The real choice was between Redu and Fucino, both solutions being acceptable and virtually equivalent from the technical point of view. A significant difference did exist, however, from the political point of view: while the earth station at Redu would be owned and operated by ESRO, the one at Fucino would be owned by Telespazio and operated under ESRO contract. The Executive definitely recommended the latter for two main reasons. Firstly, the Fucino/Telespazio option presented an appreciable economic advantage over Redu, with regard to both the total cost and the timetable of payments. Secondly, it involved a direct commitment by a telecommunication organisation and hence closer cooperation between ESRO and users; this would facilitate the transition to the subsequent operational phase of the programme.

The final choice of the site for the OTS control station pertained to the Council, as it involved a decision running counter to its own decision of 1972, but the PB-TEL was invited to discuss the issue and express its position.[981] The discussion, however, came to nothing. On the one hand, the Belgian delegation expressed "its deep regret" at the fact that the Redu solution had not been adopted outright and stressed that, in choosing the Fucino site, ESRO was delegating one of its responsibilities to a member state. On the other hand, the German delegation proposed a new site in Germany, Weilheim, near ESOC. They argued that, since the Council's previous decision had been called into question, the choice of the site should be fully open to discussion and the Executive should now assess the merits of their proposal. Italy, of course, advocated the Fucino option. After a long discussion, the Board was unable to agree on a clear recommendation and the question was deferred to the Council.[982]

At the Council meeting, one week later, the question had definitely become a highly political issue, with four Member States advocating the establishment of the new facility in their own territory: Italy supported the Fucino/Telespazio option recommended by the Executive; Belgium pressed for the Redu/ESRO solution and stressed "the capital importance of the Organisation being the owner of the ground station"; Germany argued that the choice of the Weilheim site was the most consistent with the Council's established policy about earth stations; and even Spain asked for reconsideration of the Villafranca site, which had been rejected months before.[983] The Belgian delegation was the most sanguine. According to

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979 ESRO/C/MIN/64, cit., p. 7.

980 ESRO/C(74)33, 6 June 1974. It must be noted that, after receiving the Italian offer, all Member States were invited to let ESRO know whether any other national bodies were interested in tendering for the setting up and operation of the OTS control station. In addition to Telespazio, the German Bundespost and the Spanish national telephone company (CTNE) offered their services. Both bodies, however, stated that they were not willing to accept the contractor ESRO had selected for the construction of the station nor the fact that the station itself might be used by ESRO after the end of the OTS nominal life of three years. Consequently, these offers were not taken into consideration. For these negotiations see ESRO/AF(74)89, 12 July 1974, with add. 1, 22 July 1974, and add. 2, 25 July 1974; together with ESRO/C(74)50, cit.

981 PB-TEL, 11th meeting (30 September 1974), ESRO/PB-TEL/MIN/11, 19 November 1974. At the PB-TEL meeting, the document ESRO/C(74)50, cit., was presented under the cover ESRO/PB-TEL (74)23, 17 September 1974, with add. 1, 30 September 1974.

982 ESRO/C(74)50, add. 1, 1 October 1974, and add. 2, 7 October 1974.

983 Council, 68th meeting (8 October 1974), ESRO/C/MIN/68, 22 October 1974, p. 10.

the minutes of the meeting:

> *The Belgian Delegation voiced the grave concern of its authorities about the situation that had developed in the Organisation during recent months, in particular the repeated postponement of the appointment of a Director General, the absence of a final decision on the Aerosat [aeronautical satellite] programme, and now budget difficulties. Faced with the Council's attitude towards a decision on the choice of the ground station, the Belgian authorities wanted to see the whole of these problems dealt with at political level and they reserved the right to initiate action to that end.*[984]

The ESRO Council found itself in a very delicate situation. More than one year had elapsed since the European Space Conference had finally agreed on the so-called "second package deal", which paved the way to the transformation of ESRO into a European Space Agency (ESA) devoted to all kinds of space activities (science, application and launchers). The birth of the new agency, however, had been repeatedly postponed because of persisting political and financial problems, and the Council could not add to its already hot agenda a critical consideration of the location of all the Organisation's facilities, as requested by the Belgian delegation. They still had in mind the difficult situation in which ESRO had found itself after the decision to stop the research activity at ESRIN and to wind up the sounding rocket programme based in ESRANGE. In that circumstance, it had required laborious negotiations with the Italian and Swedish authorities before a compromise about the future of these establishments could finally be reached.[985] After a harsh discussion in which the Dutch delegation supported the Redu solution and France, Sweden, Switzerland and the UK supported Fucino, the Council decided, by the narrow margin of four votes (Belgium, Germany, Netherlands and Switzerland) to one (Italy), with five abstentions (Denmark, France, Spain, Sweden and the U.K.), to defer any decision on the location of the OTS control station to its next meeting. The Council chairman, the French Maurice Lévy, who had been one of the main authors of the second package deal, expressed his "grave disappointment" at this outcome of the Council's discussion. And the Swiss delegation noted disconsolately that "concern for national interests continued too often to predominate".[986]

The problem found a solution at the following Council meeting, at the end of October 1974, but the persisting disagreement was recorded in the outcome of two votes. By the first, the Belgian proposal to locate the OTS control station at Redu was rejected by four votes in favour (Belgium, Netherlands, Sweden and Spain) and five against (Denmark, Germany, Italy, Switzerland and the UK), with one abstention (France). By the second, the Council adopted a resolution, by seven votes to one (Belgium) with two abstentions (Netherlands and Sweden), which provided for the OTS control station to be located in the Telespazio facilities at Fucino.[987]

The issue of the site having being settled, the question of the contractor came to the forefront. In October, AEG-Telefunken returned with a revised offer in which the price had escalated to 8.25 MAU, the reasons for the increase being mainly ascribed to the introduction of new sub-contractors. Under these circumstances, in which the just-return policy so considerably contrasted with the tender cost, the Executive felt obliged to re-open competition by awarding an eight-week study contract of 150 kAU

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984 ESRO/C/MIN/68, cit., p. 11. The lack of agreement on the choice of A. Hocker's successor as ESRO's director general had led the Council to appoint the Director of Administration R. Gibson as acting director general: Council, 66th (restricted) meeting (26 June 1974), ESRO/C/APP(74)17, 8 July 1974.

985 ESRIN became the seat of the new Agency's Space Documentation Centre; ESRANGE was transferred to the Swedish government but it continued to be used by ESRO for its sounding rocket "special project". The similarity between the Redu situation and that of ESRIN and ESRANGE was explicitly underlined by the Belgian delegation.

986 ESRO/C/MIN/68, cit., p. 12.

987 Council, 69th meeting (30 October 1974), ESRO/C/MIN/69, 8 November 1974, with attached ESRO/C/LXIX/Res. 1, 30 October 1974.

to Siemens in order to make this company's former offer technically acceptable.[988] Siemens, however, could not submit a revised bid before the end of February 1975, which made it impossible to meet the schedule of the OTS programme. Consequently, negotiations with AEG-Telefunken were undertaken with a view to reducing their price. The company, in particular, was now instructed to review its design using the cheapest sub-contractors.[989] The newly revised offer of AEG-Telefunken, which excluded Marconi, now amounted to 6.545 MAU, the increase compared to the original offer being mainly due to the technical requirements imposed by the move from Odenwald to Fucino. In the event, two different contracts were approved by the AFC, one directly with AEG-Telefunken, at a cost of 2.345 MAU, for the ESRO share of the station's equipment, and another with Telespazio, at a cost of 3.854 MAU, for the renting, maintenance and operation of the station over 3.5 years.[990]

10.4 Concluding remarks

The launch of the OTS, originally planned at the end of 1976, was eventually scheduled for September 1977. On Friday 13th of that month, an unfortunate date indeed, the Delta rocket carrying the satellite exploded shortly after lift-off from Cape Canaveral and the 900 kg spacecraft was lost in the ocean.[991] Fortunately enough, a back-up policy for the OTS project had been agreed in 1975, and a second flight unit could thus be integrated in six months. This was successfully launched on 11 May 1978, opening a "new era in European communications", the ESA Bulletin heralded.[992] Earlier that year the ESA Council had finally approved the undertaking of the next phase of the Telecom Programme, after two years of laborious negotiations both among Member States and between ESA and EUTELSAT, the new organisation to which the PTT administrations had delegated authority for owning and managing the space segment of the communications satellite system. The ECS development could then go into full swing and the first ECS satellite, now re-named EUTELSAT I, was eventually launched on 16 June 1983 from the ESA range in Kourou by an Ariane rocket. A second satellite was launched in August 1984 while the third was lost in September 1985 because of a launch failure. Two other satellites were then launched in September 1987 and July 1988, respectively, thus bringing to completion the full ECS system with four satellites in orbit. We should also recall that the Telecom Programme also produced the MARECS satellite, a satellite for maritime communications based on the ECS design, two of which were successfully launched in 1981 and 1984 (a launch failure occurred in 1982).

A thorough discussion of these developments will be presented in a subsequent chapter (in volume 2). Concluding this second part of our story of ESRO's telecommunications programme, a few general considerations are called for. The first, and the most obvious, concerns the long time required to get a definite programme under way and to harvest the expected achievements. First ideas on a joint European communications satellite programme were discussed as early as in 1963 and first plans were elaborated by the end of 1965. It then required six years to get ESRO's Telecom Programme approved (but only the first phase of it) and two more years before the programme arrangement was agreed on and the construction of the OTS contracted with industry. The approval of the next phase then required another four and a half years. When, in the summer of 1983, the first ECS finally began its operational life, six Intelsat V satellites were orbiting over the Earth's oceans and another was about to move on to the

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988 ESRO/AF(74)82, add. 1, 28 October 1974; AFC, 103rd meeting (29 October 1974), ESRO/AF/MIN/103, 8 November 1974.

989 AFC, 104th meeting (28-29 November 1974), ESRO/AF/MIN/104, 12 December 1974; ESRO/AF(74)154, 19 December 1974.

990 ESRO/AF(75)8, 23 January 1975; ESRO/AF(75)9, 24 January 1975; ESRO/AF(75)10, 24 January 1975. AFC, 108th meeting (10-11 February 1975), ESRO/AF/MIN/108, 20 February 1975.

991 The satellite was heavier than originally designed because in 1974 it had been decided to use the new and more powerful Delta 3914 launcher instead of the standard 2914 model. The upgrading of the OTS made it possible to design it much closer to the operational ECS than originally planned. On the other hand, the use of such a new vehicle involved some technical risk. See the discussion at the PB-TEL, 10th meeting (3 July 1974), ESRO/PB-TEL/MIN/10, 22 August 1974, as well as the documents ESRO/PB-TEL(74)17, 25 June 1974, and ESRO/PB-TEL(74)19, 26 June 1974.

992 ESA Bulletin, 14 (May 1978): OTS opens new era in European communications. This issue was completely devoted to a description of the OTS and its orbital test programme.

launching pad; domestic satellite telecommunications in the United States were being implemented by several private companies (Western Union, AT&T, RCA, SBS, Hughes), the first launchings occurring in 1974; Canada had already launched seven satellites of the ANIK series; Japan, India and Indonesia had also acquired independent space communications capability; and two Symphonie satellites were approaching the end of orbital life after several years of good performance. Not all these spacecraft were as complex and up-to-date as the ECS, but the European system was certainly too late to play a major role in the competitive market of space telecommunications.[993]

The patient reader of this and the preceding chapter will agree that it was not technical difficulties that caused such a prolongation in the development of ESRO's (eventually ESA's) telecommunications programme. Notwithstanding the sophistication of the OTS and ECS design, engineers in ESTEC and in industry seemed perfectly capable of meeting the technical challenge; at least, no evidence can be found in the IAPC and PB-TEL documents of any major delay caused by technical difficulties. What we find, on the contrary, is the evidence of the many political and institutional problems arising from the complex framework of the history of space in Europe. Let us recall three of them that deserve some further comment.

First was the laborious search for a coherent space policy for Europe. ESRO's Telecom Programme was hardly considered or evaluated just for itself; it was an element of a process which involved many other elements, such as the question of the European launcher and the relationship between Europe and the United States, or the problems of industrial policy and European economic integration. In order to start a viable space telecommunications programme, package deals had to be agreed on in which both common undertakings and national interests could be guaranteed, and this took time.

The second problem regarded the question of users. As the Swiss delegation put it at a PB-TEL meeting:

> *The initiative to develop a telecommunications system rested entirely with the ministers of ESRO's Member States, and [...] the decision had not been taken solely with a view to meeting the users' requirements, but within a much wider political context. Indeed, it had to be recognised that the users had never formally requested the introduction of such a system.*[994]

The development of space telecommunications in Europe was not spurred on by a strong demand, with generous funding provided by interest groups. On the contrary, it was political push which furthered the development. This however lacked clear objectives, firm determination and adequate funding, because of the uncertainty regarding the economic benefits and the multinational structure of the institutions called to implement the programme. Another kind of deal, in fact, had to be negotiated between ESA, the ministers and the users organisations in order to cope with the financial aspects of the ECS system.

A third reason for delay was the rather cumbersome procedures for taking decisions. This was due to the complex institutional framework in which the decision-making process developed, with several bodies involved at different levels and different times. Not only did all major decisions of the Telecommunications Programme Board have to be endorsed by the Council, but the latter was invested with all issues of political relevance (i.e. each time the PB-TEL delegations could not find an agreement). Questions affecting the budget and those regarding industrial policy had to be discussed by the Administrative and Finance Committee. Those involving more than one programme had to be discussed by the appropriate Programme Board or the Joint Programmes and Policy Committee (JPPC). Groups of experts were often set up to discuss technical questions (which often had political importance, as we have seen in the case of the STP programme), and the smoothness of the whole process depended of course on the general political conditions. The decision process was also affected by the performance of other

993 For technical information on all communication satellites up to 1992 see Martin (1991).
994 PB-TEL, 4th meeting (27 February 1973), ESRO/PB-TEL/MIN/4, 15 March 1973, p. 7.

actors, like the CEPT and its committees, the national PTT administrations, the EBU, the governments of ESRO's Member States, the individual ministers in those governments, and so on. And the multinational structure of so many decision-making bodies added a new dimension to the usual slowness of any complex bureaucratic process.

The second general consideration regards the political role of the ESRO/ESA Secretariat *vis-à-vis* the legislative arms of the Organisation. We have seen how important this role was when, after the failure of the envisaged ESRO/COMSAT cooperation, the Executive succeeded in proposing the OTS project and getting it through against the no-issue situation of competing national interests. On the other hand, they were not able to get good technical arguments recognised against "industrial policy" considerations when the choice of the OTS contractor was discussed. ESRO was capable of defending the viability of the Telecom Programme against the CEPT's pessimistic analysis on the financial aspects of the envisaged ECS system; but they failed when claimed support for a fully fledged technological research programme. A fair conclusion might be that the Telecom Programme certainly gave ESRO a more important political role than the Organisation had when its programme was limited to scientific projects. The Executive always acted now as an authoritative protagonist in the negotiating process, taking advantage of its established technical and managerial capability, as well as the political credibility which ESRO had *vis-à-vis* the setbacks of ELDO and the shortcomings of the European Space Conference. On the one hand, the Telecom Programme had provided the Organisation's technical staff with invaluable know-how on advanced space technology and on the management of important industrial contracts. On the other hand, it became clear that projects like Symphonie or Sirio could not serve a European ideal in space, and if such an ideal was to survive, ESRO was the only instrument to achieve it and the Telecom Programme its main implement.

Our last consideration regards ESRO's industrial policy. The concern about this aspect was particularly exasperated among the Organisation's Member States. The enforcement of the just return concept was always at the core of any political negotiation or technical discussion, and the difficulty of finding a compromise on this issue was often the main reason for delays and setbacks. The stakes in fact were high. Telecommunications appeared as the most promising sector in space activities, both from the viewpoint of economic investments and from that of commercial returns. Governments and industries could not afford to miss the opportunity that ESRO's Telecom Programme was offering. The just return concept was at the very core of ESRO's foundation. At the 1962 conference at which the ESRO Convention was opened to signature, the plenipotentiaries had adopted a resolution which stated that the Organisation should "place orders for equipment and industrial contracts among Member States as equitably as possible, taking into account scientific, technological, economic and geographic considerations [our emphasis]".[995] The geographic constraint, however, had not been particularly emphasised in the first years of the Organisation's existence, from 1964 to 1968, and it became an important issue only when ESRO started to develop more sophisticated scientific satellites like the TD-1. With the undertaking of application programmes, the budget escalation, and the evolution of ESRO towards a comprehensive space agency, the just return principle became the main element of the Organisation's industrial policy.

Just return, however, could not be a substitute for a real industrial policy. The latter, in fact, should also imply the planned use and development of Europe's industrial resources, with the aim of improving its competitiveness and rationalising its structure and services, but this often contrasted with the requirements of fair geographical distribution.[996] We cannot discuss this topic here, but we should recall that the pressure for fairly distributing industrial contracts among participating countries, on the one hand, and the development of both national and joint European programmes, on the other, led in fact to duplication and to productive over-capacity. In the event, this essential tension between industrial rationalisation and just return, as well as between national policies and ESA's joint ventures, led to the emergence of two parallel and competing programmes on second-generation communications satellites,

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995 See chapter 2.

996 On the discussion about ESRO's and ESA's industrial policy see Beattie & De la Cruz (1967) and Dondi (1980a). See also Müller (1990), pp. 353-357.

the Franco-German TDF/TV-SAT and ESA's Olympus. That, however, is a story to be told in a subsequent chapter.

Table 10-1
Alternative options for the orbital tests

Option I	Use of satellite of the 200-kg class. Four possible sub-options:
Ia	Sirio-B and Symphonie-B
Ib	Sirio-B only
Ic	Symphonie-B only
Id	A specially developed satellite
Option II	Development of a satellite of the 500-kg class

Source: ESRO/IAPC(71)9, 24 May 1971

Table 10-2
Financial plan for the two options of table 1 (MAU at 1971 prices)

Options	Phase 1 (preparatory)	Phase 2 (experimental)	Phase 3 (operational)	Total
Ia	5	179	211	395
Ib	5	144	211	360
Ic	5	161	211	377
Id	5	176	211	392
II	5	255	176	436

Source: ESRO/IAPC(71)9, 24 May 1971

Table 10-3
Financial plan for the three options of Table 1 (MAU at 1971 prices) *

Options	Phase 1 (preparatory)	Phase 2 (experimental)	Phase 3 (operational)	Total
Ia	5	179	211	395
Ib	5	144	211	360
Ic	5	161	211	377
Id	5	176	211	392
II	5	255	176	436
III	5	331	112	448

* Figures in this table include ESRO direct costs, industrial development contracts, and common and support costs calculated according to the new programme budgeting and accounting which took into account the eventual optionality of programmes (see ESRO/C(71)46, 21 September 1971, and add. 1, 18 October 1971). Common and support costs were estimated at 91 MAU for Option III and at 56.5 to 85 MAU for the various sub-options in Option IV.

Source: ESRO/IAPC(71)9, add. 1, 18 June 1971

Table 10-4
Cost-to-completion of Options II, III and IV (MAU at 1971 prices)

Option II	500-kg experimental satellite; 700-800 kg prototype/operational satellite	473
Option III	200-kg experimental satellite; 700-800 kg pre-operational satellite; 700-800 kg operational satellite	497
Option IV	Several alternatives, e.g.:	
(i)	ESRO/COMSAT satellite and 400-kg operational satellite without prototype	271.5
(ii)	Symphonie-B financed outside ESRO and 400-kg operational satellite with prototype	305
(iii)	Symphonie-B financed outside ESRO and 800-kg operational satellite with prototype	381
(iv)	ESRO/COMSAT satellite and 800-kg operational satellite with prototype	400
(v)	Symphonie-B financed by ESRO and 800-kg operational satellite with prototype	424

Source: ESRO/IAPC(71)28, 9 November 1971, and ESRO/IAPC/MIN/9, 22 December 1971, annex V.

Table 10-5
Programme of the experimental phase (1972-1976) with estimated costs
(MAU at 1971 prices)

1. Communication system a) Overall system studies b) Studies of transmission problems c) Propagation experiments d) Earth segment studies	7.5
2. Supporting Technology Programme (STP) a) Communication technology a1) Travelling wave tube amplifier a2) 14/11 GHz modular repeater a3) Qualification of parts and technologies a4) Advanced developments a5) Antenna developments b) Spacecraft technology b1) Structures and mechanisms b2) Thermal control b3) Attitude and orbit control b4) Energy conversion	33.0
3. Experimental satellite (including CTS) a) Definition and development b) Manufacture c) Launch	20.0
4. Pre-operational and operational satellites a) Satellite configuration definition studies (Phase A study) b) Further work on the operational system (Phase B study)	5.5
Total cost	76.0
ESRO direct costs	10.0
Common and support costs	25.0
Grand total	101.0

Sources: ESRO/IAPC(71)28, 9 November 1971, and ESRO/IAPC(72)6, 23 February 1972

Table 10-6
Cost estimates for the OTS option (MAU at 1971 prices)

	Phase 1	Phase 2	Phase 3	
			400 kg	800 kg
ESRO direct costs	1	11.5	11	11
Communication System	1	7.5	3	3
Technology	3	33.0	4	14
Experimental satellites (OTS + CTS)	--	55.5	--	--
Operational satellites	--	3.5	94	160
Sub totals	5	111.0	112	188
Total cost			228	304
Common and support costs			60	77
Grand total			288	381

Sources: ESRO/PB-TEL(72)2, 11 August 1972, and ESRO/PB-TEL(72)6, 7 November 1972.

Table 10-7
Financial envelope of the experimental phase (Phase 2)
(MAU at 1972 prices)

	Phase 2	Phase 2 bis
ESRO's internal costs	12.9	0.6
Communication system	7.1	1.1
Supporting technology		
a) microwave	17.8	0.9
b) spacecraft	9.6	3.6
Experimental satellites (OTS and CTS)	64.4	---
Operational satellites	3.3	0.4
Total	115.1	6.6

Source: ESRO/PB-TEL(73)12, 6 July 1973.

Table 10-8
Scale of contributions to the Telecom Programme

Country	Contribution share in %
Belgium	3.96
Denmark	2.35
France	23.11
Germany	25.01
Italy	14.69
The Netherlands	2.50
Sweden	4.90
Switzerland	3.39
United Kingdom	20.09
Total	100.00

Source: ESRO/C(73)64, 8 October 1973.

Chapter 11: The Long Struggle to Adopt a Balanced European Space Programme

J. Krige

The previous six chapters have described the evolution of ESRO's scientific programme and the efforts to embark on the development of a European telecommunications satellite. This turn to applications was, in fact, indicative of a complete reorientation of the priorities of the European space programme. ESRO was set up on the initiative of scientists who wanted to enter the new domain of research beyond the atmosphere opened up by satellite technology. ELDO was primarily a political and industrial project; its launcher was embarked on to draw the British government closer to its partners across the Channel and to encourage national firms to develop advanced technologies. No specific use, or user community, informed the earliest definitions of the rocket.

All of this began to change in the mid-1960s. Governments now saw space as a domain of commercial and social importance, and grew increasingly interested in the possibility of using it for a variety of purposes, above all telecommunications, but also meteorology, navigation, etc. Applications gradually began to supplant science in the eyes of many fund givers as the prime rationale for investing in space. This not only forced a reassessment of the balance of effort between space science and applications. It also forced a reassessment of the kind of launcher that was needed, if indeed Europe needed a launcher at all given its limited resources and the availability of American launch systems.

This redefinition of space priorities was a complex process, and inevitably different European countries had different, and changing conceptions of what a 'balanced' European programme would involve. Europe could not hope to do everything it would have liked. Choices had to be made, choices which had to be made against the background of changing national and international political contexts. In particular, Europe simply had to take account of developments across the Atlantic, and situate itself *vis-à-vis* the vast American effort. It is for that reason that in this section we also have two chapters dealing specifically with US-European cooperation in our period.

This chapter describes the seven difficult years during which Council delegates in ESRO and ELDO, and their Ministers meeting in the European Space Conference, struggled to define a European space policy which would win the adherence of the majority of the participants. Its most striking feature is that, notwithstanding the very different priorities adopted by the Member States, the determination to find a compromise which would hold the partners together eventually prevailed. This determination not to fail, to build a European space community, and so to consolidate European collaboration in general, was the underlying glue without which the entire edifice would have crumbled. What we are about to tell is then not just a story of policy choice but of political will, a will which eventually overcame the momentary tensions, conflicts, and threats which at times threatened to tear a collaborative European effort to shreds and to replace it with bilateral and multilateral agreements.

11.1 The Causse Report

As we pointed out in chapter 4, the Ministers meeting in Rome in July 1966 were emphatic that the time had come to coordinate the European space effort. They had before them a report drawn up by an ad hoc group headed by Michel Bignier. It stressed the need for avoiding overlap between programmes, with one eye on the potential competition between the telecommunication satellite foreseen for CETS and the Franco-German Symphonie. It identified some major gaps in European activities, notably the absence of powerful launcher able to put a satellite for direct TV broadcasting in geostationary orbit. And it insisted that governments should be prepared to double their investments in space from 0.05% of GNP to 0.1%.

To take matters further the European Space Conference (as the Ministerial meeting now became) decided to set up an Advisory Committee on Programmes. Its task was to "elaborate proposals for a joint space policy" and for "programmes in the framework of such a policy […]".[997] This policy had to conform to several guidelines. It needed to suggest projects covering several years which were "harmoniously divided between scientific and technical research activities, on the one hand, and practical applications on the other, together with the construction of the launchers required for such projects". The Committee was asked to focus its attention on improved communications satellites and a "meaningful" scientific programme concentrated on a "few" activities which opened up "new prospects in the research area". Wide-ranging proposals were not enough; the Committee had to establish priorities between the different programmes, and cost each alternative.

The European Space Conference nominated Jean-Pierre Causse, the head of the French Space Centre at Bretigny to chair this committee. He was assisted in this task by Technical and Economic Subcommittees, and by representatives from each of the organisations comprising the European Space Conference, ESRO, ELDO and CETS. The Causse Report was published within six months, in December 1967.[998]

The Causse Report began (and herein lay its great interest) by clearly differentiating the aims of a European space effort from the space programmes of the Superpowers. At the time civil space, in the public mind, was dominated by the space race between the United States and the Soviet Union, and was synonymous with international rivalry, national prestige, and man-in-space programmes. Causse and his colleagues emphasised instead the long-term commercial interest of space and Europe's need to develop the autonomy needed to collaborate from a position of strength with the space giants. "Rather than seek the 'power' objective that has characterised other space policies", it said, "Europe should above all demonstrate her determination to be independent. Rather than indulge in illusory competition, she should seek to practice the closest collaboration with the other space powers […]" on condition that she could ensure intellectual, technical and commercial benefits commensurate with her efforts.[999] Civilian space, for the Causse Report, was thus to be seen above all as a domain of major economic significance. It was an emerging field in which industrial and commercial rivalry around the exploitation of rapidly developing new technologies, notably for telecommunications, would soon eclipse the political and ideologically-inspired conflicts of the previous space decade.

The Causse Report recognised that many of Europe's space goals could be achieved for the major European powers by national efforts and through bilateral collaboration with the USA or the Soviet Union. But no single European nation acting alone would have the political and economic weight to protect its interests in confrontation with two space powers which had invested far greater resources for many more years into their space programmes and their space-related industries. Thus, even while stressing the economic, industrial and commercial advantages of space, the report stressed the political nature of the decision that had to be taken. It put two major political objectives at the top of its list of aims which could only be achieved through a cooperative European space effort, coordinated with national programmes. First and foremost, such an effort would secure "Europe's place in the world". This would be achieved by ensuring that there was a "fair partnership" in the "design, production and management of the equipment needed for space exploration and exploitation", by enabling Europe to have a "fair place" in international activities like the World Weather Watch and Intelsat, by "raising the prestige of European science" and ensuring that European scientific efforts would not be impeded by "the manner in which facilities are made available by other space powers" (e.g. launch windows, conditions on access to data), by reducing the brain drain, and by giving Europe the capacity to help underdeveloped countries. Secondly, and crucially, only a combined European programme could secure European "autonomy of political and cultural expression,", i.e. "having the possibility to procure in case of need, the necessary rockets, satellites, payloads and ground facilities for broadcasting radio and television programmes to specific areas, without the present space powers being in a position to exercise control over these broadcasts through their monopoly of launching facilities".

997 For this paragraph seeF CSE/CM(July 67)14, Final, 13 July 1967.
998 The Causse Report is CSE/CCP(67)5, December 1967.
999 Ibid. pp. 8-9.

Having explained its overall philosophy the Causse Report went on to define policy for each of the three main areas of civil space, namely, scientific and applications satellites, and launchers. Its rationale for the science programme once again attested to the group's innovative spirit. The classic justification for a collaborative European programme had always been that ESRO, like CERN, should embark on at least one satellite which was beyond the resources of any of its Member States acting alone. Hence the argument that a project like the Large Astronomical Satellite, the LAS (see chapter 5) was essential to, if not the backbone of, the ESRO scientific programme. The LAS was so expensive, and so demanding technically that it would necessarily require a cooperative venture. The Causse Report refocused the problem completely. "ESRO's scientific programme", it wrote, "*must be based on the existence of a scientific community* […]" (my emphasis). This community, the report went on, was not to be obliged to found the greater part of its activities on national or bilateral programmes, leaving it to ESRO "to manage a few large collective undertakings". ESRO's task then was not primarily to finance heavy equipment otherwise unavailable to its Member States, as was the case at CERN. It was instead to build and to consolidate a truly European space science community by giving them regular flight opportunities on a range of appropriate satellites.

Causse and his advisers estimated that the European programme had to keep 25 space science groups occupied. Assuming that each needed to undertake one experiment every two years to have a continuous activity, the Report concluded that 12 to 15 experiments, chosen by the scientific community itself of course, should be annually orbited. In round numbers this was equivalent to ESRO launching two satellites per year. These satellites were to have the same complexity as the current TD1 and TD2 or HEOS satellites in the ESRO programme; smaller and less complex satellites could be dealt with at the national level.

These suggestions, the Report stressed, were not intended to exclude large programmes like the LAS altogether, though it was felt that they might better be pursued at an international level in collaboration with the USA or the USSR. Nor were experiments with sounding rockets to be stopped. They were a useful testing ground for new ideas and for training newcomers to the field of space science and technology. At the same time the Report felt that this programme should not be expanded. ESRO's task was to play a leadership role in the field of scientific satellites, not sounding rockets, for which anyway "the framework of an international organisation provides an inevitably cumbersome environment".

Turning next to applications satellites, the Causse Report first dealt with telecommunications. It identified the development of a direct television broadcasting satellite as the long-term objective of the European programme. Such satellite broadcasts could be picked up directly by ordinary domestic receivers with a relatively small, domestically installed antenna directed towards the spacecraft. "A possibility of this nature", said the report, "appears as a revolution in many fields, such as techniques of telecommunications and the methods of television distribution (there is no need to construct new ground networks, and whole new networks could be created at one go in under-equipped or badly equipped countries) […]".[1000]

Technically speaking it seemed that to achieve this objective one would need to place in orbit a geostationary satellite weighing at least 1500 kg, preferably 2 tons. To cover most of Western Europe it would need an installed power of about 20k W, radiating at least 4 or 5 kW. Many technical problems still had to be overcome, notably regarding the electrical power generators and on-board antennae. After all the weight and installed power of the first geostationary satellites were merely some 50 kg and 50 W, respectively. To arrive at the ultimate objective Causse thus suggested a two-step programme. Firstly, the development of the CETS-C satellite. Weighing about 180 kg, and with an installed power of 200 W it

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1000 Ibid. p.23

required solar panels which oriented themselves automatically towards the Sun. This was at once an improvement on Symphonie (installed power about 100 W) and met the requirements of the European Broadcasting Union. And as "all progress towards direct television broadcasting is governed by progress in the development of power sources" this was "a step in an essential direction".[1001]

The next step proposed after the development of CETS-C was a 500 kg semi-direct TV broadcasting satellite with an onboard power of 1-2 kW to be launched in the mid-1970s. This would be based on studies, envisaged by CETS and which needed "to be conducted with vigour and continuity", into improved on-board antennae and satellite stabilisation systems, and into the most suitable frequencies to be used. The latter required in turn the development of the corresponding high-reliability components. By following this programme Europe would acquire over a decade the industrial and operational experience needed to make direct television possible.

Communications were not the only applications programme explored by the Causse Report. It also discussed the possibilities for aeronautical navigation and meteorology, and touched briefly on Earth resources satellites. Air traffic control, particularly over the North Atlantic was a "public service activity", said the report, which would improve air traffic safety on the most crowded routes and produce considerable savings for airline companies. The French were developing a twin set of satellites for this purpose; the British were improving navigation by means of marine platforms in the Atlantic which were equipped with radar. An aeronautical satellite was thus not a pressing priority for the European Space Conference, but something that should be considered carefully and planned for in consultation with the interested bodies.

Meteorology was similarly being revolutionised by the use remote sensing techniques, including satellites. Meteorological satellites were able to provide global coverage of the conditions in the upper atmosphere and so enabled forecasters to extend the period of validity of their predictions. This in turn would have obvious economic and human benefits (e.g. through providing timely and accurate storm warnings). Any meteorological programme necessarily had a global, or international component. The Causse Report thus suggested that steps be taken, in consultation with meteorologists and with other agencies developing such satellites, to define and develop a meteorological programme. It also indicated the interest of exploring the possibilities of a European satellite similar to the US's Landsat which could be used for high-resolution analysis of the Earth's surface.

Causse's committee was "convinced of the importance of an independent launcher capability for Europe".[1002] This was particularly needed, it stressed again, in the field of telecommunications where the USA and the USSR were likely to place restrictions on the use of their launchers. But it was also important for science, where restrictions ranging from approval of the scientific content of experiments to be flown to an agreement on availability of results had been imposed by NASA in the past. Causse also emphasised that a decision to abandon launcher development was irreversible, and that Europe's position would be "lost irretrievably" in such a case.

That granted the report insisted, first, that it was necessary to complete the Europa I and Europa II (=ELDO-PAS) programmes. However, it was "already apparent" that more powerful launchers were needed for application satellites. The committee recommended that this should be achieved in two steps, labelled Europa III (500 kg in geostationary orbit) and Europa IV (2 ton payload), respectively. These two launchers could be based on the use of Blue Streak with the minimum modification. Its power could be increased by using strap-on boosters or by using more efficient upper stages employing cryogenic or electrical propulsion. Significant investments had already been made in France in the former; various forms of electrical or nuclear propulsion were still in the experimental phase, even in the USA and the USSR. In the light of these considerations the Committee thought that a decision should be taken within a year on Europa III, and in the light of the results of work on the liquid hydrogen technique. A decision to

[1001] On CETS-C see R. Collette, "Space Communications in Europe. How did we make it happen?", in J. Krige, *Choosing Big Technologies* (Chur: Harwood Academic Press, 1993), pp. 83-93.

[1002] Causse Report, p. 33.

develop Europa IV could be taken three years later, and it might use electrical propulsion. As for the development of an "intermediate launcher" able to put 400 kg in low-Earth orbit – the gap identified in the Bignier report – the Causse Committee suggested that that be left to national programmes or that US launchers be used.

It was not enough to develop launchers; they also had to be produced. The Committee suggested that the Space Conference decide that an order be placed for a first batch of five launchers at a rate of two per year.

The implementation of a coherent space programme required a new institutional structure. The Causse Report suggested that the European Space Conference be the supreme body, grouping together at Ministerial level all the States wishing to participate in space activities. Its meetings would be prepared by a Standing Committee. The ESC would lay down space policy for Europe, it would coordinate national activities and it would be responsible for international activities. A European organisation for space research and development would fuse the current activities of ESRO and ELDO and would report directly to the ESC.[1003]

In setting priorities and defining a "balanced" programme the Causse Report assumed, firstly, that the space budget, starting from its present level would increase by not more than 10% per year for a period of several years., until a satisfactory balance was reached. In money terms, it assumed that the European space budget would increase from 150 MAU in 1967 to 240 MAU in 1972. Development was divided into four successive phases on which decisions were needed, respectively, in 1968, 1969, 1972 and some time from 1970 onwards.

In Phase 1 the Europa I and II launchers would be continued, and the CETS-C communications satellite for Eurovision would be undertaken, along with a research and development programme in that area. The science programme was a major headache, however, notably because of the LAS. The Causse Report defined this as a continuing astronomy programme involving four launchings beginning in 1973, the two latter carrying scientific packages different from the two former. The development cost of the satellites was estimated at 133.6 MAU, and the launchings cost 29 MAU. This was to be compared with the cost of a TD-class satellite, whose development cost was some 24 MAU and which cost 8 MAU to launch. In short the LAS programme -- and here was the key problem – was equivalent in terms of financing to about five or six medium sized scientific satellites. It thus skewed the scientific programme enormously in favour of one discipline.

Causse and his colleagues presented the Ministers with three options. They could continue with the LAS, but this could only be done if ESRO's scientific programme fell below the level they felt was necessary to build a European space science community. In the other two options the LAS was abandoned. This enabled the science programme to maintain a level of two satellites launched per year and to remain within ESRO's 8-year budget ceiling and, in one variant of the programme, also made it possible to introduce an experimental meteorological satellite.

As so much hinged on the first decision, the other three phases were dealt with far more briefly by the Committee. Phase 2 of the overall programme was to be decided on in 1969, as we said, and would involve the development of Europa III with a liquid hydrogen second stage. This was to be done within an annual limit of 90 MAU for all launcher work inside ELDO. A 500 kg-class applications satellite would be developed at the same time. Phase 3 involved the development of Europa IV within the same financial constraints along with the 2-ton geostationary satellite. Phase IV, if embarked on, would also see the financing of a major international scientific (e.g. a LAS) or applications satellite.

[1003] Ibid, chapter 5.

11.2 The ELDO Crisis[1004]

Even as the ink was drying on Causse's recommendations, they risked being overtaken by events in both ELDO and ESRO. As we mentioned earlier, the first firings with a live second stage F6/1 (4 August 1967) and F6/2 (6 December 1967) had both failed due to the malfunctioning of Coralie. A detailed investigation was undertaken by the French authorities along with representatives of the firm SEREB. They concluded that several key components (power units, autopilot unit, sequences) should be replaced by other such units already developed and qualified in France. They also insisted that major improvements were needed to the electrical and electronic systems. Only under such conditions, they concluded, could a second stage be built having a desirable standard of reliability.[1005]

The ELDO Scientific and Technical Committee discussed these proposals at its meeting on 22 and 23 February 1968. While appreciating French concerns, the committee was extremely disturbed by their implications. In particular it pointed out that the French proposal would postpone by at least one year the scheduled first flight of a live (German) third stage, firing F7. If overall time slippages were to be avoided this delay would be at the expense of the time allowed for rectifying problems that would surely emerge with Astris. If, on the contrary the schedule were rearranged to allow for time slippages, the cost-to-completion of the programme would necessarily increase.

The Secretariat considered different ways of avoiding the situation, e.g. by adding a firing F6/3 comprising a dummy second stage and a live first and third stages. They concluded that this would have no particular benefit. As a result, following the majority of the STC, it suggested that if there was to be a fundamental redesign of Coralie it would have to take place in parallel with the scheduled programme. Every possible effort should be made to fire F7 before the end of 1968 using the current Coralie modified slightly. A new revised overall plan T8 would be drawn up by April to accommodate slippages of some six months caused by the F/6 failures.

The French delegation initially opposed this plan. However, it withdrew its objection when the ELDO Council met on 27 and 28 February 1968 with General Robert Aubinière (F) as President for the first time. Insisting that Coralie required "surgery not medicine", the French delegate nevertheless accepted that it was necessary to fire F7 as planned before the end of 1968.[1006] Realising that these decisions would necessarily have implications on the cost-to-completion of the programme, the Council set up a working group chaired by L. Williams (UK). Its task was to examine the extent to which the previous ceilings on the ELDO programme of 626 MAU overall, and 331 MAU from 1 January 1967 were likely to be exceeded, and to propose a new ceiling with an adequate contingency margin based on ELDO's current Target Plan T8.[1007]

The William's Report was delivered in May.[1008] Its first striking finding was that the contingency reserve foreseen in the 626 MAU overall ceiling agreed by Ministers in July 1966 had almost all been eroded away in 18 months. Of the 107 MAU originally set aside for the cost-to-completion, a mere 22 MAU remained to be spent. The highest overrun in absolute terms was for the perigee-apogee system and its associated launchings (36.5 MAU). This was particularly disturbing, the Report said, since the estimate was for a programme which had just begun, and before most contracts had been placed. What is more the 1968 budget laid before Council had made no allowance for the failure of F6/2 and the additional costs which that would necessarily incur. It was quite evident then that the overall ceiling was hopelessly unrealistic, and indeed would have been exceeded even if the earlier Target Plan T7 had been respected.

1004 For a brief summary of the steps described here, and the pertinent documents, see ELDO/CM(July 68)3, 4 July 1968.

1005 See ELDO/C(68)PV/1, Minutes of Council Meeting held on 27, 28 February 1968, document dated 26 April 1968, and its Annex II, *Report of the Chairman of the ELDO Scientific and Technical Committee on its Meeting of 22 and 23 February 1968*.

1006 See the Minutes referred to in the previous note.

1007 See ELDO/C(68)8, Final, 29 February 1968.

1008 It is ELDO/C(68)14, 14 May 1968, *Report by the ELDO Council Working Group on the Overall Ceiling of Expenditure.*

The second point brought out by the Williams Working Group was that the cost-to-completion of the programme according to Target Plan T8 was likely to be at least 100 MAU more than the ceiling laid down by Ministers in July 1966. T8, compared to T7, foresaw a slippage of six months in the firing of F7 as caused by the Coralie failures, and shifted the last three firings (F11, 12 and 13) from Woomera to Kourou, which would be ready in mid-1970 for them. The Working Group insisted that Target Plans were merely useful critical-path analysis management tools, rather than reliable financial instruments. Granted the uncertainties in the programme they suggested that its ultimate cost would lie between the following brackets:[1009]

	Estimate of cost-to-completion of programme	**Overspend of the July 1966 ceiling of 626 MAU**
Optimistic hypothesis	710 MAU	84 MAU
Pessimistic hypothesis	770 MAU	144 MAU
Intermediate hypothesis	750 MAU	124 MAU

The Group said that it was "not in a position to assess the probability of each of these three events". But it was emphatic that the Secretariat's estimate of 720 MAU was unduly optimistic given the current state of the programme.

The conclusions of the Williams report had to be considered by the ELDO Council in the light of another major blow: the British government's refusal to support the "balanced" space programme proposed in the Causse Report and, in particular, its reiterated refusal to contribute to any excess expenditure in ELDO over and above the 626 MAU already agreed in July 1966. The Wilson government's position was spelt out in an Aide Mèmoire dated 16 April 1968 from Whitehall to the Ministers of Foreign Affairs of all the Member States of the European Space Conference. It was explained again at the ELDO Council, meeting in restricted session on 22 May 1968.[1010]

The British began by stating that they were not against technological collaboration in Europe. However, they felt that the only way to close the technological gap with the United States was through industry-led rather than government financed projects, and in projects which had prospects of sound economic benefits. Government's role was essentially enabling rather than leading. The British particularly wanted to see the mergers and amalgamations which were taking place on national level also occur at European level. Only European scale industries were capable of generating the "vast sums required for research, development and marketing" in fields like computers and electronics, airframes, nuclear energy and motor vehicles.

Within that perspective, the UK's "starting point for consideration of the proposals of the Causse Report has […] been that they should be judged on their economic merits and an assessment of the contribution they could make to the strengthening of European industrial collaboration generally". They were disturbed to see that the Report promoted a sharp increase in space spending from 150 MAU to 240 MAU annually in the early 1970s. They noted that the development of a TV relay satellite system would only be commercially viable if research and development costs were written off. This did not mean than an operational system would not be viable; only that there was no point in building the satellites themselves in Europe. The UK also remarked that one could not make a realistic economic assessment of the value of other application satellites, e.g. for meteorology. And that Europe would develop a launcher which would surely be far more expensive than its US equivalent, where the civilian programme alone called for many launchers a year.

1009 From the Report just cited at p. 25.

1010 The Aide Mèmoire is CSE/CS(68)23, add.2, 29 April 1968; the Minutes of the meeting held on 22 May are ELDO/C(68)PV/2, Annex II, Confidential, (Rev), 31 July 1968.

From this the British government had drawn the following conclusions. That they were willing to see ESRO's budget for scientific research increase by up to 6% annually for the next three years. That they were not willing to participate in the CETS project for an experimental TV relay satellite since "the economic case […] was not strong enough". And that they were not willing to accept any new financial commitments to ELDO. Not only had the programme proved to be far more difficult and costly than originally anticipated. There were anyway no economically worthwhile applications of the launcher in sight. The Aide Mèmoire concluded by insisting once again that the space programme proposed in the Causse Report made "an economically unsound use of European technological resources and would not strengthen Europe's world standing in advanced technology". "The weight of this economic and technological argument", it went on, "is so strong as to override arguments about the political or cultural benefits" which Causse's 'balanced' European space programme might have.

Faced with the cost overruns in the ELDO programme, and Britain's determination not to contribute to them, the Committee of Alternates of the ESC meeting on 10 May 1968 asked the ELDO Council to instruct the Secretariat to propose a new austerity plan. This was quickly done and became known as Target Plan T8/A.

The saving of T8/A with respect to T/8 was 45 MAU.[1011] This reduced the Secretariat's overall estimate of 720 MAU to 675 MAU including contingencies. The revised plan also had the advantage that the budget for 1969 did not exceed 626MAU, the ceiling agreed in 1966 and the limit up to which the UK delegation was prepared to contribute to the expenses of ELDO.

To achieve these objectives T8/A took into consideration work which was already so advanced that it could not be halted and let the burden of savings fall in areas where a substantial part of design and development had still to be completed. This meant that cuts fell particularly heavily on the supplementary PAS programme. Here the Secretariat proposed that "the technical objectives of the PAS test satellite should be reduced to the minimum necessary for full qualification of the launcher system (propulsion and guidance)". Developments and operations which were normally the responsibility of the customer, like attitude control of the spacecraft, orbital adjustments, accurate tracking etc were to be excluded, along with passenger experiments proposed by Italy and ESRO. As a result some foreseen elements of the tracking system (antennae at Redu and modifications at Gove) were deleted. One firing would be cut from the programme (F13), and no precise geostationary positioning would be attempted. These measures accounted for almost 30 MAU of the 45 MAU cut from T/8 by T/8A.

The burden of these cuts fell on Italy (for the PAS satellite) and on Belgium (for the tracking facilities). It was not surprising then that, when the ELDO Council met in June 1968 these two countries were the least satisfied with the revised scheme. Thus while the delegates of five Member States (Australia, France, Germany, The Netherlands and the United Kingdom) resolved that they were in favour of austerity plan T/8A (with Britain of course refusing to fund the programme beyond the ceiling of 626 MAU), the representatives from these two countries were more prudent.[1012] The Belgian delegation felt that measures should be taken to compensate it for the work that it lost, and was not prepared to recommend or to oppose the adoption of T/8A until this was resolved. The Italian delegation (which had just made arrangements to pay its backlog of 13 billion Lire to the ELDO budget) was even more emphatic. The Secretariat, it said, should have looked for solutions other than those which removed technologically important tasks from Member States. If, however, a unanimous decision was taken to cancel such tasks, and in particular the development of an 'operational' PAS system, countries should be compensated for their loss by being given work of the same nature in another programme carried out by the ELDO Member States.

1011 Target Plan T8/A is described in ELDO/C(68)19, 27 June 1968.

1012 The relevant resolution is ELDO/C(68)20 Final, 26 June 1968, Resolution passed at the Council Meeting on 24, 25 June 1968.

A Ministerial Conference of the representatives of the ELDO Member States was held on 11 and 12 July with a view to resolving some of these difficulties. And even if the determination to find solutions was there, the major partners demanded that progress could only be made if certain conditions acceptable to them were satisfied. France was emphatic that Target Plan T/8 had to be abandoned. Italy was emphatic that if T/8A was accepted it had to be compensated in the Symphonie or CETS programmes for the loss of technically interesting work on the PAS test satellite. Britain reiterated its refusal to contribute to any overspend of the July 1966 ceiling. It also insisted that any Blue Streaks produced for a firing of the Europa rocket after F12 would be supplied on a strictly commercial basis at a cost to be negotiated to the user, thus dashing the hopes of France and Germany that firings F12 and F13 could be used for Symphonie within the framework of an ELDO programme. Belgium was willing to accept T/8A on condition that it was compensated elsewhere in an overall European space programme, a view shared by the Netherlands who also sought more coherence in the overall space effort. In a final resolution the delegates agreed to proceed temporarily on the basis of Target Plan T/8A until the Ministerial meeting of the European Space Conference scheduled for the autumn. All countries except Britain also agreed to propose that their governments fund the overspend of the 626 MAU ceiling, subject to a number of "reservations and observations" e.g. France and Germany called for the UK to share in that financing, Italy required that a satisfactory technical plan be adopted, and so on.[1013]

The ELDO Ministerial Conference realised that it was essential to provide more clear-cut decisions for the ESC meeting soon to be held. It thus instructed the President of the Conference, Mr. Theo Lefèvre, the Belgian Minister in Charge of Scientific Policy and Planning, to consult with the delegations with a view to having the reservations expressed in the resolution removed as soon as possible. Delegates met again on 1 and 2 October to discuss the results of his consultations with the Ministers concerned.[1014]

Lefèvre's report was dominated by two main considerations.[1015] Firstly, considering the diametrically opposed positions adopted by Britain and by France, he suggested that there was no way of breaking the deadlock within the framework of the existing ELDO programme. Britain "could not contemplate participating in the additional cost of the programme, in the subsequent stages of development of the Europa rocket […]". And it was only prepared to ensure the availability of Blue Streak "for a limited number of years". France, on the other hand, would only continue in ELDO if all the Member States participated in Target Plan T/8A. It also insisted on "active long-term participation by Great Britain in subsequent developments of the family of launchers which, from Blue Streak onwards, will make it possible, by stages, to put satellites of 1 to 2 tons into synchronous orbit". Other countries shared some of the France's positions, though were less uncompromising. Germany, Holland and Belgium, for example, wanted Britain at least to give "adequate guarantees […] as to the long-term availability of Blue Streak". In any event it seemed clear that unless some major concessions were made, or some drastic measures were taken, the whole European launcher programme, and the collaborative space effort along with it, would be jeopardised.

The second major theme developed in Lefèvre's report was intended to refocus ELDO's difficulties and to situate them within the broader framework of European industrial collaboration. In essence the Belgian Minister's point was the governments concerned had to think more carefully about the procurement and use of the products of their investments in research and development (just as the British had insisted). "Gradually", said Lefèvre, "each of us has become aware of the inconsistency of engaging in research leading to the development of advanced equipment without at the same time providing the industrial basis and the market which these products demand in order to make a valid contribution to the economic progress of our countries". American success, he emphasised, was due not just to major government investments in R and D. It was also thanks to the support of public procurement, the scale of the firms

1013 The proceedings of this meeting are ELDO/CM(July 68)PV/1,2,3,4 and the final resolution is ELDO/CM(July 68)6 Final, 12 July 1968.

1014 The minutes are ELDO/CM(October 68)PV/1, PV/1 Restr., PV/2 Restr., and PV/3.

1015 Lefèvre's report is Annex I to ELDO/CM(October 68)PV/1 Rev., 16 October 1968 concerned and unity of a large market. In Europe, by contrast, organisation had been limited to research and development, and had not been "slanted towards the actual needs of our nations but rather towards the technical or scientific performance for its own sake". They had not attempted to establish consortia or unified industrial structures which could compete on an equal footing with US industry. And no public procurement policy which could create a genuinely unified market had been developed for the advanced products resulting from European technological collaboration. The only way to solve the ELDO problem, Lefèvre concluded, was to "consider all the sectors of high technology [the nuclear, space, and electronics] in a single renewed approach, as they are linked by the nature of the activities and enterprises as well as by the convergence of their economic and industrial effects".

Many Ministers shared Lefèvre's conviction that European technological collaboration had to be coordinated across sectors, rather than being tackled piecemeal. However, they also felt that this was a long-term problem. Their priority now was to resolve the crisis in ELDO, and to provide guidelines for the European Space Conference which was to meet in Bonn in six weeks time. In anticipation of this meeting the Ministers agreed that ELDO could "continue provisionally its activity within the framework of the T/8A Plan […]". At the same time they asked the Council to "propose a programme within the ceiling of 626 MAU […]". And they set up a Committee of Senior Officials headed by Dr J. Spaey (NL) which was asked to find a compromise between the ELDO Member States on the broad outlines of a future European space programme.[1016] The Ministers would meet again to consider the results of these deliberations on the eve of the European Space Conference, scheduled for 12 November 1968.

On 30 October the Council was able to recommend two plans to Ministers which were feasible within the 626 MAU limit.[1017] Plan A concentrated on developing the second and third stages of Europa but abandoned all efforts to approach a geostationary capability. The programme ended with firings F8, F9 and F10 from Woomera. This plan was well within the 626 MAU figure and was unlikely to consume the whole of that figure. Plan B allowed for F8 and F9 from Woomera and two further firings of the three-stage launcher from Kourou. The perigee motor would be used to put 170 kg in equatorial transfer orbit. The apogee motor would not be developed. This plan would cost 592 MAU without contingencies. It was only feasible if a strict austerity policy and tight controls were implemented.

The choice between Plans A and B depended on the future role of Blue Streak in the programme. Plan A was the obvious choice if it was decided to develop a European launcher using only the second and third stages of Europa. Plan B was to be preferred if the Member States intended to persist with the British first stage.

The Italian delegation, it should be said, could not accept either of these plans. Both were seen as striking at the raison d'être for its membership of ELDO, which was to develop a test satellite in the geostationary orbit with telecommunications potential. Italy thus proposed a third plan. Plan C maintained the objectives of Plan 8/A to place 170 kg in geostationary orbit. Its cost was 602 MAU without contingencies, and so would certainly exceed the 626 MAU ceiling imposed by Ministers. To overcome this hurdle Italy suggested that each Member State should bear the cost of any overspend occurring on its territory and attributable to technical reasons. The Italian suggestion was strongly resisted by the ELDO Secretariat and the ELDO Council. It was completely at odds, they said, with the decision taken at the 1966 Ministerial conference that the Secretariat exert more control over the ELDO programme, and that it, and not the Member States, manage the relationships with firms in the different countries. Italy, in reply, insisted that the Secretariat was and its partners were at fault for not respecting the decision, taken unanimously in 1966 to give her a test satellite.

1016 The resolution is ELDO/CM(October 68) 6, 4 October 1968.

1017 The plans are described in the *Report by the President of the ELDO Council to the ELDO Ministerial Conference,* ELDO/CM(November 68)6, 8 November 1968.

These proposals, and the Spaey Report, were laid before the ELDO Ministers meeting at Bad Godesberg on 11 November 1968. Their conclusions were passed on to the wider meeting of the European Space Conference which began the next day.

11.3 The Spaey Report and the ELDO Ministerial Meeting of 11 November 1968

A feeling of grave crisis pervaded the ELDO Ministerial meeting in Bonn/Bad Godesberg. The space policies of the participating states were so divergent that it seemed that, unless a compromise could be reached quickly, said Belgian Minister Theo Lefèvre, "I have the gravest fears for the immediate future of the space institutions and programmes we have supported and conducted until now at such great expense".[1018] The divergences over the use of launchers were at the heart of the issue, of course, but not only they. Britain in fact demanded that a whole series of other conditions be met by the European space programme. And then of course there were the difficulties faced by Italy.

A compromise solution to the launcher issue was put forward in the Spaey Report. It was deliberately intended to keep the British in the programme.[1019] It distinguished between a minimum programme of activities which did not include the development of an autonomous launch capability and a basic programme which included the minimum programme plus launcher development. The minimum programme covered application satellites, space research, as well as range logistics and infrastructure, and research directed towards future developments. Participation in these four activities was a qualifying condition for being a Member State. In other words, the launcher programme would no longer be mandatory; Britain could remain a partner in the European space effort without contributing to the development of a rocket.

While there was general agreement on the overall features of the minimum programme, there were again deep differences between Britain and the other Member States over its implementation. Firstly, regarding the scientific programme. Britain suggested that this programme be funded at the rate of 50 MAU in 1968, and that it grow by 6% per annum for six years. Her partners wanted to stabilise its expenditure immediately at 50 MAU. More importantly, they wanted scientific satellites to constitute "both a preparatory phase in and a necessary use of the filiations of satellites" developed for applications, the financing of science being phased at the same pace as commitments to applications. In short while the UK wanted to retain the scientific programme "as an objective in itself" her partners in ELDO (though not in the broader ESC) wanted it to be dovetailed into the applications programme and subservient to it.[1020]

The applications programme itself was the subject of controversy. Britain accepted that "a long-term target might be a European capacity equivalent to a two ton information transfer satellite in geo-synchronous orbit". This target would of course be approached in phases. However, she wanted the commitment to each of these stages to be conditional on there being "an operational requirement which could shown to be economically viable in the broadest sense". Her partners found that short-sighted and dangerous.

Three interconnected issues were at stake here. Firstly, all of the ELDO Member States agreed that from henceforth the commitment of member countries to a programme should 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". No longer were there to be decisions taken, like that to develop Europa I, "without stating why this rocket was necessary or the uses to which it would be put […]".[1021] Nor was it to be possible for a programme to be jeopardised by one partner just because time and money had run out. Commitment to a

1018 See his opening statement in the Minutes of the morning meeting on 11 November 1968, ELDO/CM(November 68)PV/1, 11 November 1968.

1019 The Spaey Report is the *Report to the Ministerial Conference on the Elaboration in Broad Outline of a European Space Programme,* 6 November 1968 (ELDO1003).

1020 These quotes are from the Spaey report, just cited, at p. 3, and from the *Presentation of the Results of the ELDO Ministerial Conference (11 November 1968), by Mr. Theo Lefèvre, Minister of State, President of the Conference,* Annex 1 to the Minutes of the meeting of the ESC on 12 November 1968, CSE/CM(November 68)PV/1, 12 November 1968, at pp. 5-6.

1021 Spaey Report, p. 10.

programme would be to its completion. This is just what the British wanted to avoid as far as the 2-ton satellite was concerned. Not yet convinced of its economic viability they wanted to proceed to that objective by independent stages.

Related to this was the question of voting majorities. All agreed that an initial commitment to the objectives and content of the basic programme should be taken unanimously. But what of the decisions to embark on successive stages. Britain's partners wanted this to be by majority vote, to stop any one country from blocking the programme. The UK, on the other hand, wanted the decision on each successive stage to be taken unanimously, so giving any one country veto power over the move from one phase to the next.

This had major implications for launcher policy. For it meant that "a degree of uncertainty will attach to the subsequent phases of the launcher utilisation programmes which is incompatible with the sound management of launcher development and production". Indeed, to ensure that there was a market for Europa and its successors Britain's partners wanted the launchers they had produced to be given priority, under certain conditions, in the organisation's programmes. Production could only be linked to procurement, they felt, if a "guaranteed" market was available, as in the USA. By demanding that each phase of an applications satellite programme be subject to unanimity Britain seemed to be threatening any rational planning of launcher production.

The feeling that guarantees had to be given for the use of Europa were linked to the recognition that the market would automatically be limited by cost considerations. Indeed it was admitted that the production cost of European launchers then being built was more than twice that of the US equivalent. To get around this problem the Netherlands delegation proposed that the price of launchers procured for the European programme should be "reasonable", and based on economic value and cost.[1022] But what did reasonable mean? The representatives of all countries bar the UK on the Spaey committee suggested that the cost to the satellite programme "should not exceed the price of the American launcher by more than 50%, calculated on the basis of a genuine, durable and commercial offer. The difference between the real cost and this price", they went on, "would be borne by the countries participating in the launcher programme". Britain's position, by contrast, was quite simply that European launchers should not be used when they "would compromise the viability of projects".[1023]

The general stress on the leading role to be given to applications satellites, and the launchers to place them in orbit, went along with the demand that institutional changes were needed. There was a unanimous wish for a single, simplified organisation in which policy-making authority was clearly demarcated from executive and management roles. Responsibility was to be devolved to industry, fixed price contracts were to be negotiated wherever possible and the formation of European industrial consortia was to be encouraged. "It is within the consortia that the geographical distribution of tasks would be arranged, at overall programme level and not necessarily project by project".[1024] It was also suggested that Member State contributions could be assessed independently of GNP, and in terms of their industrial returns. The Belgian Minister put it clearly: "A group of countries, to which mine belongs, regards scientific and technological cooperation as a means of transforming their industrial structures to achieve the dimension and quality required by world competition, by way of a long-term programme. […] We reserve for the national framework," he went on, "technological projects of lesser scope and short-term economic viability".[1025] In short the de-emphasis of the science programme, and the suggestion that it be tied to applications, was just part of broader determination in the majority of the Member States to make space policy part and parcel of industrial policy at the European level.

1022 The Dutch proposal is ELDO/CM (Nov 68)WP/1, 11 November 1968 (ELDO1008).

1023 Lefèvre's report to the ESC, pp. 4-5.

1024 Lefèvre's report to the ESC, p.3.

1025 Minutes of the meeting held on the morning of 11 November, ELDO/CM(November 68)PV/1, 11 November 1968.

The ELDO Ministerial Conference of 11 November 1968 could not possibly resolve all these differences. It did however take a few important decisions. Firstly, it resolved to continue with the current Europa I and Europa II programmes until the 626 MAU were exhausted in accordance with the austerity Plan B (See above) Secondly, it resolved to finance studies and experimental work for a further launcher able to put communications satellites up to 500 kg in geostationary orbit.[1026] These resolutions required that guarantees be provided regarding the future availability of Blue Streak. They also required that Italy be compensated for the loss of the apogee motor.

The first matter was settled relatively easily. Britain undertook to supply Blue Streak or components thereof "at least up to 1976 to ELDO, to Member States of ELDO, to former members of ELDO or to any grouping of former members […]" for peaceful purposes. This was on the "explicit understanding that no additional financial burden" should fall upon the UK government and that orders were placed in time.[1027] This statement both reassured Member States as to the availability of the first stage of Europa for the foreseeable future, and persuaded them of the need to develop a launcher without Blue Streak to be operational from the mid-1970s onwards (as the Resolution quoted in the previous paragraph indicates).

The Italian situation proved to be a far more thorny problem. The Italian position was that the adoption of the PAS system in 1966, which foresaw placing the Italian test satellite in geostationary orbit, "was in the nature of an international commitment unanimously adopted by Member States and thus required unanimity before it could be modified". Plan B, however, "involves cancellation of the only major tasks allocated at that time to Italy, and of the only coherent and technologically meaningful set of works assigned to Italian industry". Italy, her delegate went on, demanded "tangible compensations" for this loss. In particular, she asked that "work of a similar kind and technological importance to the tasks cancelled under the PAS be entrusted to Italy within the scope of an existing programme under control of two ELDO member countries, namely the [Franco-German] 'Symphonie' programme".[1028]

A partial solution to the Italian demands was found at the end of the day. France and Germany agreed that prime contractorship for the construction of the apogee motor for Symphonie should be entrusted to Italy, "on condition that Italy makes an economic and competitive offer respecting the time scale […]", and that, if needed, Italian industry would give priority to firms in France and Germany for subcontracts. This concession only partly satisfied the Italian delegate, however. He insisted that when the Italian Parliament had voted additional funds for the ELDO programme in 1966, trebling its contribution, it been on the assumption that the PAS programme would be completed. The apogee motor, desirable as it was, was thus not sufficient compensation for the loss of work; Italy also required a reduction in her contribution to ELDO.[1029] The matter was left at that on 11 November, the French and German delegations not then being in a position to make any further concessions.

11.4 The European Space Conference in Bonn/Bad Godesberg, November 1968

The Ministers of the three European space organisations meeting on 12 November did not only have to deal with ELDO's difficulties;[1030] they also had to try to settle a long-simmering crisis in ESRO. The revised proposals of the Causse Report were laid before them to assist their decisions.

1026 Resolution of the Ministerial Conference, ELDO/CM(November 68)7 Final, 12 November 1968.

1027 The British conditions are appended to the Resolution just cited.

1028 Minutes of the meeting held on the morning of 11 November, and Annex III to ELDO/CM(November 68)PV/1, 11 November 1968.

1029 Minutes of the meeting held on the evening of 11 November, ELDO/CM(November 68)PV/3, 11 November 1968, and *Resolution of the Conference*, ELDO/CM(November 68)7 Final, 12 December 1968.

1030 *Report by the Secretary General of ELDO* summarises the situation, CSE/CM(November 68)8, 31 October 1968.

ESRO's difficulties could be traced back to 1966. In that year it became clear that the organisation would not spend all of the resources allocated to it for the first three-year period; there was a remaining balance of 122MFF in 1965 prices. The Executive thus suggested that this be carried forward to the next three-year period (1967-1969), and that the budget for the second phase of the science programme be thus increased to 808MFF in 1965 prices. The Council refused, insisting that the original figure of 686MFF be adhered to. Meeting in December 1966 it could do more than adopt a budget of 230MFF for 1967, as against the 260MFF requested by the Executive. This meant that, if work proceeded on the projects already started (ESRO I, ESRO II and HEOS-A), there would not be enough money in the eight-year programme for the two TD satellites and the LAS. Determined to leave some funds for new projects, the LPAC decided to give top priority to the TD satellites and to restrict resources to the LAS to 300MFF maximum.[1031]

These problems only grew more intractable with the passage of time. Early in 1968, with no three-year budget yet voted, it emerged that the costs of the TD1/TD2 satellites had been hopelessly underestimated by the consortium building them. Instead of the 109MFF foreseen, the final figure looked like being at least twice or three times that figure. The problem was compounded by Italian objections that her industry was poorly represented in the TD programme, a position which led her to block the vote on ESRO's 1968 budget. A major crisis was only averted by the new Director General, Herman Bondi, who took over from Pierre Auger in November 1967. Bondi suggested that, in accordance with Article VIII of the ESRO Convention, one TD satellite could be treated as a Special Project and funded only by those states who wished to participate in it. Every effort was made to relocate some experiments from the second TD satellite on another spacecraft.[1032]

Of course the difficulties faced by ESRO were not only due to the lack of experience in the organisation and in industry as reflected in their underestimate of the cost of building satellites. They were also indicative of the re-orientation away from science towards applications and the associated determination in some Member States to cut space science spending at the European level to a minimum. Faced with this situation the Causse Report had to revise its proposals in anticipation of the Ministerial conference in November.

Causse's Advisory Committee on Programmes (ACP) realised that their original proposals would need to be modified to take account of two new developments.[1033] Firstly, they would have to accommodate the recognition, deriving from the TD experience, that the costs of building satellites in Europe was higher than originally expected. Secondly, and compounding the difficulty was the demand by some Member States that the budget should increase annually by no more than 6% over the 1968 budget rather than the 10% asked for initially by Causse. This meant that ESRO's eight-year ceiling for 1964-1971 would be approximately 1650 MFF (330 MAU), even less than the 1890 MFF (378 MAU) foreseen in the organisation's Financial Protocol.

The ACP drew several conclusions from this new state of affairs. Firstly, ESRO's first eight-year plan would have to be restricted to the launch of ESRO I and ESRO II, HEOS-A and HEOS-A2, and to TD1. Work on replacing TD2 could begin, but the LAS would have to be abandoned. No work on a new satellite could begin until 1971-2, assuming the organisation continued in being, and this would lead to a launch in 1975 at the earliest. If that satellite carried a dozen or so experiments, the average number of experiments placed in orbit by ESRO between 1968 and 1975 (no more than eight annually) would be about half the figure originally estimated by the ACP (12-15 per year) as necessary to satisfy the requirements of the European space science community. While the Committee of course did not want to impose the priorities on the ESRO scientific committees, it insisted that the Ministers should at least decide whether or not they wanted to continue with a science programme after ESRO's eight-year period expired: it was "becoming materially impossible for the Organisation to carry through any new project

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1031 See chapter 5 in this volume for more details.

1032 Ibid.

1033 See *Addendum to the Report of the Advisory Committee on Programmes,* CSE/CCP(67)5, addendum 1, 6 September 1968. See also the summary of the ACP Report, CSE/CM(Nov. 68)6, 29 October 1968.

(even the TD2 replacement)".[1034] It was also evident that if ESRO had to survive with an annual budget similar to its present one it would have to concentrate its activities on a smaller number of objectives.

Notwithstanding these re-orientations, the future augured well for ESRO when the Space Conference got under way. On 17 May 1968 ESRO-II was successfully launched. A few months later, on 3 October it was the turn of ESRO-I to be put in orbit. And with a solution found to the TD-1 problem, as DG Bondi put it to the European Space Conference in November, "The past few months have seen a dramatic change in ESRO's standing and self-confidence".[1035]

ESRO's success undoubtedly contributed to the willingness of Ministers to put it back on a secure path at the Bad Godesberg meeting. The first resolution they passed included a decision to instruct the Council to accord the space research organisation 172 MAU (860 MFF) in summer 1968 prices for the period 1969-1971, the figure the Executive had called for. The Ministers also agreed that the life of the organisation could be extended beyond this period; they accepted that commitments could be undertaken beyond 1971. What they did not do was to propose a provisional level of resources for the period 1972-1974. ESRO's future was further assured by the Ministers agreeing, in Chapter 2 of Resolution I, that it undertake a space applications programme. More specifically they resolved that ESRO devote 1MAU annually for studies on the economics, including market possibilities, and technology of application satellites such as those for meteorology, air traffic control, navigation, etc. It was hoped that they would also agree on building the CETS experimental television relay satellite for Eurovision costed at 103 MAU. This decision was, however, postponed for the time being.[1036]

Writing after the Conference Bondi was naturally satisfied with the new stability given to his organisation. However he felt that "perhaps the greatest, and essential achievement of the Space Conference was the agreement on the use of European launchers [...]".[1037] Indeed Resolution No 5 committed the partners concerned to the production and use of European launchers. It estimated that European countries would undertake an average of two launches per year in the period 1972-1976, of which one or at most two would be for the science programme. And, following the debates at the ELDO Ministerial Conference held just before, the delegates adopted a price formula for these launchings, a formula more restrictive than the one proposed earlier. The Resolution stated that the price of a European launcher would be compared to that of a non-European launcher made available without prohibitive conditions and available on the basis of a "genuine, durable and commercial supply". The user would be expected to pay 125% of the price of a non-European launcher (as opposed to the 150% suggested before), the balance being borne by the producer countries.[1038]

This Resolution, like others we will discuss in a moment, was adopted subject to an important reservation by the United Kingdom. Indeed the Bonn/Bad Godesberg meeting was marked by a major policy statement by the UK Minister of Technology, Anthony Wedgwood Benn. The basis of the British position had not changed of course. Benn declared "unqualified and enthusiastic support" for the scientific programme.[1039] At the same time he insisted that Europe had to accept that her money was limited. "The Americans do not solve their problems, they overwhelm them", said Benn. Europe could not do the same. It had to make choices and it was alarming to see "that because a thing is European, and because a thing is international, this somehow excuses us from applying economic criteria". On the basis of such criteria, Benn went on, it was clear to his government that "the launcher priority is the wrong priority". As for the

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1034 *Addendum* to the ACP Report, p. 3.

1035 In CSE/CM(November 68)7. See also H. Bondi, "The Bad Godesberg Conference, November 1968", *ESRO/ELDO Bulletin,* No 4 (January 1969), pp. 4-6.

1036 The Resolution is CSE/CM(November 68)10 (Final), 14 November 1968. All the Resolutions are also reproduced in the *ESRO/ELDO Bulletin,* No 4, January 1969, where the States that voted subject to reservation, or which abstained are also mentioned. This source will thus be cited henceforth.

1037 His analysis is H. Bondi, "The Bad Godesberg Conference, November 1968", *ESRO/ELDO Bulletin,* No 4 (January 1969), pp. 4-6).

1038 Resolution No 5 is on pp. 12-13 of the *ESRO/ELDO Bulletin,* No 4, January 1969.

1039 Minutes of the meeting held on 14 November, 1968, CSE/CM(November 1968)PV/4, 26 November 1968, p. 4

political argument that the USA would only make launchers available for some applications under prohibitive conditions, Benn was sanguine. “The Americans have spent 40 billion dollars on space”, he said, “and it is most unlikely, I speak just as an observer of this, it is most unlikely that the Americans will not want to get back some return on their investment in launchers”.[1040]

These positions informed a major, interconnected set of proposals made by the British Minister to the Conference in which, overcoming his earlier hesitancy, he made a commitment to an applications programme in addition to the scientific programme. Starting from the distinction drawn in the Spaey Report between a basic and a minimum programme the UK declared that it would be prepared to support a minimum programme having three components over and above science. Firstly, a project for an information transfer satellite based on the CETS proposal to provide a point-to-point TV relay service for the European Broadcasting Union by 1975. This could be seen as a step along the road to the 2-ton geosynchronous satellite foreseen for the 1980s, if that was shown to be economically viable. Secondly, Britain would support a programme for long-term applied technological research to make available “materials, components, sub-systems, processes and knowledge not available in European industry or research establishments but which would be needed for a viable space programme”. Thirdly, this programme would include a study of the overall market and the economic returns of applications satellites which could be used to guide further decisions. As for science, the UK was prepared to support a programme for ESRO costing 250 MFF in 1968 and growing by 6% annually for three years, while also allowing the organisation to assume, for planning purposes, the same growth rate for the period 1972-1974.[1041]

Britain's agreement to finance applications was, however, conditional. As Benn put it, “we are prepared to finance our proper share of these three programmes [i.e. elements of the minimum programme] on the basis that if we are released from our existing commitments to ELDO we would put that as a part, not the total, but as a part of our contribution towards these programmes”. This was then “a conscious switch of resources" on the part of the UK "to the applications side in European space”.[1042]

Benn’s resolve to extricate his government as quickly as possible from launcher development was met by the equally strong wish by four ELDO Member States, Belgium, Germany, France and The Netherlands, to continue with a launcher programme. The Belgian government, said Lefèvre, “accords and equal consideration to the scientific satellite programme, the applications programme, and the means of launching” and if it was not possible for other countries to accept that package “we would seek the possibility of cooperating in a more restricted framework with those who share our conviction […]”.[1043] French Minister Galley felt that, with Britain refusing to fulfil its commitments to the ELDO programme, “it was essential to make an effort to carry on the work that has already been undertaken in the launcher field with those partners prepared to continue”.[1044] German Minister Stoltenberg opened the meeting by stating clearly stating that “in order to carry through the application programme it deemed it essential that Europe should prove its ability to launch her satellites by her own launchers, even if that implied financial sacrifices”.[1045] The Netherlands Secretary of State for Foreign Affairs, H.J. de Koster, affirmed that his government believed that “scientific research projects and application projects, in which I include launchers, should complement each other, thereby making the best possible use of all available

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[1040] Annex 3 to the Minutes of the meeting held on the morning of 12 November 1968, CSE/CM(November 68) PV/1 add. 1, 3 March 1969 is Benn's statement verbatim.

[1041] In addition to Benn's statement the UK proposal is formalised in CSE/CM(November 68)17, 12 November 1968.

[1042] Benn statement just cited.

[1043] Annex I to the Minutes of the meeting held on the afternoon of 12 November 1968, CSE/CM (November 68) PV/2, 12 December 1968.

[1044] Minutes of the meeting held on the afternoon of 12 November 1968, CSE/CM (November 68) PV/2, 12 December 1968.

[1045] Minutes of the meeting held on the morning of 12 November 1968, CSE/CM (November 68) PV/1, add. 1, 3 March 1969.

facilities".[1046] The Belgians in fact went even further. Growing impatient with the complications raised by the wish to keep the United Kingdom in the European effort despite her unwillingness to finance ELDO any longer, he suggested that the time might come when those who shared the same objectives would 'go it alone'. It is probable, said Lefèvre, though regrettable, "that if we do not manage to reconcile our points of view, which I hope will not be the case, the countries whose aims and concepts are closest would have to decide to establish cooperation among themselves in accordance with their views", a move which "would threaten from 1971 the survival of the existing organisations […]".[1047]

Two other resolutions were taken in Bonn/Bad Godesberg which aimed to consolidate the fragile consensus among the Member States. Firstly, Resolution No 2 instructed a Committee of Senior Officials "to work out the procedure and the text of a Convention for a single Organisation, by October 1969". As called for in the Spaey Report, this was to be achieved by amalgamating the existing organisations, whose participation in programmes had to be based on a system which was both flexible and which obliged them to support projects through to the achievement of precise objectives. Resolution No 4 amplified this. It took up the distinction drawn in the Spaey Report between a basic programme and minimum programme, and asked that the Convention define the voting procedures required to pass from one successive stage to the next in any programme.[1048] In short it was now apparent that "the principles of European co-operation in space", to quote the title of Resolution No. 4 were going to have make allowance for the different and sometimes conflicting national interests of the collaborating Member States if a unified programme and a single organisation were going to be possible at all.[1049]

In the weeks after the Space Conference ESRO more than confirmed the confidence the Ministers had placed in it. On 5 December 1968 HEOS-A was successfully launched, the third satellite put up by the Organisation in a little more than six months. ELDO, by contrast, slid even deeper into the mire. On 29 November 1968 firing F7 of Europa took place from Woomera with three live stages. The first stage worked perfectly again, as did separation of the first and second stage. Coralie also performed as expected for the first time. Separation of the third stage went smoothly. And then, 5 seconds after ignition, the propulsion of the third stage ceased, due apparently to a major helium leak coupled with strong vibrations. The fairings opened all the same and the satellite was ejected and was followed until loss of telemetry after 15.5 minutes.[1050]

The ELDO Executive insisted that the F7 firing had satisfied many of its objectives, despite the disappointing failure not to orbit the satellite. "The success of the F7 firing", said General Aubinière, the President of the ELDO Council, "thus relieves of all anxiety delegations which doubted or feigned to

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1046 Annex 4 to the Minutes of the meeting held on the morning of 12 November 1968, CSE/CM (November 68) PV/1, 12 December 1968.

1047 Annex 1 to the Minutes of the meeting held on the morning of 12 November 1968, CSE/CM (November 68) PV/1, 12 December 1968.

1048 Resolutions No. 2 and 4 are in the *ESRO/ELDO Bulletin,* No 4, January 1969, on pp. 10, and 11-12. Resolution No 3 instructed the participating States to support the recommendations made by CETS for establishing a joint European position in the forthcoming negotiations of the Intelsat agreements. The *Statement by the Chairman of CETS* to the ESC is CSE/CM(November 68)9, 11 November 1968.

1049 Another working group, this one set up under the Chairmanship of J.H. Bannier to formulate proposals for the institutional reorganisation of space, reached similar conclusions. Its idea was that each state should have the obligation to take part in a common long-term research programme, whereas in individual programmes (scientific space research, space applications and launcher development) only those states interested in individual fields would take part. See the *Report by the Chairman of the Committee of Alternates of the European Space Conference,* CSE/CM(November 68)5, 31 October 1968. The Bannier Report itself is CSE/CS(68)43.

1050 The course of the F7 firing is described in *ESRO/ELDO Bulletin,* No 4, January 1969, on pp. 14-19.

doubt the technical possibilities of this Organisation".[1051] This was more a reflection of the Presidents anger than of the real state of affairs, however. For the failure of F7 simply reinforced Britain and Italy in their conviction that the Organisation was not living up to their expectations, and led to another crisis at the meeting of the ELDO Council on 19 and 20 December 1968.
In anticipation of this meeting the British delegation circulated another note to its partners. Taking its position in Bonn a step further, it argued that it regarded the new austerity plan put forward by France and Germany, and now labelled T9 to be a "further programme" within the meaning of Article 4(3) of the ELDO Convention. This allowed the UK to declare herself "not interested" in the plan, and so not obliged to contribute financially to it. Thus when the ELDO Council met in mid-December it proved impossible to vote the 1969 budget. 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. The balance of the amount Britain would otherwise have contributed to ELDO (i.e. £7 million) would be switched, as the UK had promised in Bonn, to applications programmes, long-term technological research and the production of Blue Streak. Italy, still desirous to receive adequate compensation for the cancellation of the PAS programme, reaffirmed that the prime contractorship of the apogee motor for Symphonie was not enough. It supported the UK's interpretation of the plan T9, declared itself "not interested" in financing this "further programme" and also refused to vote the 1969 budget. These new developments, said the German delegate, "put the organisation back in the situation in which it had been half way through 1968". The deadlock was total. The rule of provisional twelfths, which enabled ELDO to release funds one month at a time in anticipation of the budget being voted, was adopted to allow the Organisation to keep functioning. And another Ministerial meeting was planned for early 1969.[1052]

The Ministers of the ELDO Member States met again in April 1969 to try to resolve the difficulties posed by the Italian and British delegations which, Aubinière said, had "plunged the Organisation into the gravest crisis of its existence".[1053] Extensive negotiations with the partners resulted in Britain increasing her offer of funding to ELDO for the execution of Plan T9 from £10 million to £11 million (26.4 MAU).[1054] Italy, for her part, had her contribution to ELDO reduced by about 10 MAU to 57.6 MAU.[1055] Both countries then agreed to vote the 1969 budget, Italy also accepting to pay her arrears on the budgets for 1967 and 1968.

Determined to continue with the current programme the Ministers of Belgium, France, Germany and The Netherlands agreed jointly to meet the shortfall resulting from the decrease in the Italian contribution. They also accepted to absorb, by unanimous vote, any cost overruns in the Europa I and II programmes, as well as to accept the financial consequences of delays or faults attributable to firms in their countries.[1056] Nor did their commitment to developing an autonomous launcher capability end there. They also decided, with Italy's support to embark on a new programme.

By April 1969 it was patently clear that any launcher programme beyond Europa I and II would have to be undertaken without Britain. The Ministers of the remaining ELDO Member States thus confirmed their resolve to fund studies for a programme of 'Europa III' launchers with a capability of placing 400-500 kg in geostationary orbit. These studies, to be completed in time for a Ministerial meeting in January 1970, would need to define the precise objectives of such a programme, its development timescale and cost, as well as the configuration of the launcher and the participation by industry in it.[1057] A new directorate, the

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1051 In his Statement to the Ministers meeting in April 1969, ELDO/CM (April 69) PV/1, Annex 1, 10 July 1969.
1052 The Minutes of the Council meeting on 19 and 20 December are ELDO/C(68)87.
1053 In his Statement to the Ministers meeting in April 1969, ELDO/CM (April 69) PV/1, Annex 1, 10 July 1969.
1054 See Minutes of the afternoon session on 15 April 1969, ELDO/CM (April 69) PV/2, 10 July 1969, and Resolution No. 1, ELDO/CM(April 69)6/Final Add., 16 May 1969. See also ELDO/CM (April 69)4, 15 April 1969.
1055 See Minutes of the morning session on 15 April 1969, ELDO/CM (April 69) PV/1, 10 July 1969, and Minutes of the afternoon session on 15 April 1969, ELDO/CM (April 69) PV/2, 10 July 1969.
1056 The Declaration by these delegations in which they assume these responsibilities is ELDO/CM (April 69) WP/8, 14 April 1969.
1057 Resolution No. 3, ELDO/CM (April 69)8 Final, 15 April 1969.

Directorate of Future Activities, was set up within the ELDO Secretariat to carry out these studies and, if called on to do so, to execute the corresponding development programme and to manage a production programme in consultation with prospective users. J.P. Causse was nominated to head it[1058] At last, it seemed, the 'British problem' had been solved, and ELDO could move forward into the 1970s confident of the support of its remaining Member States.

11.5 The offer of collaboration in the post-Apollo programme

While the Europeans were grappling with the difficulty of defining the modalities of a comprehensive space programme which would respect their different priorities the terms of their debate were shifted once again by an offer made by the United States to participate in the so-called post-Apollo programme. As this offer and its historical context are discussed in detail in the next two chapters, we shall simply highlight some of its main developments here.

On 14 October 1969, just a few months after NASA's Apollo programme had successfully landed men on the moon, the ESC's Committee of Senior Officials was addressed by NASA Administrator Dr Thomas Paine.[1059] Paine sketched out the kind of programme that the new Nixon Administration had in mind for the next decade of space activities. The vision was grandiose and the means to achieve it ambitious. "We feel", said Paine, "that space may represent another new world, a seventh continent, which is now opening to mankind in the region 100 miles above the surface of the globe". Developing the metaphor Paine suggested that this new continent might be as economically important as was that "opened by Columbus and developed by European settlers". What the US planned to do in its post-Apollo programme was "to start building the transportation systems and the structures and ports [...] which will allow us to occupy and use this new continent for the benefit of man". This was a challenge comparable to that taken on in the first decade of space, and demanded comparable resources.

The programme's components embodied the colonising metaphor. Firstly, there was to be a reusable space shuttle. This was a new kind of space transportation system designed to carry men and materials into low Earth orbit, and to return to Earth again, i.e. it could be re-used many times. It was designed to carry payloads of 20000 to 50000 pounds. Reusability, NASA hoped would reduce the cost per pound in orbit by an order of magnitude, from $ 500 to $ 50.

The second main element of the post-Apollo programme was a space station, a place "where men could live and work in orbit for an indefinite period". It would of modular construction, with different components added successively as the need arose. Within a decade it would grow to "a very substantial permanent space base in orbit".

Finally, there was the NERVA, a nuclear powered deep space propulsion vehicle which would be used to carry the first men to the planets. It used liquid hydrogen as a propellant which was heated by a nuclear reactor and ejected through a nozzle. A prototype engine of this kind developing 70000 pounds of thrust had just completed another series of very successful tests at the Nevada test site. It was planned to use it for a nine-year human expedition to the outer planets at the end of the 1970s, a 'Grand Tour' of Jupiter, Saturn, Uranus, Neptune and Pluto.

The post-Apollo programme did not stop there however. A major scientific programme associated with the space station, e.g. optical and radio telescopes, research in biological and life sciences, etc was foreseen. As for applications, the US intended to "continue to emphasise both meteorology and communication satellite systems with new developments in such areas as navigation satellites and the new Earth resource of Earth survey satellite systems". The US, Paine mentioned, had just signed a contract with India for direct broadcasting satellite experiments to 5000 villages and was working on agreements with several Latin American countries for Earth resource satellites.

1058 Resolution No. 4, ELDO/CM (April 69)9 Final, 15 April 1969 and ELDO/C(69)PV/2, 28 July 1969..

1059 Paine's presentation is reproduced in *ESRO/ELDO Bulletin,* No 8, January 1970.

Paine made it clear on several occasions that the US would welcome European participation in this initiative. "We have in space", he said, "a unique opportunity for a new step forward in international cooperation". And as Europe defined its objectives in ELDO and ESRO, the US would "welcome your suggestions as to new means whereby we can achieve a greater degree of cooperation between our proposed space programs and your own plans for European programs".

The Committee of Alternates instructed ESRO and ELDO to study NASA's proposal. A working group was set up with chairmen J.P. Causse and J. A. Dinkespiler. Their report was ready in April 1970.[1060] It reiterated the revolutionary nature of the programme proposed by Paine to which a new element had now been added, the space tug. The tug was a sort of Shuttle third stage, a manned vehicle intended to carry payloads beyond the Shuttle's orbit, e.g. up to geostationary orbit. The report suggested that Europe's needs would best be served if her industry was able to cooperate in developing elements which were crucial to the system as a whole and sufficiently individualised for the management to be fully in European hands. As for impact, it did not seem that Europe need adjust her scientific or application programmes to the new situation. Since the Shuttle was not scheduled to be routinely operational until the mid-1980s the Causse/Dinkespiler report insisted that a launcher such as Europa III, if available in 1978, would have an active life of a decade. In any event they reported that Europe should only agree to participate in the entire effort if she was given firm guarantees that her missions would be launched. Their views were laid before the fourth meeting of the European Space Conference which opened in Brussels in July 1970.

11.6 On the brink of collapse: The European Space Conferences in 1970

a) The July meeting

The Ministers meeting in Brussels had little difficulty in coming to agreement about what to do next as regards post-Apollo. As the Chairman of the Committee of Senior Officials, Professor Giampiero Puppi put it, Europe had been invited to participate at a preliminary stage of the programme, during which it was still possible to influence final choices. While no firm decision was needed yet, it was urgent that measures be adopted to ensure that a proper decision was taken when the need arose.[1061] To this end the Conference resolved that the Causse/ Dinkespiler working group prepare a detailed report on possible fields of cooperation, along with a plan for its organisation. It endorsed the decision, taken some time before by the ELDO Council, to undertake industrial studies of the tug system, and agreed to fund these studies to the tune of 2.5 MAU up to June 1971. And it entrusted the President of the ESC, Belgian Minister Theo Lefèvre, along with representatives from France and the UK, with the task of discussing with the US government the "political, financial and other conditions for possible European participation […]". The mission was to report back by December 1.[1062]

A second resolution on the setting up a single institution for European space affairs also received general assent. It would take over the tasks then entrusted to ESRO, ELDO, CETS and the European Space Conference. As Puppi put it, the necessity was felt "not only by scientific, industrial and administrative circles in the various countries, but also within the existing Organisations". A draft convention for such an organisation had been prepared by a working group presided over by legal advisers M. Bourély and J. Kaltenecker. It was not submitted to the conference, however, pending the solution of some outstanding political issues. Indeed as Puppi put it, the creation of a new Organisation signified "an important political choice in favour of Space, in relation to other possible sectors, as a priority means of European

1060 It is discussed at length in chapter 13, this volume. See document CSE/HF(70)13, and WG/COOP-US/6, 16 April 1970.

1061 Puppi's statement is in Annex 2 to the Minutes of the meeting held on the morning of 22 July, 1970, document CSE/CM(July 70)PV/1 Rev., 30 July 1970. His first *Report of the Committee of Senior Officials,* CSE/HF(70)25, June 1970, on the reform of the organisation was also presented at this meeting.

1062 The Resolution is No 3, document CSE/CM(July 70)9 (Final), 24 July 1970.

cooperation in the technological field". And this could not be "either an easy or an obvious decision", he was quick to add.[1063]

The debate over the financial measures needed to ensure the continuity of the activities of the new agency gave a hint of just how difficult this was going to be. The Resolution proposed that the scientific and technological research programmes be adopted with provisional eight year envelopes, and with firm commitments from the Member States for five year periods. This firm commitment to the science programme contrasted with a reluctance of many delegations to make similar engagements regarding applications and launchers (see below). The French delegation thus only voted Resolution 2 subject to the reservation that all Member States eventually took commitments in all three sectors.[1064] "We consider it an essential precondition that all the member countries of the Space Conference should subscribe to the whole of the programme that is proposed to us," said the French delegate.[1065]

The Ministers meeting in July resolved to discuss in November a draft convention embodying the principles underlying a European space programme. Resolution No 2 even went so far as to ask the Belgian government to convene a conference of plenipotentiaries in January 1971 in Brussels at which this convention would be opened for signature. The friction between them over Resolution No 1, which attempted to define a long-term programme, must have led many delegates to accept this timescale more out of hope than from conviction.

Resolution No 1 had four "chapters" dealing, respectively, with applications satellites, launchers, the scientific programme and, finally, applied research and common costs[1066] It was not too difficult to establish the content of the applications programme. The delegations resolved that they would carry out a communications satellite programme costing about 450 MAU and satisfying the requirements of the European PTTs and the European Broadcasting Union. They regarded an aeronautical satellite, to be developed in collaboration with the US, of similar priority. And they expressed a strong interest in a meteorological satellite. When it came to voting the money for these projects, and deciding how to move from one phase to the next, however, there was a "profound divergence of views".[1067] For whereas France and Germany wanted to make a major commitment immediately to these programmes, some their partners insisted that a more prudent, stepwise approach was necessary.

Geoffrey Rippon set the tone. Rippon was the Minister of Technology in the just-elected, and nominally pro-European government of Edward Heath; indeed the Conservative Party formally led Britain into the EEC on 1 January 1973. He was in favour of all three satellite programmes, he said. However, he "wished to limit his country's participation to the predevelopment phase that would take place during the next twelve months". The results of these studies should be examined to see whether or not they satisfied the requirements of the relevant user communities before proceeding to funding for the development phase. This approach was taken up by the Spanish and Italian delegations, to the evident distress of some of their colleagues. The French Minister of Industrial Development and Scientific Research, Mr. Ortoli, remarked that there was no need to do another year of studies "to realise that, with its present technological and industrial potential, Europe was capable of constructing an excellent communications satellite. To lag behind in this sector of activities would amount to abandoning it altogether", he went on. The Swiss delegate pointed out that since the PTTs were currently investing in terrestrial systems they would not make any forecasts for space systems if no decision was taken quickly to invest in a satellite. In similar

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1063 See Report by E.A. Plate, Chairman of the Committee of Alternates, CSE/CM(July 70)5, 17 July 1970, and Puppi report, CSE/CM(July 70)6, 20 July 1970, from which the quotations are taken.

1064 Annex to Resolution No 2, CSE/CM (July 70)11, 27 July 1970.

1065 Annex 4 to the Minutes of the meeting on the first morning, 22 July 1970, CSE/CM (July 70) PV/1, 30 July 197.

1066 Resolution No 1 is document CSE/CM (July 70)7 (Final), 24 July 1970.

1067 The phrase is from the report by the Chairman of the Committee of Alternates, CSE/CM (July 70)5, 17 July 1970.

vein Lefèvre insisted that "It was for the space organisations to start on this project without waiting for the P and T administrations to commit themselves".[1068] But to no avail.

Three clauses of the final version of Resolution No. 1, which differed markedly from a draft proposed to their partners by France and Germany at the start of the meeting, were indicative of these differences of approach.[1069] Firstly, phrases were added to ensure that there was a genuine demand for the system from the users before the project was embarked on. Thus the communications satellite would only be undertaken "provided that the economic aspects are not disproportionate to terrestrial means". Studies on the meteorological satellite would only begin "as soon as the nature of any such [operational] system has been established in consultation with the European national and international meteorological authorities and agencies".

Secondly, the movement from one phase of the programme to the next would not be automatic, as France and Germany wanted, but subject to a double two-thirds majority. And finally, resources were cut dramatically. France and Germany had proposed that 91 MAU be voted immediately for the three projects to cover the years 1971, 1972 and 1973. The Resolution adopted by the conference estimated that no more than 70 MAU would be needed in this period and, more importantly, limited expenditure on the communications and aeronautical satellites to 5 MAU each up to mid-1971. No money was made available yet to start developing the weather satellite.[1070]

The disagreements over the applications programme led several governments to refuse to make a long-term commitment to the science programme. Resolution No. 2, we will remember, advanced the principle that this should be funded for five years. The French and the Belgians took the lead in insisting that they could not adopt a science programme unless the overall balance between the programmes was to their satisfaction. In particular they wanted science to have a lower priority than applications and launchers and tried to limit their approval of the programme to 1971 only. To satisfy these conflicting currents, the delegates agreed to vote 112 MAU for three years, i.e. for 1971, 1972 and 1973. This money was to be used to continue with projects already in the development phase, for COS-B and GEOS, for sounding rockets, and for the start-up of at least one new medium-sized project. Belgium and France agreed to this only on condition that no new commitments, or commitments extending beyond the three-year period were then entered into.

What of launchers? On the first morning of the meeting some delegates hoped for a softening of the position of the British delegation. The new Minister, who admitted to being a "long-time supporter of European collaboration", said that his delegation had come "wishing to play an active role in space matters within a European framework".[1071] This did not extend to launchers, however, where the new government moved only marginally away from that of its predecessor. "If a satisfactory agreement on launchers could be obtained from the United States then the launcher problem no longer arose", said the British representative. "If however no satisfactory answer could be obtained", he went on "his Delegation was of the view that a new situation then would arise which they would have to consider". Since France demanded "total guarantees of availability of existing and future American launchers" if it was to participate in the post-Apollo programme, it is clear that the two delegations were as far apart as ever, notwithstanding the apparent British willingness to reconsider its policy. Indeed in the vote on that part of Resolution 1 dealing with launchers, the UK was the only ELDO Member State to refuse to accept any new engagements whatsoever.[1072]

1068 All quotations from Minutes to the meeting on the afternoon of 23 July, CSE/CM (July 70) PV/2 Rev., 30 July 1970.

1069 For these comparisons see the Franco-German draft Resolution No 1, CSE/CM(July 70)7, 10 July 1970 and the final version CSE/CM(July 70)7 Final, 24 July 1970.

1070 Though another 2.5MAU were allocated for "other studies and experimental work".

1071 Annex 3 to the minutes, CSE/CM (July 70) PV/1, Rev. 30 July 1970.

1072 For the UK position see Minutes of the meeting on the afternoon of 23 July, CSE/CM (July 70) PV/3, Rev., 30 July 1970. For the French see Annex 4 to the Minutes of the meeting held on the morning of 22 July, CSE/CM (July 70) PV/1, Rev., 30 July 1970.

Belgium, France and Germany remained resolutely committed to launchers notwithstanding the ongoing difficulties in the Europa programme. The third stage had failed again in firing F8, held on 3 July 1969, due to an electrical fault. Flight F9, the last from Woomera, took place a month before the Conference, on 12 June. The rocket was essentially a slightly improved version of that used in F8 with three live stages, but 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 I failed by about 10% to achieve its intended escape velocity, and the combined third stage and nose fairings enclosing the satellite came down in the Caribbean north of Guyana.

This setback did not deter these three countries. They agreed to fund together the Europa I and II programmes through to completion, which meant accepting an increase of 15 MAU over the 626 MAU ceiling. They also accepted to assume responsibility for funding the manufacture of 4 to 6 Europa launchers of this class for potential users. And, along with The Netherlands (up to the end of 1971 only) they agreed to make 128 MAU available during 1971 - 1973 for the development of Europa III, a two-stage rocket without Blue Streak and including advanced cryogenic techniques. Their view was that since the advanced cryogenic technology needed for Europa III could be used if Europe contributed the tug to the post-Apollo programme, one should go ahead with the initial work anyway. It would not be wasted even if Europe eventually decided not to develop its own launcher.[1073]

Britain's position on launchers frustrated her partners. The German Minister for Education and Science Mr. Leussink implored the UK to contribute a small sum to start work on Europa III. The President added his voice. As Leussink said, if the UK did its bit one would have "unified support of the programme. Without it [i.e. Britain] unified support would be impossible and the whole prospect of European cooperation in space would be in danger."[1074] The UK delegation was unyielding, as we have said.

After three days of deliberations the Conference closed on a sombre note. As Lefèvre pointed out, there were still "serious uncertainties" regarding participation in the programme. If these were not resolved quickly, he went on, it was "to be feared that in the space field as in other fields, national, bilateral or multilateral action will take the place of joint action, thus aggravating the structural weakness of Europe in major aspects of technology and politics".[1075] The Conference agreed to reconvene on 3, 4 and 5 November in the hope that some of the differences which divided the major partners would be ironed out.

11.7 b) The November meeting and its aftermath

The Ministers met again as planned in November, but for one day instead of three as originally foreseen. There had been some progress in the months since the previous session. In particular some delegations were now able to lift the reservations they had placed on the Resolutions voted in July. The gathering was dominated, however, by the impossibility of forging a consensus on the need for a joint programme involving scientific and application satellites and launchers. This was partly due to there being different, not to say opposing interpretations of the results of the ongoing discussions with the USA over participation in the post-Apollo programme and its relationship to the availability of launchers for the Europeans.

1073 The arguments are those of German Minister Leussink on the afternoon of 23 July, 1970, CSE/CM (July 70) PV/3 Rev., 30 July 1970. We are still discussing Resolution no 1 of course.

1074 Minutes of the meeting held on the afternoon of 23 July 1970, CSE/CM (July 70) PV/3 Rev., 30 July 1970.

1075 In Minutes of the meeting held on the morning of 24 July 1970, CSE/CM (July 70) PV/4, 31 July 1970.

The July meeting had instructed a team headed by Belgian Minister Lefèvre, and including senior representatives of the UK and of France, to continue discussions with the Americans on behalf of the ESC. They visited Washington on 16 and 17 September 1970, where they had detailed talks at the State Department with Alexis Johnson, the Under Secretary for Political Affairs, with NASA's Acting Administrator George M. Low, and other senior US officials. Lefèvre reported to the November session on their findings, coupling them with the content of a letter dated 2 October 1970 which he had subsequently received from Alexis Johnson.[1076]

The European delegation was convinced that "the post-Apollo programme represents a completely new stage in the conquest of space", and that, to quote Lefèvre, we were "on the threshold of a technical revolution that [would] render the present techniques obsolete".[1077] They were struck by the hospitable welcome they received and the American negotiator's willingness to answer questions. At the same time the European delegation made it clear that, while it wanted to collaborate closely with the US, Europe could not afford to develop its own launchers for the practical applications it had in mind and, at the same time, make a significant contribution to the post-Apollo programme. From this it followed of course that substantial collaboration was only possible if "from 1970 to 1980 or 1985, American launching facilities could be made available on a commercial basis and without political conditions". This requirement had to be satisfied also for those satellites which, the Lefèvre team made clear, would be commercially profitable at the operational stage and which might give rise to conflicts of interest at the economic level.

The American contingent, according to Lefèvre, made every attempt to satisfy the Europeans. They agreed that if Europe made a "substantial" contribution to the post-Apollo programme – a figure of $1 billion, or 10% of the estimated cost of developing the Shuttle over ten years was mentioned –, then the US would indeed be prepared to reverse its standing policy on launch provision. Hitherto the US authorities had responded to each request on a case-by-case basis. Now they were prepared to make a "general" commitment to the provision of launches i.e. "without reserving a right of refusal or of unilateral acquiescence on a case-by-case basis". These launchers would be provided on a reimbursable basis during the period before the commissioning of the Shuttle. However. And here was the rub, they had to be used "for any peaceful purpose consistent with existing international agreements".

Two agreements were pertinent here. They were that on the Outer Space Treaty, which seemed easy to conform with, and the Intelsat Agreements, which posed "a rather more delicate problem". The problem arose if the Intelsat Assembly of Parties decided by a two-thirds majority that a European telecommunications system was economically prejudicial to Intelsat. In that event, the US representatives told the Europeans, Washington would "be released from its general promise to supply us with launch facilities for all peaceful purposes". The US, in other words, would resume the freedom of decision they were otherwise willing to relinquish. This, as Lefèvre put it, left "a doubt as to the possibility of obtaining US launch facilities for a European satellite system where such system is to be used for telephony, telegraphy or data transmission, as well as for television relays through conventional channels in Europe [...]". And, he went on, referring to France's cultural and political interest in telecommunication linkages to North Africa, "the doubt is even stronger where a wider zone is involved", i.e. when a regional system was at issue.

Lefèvre's report also defined the options open to Europe for participation in the post-Apollo programme. The Nixon Administration, he stressed, had not yet decided to embark on this venture (remember that we are in November 1970). If the scheme went ahead Europe had to choose between working on a separate

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1076 The Lefèvre report is CSE/CM(November 70)6, 4 November 1970. the European delegation comprised the Belgium Minister, M. Denisse (F) and Lord Bessborough (UK). In addition to Johnson and Low the three other main US representatives were Edward E. David, Science Adviser to Nixon, William A. Anders, of the National Aeronautics and Space Council and John H. Morse, Deputy Assistant Secretary of Defense for European and NATO Affairs.

1077 See Lefèvre's verbal report to the ESC on 4 November 1970, Annex I to CSE/CM (November 70) PV/1, 4 November 1970.

element or joining in the production of components for major systems. The former had the advantage that an "independent partnership" would be established, with Europe having "real prime contractorship responsibility", both of which were highly desirable. However, it was doubtful whether Europe could afford this. In that event it would need to consider contributing to specific components. This option left a greater margin of technical and financial flexibility, but also posed complex interface problems, with unpredictable financial consequences.

In conclusion, Lefèvre insisted that, whatever the doubts surrounding launcher availability, Europe had necessarily to place its decision-making in the framework of post-Apollo collaboration. It opened a new phase in space activities, and the techniques and technologies developed within it would add a new dimension to European efforts and give it a greater responsibility in international cooperation. However, if Europe was to enter into the decision phase proper, it had to clarify its own position on a number of issues.

To begin with, while Europe could assume that there would be "a large availability of American launching devices within the framework of post-Apollo cooperation", it had to gain American launching guarantees for a specific telecommunications mission which crossed a national frontier and which might be interpreted as being economically disadvantageous to Intelsat. If the negotiations with the US over that mission failed to give satisfaction Europe should decide to build her own launcher. And to cover both alternatives everyone should agree both to finance a specific studies programme related to participation in post-Apollo, and a re-oriented Europa III programme, which would also place particular emphasis on techniques applicable to the post-Apollo programme. A consensus was also imperative and urgent on the start of a telecommunications programme, and on the level of the science programme. The "time has come to act", said the Belgian Minister. "We must know exactly which countries are willing to continue and organise a joint effort, meaningful and reasonable, so that Europe will efficiently participate in the development of space techniques" to promote technological progress and to keep its political and cultural independence.

It rapidly emerged that the British had a somewhat different impression of the American position to that outlined by Lefèvre. The mission to Washington, said her Minister of Aviation Supply, showed that "for all purposes for which Europe is likely to require launchers , we can expect to be able to rely on a reasonable American response". The UK, he added, did not intend to launch any satellites which were not compatible with Intelsat. She did not, therefore, see any need or scientific value "for the development of an independent launching capability. We do not, therefore, feel able to bear any cost of developing Europa III".[1078]

But what of the claim made by Lefèvre that the new US policy on launcher availability was conditional on participation in post-Apollo? The UK was not convinced. "We do not believe it is correct to say that the US assurances of availability depend on 10% European participation in the post-Apollo programme", the Minister asserted. This was only needed if one wanted blanket assurances. But Britain saw no need for such assurances. There was no reason, the Minister went on, "to believe that there will not be ad hoc procedures for conventional launchers in the interim period [i.e. until the Shuttle was operational] as has been the case in the recent past, unless we collaborate in the post-Apollo programme". Britain was still prepared to contribute to studies looking into how Europe could collaborate with the USA. She was not prepared to make a commitment now to "share the costs of a 10% participation, running to as yet unquantifiable but probably very large sums of money and this in the context of a project too loosely defined to make any assessment of the benefits in relation to resources involved."[1079]

The French delegation was just as aware as was the British over the lack of definition of the post-Apollo programme and its costs. And Mr. Ortoli agreed with his British counterpart that there should be ongoing

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1078 See Annex V to the Minutes of the meeting held on the morning of 4 November 1970, CSE/CM (November 70) PV/1, 4 November 1970 and minutes of the session held that afternoon, CSE/CM (November 70) PV/2, 19 November 1970.

1079 See Annex V just cited.

consultation with the US over the content of the scheme and the role that Europe might play in it. But he drew just the opposite implications as far as launchers were concerned. It was clear that there was no longer any question of "replacing" the building of a European launcher by participation in post-Apollo. For one thing the latter option was far more expensive. And anyway the launch guarantees given by the US were "insufficient in comparison with what Europe could expect of a partner".[1080] "I do not think", said Ortoli, "that Europe can seriously envisage giving up a necessary element of its own space programme on the ground of an uncertain participation in a programme which is itself uncertain". We should not forget, he went on, that "at less cost and greater certainty for Europe, one can embark here and now on a launcher programme".[1081] In sum, both Britain and France saw in the American position the confirmation of their own previous views on the desirability of an autonomous launch capability.

The climax of these discussions was reached on the afternoon of November 4. Impatient at the impossibility of making progress, Belgium, France and Germany finally, and after several warnings, threw down the gauntlet to their partners. Together they shared the conviction that Europe needed to adopt an "integrated space programme" covering launchers, satellites and applications, and that it should continue its efforts to be associated with the post-Apollo programme. A series of votes revealed that they, and only they, were prepared to support, in principle, this multi-pronged approach. At this point, Leussink suggested that the three of them go it alone and set up a new structure coherent with these objectives. Countries that wished to join in only part of the programme had until 31 December 1970 to make their views known, and could apply for associate membership. "If Europe is not to lose its last chance of collaborating in a manner commensurate with its possibilities and capabilities in the world-wide development and exploitation of space technology", said a German memorandum, "the necessary decisions can no longer be postponed any further".[1082]

This move was bitterly resented by the Swiss delegate. The Conference, he said, was "destroying everything that had been built up". Indeed it was not just the painfully brokered compromises on elements of the scientific and applications programmes that were being put in question here. It was the very idea of a European-wide space organisation. As Leussink said, "Should we reach a point where only a relatively small 'club' carries out the overall programme then I am not sure that there would be much point in carrying to the conclusion all our fine ideas about the amalgamation of the Organisations, and the creation of a new Organisation". Regrettable as it was, the Belgian delegate said, this was "the consequences of the indecision that had prevailed. The fact that the Conference could not reach agreement did not mean that those who wished to go ahead must be prevented from doing so".[1083]

A week after the meeting, on 12 November 1970 Leussink, in consultation with Ortoli 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.[1084] 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 be spent on applications studies in the year ahead (i.e. the amount previously devoted to this).

1080 See the Minutes of the meeting held on the morning of 4 November 1970, CSE/CM (November 70) PV/1, 4 November 1970.

1081 Annex VII to Minutes of the meeting held on the morning of 4 November 1970, CSE/CM (November 70) PV/1, 4 November 1970.

1082 The memorandum is CSE/CM (November 70) 8, 4 November 1970.

1083 The quotations are from the Minutes of the morning and afternoon sessions.

1084 The Minutes of the meeting on 25 November 1970 are ESRO/C/MIN/34.

To resolve the crisis it was decided to hold an extraordinary ESRO Council session just before Christmas.[1085] 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 opposed to 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 which 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 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. And to ensure at least a minimum market for the European launcher, satellites would need to be so designed as to 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.

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 angry, 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 get their way or to leave, 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 Giampiero 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.

11.8 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.[1086] Three points are to be noted about this first stab at a solution. Firstly, he identified a transitional period, lasting from 1972-74, 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 a 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. As for 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 and 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

1085 The Minutes of the Meeting on 22 December 1970 are ESRO/C/MIN/35.

1086 The Puppi proposals are ESRO/C(71)24, with add. 1 and add. 2, and ESRO/C/APP(71)9, 30 April 1971.

prices) to 150 MAU by 1974, where he pegged it 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 per annum (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.

These proposals were discussed by the ESRO Council at the end of May.[1087] The debate, which was intended primarily to solicit first reactions, was 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 become optional, most delegations were emphatic that the scientific satellite programme 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 (in 1971 prices) seemed to be the minimum needed for a viable programme (though even that was well below what the scientists sought: 43-47 MAU). The most important discordant voice was that of the French. 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.[1088] The most striking development here was that the "big four" had accepted that there 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 them*, other Member States being free to join them on an optional basis. Contributions, as before, remained pegged to each participating states' GNP. To give substance to this commitment, Britain, France, Germany and Italy agreed to guarantee together 70 MAU per year (in 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 per year from 1974 onwards, though conceded that it could be bit 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.[1089] 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, had withdrawn from ESRO at the end of 1971, and did not commit itself to any programmes.). The same nine states also agreed 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 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 whether to undertake succeeding phases of the programme would be taken in 1975 by a double two-thirds majority.

1087 The Minutes of the 38th (extraordinary) Council session held on 25-26 May 1971 are ESRO/C/MIN/38, 11 June 1971.

1088 The Minutes of the 39th (extraordinary) Council session held on 13-14 July 1971 are ESRO/C/MIN39, 3 August 1971.

1089 The Minutes of the meeting held on 20 December 1971 are ESRO/C/MIN/44, 6 January 1972. The final version of the resolution defining the first package deal is reproduced in *ESRO/ELDO Bulletin,* 17 (February 1972), pp. 6-11, and *ESRO General Report 1971,* pp. 129-132.

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 (see Figure 8-1). These reductions could only be achieved by delaying somewhat the start of the COS-B and GEOS projects, 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 as from July 1972, and it was regretfully concluded that ESRIN's scientific research activities would have to be terminated by September 1973. Thereupon, it was suggested, its main activity should be to run a technical information service.

The amount to be spent on basic activities and common costs (finally set at 10 MAU per annum) 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 know-how 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 so-called 125% rule adopted by the ESC at Bad Godesberg some three years before, 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 US 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 US 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 which arose after the dramatic failure of Europa II 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. It satisfied the French in that it stated that the 125% rule would fall away if the US 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 it. There were bruising debates over the content of the communications satellite programme as we have seen in chapter 10. There was also 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.[1090] Finally, after several more years of protracted negotiations, the joint aeronautical satellite project was in fact abandoned.[1091]

1090 Meteosat is discussed at length in J. Krige, *The European Meteorological Satellite Programme,* (ESA HSR-22, March 1998). It is also treated in volume II of this work.

1091 Aerosat is discussed at length in L. Sebesta, *The Aeronautical Satellite System: an example of international bargaining,* (Noordwijk: ESA HSR-17, February 1996). It is also treated in volume II of this work.

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, 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 of 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.

11.9 The background to the second package deal

As ESRO was consolidating its position, and laying the foundations of a European space agency, ELDO continued to be plagued by technical and financial crises, which now had to be placed in the context of the lure of the post-Apollo programme, and the fear that maybe Europe was developing an obsolete launcher system anyway. Indeed, the determination of delegations from Belgium, France and Germany to form their own space club if necessary, so forcefully expressed at the end of 1970, soon withered. Each major partner went his own way, taking positions towards collaboration with the United States which were coherent with the foreign policies of Paris and of Bonn as they had evolved throughout the 1960s. The different tendencies were reconciled in what came to be known in the second package deal, adopted in July 1973.

The maiden test flight of Europa II proved to be the turning point. Early on the morning of the 5 November 1971 tense optimism reigned in ELDO and at Kourou in French Guyana. The new French-sponsored equatorial base had been successfully commissioned six months before with the static firing of a multistage reference vehicle fully representative of the rocket. The countdown was without a hitch. Europa II blasted off right on schedule before a crowd of assembled dignitaries 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.

The ELDO Council met on 18 November.[1092] 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 1972.[1093] 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 in their industries. This was compounded by the poor internal organisation of the

[1092] Its minutes are ELDO/C(71)PV/6, 6 January 1972.
[1093] The *Report of the Project Review Commission* is document ELDO/C(72)18, 19 May 1972.

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 themselves, who 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 took 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 commission 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 II project and, in their view, was inevitably defective due to the resulting inadequate standards of manufacture, inspection and acceptance.

Aubinière's commission concluded that the Europa II rocket "in its current configuration [was] unflightworthy". However, it was confident that the enormous technical and management 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, one could reasonably schedule the next launch of the rocket for the summer of 1973 — a slippage of about 18 months. And while success could not be guaranteed Aubinière's commission felt that, if their conditions were met, there was no reason why the Europa II vehicle would not "achieve a normal probability of correct functioning to match that of comparable space projects."

The ELDO Council meeting on 8 June considered Aubinière's report.[1094] It was loath to take a decision on whether or not to continue with the Europa II development and production programme. It also hesitated to engage itself further in the Europa III project. The design concept for Europa III proposed by the ELDO Secretariat in April 1972 foresaw the construction of a two stage rocket able to put 750 kg in geostationary orbit. Its first stage used well developed technology while its second would use cryogenic techniques not yet developed in Europe. Its cost was estimated at 470 MAU plus a 20% contingency margin, which took the price to 565 MAU (3138 MFF) in 1971 prices and exchange rates. The German delegation found this far too expensive and insisted that a number of low-cost alternatives which did not use a cryogenic upper stage should be looked into. These alternatives were presented to the ELDO Council on 8 June. They proved more expensive than the original design. The configuration also posed problems of geographical return and technology transfer.[1095] Defeated, the ELDO Council referred the launcher question to the Ministers who had been scheduled to meet in July.

In the event the date of this meeting slipped steadily. The Ministers had met informally on 19 May 1972 to plan this gathering.[1096] It quickly emerged that it would be precipitate to meet in July, as originally envisaged. The nature of Europe's participation in the post-Apollo programme was one reason for the delay. On 5 January 1972 Nixon had approved the space Shuttle programme. At the same time post-

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1094 The Minutes of the 57th ELDO Council meeting on 8 June 1972 are ELDO/C(72)PV/3, 16 June 1962.

1095 *Low Cost Launchers. Conclusions of the Europa III Ad Hoc Group,* ELDO/C(72)14 Add., 30 May 1972.

1096 The minutes of this *Informal Ministerial Meeting - 19 May 1972* are in (ESC 1473).

Apollo had undergone major changes. The space station concept had been radically altered and its development put back to after that of the Shuttle. The design of the Shuttle itself had been changed, leaving only parts of it really reusable, and the elements in which Europe could participate were reduced from twelve to five. To clarify matters the Ministers agreed that a high-level European delegation should visit NASA in June. There, to their amazement, the tug was withdrawn, the number of Shuttle elements was reduced even further to four, all of relatively minor technological interest to Europe, and "the talks on European participation — which [was] still desired — were suddenly focussed on the sortie module alone".[1097] This was a Shuttle-borne, shirt-sleeve environment laboratory for scientific research under low-gravity conditions in fields like biomedicine and materials science. Work on the tug was stopped, Shuttle technology studies were wound down and ESRO immediately intensified its work on a European sortie module concept in consultation with NASA. [1098]

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 II 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 priorities 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 III programme, and the space tug, for which it had been responsible, summarily cut from its activities.

11.10 The second package deal

The date of the Ministerial meeting was finally fixed for 20 December. It was becoming increasingly clear that procrastination was no longer possible. Nixon's endorsement of the Shuttle in January, and the identification in June of the sortie module as the only potentially interesting element for Europe in the post-Apollo programme, imposed a deadline which, if missed, would imply that the opportunity of working with the United States would be lost. In August the US informed the Europeans that NASA required a commitment in principle by the end of the year, following which the formal agreements would be prepared for adoption no later than 15 August 1973. This commitment would be coupled with the funding of a definition phase, and if the cost figures arrived at "unacceptably exceed the financial ceiling agreed by the ESC Ministerial Conference, the Europeans would be allowed to withdraw from their commitment".[1099]

These pressures from across the Atlantic went along with a basic re-orientation of the lines of force shaping European policy. On the one hand Germany, which had always been one of the most ardent supporters of a European launcher, now began to have second thoughts. The difficulties faced by German industry in the Europa I programme led the government to believe that there was much to be gained from participation in the post-Apollo programme, particularly at the level of system management. At the same time Bonn 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 US was likely to refuse to launch. The German government thus became increasingly interested in collaborating with NASA and American industry in building the sortie module.

Some people in the French government, on the other hand, remained convinced, or convinced themselves that America could not be relied on to launch regional telecommunications satellites without imposing intolerable conditions, and that an autonomous European launcher was needed. The inept US handling of the negotiations over the launch of the Franco-German satellite Symphonie provided a crucial argument to those in Paris who believed in this policy. In September 1972 NASA confirmed its earlier view that the

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1097 The quotations are from the *Report by the Secretary General of the European Space Conference on the Status of European Space Programmes,* CSE/CM (October 72)WP/1, 12 October 1972.

1098 See the report on the technical discussions between NASA and ESRO held from 26 to 29 June 1972, CSE/CS(72)18, Annex 1, 4 July 1972.

1099 *Report by the Secretary General of the European Space Conference on the Status of European Space Programmes*, CSE/CM(Dec. 72)5, rev. 1, 12 October 1972 (ESC 127).

satellite would be launched unconditionally if it was purely experimental. But it added that if the Europeans wished "to retain an option for eventual commercial use, a launching would have to be subject to the US version of the Intelsat clearance requirements". The 'US version' of those requirements, renegotiated the year before, was that if anyone wanted to launch a regional, commercial communication satellite system, as did Europe, "the US in effect will launch anything it supports or anything that two-thirds of the Intelsat membership will support".[1100] This position was judged by some Europeans to be particularly menacing. As Lefèvre put it in November 1972, America will cooperate "on condition that launching our satellites is considered when the time comes, compatible with interests the American Government feels it ought to protect".[1101] This was brought home when the French (Michel Bignier) and German (Herman Strub) negotiators went to Washington early in 1973 to discuss the terms for launching Symphonie with an American Thor-Delta rocket. They were stunned by American inflexibility; in the margin of the document laying down the US conditions Strub scribbled the words "Es ist schwer!" (That's tough!).[1102]

The US position, as we said, played into the hands of those people in France who believed that her national interest demanded that Europe have her own launcher. Indeed a three-stage launcher of geostationary capability had already been conceived by the engineers at CNES. In September 1972 they published a report entitled "Programme National de Lanceur de Satellites de Classe Identique à EUROPA III.B".[1103] It proposed that the first stage of Europa IIIB simply be recycled as the first stage of the national launcher LIIIS (labelled L150 with reference to the 150 tons of *ergols* needed). To this would be added a cryogenic stage powered by the HM6 motor, whose development was already well advanced. Carrying six tons of *ergols*, its label was H6. An intermediary second stage was also needed, however, if the rocket was to put 7-800 kg in geostationary orbit. None of France's existing civilian or military rockets were suitable, however. CNES thus proposed basing the second stage on the first, using the same materials and a single, in-built Viking motor. The label of this stage was L30. The overall configuration of the launcher LIIIS proposed was thus L150 - L30 - H6. As for cost the CNES report estimated that the development of LIIIS on a national basis would cost 1700 MFF 'hors taxes' in 1971 prices, plus a 10% contingency . A later figure increased this 1824 MFF in 1973 prices, plus a contingency of 20%. These were far less than the estimated cost of Europa IIIB (over FF 3,000 million as we saw), though somewhat more than France's contribution to ELDO.

The sortie lab and LIIIS options provided new focal points to break the existing deadlock and to define a new collaborative framework. An informal meeting of space ministers was held on 8 November 1972 to identify what common political ground, if any, existed between them. Several points emerged clearly at this meeting.[1104] Firstly, there was very little support for continuing with Europa III. It seemed, to quote the Belgian Minister Lefèvre, "too powerful for the initial missions envisaged and too advanced for operational phases of the 1980s whose requirements are moreover not at the moment sufficiently defined". At $1.5 billion it was also very expensive, insisted Germany. And it was not needed politically said Italy whose delegate was "highly confident on the future positive evolution of the political relationship between Europe and the U.S." The French disagreed, but did hint that a new proposal was in the air, a proposal involving "other methods of management than those used so far and, therefore, other technical solutions to achieve the same objective".

1100 Quotations from the NASA briefing prior to Von Dohnanyi's visit to Washington, 12 September 1972, quoted in
E. Chadeau (ed), *L'Ambition Technologique: Naissance d'Ariane* (Paris: Editions Rive Droite, 1995), p. 352.

1101 Lefèvre to the Ministerial meeting on 8 November 1972, CSE/CM(Nov. 72) Add.1, 11 December 1972 (ESC 120). The text of Nixon's announcement is reproduced in the Annex to L. Sebesta, *The Availability of American launchers and Europe's Decision'To Go it Alone',* (Noordwijk: ESA HSR-18, September 1996).

1102 Quoted in A. Lebeau, "La naissance d'Ariane", in Chadeau, op. cit, pp. 75 -91, at p. 85.

1103 The document is reproduced in part in Chadeau, op. cit, pp. 364-71.

1104 All the quotations in the next three paragraphs are from the minutes of this meeting, document CSE/CM(Nov.72),4, 17 November 1972 (ESC 120).

The second point stressed at the meeting was that Germany was determined to participate in the sortie laboratory, and that she wanted a decision quickly. Europe would miss the “post-Apollo bus” if a decision to fund the project had not been taken by 15 August 1973. Italy was fully behind Germany, insisting that definition phase studies should be authorised immediately. French Minister Charbonnel, while recognising that there was some interest in the project asserted that, in his view, “none of the economic needs of the next decade would be met by the development in Europe of the sortie lab, which can in no case be considered a substitute for the launcher programme”.

Finally, these position statements notwithstanding, the chief protagonists also sent signals to each other that they were willing to compromise. And they were encouraged by the British minister now responsible for space in the Conservative government, Michael Heseltine, who 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 in preference for collaborative European solutions. Indeed he suggested that the UK would be prepared to phase all of the money it spent on space, both nationally and at the European level into this single agency. For that to be effective though, Heseltine indicated that the new body should have specialised programmes in which Member States could participate to the level that they wished, and not necessarily proportionally to their GNP's which, he said, had always been the stumbling block up to then.

Charbonnel made a definitive move a month later. Writing to Lefèvre he said that France was in favour of abandoning Europa III. It would propose instead to the European Space Conference “the common development of a heavy launcher for which France would agree to be the prime contractor and provide the major part of the finance”. He was of course referring to LIIIS, no longer conceived as a national project but as the basis for a collaborative venture. Her partners would have to contribute at least 40% of the cost and agree that it would have priority of use in Europe compared with means of launching developed elsewhere. In return his "could envisage in parallel a limited participation in the post-Apollo programme".[1105] The French Minister developed these arguments at the Ministerial meeting on 20 December.[1106] He explained that France was “proposing to its partners to shoulder the major part of the funding and to bear the development risks of a launcher with a capability equivalent to EUROPA III, 750 kg in geostationary orbit, for an overall cost of 550 MAU, of which France would like 40% to be provided by its partners”.[1107] France wanted CNES to take executive responsibility for the project. It would entrust the work to a prime contractor, which would be a French firm or French-headed consortium. The prime contractor would be left to choose the foreign industrial partners who would participate in the venture, bearing in mind cost, timescale and the quality of their work. This was sufficiently interesting for the those present to draft a resolution in which, inter alia, they agreed in principle to carry out the sortie lab project and the French launcher within a common European framework. They also agreed to drop Europa III forthwith.[1108]

The Ministerial decisions were duly implemented by the ELDO Council meeting the next day: Europa III was formally abandoned as from 31 December 1972, and its staff officially fired as from 1 February 1973. What is more the future of Europa II was also put in question by the Council even though it had not actually been discussed the day before. Germany did not want to fund the existing programme for more

1105 Letter Charbonnel to Lefèvre, 15 December 1972, CSE/CM(Dec. 72)7, 19 December 1972 (ESC 129). The French original is in file (ESC 1457).

1106 The minutes of this meeting are document CSE/CM(Dec. 72)PV/1 for the morning session (ESC 121) and PV/2 for the afternoon session (ESC 122). Charbonnel's statement opened the afternoon session.

1107 Both these figures were of course overestimates. As we know from above the cost of 550 MAU was close to that of Europa III, and far greater than CNES's estimates for LIIIS, and the Finance Ministry in France had set a 35% limit on participation by other states.

1108 The resolution terminates the minutes of the afternoon session and was also released as CSE/CM(Dec.72)8, 20 December 1972 (ESC 130).

than a month and Belgium was bickering about its rate of contribution.[1109] France struggled on valiantly with patchwork arrangements to save Europa II for Symphonie, but finally yielded to the inevitable. At the ELDO Council meeting on 27 April 1973 the two major contributors agreed that the Europa II programme should be stopped immediately, even as the F12 launch vehicle was on its way to Guyana.[1110]

The next six months were engaged in detailed negotiations between the interested states on the management structure, financial contributions, geographical returns and legal texts surrounding these major projects.[1111] The draft arrangement for executing the LIIIS programme foresaw expenditure of 2472 MFF (445 MAU) in 1 January 1973 prices, with a technical contingency margin included. The draft agreement for the execution of Spacelab, as the sortie module was now called, was opened for signature from 1 March to 10 August 1973. The financial envelope for this programme was set at 308 MAU in mid-1973 prices. As we mentioned earlier, participating states were still free to withdraw from this programme before 10 August, however, if further studies indicated that these estimates would be significantly exceeded.[1112] ESRO DG Hocker reassured Ministers in July that these figures could indeed be kept to despite recent “rather severe changes in the shuttle specifications”.[1113]

When Ministers met on 12 July 1973 to take stock of where they stood, the situation was far from promising.[1114] France had agreed to contribute 10% to Spacelab, while Bonn offered DM 320 million spread over eight years (about 18.5%) for LIIIS. No other major contributions were forthcoming, however. Britain was not interested in the launcher and the Italian delegate was not yet able to commit his new government, though he stressed that they would give “top priority” to Spacelab. To avoid having to accept defeat, the Belgian Chairman of the Ministerial Space Conference, Charles Hanin, suggested that the meeting adjourn until the end of the month, imploring delegations which were still undecided to clarify their positions in the interim. Hanin spent the next two weeks jetting between European capitals. His efforts bore little fruit, however. The only important new development was that Britain agreed to contribute £4 million to LIIIS, equivalent to 1.8%, with UK firms being awarded the inertial guidance system on the launcher. This was conditional on France being willing to contribute to a British project called Marots, a maritime satellite costing some 60 MAU which Minister Heseltine now introduced as part of the overall package.

Marots was the product of Heseltine’s determination to rationalise space spending. He was disturbed to find that two maritime navigation satellites then under consideration: GTS, a British national satellite originally intended for telecommunications but subsequently reoriented to maritime navigation, and Marots, which had similar objectives but which had been studied by ESRO.[1115] GTS was mainly an experimental, technological development satellite of the OTS class. Marots was a pre-operational satellite (i.e. it could be the first of a system intended to perform reliably with tested technologies), and to choose it was also to make a choice for long-term European space policy. In December Heseltine's preference was to Europeanise GTS. Six months later the UK government had decided instead to finance a major part of Marots, and to use this as a bargaining chip in dealing with France and Germany over Britain's contributions to their projects.

1109 See minutes of the 61st ELDO Council session, 21 December 1972, document ELDO/C(72)PV/7, 13 February 1973 (ELDO 1549).

1110 The minutes are ELDO/C(73)PV/3, 22 June 1973 (ELDO 1600).

1111 For an account of the interministerial discussions between France and Germany see P. Louët, "Les aspects diplomatiques de la naissance d'Ariane, 1970-1973", in Chadeau, op cit. pp. 117-129, at pp. 127-128.

1112 For these data see *Report on the Implementation of the Decisions of the Ministerial Conference of 20 December 1972,* CSE/CS(73)WP/4, 27 June 1973 (ESC 738).

1113 See his contribution in Annex 5 to the Minutes of the meeting on 12 July, CSE/CM(July 73)PV/1, 24 July 1973 (ESC 132). How wrong he was! See *Proceedings of the Workshop on the History of Spacelab, ESTEC, Noordwijk, 22-23 April 1997*, Report ESA SP-411.

1114 The minutes of the meeting on 12 July 1973 are document CSE/CM(July 73)PV/1, 24 July 1973 (ESC 132).

1115 See *Report on the Implementation of the Decisions of the Ministerial Conference of 20 December 1972*, CSE/CS(73)WP/4, 27 June 1973, and the UK Amendment, add. 1, 28 June 1973 (ESC 738).

The Ministers reconvened on 31 July 1973.[1116] The Spacelab deadline was just two weeks away. Crisis was in the air. The core of the problem was Italy. Her level of commitment (an Italian contribution of as much as 20% to Spacelab was being spoken of) had major repercussions on how her partners distributed their available resources between the three projects. The Italian Ambassador was the first to speak — only to regret that he was still not in a position to commit his government which was "currently having to contend with extremely serious financial and monetary difficulties". In the hope of breaking the ensuing deadlock, the Italian Ambassador telephoned Rome. But no, the Italian position would indeed only be known by mid-September. It was now or never. Hanin suspended the meeting and consulted in private with each of the participants. His aim was to bypass the public horse-trading between them and to get each delegation to admit in private the maximum figure which it was able to contribute. Speaking years afterwards of the experience, the Belgian Minister for Scientific Policy and Planning described the process in these terms:

"I had the impression that I had taken part in an extraordinary game of poker in which each player hoped that the other would make the move that he himself did not dare make. I was also struck by the interdependence of the three projects: the success of one depended on that of the others, each country refusing to take part in the other's projects if theirs was not accepted. The third strong feeling that I had was that at certain moments it is imperative that decisions be taken at any price, failing which they will never be taken at all.".[1117] Each Minister raised his contribution as far as he could, but there will still shortfalls on all the major programmes. Exhausted by an all-night session of bargaining and "Seized suddenly by a strange sense of optimism, we decided that the countries which had not yet made up their minds would cover the shortfall" (Hanin writes).[1118] The agreement with the unusual budget line "Italy and others" was signed at 5 o'clock in the morning of 1 August 1973. At that stage the percentage contributions to the various programmes were as given in the table below:[1119]

Country	**Launcher LIIIS**	**Spacelab**	**MAROTS**
Belgium	5.00%	4.20%	1.00%
Denmark	0.50%	—	—
France	62.50%	10.00%	15.00%
Federal Republic of Germany	DM160 million +DM160 million*	52.55%	20.00%
Netherlands	1.00%	2.00%	—
Spain	2.00%	2.80%	—
Switzerland	1.15%	1.05%	—
United Kingdom	11,25MAU	6.30%	56.00%
Italy and others	6.00%	21.10%	8.00%

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

1116 The minutes of the second session are CSE/CM (July 73)PV/2, document dated 27 August 1973 (ESC 133).
1117 C. Hanin, in Chadeau, op. cit., p. 136.
1118 Hanin in Chadeau, op. cit., p. 136.
1119 From Minutes of the meeting of the Ministerial Conference held in Brussels on 31 July 1973, CSE/CM (July 73) PV/2, 27 August 1973.

With these agreements reached a sound basis had finally 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, Federal Republic of Germany, Italy, the Netherlands, Spain, Sweden, Switzerland, and the United Kingdom). The story of the transition to that Agency, and the first decade or so of its life, is told in volume II of this book.

Chapter 12: US-European Cooperation in Space During the 1960s

L. Sebesta

12.1 Introduction

Euro-American relationships in space have passed through several phases. According to the ex-Director General of ESA, Reimar Lüst, during the first, from the early 1960s to the early 1970s, the US exercised "tutorship" of Europe. During the second, which lasted until the beginning of the mid-1980s, Europe became America's "junior partner" while during the third, and current, phase there has been both "partnership and competition" [1120].

Chapters 12 and 13 will deal with the first phase, analysing the fields of cooperation and the underlying changing patterns of cooperative policy between NASA and ESRO/ELDO from 1958 to 1973. The first will concentrate on 1959 - 1968, while the second will deal with the opening stages of the period of "junior partnership" which will be explored further in vol. II.

12.2 Which kind of space cooperation for the post-war period?

Space was chosen as a privileged field of international scientific cooperation as early as 1950 when, under the inspired leadership of Lloyd Berkner[1121], an institutional framework to set up an International Geophysical Year (1957 -1958) was put in place. The IGY materialised in 1957 - 1958 and consisted of a coordinated study of the Earth and its cosmic surroundings, involving thousands of scientists and technicians from more than 60 nations (among which the US and the USSR). Investigations within its framework mainly dealt with the physics of the upper atmosphere, the Earth's heat and water regime and the Earth's structure and shape. The first artificial satellites, among which the Soviet Sputnik, were proposed and built to carry out some of the investigations proposed within this framework.

During the IGY, however, "there was no significant *integration* of national programmes involving governmental agreement". All the national programmes were coordinated by a non-governmental mechanism, whose main body had no supranational authority[1122].

Before the end of this activity, much thought was given to the possibility of continuing the coordination of peaceful activities in outer space. Following up the final recommendation of the Fifth General Assembly of the IGY Committee, held in Moscow in August 1958, the International Council of Scientific Unions (ICSU)[1123] decided in October to set up a Committee of Space Research (COSPAR) on a provisional basis. Reflecting the dual nature of ICSU, COSPAR had a mixed membership: representatives of 18 national academies (or equivalent institutions) and of 10 international scientific unions being in the

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[1120] R.Lüst, "Cooperation between Europe and the US in Space", *ESA Bulletin*, no. 50, May 1987, pp. 98-104.

[1121] Chairman of the National Academy of Science's Space Science Board, which had a fundamental role in devising US space international programmes: H.Newell, *Beyond the Atmosphere. The Early Years of Space Science* (Washington: NASA History Series, 1980), p.120. See also: A.A. Needell, "From Military Research to Big Science: Lloyd Berkner and the Postwar Era", in P. Galison & B. Hevley (eds), *Big Science* (Stanford University Press, 1992), pp. 290 – 311.

[1122] Arnold Frutkin, *International Cooperation in space* (Englewood Cliffs: Prentice-Hall, 1965), pp.18-19.

[1123] Set up in 1931 to coordinate and facilitate the activities of the international scientific unions in the field of natural sciences. National Archives, Washington DC (NAW), RG 359, box 19, Report of the Secretary-General, ad hoc Committee on the Peaceful Uses of Outer Space, International Scientific Organizations June 16, 1959.

Committee. All the countries having a major programme in rocket research (Australia, Canada, France, Japan, USSR, UK and the US) were represented[1124].

COSPAR's aim was "to further on an international scale the progress of all kinds of scientific investigations which (were) carried out with the use of rockets or rocket-propelled vehicles". The organisation, though, should "not normally concern itself with such technological problems as propulsion, construction of rockets, guidance and control"[1125]. It would keep itself informed of United Nations or other international activities in the space field and proposed itself as a forum for exchanging information about the results attained through bilateral or multilateral cooperation. It took one year for the members to agree on the organisation’s definite charter, which was eventually approved in November 1959. During this time, the Soviet Academy of Sciences did not participate in the COSPAR work[1126].

The effort to broaden scientific cooperation took parallel and alternative paths during the same period. In the mid-1950s, consideration was given to the opportunity to extend the Atlantic Alliance, the military alliance that, since 1949, linked Western Europe to the USA, beyond the purely defensive aims with which it had been associated since its inception. The increase in cooperation in the economic, scientific and social fields (art. 2 of the Treaty) was accordingly suggested by an official report in late 1956[1127]. This led to the creation, in 1958, of the NATO Science Committee, with a full-time American Science Adviser, the brilliant nuclear physicist from Harvard, Norman Ramsey, who served as its chairman[1128].

In November of the same year, speaking in front of the Fourth NATO Parliamentarian's Conference, American Senator Henry Jackson[1129] called for an appropriate response to the Sputnik lunched by the USSR in October 1957. A shift in the balance of scientific power between the eastern and western blocs was seen by Jackson as an essential component to upset the balance of military power in terms favourable to the West. As a catalysing element in the quest, Jackson proposed "a satellite for peaceful outer space research, bearing the emblem of the Atlantic Community and circling the Earth by 1960"[1130].

Soon after (January 1959), the Avionics Panel of AGARD — the NATO Advisory Group for Aeronautical Research and Development set up in 1952 under the aegis of the aeronautical engineer Theodore von Kármán — elaborated the proposal and suggested "to make a technical review and study of a satellite as a tool for research" in some specific areas[1131].

Meanwhile, NASA was founded as an independent civil agency exercising control over the aeronautical and space activities of the USA (except those related to military affairs). Its founding act, approved in July 1958, adopted international cooperation as a fundamental principle of US space policy. It provided, *inter alia*, that "the space activities of the United States shall be conducted so as to contribute materially

1124 *Ibid*.

1125 H. Massey and M.O.Robins, *History of British Space Policy* (Cambridge: Cambridge University Press, 1986), Annex 2, Charter of COSPAR, p. 449 for the citation.

1126 NASA Historical Office, Washington DC, RG 255, 64-A-664, box 1, ICSU, Ninth General Assembly, Report of the President of the COSPAR, September 25-28 1961.

1127 The text of this proposal is in *Department of State Bulletin*, January 7, 1957, pp. 18-28.

1128 Library of Congress, Manuscript Division, Washington DC (LCMD), Rabi's papers, box 25, Discussion Meeting Report, Council of Foreign Relations, Science and Foreign Policy, November 4, 1963.

1129 Chairman of the Subcommittee on Military Applications of the Joint Committee on Atomic Energy of the US Congress and Chairman of the Scientific and Technical Committee of the NATO Parliamentarian's Conference.

1130 National Air and Space Museum, Washington DC (NASM), von Kármán's papers (microfiche version - the original collection is at the California Institute of Technology, Pasadena, Ca), box 36.10, NATO Parliamentarians' Conference, Fourth Annual Conference, 17-21 November 1958.

1131 National Air and Space Museum, von Kármán's papers, box 35.3, Notes for national delegates meeting, 23 January 1959.

to (...) cooperation by the United States with other nations and groups of nations in work done pursuant to this Act and the peaceful application of the results thereof" (sec. 201)[1132].

An official offer of cooperation in space was subsequently extended by NASA to the international community through COSPAR. At the March 1959 meeting of the Committee, the National Academy of Sciences representative (R.W. Porter, Chairman of the Space Science Board's Committee on International Relations[1133]) was authorised by NASA to offer support for projects intended to orbit individual experiments or complete satellite payloads, of mutual interest, prepared by scientists of other nations. NASA made available launching vehicles, spacecraft, technical guidance, and laboratory support for projects of this type. Resident research associateships at NASA were offered as well.

The idea of a "NATO satellite" was finally dismissed by the Science Committee soon after the COSPAR meeting, in April 1959[1134]. All the same, von Kármán and the new American Science Advisor inside the NATO Science Committee, F. Seitz, were unconvinced. "The leading space research of scientific quality" Seitz explained "will follow closely upon the heels of the development of military vehicles, appropriate modifications in loading, propulsion and instrumentation being made to provide information of basic research interest". As the development of most advanced ballistic missiles and engines would continue to be tremendously expensive in the future, it was considered unlikely that European states, both individually or collectively, could develop such missiles at their own expense. An independent centre for space science, such as CERN for high energy physics, entirely financed by European funds, was considered to be "improbable and, in fact, impracticable". Indeed, duplication between the two sides of the Atlantic would be deplorable. What was alternatively suggested was the establishment of a NATO agency in Western Europe resembling NASA and which could work with it in planning the utilisation for scientific purposes of “the best missiles available for space research in the NATO family"[1135].

Seitz's reflections brought to the forefront a special feature of space research, the tools and objectives of which are partly shared by the military and science[1136]. Two groups were clearly facing each other on the question of which kind of cooperation should be adopted for space. On the one hand there were those who thought it possible for international space science to benefit from military developments and, for this reason, rejected the idea of extending cooperation via an organisation, COSPAR, that had the USSR among its funding members. They were "realist" enough to reject implicitly the idea of the "neutrality" of science and, for practical purposes, saw it much more profitably linked to the existing military cooperation. However, their realism stopped at the scientific and technical field; on the political level, they seemed to be so naive as to think that military secrets were to be kept from the USSR, but not from the allies.

The other group relied on the neutrality of science as a major legitimising factor of its international character. It also made implicit reference to the need, for security reasons, to keep all military-

[1132] The first director of NASA's Office of International Programs, Henry Billingsley, who, according to Frutkin's testimony, favoured the NATO satellite idea, was soon replaced, in September 1959, by Arnold Frutkin, who would remain for more than a decade. NASA Historical Office, RG 255, Press Release no. 59-210, 3 September 1959, Arnold Frutkin appointed NASA's Director of International Programs. *Interview with Arnold Frutkin*, Washington DC, 8 November 1993 (interviewers John Logsdon and Lorenza Sebesta).

[1133] The Space Science Board was established in June 1958 by the President of the National Academy of Sciences to serve as the focus of the Academy's interests in space science, with advisory and consultative functions. Lloyd Berkner had acted as chairman of this body from the beginning. *US Aeronautics and Space Activities, January 1 to December 31, 1960* (Washington DC: United States Printing Office, 1961). See also H. Newell, op. cit, pp. 205 – 206.

[1134] LCMD, Rabi's papers, box 39, AC/137-D/54, Science Committee, Memo on Space Research by the Science Adviser (Seitz) already distributed to members of the Science Committee in the form of a letter dated 24 November 1959, 9 December 191959.

[1135] *Ibid*.

[1136] A.Frutkin, *op. cit*., p.5.

technological information linked to space (those related to launcher and spy satellites, for example) safe from international intervention. Last but not least, there was a widespread fear that "a Western cooperative effort based on NATO would be divisive, risking the effect of a Russian countervailing action in the establishment of an Iron Curtain cooperative effort"[1137]. If science were neutral, it had to be shared with everyone, not in a politically-oriented organisation such as NATO. If information related to military-oriented space technology were a national prerogative, it should be shared neither with the USSR nor with NATO allies. Space cooperation could not change this basic fact.

Supporters of this second group were to be found among scientists and politicians (coming from the State Department and NASA[1138]) who struggled vigorously, in view of different interests, for the same aim. They were the people who conceived and managed US cooperative space policy in the entire post-war period.

Their efforts produced a hybrid, whereby the intellectual and geographical scope of cooperation in space was somehow artificially limited. First of all, cooperation was reduced to its purely scientific aspects (even if the difficulty of drawing the line between civilian and military projects was always recognised at a more general level[1139]), i.e. those experiments with no military or commercial relevance. On the other hand, cooperation was formally offered within an international forum, COSPAR, where the Soviets were theoretically, if not physically present. Inevitably, as happened even more forcefully in 1947 with the Marshall Plan, in practice the offer took a "Western" flavour and materialised in a series of US-European bilateral agreements - coupled with some arrangements favouring under-developed countries.

12.3 The original rationale for space cooperation in Europe.

US-European cooperation in space had its origins in the aftermath of the "Sputnik crisis" and was conceived by the USA as part of a larger space strategy to recover from the loss of prestige linked to that event. This strategy had two pillars:

1. staying ahead of the USSR in areas which had a special military or symbolic value (ICBM, ABM and Apollo mission); reaching with them an informal agreement on the acceptability of reconnaissance through satellites and agreeing on some minor goodwill cooperative ventures in civilian space[1140];

2. "demonstrating and reaffirming"[1141] US political leadership among its allies by engaging them in cooperative ventures in which the US served mainly as the provider of launching facilities, the most technologically sophisticated space devices. Granting launching services should demonstrate, at a low price, the US benevolence and advance with regards to her European counterparts and, at the very least, were to symbolise the benefits of a technologically-oriented democratic society [1142].

1137 NASA Historical Office, RG 255, 64-A-664, box 4, Frutkin Memorandum for the file, 1 December 1959.

1138 For the State Department position, see Theodore von Kármán with Lee Edson, *The Wind and Beyond: Theodore von Kármán, Pioneer in Aviation and Pathfinder in Space* (Boston: Little, Brown and Co, 1967), pp. 323-339; and this volume, Chapter 1.For references to NASA's strong opposition to the idea set forth by Senator Jackson, see *Arnold Frutkin inverview* (cf Note 1132).

1139 See, for example, RG 255, 64-A-664, b.3, Frutkin Memorandum for the file, 23 May 1960.

1140 A bilateral Space Agreement was signed in 1962 by NASA and the Academy of Sciences of the USSR, involving the coordinated launching of meteorological satellites, the exchange of data from these satellites and the program to map the magnetic fields of the Earth by means of coordinated launching of geomagnetic satellites and related ground observations; it was implemented by a second Memorandum of Understanding approved by the two organisations on November 5, 1964. National Aeronautic and Space Council, *U.S. Aeronautics and Space Activities*, 1968 (Washington DC: U.S. Government Printing Office, n.d.).

1141 K. Pedersen, "Thoughts on international space cooperation and interests in the post-cold war world", *Space Policy,* August 1992, p. 207.

1142 For this last concept, R. Colino, "The US Space Program. An International Viewpoint", *International Security*, Spring 1987, vol. 11, n.4, p. 159. See also S.M. Shaffer and L. Robock Shaffer, *The Politics of International Cooperation: A Comparison of the US Experience in space and in security*, vol. 17, book 4, Monograph Series in World Affairs (Denver: Univ. of Denver, 1980).

Political willingness, though, had to be coupled with technical and scientific soundness, which was to be the basic criterion for an appropriate cooperative venture. Arnold Frutkin, the main author and executor of NASA cooperative policy, refers to it as reflecting "conservative values"[1143]. Speaking in front of the newly created Subcommittee on International Cooperation in Science and Space[1144], he clarified in 1971 the guidelines that had inspired NASA's effort during the previous decade.

1. To "work on a project-by-project basis rather than on the basis of generalised program agreements". Following a well-established national tradition in scientific research, cooperation should not be institutionalised, but approved on the basis of projects presented and executed by scientists individually.[1145] More to the point, one could not but notice the enormous difference in absolute terms of the space expenditure in the USA and Europe taken as a whole, these last being but a small fraction of the first. Europe could not be considered an equal partner and, thus, the USA could not commit itself to a real partnership, but to a cooperation limited in scope and time [1146].

2. To judge the soundness of a project on the basis of its "scientific or technical validity". "We appreciate" Frutkin added "the intangible values of international cooperation, but we believe they are best served by projects valid in themselves";

3. To ask real contributions by everyone involved; a project, in other words, should be valuable for all its participants, with mutual benefits, even if not always in kind;

4. Each nation had to fund it own activities; there would be no "give-away", thus no exchange of funds.

This concept of cooperation not only fitted in the more general American strategy for space policy, but perfectly suited the European space philosophy as originally set out in the preliminary stage of ESRO and ELDO. It was a space philosophy that emerged from economic contingencies, from a straightforward political willingness to leave military affairs out of any cooperative venture, from a yet unsettled judgement

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1143 A.Frutkin, op. cit., p.32; see also S.Shaffer and L.Robock Shaffer, *op. cit.*, p. 49.

1144 Created by the Chairman of the Committee on Science and Astronautics, House of Representatives, George P.Miller (California) in Spring 1971 "in view of the increasing interest in and activity on the international scene in space, and in science generally, and because there appear to be excellent opportunities in the years just ahead for our Nation to enter into more extensive cooperative ventures in many of these fields". Opening speech by Fuqua, *Hearings before the Subcommittee on International Cooperation in Science and Space of the Committee on Science and Astronautics*, US House of Representatives, 92nd Congr., 1st Sess., May 18-19-20, 1971, A General Review of International Cooperation in Science and Space, US Government Printing Office, Washington, 1971, p.1. The Subcommittee consisted of Don Fuqua (Florida), Chairman, John W. Davis, Robert A.Roe, William R. Cotter, Morgan F. Murphy, Mendel J.Davis, James G.Fulton, Charles A. Mosher, Alphonzo Bell, Larry Winn jr. On its creation, see Ken Hechler, *Toward the endless frontier. History of the Committee on Science and Technology, 1959-79* (Washington DC: US GPO, 1980), pp. 398-399.

1145 For this as being a fundamental characteristic of American research policy as opposed to the European one, where research tend to be institutionalised, i.e. entirely entrusted to universities. J.-J.Salomon, *General Introduction*, in G.Caty, G.Drilhon, G.Ferné, J-J.Salomon and S.Wald, *The research system. Comparative Survey of the Organisation and Financing of Fundamental Research, vol.I* (Paris: OECD, 1972), pp. 20-21

1146 These were but a confirmation of the views already expressed in 1965 in Frutkin's book on cooperation, where he wrote: "Valuable individual and specific technical exchanges and cooperation may be had, together with valuable political impact, but no large-scale sharing of major research and development programs is yet in view". A. Frutkin, *op. cit.* p.141.

about the soundness of high technology industrial cooperation, and from some entrenched European cultural traditions, best embodied in one of the founding fathers of the European space organisations, Edoardo Amaldi[1147]. For him, space research should not touch upon anything that could be connected with "interest", military first of all. It was the dominant concept of science at the time, well entrenched in western scientific culture, that had its adherents, as we have seen, in both the USA and Europe. Few were the European voices, among the scientists as well as the administrators of science (Blackett, Snow and Salomon, just to cite a few names), which, on the basis of the world war II experiences, begun to challenge something which had been considered for a long time a permanent assumption[1148].

12.4 How US-European space cooperation was put into practice

America's official offer, which had been preceded in some cases by contacts outside diplomatic channels[1149], was followed by a series of bilateral memoranda of understanding with western allies. Cooperation covered various fields which can be broadly divided into:

1. space segment cooperation -including foreign contributions to US projects and reimbursable launches of foreign satellites;

2. tracking, telemetry and command duties;

3. ground based cooperation in data reception[1150].

Attention will be devoted, above all, to cooperation within the space segment, which represented the field in which the majority of cooperative agreements were signed throughout the 1960s. We will refer primarily to the bilateral agreements signed with Great Britain, France, Italy and the Federal Republic of Germany that, even if not covering all agreements signed by the USA with European countries, were the most conspicuous from a financial point of view.

It must be remembered that, along with the major cooperative ventures described here, these countries were offered, and accepted, from 1962, the opportunity to launch national experiments in NASA scientific programmes, such as the orbiting solar observatories or the Polar Orbiting Geophysical Observatory (POGO), where COPERS functioned as an administrative filter between NASA and the national teams of experimenters.

A) The first satellites built under this programme were prepared by the UK and Canada. The UK satellite, S-51 or UK-Q (later named Ariel I), the world's first international satellite, carried devices to study electron temperatures and concentrations in the ionosphere, and instruments to determine electron densities in the vicinity of the satellite, to measure solar radiation and correlate it with ionospheric phenomena, and to observe primary cosmic rays and study their interactions with the Earth's magnetic field. The choice of these experiments was based on previous experience with British Skylark rockets[1151]. The selection was made by scientists of the UK "in consultation" with NASA counterparts. Devices were built by UK scientists, who were responsible for data analysis. NASA designed, fabricated and tested the prototype and flight models. A joint US-British working group was set up after the signature of the exchange of

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[1147] This volume, Chapter 1.

[1148] The conceptualisation, in critical terms, of the "scientist-gadgeteer" (he who is fascinated essentially by his tools and researches) and the political dangers of this position is skillfully outlined by C.P. Snow in his famous 1962 booklet on *Science and Government*.

[1149] NASA Historical Office, RG 255, 64-A-664, Frutkin Memorandum for the file, 3 August 1960. Frutkin makes reference to the cases of Great Britain and Italy.

[1150] S. Shaffer and L. Robock Shaffer, *op. cit.*, p. 19.

[1151] NASA Historical Office, RG 255, 64-A-508, box 1, Conference Report, Discussion on 20 January 1960 of the proposed British experiments to be flown on the Scout vehicle, 20 January 1960.

notes in September 1961 and met regularly in order to solve technical problems in design and test requirements[1152].

After Ariel I was launched from Cape Canaveral on 26 April 1962 with a Thor-Delta rocket, work went forward in 1962 on a second joint satellite, S-52 (later named Ariel II) and discussions continued on definition of the experimentation for a third satellite, S-53, to be engineered, built and tested entirely in the United Kingdom, that would eventually deliver a flight-qualified spacecraft to the launching site. Ariel II, still a US-built spacecraft, was to regularly transmit data on galactic radio noise, vertical distribution of ozone, and micrometeoroid flux. By the end of the 1970s, the number of Ariels developed cooperatively would be six [1153].

In 1962, Vice President Lyndon Johnson and Italian Foreign Minister Attilio Piccioni exchanged notes in Rome to confirm the establishment of the joint NASA-Italian Space Committee project San Marco. The project was divided into three phases and was to culminate with the launching of an Italian satellite into equatorial orbit from a towable platform off the cost of Kenya, to be built by the Italians. San Marco's main objective was to determine the local density of the upper atmosphere in the equatorial planes. Italian engineers began training related to the project and took operational assignments at NASA field centres. Phase I of the project, as usual in this type of project, required first the sounding rocket test of satellite components, i.e. of the atmospheric drag balance mechanism, the heart of the San Marco spacecraft. It took place, as scheduled, at Wallops Island on 20 April 1963. As the test was only partially successful, (the rocket's despin mechanism failed to operate properly, preventing a true test of the sensitivity of the balance), it was rescheduled for late summer. The new, successful, flight test was conducted on 3 August 1963 on a Shotput sounding rocket launched at the same range by an Italian crew. After the testing of the operational state of the towable ocean-going platform, by launching sounding rockets from it in coastal waters off Kenya in March 1964, Phase II of the cooperative venture took place in December 1964. An Italian crew launched the first San Marco-1 satellite on a Scout vehicle from Wallops Island. The three-phase scientific venture culminated less than three years later with the launch of San Marco-2 from the towable floating Italian platform. This launching-site was later used by NASA, on a reimbursable basis, for the launch of its own rockets[1154].

After a first programmatic agreement between NASA and the Comité de la recherche spatiale in March 1961, NASA agreed, in February 1963, to cooperate with the newly-born CNES (the French National Centre for Space Studies),in a programme for launching French very low frequency (VLF) experiments on Aerobee sounding rockets from Wallops Island in 1963. This was to be followed by the launching of a VLF satellite if these rocket flights should demonstrate its feasibility. FR-1, the first satellite launched in cooperation with France, was duly placed in orbit on December 6, 1965, to provide data on very low frequency electromagnetic wave propagation. Although it was only planned to send data over a three months period, the design lifetime of the spacecraft, this only failed to respond to commands 33 months later, in August 1968. A second satellite, FR-2, was planned for launching by NASA at the beginning of the 1970s.

On the other hand, in a unique reversal of roles, in 1963 NASA made plans to fly US payloads on French rockets from a French range, Hammaguir, in Algeria. These launches were devised to carry joint experiments from the Goddard Space Flight Center and CNES, to measure simultaneously electron and ion temperatures in the upper atmosphere. The launchings took place in 1964: instrumentation prepared

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1152 *US Aeronautics and Space Activities, 1961*, (Washington DC, US Government Printing Office, 1962), pp.26-27.

1153 H.Massey and M.O.Robins, *op. cit*., chap.5. See also *US Aeronautics and Space Activities, 1961 cit*. pp. 26-27; *Report of the Projects and Progress of the NASA for the period of January 1, 1963 through June 30, 1963* (Washington DC: US GPO, 1964), p.134;

1154 *Reports of the Projects and Progress of the NASA for the period July 1 through December 31, 1962* (Washington DC: US GPO, 1963), p. 144. See also G.Caprara, *L'Italia nello spazio. Storia, realizzazioni e programmi della ricerca spaziale italiana* (Milano:Valerio Levi, 1992), chaps 2 and 3 by the Goddard Space Flight Center was launched on two Dragon and two Centaure rockets supplied by CNES[1155].

On the basis of a general offer extended by a NASA team travelling in Europe in 1965, discussions began between NASA's administrator and the German Minister of Scientific Research, Stoltenberg, in Bonn in September 1966. The aim was to undertake a cooperative solar probe project, Project Helios, by far the most ambitious US-German collaborative venture[1156]. In June 1967 a formal written proposal was received by NASA from the German Ministry. This became the basis for a two-year comprehensive study by the Joint Mission Definition Group. The group's final report in April 1969 led to the signing of a Memorandum of Understanding in June of the same year. Project Helios provided for the launching of two German-built probes to within 45 million kilometres of the Sun. The Helios solar spacecraft were designed to contribute to an understanding of solar processes and solar-terrestrial relationships. The FRG designed, manufactured and integrated the two spacecraft, provided seven out of the ten experiments, the rest being American, operated and controlled the spacecraft from a German control centre and provided data to all the experimenters. NASA provided two advanced launch vehicles, and the use of its deep-space network to support the mission. Helios-A was placed in heliocentric orbit by a Titan III/Centaur rocket on 10 December 1974; it was followed by Helios-B on 15 January 1976. The interesting feature of the Helios project was that the construction of the spacecraft imposed technical requirements of an advanced character on German industry, particularly for the development of the on-board power system and thermal controls. On-board data-processing systems also had to be highly sophisticated. Scientific payloads had to be supplemented by a large group of experimenters, representing 12 universities and government laboratories in Germany, the US, Italy and Australia[1157].

Contacts between NASA and European representatives as a single negotiating agent were taken since the times of the ESRO Preparatory Commission. After discussions held in Washington (December 1963) and Paris (January 1964), Europeans submitted two satellite projects to their NASA counterparts. Soon after the birth of ESRO (March 1964), a memorandum of understanding was signed by Auger and Dryden on behalf, of ESRO and NASA (July 1964) concerning the preparation, launch and use of ESRO's first two small non-stabilised satellites, ESRO-I and ESRO-II. The two satellites would be launched with a Scout rocket, free of charge as a "christening gift" for ESRO[1158]. In exchange for the launchings, it was agreed that scientific results obtained from these satellites would be shared between the two parties[1159].

Responsibilities for the projects were divided between the agencies as follows:

1155 *NASA News*, no. 63-49, March 11, 1963;*The Tenth Semi-annual Report by the NASA for the Period July 1 to December 31, 1963, cit*, p. 154; *United States Aeronautics and Space Activities, 1964* (Washington DC: US Government Printing Office, no date), p.38; Library of Congress, Manuscript Division (LCMD), Paine Papers, box 33, Summaries of European space activities, prepared for Paine on his European visit 3-16 June 1969.

1156 The previous cooperative programme agreement was signed in July 1965. It consisted, as was usually the case, of a two-phase project, the first phase consisting of a series of sounding rocket launchings designed to check out the German satellite (GRS-A, later called Azur) instrumentation and the launching of the satellite intended to perform an integrated study of the spectra and fluxes of energetic particles in the Earth's inner radiation belts; LCMD, Paine Papers, box 34, NASA press kit, release 69-146, 2 November 1969. In general, see A. Frutkin, "International Cooperation in Space*", Science,* vol. 169, no.3943, July 1970, p.336.

1157 *A General Review of International Cooperation in Science and Space*, Hearings before the Subcommittee on International Cooperation in Science and Space of the Committee on Science and Astronautics, US House of Representatives, May 18 to 20, 1971 (Washington DC: US GPO, 1971) p.86. LCMD, Paine Papers, box 25, Memorandum Frutkin to Paine on Cooperative solar probe project with the Ministry for Scientific Research, Federal Republic of Germany (Project Helios), 23 May 1969. See also, J.Krige and L.Sebesta, *US-European Cooperation in Space in the decade after Sputnik,* in G. Gemelli (ed.), *Intellectual Cooperation in Large-Scale Cultural and Technical Systems* (Bologna: Kluwer, 1994) pp. 268-285..

1158 ESRO/25, 18 July 191964.

1159 M. Bourély, "The Legal Hazards of Transatlantic Cooperation in Space", *Space Research*, November 1990, p.325.

- ESRO would provide the experimental instrumentation; design, construct and test the spacecraft; provide ground checkout and launch support equipment; track and acquire data from the spacecraft within the capability of its projected network; and reduce and analyse all data.

- NASA would train ESRO personnel as mutually determined, provide the Scout launching vehicles and conduct launching operations. NASA would also provide necessary supplemental tracking and data acquisition support[1160].

Two years later, while there was intense discussion about the opportunity to carry on the building of an autonomous European launcher, NASA and ESRO signed a Memorandum of Understanding (30 December 1966) whereby NASA would carry out, against reimbursement, the launching of future ESRO scientific satellites and provide initial tracking and reception of telemetry data from these spacecraft.[1161]. The drafting of the definitive text was slowed down by one major divergence. It concerned the availability of raw data coming from European satellites launched by NASA: NASA insisted on its right of access to data without reservation, agreeing to provide guarantees about the use (in publications) of such material in order not to compromise the intellectual property rights of ESRO and its experimenters. European scientists reminded US negotiators in strong terms that it was normal scientific practice for such data to be made available only upon request[1162]. Finding the proposed clause to be in conflict with the principles of intellectual property rights, their reaction went from "the deep concern" expressed by the German delegate, to the description of the US wording as unacceptable (the French delegate). The only different opinion came from the UK, which had experienced the liberal rights of access granted by NASA to the data received from US satellites by the American tracking station in Great Britain (Winkfield). To this, the French retorted that this was neither an agreement on a telemetry station, nor an agreement of cooperation, relating more appropriately to the purchase of launching vehicles and associated services[1163].

As had been made clear since the Autumn of 1966, NASA's inflexibility was based not so much on scientific or intellectual principles, but on questions of national security - NASA should "be in a position to reply to any question about its activities for ESRO"[1164] - and, more precisely, as was made clear by NASA's administrator Webb, satisfy concerns about the Agency's ability "to be in a position to report to Congress and the people that it does, in principle, have full access to data acquired by any satellite launched from United States' territory"[1165].

The problem was solved by producing a text that, though complying with American wishes, satisfied European desires that data should be provided only "upon request" and gave sufficient safeguards for the intellectual property rights of ESRO and its experimenters - the period of protection of priority rights of experimenters being identified with that in (then) current ESRO practice (see art. IV c. of the Memorandum of Understanding).

Another point of conflict, NASA's liability in case of failure of a launch - the case in point was ESRO's accountability as regards reimbursement to NASA of costs resulting from damage to or loss of a vehicle -, was solved by charging ESRO with financial responsibility in connection with and during preparation (not the launch) for an agreed launch, thereby restricting the field of ESRO responsibility (see art.III of the Memorandum of Understanding) [1166].

1160 NASA News, no. 64-178, July 22, 1964.
1161 ESRO/CERS Bulletin, no.1, 1967, p.23; see also M.Bourély, *art. cit*., p. 325.
1162 ESRO/ST/MIN/10, 6 July 1966, Draft Summary Minutes of ESRO Scientific and Technical Committee.
1163 For the German reaction, see ESRO/C/MIN/14, 20 January 1967, p.35; for the French and British views, ESRO/C/MIN/12, 21 November 1966 p.11.
1164 ESRO/C/233, Note by the Secretariat, 14 November 1966.
1165 ESRO/C/233, Memorandum of Understanding with NASA concerning the furnishing of satellite launching and associated services, Note by the Secretariat, 14 November 1966.
1166 ESRO/C/MIN/12, 21 November 1966, p.19; for the exact meaning of the very confused article, ESRO/C/233, Memorandum of understanding with NASA concerning the furnishing of satellite launching and associated services, Note by the Secretariat 14 November 1966.

In 1968, after almost five years of active cooperation, NASA launched three ESRO satellites. ESRO II (renamed Iris after the launch), designed for the integrated study of cosmic rays and solar radiation, was launched from the Eastern Test Range in May; ESRO-I (renamed Aurorae) which was launched in October from the Western Test Range, continued to study high-latitude energetic particles and their effects on the ionosphere. It was designed and built in Europe and carried eight experiments from Denmark, Norway, Sweden and the UK to study the *Aurora Borealis* and related phenomena in the polar ionosphere. Both satellites were launched by Scout vehicles. In December, the Highly Eccentric Orbit Satellite (HEOS-A, then renamed HEOS-I) was launched from Cape Kennedy on a Thor-Delta vehicle for a study of interplanetary physics - plasma, magnetic fields and cosmic rays. This last one was launched following the new rules set out by the 1966 Memorandum of understanding; it was the first foreign satellite to be launched by NASA on a reimbursable basis[1167].

B) NASA's cooperation focused from the beginning on scientific investigations with sounding rockets. They were a relatively cheap and uncomplicated method to get valuable information about the Earth's atmospheric envelope and its near-space environment and to test proposed satellite instrumentation and to verify the performance of the proposed experiments.

The first of these launches took place in Italy, in 1961 and involved the emission of sodium vapour clouds for a measurement of winds and temperatures in the high atmosphere. Bilateral contacts materialising in launching of sounding rockets were held with France, Norway, Denmark, the Federal Republic of Germany, the UK and Sweden (as far as Europe is concerned); their aim was to investigate the ionosphere, the upper atmosphere, and the geomagnetic and auroral phenomena[1168].

C) Tracking and data acquisition systems were also developed from 1959 onwards. Generally speaking, these stations were specialised in tracking the satellites, both during and after the launch; receiving telemetry data back from the satellites, providing information on their performance and status; and transmitting commands when necessary to change the position of the satellites or to initiate onboard activities.

During 1959, the Minitrack system (composed of 10-station Minitrack Earth satellite network), established for the IGY for tracking Earth satellites, began to be expanded to high-latitude coverage and to be placed on a more permanent basis. A network of deep-space stations, to provide communications with and control of, spacecraft orbiting at lunar and planetary distances, was begun. It consisted of ground tracking stations spaced at intervals of approximately 120 degrees longitude around the world in California, Australia, Spain and South Africa (together with a control centre located at the Jet Propulsion laboratory, Pasadena, California) [1169].

The European ground segment consisted at first of the Redu tracking station (in Belgium) and the control centre at ESTEC, at Noordwijk in the Netherlands. To extend the tracking network, the stations at Fairbanks, Alaska (USA), Spitzbergen (Norway) and in the Falkland Islands (UK) were added, while the European Space Operations Centre, ESOC, in Darmstadt, FRG, became fully operational in 1968[1170]. The ESRO polar telemetry, command and tracking station at Fairbanks, Alaska, was established in November 1966, by exchange of notes between ESRO and NASA[1171]. Major discussions focused on the question of access and use of the raw data received by ESRO from its satellites within this station. They paralleled those taking place at the same time with respect to the Memorandum of Understanding on the furnishing of launching and associated services and were solved by the wording of the relevant article, which was very similar to the one described above.

1167 *US Aeronautics and Space Activities, 1968*, *cit.,* pp.4 and 31. For the other ESRO satellites launched by NASA in 1972 and for a detailed description of the first ESRO scientific satellites, see this volume, Chapter 5.

1168 *US Aeronautics and Space Activities, 1961*, p.27, A. Frutkin, *op. cit*. pp 51-59.

1169 *US Aeronautics and Space Activities, 1965*, p.40.

1170 B. Lacoste, *Europe: Stepping Stones to Space* (Bedfordshire: Orbic, 1990), p. 53.

1171 LCMD, Paine Papers, box 33, European space activities, Paper prepared for Paine's European visit, 3-16 June 1969. See also G. van Reeth and K. Madders, "Reflections on the quest for international cooperation", *Space Policy*, August 1992, p.223.

D) Exchange of technical and scientific information between ESRO, ELDO and NASA was formalised with an exchange of letters in May 1964. Following a generalised concern that has always been at the core of scientific cooperation since the beginning of the twentieth century, a big effort was given to the improvement of the circulation of information[1172]. This led, among other activities, to the establishment of a joint ESRO/ELDO Space Documentation Service (SDS) to cover both space research and space technology; exchanges of information with the NASA Information System were begun. NASA STAR (Scientific and Technical Aerospace Reports) and IAA (International Aerospace Abstracts) databanks were maintained by SDS. This single databank, still functioning today, has been continuously updated by American and European partners[1173].

E) Personnel exchanges, training programmes and NASA International University fellowships in space science were initiated in 1961 while NASA Post-doctoral and Senior Resident research associateships had already been set up in 1959[1174].

F) A programme of ground-based cooperation in data reception was organised in relation to a number of experimental and operational application satellite projects. Some of the most interesting experiments took place in the field of telecommunications. Ground terminals were built in the 1960s in the UK, France, the Federal Republic of Germany, Italy and Spain for experiments in overseas television, telephone and telegraph transmissions via satellite. Echo I, the first passive telecommunication satellite, reflected radio waves from transmitters in the USA to receiving stations in Europe in 1960. With the cooperation of French and British facilities, the experiment resulted in the first transatlantic real-time communications by means of an artificial satellite[1175]. In July 1962 the first live television pictures were relayed by Telstar to Europe. In 1963, Syncom II, the first experimental geosynchronous satellite, was launched. In 1965, a transatlantic commercial communications service was established, using Early Bird (later renamed Intelsat I)[1176]. While a sizeable ground station network was in existence throughout Europe, by the end of the 1960s, the whole space segment was provided by the USA[1177].

Beginning in 1959, another extensive ground-support programme was organised jointly in the field of meteorology. The USA played a leading role in bringing to the attention of the World Meteorological Organisation (WMO) the operational and research potentialities of satellites and declared their willingness to share the benefits that could come from such a use. Meteorological satellites of the Nimbus and Tiros type were developed by NASA (to which Tiros was transferred from April 1959 by the Department of Defense[1178]) in order to survey and transmit to the ground information about cloud coverage of the globe in order to improve weather forecasting. An extensive network of weather satellite cooperation was established by NASA and the US Weather Bureau following the successful operation in 1960 of Tiros-1, the first US

1172 J-J. Salomon, *Science et Politique* (Paris: Ed. du Seuil, 1970), p. 325.

1173 M. Bourély, "The legal hazards of transatlantic cooperation in space", *Space Research*, November 1990, p.325.

1174 *US Aeronautics and Space Activities 1968, cit.* and A. Frutkin*, op. cit,* Table V.

1175 *US Aeronautics and Space Activities 1961, cit*. p. 27 and this volume, Chapters 9 and 10.

1176 Pleumeur Bodou no. 1 (France), Raisting (FRG), Goonhilly Downs (UK) and the small station at Fucino (Italy) were used from 1965 for commercial service via Early Bird. Spain was also active in the second half of the 1960s in the establishment of satellite earth-stations. A detailed report on the status of the 51 stations operating around the World by the end of 1970 is given in *Hearings of the Committee on Science and Astronautics*, US House of Representatives, 18 to 20 May 1971 (Washington DC, US GPO, 1971).

1177 In order to coordinate the European position in negotiations on the future Intelsat agreement and to promote European programmes in the field, a European Conference for Satellite Communications (CETS) had been established by European countries in 1963. A. Russo, *op. cit*., pp 16-21. See also CSE/CM (July 1967) 9, Report of Director General of ESRO. Present state of development of the European Space Research Organisation and proposals for its activities during the period 1968 – 1975, 23 June 1967.

1178 *US Aeronautics and Space Activities, January 1 to December 31, 1959*, (Washington DC: US GPO, no date), p.vi.

weather satellite. "Tiros-1 could only take pictures by day of zones of non-extreme latitudes. But experts were amazed to see the photo-mosaic of pictures taken 720 km out in space. Through its tiny TV cameras, Tiros-1 carried the human eye into space so that man for the first time saw clouds from above, riding the backs of invisible winds, the key to global weather systems" [1179]. Tiros not only showed the complexities of weather systems with a clarity never seen before, but it revealed previously unknown phenomena. More Tiros satellites followed, with improved cameras, longer lifetimes and increasing applications to weather forecasting. European and Extra-European nations agreed to conduct special observations of weather phenomena, to be coordinated with the cloud-cover photographs made by Tiros-2 and subsequent meteorological satellites[1180].
The WMO pushed ahead with its plans for a world weather system, while invitations to European and other countries were extended in 1963 to participate in tests of the Automatic Picture Transmission (APT) Systems. The incorporation on subsequent US polar orbiters of the APT system made it possible to receive local cloud-cover images anywhere in the world using ground equipment costing only a few thousand dollars. Any station with a relatively inexpensive receiver might receive these pictures when the satellite was overhead[1181].

12.5 Changing political and technological frameworks

The 1960s was a period of great political, social and economic development for Europe. Governments had overcome the phase of post-war economic recovery and reached internal political stabilisation by the mid-1950s. They were experiencing economic growth (of production and markets) and a parallel willingness to recover at least part of their pre-war international political assertiveness. Technology had acquired a central importance in this endeavour[1182].

The growing attention to technology as an important factor in the economic growth was mainly channelled into and institutionalised by OECD. The Freeman and Young study published in 1965 marked the official recognition of the problem by the organisation and functioned as a major element in rising American interest in European disaffection. Related to 1962 data - and, thus, still linked to old "national" statistics[1183] - the study referred to the US-European disparity in resources devoted to R and D. It quantified it in terms of the amount of R and D in dollars, in manpower and in patent rights and concentrated on the dominant position of US firms in research-intensive industrial areas such as aircraft, vehicles, electronic and non-electronic machinery, chemicals. These were the same firms that were exporting their capital , but not their know-how, towards Europe in the 1960s[1184].

Some of the conclusions of the study are worthwhile citing: "(...) the existence of a major difference in the resources committed to research between two countries or areas" the authors said "does not necessarily mean that policy should be directed towards its reduction. Circumstances are different in every country, and so are policy objectives. Military, economic and welfare aims will all influence the allocation of resources to research and development, as well as more direct scientific considerations. The balance and the priorities in any one country will depend to a large extent on political decisions. The available resources, especially in scientific manpower, will often be the limiting factor. Some countries, especially smaller ones, will inevitably be obliged to concentrate their effort on a limited number of fields and cannot hope to compete in

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1179 For the citation, see B. Lacoste, *op. cit.*, pp. 59-60.

1180 *US Aeronautics and Space Activities, 1961*, *cit.* p.27 and A. Frutkin, *op. cit.*, Table IV.

1181 R. Barnes,"A useful though incomplete primer", review of J.Johnson-Freese's book, *Space Policy*, August 1991, p. 273.

1182 This is not the place to elaborate on the relationship between technology and political assertiveness; autonomy in the security field is an essential element in it.

1183 In June 1963, the Frascati Conference of experts from member countries of the OECD adopted a manual for "Standard Practice for Surveys of Research and Development", providing for the first time an agreed basis for international comparisons in the field.

1184 A. Grosser, *Les Occidenteaux: les pays d'Europe et les Etats Unis depuis la guerre, 1944-1977* (Paris: Fayard, 1978), pp278-279.

some very expensive fields of research and development, except in association with a larger group of countries, or through international organisations. (...) The most rapid and widespread dissemination of new knowledge is the fundamental interest of all countries and any policy aimed at limiting this flow or substituting a kind of scientific "autarchy" would damage the prospects of all"[1185].

At the same time, the 1960s experienced not only a quantitative growth in the interest in space science and technology, but a progressive, though indecisive, reorientation of European interest away from "pure" space science toward a kind of activity linked not only to military but also to commercial interests, especially in the field of satellites. This trend was coupled with a greater sophistication in the research itself (from balloons to rockets, from non-stabilised to attitude-controlled rockets, from small non-stabilised satellites to medium-stabilised satellites) and, thus, with rising costs.

Space developments, however, had been almost entirely "the preserve of the US and Russia" since the war. Nowhere else had the requirements been sufficient to support firms exclusively or even largely engaged in space technology. The smallness of national and international programmes and the uncertainty which had characterised their development had not created, generally speaking, a propitious climate for growth in Europe [1186]. France, under the energetic leadership of de Gaulle, had been the only case in which the state, in the framework of an independent security policy and within a generalised interest for a new public policy for research, had intervened to support both the research and the productive sector linked to space activities[1187].

This progressively led Europeans to a double concern.

- Technological gaps that had arisen between Europe and the USA since the 1950s were becoming more pronounced "putting Europe in a position where it (would) be impossible to catch up technologically if decisions (were) not taken soon". This stemmed from various factors, above all the lack of leading edge basic research in such fields as high-energy physics, electronics and special alloys, where military financing, in some cases used for space-related devices, had been abundant in the USA. In addition, the existence of huge space programmes (like Apollo) had led to an expansion of the field of systems engineering-management, while the absence of such major programmes - and the political restrictions imposed on the main one, i.e. ELDO - had impeded European training in this field. Nor had Intelsat given any impetus to European knowledge, because within its framework European industries could only work as subcontractors to American companies [1188].

- On the other hand, the growing importance of communication satellites forced Europeans to think about launchers not only as means to send small or larger scientific spacecraft into low orbit, but as a means to place heavy commercial spacecraft in geostationary orbit. Europeans had two choices: a) improve qualitatively and quantitatively their own original ELDO launcher, Europa I; or b) rely on the availability of American launchers, inside the framework of Intelsat. In this context, collaboration between Europe and the USA in the second half of the 1960s progressively came to be viewed by the Europeans, as we shall soon see, as one answer to these concerns.

1185 C.Freeman and A.Young, *The Research and Development Effort. Western Europe, North America and the Soviet Union. An Experimental International Comparison of Research Expenditures and manpower in 1961* (Paris: OECD, 1965), p.70.

1186 CSE/CM (July 1967) 9; cit. in footnote 11778.

1187 L. Sebesta, "La science, instrument politique de securité nationale? L'espace, la France et l'Europe, 1957 – 1962", *Revue d'histoire diplomatique*, no.4, 1992, pp. 313 to 341.

1188 Project management was all the more important because in the mid-1960s it began to be used extensively in public policy projects, such as the construction of motorways and other infrastructures. For the citations, see CSE/CM(July 1967) 6, June 30, 1967, Report by the chairman of the ad hoc working group on programmes (May 30, 1967).

In April 1965, during his visit to Paris, Soviet Foreign Minister Gromyko accused the USA of using international scientific cooperation as a vehicle for domination and the brain drain and opened prospects for a technological alliance with Europe. French President de Gaulle echoed Soviet proposals, encouraging possible multiplication of scientific and technical contacts with the USSR. In the summer of 1966, these gestures materialised in the signature of a series of bilateral agreements between the two countries, including a space research agreement envisaging the launching of a French Earth satellite by the Soviet Union and cooperation in the field of weather and communication satellites[1189].

From 1965 to 1967, British Prime Minister Wilson, German Federal Chancellor Erhard, Belgian Prime Minister Pierre Harmel and Italian Foreign Minister Amintore Fanfani took formal and informal actions to counteract the French proposal with ideas of a much more Atlantic flavour. In particular Fanfani, in a proposal delivered to Secretary of State Rusk in September 1965, suggested the creation of a 10-year "technological Marshall Plan" for Europe, while Harmel, in a private talk with Donald Horning (Special Assistant to the President for Science and Technology and Director of the Office of Science and Technology, 1964-1969), referred in strong terms to the technological gap as being a major problem in transatlantic relationships[1190].During a following visit, Harmel handed over to Horning a note in which two alternative courses for future European action were stated:

1. an autonomous one, which Harmel referred to as sponsored by the French;

2. an intensification of the Atlantic partnership, which was offered as the only viable (Belgian) alternative to the previous one.

During this meeting, Harmel stressed the urgency of the problem and the need for effective action by the US[1191]. These preoccupations were echoed in a 1967 NATO report on "The Future Task of the Alliance", where Harmel argued in favour of a policy based on the twin pillars of defence and détente. This had to be coupled with an extension of intergovernmental cooperation, in the framework of NATO, on foreign policy, defence, security and technology.

12.6 New ideas

These complex shifts in US-European relationships were paralleled by a debate in the USA and in Europe over the nature of future space cooperation.

Some sectors of the US administration were inclined to consider space as a privileged laboratory to prove their willingness to help Europeans bridging the technological gap. The space field represented an advanced technological sector *par excellence* (high research and development costs, lengthy development time, rapid obsolescence)[1192]. Moreover, because it was heavily subsidised by the state, which also functioned as a major buyer, it seemed to be, among all the technological sectors, the most suitable to be used as a political tool.

From 1965 onwards, the State Department, the National Security Council, NASA, the PSAC and the President himself were working on possible solutions to "the frequently-stated European desire for greater

1189 *Keesing's Contemporary Archives*, vol. XV, 1965-66 (Bristol: Keesing's Publ. Limited, no date), pp.20782 and 21545.

1190 In his meeting with Horning, Harmel referred to a paper prepared by Lefèvre, the future European negotiator in post-Apollo negotiations, in which figures on license fees and patent registrations were cited to demonstrate the seriousness of the widening technological gap between Europe and the USA. See NAW, RG 359, box 610, Letter Donald Hornig to Philip Trezise, US Representative to the OECD, 2 March 1966. For previous information, see B. Nelson, "Horning Committee: Beginning of a technological Marshall Plan?", *Science*, vol. 154, 9 December 1966, pp. 1307-1309.

1191 NAW 359, box 610, Memorandum of conversation on technological gap between the US and Europe, between Belgian and American representatives, 20 May 1966.

1192 J.W. Müller, *European Collaboration in Advanced Technology*, Amsterdam, Elsevier, 1990, pp. 8-11.

participation in the development of space technology"[1193]. There was a shared conviction that imagination and thoughtfulness at the highest political levels were needed to study how science and technology could be used to mutual advantage and to improve international relations[1194].

Since his meeting with Erhard in December 1965, Johnson had made clear his willingness "to consider cooperative projects of considerably greater magnitude and more far-reaching technological implication than anything proposed heretofore". The President's specific suggestion of Jupiter or solar probes as possible fields of cooperation, reiterated by an official NASA mission which briefed the European Space Conference in February 1966, should be understood only as examples of what could be done. Values referred to by the Department of State as the core of these attempts were "the contribution major advanced technological exercises can make to the partnership between government, university and industry, to the development of critical management capabilities, to economic security, and to common political objectives of institution-building and Western cohesion". The immediate aim was to "direct discussion toward spacecraft responsibilities for Europe rather than delivery-vehicle-related responsibilities". American experience and competence would be transferred to European partners through two channels:

1. a joint working group at the project level;

2. commercial ties between firms, with export arrangements facilitated by the USA[1195].

Proposals focussed around a political mission to Europe, which should include NASA's Director. By January 1966 Hornig suggested that highly visible pro-European personalities be included, such as John McCloy, "with a view of using space cooperation as a lever to give new vitality to European integration and to strengthen US-European ties in science and technology".

There was, however, strong disagreement about the potentialities of this lever. While there was an inclination, shared by American Ambassador in Paris, Cleveland, and by Rabi, to frame this offer in a multilateral framework, possibly NATO, Arnold Frutkin thought NATO was disqualified because of its military features. Moreover, he stated, an ambitious programme was "not warranted by realities of possible cooperation in space"[1196].

Frutkin's views apparently won and the NASA team which visited Europe in 1966 was not headed by the Director of the Agency, but by the responsible for scientific affairs. The offer of collaboration on a solar or Jupiter probe was coolly received by the Europeans with the exception of the Federal Republic of Germany. In a time of tight finances and difficulties over the re-orientation of the European organisation toward commercially-oriented endeavours, the US proposal seemed to avoid rather than to appeal to Europe's main worries[1197]. It concerned a spacecraft of a higher technological and scientific relevance than the previous satellites put in orbit by NASA on behalf of some European nations; it did not meet, however, any of the new European needs in the fields of application satellites and launchers. As we saw earlier in this chapter, the offer was eventually accepted by the Federal Republic of Germany. In this case, however, there seems to have been an important external cause pushing the Federal Republic towards collaboration. Since the end of the war the government had to meet "offset" obligations with the USA (a sort of compensation for the stationing of American troops on its soil) by the purchase in the USA of military items. For several reasons, the German government was now keen to extend its "shopping-list" beyond military material and suggested that space expenses be included in this broader package [1198].

1193 NAW, RG 359, box 610, Position Paper for Advance Team on European Space Cooperation, Nesbitt, 7 February 1966; box 458, Memo PSAC from Daniel Margolies to members PSAC, 10 December 1965.

1194 NAW, RG 359, box 564, Memo by Margolies, 3 January 1966.

1195 *Ibid.*

1196 NAW, RG 359, box 564, Memorandum Horning to Margolis on Webb Mission in space, 3 January 1966.

1197 J.Krige and L.Sebesta, *US-European Cooperation in Space in the Decade after Sputnik*, *cit.*

1198 Johnson's Library, Austin, Texas, NSF, Country File, Germany, box 187, Memorandum for the President, Visit of Chancellor Erhard, September 26-27, 1966. I am indebted to Hubert Zimmermann for passing me this document.

Soon after, during the Summer of 1966, the new "imaginative" US approach to cooperation with Europe became concrete, at least on paper. It was spelt out in an internal document approved by the National Security Council, the body at the top of the decision-making hierarchy on topics related to national security. Focus was shifted, in the document, from collaboration on spacecraft to collaboration on launchers. Three conditions for cooperation were laid down. Launcher vehicles, components and technology sold by the USA should not be used:

1. for improving communication satellite capability other than a) to permit participation in the US National Defense Communication Satellite System; b) in accordance with the Intelsat agreements regulating (civilian) telecommunication satellite policy (see below);

2. for improving nuclear missile delivery capabilities;

3. for transmittal to third countries[1199].

Intelsat was a consortium for the development and management of "a single global commercial communications satellites system". Its signatories, the telecommunications entities of the countries involved (a rapidly increasing number from the original 12, to 83 in 1972) had been operating a global communication satellites system since 1964 under "interim arrangements". In the American case, the signatory was Comsat, a private corporation which also ran the system from a managerial point of view, but in most cases the signatories were the national postal, telephone and telegraph (PTT) administrations. The voting power was based on the percentage contribution to the system. Comsat was guaranteed an absolute majority of at least 50.5% and a veto power over its partners. The interim agreements were to be renegotiated five years later, when the Europeans hoped to have more power to shape the policy of the organisation[1200]. As things stood they feared that the USA would use Intelsat to impede their developing a telecommunication satellite industry. The limits of America's willingness to collaborate with foreign countries in space were clear, being set by the increasing commercial interest of communications.

In August of the same year, Europeans were informed about American willingness to support them in the development of a European launch vehicle capability through ELDO. Among the many ways suggested to do this, the USA offered:

1. to enable the procurement of flight hardware in the USA, including such items as a miniature integrating gyro (MIG) strapped down "guidance" (auto-pilot) package used on the Scout vehicles.

2. to assist in the long range development of follow-up ELDO projects using high-energy cryogenic upper stages (e.g. ELDO B) through a) technical information and contacts; b) bringing ELDO personnel into close touch with the major problems linked to systems design, integration and programme management of a high-energy upper stage such as Centaur; c) joint use of a high-energy upper stage developed in Europe
3. to supplement ELDO launch capabilities either by the sale of configurations of Scout, Thor and Atlas vehicles, or by the sale of launch services for scientific and applications satellite projects[1201].

1199 NAW, RG 273, NSAM 354, US Cooperation with the European Launcher Development Organisation (ELDO), 29 July, 1966.

1200 See this volume, Chapters 9 and 10.

1201 Annex to ELDO/CM(July 68)WP/2, Possibilities and Problems of future US-European cooperation in the space field, Remarks by T.H.E. Nesbitt, Deputy Director, Office of Space and Environmental Science Affairs, Department of State, at the Meeting of EUROSPACE, Munich, Germany, 21 June 1968.

12.7 Unfruitful discussions

The US offer reinforced the necessity, already stressed by various quarters in Europe, to tackle the problem of the nature and extent of ESRO-ELDO space programmes.

Asked to analyse this problem, an ESC *ad hoc* group on programmes stressed in 1967 that the choice on whether or not to build a heavy launcher should be made "bearing in mind the need for Europe to retain its political, technological and cultural autonomy, not on the basis of purely economical considerations"[1202]. Along the same lines, the Causse Report (December 1967) stated that a sound and imaginative European programme was a prerequisite to any "fair partnership" in the design, production and management of space devices. In the words of Causse, "(...)Europe should attempt to achieve independent capabilities of its own in such areas as application and scientific satellites, placing it in a position to share early benefits of space exploration, to become eventually a desirable, respected and essential partner of other space powers in order to share full benefits of space flight activities in the decades ahead". Developing a wide range of space potentialities was both a prerequisite for a fairer partnership with the major ally, the USA, and a pillar for European political and cultural autonomy *vis-à-vis* the Americans. A case in point was, again, represented by the launchers. The capacity of broadcasting radio and television programs to specific areas being considered one important expression of political and cultural autonomy, the major space powers could not be left in a position to exercise control over these opportunities through their monopoly of launching facilities[1203].

This position, though, was not universally shared within ESRO and ELDO. There were those who, in the words of British Ministry of Technology Anthony Wedgwood Benn, were "very much alarmed at the thought that because a thing is European, and because a thing is international, this somehow excuses us from applying economic criteria"[1204]. European cost estimates at that time made clear that ELDO launchers were expected to be twice as expensive as their American counterparts[1205].

In June 1968, the European Space Conference decided that a mission should be sent to the USA in order to meet representatives from both the NASA and the Department of State to discuss matters relating to launchers. The problem was threefold:

1. availability of American launchers
2. possibility of joint development of launchers
3. possible use by the USA of European launchers

The mission would comprise the chairman of the Committee of Alternates, one representative each of UK, France,. Italy and possibly Switzerland together with a representative of ESRO and ELDO[1206].
Some days after this decision was taken, the Department of State representative Trevanion Nesbitt, reiterated August offers in terms of launch vehicles and affirmed the liberal character of US policy about the granting of export licenses, in both the satellite and launch vehicles fields. Of a total of approximately 31.000 requests for export licenses received by the Department of State during 1966, only 2%, he stated, were not approved by the Department of State -which was responsible for controlling the export of technology and hardware. The cases not approved related to communication satellites, whose relationship with Intelsat had not been clearly defined[1207].

1202 CSE/CM (July 67)6, *cit*. in footnote 1188; see also Volume II, chapter 10.

1203 CSE/CCP(67)5, December 1967, Report of the Advisory Committee on Programmes, Causse Report. See also, this volume, Chapter 11.

1204 Cited in J. Krige, "Britain and European Space Policy in the 1960s and early 1970s", in *Science and Technology Policy*, vol.5, no.2, 1992, p.15.

1205 CSE/CM (November 1968) 15, Add.1, Cost Estimates of the experimental satellite CETS-C, 11 December 1968.

1206 CSE/CS(68) 39, Note by the Secretariat, Twelfth session of the Committee of Alternates held in Neuilly on 10 and, 11 June 1968, 13 June 1998.

1207 Ibid.

Ten days later, in order to focus on the questions to be asked to the American counterpart, ELDO formalised a list of coordinated requests to the USA in the field of systems management and launcher systems, mainly guidance and boosters[1208]. The meeting was duly organised in mid-July 1968. Problems related to the availability of US launchers for foreign commercial satellites were at the core of the discussions. The necessity for all cross-frontier telecommunication satellites to be submitted to a judgement of compatibility by Intelsat was clearly stated. However, "the possibility of establishing domestic or regional traditional telecommunications systems outside the framework of Intelsat was not ruled out, but they would have to be technically compatible with Intelsat satellites, and, in case of regional systems, not detract from the revenue of the global system".

As a secondary element, to European enquiries about the practicability of the suggestion advanced in 1966 to ELDO on a joint US/European development of a liquid upper stage, NASA replied that the expected number of American missions which would use this stage were too few to justify its development. At the same time, the "joint development of space capabilities" was dismissed on the basis of the problems related to reliability, costs of development process and cost/effectiveness of the overall launcher operation. As an interesting, if marginal, aspect of the negotiations, the US representatives defined a broad category of satellites that, by their nature (the communication part not being the essential factor) would not to be submitted to any compatibility judgement by Intelsat. Among them were meteorological, navigation and air-traffic control satellites. The opportunity for a joint air-traffic satellite project (the future fateful Aerosat) was discussed for the first time and considered to have "excellent possibilities"[1209].

American willingness to launch European telecommunication satellites was put to test three months later, when the directors of the Franco-German programme to construct an experimental telecommunication satellite asked NASA if they could provide launch vehicles and service for two Symphonie satellites then under development. After consulting with the Department of State, NASA replied that it would launch the two satellites only if their experimental (as opposed to operational) character could be demonstrated[1210].

Here was a case where the Causse Report's prophecies seemed to be verified: American willingness to collaborate with foreign countries was clearly in conflict with the rising commercial interests in the field of communications. In April 1969, ministers of ELDO Member States decided in favour of the development of a new launcher system. After stressing the importance gained by application satellites in space policy, Australian, Belgian, French, German, Italian and Dutch representatives decided to support the study of the execution of a programme for Europa III launchers, corresponding, in principle, to the launching of geostationary satellites with a mass of 400 to 700 kg, the reputed size of the new generation of communication satellites[1211].

At the same time, in view of the approaching European decision on the opportunity to approve the then so called CETS television relay satellite (Eurafrica or Eurovision), due to be approved at the European Space Conference of November 1969, the Committee of Senior Officials of the ESC decided that Secretary General of the Space Conference, Hermann Bondi, should make inquires on the prospects of the American launcher availability for this satellite. To this end, a meeting was held in Washington between NASA and

1208 ELDO/CM(July 68) WP/2, Cooperation with the United States, July 10, 1968.

1209 CSE/CS(68) 2 September 1968, Meeting between US representatives and members of the Committee of Alternates, held in Washington on 19 July 1968; see also CSE/CS(68)45 rev. 17 September 1968, Meeting between US representatives and members of the Committee of Alternates, held in Washington on 19 July 1968; 17 September 1968. On this point, see *L. Sebesta US-European relations and the decision to build Ariane, the European launch vehicle*, in Andrew Butrica (ed), *Beyond the Ionosphere. Fifty years of Satellite Communication*, Washington DC: NASA, 1997.

1210 Library of Congress, Manuscript Division (LCMD), Washington, Thomas Paine Papers, box 26, Paine to Clinton Anderson, September 9, 1970. See Volume II, chapter 10.

1211 ELDO/CM (April 1969) 8 Final, 15 April 191969, Resolution.3, Studies on Future Programme.

State representatives on the one hand and Bondi on the other. American's basic attitude was in favour of the supply of launchers for any peaceful satellite, provided that it was not in contravention of their international obligations. Due to the fact that the treaty then ruling the use of telecommunications satellites was then in the process of being revised, the USA could hardly be anything other than non-committal as far as these obligations were concerned. At a very general level, while for domestic systems only technical compatibility was requested (in terms of frequency etc.) for regional international systems, some test of economic compatibility would be required, in order to verify that they posed no economic harm to the existing organisation's members. As for as the nations that would join the regional system (the European regional system, in European eyes, extended to Africa and the Middle East), no nation could have joined it until after it had joined the Intelsat network[1212].

In the course of another meeting during the same visit, Bondi was briefed by Frutkin about the future US programme and showed much enthusiasm for the prospective new post-Apollo programme, mainly consisting at the time of a space station and a shuttle. It seemed to be a shared assumption for both Bondi and his counterpart, the Administrator of NASA Thomas Paine, that European willingness to build its own launcher arose from a fear that the USA could block any expansion of future European telecommunication satellites by simply not providing the launching facilities. If Europe could abandon its "trouble-plagued and obsolescent vehicle program", Paine suggested, and reorient itself toward the purchasing of US launchers, "European funds would be freed for more constructive cooperative purposes", i.e. the post-Apollo programme [1213].

Discussions that took place during the second part of the 1960s, even if unfruitful, set the stage for a broadened perspective for US-European cooperation. The so-called post-Apollo negotiations showed how painful and controversial this process was. The following chapter is devoted to an analysis of the various interlocking elements that influenced the outcome of these negotiations.

1212 CSE/HF(69)32, Report on the Secretary General's activities resulting from instructions given to him by Senior Officials on 28/29 July 1969, 10 September 1969.

1213 LCMD, T. Paine Papers, box 23, Letter Paine to the President, August 22, 1969 and *Interview with A. Frutkin*, Washington DC, 8 November 1993 (interviewers: J. Logsdon & L. Sebesta).

Chapter 13:
US-European Space Cooperation in the Post-Apollo Programme: Setting the Stage

L. Sebesta

13.1 The American offer

NASA's offer of collaboration in the post-Apollo programme was put forward to the Committee of Alternates of the European Space Conference by Thomas Paine, in October 1969 [1214]. Though rather general in tone, it made constant reference to a much more detailed document, the Space Task Group Report, which was conveyed to European partners and served as a basis for a closed discussion session that took place after Paine's public presentation[1215]. The document mainly dealt with the "Post-Apollo programme" scenarios in the USA and suggested some main technological developments, the most outstanding of which were a space station module (which could be coupled with other similar modules and eventually take the form of a space base), a reusable space transportation system (the Shuttle), a tug (intended for transfer of payloads from the Shuttle orbit into geosynchronous orbit) and a nuclear propulsion stage (NERVA prototype engine) to be used for interplanetary transportation.

Although it was ranked as the last goal of the post-Apollo program, "international participation and cooperation" was nevertheless given an articulate definition. Two prerequisites for its full development were suggested:

1. "a substantial raising of sights, interest and investment in space activity by the other nations"

and

2. the "creation of attractive international arrangements to take full advantage of new technologies and new applications for peoples in developing as well as advanced countries". Despite the inclusion of foreign astronauts in national missions as "the most dramatic form of foreign participation" in American programmes, the document recognised as legitimate the desire shown by advanced countries to receive "technical assistance to develop their own capabilities". In this context, the USA should move toward a liberalisation of their policies affecting cooperation in space activities and should "stand ready to provide launch services and share technology wherever possible, and should make arrangements to involve foreign experts in the detailed definition of future United States space programs and in conceptual and design studies required to achieve them".

To achieve this, three major steps were suggested:

1. "The establishment of an international arrangement through which countries [might] be assured of launch services without being solely and directly dependent upon the United States.

1214 The European Space Conference was a coordinating body for ESRO, ELDO and CETS, set up at the end of 1969: this volume chapter 11.

1215 The Space Task Group (consisting of Spiro Agnew, Vice President of the USA, Robert Seamans, Secretary of the Air Force, and Thomas Paine, Administrator NASA) had been charged by the newly elected President Nixon in February 1969 with setting up the future goals of America's post-Apollo space policy. The report, adopted by the group in September 1969, failed to support the financial concerns shared by the White House and the Congress and was never adopted as the "blueprint" for the future. See *The Post-Apollo Space Program: Direction for the Future*, Space Task Group Report to the President, September 1969. The document is reprinted, with an introductory note, in John Logsdon (ed), *Exploring the Unknown. Selected Documents in the History of the US Civil Space Program*, vol I, (Washington DC: NASA, 1995), pp 522-543; H. Newell, *Beyond the Atmosphere. Early Years of Space Science* (Washington: NASA, 1980) p.288.

2. A division of labour between the USA and other advanced countries or regional space organisations permitting assumption of primary or joint responsibility for certain scientific or application tasks in space.

3. International sponsorship and support for planetary exploration such as that which was associated with the International Geophysical Year"[1216].

Paine was extremely elusive in answering the questions put to him by European representatives after his speech: the real nature of the international agreement he alluded to in point 1 was not clarified[1217]. To the observation advanced by Robert Aubinière, then chairman of the ELDO Council, on the "very considerable impact" that his proposals could have on the European launcher programme, Paine answered that "It is precisely for this reason that we have brought before you our planning, so that indeed it will be possible for you to review your plans in the light of what it is that we now propose to do"[1218]. This comment spurred French concern about the possibility that post-Apollo would "crowd out" their project for achieving an independent European launch capability: cooperation would obviously tie a significant part of the scarce European space resources to a programme led by the USA, reducing the chances of a serious challenge to US supremacy[1219]. Nor was it the first time that the USA were conscious of these European fears. In a letter written to the newly elected President Nixon in February 1969, Paine, then NASA Acting Administrator, had stressed how Europeans considered that NASA was "attempting to divert European activities toward scientific pursuits and away from 'high pay-off' projects in space communications" and thought that offers to provide launch facilities were "calculated to undermine support for ELDO's development of a European booster"[1220].

Notwithstanding these *caveats*, the striking difference between this proposal and the previous American cooperative offers in space cannot be overlooked. Whereas the USA had been very careful, until then, to avoid any commitment in cooperative technological development with commercial or military interest, this is what they seemed willing to offer now, even if under certain conditions.

1216 *The Post-Apollo Space Program: Directions for the Future*, Space Task Group Report to the President, September 1969.

1217 Neither did he clarify this point in front of the Senate Committee which discussed NASA authorisation for FY 1971 some months later. Paine would just offer a short answer "off the record" to those US Senators, who asked the same question and would repeatedly characterise the wording as "somewhat awkward". Later in the hearings, he would make clear that "this suggestion was prompted by the realisation that arbitrary US restrictions upon the availability of its launch services could stimulate independent activities in Europe on political rather than simply technical or economic grounds". *Hearings before the Committee on Aeronautical and Space Sciences*, US Senate, 91 Congress, 2nd session on S 3374, March 11 1970, part 3, International Space Cooperation (Washington DC: US GPO, 1970), p. 1047 and p.1062.

1218 CSE/HF(69)39, Annex 2, Text of exchange of views between the members of the Committee and the NASA representatives, 24 November 1969. See also P. Creola, "European-US space cooperation at the crossroads", *Space Policy*, May 1990, p. 100. As Paine would later explain to the President, his primary goal in offering Europeans collaboration in the post-Apollo ventures was "to stimulate Europeans to rethink their present limited space objectives, to help them avoid wasting of resources on obsolescent developments, and eventually to establish more considerable prospects for future international collaboration on major space projects". Library of Congress, Manuscript Division (LCMD), Washington DC, Thomas Paine papers, box 24, Letter Paine to the President, 7 November 1969.

1219 The Space Station cooperative experience seemed, later, to generate among European partners the same kind of apprehension; G. Van Reeth and K. Madders, "Reflections on the quest for international cooperation", *Space Policy*, August 1992, p. 228.

1220 NASA History Office reference collection, International Cooperation File, Nixon Administration Collection, Letter Paine to the President, 12 February 1969, cited in R. Launius, "NASA, the Space Shuttle, and the Quest for Primacy in Space in an Era of Increasing International Competition", in Emmanuel Chadeau (ed), *L'ambition technologique: naissance d'Ariane*, (Paris: Editions Rive Droite, 1995), pp. 39-40.

In the first "official" call in favour of international cooperation in space (March 1970), President Nixon seemed to confirm this impression, declaring that "both the adventures and the applications of space missions should be shared by all people". He then went on to make a brief reference to his willingness to extend the availability of American launching facilities to "larger applications satellites and astronaut crews"[1221]. As would later become unmistakably clear, the President's interest rested mainly in this second option. The hypothesis of having foreign astronauts on board American space vehicles was the one that better fitted his vision of cooperation as a way to reinforce US political leadership by means of a highly visible option involving human beings. Thus, not by chance, he favoured the presence of astronauts from the Federal Republic of Germany and Japan, the ex-enemies defeated by superior American democracy and technology.[1222]

Testifying during the NASA authorisation hearings for fiscal year 1971 held some days after the Presidential declaration, Paine restated the original characteristics of his proposal by declaring that opportunities for foreign participation in the post-Apollo programme would be "most meaningful and satisfactory to all concerned if they (were) taken up as part of a substantive developmental, operational, or experimental involvement in the program itself"[1223].

13.2 Initial European reactions

The Committee of Alternates instructed ELDO and ESRO to study the proposal. A joint ESRO/ELDO working group to analyse the technical implications of European participation in the American programme was set up. Visits to NASA headquarters, centres and industrial establishments by European representatives were organised; they were invited to attend management reviews and to receive updated briefings regarding the space station and the shuttle. By April 1970, the working group was able to give a first assessment of the problem it had been charged to study [1224]. The document, signed by the two co-chairmen of the working group, J.P. Causse and J.A Dinkespiler, first made reference to the innovative nature of the American project. The post-Apollo space programme was not geared, as had been the case in the decade, to the attainment of a specific goal—the landing of human beings on the moon, for example; it was aimed instead at changing the nature of activities in space by:

1. the use of the space environment for scientific and technical research by non-professional astronauts who would be living in orbit;

2. the use of space for particular new applications purposes;

3. the exploration of the solar system by means of manned missions.

The system envisaged provided the necessary elements for the execution of missions in low Earth orbit:

1. a space station, to be followed later by a space base;

2. served by a recoverable launcher, or space shuttle.

1221 *Statement by President Nixon on the Space Program*, 7 March 1970, reproduced in Appendix J, H. Newell, *op. cit.*, p.443.

1222 LCMD, Thomas Paine Papers, box 24, Paine's Memorandum for the Record, Meeting with the President, January 22, 1970; Rensselaer Polytechnic Institute, Folsom Library (RPIFL), Troy, George Low Papers, box 69, Fletcher to Low, Summary of meeting with the President on June 15, 1972.

1223 *Hearings before the Committee on Aeronautical and Space Sciences,* cit., p.1065.

1224 WG/COOP-US/6, 16 April 1970.

Complementary launchers should make possible the passage from this stage to a further one:

1. from low orbit to geostationary orbit (space tug);

2. from low orbit to lunar orbit (space tug);

3. from lunar orbit to the lunar surface (space tug);

4. from low orbit to interplanetary trajectories (nuclear shuttle, NERVA, which could serve, in certain cases, even for Option 2.).

Studies on the station were the most advanced, reported as being in the competitive definition phase (Phase B0, with two firms taking part, under the direction of two NASA centres, themselves in competition). The activity of the station would be oriented towards scientific and technical research. The scientific field was to cover biology, astronomy, geophysics and solid state physics. Fields that had been purely terrestrial would find new prospects when the space tool would be available. The station was conceived as work in progress, and was to be capable of adaptation and extension. This is why its design concept was modular, with modules capable of becoming elements of the base as well as planetary modules.

The station would require an economic means of transport for putting men and equipment into orbit and bringing them back to the ground. This means was the space shuttle. While the feasibility of the space station seemed guaranteed, the feasibility of the shuttle in its original configuration appeared to be dependent on technological progress that had yet to be achieved.

The space tug was the least known element of the system (a call for tenders had been launched by NASA for a preliminary study prior to Phase A). It was considered to be a sort of shuttle third stage, because it was thought to be used to propel spacecraft beyond the orbits reached by the shuttle itself. The tug was bound to be a manned vehicle, chemically propelled and capable of being placed in orbit not only by a Shuttle but also if necessary by a Saturn launcher; it would not return to Earth.

A nuclear motor called project NERVA had been studied for several years by the Atomic Energy Commission. This project was little known in Europe because much of it was classified. The motor would only be switched on once the vehicle was in orbit, thereby reducing the dangers of radioactive contamination in the event of malfunctioning of the launch vehicle.

While no timetable had been officially approved by NASA, the document gave a tentative one which called for the first operational flight of the shuttle in 1977, the assembly of the station after 1977 and its entry into service around 1978-79. The entry into service of the base was considered to be realistically possible around 1983-84 and the first operational flight for the tug around 1980-82.

The strategy for enabling the objectives to be attained was based on three main principles: reusability, commonality (in order to produce a lowering of costs) and "widening the objectives of space flight", so that "it is no longer reserved to the small community of professional astronauts, but takes in categories of research workers for whom space is not simply an end in itself but a particular means of advancing science and technology".

"*A total metamorphosis of space activity*" (emphasis in the original text) by some 15 to 20 years was forecast in the document. By 1990, the new system would, it was claimed, have completely replaced the present launching facilities.

What problems would these metamorphoses pose to Europe? The nature of the problem was twofold:

1) on the one hand, questions would arise about Europe's possible participation in the new NASA programme;.

2) on the other, it would be necessary to analyse the effects of this American programme on the programme decisions to be taken by Europeans in the following months.

   a) Ideally, participation should be "additional to the activities already embarked on" by Europe. An alternative could be to achieve all or some of the aims currently pursued in association with the USA, thus saving on new developments for Europe for which American solutions already existed. For example, "a guarantee that launchers would be supplied for peaceful missions corresponding to the European objectives would be negotiated in exchange for European participation in development of the new system. Such participation should carry with it, from the outset, an 'entitlement' to launchings". The kind of cooperation envisaged involved:

      i) the development of certain elements important for the system as a whole and sufficiently individualised for the corresponding management to be fully assumed by Europe, within the overall system management;

      ii) a large number of sub-contracts for a valid range of elements, in order to have access to the largest possible amount of technological information.

   b) As far as the impact of the American programme on European programme decisions, three fields were taken into consideration:

      i) space science. The station was considered to be a very rigid instrument because it would not be operational for some time (forecast for the end of the 1970s), because it would lack many specialised modules and because it would have a very special orbit. The only missions affected would be those deriving such a benefit from it that it would be absurd to try to gain a few years by using an automatic vehicle at the price of enormous sacrifices in terms of quality and quantity of results. Optical, infrared and ultraviolet astronomy were identified as priority customers of the station. Most of the other fields did not appear to be affected in the short term.

      ii) space application. Missions in geostationary orbit (mainly telecommunications, scientific satellites and certain meteorological satellites) would not be technically possible until the base and the tug were operational, i.e. around 1983-84. The new American programme did not therefore in any way affect the decisions the Europeans might take at the present time in respect of application satellites.

      iii) launchers. According to the plan for using the shuttle in 1985 only two journeys would be devoted to the transport of automatic spacecraft, the other sixty being divided between lunar or planetary missions and serving the base. "Routine use of the shuttle" to place in orbit automatic spacecraft (such as the satellites of the European application programme) would not happen until the end of the 1980s at the earliest. Thus, "a launcher such as Europa III, available in 1978, would have the prospect of a career of at least eight to ten years".

From the organisational point of view, it was suggested that ESRO should remain primarily responsible for matters relating to the space station and a task group of experts from the national administrations be formed under the chairmanship of J.Collet. ELDO would be entrusted with the questions related to the means of transport, such as the shuttle, the tug and the nuclear transporter; a task group had been already set up under the leadership of H. Hoffmann.

A briefing activity soon got under way. The presentation by American representatives of the space station took place in Paris, in June 1970, with the presence of some 300 Europeans scientists and space program authorities[1225]. A month later, a NASA team briefed European industrial and space representatives gathered under the aegis of ELDO in Bonn on the Space Shuttle and Space Tug[1226].

[1225] D.Lord, *op. cit*., pp. 12-13.
[1226] D.Lord, *op. cit*., p. 13.

The Ministerial meeting of the European Space Conference of July 1970 entrusted the President of the ESC, Theo Lefèvre, the Belgian Minister for Scientific Policy and Programming, supported by representatives of France and the UK, the task of exploring, on behalf of the ESC, with the government of the USA the political, financial and other conditions for possible European participation in the post-Apollo programme and requested him to report on these before the end of the year. It also stated that "in the light of the outcome of the negotiations, the participating states [should] together reconsider the conditions for the carrying-out of the European programmes, in particular where launchers [were] concerned". No votes against were registered; only three countries, Australia, Norway and Sweden, abstained [1227]. Only Belgium, the Federal Republic of Germany and France were willing to commit themselves to finance long term studies for Europa III until an agreement had been reached with the USA. The other countries were not prepared to go along with their partners[1228]. Against the UK suggestion in favour of a *menu-à-la carte* which should leave members free to choose between launchers and satellites, Belgium, the FRG and France considered it necessary to agree on the launcher and satellite program as a whole.

The divergence between those who wanted to concentrate on the building of satellites and those who wished to consider both satellites and the facilities to launch them was one of the most important unsettled problems against the background of the European position on post-Apollo negotiations[1229].

The same meeting provided financial support for the period to June 1971 up to a maximum of 2.5 MAU (Million Accounting Units); this permitted the extension of the system studies in respect of both the space transport system and the space station and enabled technological studies to be undertaken, mainly in connection with the space shuttle[1230]. In addition, firms in several Member States, financed in most cases by

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1227 CSE/CM(July 70)9 (Final), Res. 3 "Cooperation in the Post-Apollo Programme" 24 July 1970. See also *ESRO/ELDO Bulletin*, no.11, September 1970.

1228 Interest in the studies for Europa III had been expressed (without any financial committment) before the American post-Apollo offer, by Australia, Belgium, the Federal Republic of Germany, France, Italy and the Netherlands at the ELDO Ministerial conference of April 1969; see *ESRO/ELDO Bulletin*, no.5, May 1969, res.3 concerning the studies on future programmes. American unwillingness to launch the Franco-German Symphonie satellite, if operational, had probably played a relevant role in persuading some European countries to support studies for Europa III. See this volume, chapter 12.

1229 The need for proceeding with both programmes was stated in the Puppi report (from the name of the head of the Committee of Senior officials set up by the European Space Conference in 1968), in CSE/CM (July 70)PV/1 rev., Annex 2, Presentation of the Report of the senior officials by Professor Puppi, 30 July 1970.

1230 In this period, one Accounting Unit (AU) was equivalent to the value of the US dollar.

their governments, entered into partnership with various NASA contractors responsible for studies on the station and the shuttle[1231].

System studies (in preparation of future projects) on the lines of those set up by NASA were organised by European in two areas: on the space tug whose propulsion techniques were considered to be sufficiently close to those being studied in connection with Europa-III (by ELDO) and scientific modules, intended as a peripheral element of the space station (by ESRO). Much less was done in the field of technological and predevelopment studies (intended to make possible an eventual execution of the project by furthering the progress of certain essential new technologies to the maximum extent)[1232].

13.3 The first political contacts

On 16 and 17 September 1970, Minister Lefèvre, accompanied by Lord Bessborough, representing the UK, and Denissse, representing France, had several meetings with their American counterparts on the political and financial aspects of European participation in the post-Apollo programme [1233]. The talks were highly exploratory in nature because the programme's future shape and fate was still unresolved on the national level. Thus, no mention was made of the specific content of the cooperation.

The discussions had two focuses: the relationship between the present negotiations and the availability of American launchers and the nature of future cooperation in terms of decision making and management.

1231 CSE/CS (72) WP/5 Report by the Secretary General of the ESC on the discussions between Europe and the United States on participation in the post-Apollo programme, 6 July 1972.
In 1971 a broad spectrum of exploratory studies, though of short duration and low-cost, was contracted to European industry as follows:

MATRA (France)	Comparative study of a scientific satellite to be launched by a Shuttle as opposed to the Thor Delta and study of a telecommunication satellite to be placed in synchronous
MBB (West Germany)	Cost study of a biological research module to be attached to a Space Station
HSD(UK)	Cost evaluation of a free-flying astronomy module
BAC (UK)	Parametric cost analysis of research and applications modules
HSD (UK)	Study of advanced telecommunication station
GETS (France)	European technological capability survey
BERTIN (France)	Study on use of space facilities for research and advanced technology
Thomson-CSF (France)	Cost Evaluation of a cosmic ray facility

In D.Lord, *op. cit.*, p.49.

1232 ESRO/ELDO working group, July 1970, (WG/COOP-US/9), July 1970. By October 1970 "ESRO had already conducted some 15 applications studies related to experiments modules and shuttle payloads. ELDO had sponsored 14 technology activities in areas related to the Shuttle development and its use and had also conducted preliminary studies related to a Space Tug". D.Lord, *op. cit.*, p. 16.

1233 The European delegation was assisted by members of the ESC Secretariat, led by the Secretary General, Renzo Carrobio di Carrobio.On the American side, the participants were: Alexis Johnson, Under Secretary for Political Affairs, Department of State; George Low, Acting Administrator, NASA; Edward David Jr., Science Adviser to the President; William Anders, Executive Secretary, NASA; John Morse, Deputy Assistant Secretary of Defence for European and NATO Affairs. The talks were held at the State Department, Washington DC. Because of their explorative character no minutes were taken; viewpoints expressed were later reported in CSE/CS (70) 23, Statement by Mr. van Eesbeek relating to the Washington Talks (16-17 September 1970) between the ESC delegation and the American authorities,
8 October 1970.

The main interest of European negotiators was the relationship between European participation in the post-Apollo programme and the development of an autonomous European launching capacity. "Owing to its limited means" European representatives declared "Europe would be unable to finance at one and the same time the development of launchers for these programmes (defined early on as being essential European programmes, particularly in practical applications) and a significant participation in post-Apollo programme developments". In order to be consistent with the missions that Europe had assigned itself, European cooperation in the Post-Apollo programme had to be supplemented, Lefèvre stated, in the interim period "from 1970 to 1980 or 1985", with American launching facilities granted "on a commercial basis and without political conditions".

The Americans replied that, "(...) *on the assumption of substantial European participation in the post-Apollo programme*" [emphasis in original] they were prepared to provide Europe, on a reimbursable basis and before the commissioning of the new Space Transportation System, "with launch service for any peaceful purpose consistent with existing international agreements"[1234].

As to the meaning of "substantial", it was made clear that the Europeans would be required to contribute to at least 10% of the overall development costs of the Space Transportation System. These costs were forecast as amounting to $10 billion over ten years; for Europe, this would mean $1 billion spread over the same period. Broadly speaking, Lefèvre said, this would correspond to the effort Europe was supposed to make in order to continue the development of the European launcher (some disagreement seemed to exist on this point, because in Ortoli's view, the cost of European participation in the post-Apollo programme would be double that of the development of the European launcher)[1235].

In reply to a request made by European representatives, the American delegates specified that "any peaceful purpose" would "include commercial purposes which could, as such, compete with American interests" (this possibility was made quite clear by the European Delegation before the American stated their position). These launches would take place at reimbursable costs - reimbursement for actual costs plus a certain margin for management expenses, but excluding amortisation of development costs. The American commitment was general in nature, that is, the USA would undertake to provide launch services requested by Europe "without the right of refusal or of unilateral acquiescence on a case-by-case basis"[1236].

It is to be remembered that this exchange of opinions took place within the context of a major debate related to the new Intelsat agreement which was in the process to replace the interim agreement of 1964 as the ruling charter for the international communication satellites policy. Within this broader context, the Europeans were striving to obtain more permissive rules in the establishment of regional satellites, for example Symphonie, as opposed to the global communications satellites which were to remain under the monopoly of Intelsat. Whereas the USA initially argued against the right to construct a regional system, the final approved draft (which would eventually become part of the definite agreement of 1971) seemed to open the way for the establishment of separate space segment facilities to meet international public telecommunications services requirements of the various members. In each case, the members would ensure the technical compatibility with the Intelsat space segment and avoid significant economic harm to the global system. However Intelsat was not permitted, as requested by the USA, to enforce sanctions against violators, nor were its recommendations considered binding; moreover, Comsat, the American signatory, was deprived of what amounted to a veto power according to the Interim agreement [1237].

1234 CSE/CS(70) 23, Statement by Mr van Eesbeek, *cit.*

1235 CSE/CM (November 70) PV/1, Annex 1, Declaration by Theodore Lefèvre, 4 November 1970.

1236 CSE/CS (70)23, Statement by Mr van Eesbeek, *cit.*

1237 S.A. Levy, "Intelsat: Technology, politics and the transformation of a regime", *International Organization*, vol. 29, n.2, Summer 1975, pp.669-671

The relationship between Intelsat and American willingness to launch European satellites was specified in a letter written by Johnson to Lefèvre on 2 October 1970; the document stated that the USA were prepared to launch European satellites "in those cases where no negative finding is made by the appropriate Intelsat organ, regardless of the position taken by the US in the vote"[1238]. "To put it simply" Theodore Lefèvre declared in relation to the US launcher availability at the ESC meeting of November 1970 " (...) 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 problem thus remained as "the first substantial point" to be dealt with in any further post-Apollo negotiations[1239].

As far as the decision making was concerned, two possibilities were discussed in the September talks:

1. to work on a separate element in the programme

2. to join in the production of components for major systems

The first solution would fall better with the concern to bring about an interdependent partnership, a principle "put forward by the European delegation and not rejected by the US representatives"; at the same time it would help Europe to be entrusted with real "prime-contractor responsibility". What was necessary to verify was whether this could be achieved with the relatively small financial European effort and whether the Europeans had adequate technical capacities to succeed in this kind of collaboration. On the other hand, the second solution would afford greater financial and technical flexibility, challenging, at the same time, the principle of interdependence and of European "prime-contractorship". In view of the many interface problems that would eventually rise, there was a risk that it might prove financially harmful and nullify the effect of the limited European contribution.

In the written exchange that followed the meeting, this aspect was further elaborated. The question was split in two:

1. decision making and management

2. access to information and facilities

What the Europeans wanted was participation in decision making at all levels of management and detailed access to technology used in the post-Apollo Programme. These were the two questions on which disagreement would be especially pronounced.

The Americans considered that Europe's role in decision-making and management should "relate to, and be commensurate with, the measure and character of European participation". Participation expected was, again, defined as "substantial". In this case, "arrangements for collaboration should assure consultation in the development of the Space Transportation System and Space Station wherever of significant, mutual concern to both parties". An extensive role was forecast for Europe only in the management of those aspects of the systems in which European contractors would be involved, either directly under European governments or working as subcontractors to American prime contractors. Europe, in other words, would be a "partner in reaching any decisions which have a measurable impact upon European costs or upon European tasks in discharging their commitments to the program". Overall responsibility for

[1238] CSE/Comité ad hoc (71) 9, Letter from Johnson to Lefèvre, October 2, 1970.
[1239] CSE/CM (November 70) PV/1, Annex 1, Declaration by Theodore Lefèvre, 4 November 1970.

management, however, "would necessarily rest with the US". "Wherever there is a basis for European use of the Space Transportation System or Space Station" the Americans expected "Europe to take part in mission planning and experimental programs in generous proportion to their use".

As far as access to information and facilities is concerned, the American position was that "each participating party must have detailed access to technical data and facilities which they would need to accomplish their specific tasks under the agreed collaboration, but should also have general access to all technology and facilities in the overall development of the program". Design, development and production data at the level of commercial know-how meant detailed access. General access included only access thorough visits and published or publishable documentation. Data which might be "sensitive in terms of national security" would be exchanged, "but handled within agreed security safeguards". As for cost estimates, development costs, not including cost estimates for production, facilities and operations were estimated as being $13.7 billion from 1972 to 1981 for the Shuttle, Space Tug and Space Station. To avoid the simultaneous peaking of Shuttle and Space Station expenses, the administration expected to concentrate first on the Shuttle and later on the Space Station [1240].

Lefèvre gave an account of his visit during the Space Conference of 4 November 1970. He called for the beginning of a negotiation phase proper, and stressed that the talks had enabled the Europeans "to consider as a priority the hypothesis that Europe will have a large availability of American launching devices within the framework of post-Apollo cooperation". In consideration of the nebulous US guarantees on launchers, however, he suggested to follow a two track procedure, whereby the European programme would be based "mainly and by priority on the development of the Post-Apollo Transportation System, but with the alternative solution of building a second generation European launcher". Europeans "should decide to build [their] own launchers, should these negotiations be a failure" [1241].

13.4 National positions

The European Space Conference of November 1970 was described by journalists as dramatic and recorded later as the most troublesome of the ESC history[1242]. Post-Apollo was but a minor topic of discussions, which centred on complex topics such as the unification of European space institutions and future applications, launchers and scientific programmes[1243].

Delegations were called to vote on three linked concepts:

1. programmes (subdivided in applications, launchers and scientific programmes);

2. unification of the institutions;

3. continuation of negotiations with the USA on the post-Apollo programme.

The positions varied widely, going from the most favourable West German one (the Federal Republic delegate was in favour of application, launchers, scientific programme, plus continuation of post-Apollo negotiations and abstained only on the unification, while it had abstained on the space programme voted during the July session) to the less manageable British one (the UK delegate voted against the launcher

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1240 CSE/Comité ad hoc(71)9, 22 April 1971, Letter from Johnson to Lefèvre, October 2, 1970. pp.8-9 (decision making) and pp 10-12 (Access to information and facilities)

1241 HAEUI, CSE/CM (November 40) PV/1, Annex 1, Declaration by Theodore Lefèvre, 4 November 1970.

1242 Dominique Verguèse, "European space research totters", *New Scientist*, 12 November 1970. R.Fraysse, "Retour sur le passé: la décision de l'Europe de participer au programme post-Apollo", *ESA Bulletin*, November 1984, n.40, p.61. See also, Arturo Russo, section 11.7 of this book.

1243 Krige and Russo (1994).

programme, abstained from the applications programme, the unification of the institutions and the continuation of discussions on the post-Apollo project, which he favoured in the July Conference, and was in favour of the scientific programme). In the middle was Italy, which vetoed the development of an autonomous European launch capability (preferring to rely on the American one) and was in favour of collaborating with the Americans on the post-Apollo project provided that, restricted as Europe's participation would be in financial terms, "the right of total access to the technology of the whole programme and not only that part of it identifiable as financed by Europe" could be obtained as "an absolute preconditioning". The continuation of discussions on the post-Apollo programme was not vetoed by any delegate, but five abstained: Australia, Denmark, Norway, Sweden and the United Kingdom (Denmark and the UK changing their position from the previous favourable advice given on preliminary studies in the July conference). Belgium, The Federal Republic of Germany, France, Italy, the Netherlands, Spain and Switzerland gave their approval. The whole European launcher programme including Europa III , on the other hand, was favoured only by Belgium, the Federal Republic of Germany and France[1244].

The British Minister of Aviation Supply, could not see any need or scientific value, in the light of the progress made by the mission, for the development of independent launching capabilities[1245]. He also made it clear that he considered that the question of the supply of launchers should be studied separately from that of participation in the post-Apollo programme.

To this the President (Lefèvre) retorted that as a result of his American mission the link did in fact exist. This statement was repeated by Ortoli, the French Minister of Industrial Development and Scientific Research, who stated "At the conference in July, the idea had been current that a European launcher could be replaced by participation in the post-Apollo programme, but it is now clear that the cost of the latter would be at least double that of a European launcher programme". It has to be stated that in July, the French representative considered the availability of launching facilities to be part of the post Apollo project[1246]. The ratio might become even more unfavourable, in consideration of the fact that plans for the post-Apollo programme had not yet been finalised and its financial scope was not yet sufficiently defined.

After noting the very preliminary stage of consultations with the USA and the vagueness of elements, Ortoli went on to state that "if Europe does really want to be present in the telecommunication market, then it should not make satellites which will be subject to outside control - which may or may not be launched - and should make a firm resolve to provide the means for launching its satellites itself, if it is true, as I believe it is, that the telecommunications market, the communication of information, will be one of the major markets of the next fifteen years". The German delegate, Professor Leussink (Federal Minister for Education and Science) agreed on that and on the fact that "the link between participation in the post-Apollo programme and the availability of United States launchers must be assumed"; in the sense that American launchers could not be obtained without participation to the post-Apollo programme. In general terms, the British delegate was isolated on this point[1247].

13.5 The industry; the case of Eurospace

Eurospace had been created in 1961 as a non-profit association, bringing together leading European companies from seven countries (Belgium, the Federal Republic of Germany, France, Italy, the Netherlands, Switzerland and the United Kingdom) dealing with aerospace-related fields such as aircraft, electronics, chemicals, steel and machinery to promote the development of air and space activities in Europe.

1244 CSE/CM (November 70) PV/2, Minutes of the meeting held on the afternoon of 4 November 1970, 19 November 1970.

1245 CSE/CM (November 70) PV/1, Annex V, Declaration of the British Minister of Aviation Supply, 4 November 1970.

1246 CSE/CM(July 70) PV/1 Rev., Annex IV, 30 July 1970.

1247 CSE/CM(November 70) PV/2, 19 November 1970.

Contacts had been made by ELDO and ESRO with Eurospace in order to convince some of its members to carry out certain preliminary studies related to the post-Apollo project free of charge. In June 1970 Eurospace produced a memorandum on US-European cooperation in which it favoured collaboration in the post-Apollo programme. With the participation of its affiliated American firms, Eurospace organised a symposium in Venice during the same summer (September 1970)[1248].

Yet, in 1971, its position on the post-Apollo programme was shifting toward a much more cautious one. Through its Secretary General Yves Demerliac, Eurospace publicly expressed its scepticism on cooperation at the American Astronautical Society's Ninth Goddard Memorial Symposium held in Washington DC on 10 and 11 March 1971. Demerliac, who declared to have consulted more than 80% of the industrial space potential in Europe, set out industrial and political motivations to support his cool reception of the American offer on post-Apollo. From an industrial point of view, he made clear that the main aim of European industry was "to manufacture operational equipment in quantity and to be able to master the management and operation of the application systems" like telecommunications, meteorology, oceanography, oil detection etc. The rather optimistic target for European industry was set out to be "to acquire prime contractor ability for all space application systems". Technological excellence *per se* was, thus, not a priority aim. The two main concerns, instead, were the technological and managerial capabilities to produce space applications in mass quantities in order to substitute them for traditional equipment without losing the share of the markets for the new production. Cables and microwave links against telecommunication satellites was a perfect case in point. The progressive substitution of the first by the second would lead to a loss of vital markets for the industry concerned unless its market share in the new products was comparable to that in the old, conventional ones.

As far as political aims were concerned, Demerliac referred first of all to the unsatisfactory share of Intelsat contracts in the telecommunication sector. The only means to improve this situation would be "the development and operation of complete European regional application systems". This went hand in hand with the development of an autonomous European launcher capability. "Only one British firm" Demerliac specified "took the view that participation in post-Apollo was more urgent and vital than the development of Europa III". The size of European participation to post-Apollo should, thus, make reference to such political priorities.

For this reason, a two-track approach was proposed. In the first phase, up to 1975-76, when the peak expenditures for Europa III would be over, Europe could not devote more than a few million dollars per year to post-Apollo. In this context, a tug-type project would not be financially viable nor would it satisfy industrial requirements as stated above. European firms would thus prefer to negotiate agreements with American contractors and to be funded, at the same time, by the respective governments.

In the second phase a "more massive and integrated European participation" in post-Apollo could be envisaged. However, even in this medium term prospective, the tug seemed not to be preferred industry. The only industrial representatives who seemed to like it were the Germans, who expressed interest in a tug delayed in time (entering operational service by 1985). French and British firms preferred the development of one or two major systems of the Shuttle, i.e. the orbiter wing and the avionics system. In this case, however, it was very difficult to see how this participation could be integrated on time into the post-Apollo schedule.

[1248] WG/COOP/9, Second report by ESRO/ELDO joint working group, 16 April 1970; see also Y. Demerliac (Secretary General, Eurospace), "European Industrial Views on NASA's plans for the `70s", *International Cooperation in Space Operations and Exploration*, AAS Science and Technology Series, vol. 27, proceedings of the AAS Ninth Goddard Memorial Symposium held at Washington DC, 10-11 March 1971 (Tarzana, Cal.: American Astronautical Society, 1971) pp. 29-35.

On the other hand, because the ESRO community seemed to be favourable to shift part of its scientific budget to the space station or its cheaper replacement, the development of a European module seemed to be an attractive proposition[1249].

Even on this last point, however, French industrialists had in previous occasions expressed their doubts. It is useful to remember that, while it had been one of the original aims of Eurospace to encourage European countries to finance big and technologically innovative space programmes at a time when commercial uses and profits were but distant possibilities, the organisation was now operating in a changing context, where real commercial opportunities (outside the "protection" of the government) were opening up for firms involved in space.

As an illustration of how this influenced the investment strategies of firms, a letter had been sent to Ortoli in December 1970 by French electronic and aerospace industry groups, indicating their scepticism about the prospects of European participation in the post-Apollo programme. The (rather prophetic) rationale behind the decision was threefold:

1. Applications in space were considered feasible with non-inhabited systems at a much lower cost than with inhabited ones. The case against financing an inhabited device would always be strong, especially in cases of economic crisis. Thus, such a system would have risked to have its funds cut off in the future, before being completed.

2. The marginality of European cooperation, due to its objective weakness in technological and financial skills, would lead to "an undesirable situation of dependence"; Europeans would be excluded from the development of the new transportation system.

3. participation in post-Apollo would crowd out funds for the independent European expandable launcher. Because it would be substantially higher that the forecast cost of Europa III, it could also compromise some major satellite programmes. In view of the impossibility of obtaining a reliable guarantee for the availability of American launchers, a programme of European launchers should receive a priority endorsement[1250].

1249 Y. Demerliac, "European Industrial Views on NASA's plans for the '70s", *International Cooperation in Space Operations and Exploration*, AAS *cit.*, pp. 29-35.

1250 ELDO Papers, box 464, Letter Syndicat des Industries de Matériel Professionnel Electronique et Radioélectrique et Union Syndicale des Industries Aéronautiques et Spatiales to Ortoli, Ministre du Développement Industriel et Scientifique, 10 December 1970.

13.6 The changing framework for cooperation: the revised post-Apollo programme and its "decoupling" from the question of launchers

By the end of 1970, the post-Apollo programme had undergone a major change in its nature: instead of being focused on a space station and a shuttle as a means to reach it and supply it with materials and human beings (be that aim portrayed in the framework of the ultimate goal of a manned mission to Mars or not), it became centred on the shuttle itself. The rationale for this choice was found in the wide range of possible commercial and scientific uses of the shuttle and by its potential use, with the possible addition of a research and application module (RAM) capable of being orbited by the shuttle, a substitute for the permanent space station[1251]. Along with this new modular concept, some RAMs could remain docked to the shuttle and be brought back to Earth by it; others could be left in orbit and merely visited and eventually recovered by the shuttle.

On the European side, by the end of the year, feelings began to be aired in the press that the USA was "trying to lure Europe into curtailing the development of launchers and communications satellites in order that she will continue to be dependent on the US for these items"[1252].

European and American delegations met again at NASA headquarters in Washington on 16, 17 and 18 February 1971[1253]. These talks centred on a presentation of the new, reduced, post-Apollo programme and a discussion about the technical fields of possible European participation.

NASA's representatives seemed to join the Europeans in considering two kinds of possible European participation: one concerning a major element of the system (tug or RAM) in which the prime-contractorship would be European, the other concerning smaller and dispersed elements of the shuttle - and in this case European firms would be sub-contractors. Parts of the orbiter and booster (the two main elements, at this stage, in the configuration of the shuttle), in this second case, could be built in Europe.[1254]

The American presentation of the Shuttle made reference to the concept of a completely reusable shuttle made up of two parts, booster and orbiter, both operated by human crews[1255]. Because funds had not yet been granted by the American Congress, NASA was in the unfortunate situation of offering cooperation on a project whose configuration could not be considered as final - and which was substantially reviewed due to financial restrictions.

At the same time, the existing linkage between European "substantial" participation in the post-Apollo programme and the availability of American launchers for European telecommunication satellites, along with the uncertain fate of the new Intelsat agreement (due to be opened for signature in August 1971) which would govern this availability, contributed to a deadlock of the negotiations.

1251 J. Logsdon, "Choosing Big Technologies. Examples from the US Space Program", in J. Krige (ed.), *Choosing Big Technologies* (Chur: Harwood Academic Publishers, 1993), pp. 145-146.

1252 B. Valentine, "Europe and the post-Apollo experience", *Research Policy*, 1 (1971/1972), p.115; for press position, the author cites "Space brinkmanship", *New Scientist*, 12 November 1970, pp. 310-311 and *Münchner Merkur*, 8 July 1970.

1253 The Europeans were headed by Causse and Dinkespiler (on the 16^{th}) and thereafter by Ortner (17^{th} and 18^{th}). On the American side, the delegation was composed solely of NASA representatives together with one observer from the State Department; it was led by Charles Donlan, Director of the Space Shuttle Program.

1254 This was the only possibility, taking into account that the estimated cost of the orbiter represented 55% and that of the booster 45% of the overall cost of the shuttle. The prime contractor was to be responsible for at least 50 or 60% of the work which would be, for the orbiter, about $2 billion. CSE/Comité ad hoc(71)8, Report of the Mission to Washington, 4 March 1971.

1255 J. Logsdon, "Choosing big technologies. Examples from the US Space Program", in John Krige (ed), *op. cit.*, p.145.

By the beginning of 1971, post-Apollo project negotiations between the USA and Western Europe were not going well. This was officially announced by President Nixon in his report to the Congress on the future of American foreign policy, in which he said: "I have asked NASA to explore in the most positive way the possibilities for substantial participation by Western Europe, Japan, Canada, and Australia in our post-Apollo programs. The result is uncertain, for there are very real difficulties to be solved. We will continue our efforts to meet these problems, for a successful international program of space exploration could set a precedent of profound importance"[1256].

It was not until September 1971, after the opening for signature of the new Intelsat Treaty, whose main features related to the availability of US launchers we have already recalled, that the deadlock was solved. At that time, "some soul-searching took place within the US delegation"[1257]. In reply to Lefèvre's request of 3 March 1971, Johnson announced the new American position in a letter of 1 September 197: the availability of American launchers would not be "conditioned on European participation in the post-Apollo programme".

Secondly, the letter dealt with three main topics:

1. the general conditions for supply of launchers for European programmes

2. the conditions for supplying launchers in the particular case of a European communications satellites

3. the offer of broadening cooperative relationships with the Europeans, including "an exchange of views regarding the content of space activities in which Europe might wish to participate in the post-Apollo era". Johnson proposed that the possibility be discussed in a joint working group (Joint Expert Group), as previously suggested by the Europeans. The main object of their work would be to define - before political discussions were resumed - what elements of the post-Apollo programme would be suitable subjects of participation.

As for the conditions upon which the USA would offer its launching services for satellites intended to provide international public telecommunication services, including European regional satellites, the USA adopted a restrictive interpretation of Article XIV of the definitive Intelsat arrangements, whereby the governing body would have to make "a favourable recommendation" (and not merely, as indicated in Johnson's letter of October 1970, abstain from voting against it). A failure to reach a favourable recommendation seemed to be considered binding by the USA, contrary to the general interpretation of the article (see earlier in this chapter).

As to the operational system of European communication satellites presented by Lefèvre during February's discussion, Johnson stated that "it would appear to cause measurable, but not significant, economic harm to Intelsat. Thus, if this specific proposal were submitted for our consideration" he continued "we would expect to support it in Intelsat"[1258].

The document was discussed among the representatives of the Committee of Alternates of the ESC; the new decoupling between launcher availability and the post-Apollo programme was warmly received.

1256 *Cit.* in B. Valentine, "Europe and the post-Apollo experience", *Research Policy*, 1 (1971/72), p.104.;original source, *US Foreign Policy for the 1970s; Building for Peace*, a Report to the Congress by Richard Nixon, President of the United States, 25 February 1971, (Washington: GPO) p. 222.

1257 D.Lord, *op. cit.*, p. 16. On this and other aspects related to the American decision-making process during the negotiations, see L.Sebesta, "The politics of technological cooperation in space: US-European negotiations on the post-Apollo programme", *History and Technology*, 1994, vol. 11, no. 3, pp. 317-341.

1258 CSE/Comité ad hoc (71)18, Annex I, text of the letter from Under-Secretary of State Johnson to Minister Lefèvre, dated 1st September 1971. The letter, which was to be confidential in line with an American request, was passed to the Belgian press (*Le Soir*, 30 September 1971) and then given widespread publicity.

Europeans could now get rid of the conditional form in which the Americans proposed to support the CEPT project and provide the US with additional information [1259].

13.7 The first technical discussions and some clarification on the availability of American launchers.

After an updated presentation of the post-Apollo project [1260] by a NASA team, the first meeting of the Joint Group of Experts on US-European cooperation was held in Washington from 30 November to 2 December 1971. J.P.Causse and J.Dinkespiler acted as spokesmen for the European delegation which was composed of members of the ESC Secretariat as well as of experts nominated by the Member States, while Charles Matthews headed the NASA group.

Despite the various potential areas of cooperation singled out, discussions were bogged down by the uncertainty regarding the final configuration of every element (even the most advanced shuttle). Moreover, as stated by the report, the USA were waiting for "the identification by the European side of a more definite list of candidate subjects for possible participation" which could eventually lead to a joint "detailed examination of financial, management and programmatic implications".

As far as the shuttle was concerned, as the most advanced project among those in which collaboration was envisaged, a few important characteristics of future cooperation were identified at this time:

1. in the field of utilisation, NASA indicated that participants in the development program "probably would have an advantage over other users"; no pricing policy, however, could be established at this time;

2. the kind of cooperation envisaged was limited to a relationship of subcontracting by European firms. This could be done by individual firms and, for larger elements, by a consortium of European firms. As for the subcontracts already in place, Europeans lamented the lack of formality shown for participation by European firms in the preparation of proposals by would-be US prime contractors. US representatives, on the other hand, stressed the necessity to vest clear management responsibility in the American prime contractors as far as the orbiter and booster were concerned.

3. the content of the cooperation seemed to favour the limiting of work packages on propulsion and avionics for technical reasons: criticality of integration, complexity of interrelationship between various systems and the considerable amount of experience already available to the USA. Twelve elements of the shuttle could be developed in Europe; among these, the airframe seemed to offer the best possibilities for European participation.

As far as the tug was concerned, the time did not seem ripe for a definite decision because it was so early in its development. It nevertheless seemed a logical area for European participation since it was an easily separable item with a relatively clean set of interfaces; moreover, ELDO, in close cooperation with NASA, had elaborated a Phase-A work statement. In the orbital systems field

1259 CSE/CS(71)PV, Minutes of the Joint Meeting of the Committee of Alternates and the ad hoc Committee of Officials of 22 September 1971, 27 October 1971.

1260 Charles Mathews, then NASA Deputy Associate Administrator for Manned Space Flight, designated head of the American team and Capt. Robert Freitag, visited European companies involved in space studies and concluded their tour with a presentation to the Committee of Alternates of the ESC on 22 October 1971. D. Lord, *op. cit*., p. 16. Charles Mathews' briefing was not printed as part of the conference minutes, but as a separate leaflet, not to be found in the archives; CSE/CS(71)PV/3, Minutes of the Joint Meeting of the Committee of Alternates and the ad hoc committee of officials of 22 October 1971, 11 November 1971,.

(RAMs, sortie cans, sortie pallets) and automated satellites, various levels of involvement were identified both in the development of the elements of the system and in the scientific experiments to be hosted[1261].

On 20 December 1971, the ESRO Council adopted a resolution on the reform of the organisation, which called, *inter alia,* for:

a. the US/European Joint Aeronautical Satellite Program, Aerosat (even if the work on the Aerosat payload pre-development has started in European industry, the failure of the USA to approve the Memorandum of Understanding concerning the Aerosat programme had delayed the start of a full-scale development of the spacecraft);

b. the Meteorological Satellite Programme;

c. the Communication Satellite Programme [1262].

Aerosat was a joint air traffic control satellite for civilian aircraft the first exploratory meeting of which had taken place in June between the USA, Europeans, Australia, Canada, Japan and the Philippines. The Europeans had made unequivocally clear that they would not accept a pre-operational programme in which they would be merely subscribers to services provided by a system unilaterally established by the USA. They had also guaranteed financial support for a cooperative programme; if such a programme were not attainable, Europe would be prepared to proceed on its own[1263]. After negotiations in Washington and Madrid, the FAA reached agreement on a joint project with ESRO representing the European nations, whereby Europe would pay half the cost and get about a third of the work (because of the need by Europe to purchase US assistance in order to satisfy European responsibilities in the programme). The agreement was limited to a pre-operational system for developing procedures, with the operational follow-on system to be negotiated in the future[1264]. Between the end of 1971 and the beginning of 1972, the White House declined to sign the memorandum arrived at by the FAA and ESRO, giving rise to yet another round of negotiations, whereby the scope of the cooperation was restricted[1265].

The ESRO resolution also contained a statement on the policy to be followed by Europe concerning launch services (which took into account the new information given by Johnson in his letter). The resolution reaffirmed that European launchers would be given priority, on condition that their cost would not exceed 125% of relevant non-European ones; should, however, such American launchers be denied, the price would be based on the cost of production, or even supplemented by the cost of specific development, if required.

In consideration of the resolution, Lefèvre asked Johnson for a clearer statement on the availability of American launchers for European telecommunication satellites[1266]. In particular, an account of the

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1261 CSE/CS(71)18 Neuilly, Report of the meeting of the joint group of experts on US/European cooperation in Space Programmes in the post-Apollo period, 8 December 1971.

1262 CSE/CM (Dec.72)5, Report by the Secretary General of the European Space Conference on the Status of European Space Programmes, 7 December 1972. See also: this volume, chapter 9.

1263 Nixon Project, NARA, Washington DC, WHCF, Subject files, vt 1, box 14, Department of State, Summary of international aviation and foreign policy issues in the aeronautical satellite program, no date.

1264 Nixon Project, NARA, Washington DC, WHCF, Subject files, vt 1, box 14, Memorandum Welsh to General Haig, National Security Council urgent action, 21 October 1971.

1265 Despite the signature of a new memorandum in 1974, Aerosat as originally conceived, would eventually fail in 1977; see *ESA Annual Report, 1977*, pp. 53-54. A special chapter is devoted to Aerosat in vol. II

1266 CSE/CS (72)1, Annex, Letter Lefèvre to Johnson, 23 December 1971. The whole exchange of correspondence between Lefèvre and Johnson until this date is in CSE/Comité ad hoc (71) 22, 22 December 1971. For the ensuing correspondence on launchers, see P. Creola, "European-US space cooperation at the crossroads", *cit*., pp 98-99. On the European Communication Satellites Programme, see this volume, chapter 9.

operational system and mission of the European telecommunication satellite system was transmitted and Johnson was requested to state, on the base on this document, "whether, considering the concept of the system as now decided in its final form" he could confirm that his government would be willing to support the project when it would be officially submitted to Intelsat by the participating countries, as specified in his letter of September 1971. In his reply, Johnson made reference to three difficulties related to the proposed European Communication Satellites Programme: the economic impact (in terms of higher charges to users), the technical incompatibility, which could be overcome by adopting a different orbital position, and, most important of all, the definition of the European region. Johnson clarified once for all that the USA would not support the program within Intelsat if an expanded coverage was expected in respect to the European geographical area. In line with the ITU definition, the Europeans gave the "European Broadcasting Area" a much larger scope than the purely geographical one. It was bounded "on the West by the Western boundary of Region 1, on the East by the meridian 40° East of Greenwich and on the South by the parallel 30° North [thus, including the former French colonies in North Africa], so as to include the western part of the USSR and the territories bordering the Mediterranean, with the exception of the parts of Arabia and Saudi Arabia included in this sector. In addition, Iraq (was) included in the European Broadcasting Area"[1267].

Lefèvre also informed Johnson of the decision taken at the ESC on 17 December 1971 to open fresh credits to a total of 2.25 million dollars for pursuing studies carried out on the European side on participation to the post-Apollo programme. It was envisaged that by Spring 1972 Europeans and Americans would "be able to tackle " the "political aspects" of the question[1268].

13.8 The new shuttle

On 5 January 1972, President Nixon publicly announced his decision to go ahead with the development of the space shuttle, though heavily modified in its configuration. The President emphasised the need to take the "astronomical costs out of astronautics" -a recurrent criticism of public opinion - and to make transportation in space *routine* ("the space shuttle will give us routine access to space by sharply reducing costs in dollars and preparation time").

The new shuttle did not represent a new challenging purpose in American space policy (such as planetary exploration, a moon landing etc.). Nevertheless, in a time of economic crisis, it was tuned to the public's expectations, as being "a potential low-cost replacement" to the costly expendable launch vehicles in use. Its "multifaceted capability for satellite placement and retrieval"[1269] seemed to make it a perfect device to obtain the same services as before at a lower price [1270].

In this last configuration the shuttle consisted of an aeroplane-like orbiter (about the size of a DC-9, capable of carrying into orbit and back again to Earth useful payloads up to 18 metres in length and 4.5 metres in diameter, weighing up to 29.500 kg) and a booster. The orbiter would be designed for reuse more than 100 times. It would be able to operate in space for about a week, after which it would return to Earth and land on a runway like an aeroplane.

The shuttle would be boosted into space through its solid-propellant booster engines and its orbiter stage liquid oxygen-liquid hydrogen main engines. The booster rockets would detach at an altitude of about 40 km

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[1267] The ITU definition is cited in ESRO/PB-TEL(72)5, Availability of launchers for the European Communication Satellites Programme, 22 September 1972.

[1268] CSE/CS(72)1, Annex 1, Letter from Minister Th.Lefèvre to Under Secretary of State A.Johnson, 23 December 1971.

[1269] D. Lord, *op. cit.*, p.39.

[1270] CSE/CS(72)2, Annex 1, Statement by the President, 5 January 1972 (Taken from *NASA News*, release no. 72-4, 6 January 1972). For a general overview, see John Logsdon, "The Decision to Develop the Space Shuttle", in *Space Policy*, May 1986, pp 103-119.

and descend into the ocean to be recovered and reused. Fuels for the orbiter's liquid-hydrogen liquid-oxygen engines would be carried in an external expendable fuel tank that would be jettisoned in orbit[1271].

As pointed out by McCurdy, "What began as a $10 to $13 billion initiative emerged from the White House as a $5.15 billion program, leaving NASA with a shuttle configuration that many believed was technologically inferior to the two-stage reusable system and a cost estimate that Agency managers could not meet"[1272].

In a public statement, Fletcher indicated that the shuttle in this new configuration would encourage greater international participation in space flight[1273]. As stated more clearly by Nixon, the shuttle would broaden American "opportunities for international cooperation in low-cost, multi-purpose space missions". The shuttle, apparently, would be a means through which to expand future cooperation, but not an object of cooperation in itself.

Less than three months after Nixon's approval of the programme, in March 1972, NASA completed the definition of the configuration for the new device and issued a request for proposals from industry. Replies were expected by 12 May and NASA planned to select the prime contractor for the new space shuttle by July 1972.

This decision had a threefold impact on the post-Apollo negotiations:

1. first of all, there was a new urgency to define the precise managerial framework, financing problems, and real contents of the eventual cooperative venture on the shuttle, because of the tight schedule devised by NASA and required by the Congress.

2. moreover, because the first operational flight of shuttle was now forecast for 1979 and because RAMs (free-flying and semi-permanent laboratories) would only be placed in orbit starting 1982, the need arose for a new element to cover the interim period. Orbital systems of (relatively) low cost and requiring a short period for development and construction, the sortie module or sortie-can (a small laboratory carried by the shuttle whose studies had been initiated by NASA and Europe in October 1971), acquired greater importance than the RAMs.

3. lastly, the overall technology of the shuttle in its new configuration had a much lower technological appeal for the European partners than the original one. Its only real technological novelty lay, in their view, in two areas (propulsion and the heat shielding system), both of which had been both excluded from European participation. This being the case "the technological interest of the items proposed to Europe (was) much smaller than it (might) have appeared at first sight". Consequently, the interest in manufacturing one or more items proposed would lie chiefly, for the Europeans, "in securing access to the orbiter and shuttle project and so gleaning general information about it and possibly some items of particular interest"[1274]. Thus, if the European principle of free access to the technology developed for the

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1271 CSE/CS(72)2, Annex II, Statement by Dr. Fletcher, concerning the development of the new Space Transportation System January 5 1972 (taken from *NASA News*, no. 72-4, 6 January 1972). NASA's desire to have it as an entirely reusable single-stage to orbit, with no expandable parts, was considered unrealistic for the available technology and budget requirements. "National Security Space Policy", *International Security*, Spring 1987, vol.11, no.4, pp.169-170. By mid-1971, NASA's plans for a two-stage reusable shuttle had to undergo a complete reassessment, in view of the Office of Management and Budget's wish to keep NASA's budget constant for at least the duration of the then present administration. This seemed to be incompatible with a programme that would cost over $2 billion annually at its peak. J.M. Logsdon, "Choosing Big Technologies. Examples from the US Space Programs", in J.Krige (ed.), *Choosing Big Technologies, cit.*, p.146

1272 H. McCurdy, *The Space Station Decision: Incremental Politics and Technological Choice* (Baltimore: Johns Hopkins University Press, 1990), p.231.

1273 CSE/CS(72)2 Annex II, Statement by Dr.Fletcher, 5 January 1972.

1274 WG/COOP/US (72)2, European Space Conference, Report on European Participation in the post-Apollo programme, March 1972.

entire system was denied, as seemed highly probable, European interest in this kind of cooperation would be considerably weakened.

13.9 Toward a definition of the final contents of cooperation

The attention of the second ESC-NASA joint group of experts which met at Neuilly (Paris) from 8 to 11 February 1972 took account of the changing context of US-European cooperation[1275]. Apart from the prospects of European participation in the shuttle even in reduced terms, two other areas of cooperation were envisaged:

1. the tug system, on which ELDO had issued a Phase A report since the first meeting;

2. an orbital system or module and some studies on experiment definition. From the beginning of 1972 the various orbital system concepts crystallised in the form of a "sortie module", i.e. a laboratory transported by the shuttle that would remain attached to it throughout its stay in orbit.

Criteria for choosing among the package works were spelled out as being:

1. Items should not be scheduled as critical nor involve high technical risk;

2. they should involve relatively few and simple interfaces;

3. they should not be those for which there would be a high probability of frequent design changes.

Compared to those spelt out during the previous meeting, these criteria seemed to be more restrictive and, in the case of the first item, rather vague (no explanation was given about what "critical" and "high technical risk" meant).

The nature of the cooperation envisaged was far from being defined. NASA experts declared that they would approach "the concept of European participation in development of the shuttle within the context of a broader programme of participation which included multilateral European responsibility for development of a major element of the post-Apollo programme, such as Sortie RAMs or the re-usable Space Tug". Certain government level decisions and assurances would be necessary before the European contractual proposals for the shuttle were submitted to the US prime contractor. These decisions and assurances would involve government-to-government agreements in principle concerning collaboration in "the development of the tug or family of RAM vehicles".

NASA felt that "participants in such major development programmes should bear full responsibility for development cost risks related to the tasks they had undertaken". "No exchange of funds" principles were reaffirmed, by which a firm working as sub-contractor would receive "technical direction from the prime contractor, but would receive payment directly from its own government authority after certification of satisfactory work progress by the prime contractor". This system, it was stated by the Europeans, could create many problems, especially in the fields of "source selection, the negotiation of out-of-scope changes, limitations on the control by the prime contractor over the subcontractor and the relations between the subcontractor and its own government authority". Alternatively, European spokesmen proposed a different application of the "no exchange of funds" principle, under which "a prime contractor on either side of the Atlantic would be responsible not only for the technical management and direction of his subcontractors, wherever they were located, but would also be responsible for their funding". No conclusion could be reached over these innovative proposals and both sides postponed any decision, claiming the problem was not covered by their instructions.

[1275] CSE/CS(72)6, Neuilly, Report of the meeting of the Joint Group of Experts on US/European cooperation in space programs in the post-Apollo period, 14 February 1972.

Neither could an agreement be reached on how to select the European contractors. The ESC indicated that it should be a European responsibility; the new funding approach suggested, on the other hand, that the weight of responsibility should shift, even in this sector, to the USA. In any case, the final choice would have required a joint agreement by ESC, NASA and the prime contractor The creation of a joint NASA/ESRO user group in scientific, application and technology areas for planning payload and missions was envisaged.

Three major questions remained open at the end of the meeting:

1. A European decision on whether or not to make a commitment to participate in the post-Apollo programme, which the Europeans undertook to reach by July 1972, and then, eventually, postponed;

2. the political rules on the management and funding under which such participation would eventually be carried out;

3. the technical content of cooperation.

The question was of special relevance for the shuttle; in view of the timetable drawn up by NASA after Nixon's decision, without an early decision on these linked problems, it would be no longer possible for European industry to be awarded subcontracts.

By this time, two main features of post-Apollo cooperation were clear to the Europeans:

1) the partnership would be asymmetrical, in the sense employed by John Logsdon for the Space Station[1276], in two major respects:

    a) the USA would be dominant in its financial contribution;

    b) while the USA would be able, if necessary, to continue their project even without a European contribution, Europeans joining the partnership would become dependent on the USA for an important aspect of their future activities, because device they would produce could only be carried by a shuttle.

2) this partnership had weak foundations, as was clearly shown by the financial constraints which had urged the President to change the overall contents of the post-Apollo programme and caused significant modifications in the technical configuration of the items still left open for cooperation (the shuttle, for example)[1277].

Moreover, a major question continued to preoccupy the Europeans. As Lefèvre made clear in a letter to Ministers of member countries "for a certain number of us, the question of participation in the post-Apollo programme falls within the general framework of Europe's policy on launchers"[1278].

In March 1972, the Secretary General of the ESC submitted to the organisation an overall report on the studies carried out in respect of possible European participation in the post-Apollo programme.
The report favoured the selection of one among three options:

1. participation in the development of the space shuttle to a total sum of about 100 MAU, in the form of a series of subcontracts financed by the European governments concerned;

[1276] J. Logsdon, "International cooperation in the space station program. Assessing the experience to date", *Space Policy*, February 1991, p.37.

[1277] See J. Logsdon's reflections on cooperation in the space station programme, *ibid*., p. 44.

[1278] CSE/CS(72)7, Letter from the Chairman of ESC to the Ministers of the member countries, 6 March 1972.

2. a joint development of the tug by Europe, sub-contracting to the USA being offset by European industry's participation in the shuttle development (costs: about 500 MAU);

3. a joint development of the sortie module by Europe, sub-contracting to the USA being offset by European industry's participation in the shuttle development (costs for Europe: 200 MAU).

Until now discussions had been focused on studying the possible content of European participation. It was time, the report stressed, to define the terms under which participation could take place. The Committee of Alternates and the *ad hoc* Committee would be charged to examine the legal, financial and institutional terms on which the European governments envisaged taking part in the programme[1279].

The various options regarding participation in post-Apollo within the wider framework of space activity in Europe - taking into consideration for each series of programmes its essential objectives, technical implications and long-term and short-term financial implications, as well as the other elements of a European Space programme - were submitted to the Committee of Alternates[1280].

13.10 Political discussions resumed

Informal discussions between Europeans and American representatives of both the Department of State and NASA took place in April 1972[1281]. Pending Europe's final say on the whole question of post-Apollo cooperation, two hypotheses emerged from the discussions as being the most suitable to both the USA and Europe:

1. participation in the shuttle plus tug;

2. participation in the shuttle plus sortie module.

The problem of funding was, not surprisingly, the first to be reported on. Once more, the USA made clear their unwillingness to accept the European proposal, labelled "reciprocal funding", unless "in return for an undertaking on their part to finance certain work in Europe, they received a simultaneous undertaking from the Europeans regarding the nature of the tasks for which the latter would assume responsibility and part of which would be carried out in the United States". Europeans had to take responsibility for possible failures and had to reciprocate external funding giving back work to the USA.

Neither were they willing to provide any guarantee in respect to the access to the system or to the purchase by the USA of a European tug or module. If they decided in favour of the purchase, the USA required the application of marginal prices by Europeans - excluding any amount for amortisation of development costs - and the conclusion of licensing agreements by Europeans to give the USA the ability to manufacture the devices themselves in the event of an European failure to build the device.

As for reciprocal access to technology, in the most "sensitive" cases of classified technology, if the basic technology could not be transferred, the USA would undertake, if necessary, to sell Europe the hardware itself. A European decision in favour of merging their two space agencies would help to establish, in American eyes "a very favourable climate for cooperation" in the programme.

1279 CSE/CS(72)8, att:WG/COOP/US(72)2, Report on European participation in the post-Apollo programme, 30 March 1972.

1280 CSE/CS(72)14, Post Apollo Programme options within European overall space activities 8 May 1972. CSE/CS(72)14 add., Revision of options for European participation in post-Apollo programme, 5 July 1972.

1281 CSE/CS(72)13, Report by the Secretary General of the ESC on the informal discussions with American officials regarding participation in the post-Apollo programme, 8 May 1972.

At an informal meeting of the ESC Ministers held in Paris on 19 May, it was decided to ask the USA a certain number of questions of a political nature, which had deliberately been left aside since the time of the Lefèvre/Johnson talks which mainly concerned the terms governing European use of the post-Apollo system as a whole and American use of the various elements supplied by Europe. A list of questions was compiled, to be presented at the next US-European political meeting, scheduled for June. They touched upon the availability of US launching systems (both expandable and reusable), the criteria for establishing priority among users, the conditions of access and use of the technology necessary for the execution of work undertaken in Europe within the post-Apollo programme, financing rules, the US commitment to procure from Europe the hardware developed by the latter, the nature of negotiations between agencies and the pricing policy for users of the transportation system[1282].

This was actually the agenda of the meeting between American and European representatives which took place in Washington from 14 to 16 June 1972.[1283] Behind the rhetorical requirements of diplomacy, both the opening and the concluding remarks by Herman Pollack (Director, Bureau of International Scientific and Technological Affairs of the Department of State) revealed the tense atmosphere of the gathering.

Cooperation on the tug and the shuttle was discarded and the responsibility for this choice was attributed to European behaviour. "In the absence of a clear indication of the measure of European interest in possible participation", Pollack stated, "we shall do our best to make the US views regarding the questions you have raised as helpful as we can. Were it possible during the early part of our discussions to obtain a clearer understanding of the measure of European interest, and possible participation, our views could possibly be more responsive and useful to you". The limitations officially announced by Pollack regarding the possible field of cooperation were drastic and, as made clear during the discussions, not subject to change.

As for the shuttle, of the residual work packages proposed for Europe, the nose cap, the radiator and the instrumentation were definitely suppressed, the remaining items were the tail assembly, elevons, landing gear and cargo door. American representatives stressed the potential difficulties "that might ensue from an inter-governmental effort to produce a relatively small number of components of a massive piece of highly complex hardware, whose timetable is pressing and in whose success the political and economic stakes are so high". The conditions to be met in order to satisfy US concerns were so stringent that Pollack acknowledged that the conditions they were obliged to impose as regards the funding and management of the shuttle elements were discouraging and would substantially diminish the attractiveness of participating in the Shuttle items.

While the final veto on participation in the development of the shuttle was the end of a progressive restriction of possible cooperative work packages which had begun soon after the beginning of discussions of the Joint Group of Experts on US/European cooperation in space programmes, and had progressively developed over time, the veto on the tug came as a sudden surprise. This was the part of the post-Apollo programme in which Europe could have best profited from technology transfer[1284]. The reason officially given to justify this decision was mainly technical. This, it was said, was the less advanced project, in terms of the development phase, of the post-Apollo programme; it was not clear how, when and indeed if ever it would be built (indeed it never was).

The secondary literature gives additional reasons for the US withdrawal, including:

1282 CSE/CM(May 72)WP/1 rev.1, List of questions to be discussed by the European post-Apollo Mission (14-16 June 1972), 29 May 1972.

1283 CSE/CS (72)15, Report of the ESC Delegation on discussions held with the US Delegation on European participation in the post-Apollo program, 22 June 1972.

1284 D.Lord, *op. cit*., p.59.

1. American scepticism, widely shared in Europe, over Europe's technical ability to develop the tug on its own, especially as far as propulsion was concerned[1285];

2. The necessity for the USA not to transfer sensitive and/or economically valuable US technology;

3. NASA's concern over the safety of housing a tug with its planned cryogenic fuel in the shuttle's payload bay[1286];

4. Military willingness to take complete control over the device[1287].

Of course removing the tug and the shuttle did not mean that there was nothing left for Europe to do. We have already seen that, as NASA firmed up its post-Apollo configuration, the RAMs were complemented by other, simpler orbital systems. They now became the best candidates for potential European participation.

In American eyes, these orbiting platforms, later called sortie laboratories or modules and, finally, space laboratories or spacelabs, satisfied all necessary qualifications for a viable cooperation of the 'conservative' type that had characterised US-European collaboration during the 1960s. Here was a project defined in time and limited in scope, whereby cooperation could take place across "clean interfaces", each partner providing its own technology and financing its work with NASA retaining overall operational control[1288].

13.11 Interlude

In Summer 1972 the sortie laboratory became the major topic of discussion and concern within the European-American post-Apollo project cooperation. It was the subject of a detailed presentation by NASA to the Europeans at ESTEC at the end of June 1972. From June to November 1972, the sortie laboratory was the subject of three definition studies (Phase A), which ESRO entrusted to the COSMOS, MESH and STAR consortia[1289].

The latest developments were presented to the Committee of Alternates on 6 July 1972. Limiting cooperation to only the sortie laboratory, and thus limiting the costs of cooperation[1290], only partially solved the problems connected with the post-Apollo programme that Europe had to confront, "since not only (had) interest in

1285 P. Creola, "European-US space cooperation at the crossroads", *cit.*, p. 100.

1286 J. Logsdon, "International involvement in the US space station program", *Space Policy*, February 1985, pp. 18-19.

1287 M. Schwarz, "European policies on space science and technology, 1960-1980", *Research Policy*, vol. 8, 1979, p. 220.

1288 This description draws on Pedersen's definition of the general guidelines shaping NASA's early cooperative efforts; K.S. Pedersen, "The changing face of international space cooperation. One view of NASA", *Space Policy*, May 1986, p. 121. A last Joint Tug Steering Group meeting was held on 5-6 October 1972; European studies on the tug, that ELDO was instructed to terminate following the Committee of Alternates meeting on 12 June 1972, were presented to NASA as well as the shuttle technology studies which had been brought to a normal completion.

1289 CSE/CS(72)18, att. annex I, Report on the technical discussions between NASA and ESRO (26-29 June 1972), 4 July 1972; CSE/CSWP/5 rev.1 Report by the Secretary General of the ESC on the discussions between Europe and the United States on participation in the Post-Apollo programme, September 1972. See also “Europe and post-Apollo”, *ESRO-ELDO Bulletin*, no. 22, August 1973, p. 10.

1290 The cost of the Sortie lab was then estimated at \$200 million, against an estimated cost for (the abandoned) tug of about \$500 million. This difference has been considered in the literature to be an important element in favouring the positive resolution of the launcher-versus-post-Apollo dilemma, since it freed relevant European financial contributions in favour of Ariane. See J. Logsdon, "International involvement in the US space station program", *Space Policy*, February 1985, p.24.

participation (to) be balanced against cost, but participation (had) also (to) be considered in the context of all the different aspects of a European programme"[1291].

The ESC Secretariat and NASA officials met in Washington on 17-18 August 1972 to discuss the form and content of possible agreements following the new standards set out in June[1292]. It was agreed that the sortie module was an essential part of the US space transportation system and that it would not be developed in parallel in the USA, should the Europeans take responsibility for its production.

NASA reaffirmed its willingness to retain overall responsibility for the total programme and the last word in such vital areas as shuttle/sortie laboratory interfaces, quality control and safety. In particular, NASA would wish to be in a position to assess the efficiency of the management plan proposed by the European agency for the sortie module and stressed the necessity for a "unitary management agency" on the European side. On the other hand, NASA suggested arrangements by which the European agency could participate in the shuttle interface control activity, defining user requirements and in the regular review of the shuttle programme. Moreover, a wide range of NASA assistance would be available free or at marginal cost, including provision of US designs and technology (except where specific considerations from the security and proprietary rights point of view prevented this), quality control, acceptance testing, cost control, audit and use of US facilities. The US would favour a very "slender government agreement" containing the clause about US abstention from any parallel development. The American team also insisted on the importance of an early identification of areas in which Europe foresaw the need for access and to what extent. Construction of the sortie laboratory would not guarantee any preferential treatment in the use of the system. All the same, countries participating in the development of the Sortie Lab would enjoy priority rights in its use and would be entitled to appoint crew members for its flights.

A few days later, the Department of State informed the ESC of an amendment to the overall system planning. In the case of European withdrawal, NASA would not need to embark on the development work for the Sortie Lab before 15 August 1973 (it was considered that it would take the US one year less than Europe to build one)[1293]. It was proposed that European commitment would in principle be made at the September Conference and that formal agreements would be concluded by end-October. This commitment would lead Europe to start the thorough definition phase (full-scale project definition effort) immediately. Should the cost established by this study unacceptably exceed the financial ceiling agreed by the ESC Ministerial Conference, the Europeans would be allowed to withdraw from their commitment at any time before 15August 1973.

The feasibility of the sortie laboratory programme in Europe was considered from two points of view[1294]:

1. the technology aspects;

2. the schedule constraints that it would have to satisfy in order to be a meaningful contribution to the Post-Apollo programme.

Technology in this context could have two different meanings:

a. the conventional one, associated with the state of the art in a certain number of engineering disciplines;

b. a broader one, related to frontier exploration of a wholly new approach to the utilisation of space.

1291 CSE/CS(72)WP/5, rev., *cit.*

1292 CSE/CS(72)25 and Annex I to VI, Report on discussions between the ESC Secretariat and NASA officials in Washington on 17-18 August 1972 regarding the form and content of agreements necessary in the event of European participation in the post-Apollo programme, 28 August 1972.

1293 ESRO/C(72)48, Annex I, US Aide Memoire of 21 August 1972.

1294 CSE/CS(72)WP/5, rev., *cit.*

While the challenges to technology presented by the Apollo programme were in terms of launch vehicle capability, communications at distances of more than 300.000 km, landing and take-off from the Moon’s surface and impossibility to terminate the mission rapidly, those presented by the Sortie Lab were linked to the constraints of:

- supporting life in space for long duration;
- flexibility;
- multiple reuses

and

- economy of operation.

The Sortie Lab as conceived by NASA in mid 1972 could be built in Europe without any doubt. However, some technological areas would have to be advanced, if the programme was to be 100% European. In fact, a certain number of "off-the-shelf" items (available from stock or to be obtained from a running production line in the most extreme definition) would be available with little or no development in Europe, while a few of them consisted of such long term and costly development products in the USA that their development in Europe would represent a major undertaking not commensurate with the Sortie Laboratory time scale and cost envelope.

Decisions on feasibility would entail trade-off studies between:

- performance;
- cost;
- schedule.

No relevant technology transfer was expected from collaboration in the sortie lab project. The major reasons for European interest in the collaboration stemmed from hopes to gain "programme management and systems engineering experience in a programme of this magnitude, rather than in specific technical know-how or direct commercial benefits"[1295]. No one doubted that Spacelab, above all, signified European willingness to enter the field of manned space activities and to pay its entrance fee.

13.12 Europe’s final decisions on Spacelab

By the end of 1972, the European countries involved in ESRO and ELDO were passing through hard times. Three main interlocking questions had to be solved:

1. the future organisational nature of Europe in space, in the context of two concerns: from the tactical point of view, the disruptive power of the impending liquidation of ELDO (see below) had to be neutralised; from the strategic point of view, the new European concerns linked to the application capabilities of satellites (first of all in telecommunications) could not be coped with by an organisation, ESRO, set up mainly for scientific purposes;

2. the new configuration of a launcher capable of meeting all the new European needs in the field of application satellites;

[1295] D.Lord, *op.cit.*,p.59.

3. the European participation in the post-Apollo programme in its reduced form[1296].

The apparent irreconcilability of the French and British positions over these points came to the fore during the informal meeting of ESC Ministers and representatives of participating states (8 November 1972) called to organise the subsequent December CSE meeting[1297]. Attention was focused on a difficult dilemma: what should be given priority, the institutional framework or the programme toward which this framework would orient its work?

Charbonnel, the French representative, subordinated the solution of the European space institutional problems to the "definition of a programme worthy of Europe", i.e. a common programme of heavy launchers capable of orbiting the payloads which Europe would develop for its needs in the field of space applications (in the three main fields of telecommunications, air navigation control and meteorology) and which would even enable it to export commercially viable complete systems.

Faced with the reluctance of certain states to join in the Europa III programme of ELDO, France was prepared to carry out, on a different technical and institutional basis, a programme meeting the same objective though with different technical characteristics (see below), the future Ariane.

Considering the organisational question as one which would have implied a great loss of time and energy, France was more prone to begin by solving the problem which, it felt, was most urgent for the future, the one of launchers. Why this choice?

1. because dismissing the programme would be seen by public opinion in Europe as an unacceptable abdication of political responsibility;

2. because it would be an economic mistake, since the funding needed to complete the programme was minimal compared with the sums Europe had so far invested. As mentioned by President Lefèvre during his opening remarks, this would have implied not only a loss of technology, but also a loss of markets;

3. because it would deprive the Symphonie project, whose exemplary value was paramount at a time when Europe was undertaking important application programmes, of some of its meaning.

As for Britain, taking into primary consideration the financial restraints in which the conservatives (back in power since 1970) found themselves, their representative, Heseltine, subordinated any decision on the programme to the prior solution of the institutional framework. In view of what was thought to be poor cost-effectiveness of Europe's performance in space during the previous decade (whose results did not measure up to their financial commitment), the UK singled out the organisational problem as it cause ("we are spending enough money to achieve results but we are not spending it in the way it ought to be spent").
Moreover, neither France nor the UK seemed enthusiastic about joining the USA in the post-Apollo programme. France, noting that while the sortie lab. "would enable Europe to take an interest for the first time in the problems of manned flight", added "...none of the economic needs of the next decade would be met by the development in Europe of a sortie lab, which can in no case be considered a substitute for a launcher programme". It was ready to participate to the programme only if all measures were taken to satisfy Europe's requirements particularly with regard to launchers. The UK, for its part, stated that, for the time being, the UK would not participate in the post-Apollo programme and thought it could change this position only if progress were made in the creation of a single European Agency.

Taking an intermediate position, the German and Italian representatives were against defining a priority between programmes and the institutional problems. In particular, Von Dohanyi, the German representative,

[1296] For these three aspects of the ESRO-ELDO crisis, see J. Krige and A. Russo, *Europe in Space 1960-1963*, *cit*.
[1297] CSE/CM(Nov. 72)4, 17 November 1972, Meeting of Ministers in Paris on 8 November 1972 under the Chairmanship of Theo Lefèvre, plus Annexes, 17 November 1972.

thought the question of whether the programme or the institutions should be settled first "rather like the question of the chicken and the egg". However, he was not prepared to go along with the Europa III project (which the FRG had initially supported), arguing that it was financially too demanding. The Federal Republic of Germany preferred to concentrate on promoting a launcher technology - an objective-oriented one - using existing European launchers and develop them further. The German delegate also stressed how "the deterioration of the European position in post-Apollo (was) not the fault of the Americans but the fault of the Europeans" who had been unable to decide in good time on various steps. The FRG was ready to give the USA any additional assurances concerning its participation in the post-Apollo programme.

The Italian representative, Romita, referred to three conditions which made cooperation with the USA difficult:

1. one of the prominent aims of US space policy was to keep the leadership in this sector;

2. the USA was not prepared to freely surrender technical and industrial know-how and competence, as this would represent an instrument for possible European competition;

3. because of the ratio between the possible European participation in the post-Apollo programme and the American contribution to this programme, the US would keep the control of the programme, both at the realisation stage and at the stage of engine utilisation.

Notwithstanding these ongoing divergences, some countries (Belgium, the FRG, Italy and Spain) agreed, under certain conditions, to finance Phase B studies for the Sortie Lab (finalised to the choice of a single approach from among the alternative approaches selected through the first phase), the Committee of Alternates gave it its political blessing and invited the ESRO Council to comply[1298]. The ESRO Council accepted this request on 9 November 1972 and authorised its Director General to take the necessary implementing steps[1299].

The European Space Conference Ministerial meeting of December 1972 (two years after the previous one) was a crucial step in respect of both the reorganisation of Europe in space, the policy of acquiring an independent launching capability and Europe's relationship *vis-à-vis* the USA[1300].

Reports on the activities of ESRO, ELDO and the post-Apollo programme were presented at the start of the conference. Each of the three areas had its specific sets of unsolved problems. Among the more prominent was Britain's final notice of denunciation of the ELDO Convention (given on 27 September 1972), which confirmed the declaration made one year before by the UK delegation to the ELDO Council[1301].

In spite of the dilatory position of the UK - whose delegates stressed how the "government did not believe in the need for a European launcher programme" and how the arguments in favour of the post-Apollo programme were not considered "overwhelming" - and some uncertainty on the part of the Italians - who subordinated participation in the launcher programme to a fruitful cooperation in post-Apollo and asked that the rule of *juste retour* for the common programmes be respected - the resolution of the Ministerial Conference registered an important agreement on some points which had been objects of intense debate:

1298 Technical studies on the sortie lab were reviewed at a meeting with NASA on 18-19 September and some possible module concepts were selected for further detailed study, see also "Europe and post-Apollo", *ESRO-ELDO Bulletin*, cit. in footnote 1290 p. 10.

1299 CSE/CM(Dec.72)5, 7 December 1972.

1300 CSE/CM(Dec.72)8, 20 December 1972; CSE/CM(Dec.72)PV/2, 10 January 1973, plus Annexes.

1301 The UK decision would become effective on 1 January 1973 (date after which the UK delegation would become an observer). After the failed launch of the ELDO rocket Europa II in November 1971, a reorganisation of the ELDO Secretariat was undertaken in the first half of 1972; Aubinière replaced Carrobio di Carrobio from 1 January 1972.

1. the setting up of a new organisation, formed out of ELDO and ESRO, i.e. the future ESA, by January 1974, if possible;

2. the Sortie Lab and the French launcher proposal (L3-S) to be managed within a common European framework (Europa III being dropped);

3. there should be a rationalisation of the various satellite programmes, including the geostationary technology satellite (GTS). This programme had been initiated in the UK as a national project; originally intended for telecommunications purposes, it was subsequently reoriented to meet requirements for aiding maritime navigation and was later merged with Marots[1302].

The first element of the far reaching decisions taken at the meeting was the decision to set up a new unique European Space Agency (ESA), whose programme would consist of a compulsory "basic" programme - science, general activities and facilities - with GNP-related contributions and an "optional" programme (including Spacelab, launcher and application satellites) in which the Member States were free to decide on their participation and financial contribution [1303].

One decisive element to convince hesitant states like Italy to comply with the second decision was the suggestion put forward by France and Germany about the financing of the launching programme - a fixed amount for European countries other than France instead of a fixed percentage. The other one was the French proposal dealing with a launcher (L3-S) nearly as powerful as Europa III, but not requiring such a large and sophisticated cryogenic stage; the device would be capable of putting payloads of 1500 kg into transfer orbit, or of 750 kg into geostationary orbit with the aid of an apogee motor. The French government was willing to assume 60% of the expenses of the development phase (estimated as 550 MAU by Charbonnel) which was due to start on 1 January 1974 and to end with qualification of the launcher in 1980. This launcher should be guaranteed a suitable priority of use in Europe compared with launchers developed outside Europe. The technical and financial management of L3-S would be entrusted to CNES which would define the industrial arrangements and place contracts with industry on behalf of the programme participants; there would be a Programme Board to monitor the distribution of work among the various participants and to act as the appeals body for a participant with respect to the choice of firms made by CNES. The decision was taken as far the development programme was concerned, not on the production programme, about which participing states would have to decide before the end of the development phase[1304].

A compromise was arrived at on two projects which had for a long time seemed to be mutually exclusive, mainly for economic reasons: the European launcher and participation in the post-Apollo programme. This equilibrium was reached thanks to an agreement between France and the FRG on a reciprocal participation in the launcher and Spacelab projects, where the two countries would provide the majority of funds for the two projects respectively. The agreement was reached after bilateral talks, because the UK had moved away from all discussions on the European launcher. The changed position of Germany, which previously declared itself to be satisfied with American guarantees on availability of launchers, was "a heavy political decision. It was taken in the knowledge that a negative response would almost certainly bring to an end the European ideal in space". The decision to carry on the sortie lab project within a European framework (the management of the

1302 In April 1973, the UK delegation submitted to both the ESRO Council and the Committee of Alternates a proposal to "Europeanise" the GTS programme, taking into account the state reached by the programme at the national level. The programme comprised two alternative options, GTS and Marots, whose main distinction concerned the actual management. In GTS, because of the stage already reached in defining the project, Member States' financing would be limited to 25% and management would be entrusted to the UK procurement executive. In Marots, the UK's contribution would be of the order of 55% and it would be developed as an ESRO programme, with the management being responsibility of the organisation. CSE/CM(July 73)5, Report of the Secretary general of the ESC on the Implementation of the decisions of the Ministerial Conference of 20 December 1972, 2 July 1973.

1303 J. Krige and A. Russo, *Europe in Space 1960-1973*, in footnote 1290, p.10..

1304 CSE/CM (Dec.72)PV/2, minutes of the Afternoon Session of the ESC held in Brussels on 20 December 1972, Statement by Charbonnel, Ministre du Développement Industriel et Scientifique, France, 10 January 1973.

programme being entrusted to ESRO) was communicated to the US Secretary of State by the President of the ESC on 29 December 1972. On 18 January 1973, the ESRO Council authorised its Director General to negotiate with the USA the terms of an arrangement concerning the implementation of the programme[1305].

13.13 The major features of the final agreement on Spacelab

The sortie lab was conceived as a two-element device. Consisting of a pressurised manned laboratory module and an external non-pressurised instrument platform or pallet, it was suitable for conducting research and application activities on shuttle sortie missions lasting from seven to thirty days. The sortie lab would be carried into orbit in the payload bay of the shuttle orbiter and would remain attached to the shuttle throughout the mission. At the end of each mission, the orbiter would make a runway landing and the laboratory would be retrieved from its bay. The sortie lab was to have the flexibility to accommodate both multidisciplinary experiments and complements devoted to a single scientific or applications discipline. The laboratory module would host experimental devices, data processing and electrical power equipment, an environmental control system and crew control stations. The staff of up to six scientists would eat and sleep in the shuttle orbiter, but carry out their experimental activities in the laboratory module. Pallet experiments would be remotely controlled from the laboratory[1306].

On 15 February 1973 the ESRO Council, in accordance with article VIII of the Convention, approved an Arrangement between certain ESRO Member States and ESRO for the development, as an ESRO special project, of the Spacelab. It determined the objectives and elements of the programme together with the conditions for its execution and their monitoring by the Spacelab Programme Board. The arrangement was open for signature from 1 March to 10 August 1973. The participants, Belgium, the Federal Republic of Germany, Italy and Spain, with the FRG playing the leading role, decided to establish a financial envelope of 308 MAU at mid-1973 prices. The arrangements provided for a review of the overall amount at the end of sub-phase B 2 (end July 1973) of the definition phase. If the financial hypothesis would not be confirmed, but significantly exceeded, those participants who so wished could withdraw. ESRO appointed a Head of Programme and formed a team within the ESTEC establishment and at the headquarters of the organisation[1307].

The legal framework for cooperation on Spacelab was set out in two documents:

a. an intergovernmental agreement negotiated between the Member States and the US government, dealing with the political commitment of the Member States with regard to carrying out the programme. It situated this endeavour in the general context of cooperation between the USA and Europe and in relation to the space shuttle system [1308];

b. a Memorandum of Understanding (MOU) negotiated between ESRO and NASA to define the tasks and responsibilities of each organisation in carrying out this cooperative programme[1309].

1305 Schwarz, *art. cit.*, p.225 and "Europe and post-Apollo", *cit.*, p. 10..

1306 *Ibid*. p. 7 and *NASA News Release* no. 73-12, 19 January 1973. See also Volume II, chapter 13.

1307 CSE/CM(July 73)5, Report of the Secretary General of the ESC on the implementation of the decisions of the Ministerial Conference of 20 December 1972, 2 July 1973. In the Spring of 1973 France, the Netherlands and the UK signified their agreement to participate in the work of sub-phase B2, i.e. until July 1973. They were later joined by Austria and Switzerland. See "Europe and post-Apollo", *cit.* in footnote 1289, p. 10. Ten Member States participated, in an optional framework, in the project.

1308 ESRO/C(73)46, rev. 1, 26 July 1973.

1309 ESRO/C(73)45, rev.1, 26 July 1973, Draft Memorandum of Understanding between the NASA and the ESRO for a cooperative programme concerning development, procurement and use of a Space Laboratory in conjunction with the Space Shuttle System, reprinted integrally in D. Lord, *op. cit*.

On 14 August 1973 the Intergovernmental agreement was opened for signature in Paris; to implement this agreement, the NASA-ESRO Memorandum of Understanding was also signed. Less than one month later, the ESRO Council approved the draft agreement between certain European governments and ESRO concerning the execution of L3-S, by then renamed Ariane, first phase (development and qualification)[1310].

According to Article 1 of the MOU, ESRO would undertake to design, develop, manufacture and deliver the first flight unit of the SL (Space Laboratory), and other materials described in the Memorandum. The SL would be used as an element to be integrated in the Space Shuttle. NASA would set its specifications, following technical modifications of the shuttle and its timing. The first operational shuttle flight was scheduled for late 1979; accordingly, the SL flight unit ought to be delivered to NASA one year before. Although recognising "the desirability of avoiding changes resulting in a disproportionate impact on the SL programme, NASA reserved to itself "the right to require changes affecting the interfaces or operational interactions between the Shuttle and the SL" (art. IX).

Relative costs in SL development contracts would be borne by Europe. NASA retained the overall responsibility for the total programme and the last word in such vital areas as shuttle/SL interfaces, quality control and safety, "including the right to make final determination as to its use for peaceful purposes" (art. XI)

Construction of the SL would not guarantee any preferential treatment in the use of the shuttle system; NASA, on the other hand, would provide access for the use of SL's for experiments or applications proposed for reimbursable flights by governments participating in the SL program in preference to those of third countries. Selection on cooperative (i.e. non-cost) flights would follow normal NASA policy, with European governments given preference over the proposals of third countries if their proposals were at least equal to the merit of the third country's proposals (art. XI). Countries participating in the development of the SL, however, would be entitled to appoint European crew members for its flight -"It is contemplated that there will be a European member of the flight crew of the first SL flight"(art. XI).

Generally speaking, European firms were considered to have the technology they needed well in hand, despite their weaknesses in the system engineering and data management fields. The Americans were ready to sell existing American equipment (black boxes) without the need to share information, thus, eventually helping in development problems on a case-by-case basis [1311.] Article 6 of the intergovernmental agreement on the Space Laboratory and article X of the NASA-ESRO MOU - both referring to access to technology and information - complied with the American position as stated above.

NASA agreed to procure from ESRO "whatever additional items [SL] of this type it may require for programmatic reasons, provided that they are available to the agreed specifications and schedules and at reasonable prices to be agreed" (art. VIII). NASA committed itself to buy "at least one SL" after the one given by ESRO, which actually happened (art. VIII). It also agreed to refrain from "separate and independent development on any SL substantially duplicating the design and capabilities of the first SL unless ESRO fails to produce such SL" (art. VIII).

The initial configuration and capabilities of the SL would be shaped following the shuttle requirements; Europeans were completely excluded from operating the device they were going to produce. As Douglas

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1310 *ESRO-ELDO Bulletin*, no.23, November 1973, pp. 18-20.

1311 CSE/CS(72)15, Report of the ESC Delegation on discussions held with the US delegation on European participation in the post-Apollo programme, 22 June 1972. As already stated in informal discussions in April 1972, in the most "sensitive" cases of classified technology, if the basic technology could not be transferred, the USA would undertake, if necessary, to sell the hardware itself; CSE/CS(72)13, Report by the Secretary General of the ESC on the informal discussions with American officials regarding participation in the post-Apollo programme, 8 May 1972.

Lord, NASA's director of Spacelab, has so properly commented, "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"[1312].

13.14 Concluding remarks

The magnitude of the elements involved in the prospective post-Apollo cooperation gave rise to very high political and technological expectations from some European partners. But the range of elements was progressively restricted in the course of negotiations; political and technological European expectations were only partly fulfilled.

The post-Apollo negotiations had the merit of throwing into relief the difficulties of changing the pattern of international cooperation from a "conservative" approach geared to bilateral (and less frequently multilateral) scientific agreements to much more complex cooperative ventures in development and technological fields. In this last case, political willingness to cooperate would have to cope with direct or indirect, but altogether well rooted, commercial and security considerations [1313].

The negotiations made unmistakably clear that a fruitful cooperation is the one in which every partner gets something that appeals to him/her (as opposed to the competitive zero-sum game). In order to do this, everyone has something valuable to offer. In this respect, the negotiations served the useful purpose of giving a new compelling force to the directives stated in the Causse Report of 1967, whereby the European effort in space had to be imaginative and substantial in order to give credibility to Europe on the international scene and as a viable partner in international cooperation. The process of assessing new (commercial) interests, harmonising them with the previous scientific nature of ESRO-ELDO, building up a credible organisational structure to wage this policy and find the financial means for it took place in parallel with the post-Apollo negotiations and noticeably weakened the bargaining position of Europe.

The difficulties of a normal governmental decision-making process were multiplied by the absence of a supranational structure and a clear hierarchical chain of power, whereby different European positions could be reduced to a single one by recognising a single legitimising authority. If the Italian Minister of Scientific Research asked for a total technological sharing, the European negotiator, Lefèvre, had "to take account" of this position, without being able to enforce any change in the government's position. Nor was it easy for European representatives to practice any form of bargaining, through which one actor within the national range is normally free to be flexible within predetermined borders, in order to exert concessions from the other negotiator.

On the other hand, the nature of the American offer changed remarkably during the negotiations, defusing the offer of its original political meaning. Born from an American desire to allay European fears about the "technological gap" in the space field, it ended up by reinforcing instead of relieving them. Many reasons for the evolution of the American position are to be found in the internal interplay between NASA, the Department of State and the White House, marked by an increasing fear about technological transfer[1314].

[1312] D. Lord, *op. cit.*, p. 31. The first Spacelab was handed over to the US in 1980 and the German astronaut Ulf Merbold, ESA's payload specialist, took part in the first mission in November 1983. For the scientific aspects of Spacelab missions, see D. Shapland and M. Rycroft, *Spacelab. Research in Earth Orbit* (Cambridge: Cambridge University Press, 1984). On Spacelab in general, see Volume II, chapters 13 and 14.

[1313] On these problems, see Volume II, chapter 13; see also L. Sebesta, "The Politics of Technological cooperation in space: US-European negotiations on the post-Apollo programme", *History and Technology*, 1994, vol.11, No. 3, pp 317-341.

[1314] On the development of US behaviour *vis-à-vis* cooperation with Europe during post-Apollo negotiations, see L. Sebesta, *art. cit.*

The parallel failure to cooperate on Aerosat seems to indicate the absence of a political willingness to sustain cooperation with Europe and a lack of coordination between the various policy-making sectors on the American side[1315].

Finally, it should be noted that the substantial reduction of the US offer conveyed in June 1972 was preceded by the US-USSR Moscow meeting of May 1972 where, beside the SALT and other fundamental elements of détente, an agreement on Apollo-Soyuz docking was signed[1316]. Nixon's interest seemed to be progressively shifting towards spectacular USSR-US cooperative achievements, while European importance in the US foreign policy agenda seemed to be decreasing accordingly.[1317]

1315 See for example Nixon Project, NARA , Washington DC, WHCF, Subject files, vt1, box 14, Memorandum Welsh to General Haig, *cit. in footnote 1264*

1316 J. Krige and A. Russo, *Europe in Space, 1960–1973*, cit.,

1317 While historical work based on primary sources is not yet available, good accounts based on a carefully balanced analysis of memories and official documents are beginning to appear. The most outstanding is P. Melandri, *Une incertaine alliance. Les Etats-Unis et l'Europe, 1973-1983* (Paris:Publications de la Sorbonne, 1988), esp.. pp.45-77. For an insightful account written by a key actor (the American ambassador at the European Communities), see R. Schaetzel, *The Unhinged Alliance. America and the European Community* (New York:Harper, 1975), esp. pp.42-53.

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Appendix 1: Chairmanships in ESRO/ELDO/ESA

ESRO Council Chairmen		
Sir H. Massey	(UK)	1964
A. Hocker	(D)	1965-67
H.C. van de Hulst	(NL)	1968-70
G.P. Puppi	(I)	1971-72
M. Lévy	(F)	1973-75
ELDO Council Chairmen		
G. Bock	(D)	1964-66
A.C. Paternotte de la Vaillée	(B)	1967
R. Aubinière	(F)	1968-70
W.J. Schmidt-Kuster	(D)	1971
E.A. Plate	(NL)	1972-73
ESA Council Chairmen		
W. Finke	(D)	1975-78
J. Stiernstedt	(S)	1978-81
H. Curien	(F)	1981-84
H. Atkinson	(UK)	1984-87
H. Grage	(DK)	1987-90
F. Carassa	(I)	1990-93
P.G. Winters	(NL)	1993-96
H. Parr	(N)	1996-99

ESRO DGs		
P. Auger	(F)	1964-67
H. Bondi	(UK)	1967-71
A. Hocker	(D)	1971-74
R. Gibson	(UK)	1974-75
ELDO Secretaries General		
R. di Carrobio	(I)	1964-72
R. Aubinière	(F)	1972-73
G. Van Reeth	(B)	1973-75
ESA DGs		
R. Gibson	(UK)	1975-80
E. Quistgaard	(DK)	1980-84
R. Lüst	(D)	1984-90
J-M. Luton	(F)	1990-97
A. Rodotà	(I)	(from 1 July 1997)

ESRO

Council (see above)

AFC

Mr. Sassot	(E)	1964-65
E. Bettini	(I)	1966-67
M. Bignier	(F)	1968-70
J.F. Hosie	(UK)	1971-72
P. Creola	(CH)	1973-74

Scientific and Technical Committee

R. Lüst	(D)	1964-65
J. Coulomb	(F)	1966
H.C. van de Hulst	(NL)	1967
P.A. Sheppard	(UK)	1968-70
R. Lüst	(D)	1971

Launching Programme Advisory Committee

R. Lüst	(D)	1964-70
J. Geiss	(CH)	1970-72
H. van de Hulst	(NL)	1973

Joint Programmes and Policy Committee

M. Bignier	(F)	1972
F.R. Güntsch	(D)	1973
W. Finke	(D)	1973-74

Programme Boards

Aeronautical

L. de Azcarraga	(E)	1973-74

Ariane

J. van Eesbeek	(B)	until 4 December 1973
J. Stiernstedt	(S)	4 December 1973-6 September 1974
J. van Eesbeek	(B)	from 4 October 1974

Maritime

M. Lévy	(F)	until 5 December 1973
J. van Eesbeek	(B)	5 December 1973-4 October 1974
J. Stiernstedt	(S)	from 4 October 1974

Meteorological

J. van Eesbeek	(B)	1973
H. Lottrup Knudsen	(DK)	1974

Scientific

M. Lévy	(F)	1973-74

Spacelab

M. Trella	(I)	1973-74

Telecommunications

J.R. Steele	(UK)	1973
D. Cavanagh	(UK)	1974

CHAIRMANSHIP OF THE ESA DELEGATE BODIES

BODY	FROM 1 JULY 1975 TO 30 JUNE 1978	FROM 1 JULY 1978 TO 30 JUNE 1981	FROM 1 JULY 1981 TO 30 JUNE 1984
COUNCIL	Chairman: Dr W. Finke (D) Vice-Charimen: General L. Azcarraga (E) Mr J. Stiernstedt (S)	Chairman: Mr J. Stiernstedt (S) Vice-Chairmen: Prof. L. Broglio (I) Mr M. Manahan (IRL)	Chairman: Prof. H. Curien (F) Vice-Chairmen: Dr H.H. Atkinson (UK) Mr H. Grage (DK)
AFC	Mr A.L. Goedhart (NL	Mr A. de Eulate (E)	Dr K. Buschbeck (D) Dr C. Patermann (D)
IPC	Mr P. Creola (CH)	Dr H. Strub (D)	Mr J. Laurent (B)
IRAC	Mr R. Fourdin (B)	Mr H. Grage (DK)	Mr M. Manahan (IRL)
SPC	Prof. M. Lévy (F) Prof. H. Curien (F)	Prof. H. Curien (F) Mr E. Amaldi (I)	Prof C. de Jager (NL)
JCB	Mr D. Cavanagh (UK) Mr E.S. Mallett (UK)	Mr E.S. Mallett (UK) Mr J. Hawkes (UK)	Mr M. De Leo (I)
PB-AERO	General L. Azcarraga (E)	Gen. L. Azcarraga (E)	Gen. L. Azcarraga (E)
PB-MET	Prof. H.L. Knudsen (DK)	Mr J. Laurent (B)	Prof. G. Formica (I)
PB-RS	-	Mr F. Engström (S) Mr G. Brachet (F)	Mr A. Nicolas (UK)
PB-EO	-	-	-
PB-µGr.	-	-	-
PB-ARIANE	Mr J. van Eesbeek (B)	Mr P. Creola (CH)	Mr J.C. Joseph (CH)
PB-SPACELAB	Prof. L. Broglio (I)	Mr J. Flinterman (NL) Dr J. Ortner (A)	Dr J. Ortner (A)
FINANCE GROUP	-	-	-

CHAIRMANSHIP OF THE ESA DELEGATE BODIES (cont.)

BODY	FROM 1 JULY 1984 TO 30 JUNE 1987	FROM I JULY 1987 TO 30 JUNE 1990	FROM 1 JULY 1990 TO 30 JUNE 1993
COUNCIL	Chairman: Dr H. Atkinson (UK) Vice-Chairmen: Dr H. Strub (D) Mr J. Stiernstedt (S)	Chairman: Mr H. Grage (DK) Vice-Chairmen: Mr J. Laurent (B) Mr P. Creola (CH)	Chairman: Prof. F. Carassa (I) Vice-Chairmen: Mr H. Grage (DK) Mr A. Mortensen (N)
AFC	Mr J-M. Luton (F)	Dr H. Strub (D)	Mr K. Inglis (UK)
IPC	Mr H. Grage (DK)	Mr P. Linssen (NL)	Mr D. Sacotte (F)
IRC	Dr C. Patermann (D)	Mrs A. Aylward (IRL) Mr A. Minuto-Rizzo (I)	Mr J.M. Lopez-Aguilar (E)
SPC	Prof. L Van Hove (B)	Dr K. Fredga (S)	Dr J.A.M. Bleeker (NL)
JCB	Mr N. de Boer (NL)	Dr G. Stette (N)	Dr W. Lothaller (A)
PB-AERO	Gen. L. Azcarraga (E)	-	-
PB-MET	Gen. L. Azcarraga (E)	-	-
PB-RS	Mr J.L. Joseph (CH)	-	-
PB-EO	Mr Zenker (S)	Mr J.C. Leeming (UK) Mr J. Harris (UK)	Mr H. Stoewer (D)
PB-µGr.	Mr B. Landmark (N)	Mr L. Pueyo (E)	Mr J.P. Ruder (CH)
PB-ARIANE	Mr J. Laurent (B)	Mr M. De Leo (I) Mr F. Mazzuca (I)	Mr Lübeck (S)
PB-COLUMBUS	Mr M. De Leo (I)	Mr D. Sacotte (F) Mr Traizet (F)	Mr M. Praet (B)
FINANCE SUB-COMMITTEE	Mr M. English (IRL)	Mr C. Wild (A)	Mr Infante (I)

Appendix 2: The History Study Reports

HSR-#	Date	Title	Author
1	July 1992	The Prehistory of ESRO 1959/60	J. Krige
2	October 1992	ESRO's First Scientific Satellite Programme 1961-1966	A. Russo
3	November 1992	Choosing ESRO's First Scientific Satellites	A. Russo
4	January 1993	The Early Activities of the COPERS and the Drafting of the ESRO Convention (1961/62)	J. Krige
5	March 1993	Europe in Space: Edoardo Amaldi and the Inception of ESRO	M. de Maria
6	March 1993	The Definition of a Scientific Policy: ESRO's Satellite Programme in 1969 - 1973	A. Russo
7	March 1993	The Launch of ELDO	J. Krige
8	May 1993	Europe into Space: The Auger Years (1959 - 1967)	J. Krige
9	May 1993	The Early Development of the Telecommunications Satellite Programme in ESRO (1965 - 1971)	A. Russo
10	September 1993	The History of ELDO Part 1: 1961 - 1964	M. de Maria
11	January 1994	Reflections on Europe in Space	J. Krige & A. Russo
12	January 1994	The Origins of the Federal Republic of Germany's Space Policy 1959 - 1965 — European and National Dimensions	P. Fischer
13	February 1994	ESRO's Telecommunications Programme and the OTS Project (1970 - 1974)	A. Russo
14	July 1994	United States - European Cooperation in Space During the 1960s	L. Sebesta
15	February 1995	United States - European Cooperation in the Post-Apollo Programme	L. Sebesta
16	February 1995	The Scientific Programme Between ESRO and ESA: Choosing New Projects (1973 - 1977)	A. Russo
17	February 1996	The Aeronautical Satellite System: An Example of International Bargaining	L. Sebesta
18	September 1996	The Availability of European Launchers and Europe's Decision 'To Go It Alone'	L. Sebesta
19	August 1997	Big Technology, Little Science The European Use of Spacelab	A. Russo
20	September 1997	The Definition of ESA's Scientific Programme for the 1980's	A. Russo
21	October 1997	Spacelab in Context	L. Sebesta
22	March 1998	The European Meteorological Satellite Programme	J. Krige
23	September 1998	The Third Phase of the Telecommunications Programme ECS, Marecs and Olympus	A. Russo
24	May 1999	ESA’s Scientific Programme Towards the Turn of the Century	A. Russo

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