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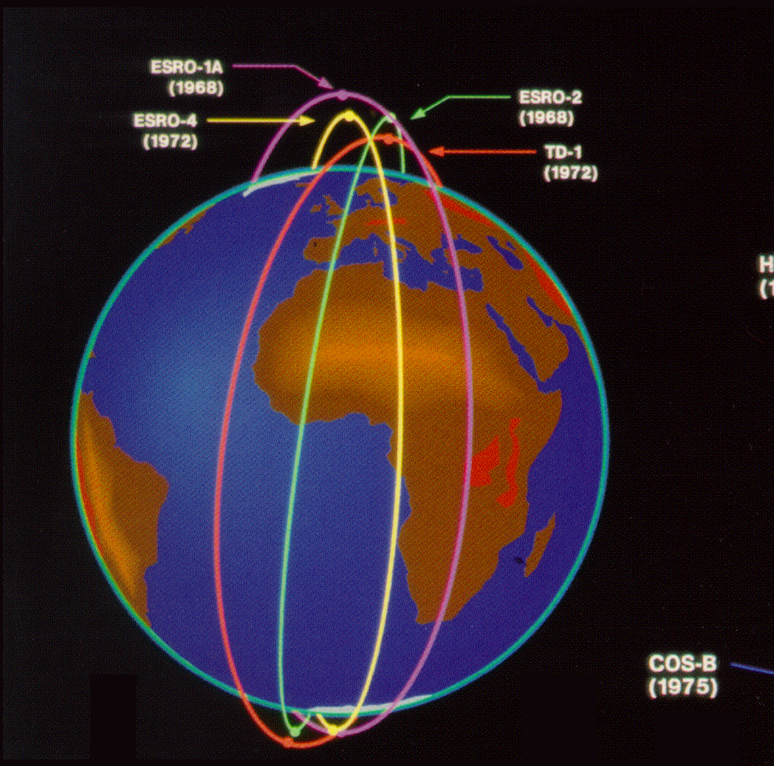
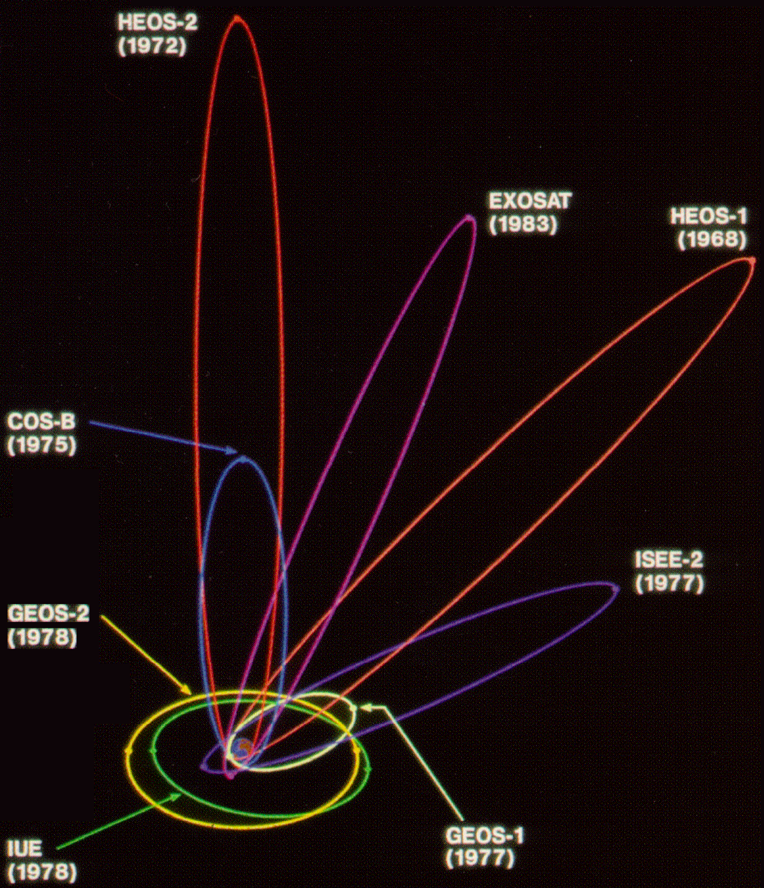
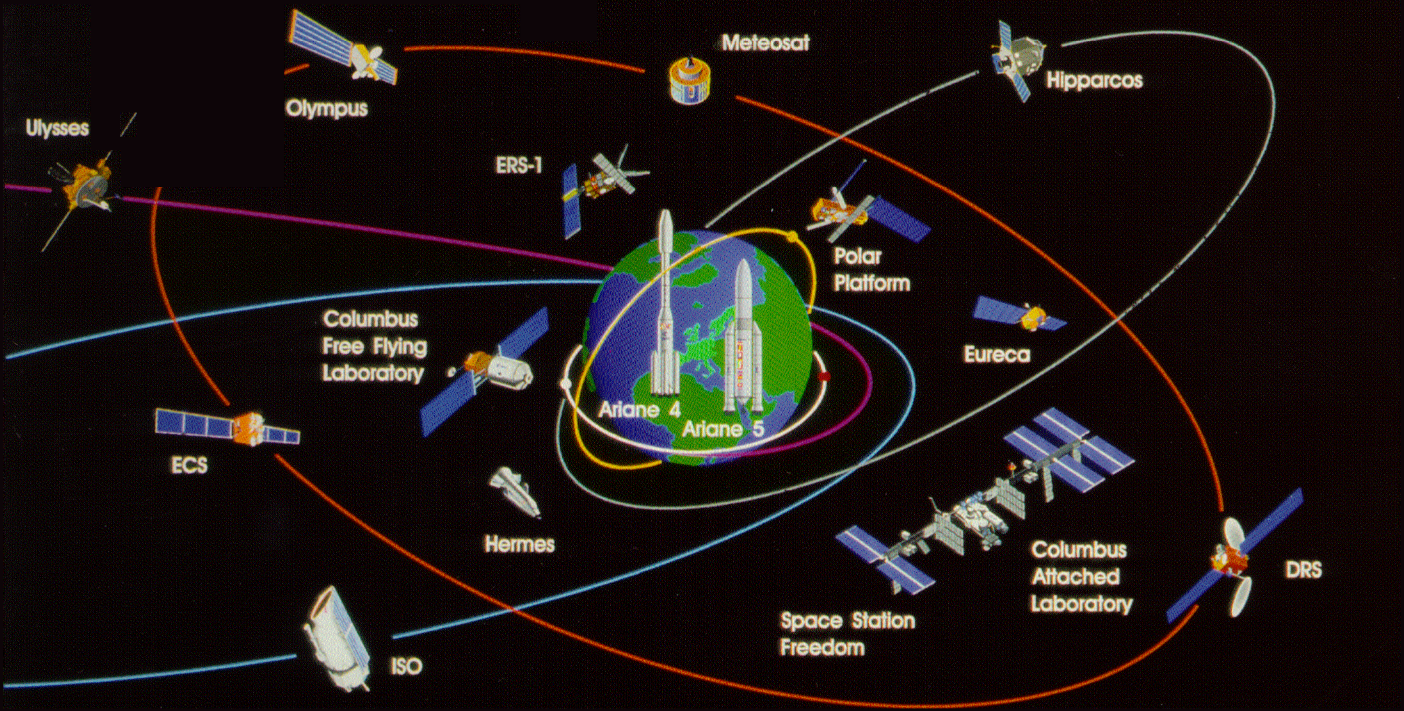




Europe into Space:
The Auger Years (1959 - 1967)

by John Krige



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The ESA History Study Reports are preliminary reports of studies carried out within the framework of an ESA contract. As such they will form the basis of a comprehensive study of European Space activities covering the period 1959-87. The authors would welcome comments and criticism which should be sent to them at the appropriate address below.

The opinions and comments expressed and the conclusions reached are those of the authors, and do not necessarily reflect the policy of the Agency.

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EUROPE INTO SPACE: THE AUGER YEARS (1959-1967)

John Krige

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Pream ble

This is the first of a series of working papers dealing with an overview of the history of ESRO, ELDO and ESA. As such it represents a synthesis of hundreds, even thousands of pages of source material. To reduce the volume of material in this way the historian has to make two related intellcctual choices. The first concerns what to include (and what to leave out), the second the leve1 at which an issue is to be handled. Both of these choices are difficult and negotiable, in the sense that disagreements are inevitable both between historian and those who lived this history, and between the historian and his or her professional colleagues.

The topics 1 have chosen to concentrate on in this rich and difficult start to Europe's space effort are identified in the table of contents above. As source material 1 have drawn on previously published, more detailed, work by myself and my colleagues in the ESA History Team, notably results which have already appeared in this series of working papers. It has been supplemented by original documents, particularly those which arrived at the leve1 of the ESRO Council, as well as by articles in the ESRO and the ESRO/ELDO Bulletins. References, as well as material in the notes, have been restricted to the minimum so as not to impede the narrative flow.

The series of overviews, of which this is the first, has two main purposes. Firstly, it is intended to provide the genera1 intellectual framework for the detailed two-volume history of the European Space Agency which the Team is to produce. Secondly, parts are to serve for a shorter volume to be published in 1994 to coincide with ESRO's thirtieth birthday. More than ever, then, comments, criticisms and suggestions are welcomed by the author at the address on the inside front cover of this report.

1. The background[1]

The space age dawned with the launch by the Soviet Union of the first artificial satellite *Sputnik* on 4 October 1957. Seen and heard by millions, *the* significance of *Sputnik* lay primarily in the fact that the Soviets had succeeded in building a launcher sufficiently powerful to escape the gravitational pull of the earth, and to place a useful payload in orbit. A rocket that was able to achieve this feat was also an intercontinental ballistic missile able to strike American cities directly from Soviet soil with nuclear warheads. The entire balance of power was tilted temporarily in favour of the United States' arch enemy. In the near hysteria that followed, heightened by the initial failure of the USA to repeat the Soviet achievement a few months later, a rather reluctant and initially unpanicked president Eisenhower had little choice but to commit his country to a major space effort. Within less

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1 The literature for this section is vast, but see for example McDougall (1985), Rosholt (1966) and Stares (1985).

than a year of the launch of *Sputnik,* on 1 October 1958, the National Aeronautics and Space Administration (NASA) came officially into being. Growing out of the NACA (National Advisory Committee for Aeronautics), which had long historical links with the aeronautical industry and the Department of Defence, NASA began with a staff of 8000 and a budget of $433 million for calendar year 1959. By 1963 staff numbers had climbed to over 30,000 and the NASA budget was almost ten timcs greater.

In the context of the Cold War the conquest of space, like that of the nuclear before it, was a military, political and industrial necessity for any country aspiring to great power status. A viable defence system demanded powerful rockets, and satellites for telecommunications, reconnaissance and weather forecasting. National prestige and ideological rhetoric mingled in a sequence of successful and dramatic space feats which fircd the public imagination and which spawned a space race between the super powers. And the prospect of transmitting telephone signals and TV images by satcllite opened up the possibility of new and profitable markets for the giant telecommunications corporations.

While the Europeans could not hope to match the American or the Soviet space efforts in terms of human or material resources, they were not unprepared for the exploration and exploitation of space in the late 1950s. Both Britain and France, the two powers with major nuclear aspirations, had rocket programmes and engaged in some scientific research in this decade. The former were particularly advanced. Indeed in the late 1950s the UK was building its own medium range ballistic missile designed to strike targets at a distance of 2500-3000 miles. French efforts were initially more modest but were given a decisivc boost with the arrival in power of de Gaulle whose plans to achieve French independence with a *force de frappe* necessarily included a major military space component. Other European countries were also alert to the importance of the new domain, and in the late 1950s and early 1960s set up national committees to define appropriate scientific research programmes.

The strategic significance of space — its political, military, ideological and commercial importance — tended to obscure, for both politicians and the public alike, the opportunities for scientific research opened up by the advent of new powerful rockets. Indeed for much of the 1950s scientists had been activcly studying the upper atmosphere using balloons and sounding rockets (smal1 ballistic devices which canied an instrument package up to 100-150 kilometres, before plunging back to earth). Ironically too *Sputnik* was launchcd as part of the USSR's contribution to the International Geophysical Year. Lasting from July 1957 to December 1958, the IGY was one of the most ambitious and extensive attempts at intemational scientific collaboration yet undertaken. With this history of collaboration behind them it is perhaps not surprising that it was the scientists, rather than the politicians who were stil1 feeling their way towards co-operating economically and politically, that took the first important initiatives to establish a European organization dedicated to space research. It is with them, then, that our story begins.

2. *Laying the foundations*

2.1. *The birth of ESRO*

2.1.1. 1958/59: the first initiatives by Amaldi

The first important steps towards setting up a European space organization were taken by the Italian physicist and scientific statesman Edoardo Amaldi in mid-1958.[2] The timing was not coincidental. The International Geophysical Year was drawing to a close, and it would have been a pity not to capitalize on the linkages that had been established between scientists during this very successful initiative. At the same time, European governments were more than likely to welcome such a move. The superpowers were clearly making space a high priority, and there was no way in which major European states could stand aside from the domain. At the same time important European scientific and technological collaborative projects were coming to fruition. CERN, the European Organization for Nuclear Research set up in the early fifties just outside Geneva, had just commissioned its first accelerator, and was well on the way to bringing its second major facility onstream. And provision was being made to create a European atomic energy organization within the framework of the negotiations leading to the setting up of the Common Market.

It was against this background that between July 1958 and March 1959 Amaldi sounded out the views of a number of colleagues about the possibility of setting up a European space organization dedicated to the development and construction of both launchers and of scientific satellites. He contacted Italian rocket engineers Luigi Broglio and Luigi Crocco. He heard the views of Isidor I. Rabi, who had played an important role in the founding of CERN and who was a senior American scientific statesman, and of Theodore von Karman, the brilliant Hungarian engineer who had founded NATO's Advisory Group for Aeronautical Research and Development (AGARD). He also got in touch with physicists Francis Perrin and Cecil Powell, both of whom believed strongly in CERN. At the suggestion of Perrin, Amaldi also contacted Pierre Auger. It was with Auger that Amaldi had played a key role in the launching of CERN. Now, in the late fifties, Auger's interest had turned to space — in fact early in 1959 he had been elected president of the newly created French Comité des recherches spatiales (Committee for Space Research).

While all of those approached by Amaldi were interested in his idea, a number of difficulties immediately came to light. Firstly, there was the question of cost. There was little hope, Crocco stressed, of governments being prepared to invest the huge amounts of money that would be needed

2 What follows is based on De Maria (1993), esp. sections 1 and 2.

for a space effort simply to do scientific research with no obvious utilitarian spin-offs. Secondly, there was the question of the involvement of the military. Amaldi was emphatic that any future organization should not have a military character nor any connection whatsoever with a military agency. His difficulty was that everything important done in the field of missiles, rockets and satellites to date had been either carried out directly by the military or under its patronage. Thirdly, there was the question of the scope of the organization. Amaldi wanted it restricted to western Europe, favouring particularly the countries of the EEC, Great Britain and the Scandinavians. Powell pointed out to him that if anything comparable to the effort being made by the superpowers was to be undertaken it would need wider international collaboration. Finally, there was the question of how to proceed. Both Rabi and von Karman offered US help through NATO, at least in the initial stages. Amaldi rejected this idea both because he saw it as an unnecessary militarization of the programme and because it would, in his view, dilute the European character of the project by giving the United States too much say in its development. Instead, inspired by Auger's success in setting up a national committee in France, Amaldi thought that organizations of this kind would be the best nuclei around which the project could gel. He hoped that such bodies could be established rapidly in Italy and Germany, and that along with those in France and in Great Britain, pressure could be put on governments to set up a European organization for space research.

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Two points are to be bome in mind regarding these early discussions. Firstly, Amaldi, drawing on his past experience, was thinking very much in terms of modelling the new organization on CERN. It was to be west European in membership, the military were to be kept completely out of the picture, and the control over the programme was to be in the hands of scientists and engineers. This he hoped to achieve despite the fact that he also saw any future organization as rather like a European NASA, i.e., a civilian body in which member states pooled their resources for the development of launchers and of satellites.

Thc second point to note is that it was precisely the inclusion of launchers in the package that made it so difficult for Amaldi to export the CERN model to space. It was because of their presencc that a direct link with national and with military interests was inevitable. These interests were nccessarily a centrifugal force working against the pooling of knowledge, information and skills. Whcn CERN was set up reactors wcre deliberatcly excluded from its programme for these reasons. Similarly it was clear, though not yet to Amaldi at this time, that launchers could not easily be built along with scientific research satellites in the same European organization, at least not in the Cold War context of the carly 1960s.

This is not to say that the difficulties surrounding the construction of a European heavy launcher would necessarily sabotage a European space science effort. There were altemative means for putting scientific payloads into space. Major countries like Britain and France had nationally dcveloped rockets in various stages of development which could be used. In addition, there was NASA. At an intemational scientific meeting in the Hague in March 1959, the American delegate announced that his government, through NASA, would be willing to launch experiments proposed by scientists from other countries using American rockets.[3] In discussion NASA made it clear that it was seeking bilateral agreements for joint programmes, and even hinted that it was prepared to launch at least some equipment free of charge. This offer not only provided European space scicntists with quick access to scientific satellite experiments, and the added bonus of working with NASA engineers. It also detached them from the political struggles over the development of a jointly-built European launcher. For the scientists, a rockct was simply a means to an end. With several altematives available, they would shop around for the onc that best suited their purposes, ignoring as best they could the political and ideological issucs surrounding their choices.

2.1.2. Building political and scientific support

In February 1959 Amaldi and Auger met in Paris and, during a peripatetic conversation in the Jardins dcs Luxembourg, discusscd how next to proceed. Shortly thereafter the Italian scientist drafted an important document entitled *Space Research in Europe.* It drew together the ideas which had bccn maturing in his mind over the previous nine months. Amaldi sent ten copies each to Auger and to six othcr key pcrsonalities in Europe. Three of them were influential members of national bureaucracies who could be countcd on to support Amaldi's project and to share his conception of how such an initiative should be institutionally organized. These were Jan Bannier in the Netherlands, Alexander Hocker in (West) Germany and Jean Willems in Belgium. The other three were CERN Dircctor-Gencral Comclis Bakker, Francesco Giordani, the president of the Italian Consiglio Nazionale delle Ricerche, and a founding member of the NAT0 science committee, and Etiennc Hirsch, the president of the Euratom commission. A French version of the text was published in Dccember 1959 under the more explicit title *Créons une organisation eurupéenne pour la recherche spatiale*. It differed only slightly from that circulated in May, but was supplemented by vcry positive reactions from a number of high-leve1 European academics and administrators and an additional statement by Amaldi. In it he stressed that the ncw organization should be modelled on CERN, should develop a European launcher, and should be kept out of the hands of the military.

The timing of the publication of this article in French was not coincidental. Indeed, it was sandwichcd between the succcssful commissioning of CERN's giant new powerful accelerator, the protron synchrotron (PS), in Novcmber 1959, and an important meeting of the COSPAR (Committee on Spacc Research), which had grown out of the IGY, and which was due to be held in

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3 For this offer sec Massey and Robins (1986), Annex 4.

Nice in January 1960. The commissioning of the CERN PS was potent proof for govemments that European scientists and engineers could collaborate successfully in the construction of big equipment comparable to the best that the United States could offer. The COSPAR meeting was the first of its kind and, in Auger's view, would play for space a role analogous to that which the 1955 Geneva conference had played for the atom, i.e., it would regenerate intemational collaboration in the field, superpower rivalry notwithstanding. It was this happy coincidence that Auger and Amaldi sought to exploit. And thcy were encouraged in their efforts by a very positive reaction to their idea by Henk van de Hulst, the Dutch president of COSPAR's executive committee, who ensured them that the organization would give them all the support that they needed.[4]

The first genera1 assembly of COSPAR was held in Nice from 9-16 January 1960. During the course of the meeting Auger convened two informal gatherings, the first attended by reprcsentatives of countries which already had organized national space committees (i.e., B, F, 1, NL, S, and the UK), the second also by Germany and by Switzerland who were hoping to set up similar bodies in due course. The most striking feature about these meetings was the enthusiasm shown by the UK, in contrast to their early attitudes vis-à-vis the founding of CERN. Indeed Massey, who was also the president of the British National Committee for Space Research (BNCSR), not only proposed the kind of scientific topics which a future European organization might study. He also suggested a solution to the question of the launcher. Britain, he said, may soon dccide to dcvelop a satellite launcher for civilian purposes and a future European organization could play an important role in encouraging her to go ahead with this scheme.[5]

Encouraged by these reactions another meeting was arranged in Auger's flat in Paris on 29 February 1960. All eight of the countries involved in the Nice discussions were represented by high-leve1 scientists including Amaldi, Auger and Massey. Once again Massey took the lead in confirming the interest which British scientists had in European collaboration. Going further he suggested that, to placc the discussions on a more forma1 footing, the BNCSR invite suitable delegates to a meeting in London in late April with a view to setting up a recognized committee or working group.[6]

About 20 European spacc research scientists from ten west European countries (the eight that wc have mentioned plus Norway and Dcnmark) duly met in the rooms of the Royal Society, London on 29 April 1960. After representatives from several countries had reported on their national activities, the discussion focussed on three main issues: the possibilities for cooperation using exist-

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4 For a more detailed discussion of these reports see Krige (1992a), section 1.

5 For this paragraph see De Maria (1993), section 4.

6 For this paragraph see De Maria (1993), section 4 and Krige (1992a), section 2.

ing or soon to be developed national facilities, the possibilities for a jointly-funded European cooperativc effort in spacc research, and the most desirable procedure to be followed for implementing such an initiative. Once again the British took the lead. Their dclegates now explained in some detail the experiments that they might like to perform during the next five years, in particular the construction of a large, high-resolution astronomical telescope for studying ultraviolet and X-ray stellar spectra. Massey's earlier suggestions about the possible collaborative development of a launcher were also fleshed out. In fact a fortnight before the British government had officially announcced its decision to abandon the development of its intercontinental ballistic missile *Blue Streak* as a military weapon, and to explore the possibility of developing it jointly with other European partners as a civilian satellite launcher. *Blue Streak*, the scientists said, could be used as the first stage of such a satellitc launcher with a modified version of the British rocket *Black Knight* as the second stage. Going even further the chairman of the meeting inquired "if any country represented would be prepared to indicate the possible order of their contribution should the *Blue Streak* rockct be used to placc a European satellite in orbit."

The British idea was gencrally well received. The only recorded qualms were those expressed by Amaldi and van de Hulst. They made it clear that their govemments would obviously not be willing to contribute to the development of a British rocket if that rocket was not properly integrated into a European programme. There were also doubts raised by these two delegates and by Auger over Britain's wish to have Australia associated with any collaborative European space effort. The UK madc cxtensive use of a launching range in the south of the country at Woomera for its missile programme, and wantcd to continue doing so. In the event, and these hesitations notwithstanding, the meeting passed a resolution which stated that those present were "strongly in favour of a cooperative effort by Europcan nations towards further research in space science including the placing in orbit of artificial satellites by a launching vehicle developed and fmanced cooperatively."[7]

Thcre remained the thomy question of the appropriate means whereby to push the programmc forward at an intcrgovernmental level. UNESCO was ruled out on the grounds that Auger's successor there was a Soviet who would be unlikely to associate himself with a strictly west European initiative. The Organization for European Economic Cooperation (OEEC) had also offered to cooperate. This too was excluded, once again for fear that countries like America and Canada, who werc about to enter the OEEC, would jeopardize the west European nature of the hoped for organization. In the event it was an offer by the Swiss federal authorities, prodded by their delcgate to the April meeting Marcel Golay, that was adopted. The Swiss undertook to provide all the necessary financial, administrative and diplomatic assistance required to convene a meeting of govemmcnt rcprcsentatives. Thcsc were to be empowered to set up a preparatory committee to plan

7 For this paragraph sec Krige (1992a), section 2. For the circumstances surrounding the cancellation of *Blue Streak* see Krige (1993b), section 2.

a collaborative European space effort. Auger was mandated to call the meeting which, it was hoped, could be held within two months.

* * *

A comment on the role of thc British is apposite. Naturally their enthusiasm for the European venturc was heartily welcomed by the other delegates. Scientifically, it would allow relatively less well advanccd nations to benefit from the expertise of their British counterparts. Politically, it would cnsure a wider and deepcr European representation in any future organization. Bureaucratically, it would enable any such organization to benefit from the experience which the British had in the financial and lcgal aspccts of intemational scientific collaboration. Financially, it would ensure that a substantial fraction of the costs of any body would be bome by the UK, so reducing the burden on other countries, and on smal1 countries in particular, who could thus more easily associate themselves with the project. At the same time there were obviously risks involved. In particular the fact that the British werc effectivcly seeking to Europeanize *existing* costly and complex programmes for a large satellite and a launcher not only implied that they would play a dominant rolc in the future organization. It also carried the danger that its expenditure profilc, and its research programmc, would be heavily biassed from the start. No-onc was particularly concemed about this in 1960. The excitcment of starting a new adventure with the British on board, and the inexperience and thc lack of well-articulated ideas among many of the continental space science communities, which werc stil1 vcry young, made the British proposals seem to be an excellent way of getting startcd quickly at the European level. The possible disadvantages which they entailed were simply overlooked for the time bcing.[8]

2.1.3. Setting up thc GEERS

In the wecks that followcd Auger sct about the task of cstablishing a preparatory committce, as instructed by the resolutions passed at the Royal Society meeting. On 23 and 24 June 1960 he gathered together a sclect group of representatives in Paris to discuss his "Draft Agreement Creating a Preparatory Commission for Europcan Collaboration in the Field of Space Research". It immediately appeared that those present would not be able to set up any such commission. For one thing the prccisc domain which should be covered by the organization was stil1 not clear, at least to thc British. Masscy, in particular, wanted clarity on whethcr or not other states were willing to collaborate in the developmcnt of a launcher as well as in the construction and orbiting of satellites. Then therc was the problem of the mcmbership of the envisagcd organization and of Australia's position in particular. The British were emphatic that Australia should be a fully-fledged participant

8 For thc above paragraphs scc Krigc (1992a), scction 2.

in any new body, whilc a numbcr of delcgates, notably the Swiss, thought that this would tamish the Europcan character of the new organization. Finally, it was clear that those present simply did not have the authority to take decisions which would be binding on their govemments. In the light of these considerations, and much to the distress of Auger and others, it was decided that it was first neccssary to establish a study group whose main task would be to define the areas in which European cooperation would take place. Thc meeting duly constituted itself as the GEERS (Groupe d'étude européenne pour la collaboration dans le domaine des recherches spatiales or, in the English version, the Europcan Space Research Study Group) and nominatcd its bureau. H. Massey was clected chairman, L. Broglio, M. Golay and L. Hulthén (Swedcn) were elected vice-chairmen and P. Auger was nominatcd executive secretary. An offer from the French to host such a bureau was accepted, as was a repeat offer from the Swiss to convene an intergovemmental meeting which would bc called upon to set up the commission later in the year.[9]

The first meeting of the GEERS was held in the rooms of the Royal Society from 3-6 October 1960. It was attended by some three dozen scientists and engineers, about half of them from Britain and France. The meeting was important in that, in anticipation of the convening of govemment rcpresentatives, it defined thc scientific programme, the genera1 principles and organizational structurc, and the future steps that were to be taken by the envisaged European space agency. Five working groups were set up. One was to define the administrative and technical framework of the new organization. The other four were to deal with its scientific and tcchnical aspccts: the scientific programmc, to be based essentially on sounding rockets and satellites, the launchers and their launching sites, the possible fields for advanced technological research, notably new methods of propulsion and, finally, the requirements for telemetry and tracking.

The main facility of the agency foreseen in October 1960 was a centra1 establishment for the engineering of satellites and large scientific payloads, the integration of instruments into the payloads, and for making arrangemcnts for launching. The scientific instruments themselves would bc built in national laboratories and universities. A scientific committee would define a programme for rcsearch in the light of the experiment proposals submitted to it. Administrative and budgetary decisions were to be in the hands of a council of member states' representatives, who would have overall control over policy and finance. In the scheme of the organization that Auger sketched on a blackboard at the meeting he put the scientific committee and the council at the same level, reflecting the scientists' determination not to bc dominatcd by politicians and bureaucrats.

A three-phase scientific satellite programme was defined to complement a sounding rocket programme. In the first phase, which would last about three years, satellites of about 100 kg for scientific research would be orbited. These would not be particularly sophisticated devices but would

9 For this paragraph see Krige (1992a), section 3.

help build European capability in the field. In the second phase, which would start after about five years, satellites of 500-1000 kg would be launched into terrestrial orbits, with lighter payloads being placed in the lunar field. Finally, there was a third phase to be developed in parallel with the first two. This would be more ambitious, leading to landing scientific equipment on the moon and to exploring other planets as well as the neighbourhood of the sun.

Two important points emerged at this meeting. Firstly, those present were emphatic that the envisaged international organization should not compete with national activities and programmes, but rather "enhance their efficiency". In other words, the European organization was to be developed *in parallel with* national space research efforts, and was not to supplant them. Secondly, we can see the first signs of a new attitude on launchers emerging. This issue could not be discussed openly because, apparently, the British delegation has been instructed not to make any reference to the ongoing debate about the Europeanization of the *Blue Streak/Black Knight* combination. At the same time it is noteworthy that the experts in the relevant working group discussed the use of *Blue Streak* and of Woomera *as one option among others,* which included using American launchers and French and American launching bases. In short, as the disadvantages of having a single organization dedicated to both scientific research and launcher development began to emerge more clearly, so the scientists began to think of hiving the two activities off from one another.[10]

2.1.4. Setting up the COPERS

A meeting of government representatives authorized to set up a preparatory commission was duly convened by the Swiss authorities. It was held at CERN in Meyrin, just outside Geneva, from 28 November to 1 December 1960, and was attended by mixed delegations of scientists and government officials from the now usual ten countries plus Spain. Three working groups were set up, one to study the budget and scale of contributions to the envisaged preparatory commission, another to study the legal aspects of the draft agreements setting it up, and a third defining the scientific and technical objectives of the organization to be created.

At the start of the meeting the British and French delegations made it clear that the conference should not discuss the question of launchers. It was feasible, they said, to create in Europe an organization dedicated solely to scientific research, which was not concerned with commercial applications like telecommunications or with the construction and development of rockets. Leading representatives of the scientific community concurred. On the one hand they feared that launchers would inevitably swallow up all the funds dedicated to scientific research inside the new body. On the other, they had the alternatives of national rockets and of taking up the offer made

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[10] For these two paragraphs see Krige (1992a), section 4 and Russo (1992a), pp. 4-5.

by NASA to provide American launchers for putting European satellites in orbit. Splitting off space rescarch from launcher development also guaranteed a wide participation of European states, particularly the smaller countries which might otherwise be reluctant to participate for fear of incurring heavy expenditure and/or jeopardizing their neutrality (particularly important for countries like Sweden and Switzerland). It would also solve, or rather dissolve, the problem of Australia, as this country would have no particular interest in joining the organization if it was not dedicated to building rockcts to be fircd from Woomera.

The delegates to the Geneva meeting formalized the so-called Meyrin Agreement setting up a “preparatory commission to study the possibilities of European collaboration in the field of space research” (the COPERS). Its tasks were to “consider arrangements for the design, development and construction of space research satellites, and arrangements for the launching of satellites.” A budget of some onc million new French francs for its first year of operation was defined, and a scale of contributions similar to those in force at CERN (i.c., proportional to the gross national product of the participating states) was drawn up. The agreement was opcned for signature on the afternoon of 1 December 1960 and signed immediately without reserve by representatives from five countries. It entercd into forcc on 27 February 1961.

The Meyrin Agreement was prolonged four times, and twelve countries finally participated in the work of the COPERS. These were Austria (which joined in October 1961 but withdrew later), Bclgium, Dcnmark, France, the Federal Republic of Germany, Italy, the Netherlands, Norway (which withdrcw from membership in June 1962), Spain, Sweden, Switzerland and the United Kingdom.

Two months after the Meyrin conference Britain and France, at a jointly convened meeting in Strasbourg, proposed to thcir European partners that they collaborate in the setting up of an organization devoted to the common development of a heavy satellite launcher. In short, by February 1961 it was clear that Europe would enter space with not one organization, as Amaldi and Augcr had hopcd that spring day in Paris almost two years before, but with two.[11]

2.2. *The launch of ELDO*[12]

2.2.1. The recycling of *Blue Streak*

The origins of the European Launcher Development Organization can be traced back to the mid-1950s. In spring 1954 the American Secretary of Defence, Charles E. Wilson, suggested to the

[11] For this paragraph see Krige (1992a), section 5.

[12] This entire section is based on Krige (1993b). See also De Maria and Krige (1992); ELDO (1966).

British Minister of Supply, Duncan Sandys, that Britain might like to collaborate with the United States in the development of a long-range ballistic missile. Wilson indicated that whereas Britain could work on intermediate range missilcs (IRBM) which could strike at distances of about 1500 miles, the US should concentratc on intercontinental ballistic missiles (ICBM) with a range of some 5000 miles.

While the American motives for making this stunning offer are not clear, it seems that they were inspircd by the realization that IRBMs would be of strategic interest to the UK, and by an unwillingness to divert relatively scarce resources away from their own ICBM programme. The British, for their part, were at this time redefining their military strategy, and had decided to build an H-bomb. The development of an IRBM was one component of a new will inside the country to establish an independent nuclear deterrent.

In the event the two countrics very soon went thcir own ways. On the one hand, it quickly emerged that the Americans were far ahead of the British in the development of missile technologies, and had little to learn from them through any kind of “joint venture”. On the other hand, a reassessment of American needs by an advisory panel under James Killian, indicated that a crash programme in both intermediate and long-range missiles was essential if America was to maintain its dcfcnces against a Soviet attack. In the light of these developmcnts, in November 1955 Wilson informed all the armed services that an American IRBM was to be developed at the maximum speed pcrmitted by technology. Within weeks Werner von Braun and his army team had the *Jupiter* missile authorized. Very soon after the airforce had put forward plans for its *rival Thor.* In parallel and probably some time in 1955, Britain too embarked on its own IRBM programme, the product of which was *the Blue Streak* missile.

The Americans rapidly overhauled the British. In February 1958 an agreement was signed for the installation of 64 *Thor* missilcs on British soil. At the same time, to avoid duplication, *Blue Streak*'s range was increased to 2500 miles, and provision was made for housing the missile in hardened underground silos. Even this could not save the weapon. *Blue Streak* was a liquid fuel rocket which took about 30 seconds to prepare when in a state of readiness and some 7 minutes otherwise. In addition, it was not mobile. In using it the military thus had to choose between launching the missile rapidly, and so risk starting a nuclear war, or delaying launch until they were certain that the use of the missile was esscntial, and so risk having the deterrent destroyed before it had left its silo. Reviewing the programme early in 1960 high-leve1 British officials decided that it was unwise to rely any longer on *Blue Streak.* They preferred instead to buy the American *Skybolt* missile, which could be launched by the V-bomber force, and to supplement it later with *Polaris* missiles which could be launched from submarines. However, rather than cancel *Blue Streak* altogether, the govermnent considered recycling it as a satellite launcher for both military (reconnaissance and telecommunications) and civilian (scientific research) purposes. This solution would not only save the £60 million already spent on the development of the missile. It would also preserve the inhouse skills and industrial infrastructure which had gone into its development, resources which could later be dcployed if Britain wanted once again to develop its own missile capability.

2.2.2. Bringing the French on board

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

The initial reactions of Britain's potcntial partncrs on the continent were very encouraging. It was the position of the French though, regarded by Minister of Aviation Petcr Thomeycroft as the potential comerstonc of the intemational organization, that mattered most to the UK. France had not only developed an important sounding rocket called *Véronique* in the 1950s. It was also in the throes of embarking on a major new programme (the so-called "Precious Stones" rocket programme) for both civilian and military purposes. What is more Thomeycroft certainly hoped that de Gaulle would sec the UK offer as a sign of Britain's wish to draw closer to the continent both politically and economically.

By mid-November 1960 the French had clarified their position. They were certainly interested in studying the possibilities of producing a system of launchers in Europe which could be used to placc heavy satellitcs in orbit. However, thcre were certain features of the British proposal which they did not likc. Firstly, it had too much local content: the French wanted the second stage to be built at home, rathcr than it bcing the British *Black Knight* rocket. Secondly, there was the question of cost. The space scientists were particularly emphatic about this, insisting that under no circumstances was any joint project with the British to be funded at the expense of their national research programme whosc budget had just bcen voted. They added that in any case they would be looking into the possibility of using American rockets to launch their satellites.

Britain rcsponded positively to these demands. There had already been certain technical criticisms in the UK regarding the coupling of *Blue Streuk* with *Black Knight,* and so this was a small price to pay for collaboration. At the same time Thomeycroft saw in the French offer an opportunity for sharing costs more equitably between the two nations. Arguing that a rocket built with a British first stage and a French second stage would undoubtedly cost more than the all-British altemative, Thomeycroft proposed that the financial burden be shared on a 50-50 basis, the absolute amount being reduced by the contributions made by other participating countries.

The French were resolutely opposed to cost-sharing. By now, mid-December 1960, the Geneva conference setting up the COPERS had been held, and it had been effectively decided to separate launcher development from the construction and orbiting of satellites. This meant, said the French, that the moncy for a joint launcher had to be taken from the military budget. To justify this the British would have to providc military technology. In particular, the French said, they would have to share knowledge of inertial guidance systems and the characteristics of nose-cones designed to re-enter the lower layers of the atmosphere. Unfortunately for the UK, these were just the technologics that Britain had promised the United States she would strip from *Blue Streak* when it was markcted as a candidate for a European civilian launcher.

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

France's attitude changed dramatically a few days before the conference, scheduled to start on 30 January 1961 in Strasbourg. Technical exchanges were reinstated and, even more importantly, the French appeared to drop their demand that their participation was conditional on the provision of militarily sensitive technology by the British. The main rcason for this seems to have been the pressure that French president de Gaulle put on his negotiators. From 27 to 29 January de Gaulle met with Macmillan for one of their frequent *tête-à-têtes* at the Château de Rambouillet. The British premier had decided that Britain should apply for entry into the Common Market and this was one of the first occasions which he had had to sound out de Gaulle's views on the matter. The two men discussed the heavy launcher during a walk on the aftcmoon of the 28th. According to a British record of their conversation, de Gaulle said that he was "attracted by the idea of Europe becoming the third space power" and that he would take a constructive line at Strasbourg. He made no mention of the military aspect.

*   *   *

De Gaulle's support for Macmillan at Rambouillet on the eve of the Strasbourg conference 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*. Technological exchange was far less important to the British who at this time were amongst the world leaders in the nuclear and aerospace fields. Their objectives in seeking collaboration with the French, apart from saving the resources already invested in *Blue Streuk*, were essentially political. The UK had originally stood aloof from the negotiations surrounding the formation of the Common Market, at the same time championing the development of an altemative free trade area (EFTA) with the "outer six" (in addition to Britain, the Scandinavian countries, Austria, and Switzerland) plus Portugal. As the Common Market began to take shape during 1960, the wisdom of this move began to be seriously doubted and by the end of the year Macmillan had decided that an application for EEC membership should be made. Technological collaboration for him was one dimension of a broader British strategy directed towards proving its European credentials and entering into closer ties, economic, military and political, with his continental neighbours. In short, whereas for de Gaulle technological collaboration was quite distinct from economic and political integration, for Macmillan the two were closely coupled. Despite a number of serious wamings to the contrary, Macmillan submitted Britain's application for membership of the Common Market six months after this meeting, on 31 July 1961. It was a move for which he was to pay a high price.

2.2.3. Persuading Germany and Italy to join

The jointly called Anglo-French conference was duly held in Strasbourg from 30 January to 2 February 1961 with Thomeycroft in the chair. After three days of delibcrations the text of an Anglo-French memorandum summarized the main conclusions reached. The envisaged organization, should it be set up, would "study, plan, develop and manufacture a rocket system using *Blue Streuk* as the first stage and a French rocket as the second stage. The development and manufacture of the third stage," the memorandum went on, "would be carried out on the continent". Provision was also made for the planning and construction of a first series of satellite test vehicles. Britain and France made it clear that the existing facilities which had already been created would be put at the disposal of the organization at no extra charge. All existing or new technical information would also be freely available to thc participating states. The only unusual requirement was that the contracts for the work to be done on the various stages of the rocket and the satellites would not be placed by a centra1 authority with executive powers, but by the national govemments themselves. A distribution of costs was provisionally agrecd upon. The British hoped that these could be based on gross national income and that no single participant would have to pay more than 25% of the organization's budget. Both France and the smaller countries found this unacceptable. In the event, desperately wanting thc project to go ahead now that she had committed herself thus far, Britain agrccd to pay one-third of the budget of any new organization. France, Germany and Italy were to pay the same percentages as they were contributing to CERN for 1961/62 i.e., respectively about 20%, 19% and 10%. The remaining 17% would be shared between other countries who joined in the scheme, also according to thcir gross national incomes.

The political and financial viability of this arrangement required, of course, that Germany and Italy in particular participated. Both were only persuaded to join with considerable difficulty, and not a little direct pressure by Macmillan on his homologues abroad. While the German foreign minister and the Minister of Economics were broadly in favour, the technical experts were hesitant. They felt that it would be unwise to base a European launcher on an obsolete missile technology, like *Blue Streak*, and to couple it with a second stage built in another country. Why not rather build a launchcr under licence from the Americans?, asked thc German experts. This suggestion was totally unacceptable to the British, of course, as it entirely sabotaged their scheme. Once again, high-leve1 lobbying was required to secure German participation. On 29 June 1961 Adenauer personally informed Macmillan that the Federal Govemment had approved the project the day before, provided that the interests of German industry were protected. He hoped, Adenauer added, that this agreement would pave the way for a European organization "to secure for European science and technology a proper place in the field of space travel and space research."

To encourage Germany's participation they were promised the third stage of the launcher. This only left the test satellites for the Italians. And, like the Germans before them, their scientific experts were initially most unenthusiastic about the scheme. Their position was explained by Amaldi and Broglio to a British delcgation which visited Rome towards the end of September 1961.

Amaldi aired three main objections to the scheme. There was nothing of interest in it for Italian industry. It was managerially absurd to try to build a rocket whose three stages and the test satellite were built in four different countries. Finally, the first stage of the rocket was already technologically obsolete. Behind Amaldi's arguments there was the determination to protect a blossoming Italian national space programme. The month before this meeting the Italian government had approved a three-ycar space programme which included the construction, in collaboration with the Unitcd States, of the San *Marco* ncar-equatorial launching platform. Ten days after the meeting with the Anglo-French team in Rome Broglio left for Washington to define the details of this project with his NASA colleagues. In short, in September 1961 the Italian experts' main concern was to place their national programme on a sound footing within the framework of collaborative ventures with the United States.

With the prcssure mounting on Macmillan's government to bring matters to a head, the British and thc French callcd another meeting of all European states represented at Strasbourg, plus Australia. It was to be held on 30 Octobcr 1961 at Lancaster House in London. Its aim was to discuss thc draft of a convention for establishing a European launcher development organization. A week before Britain was stil1 far from sure that a suitable basis for collaboration could be found. Amaldi was intensifying his efforts against the venture and the Italians seemed to be insisting that *Blue Streak* be abandoncd as a condition for their participation. The French, for their part, had suggested cancelling the meeting if their Latin neighbour withdrew. On top of that there were persistent problems with the Australians who felt that the use of Woomera should serve as a contribution in kind not only to the initial programme of any European launcher organization, but also to all subsequent programmes.

The question of Italy was not resolved at Lancaster House. According to one source, some Italian experts were coming round to the view that, for all its faults, Italian participation in ELDO might have some benefits for the country. In particular the development of a test satellite would dovetail neatly with Italy's own plans for building scientific satellites at the national level. However, they were not able to make any firm commitments in London because, at the last minute, and after consultation with the USA, Prime Minister Fanfani insisted that the delegation remain aloof. This vacillation naturally raised the qucstion of who would pay for the shortfall in contributions if Italy did not join. France and Germany made it absolutely clear that they would be unlikely to help, despite the considerable pressure put on them by the UK delcgation. Instead they suggested that if Britain paid the Italian contribution of almost 10% they might be willing to share any outstanding deficit caused by the defection of smaller member states.

Thomeycroft's request to the cabinet that Britain be prepared to pick up the bill if Italy did not join a possiblc ELDO was greeted with hostility both by the Chief Secretary of the Treasury and by the Minister of Science. They insisted that the money were much better spent in other ways. In the event the Minister of Aviation was saved the embarrassment. When the ELDO convention was signed on 30 April 1962 Italy was among one of the seven participating member states, the others being Britain, France, Germany, Belgium and the Netherlands, and Australia. In the agreed division of labour the two smaller countries were given responsibility for the down-range guidance station (Belgium) and the long-range telemetry links, including the requisite ground equipment (the Netherlands).

In 1963 negotiations started between Britain, France and Germany on how to share the shortfall in contributions to the budget of a little under 12%. Britain's final share rose to almost 39% while France, Germany and Italy paid respectively 24%, 19% and 10% of the costs. Belgium and the Nethcrlands. each a little under 3%, made up the balance. As for Australia, it was understood that Woomera would act as a contribution in kind to the initial programme, and that its request for participation as a full member in subsequent programmes on the same basis would be rediscussed as and when the occasion arose. The convention establishing ELDO came into force on 29 February 1964.

* * *

The most striking feature about the birth of ELDO, and one that has been noted many times before, was the skepticism, even opposition, to the project by many experts in the main participating countries. Scientists feared that the enormously costly rocket, paid for from the civilian budget, would be financed at the expense of their national research programmes. Engineers saw little point in building a device that was already obsolete, and regarded the managerial system which distributed the work on each stage and on the test satellites between four different countries, to be unwieldy and doomed to failure.

Two pressures swept aside these doubts. Firstly, there was the lobbying by industry. It was always understood that the aerospace sector would have some interest in building rockets. Much of the technology was not only freely interchangeable between the civilian and military sectors of the economy. Thcre was also the possibility of exploiting what was thought to be the enormous potential of space for reconnaissance, telccommunications, meteorology, and other purposes over and above scientific research. This dimension was ever present in the minds of the senior political decision-makers throughout the process that we have just dcscribed. More to the point perhaps, as negotiations thrcatcned to become bogged down in 1961, British and French executives in the aerospace industry moved into action and launched a sustained campaign to influence the outcome. In September 1961 thc European space industry established a supranational body called Eurospace which countcd among its members all the leading companies in aircraft and missile manufacture. Its aim, according to its constitution, was "to promotc the development of aerospace activities in Western Europe." This included helping the European embryonic space organizations carry out their programmes. As F. Vinsonneau of the French company Sercb (Société pour l'étude et la réalisation d'engins balistiques) put it, "what we did say, and repeat with conviction, was that the only solution in the [spacc] field was a united Europe [...] The experience and methods gained by the United Kingdom formed a large part of our common fund of knowlcdge and it would be our duty [sic] to support them and prcvcnt thcir dispersal."

The lobbying activities of the aerospace industries notwithstanding, it was above all political considerations that lay behind Britain's insistent search for partners, and her willingness to take on an ever-increasing financial burden to see ELDO come into being. Certainly Thomeycroft's stubbom defence of *Blue Streak* was informed by a wide range of concerns: to avoid U.S. dcpendency, particularly in telecommunications, to benefit industry, to enable Britain to take advantage of possible military applications of space, and to avoid criticism in Parliament for not having cancellcd the venture carlier. But if hc won support at other lcvels of the cabinet it was because technological collaboration with contincntal powcrs was perceived by his prime minister, in particular, as proof of Britain's European credcntials, and as a way of buying entry into the Common Market. This determination in the UK to press ahead at all costs was to prove to be disastrous. By 1963 Britain not only found itself committed to paying almost 40% of the budget of the new organization. It had also been brutally excluded from the Common Market by an uncompromising de Gaulle. Macmillan and his cabinct had failed to meet eithcr their financial or political objcctives, and the country was saddlcd with developing a technically obsolete rocket. It is hardly surprising that Britain very quickly began to rcconsider its continuing membership of the very club that it had brought into being.

2.3. *Defining ESRO 5 initiul programme und budget*

Thc European Preparatory Commission for Space Research (COPERS) held its first session in Paris on 13 and 14 March 1961, two weeks after the agreement cstablishing it had entered into force. It electcd its bureau — chairman H. Massey (UK), vice-chairmcn L. Broglio (1) and H. van de Hulst (NL), and exccutive secretary P. Auger (F). It also established two working groups. One, which was chaircd by A. Hocker (FRG), was to deal with legal, administrativc and financial matters (the LAFWG). The other, thc interim scientific and tcchnical working group (STWG), was to prepare the short and long-tcrm scientific programmes for ESRO, paying attention to the technological implications of its proposals as well as to the time, pcrsonnel and cost of the projects it put forward. L. Hulthén, from the Royal Institute of Technology in Stockholm, was nominated chairman of this group and R. Lüst from the Max-Planck-Institute für Physik und Astrophysik near Munich was nominated its coordinating secretary. All member states were represented on both working groups, which were empowered to set up subgroups to facilitate their work. The STWG did this immediately at its first meeting in Stockholm on 4 and 5 April 1961. Their work was divided into scientific programmes (chairman: B. Hultqvist, director of the Kiruna Geophysical Laboratory, Sweden), technology (A.W. Lines, from the Royal Aircraft Establishment at Famborough), tracking and data handling (J.C. Pecker, from the Observatoire de Meudon, Paris) and vehicles and ranges (J.A. Vandenkerckhove, from the Institute of Aeronautics at the University of Brussels).

2.3.1. Thc scientific programme[13]

In the summer of 1961 the STWG and its subgroups defined a draft scientific programme and a launching schcdule for ESRO's first eight years. Their proposals were gathered together in a report laid before the third session of the COPERS held on 24 and 25 October 1961 in Munich, where it was warmly received.

The report, popularly known as the *Blue Book,* divided the projects into three main catcgories (short-, medium- and long-term projects) according to when they would first produce

13 For this section see Krige (1993a) and Russo (1992a).

scicntific results. Short-tenn projects were those which could be started immediately using sounding rockcts and resourccs which alrcady existed or which could be quickly developed. The first satellites in the medium- and long-term programmes were expected to be producing data after four and six years respectively.

Three fields of study were included in the short-tcrm programme. The best worked out proposal was that put forward by Hultqvist to investigate upper atmosphere physics in auroral zone. The medium-term projects included experiments involving smal1 satellites in ncar-earth orbits and smal1 space probes. Some 75 experiments had been proposed by the scientific community and it was assumed that each spacecraft would carry five of them. No priority was indicated as the list was very preliminary at this stage. As regards long-term projects, it was proposed that one be commenced as soon as possible after the establishment of ESRO and that a second get under way after two years. It was the British, and particularly Robert Boyd from University College, London, who took the initiative here. Boyd proposed that ESRO first build a series of satellite astronomical observatories, or "flying telescopcs", stabilized in sidereal coordinates, and then later devclop lunar satellites. The list of scientific goals for both projects was long and heterogeneous, but the first astronomical observatory was effectively the large satellite for high-resolution UV spectroscopy which was already under study in Britain, and which her space science community hoped to "Europeanize".

The launching programme put forward in the *Blue Book* is given in Table 1. Care must be taken in interpreting these data since, for budgetary purposes, the STWG assumed that two launches were requircd to put each successful satellite or space probe into orbit. This schedule was accepted more or less unchanged by the conference of plenipotentiaries which signed the ESRO Convention in June 1962. They resolved that during the initial eight-year period the organization should aim to achieve a sounding rocket programme which built up to a steady leve1 of about 65 medium-sized vehicles per year by thc third year of its existence. It should also aim to launch successfully two smal1 satellites per ycar in near-earth orbits from year four onwards (so ten small satellites in all) and two spacc probes or major satellites annually from year six onwards (so six in all).

Table 1 Number and type of **launches** during **ESRO's** first eight years, as proposed by the Interim STWG to the third session of the COPERS, Munich, 24-25 October 1961. It assumes that two **launches** are required for **each** successful satellite **or** space probe **placed** in orbit.

DEVICE/YEAR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
sounding rockcts	<10	40	65	65	65	65	65	65
small satellites in near-earth orbits				4	6	4	4	4
space probes						2	3	3
stabilized astronomical satellites and lunar satellites						2	1	1

* * *

This first scientific programme calls for a number of comments. Firstly, there is the very important role played in it by sounding rockets. While Broglio, in particular, felt that the sounding rocket programme was not suitable for intemational collaboration and were best conducted on a national scale, hc was very much in a minority. Sounding rockets provided a relatively simple and cheap means of satisfying many disciplines in a heterogeneous field at a relatively low cost. They enabled the European community to get significant results in a short time, before the satellite programmes got under way, and independently from the American programmes. They provided an opportunity for relatively inexperienced and smal1 research groups in Europe to cut their teeth in the field before moving on to the more demanding satellite projects. They were a means of involving smaller countries with low budgets more effectively in ESRO's activities. And they were a hedge against disappointments in the satellite programme in which competition was intense and lead times were long. This was particularly important in teaching institutions where a student's degree depended on having new scientific data at hand.

The medium- and long-tenn satellite projects also served rather different interest groups. The former predominantly satisfied the interests of physicists newly entered into the field of space science who favoured a programme based on a large number of smal1 and medium-sized satellites capable of meeting thc needs of numerous research groups. The latter was the preferred altemative of thc astronomers, who were particularly interested in developing a few, highly complex, highly performing space telescopes. Admittedly, it met the needs of a far smaller segment of the community and absorbed a high proportion of the organization's resources. At the same time such projects had the advantage that it was extremely difficult for any single participating country, even the larger ones, to undertake them on their own. In other words, the large projects were a way of cementing the major member states, and Britain in particular, with their important human and material resources, in a European programme.

Finally it must be stresscd that the initial programme defined in the *Blue Book* was more a declaration of intent than a definite programme of work — and a way of avoiding painful choices betwecn the very different needs and interests of various sections of the space science community. It provided a rough, and as it tumed out highly optimistic, basis for a first estimate of costs, and a framcwork in terms of which the community would later set its priorities by hard bargaining.

2.3.2. The eight-year budget and the mechanisms evolved for keeping it under control[14]

The first estimates of the costs of ESRO were prepared by the STWG immediately after the COPERS was set up. They were laid before its second session in May 1961. The spending plan showed costs rising steadily for the first five years as the necessary capital facilities were acquired, and the medium-term scientific programme came into operation. Costs then jumped to a plateau for years six to eight as the large satellites became operational. On this scheme over half the money for ESRO was spent in these last three years. The global estimate, which excluded a provision for a hcadquarters building, was 1360 MFF (million New French francs). In the months that followed this number climbed by about 10% to some 1470 MFF. With the cost of headquarters added, as calculated by the LAFWG budget subgroup, the scientists' estimate for thc eight-year programme was some 1550 MFF.

These relatively minor increases to the STWG's global budget estimates took place against the background of a debate about how best to control ESRO's finances. It was a dcbate which led some members of the budget subgroup to insist that the scientists' figure would have to be revised upwards if the programme was not to bc seriously reduced.

It was the British who took the lead, with the support of several other delegations, in trying to find a way of controlling ESRO's expenditure. By the end of 1961 they had come up with a complex package of proposals which combined strict budgetary ccilings with a number of procedures for ensuring that were enforced inside the organization. Britain's idea, which it said were shared by many other delcgations, was that it would be essential to define an overall eight-year ceiling for ESRO's expenditure. This would be fixed at the intergovernmental meeting which signed the convention establishing the organization. Within this eight-year ceiling, three-year ceilings would also be defined. Thc first would be set on the occasion when the overall ceiling was laid down. The same meeting would set the annual budget within each year of this first three-year envelope. For subsequent triennial reviews the British proposed two altemative ways of controlling expenditure. Either the ESRO Council itself, meeting at ministerial level, could set the ceiling for the second three-year period by a qualified two-thirds majority. Or the Council might simply recommend to govemments an appropriate leve1 of expenditure for the next three years, leaving it to the national authorities to agree among themselves what the final figure should be.

Two aspects of these British proposals were particularly unpopular. Firstly, many of the smaller states, led by the Dutch, resented the idea that budget decisions should be taken by a qualified two-thirds majotity in which member states contributions were taken into account. This was a procedure which would effectively have given veto powers over expenditure to larger

[14] For this section see Krige (1993a), section 4.

countries, simply on the basis that they paid more in absolute terms to the ESRO budget than did their smaller partners. Such a procedure, said the Dutch, was unwise in practice, as it unnecessarily complicated thc decision-making process. It was also offensive in principle, since even if the Nethcrlands paid far less than a major mcmber state to the costs of ESRO, its contribution stil1 represented a lot of money for it.

The imposition of long-term ceilings on ESRO's expenditure was also greeted with great skepticism, notably by the administrators in the LAFWG's budget subgroup. Everyone agreed that it would be fcasible to set a limit on ESRO's expenditure for the first three years while it was building up the required infrastructure for the European space programme. After this, however, it was argued, there were so many imponderables in the ESRO programme that it would be illusory to try to impose a ceiling on its expenditurc. Europe, it was pointed out, had as yet no experience in any satellite project taken to completion, and no-one in the world had experience of very large projects. Cost overruns were therefore unavoidable. In addition, there was the question of the cost of the launchcr. For budgetary purposes the *Blue Book* had assumed that European scientists would make use of the ELDO launcher to put their large satellites in orbit. If this launcher was not successful, and the organization was forced to rely on *American Thor* and *Atlas* rockets, the costs of launching such satellites would be much higher than the figures given in the initial estimates. Finally, the members of the budget subgroup pointed out that provision should be made during the later years of ESRO's life for starting programmes which came to fruition after the initial eight-year period. In line with these convictions the subgroup revised upwards the estimates of expenditure proposed by the GTST from about 1500 to about 2100 MFF, including large margins for contingency in the last three years of the organization's lifc.

In the light of these considerations the British came up with a slightly modified set of proposals in January and February 1962. They dropped the idea that budget votes should be taken by qualified majorities. They also dropped the suggestion that major financial decisions should be taken betwcen member states' governmcnts themselves, so bypassing the ESRO Council. On the other hand they were emphatic on the necd to keep ceilings. ESRO, they proposed, should have an eight-year envclope set by a unanimous vote of the Council and, within that envelope, triennial ceilings, also set by a unanimous vote of the Council. The Council could then set the annual budget of the organization within each three-year ceiling by a simple two-thirds majority. The British were also emphatic that the original estimate put forward by the STWG for an overall eight-year expenditure of 1500 MFF should not bc exceeded. They rcalized that the proposed scientific programme may not be fcasible within this cnvelope but, they insisted, if that were the case it would simply have to be reduccd.

In the subsequent debate on these revised proposals, the scientists strongly objected to the idca that thrcc-year ceilings should be set by a unanimous Council vote. This procedure, they argued, could effectively paralyze the workings of the organization. By contrast, they were far less concemed about the leve1 of the overall eight-year ceiling. An ad hoc committee of experts chaired by van de Hulst was asked to report on the British proposals. “It is considercd improbable but not impossible that the approximate programme as outlined in the *Blue Book,* can actually be carried out within the adopted ceiling of 1500 million French francs,” the committee reported to the COPERS Council. “If it could not”, van de Hulst’s group added, “the consensus of opinion was that a programme thus reduced would stil1 yield valuable scientific results [. . .] .”

It goes without saying that the British triumphed at the conference of plenipotentiaries held to sign the ESRO Convention and a number of associated protocols on 14 June 1962. The conferencc adopted an overall eight-year cciling of 1500 MFF (306 million accounting units or MAU)[15] at pricc levels ruling at the date of signature of the protocol. Against the advice of the scientists it was also agreed that, within this lcvel, the Council would determine every third year by unanimous decision of all mcmber states the level of resources for ESRO for the succeeding three-year period. This was set at 384 MFF (78 MAU) for the first three years of ESRO and a provisional ceiling of 601 MFF (122 MAU) was agreed for thc second three-year period after the entry into force of the convention (all in 1962 pricc levels). The annual budget was to be adopted within these limits by a simple two-thirds majority of the Council.

The ESRO convention entered into force on 20 March 1964, three weeks aftcr ELDO's. The founding states were Britain, France, (West) Germany and Italy, Belgium and the Netherlands, Swedcn and Dcnmark, and Spain and Switzerland. Austria and Norway had obscrver status.

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Two factors lay behind the British govemment’s determination to impose a ceiling on ESRO's expenditurc, and to ensure that it was binding on the organization. The first, based on their experience at CERN, was the need to restrict the power of the ESRO Council. The second was their estimate, made towards the end of 1961, of the maximum acceptable levels of UK expenditure on space scicnce at both the national and the intcmational levels for the next six to eight years.

Ever since 1957 thc British govemment had been trying to impose two or three-year ceilings on expenditurc at CERN. Their proposals were greeted with widespread hostility both by the high-energy physics community and by many of the member states’ delegates. They insisted that it was impossible to predict thc costs of rescarch in advance, and that the policy of ceilings would stifle the growth of the laboratory. Matters came to a head towards the end of 1961. On the one hand thc British Trcasury had found that its CERN Council delegates were unablc to persuade their

[15] One MAU was defincd as the value of 0.88867088 grams of fine gold, and at the time was equivalent to 1 U.S. dollar.

collcagucs to accept a firm and binding ceiling policy. At the same time there was increasing pressure inside thc laboratory, and from some of the member states, to have the laboratory grow annually at thc rate of about 8% in rcal terms. Frustrated by their impotence, the Foreign Office took thc unprccedented step for CERN of approaching other governments directly, and suggesting that the leve1 of thc CERN expenditure should be settlcd between them, leaving the Council simply to vote the annual programme within these limits. This attempt to bypass the CERN Council was violently rcjected at a meeting of that body in December 1961, and the British had to step down.

The UK's various proposals within ESRO were articulated in parallel with these moves. What thc British govcrnment had leamed from its experience in the Geneva laboratory was that firm ceilings should be legally enshrined in the convention establishing any new scientific facility working at the leading edge of research and development, along with mechanisms for ensuring that those ceilings were enforccd. The unpopularity of qualified majority votes, as well as of the idea that the Council of the organization should be bypassed in major financial decisions, led them to modify their original proposals for ESRO. The solution that they came up with, and which was accepted by the COPERS Council, was one which was more than satisfying from their point of view. Thc power to set annual budgets was left in the hands of the Council, but it was heavily circumscribed by establishing a series of ceilings over which any member state had the power of veto.

Britain’s determination to stick to the ceiling of 1500 MFF, with expenditure limited to about 240 MFF in the last three years of ESRO's life, was effectively a response to proposals made by Massey as early as July 1961. Indeed, the basis for British planning was the first set of estimates drawn up by the STWG in summer 1961. Massey submitted these to the British National Committee for Space Research as a basis for calculating the UK's contributions to the cost of the future European organization. The figures were passed on to the government machinery, from which they emerged more or less unscathed at the end of 1961, and with the ceiling of 1500 MFF for ESRO as “sacrosanct” in British eycs.

It remains, of course, to ask why the other members of the European space science community accepted this cciling for their programme with relatively little opposition, and despite the misgivings of the bureaucrats in the budget subgroup. Three main reasons may be adduced for this. Firstly, it must not be forgotten that at this time the Europcan space science community was relatively young and inexpetienced. They had, as van de Hulst has stressed, a sense of euphoria as they saw the various elements of their future organization being put in place. And they were more or less prepared to accept whatevcr they could get (Lust). Secondly, as we have mentioned before, whcn ESRO was set up the leaders of this community were absolutely emphatic that it should not compete with their national space programmes. Their willingness to see ESRO's expenditure restricted, in other words, was simply part and parcel of their determination to build up and defend a national inhouse capability. Finally — and this point is related to the previous one — there was the offer from NASA to enter into bilateral agreements with national bodies for flying scientific satellites. ESRO was not the only means whereby space scientists could achieve their objectives. In fact cooperation with NASA actually offered them at this stage a quicker and perhaps more reliable way of entering the space field. It is hardly surprising then that the space science community did not fight to extract every possible penny they could from the member states when ESRO was set up.

3. The organization and functioning of ESRO

3.1. The establishments

3.1.1. The definition of the facilities and the choice of their sites[16]

The scientists who drew up the first plans for ESRO in 1960 and 1961 were more or less unanimous on the main facilities which they required. These were

- ESTEC, the European Space Technology Centre, originally called the Payload Engineering Unit. This was to be the core of ESRO. Its main task was to be responsible, either itself or through placing contracts with industries and with national research institutes, for the engineering and testing of satellites and their payloads, the integration of scientific instruments into these payloads, and for making arrangements for launching;

- ESRANGE, the facility for carrying out a sounding rocket programme in the auroral zone. Sounding rockets were particularly suited to this as auroral phenomena were of a transient nature. It was more or less taken for granted from the start that this rocket launching range would be based at Kiruna near Hultqvist's geophysical laboratory;

- ESTRACK, a network of tracking and telemetry stations which would control the spacecraft once in orbit and serve as receptors for data transmitted back from the satellite; and, fourthly,

- ESDAC, the European Data Analysis Centre, whose task it would be to predict and analyze satellite orbits in anticipation of the launch, as well as analyzing and processing the data received through the tracking network once the satellite was operational.

There was also a headquarters building, which would house the Director General and his staff, and which would be responsible for the overall administration of the organization.

The striking omission from this list is the construction of the scientific payloads themselves, the apparatus required to perform space experiments using sounding rockets and satellites. Indeed, the initial idea was that no provision should be made for this inside the organization itself. The

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[16] For this section see Krige (1993a), sections 2 and 3. See also Russo (1992a), pp. 10-15.

experimental work was divided into three categories depending on the source of funding. There were to be pure ESRO expcriments, typically those for large satellites. There were to be combined ESRO and national experiments, which were expccted to be the norm. And there were to be purely national experimcnts, in which ESRO might be asked to help, say, with the launching, but not expected to contributc financially even to that. In all cases the construction of the scientific payload, even when paid for entircly by ESRO, was to be under the control of national groups. To cover these costs, the scicntists said, member states needed to providc an additional 16 MFF for their national groups, over and above their contribution to ESRO.

This reduction of ESRO to what was essentially a service function for the European space science community was widely, though not unanimously, accepted inside the scientific community during 1961 and 1962. Several influential members felt that the organization should have a scientific function in its own right, and proposed two main ways in which it could achicve this. On the one hand, it could do basic theoretical and experimental work on processes occurring in the atmosphere. On the othcr, it could have an inhouse staff which, as at CERN, could compete or combine with national groups and fly experiments on sounding rockcts or satellites. This latter option was felt to be particularly important for scientists in some of the smaller member states, who did not have the neccssary infrastructure and resources to build scientific experiments on their own.

The main objections to thcse ideas were spelt out eloquently and explicitly by the director of Kiruna. Hultqvist feared that if ESRO built up a strong inhouse staff it would drain away the best brains from the national ccntres. These scientists and engineers would rapidly become a privileged group with a monopoly over the best cquipment and so, automatically, with more ready access to spacc on satellites. The policy would also lead to an unhealthy concentration of resources in one centre, rather than a more even distribution among many participating countries. After a “long and difficult discussion” it was finally agreed that an additional laboratory be set up near ESTEC to do scicntific research. Labelled ESLAB, its tasks were defined in the *Blue Book* as “to undertake theoretical studies and fundamental theoretical research of importance to space science” and “to providc experimental facilitics to enable individuals and smal1 institutions to undertake research in spacc science.” The staff was so defined in the *Blue Book* as to be below the minimum which the scientists felt was necessary to prepare experiments to fly on satellites.

By October 1961 several member states had made bids for some of the more technically important and prcstigious of these facilities. France (Paris) and the Netherlands (the Hague) were intcrested in hosting thc headquarters building. Belgium and the United Kingdom offered sites for ESDAC. And six countries (Francc, Britain and Germany, Belgium and the Netherlands, and Switzcrland) were willing to host ESTEC, the most important facility of all.

To choose between these sites the COPERS Council originally proposed that a working group be set up to explore the various offers. In the event this scheme was dropped "in view of the delicate nature of the matter". Instead Odd Dahl, a Norwegian engineer who had also been extremely active in the launching of CERN, was invited to make proposals as to the geographical location of the sites.

Dahl initially interpreted his task as being to find a compromise suitable to as many of the member states as possible. However, as he made his tour of European capitals, he found the number of candidate sites increasing rapidly, apparently "on the assumption that something is better than nothing", as he put it.

In drawing up his recommendations about the distribution of the sites, Dahl distinguished between three main questions. These were: whether the sites should be concentrated or dispersed, whether ESRO's headquarters should be close to ELDO's headquarters or not, and whether or not it was dcsirable to put ESRO's headquarters near to ESTEC. There were no ambiguous arguments one way or the other. Cost, efficiency and the possibility of making a quick start to the European space effort favoured concentrating the establishments; the obvious desire of each member state to have a site on its soil favoured dispersion. The advantages of sharing certain administrative functions bctween ESRO and ELDO favoured placing the headquarters close to each other; the very different structurcs of the two organizations favoured dispersion. The advantages of having close links between the administrative arm of the organization and the engineers in ESTEC who would be placing hundreds of contracts in industry favoured situating ESRO's headquarters adjacent to the payload engineering unit; the belief, particularly strongly held by the British, that ELDO headquartcrs should be near to ESTEC confused the issue, since many also felt that ESRO's and ELDO's headquarters should be kept well away from one another.

When Dahl came to frame his proposals it was generally agreed that ELDO's headquarters would be in Paris. He thus opted for what he called moderate concentration. He proposed that ESRO's headquarters, along with ESTEC and ESLAB should be on the site proposed by the Netherlands in Delft. ESDAC, he suggested, should be located on German soil in Darmstadt. The report was laid before a joint meeting of the COPERS Bureau and the heads of the member state delegations on 26 and 27 March 1962 — and was summarily dismissed. While paying tribute to Dahl for the work that he had done, those present felt that it did not provide an appropriate basis for discussion. Whereupon several rounds of hard bargaining and politica1 horse-trading began.

We have no way of following the details of these negotiations with the documents presently at our disposal. Instead we can simply try to reconstruct rationally the sequence of events. Firstly, it was generally agreed that ESRO headquarters should also be in Paris, and close to ELDO's. The French were keen to have them there, and were willing to withdraw their bid for a site for ESTEC in return. This reduced the choice for ESTEC to five sites, in Britain, Switzerland, Italy, and each of the two Low Countries, Germany having withdrawn its candidature in favour of concentrating its efforts on winning ESDAC. There was little support for any of these first three candidates, and so thc choice of ESTEC came down to a straight contest between the site proposed by the Dutch in Delft and that proposcd by the Belgians in Brussels. A vote was taken at a meeting of heads of delegations in April 1962, and the Dutch pipped the Belgians at the post by six to four. The choice for ESDAC was between Darmstadt and Commugny, near the Observatoire de Genève in Switzerland. Two-thirds of those who votcd favoured the former location.

These difficult negotiations were complicated at the last minute by the fact that Italy, finding itself marginalized and without a site on its soil, made a bid for ESLAB. This move was most unpopular because the draft of the convention, agreed on after months of deliberations, specifically stated that ESLAB had to be near ESTEC, and there was no suggestion that ESTEC should be in Italy. The deadlock was broken by Broglio suggesting that his country would be satisfied to host a laboratory which need not in fact be ESLAB, but a research facility with a rather different focus. There was little that the COPERS delegates could do but to accept the Italian position: the altemative was to reopen lengthy and protracted negotiations virtually on the eve of the planned conference of plcnipotentiaries which had been called to sign the ESRO convention. Thus was bom ESLAR (later rcnamed ESRIN): a laboratory for advanced scientific research.

3.1.2. Scttling in: a long and difficult process

3.1.2.1. Choosing a new site for ESTEC

Thc decisions taken in 1962 on the facilities and sites of the ESRO establishments were far from final. Thc activities of ESLAR had stil1 to be defined and a suitable site found for it in Italy. The role of ESLAB was stil1 unclear. A network of tracking and telemetry stations stil1 had to be agreed upon. Indeed, of thc scientific centres only the location and function of ESTEC (at Delft) and of ESRANGE (at Kiruna) seemed scttled. And even here there were soon to be dramatic developments, in particular rcgarding the location of the payload engineering unit.

The difficulties of siting this unit 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 leaming tumed 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. Abovc all though there was thc problem of the stability of the soil in the polder on which ESTEC was to bc built. “I know now why thc cows are always running on thc land offered to US by the

Dutch," Freddy Lines is reputed to have joked to Jean Mussard, a senior colleague in the COPERS secrctariat. "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 metrcs 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, concludcd thc experts, a site on coastal sand was preferable. It would be "more predictable in terms of foundations and more flexible in terms of intemal modifications and extensions [...]."[17]

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. On the other hand, the proximity to the sea created additional concems regarding the effects of salinity and of blowing sand on delicate apparatus. [18]

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 genera1 disillusion among the member states' delegates over the inadequacy of the acccpted location in Delft. Spain and Belgium were particularly militant, insisting that the whole question of the site should be reopened and, if necessary, another confcrencc of plenipotcntiaries held to settle the issue. Council chairman Massey, on the other hand, strcssed thc delays to the build-up of the organization, and the dangers to staff morale and to ESRO's rcputation, 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 peoplc were laid at Noordwijk.[19]

3.1.2.2. 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 Auger years. 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 cxpanded bctween 1964 and 1966, though never fully clarified. To give the laboratory an

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[17] See ESRO/C/12, rev. 1, 5/6/64; Lines (1966).

[18] Sec ESRO/C/43, 10/7/64 and ESRO/C/53, 28/9/64.

[19] For the Council dcbates see ESRO Council, 2nd session, 15-17/6/64, ESRO/C/MIN/2, 8/7/64; ESRO Council, 3rd session, 28-9/7/64, ESRO/C/MIN/3, 2/9/64; and ESRO Council, 4th session, 22/10/64, ESRO/C/MIN/4, 4/11/64.

identity of its own and to attract top-quality scientists who could liaise effectively between national groups and ESTEC engineers, it scemed essential that ESLAB do advanced scientific research inhouse. This of course conflicted with the conviction, strongly held in some quarters, that a powerful inhouse scientific staff with its own research programme would have a major competitive advantage over national groups.

The first forma1 steps towards placing senior scientific staff in the laboratory attached to ESTEC were taken in June 1964. At this time the plans for the sounding rocket programme and the payloads for the first two smal1 satellites, ESRO-1 and ESRO-11, were well under way. The project scientists whose task it was to providc 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 crcated in or near ESTEC to ensure coordination with the technologists in the preparation of payloads. Later that year the role of the laboratory 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 (as just explained), and coordinating the work on scientific payloads for the LAS, the large astronomical satellite (the "British" UV telescope to be funded by ESRO). To implement this scheme it was understood that it was essential to provide the top scientists at ESLAB with opportunities for doing thcir own research for as much as 50% of their time.[20]

But what research were they to do? In an idcal 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 his national facility.[21] 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 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 thc recommcndations of the Bannier report (see section 3.2) ESLAB became a fourth department of

[20] For this paragraph sec ESRO/C/34, 16/6/64; ESRO/C/110, 18/3/65; ESRO/C/125, 13/7/65; ESRO Council, 2nd session, 15-17/6/64, ESRO/C/MIN/2, 8/7/64; and ESRO Council, 5th session, 25-26/11/64, ESRO/C/MIN/5, 11/1/65.

[21] For the dcbatc about the LAS programme management see Krige (1992b). See also ESRO/ST/158, 26/10/65 and the comments by the Danish and Italian delcgations on this paper, ESRO/ST/158, add. 1, 10/2/66, and ESRO/ST/158, add. 2, 10/3/66. See also ESRO/ST/182, 28/1/66 and accompanying paper ESRO/C/178, 11/3/66.

ESTEC. It was renamed the Space Science Department and E.A. Trendelenburg was nominated its dircctor.[22]

3.1.2.3. Dcfining the characteristics of ESLAR/ESRIN

Whcn Italy originally made its unexpected bid for an advanced research laboratory on its soil, it had an ambitious programmc of activities in mind. It was proposed that ESLAR (as it was then called) set up groups to explore, e.g., the feasibility of planetary probes and to study drag-frce unrelativistic satellites. The basic theoretical and experimental research required for these programmes was also indicatcd, and includcd studies on advanced systems for cnergy conversion, on smal1 nuclear rockets for satellite stabilization and control, and on scientific spacecraft shapes 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 Council chairman Massey, so that whcn ESRO came into bcing ESLAR's function was defined as being "to undertake laboratory and theorctical research in the basic physics and chemistry necessary to the understanding of past and thc planning of future experiments in space." Subsequently considerable stress was laid on plasma physics studies, the characteristics of a plasma most ncarly corresponding, on a laboratory scalc, to those of space.[23]

The first dircctor of thc European spacc research institute (ESRIN), H.L. Jordan, was appointed on 29 July 1964. The two most eligible sites for his laboratory were near Florencc, which had an important centrc in astronomy, and which was preferred by the Italian delegation, and near Rome at Frascati. 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 Florence bccause of this concentration of establishments with similar interests, and the Italian dclegation reluctantly rcspccted his wishcs in March 1965.[24]

Ninc months later a smal1 group of five scientists, six technicians and four administrators were installcd in temporary accommodation in the Park Hotcl ncar Frascati. They quickly arranged their first conference on plasmas in spacc and in the laboratory to bc held in May that year. It took some timc to find a pcrmancnt sitc for the laboratory — indced the comerstonc for its new building was only laid in Scptcmbcr 1968.[25] ESRIN was always the Cinderella of thc ESRO establishments.

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[22] For this paragraph see Manno *et al* (1968), and ESRO/AF/613, 15/11/66, ESRO/C/251, 29/11/66, and ESRO/C/266, 14/2/67 on the fire at Noordwijk.

[23] See COPERS/89 (rev. 1), 9/5/62, and Massey and Robins (1986), Annex 12.

[24] See ESRO Council, 5th session, 25-26/11/64, ESRO/C/MIN/5, 11/1/65 and ESRO Council, 6th session, 24-25/3/65, ESRO/C/MIN/6, 14/6/65.

[25] Scc Jordan (1968).

Its dircctor ncvcr had the status of those of ESTEC or ESDAC, for example, and its new buildings were hardly complctcd before there were serious proposals that the facility be closcd down. In the event it survived, but only with a sharp reorientation in its mission.

3.1.2.4. 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 intcrests, along with a passionate determination by member states' delegates to control costs, impcded the rapid establishment of the network.

The network foreseen for thc first phase of ESRO's programme consisted of four stations: at Rcdu, in the Belgian Ardennes, which was to be used for both tracking and tclemetry, at Fairbanks in Alaska, at Spitzburg in Norway, and on the Falkland Islands off the coast of Argentina. Only the first of these was set up without considcrable difficulty. The Frcnch consistently opposed the site in Norway, which was not an ESRO member state, and strongly rescnted the escalation in the costs of the facility. 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 thc fccling in the Council that the case for the station had not been propcrly prepared by the ESRO sccretariat, which was anxious to gct a site in the region approved quickly in anticipation of the launch of ESRO-1 and ESRO-11. Politically, there were repeated objcctions from Spain against ESRO funding a station in, what it said, was a country with disputed sovereignty. Despite these difficulties thc Council managed, in March 1966, to agree to insta11 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. Thc French let the matter pass at the time, but within a month the Ministry of Forcign 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 vcry 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.[26]

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 somc Council delegates, were most unhappy about this. NASA's demand, they

[26] Scc ESRO/C/171, 9/3/66; ESRO/AF/472, 19/4/66; ESRO/C/203, 22/6/66; ESRO/C/236, 23/11/66; ESRO/C/254, 15/2/67; ESRO Council, 10th session, 24-25/3/66, ESRO/C/MIN/10, 10/6/66; ESRO Council, 11 th session, 22-24/6/66, ESRO/C/MIN/11, 15/7/66.

felt, violated their intellectual property rights, as well as ESRO's arrangements with its own experimenters. After lengthy negotiations a compromise was reached (see section 3.4). 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.[27]

Another important development during the Auger years regarding ESTRACK concerned the site of its control centre. Staff at the centre liaised closely with the scientific project teams during the development of a spacecraft. Their computers were the heart of the telemetry, telecommand and tracking station network, through which they monitored the satellite during its working life. And the scientific data obtained from the spacecraft were first sent to the control centre where the analysis and other work necessary for it to perform its operational task were carried out. Only then were they transferred to ESDAC for further study.

ESRO's control centre was initially situated at ESTEC in order to be close to the scientific users. The commission under Bannier which was set up to study the internal structure of ESRO found this arrangement unsatisfactory. The close connection between much of the work of the control centre and of ESDAC implied that they should be on the same site. Recognizing that it would be impossible to move ESDAC to Noordwijk, which Bannier thought would be much the better solution, it was proposed that the control centre be moved to Darmstadt. There it would be placed under the direct responsibility of the director of what would now be called ESOC, the European Space Operations Centre. The Council supported this recommendation and by the end of 1967 ESRO's control centre had been transferred to Germany.[28]

3.2. *The legislative and executive arms of ESRO and the Bannier reforms*

3.2.1. The "legislative": the decision-making system[29]

ESRO's committee structure was very similar in conception to that of CERN. The supreme governing body, the Council, was advised by an administrative and finance committee (AFC) and a scientific and technical committee (STC). The latter in turn considered recommendations laid before it by a launching programme advisory committee (LPAC). The LPAC's task was to define an appro-

[27] For the debate on the Falklands see ESRO Council, 12th session, 18-20/7/66, ESRO/C/MIN/12, 1/9/66; and ESRO Council, 14th session, 30/11-2/12/66, ESRO/C/MIN/14, 20/1/67.

[28] For the above material see Fraysse (1966) and Tootill(1967). The Bannier report is document ESRO/C/APP/48, 29/3/67.

[29] For what follows see Russo (1992a), 22-27; ESRO (1966); and the Bannier report, document ESRO/C/APP/48, 29/3/67, section 11.3. See also ESRO Council, 1st and 2nd sessions, 23-24/3/64 and 15-17/6/64, ESRO/C/MIN/1, 21/4/64 and ESRO/C/MIN/2, 8/7/64.

priate scientific programme in thc light of proposals it rcceivcd from a number of working groups (roughly equivalent to CERN's cxperiments committees) whosc members were specialized in different ficlds of space science.

Each member state had one vote in the Council, where it could be represented by not more than two delegates, one of whom was generally a scientist, the other an important national science administrator. The main tasks of the Council were to determine the organization's scientific, technical and administrative policy, to approve its programme and annual workplans, and to determine its leve1 of resources both annually, and cvery third year for the subsequent three-year period. The AFC, which was composed of member states' delegates drawn from the appropriate positions in national burcaucracics, advised it on legal, administrative and financial matters. It also took decisions in some key arcas, notably on the award of contracts to industry. Thcre was some debate over the composition of thc STC. Whcn ESRO was formed it was suggested that scientific and technological matters be split from one another. This was because, in the light of the expcrience 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 cxpense of scientific debate, so proving a somewhat unattractive committee to the best scientists in Europe.[30] In the event this proposal was rejected. ESRO's STC, unlike CERN's SPC (Scientific Policy Committee) was inevitably "politicized". The members of CERN's SPC were chosen esscntially on merit. The delegates to ESRO's STC were not only scientific experts but also reprcsentatives of their membcr states, two roles which could easily be in conflict with one another.

The LPAC was a smal1 body of four or five scientific experts 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 resourccs available. The experimental proposals considered by the LPAC were lùnnelled to it by six ad hoc groups representing various disciplines in the field. When ESRO was set up the structure of these groups differed slightly from that of the COPERS. COPERS had had eight such groups, and it was felt that this was excessive. One of thcm, that dealing with geodetics, relativity and gravitation, was suppressed. Another, dealing with mcteorology, was merged with the group responsible for atmospheric structure studies, labclled ATM. In addition to the ATM group ESRO had groups dealing with ionospheric and auroral phenomena (ION), with solar astronomy (SUN), with the moon, planets, comets and the interplanctary medium (PLA), with stars and stcllar systems (STAR), and with cosmic rays and trapped radiation (COS).

This division into groups reflectcd the rapidly evolving state of space research at the time. Spacc science can be divided betwcen disciplines interested in the earth's atmosphere and the sun-earth relationship (roughly speaking, geophysics) and those interested in the study of celestial bodies

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30 See ESRO/C/4, 21/3/64.

(astrophysics). The ION group chaired by B. Hultqvist, was one of the most important in the former catcgory, and since it required relatively smal1 and simple spacecraft to explore the properties of the ionospherc it rapidly rose to prominence in the early 1960s. Thc astronomers were more heterogeneous. The advent of the space age offered thcm the opportunity to study the moon and planets at close range, and to explorc sources of electromagnetic radiation from celestial bodies at wavelengths which were absorbed by the upper layers of the earth's atmosphere, notably UV and X-radiation. The PLA group, chairman L. Biermann in 1964/5, was somewhat disadvantaged in having to compete with major planetary missions in the superpowers. The STAR and SUN groups, chaired by P. Swings and C. de Jager, would concentrate on UV astronomy. X-ray and gamma-ray astronomy, which required the use of detector techniques drawn from experimental physics, opened the domain of astrophysical research to cosmic ray physicists. Through the COS group, chairman G. Occhialini, they became one of the most dynamic and successful users of ESRO.

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Within a little over two years of ESRO bcing 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 vcnue of a proposed summer school and the design of a suitable emblcm 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 inhouse. Time and again the secretariat 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 intemal staff structure and complements were causing concern and indced a special committee headcd by the Dutch AFC delegate Dr. Ferrier advised on this issue very soon after ESRO officially came into being. Finally the organization's expenditure profile was tilting heavily in favour of administrative expenses. In 1963 it had been agreed that intemal expenditure should not exceed 45% of total expenditure. By mid-1966 it had climbed to 50%, placing enormous pressure on the operational programme.

In rcsponsc to what was perceived to be a "state of crisis" in the organization the Council, at its twelfth session in July 1966, set up a group of experts to study the intemal 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 organization 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.[31]

[31] For this paragraph and for what follows see the Bannier report, ESRO/C/APP/48, 29/3/67, as well as ESRO/C/192, rev. 1, 21/7/66.

The most important proposal made by the Bannier commission, as summarized by the chairman himself in onc phrase, was "delegation of authority". There was a "crisis of confidence" in ESRO, Bannicr wrote, because there was not a clear enough distinction between the legislative and executive arms of the organization. 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 organization and to concentrate on certain, particularly important executive tasks, notably the adjudication of certain contracts, the authorization 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 practica1 recommendation which Bannicr 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 proposcd 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 concemed the functions of the LPAC and STC in the decision-making process. The LPAC, it was suggestcd, should put its proposals directly to the Directorate, rather than having them funnelled through the STC. It would then be up to the Dircctorate to draw up a proposed programme for the organization 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 thc LPAC and the STC. At the same time he aimed to give the STC thc status of an independent and "objective" judge of ESRO's scientific programme. Its membcrship, he proposed, should no longer be based on national representation but solely on recognized expertise in the scientific and technical aspects of the programme which the organization was following at any given timc. All of the Bannier group's proposals for streamlining the committee structurc of ESRO were welcomed bar this one. In mid-1967 the STC decided to maintain the status quo rcgarding its composition and its own terms of reference.[32]

[32] See ESRO/C/303, 27/7/67 and ESRO/C/306, add. 4.

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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 organization. His insistencc 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 genera1 desire to roll back the influence of member state bureaucracies and their interests in the functioning of the organization. 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 organization. Now that the body was established though, it was essential that the reigns be loosened, that confidence be place in the Directorate, and that its newly granted executive authority be supervised by proper forward planning and careful *a posteriori* control.

It is striking that Bannier failed to achieve his objectives as far as the STC was concemed. For it cannot be doubted that in these years it was extremely difficult for the Directorate and the Council to have neutral advice on the content and direction of the scientific programme. Table 2 shows the extent to which a relatively smal1 group of 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 concemed. As scientists they competed to have their preferred scientific payloads flown. As national representatives they competed to protect the interests of thcir 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 thc "political" exigencies of the national bureaucracies. Banmer’s failure to push the system towards greater “objectivity” was indicative of the determination of scientists and of their govcmments alike to fight for every kilogram of a satellite payload.

3.2.2. The executive: ESRO's intemal structure

The Council and its committees apart, the Bannier commission made a number of important recommendations regarding the intemal organization of ESRO. Their thinking was shaped by two main considerations. Firstly, they were emphatic that the executive function of the organization should be clearly scparated from the policy and the planning function. Secondly, as far as the scientific programmc was concemed, they recommended that there be a clear institutional distinction drawn between spacecraft development and spacecraft operation after launch.

Table 2 Overlap in national delegates to the ESRO Council, the STC, the LPAC, and the LPAC Working Groups. The key criterion for inclusion is that one be a scientist and a member of the STC. The list is not **quite** complete, though **all** major figures are included. (Source: **Annexes** to ESRO Genera1 Reports)

Year	**Name**	**Country**	**Council**	**STC**	**LPAC**	**LPAC Wkg. Groups**
1964/65	J.Blamont	F	-	Delegate	Member	ATM
	B.Bolin	S	-	Delegate	-	ATM
	R.Boyd	UK	-	Delegate	Member	ION, SUN
	J.Coulomb	F	Delegate	Delegate		
	C.de Jager	NL	-	Delegate	Member	SUN (Ch), STAR, PLA
	M.Golay	CH	Vice-Chrman	Delegate		STAR
	L.Gratton	I	-	Delegate	-	STAR
	L.Hulthén	S	Delegate	Delegate		
	B.Hultqvist	S	-	Delegate	-	ION (Ch)
	R.Lüst	FRG	Delegate	Chairman	Chairman	
	G.Occhialini	I	Delegate	Delegate		COS (Ch)
	B.Peters	DK	Delegate	Vice-Chrman		COS
	H.van de Hulst	NL	Vice-Chrman	Delegate		

Year	**Name**	**Country**	**Council**	**STC**	**LPAC**	**LPAC Wkg. Groups**
1966	J.Blamont	F	-	Delegate	Member	ATM
	J.Coulomb	F	Delegate	Chairman		
	C.de Jager	NL	-	Delegate	Member	
	M.Golay	CH	Vice-Chrman	Delegate		STAR
	B.Hultqvist	S	Delegate	Delegate		
	R.Lüst	FRG	Delegate	Vice-Chrman	Chairman	
	G.Occhialini	I	Adviser	Adviser		
	B.Peters	DK	Delegate	Delegate		COS (Ch)
	P.Swings	B	-	Delegate	-	STAR (Ch), PLA
	H.van de Hulst	NL	Delegate	Delegate		

Year	**Name**	**Country**	**Council**	**STC**	**LPAC**	**LPAC Wkg. Groups**
1967	J.Coulomb	F	Vice-Chrman	Delegate		
	M.Golay	CH	Delegate	Delegate		STAR
	L.Gratton	I	Adviser	Delegate	-	STAR (Ch)
	L.Hulthén	S	Delegate	Delegate		
	B.Hultqvist	S	Adviser	Delegate	-	ION
	R.Lüst	FRG	Delegate	Vice-Chrman	Chairman	
	G.Occhialini	I	Adviser	Delegate		
	B.Peters	DK	Delegate	Delegate		COS
	H.van de Hulst	NL	Delegate	Chairman		

To achieve these objectives the Bannicr group suggested that ESRO's top management structure be complctely changed. Between 1964 and 1967 the ESRO Directorate, in addition to the Dircctor Gencral, was composed of an administrative director (M. Depasse), a scientific director (B. Bolin) and a technical director (A.W. Lines). The directors of ESRIN, ESDAC and ESLAB reported to the scientific director, the director of ESTEC reported to thc technical director. This dichotomy bctwecn scientific and technical dircctorates was, in Bannier's view, wrong in principle for an organization like ESRO. To overcome it he suggested that the two posts be abolished. In its stead a new structure was proposed. It comprised the 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 Plating, whose task it would bc to prepare draft programmes of the organization based on the scientific, technical, financial and time implications of the diffcrent proposals. The second member of the directorate concemed with forward planning would be thc director of administration whose task it would be to prepare policy on the future needs of personnel, finance and contracts, and to organize and implement the necessary procedures to maintain *an a posteriori* control over the organization's functioning. The two posts in the directorate having exccutive authority would be filled by the director of ESTEC and of ESDAC, which was to be rcnamed ESOC, the European Space Operations Ccntre. As for ESRIN, the Bannier group judged its research to be marginal to the major activities of the organization. Its director, they felt, should not be a mcmber of the dircctorate but should rather report directly to the DG.

The Bannicr 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 organization. On the other hand they realized 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 onto geographical oncs. ESRO headquartcrs was to bccome 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 recommcnded that ESLAB be merged with ESTEC and that the satellite control centre be moved from Noordwijk to Darmstadt. Bcing essentially responsible for launch and post-launch operations, ESOC's dircctor would be responsible for ESRANGE and for ESTRACK.

By the end of 1968 thc Bannier group's recommendations on intemal structure had been more or less fully implemented.[33] J.A. Dinkespiler had bccn brought into the new key post of Director of Programmes and Planning. M. Depasse rcmained as Director of Administration. A new dircctor had been appointed for ESTEC (W. Kleen), who replaced M. Schalin, who in turn had brief-

[33] For the debate see rcstricted Council session, 25-26/4/67, ESRO/C/APP/54, 22/5/67, and Council Resolution ESRO/C/XVI/Res. 3, 27/4/67.

ly 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 dircctor of ESRIN. Two deputy directors of ESTEC had also been appointed. One was P. Blassel, the head of thc satellite and sounding rocket department. The other was R. Gibson, who had taken up post in January 1967, and hcaded a grcatly expanded administrative dcpartment whose size reflected the incrcased executive authority of the Noordwijk establishment.

The "geographical" reorganization 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 wclcome there than would have been possible in an establishment the size of ESTEC and basically devoted to technical activities".[34] ESLAB's director, E.A. Trendelenburg, was retained and became the head of what was now called the Space Science Department. The control centre was moved to Darmstadt, the timing being complicated by concerns that it would clash with the launching of the ESRO-1 and ESRO-11 satellites.[35] Finally, as part of the overall "rationalization" 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 organization'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 thc member states to forge a coherent, integrated space policy for Europe.

3.3. *Relations with industry: the geographical distribution of contracts*[36]

When ESRO's convention was first drafted no specific provision was made to distribute the contracts passcd by the organization on a geographical basis. The convention was modelled on CERN's, in which major contracts were awarded competitively, the succcssful bidder being the one who made the lowest offer satisfying the laboratory's technical and delivery requirements. It was the Austrians who suggestcd to thc COPERS that some attempt should be made to ensure that all member states had a guarantced return from the European space effort. As a result, the conference of

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34 See the minutes of the restricted Council session referred to in the previous note.

35 ESRO/C/292, 20/7/67.

36 This scction is based predominantly on the debate surrounding ESRO's financial rules found in document COPERS/AWG/Fin/57, rev. 10, Addenda 1-17, 14/5/65 to 31/8/65 as well as documents ESRO/AF/361, 27/10/61; ESRO/AF/461, rev. 6, 14/11/66; ESRO/C/139, 16/9/65; ESRO/C/139, rev. 1, and rev. 2, 10/3/66 and 4/11/66; and ESRO Council, extraordinary session, 24/9/65, ESRO/C/MIN/8, 19/11/65.

plenipotentiaries which met in June 1962 resolved that "the Organization shall place orders for cquipment and industrial contracts amongst Member States as equitably as possible, taking into account scientilic, 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 debatc in detail. Rather, what we shall do is to identify the key issues which dominated the procccdings betwcen 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 ptinciple. The first conccmcd the range of the contracts over which it should apply. It was obvious that the policy could only bc applied to that part of thc 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 statc 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 fumished the facilities and supplied them with everything from paint to paperclips.[37] 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 concemed the time which should be allowed, and the procedures to be used, to establish rough parity between contributions and contracts. By

[37] Krige (1990) has illustrated the enormous advantages accruing to France and Switzerland in the award of contracts by CERN, which has no principle of just return.

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 authorized since 1962 — about double the Dutch percentage contribution to thc budget. Similarly the French contract/contribution ratio was about two, with the 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 acceptcd 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., a factor of 2) at the end of 1965 should not cxceed 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" mcmbcr statcs 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 exccss 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-mcmbcr states. Thcir industries could stil1 compete for ESA contracts, but their tenders would only be considcred if a substantial scientific or technical advantage, or a substantial price advantage (10-20%) could be obtaincd.

Thc French, with some support from the British, vigorously opposed this idea. Being the country whose space industry was the most likely to be "penalized" for having a "disproportionate" share of thc contracts, it was not at all keen on the principle of just return being applied too rigidly. Ir was also totally against the idea that member states which had exceeded their quotas should be treated as if thcy were non-member states. As an altemative 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 organization'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-1 and ESRO-11. 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.[38]

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 organization 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 Director General 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 the Director General 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. As Table 3 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

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38 For the formation of consortia see Beattie and De la Cruz (1967). See also Schwarz (1979).

previously for compensating inequalities in the geographical distribution of contracts. Whereas until this time the idea had always been to penalize 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. This is a story that we will recount in a subsequent report.[39]

Table 3 Distribution of contracts signed or approved for signature by COPERS and ESRO from 1963 to October 1966, calculated by value using the weighting **factors** agreed on by the **AFC** in 1966 (Source: **ESRO/AF/461,** rev. **6, 14/11/66)**

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	38.9	19.1	2.03
Germany	12.8	12.3	22.6	0.54
Italy	9.7	8.9	11.7	0.76
Netherlands	2.5	6.4	4.24	1.51
Spain	1.1	1.0	2.66	0.38
Sweden	2.2	3.3	5.17	0.64
Switzerland	7.1	6.5	3.43	1.90
United Kingdom	15.8	15.09	25.0	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

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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 technoiogy, its importance should not be exaggerated. As the Secretariat 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

39 See FIN/WP/85, 21/12/67 and ESRO Council, 20th session, 29-30/11/67, ESRO/C/MIN/20, 13/12/67.

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 (see section 5). If compromises were reached after three years of tortuous discussion it was also because the AFC realized that it needed to converge rapidly on a workable system in anticipation of calling for tenders in the potcntially 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 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 centra1 budget. For the majority of the member states, however, the value of contracts was to be assessed *qualitatively*, and not simply quantitavely. 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 charme1 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 thc imposition of weighting factors for different kinds of contracts and indeed to object that the 25% that was finally agrced 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 organizations 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.[40]

3.4. Relations with NASA

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 “suitablc and worthy experiments proposed by the scientists of other countries”. NASA was prcparcd to launch single experiments as part of a larger payload or groups of expcriments comprising an entirc payload. To achieve these objectives it offered a range of assistance, including advising on the feasibility of experiments, hosting foreign scientists in

[40] Krigc (1992c).

American laboratories, and performing the necessary pre-flight environmental testing.[41] This offer was rapidly taken up, and arrangements quickly reached with Britain, France and Italy to fly nationally built expetiments 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.[42]

This wish to collaborate continued once ESRO was set up. A Memorandum of Understanding conceming the preparation, Iaunch and use of ESRO's first two smal1 satellites ESRO-1 and ESRO-11 was signed by Auger on behalf of the European organization 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.[43] 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 authorize the NASA/ESRO project were enough to kill off the scheme.[44]

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 over-shadowed 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 cffort 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 intemational 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 organization. The

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41 For the NASA offer see Massey and Robins (1986), Annex 4.

42 For the San Marco programme see the memorandum submitted by Broglio to the COPERS bureau meeting on 17-18/6/63, Mussard files, Villa Il Poggiolo, EUI, Florence, folder "Bureau".

43 See ESRO/25, 18/7/64.

44 See ESRO/C/199, 16/6/66; ESRO/ST/200, 21/4/66 and ESRO Council, 1 lth session, 22-24/6/66, ESRO/C/MIN/11, 15/7/66.

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, thc availability of American launchers might also have been intended to impede, if not totally stop, Europe developing her own powerful rocket/missile. Earlier we alluded to the wish of certain officials in the Department of Defence 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 usc of NASA's facilities. The enormous disparity of resources, both human and financial, between thc two organizations, necessarily meant that NASA negotiators could impose conditions on their ESRO countcrparts which the latter did not like. The negotiations over the Memorandum of Understanding conceming the fumishing 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 unrestrictcd access to the raw and reduced data from any satellite that it launched, regardless of thc 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 scicntific community found this to be an infringement of intellectual property rights, and a derogation of their responsibilities to the scientific groups who flew expcriments on the satellite, and who obviously wanted prior and undiluted rights of access to the data obtained thercfrom. 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 negotiablc section of this clause, as far as he was concemed, concemed 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 thc intellectual property rights of the scientists.

There was a lesson to be leamed from this. In dealing with NASA it was clear that ESRO would oftcn have to stomach terms and conditions which, it felt, were against its interests. There were cases in which, as the Secretariat 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 programmc under these conditions, even a scientific programme, the Europeans necessarily had to make concessions. Put differently, European "independence" was impossible without a powerful European launcher. It was a point which was not lost on many European govcrnments in the 1960s.[45]

4. *The scientific programme*

4.1. *Sounding rockets*[46]

The first sounding rockcts were launched under the auspices of ESRO from the Salto di Quirra range in Sardinia on 6 and 8 July 1964. A boosted (British) *Skylark* rocket carried a canister which released barium and ammonia "clouds" into the ionosphere. The experimental packages were provided by rescarchers from the Institut d'Astrophysique in Liège and the Max-Planck-Institut für Extraterrcstrischc Physik in Garching. One other launch, somcwhat less successful, was canied out that ycar. A (French) *Centuure* rocket was launched from the Ile du Levant on 30 October 1964 but no useful data werc obtained as the scientific instruments failed.

The number of launches carried out annually climbed gradually during the following years. There wcrc eight in 1965, 27 in 1966, 18 in 1967 and 20 in 1968 (see Table 4). The figures for 1966 are somcwhat misleading as they include nine launches made during a special solar eclipse campaign at Karystos on the Greck island of Euboea. Sevcn rockets, two *Centaures* and five (American) *Arms* werc launched within a narrow time window ccntred on the total eclipse of the sun, while one *Centuure* and onc *Arcas* werc launchcd a few days earlier. With this campaign excluded, we can see that in our period ESRO achieved a steady state of some 20 launches per annum.

Of the 56 launches carried out between 1964 and 1967 almost half — 28 — were dedicated to ionosphcric and auroral studies. Eighteen carried experiments for atmospheric physics, and ten dealt with solar, stcllar and gamma-ray studies. Thirty-onc different experiments were launched, most (23) of thcm twice, as ESRO had a policy of duplicate launchings of each payload. At the other extreme onc experiment was launched no less than 19 times. The major membcr states participating in the programme wcrc the UK (35% of the experimcntal proposals receivcd by 1967), Germany (22%) and France and Swcden (12% of the proposals received). Payloads were assembled both by industry (for 30 rockets) and by ESTEC (26 payloads).

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[45] For the ncgotiations with NASA sce ESRO/C/198, 9/6/61 and Add. 1, 18/7/66; ESRO/AF/548, 7/7/66; ESRO/C/233, 14/11/66. Sec also STC, 10th meeting, 21/6/66, ESRO/ST/MIN/10, 6/7/66 and ESRO Council, 12th session, 18-20/7/66, ESRO/C/MIN/12, 1/9/66 and 14th session, 30/11-2/12/66, ESRO/C/MIN/14, 20/1/67.

[46] This section is based on ESRO Annual Reports, and on Eaton (1989), Jaeschke (1971), and Rocket (1967).

Table 4 Survey of ESRO sounding **rocket** programme from 1964 to 1967 (Source: ESRO Annual Reports)

Pld	Date	Rocket	Range	Result
S01	6/7/64	Skylark	Sardinia	Successful
	8/7/64	Skylark	Sardinia	Successful
C02	30/10/64	Centaure	Ile du Levant	Rocket functioned. Scientific instruments failed
S03	31/3/65	Skylark	Sardinia	Failure. Nose-cone opened prematurely
	3/4/65	Skylark	Sardinia	Successful
S04	30/9/65	Skylark	Sardinia	Successful
	2/10/65	Skylark	Sardinia	Successful
S05	11/8/65	Skylark	Sardinia	Failure. Technical auxiliary equipment failed
C06	14/12/65	Centaure	Sardinia	Partial success. Protective belt for some experiments failed
C07	7/11/65	Centaure	Sardinia	Failure. Nose-cone opened prematurely
	11/12/65	Centaure	Sardinia	Successful
C15	5/2/66	Centaure	Andøya	Partial failure. Telemetry transmitter broke down
	11/2/66	Centaure	Andøya	Failure. Telemetry signal ceased after 6 seconds
C14	22/2/66	Centaure	Andøya	Partial success. Rocket did not reach expected apogee
	24/2/66	Centaure	Andøya	Partial success. Rocket did not reach expected apogee
C13	9/3/66	Centaure	Andøya	Partial success. Rocket did not reach expected apogee
	10/3/66	Centaure	Andøya	Partial success. Rocket did not reach expected apogee
A23	20/5/66	6 Arcas	Karystos	Solar eclipse campaign. 4 rockets succeeded, 2 failed
C22	20/5/66	2 Centaure	Karystos	Solar eclipse campaign. Overall success
C06	20/5/66	Centaure	Karystos	Partial success. Protective belt ejected prematurely
S17	16/6/66	Skylark	Sardinia	Successful
	18/6/66	Skylark	Sardinia	Successful
S08	20/6/66	Skylark	Sardinia	Failure. Telemetry signals stopped after 35 seconds
	28/6/66	Skylark	Sardinia	Successful
S18	8/7/66	Skylark	Sardinia	Successful
	13/7/66	Skylark	Sardinia	Successful
B12	20/7/66	Bélier	Sardinia	Successful
	25/7/66	Bélier	Sardinia	Failure. Parachute not ejected
C21	20/11/66	Centaure	Kiruna	Failure. Nose-cone not ejected
C09	29/11/66	Centaure	Kiruna	Successful
	30/11/66	Centaure	Kiruna	Successful
S 11	26/11/66	Skylark	Sardinia	Failure. Motor failed to ignite and rocket crashed
C 2 1	5/2/67	Centaure	Kiruna	Successful
C10	16/2/67	Centaure	Kiruna	Failure. Telemetry transmitter malfunctioned
	22/2/67	Centaure	Kiruna	Failure. Telemetry transmitter malfunctioned
C24	19/4/67	Centaure	Kiruna	Rocket went off course. Payload recovery 4 weeks later
S11	22/5/67	Skylark	Sardinia	Mostly successful
S05	26/5/67	Skylark	Sardinia	Successful
C20	31/7/67	Centaure	Kiruna	Successful
C32	31/7/67	Centaure	Kiruna	Payload crashed. Some data obtained
D34	4/10/67	Dragon	Andøya	First stage of rocket exploded. Some data obtained
	10/10/67	Dragon	Andøya	Failure. Rocket motor exploded and launcher crashed
D30	7/10/67	Dragon	Andøya	First stage of rocket disintegrated. Some data obtained
S19	4/10/67	Skylark	Sardinia	Successful
	10/10/67	Skylark	Sardinia	Successful
S26	27/9/67	Skylark	Sardinia	Successful
	7/10/67	Skylark	Sardinia	Successful
C13	24/11/67	Centaure	Kiruna	Partial success. Protective belt did not come off
C31	26/11/67	Centaure	Kiruna	Successful
	6/12/67	Centaure	Kiruna	Successful

The *Centaure* and *Skylark* rockets were the workhorses of the programme. They were supplemented in 1966 by the French *Bélier* and *Dragon* rockets. These were used for experiments requiring special facilities such as parachute descent or high altitudes. The limited size of ESRO's own range at Kiruna, which was inaugurated on 24 September 1966, meant that these more powerful rockets could not be launched there. Campaigns with them were thus carried out from the Italian base in Sardinia and the Norwegian base in Andøya.

The most striking thing about these figures is the difference with predicted estimates of the rate of sounding rocket firings. This did not simply happen as regards the inevitably optimistic prognostication made in 1961/1962. It occurred throughout our period. The conference of plenipotentiaries, guided by the *Blue Book*, resolved in June 1962 that ESRO's activity in this area would level off at 65 rockets annually by the third year of its existence (i.e., 1966). This figure was revised down by ten a year later, and to 40 rockets annually in 1966. Half this number were in fact launched in 1967. Yet the optimism persisted. In official figures published at the end of that year 39 launches for 1968 were announced, 32 of them from ESRANGE. In fact there were only 20 launches in 1968, 14 of them from the Kiruna base and the remainder from Salto di Quirra. The envisaged scientific programme suffered accordingly, of course. In fact, of the 172 experiments submitted and allocated to payloads at the end of 1967, only 39 had actually been launched.[47]

There is no single or simple reason for this slippage. There were teething troubles with the rockets, notably the French *Centaures* and *Dragons* (see Table 4). These caused some experiments to be postponed and others to be abandoned. The payloads became increasingly complicated both technically and organizationally. Scientists increasingly called for stabilization, attitude control, and payload recovery, and there was a trend towards flying two or more experiments from different institutions in different member states. There were corresponding budgetary difficulties. The all-in cost for payload and components, estimated at 108,000 FF in 1963, was averaging about 350,000 FF in 1967.[48] There were staff problems. The failure to recruit personnel at ESTEC for payload assembly caused delays and more payloads than anticipated had to be contracted out to industry. There were also difficulties at the ranges. In 1965 there was a conflict over the use of the telemetry station at Sardinia, and one of ESTEC's payload engineers was excluded from the site.[49] ESRANGE imposed constraints of its own. 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.

[47] See Rocket (1967), table 4.

[48] See ESRO/C/283, 22/5/67.

[49] See ESRO/ST/140, 30/9/65.

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 frequent failure.

It is a corollary of this that a spirit of companionship and of solidarity was built between the "rocketeers". This was stil1 "little science", with relatively smal1 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 al1 the ingredients for building a community tied togcther by strong bonds of professional and personal allegiance. They shared a spirit of adventure, heightened by the feeling that they were the underdogs in an organization 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 elements of this "rationality" were already beginning to emerge towards the end of our period. On the basis of the experience gained during these first trying years, the successful launch rate doubled from 38% in 1965 to 67% in 1967 and continued to climb. In addition in the late 1960s an attempt was made to iron out the inefficiencies resulting from a failure to take launch requirements into account, in addition to cost and scientific merit, when defining a launching programme. Such steps were unavoidable as the sounding rocket programme became increasingly sophisticated and costly. But they were taken at a price. Sounding rocket activity was depersonalized, and its pioneers could only look back with nostalgia on those early days in which, together, they had laid the foundations for a European space science community.

4.2. *Satellites*

It will be remembered that the conference of plenipotentiaries agreed in June 1962 that ESRO should aim to launch 17 satellites beginning from the fourth year of its life (i.e., 1967). Initially it would place two or three smal1 satellites per annum in orbit, this number increasing to four per annum, including space probes and large satellites, in the last two years of the first eight-year period. These figures were to be pared down dramatically in the years to come, just as with the sounding rockets.

Before exploring the evolution of the scientific programme it is important to stress that the acceptance of a satellite by ESRO was a long process involving frequent and repeated interactions between scientists, engineers, industry and the decision-making mechanism of the organization. Schematically the process began when the ad hoc groups of scientists put forward a suggestion for one or more *experiments* which together constituted what we shall call a *mission (e.g.,* solar astronomy). Corresponding to each experiment and never carefully distinguished from it were the *instrument* or instruments required to carry out the experiment and which together comprised the *payload.* As we mentioned before, in the period we are dealing with here, the instruments were built by scientific groups in the member states, with the help of national industry where necessary. Payload integration in the spacecraft took place in ESTEC, or under the supervision of ESTEC engineers, and in consultation with the scientists flying experiments on the mission. A *satellite* refers ambiguously both to just the hardware which supported the experiments, and to the entire object, hardware plus experiments, which was placed in orbit.

When the green light was first given to a certain payload by the LPAC the experiments were still defined in general terms — e.g., "gamma-ray astronomy experiment". The definition of the instrument, and the refinement of the experimental goals, were shaped by scientific, technical and financial considerations.[50] The technical compatibility of different experiments in the same payload had to be assured (e.g., the possible influence of the magnetic field of one instrument on another). Their effects on the behaviour of the satellite had to be considered (e.g., a long antenna could severely affect the dynamic behaviour of the spacecraft). The satellite itself imposed limits of weight and of power consumption on the instruments which, above all, had to be sufficiently robust to withstand the shock and vibration loads during the launch. It was only after all these constraints had been met — and the payload modified accordingly — that the technical specifications of the project could be drawn up, and a call for tenders issued. These tenders were then submitted to the AFC for approval, and accepted in the light of available funds bearing in mind the need to distribute contracts on a geographical basis. It is clear then that it took several years for the design of even a relatively simple satellite to be frozen. During this time the payload was constantly renegotiated. And as the payload evolved so new decisions were needed, and new battles fought, within the ESRO committee structure.

4.2.1. Defining the first programme

It was always understood that the scientific programme drawn up in the *Blue Book* in October 1961 was indicative, and would need to be fleshed out once ESRO began to get into its stride. Important revisions were made in 1963, some of the first missions and payloads were settled in 1964, and by spring 1965 a new programme, based on extensive deliberations among the scientists in the ad hoc working groups, in the LPAC and in the STC, was laid before the Council.

[50] See Busch (1966) for the following.

The satellitc programme had evolved along two main axes.[51] Firstly, interest shifted away from smal1 unstabilized satellites to be launched by *Scout* rockets, towards stabilized satellites which could be launched by the *Thor-Delta* rocket. The latter would be more complex but the cost per kilogram put in orbit was considerably lower: about 1.5 MFF for a Scout-type vehicle and about 1 MFF for the largcr launchcr. Secondly, the idea gained ground that it might be advisable to develop a "streetcar" vehicle for the *Thor-Delta* (TD) satellites, i.e., a standard platform which housed different successive experimcntal payloads. The proposed launching programme for the first eight years was reorganizcd accordingly. The eleven smal1 satellites foreseen in the *Blue Book* were cut back to just two. Six medium-sized TD satellites of essentially similar basic design were added. The number of space probes was retained at four and it was agreed that they would be satellites launched on a highly eccentric orbit (HEOS) with an apogee of some 200,000 kms. The number of large satellites was also kept at its original number of two, though the possibility of launching a third in 1972 was also canvassed. In short, compared to the very earliest proposals put forward by the scientists in October 1961, the launching programme as proposed by the LPAC and the STC in spring 1965 did not involve a major rcduction, but rather a reorientation towards more complex experimental packages.

This programme, it was suggested, could be achieved within the agreed financial limits. Firstly, there had been an important shih in resources away from launching costs towards spacecrah dcvelopment. The scientists achieved this by eliminating back-up launches, as had been proposed in the *Blue Book*, and by re-evaluating downwards the cost per launch. Whereas the first estimates of ESRO's scientific programme evaluated launch costs to spacecraft development as being (roughly) in the ratio 2:1, thc proportions were now reversed. Some 225 MFF would be needed for launching costs, including that of the large satellite, while 455 MFF would be set aside for spacecrah development. Secondly, it was argued that there would be financial advantages pursuant on the streetcar design, for once the first satellite in a series had been developed the costs of the later models would be drastically lower. Thus it was suggested that whereas it would cost 60 MFF to dcvelop the first stabilized TD satellite, the next five would cost only 15 MFF each. Similarly the cost of the first HEOS would be 35 MFF, the cost of the next three 15 MFF. Finally, and dramatically, the cost of the first largc satellite would be 160 MFF, the cost of the next two only 20 MFF each.

Concerning the scientific content of the programme, it had been agreed by spring 1965 that the two smal1 and unstabilized satellites, ESRO-I and ESRO-II, would carry into low orbit simple experiments dcsigned to measure the radiation environment around the spacecrah, i.e., the payloads were essentially an extrapolation to satellites of experiencc gaincd with sounding rockets. ESRO-I

[51] For the following see Russo (1992a, 1992b). See also COPERS/GTST/116, 3/9/63; COPERS/GTST/117, 27/9/63; and ESRO/ST/109, 3/3/65.

was to study the polar ionosphere; ESRO-II was for solar astronomy and cosmic ray studies. After some revision of the provisional payloads due to wcight considerations, the "final" payloads were agrccd by the Council at thc end of 1964. Experiments by British groups dominated in their composition, confirming their leadership in this field at the time.

The priorities and payloads for the first two HEOS series of satellites had also been established. HEOS-A, as it was called, satisfied the representatives of the COS group, whose payload compriscd experiments for the simultaneous measurement of plasma, magnetic field and cosmic ray particles. HEOS-A was to be followed, ideally a year later, by a payload proposed by the PLA group, who had been the COS group's main rivals for experiments in this part of the programme.

The adoption of HEOS-A by the Council was delayed by concerns over the additional cxpenditure needed to provide a deep-space telemetry network. The proposed ESTRACK system, which was essentially dcvised for low-orbit satellites, was of limited use both geographically and technically for satellites and probes on highly eccentric paths. In the event a cheap solution was found which combined the ESTRACK and the French CNES stations with an ELDO station to be built in Australia.

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

Three main areas of controversy surrounded this programme. Firstly there was the distribution of funds between the various interest groups. The policy of the LPAC, as Lüst, its chairman, specifically said, was "to maintain a fair distribution in the scientific programme between the various fields of activity in space science".[52] This was obviously intended to give each discipline in the variegated field an opportunity to do satellite research. However a "fair" balance in scientific opportunity entailed major imbalances in resource allocation — in particular the large satellite projects required for astronomical studies were cstimated to absorb well over 40% of the available resources. This share bore no relation to the interests of the community as measured by experimental proposals submitted to ESRO, only 24% of which had come from the SUN and STAR groups. Members of other groups, particularly ION and COS, were quick to object to this.

The second major area of dispute concemed the "streetcar" concept for the TD series of satellitcs. This concept was introduced precisely to satisfy as many different interest groups as

[52] See ESRO/ST/109, 3/3/65.

possible without unduly incrcasing costs. The French and German delegations insisted that it was inhcrently contradictory. It was mistaken, they said, to think that one could hope to get useful scicntific results from four vcry different payloads integrated into a single spacecrah design. "There would be such great problems of adaptation," a senior member of the French delegation, J. Coulomb, said, "that the final cost of the four vehicles [might] well be greater than that of the four ad hoc vehicles." These severe reservations about the feasibility of the proposed TD programme simply reinforced the Frcnch's view that the estimates for the cost of the entire launching programme were much too low.[53]

Finally there was the problem of the first major project, the large astronomical satellite (LAS).[54] Two sources of controversy had emerged over this key project, thought by many to be the kind of costly and complex venture which provided ESRO with its *raison d'être.* Firstly, there were its specifications. In 1963 the LAS's instrument was specified as being able to make observations from 9 12 Å (Ångstrom) to 3500 Å with a resolution of 1 Å. The telescope was to be mounted on a platform which could be stabilized to a few minutes of an arc. These criteria were tightened up in mid-1964 in the light of developments across the Atlantic. The resolution was increased to a few tenths of an Ångstrom, and the pointing accuracy was increased to one minute of an arc. When proposals were callcd to build this payload, a British consortium led by a group from Culham, as well as a combincd German-Dutch group (Gemelas) submitted proposals coherent with the new specifications. A Belgian-Frcnch-Swiss group, however, refused to do so, feeling that the new requirements were technically over-ambitious and unrealistic. Faced with the impossibility of finding a compromise, in January 1965 the STC awarded design contracts to all three groups, all the while, and without much hope of succeeding, exhorting them to try to combine their proposals.

In parallel with this debate there was a simmering conflict over project management. Although ESRO was paying for the LAS and its scientific payload, the British, supported by the French, wanted authority for the project to rest with the national groups. This was intended partly to avoid the growth of a large inhouse staff at ESLAB (see section 3.1) and partially to preserve the autonomy of thcir national scientific teams. On the other hand, the British and French proposals seriously jeopardized the "intemational" character of the project which was supposed to be one of its main attractions. To meet this objection the UK suggested that not one but two, three or even four LASs be flown on the streetcar concept — a basic design with different scientific packages. This proposal was acccpted with some hesitation by the Council in 1964 and was reflected in the budget figurcs drawn up by the STC in March 1965. It certainly also informed their decision to award design contracts to all threc groups who had proposed payloads.

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53 See ESRO/C/114, 24/3/65.

54 See Krige (1992b).

4.2.2. Reducing the programme. The budget crisis of 1966

For the next 15 months, from spring 1965 to summer 1966, the debates on the scientific programmes were dominated by fears that financial constraints would force important cuts. The TD programme was the first to suffer. It was decided to abolish TD-3, and to merge its payload with TD-2. The latter now became a "solar, ionosphere and geophysical satellite" rather than simply a satellite dedicated to solar astronomy, and new proposals for experiments were solicited.

This was an unwise decision. The main experiment in TD-3 had been a German proposal to study the top side of the ionosphere with a special sounder, the so-called top-side sounder experiment. It was proposed again for TD-2 with strong support from the ION group. The LPAC, however, turned down this experiment on the grounds that TD-2 (like TD-1) was to be stabilized, and that since the top-side sounder did not require stabilization it would force major changes in the design of TD-2. These in turn would impede the implementation of the streetcar concept. After a furious protest by the ION group, who accused the LPAC of bias, STC and the Council insisted that the top-side sounder be included on TD-2. However, when it came to trying to fit the instrument into the payload it was found that it would absorb about half the total telemetry capacity of the satellite. The top-side sounder also pushed up the cost of the TD-l/TD-2 pair from 80 MFF (when a standard streetcar spacecraft was used) to 160-275 MFF. It was thus decided to build two standard TD satellites and to find an alternative solution for the top-side sounder. One idea was that it be launched on a Scout-type satellite. Even this was deemed too expensive by the LPAC (30 MFF). The STC and the Council shared their opinion and, in June 1966, the latter lamely recommended that NASA be approached for help in flying the German group's experiment.

This was also an unhappy period for the LAS. The three scientific groups who had been authorized co submit the designs for its payloads did so early in 1966. They were assessed by a board of consultants who judged the British (Culham-led) high-resolution instrument to be the best. They also thought that the low resolution instrument proposed by the Belgian-French-Swiss (BFS) collaboration was the weakest of all. This verdict was heavily contested by the losers who argued that their instrument was at least as useful scientifically, was technically feasible and avoided unnecessary risks, and would cost far less than the more complex and sophisticated Culham design. Despite a vigorous campaign by the BFS group in the STC and the Council, the verdict of the consultants was upheld, however. In July 1966 it was finally agreed that there should be one basic design for the LAS, that a back-up unit should be built in case of failure, and that the primary scientific package was to be in the hands of the Culham group. The management structure remained unsolved. The French and British delegations felt that it should be confided to the national team, while other delegates, notably those from the smaller countries (e.g., D, NL, CH), felt that ESLAB should have an important role in the project.

By mid-1966 thcn ESRO's first satellite programme had been more or less settled regarding both the spacccrah and thcir payloads. It comprised the two smal1 unstabilized Scout-type satellites, ESRO-I and ESRO-II scheduled for launch in 1967, one highly eccentric orbit satellite (HEOS) whosc final contract had been negotiated but was not yet signed, two stabilized and similarly designed *Thor-Delta* satellites, TD-1 and TD-2, for which tenders had been called, and one large project, the LAS, with its back-up unit, which was still in a preliminary design stage.[55] As for the futurc programme, prcliminary discussions had got under way in the ad hoc working groups as to what kind of missions they might be interested in having, but no attempt had been made to establish priorities.[56] Indeed the key question on everyone's minds was not simply the 1966 budget, but the amount that the Council would allocate ESRO for its next three-year period, running from 1967 to 1969. Its dccision proved to bc a nasty shock.

Thc cxtent of the budgetary difficulties emerged in July 1966.[57] The Council, advised by the AFC, were to determine, *inter alia*, the ceiling for ESRO's second three-year pcriod (originally set at 602 MFF in 1962 prices), and the leve1 of expenditure for each of 1967, 1968 and 1969. The secretariat had put forward a figure of 808 MFF in 1965 prices for these three years. This was arrived at by adjusting the 602 MFF figurc for inflation, and adding 122 MFF of monies that had not been spent bctween 1964 and 1966 to the draft budget for the following tricnnium. The surplus had arisen because thc build-up of capital facilities had not bccn as rapid as expectcd during the first three years of ESRO's life. To the sccrctariat's dismay, the Council refused to carry over these unspent funds. With intcmal expenditure at 50% of total outlay, rather than the "required" 45%, several delegations criticizcd the organization for its "lack of financial discipline, its too heavy investment and [its] staff plans". The ESRO secretariat was instructed to prepare a budget for the next three years of 690 MFF (in 1965 prices), being the original ceiling of 602 MFF increased for inflation. At the same time the draft budgct for 1967 was not to exceed 230 MFF at 1965 prices.

The Council's refusal to carry forward some 120 MFF to the period 1967-1969 placed cnormous strains on the operational programme. With many construction contracts awarded and with most staff recruited, there was little scope for savings in internal expenditure at this stage. In August 1966 the LPAC considered various altemative scenarios for making cuts in the research programme, all thc while trying to ensure "the viability of ESRO as a reputable scientific organization". It finally resolved that the highest priority should be givcn to the TD-1/TD-2 programme, that a ceiling of 300 MFF should be imposed on the LAS of which a maximum of 200 MFF should be spent in the first

55 See ESRO/C/238, 21/11/66.

56 Sce ESRO/ST/199, 21/4/66.

57 For the following see ESRO/AF/549, 7/7/66; ESRO/AF/561, 7/9/66; and ESRO Council, 12th session, 18-20/7/66, ESRO/C/MIN/12, 1/9/66.

eight-year period, and that some money should be set aside for starting new medium-sized satellite and space probe projects. Their aim was to ensure that, on average, two launchings took place per year compared with the four originally hoped for.

The minimum steps needed to keep these options open were taken by the Council at its December 1966 session.[58] Realizing that if work did not begin on the TD pair in 1967 they would lose their scientific rationale — they had to be launched to coincide with the solar maximum in 1969 — the Council instructed the secretariat to find 47 MFF in the 1967 budget to initiate the construction of the two spacecraft. As for the LAS, the month before the STC, after another extremcly divisive debate, had recommended that work on the scientific payload be temporarily halted. To have some idea of its costs, a tender action was to be initiated for the spacecraft on the basis of the Culham group's design. A ministerial conference, scheduled for the following year (see section 5), would then examine the new cost estimates and decide on the future of the satellite. Council endorsed these recommendations, which incensed the British, adding that ESRO should provide minima1 finance for the continuing work of the Culham group until the ministerial conference was held.

The shape of the long-term programme was left obscure in December 1966. Indeed the Council failed to agree on the leve1 of expenditure for the next three-year period as it was supposed to do. Instead, it was accepted, somewhat reluctantly, to adopt a budget for 1967 of 240 MFF (in 1966 prices) without having first agreed unanimously on the leve1 of resources for the next triennium. It was left to the planned ministerial conference to provide guidance for the future funding of ESRO.

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

* * *

The debate over the scientific programme during thc Auger years brought home two points to scientists, engineers and mcmber states' representatives alike. Firstly, there was no point in trying to achieve a balanced scientific research programme in the short- to medium term which satisfied the

[58] Sec ESRO Council, 14th session, 30/11-2/12/66, ESRO/C/MIN/14, 20/1/67.

various, and often conflicting, interests of the several disciplinary groups. The hope that one could launch a large number of satellites with different payloads in quick succession, so keeping everyone happy, was a forlorn one. It was far better to try to achieve "balance" over the long term with a financially realistic programme in which different interest groups took turns at flying complex payloads which provided them with a rich store of data for many years. In short, a satellite was not to be treated as if it were an extension of a sounding rocket, but as a qualitatively different kind of spacecraft whose launching programme had to be shaped by quite different considerations.

The second important point that emerged was that any viable attempt to fit the launching programme to available resources was conditional on engineers both in ESTEC and in European industry acquiring the management skills needed to make meaningful costings of projects. The ESRO secretariat lamented at the end of 1966 that it was unfair to expect them to draw up reasonable plans when European space industry, with all its resources and experience, differed in its own estimates for the costs of the TD pair of satellites by about 75% (the tenders received had varied from 99 MFF to 176 MFF).[59] They were right, of course. But the fact remained that until a procedure was devised which enabled realistic estimates to be made of the costs of spacecraft, and which systematically controlled expenditure at each phase of their development, all the attempts of the scientists to devise a launching programme could be reduced to nought. There were many respects in which the Europeans lagged behind the Americans in the 1960s, and project management was one of them. It was one of the points to which ESRO's new Director General, Hermann Bondi, would devote particular attention.

5. *The first steps towards redirecting ESRO's mission*

5.1. *The rise of telecommunications satellites and the establishment of the CETS*[60]

As we mentioned in section 2, the use of satellites for applications of a commercial and military nature was never far from governments' mind from the late 1950s onwards. The definition of a programme, and the establishment of the structures needed to implement it, however, waited on a demonstration of technical and economical feasibility. This was achieved satisfactorily in the USA first by the launch of the *Telstar* and *Relay* satellites in 1962/63, followed by the *Syncom series* in 1963/64. The latter was the first to be placed in a geosynchronous orbit, i.e., an orbit about 36,000 kms above the earth and synchronized with its rotation in such a way that the satellite remained effectively stationary over any desired point on the equator. It was followed by *Early Bird,* launched in April 1965, which added telephone and teletype linkages between Europe and the USA to the tele-

[59] See ESRO/AF/561, 7/9/66.

[60] For this material see Blassel and Collette (1968), Collette (1992), De Maria and Krige (1992), Giget (1992), Russo (1993a) and ESRO/C/225, Appendix 3, containing CETS document TPS/116/Supplement, 6/9/66. See also ESRO/C/182, 14/3/66.

vision broadcasts already tested with earlier generations of satellite. The Soviet Union, for its part, was following a similar path with its *Molnya* series of satellites. By February 1966 the advantages of a geostationary system were evident. Though it required a heavier launcher and an equatorial launching base to take advantage of the earth's rotational velocity, the ground segment costs of geosynchronous satellites were considerably lower than those for satellites at medium altitudes. A far greater surface could be "seen" by a satellite perched above the equator, and moveable aerials were not needed to receive signals from it.

In parallel with these technico-commercial developments, a number of steps were taken in the USA to ensure that it reaped the maximum benefit from the technical lead it had established in the field of communications satellites. In August 1962 the US Congress passed a Communieation Satellites Act which led directly to the formation, in February 1963, of COMSAT. COMSAT was a private corporation half of whose shares were owned by giant firms like AT & T and RCA, and half by private individuals. Its aim was to foster the development of experimental and operational satellites. At the same time an "interim" organization called INTELSAT was set up in Washington in 1964 to coordinate a global system of telecommunications satellites. Nominally intergovemmental — INTELSAT had some 60 "member states" by the mid-1960s — the body was unusual in that America's interests were represented by COMSAT. What is more as COMSAT was the operating manager of INTELSAT, and held over 50% of the voting power in the organization, "the USA effectively, at least in the early years, had total control on all telecommunications satellites at the intemational level."[61]

Table **5** Member countries of ESRO, **ELDO and CETS** as of 1965

Country	ESRO	ELDO	CETS
Australia	-	X	-
Austria	-	-	X
Belgium	X	X	X
Denmark	X	-	X
Germany	X	X	X
France	X	X	X
Italy	X	X	X
Monaco	-	-	X
Netherlands	X	X	X
Norway	-	-	X
Portugal	-	-	X
Spain	X	-	X
Sweden	X	-	X
Switzerland	X	-	X
United Kingdom	X	X	X
Vatican City	-	-	X

61 Sec Collettc (1992), p. 83.

In response to these developments across the Atlantic the Europeans created, in May 1963, the CETS, Conference européenne de télécommunications par satellites. The member countries of the CETS, which was not a formally established organization like ESRO and ELDO, are given in Table 5. The CETS' aim was to harmonize the position of European govemments vis-a-vis the USA inside INTELSAT. Its members were particularly concemed that, given its relative backwardness, European industry would be seriously disadvantaged when contracts were let by INTELSAT for a global network of communications satellites. To this end the CETS, at a meeting in Bonn in October 1964, established an expert group, the Technical Planning Staff (TPS), to define the scientific, technological, economic and financial aspects of an appropriate European telecommumcations programme. By the end of 1965 a proposal covering five years and costing an estimated 370 MFF had been put forward. It had three components. The test satellite on the ELDO launcher would first be used to make preliminary studies of telecommunications components beginning with firing F-9, schcduled for October 1968. In parallel an experimental satellite would be dcveloped for launching in 1969/70 to serve as a first step towards an eventual European system. An advanced research programme gcared to future needs, including other applications, would also be undertaken. To implement this scheme the CETS planners recommended that ESRO take overall management responsibility for the programme, while ELDO provide all the launchers that would be needed.

*   *   *

The striking feature about these early developments in the field of telecommunications is the enormous technical/industrial/political gap which separated the Europeans from the USA in the early 1960s. The Europeans were, inevitably, reactive, leaving it to the US to determine the technical feasibility of (civilian) telecommunications by satellite and to take the lead in setting up an organization, which thcy dominated, to manage a global network. Three things were required for Europe to make up thc gulf, and to negotiate with Washington from a position of relative strength. Firstly, industry nceded to develop the skills in telecommunications satellite engineering which the Americans had rapidly acquired with their first and second generations in the early 1960s. The extent of the problem, and its political implications, was revealed when INTELSAT awarded the first contract for a geostationary system in 1966. It went to an intemational consortium headed by the US firm Thompson-Ramo-Wooldridge. The European share, with launching costs added, was expected to be only about 4.5% of the total cost of establishing the system, compared with Europe's contribution to INTELSAT of almost 28%. Secondly, the Europeans needed to consolidate the institutional framework in which the telecommunications programme was undertaken. No-one wantcd to sct up a third organization, alongside ESRO and ELDO, for this. On the other hand these two bodies differed both from one another and from the less forma1 CETS in terms of mission and of membership. A mergcr now was extremely difficult, particularly since the different sensitivities — scientific, technical, economic and political -, which had led to the creation of separate organizations in the first place, were stil1 very much alive. Finally, there was the question of access to a heavy launcher, and in particular of whether Europe could rely on the USA to place her telecommunications satellites in orbit once they were built. The French, backed forcefully by the Belgians, were convinced that they could not. Others felt differently. It was to remain one of the thomiest and divisive issues in European space policy for almost a decade.

5.2. *1965/66. Consultations at ministerial level and the reshaping of ELDO's programme*[62]

The growing importance of telecommunications satellites was to provide a new impetus to, and a new mission for, ELDO. The technical objectives to be achieved by its rocket, labelled *Europa-I*, had been rather vague when ELDO was set up and, more to the point, directed to placing payloads in near-earth orbits. Early in 1965, and particularly after the successful use of *Early Bird* for telephonic communication, it was clear that a worthwhile European launcher had to be able to put a commercially viable payload into geostationary orbit. At intergovemmental consultations held in January and again in April 1965 the French proposed to abandon the existing design forthwith, a design which was proving far more expensive than anticipated, and to concentrate all resources on a more powerful rocket incorporating cryogemc upper stages. This move was rejected as wasteful of existing investments. Instead the ELDO secretariat was asked to prepare altemative proposals for ELDO's launcher. At the same time, granted the gravity of the financial situation, and the need to commit even more resources to an upgraded launcher, it was clear that if any progress was to be made the next round of consultations should be held at ministerial level.

The proposal prepared by the secretariat for the ministers foresaw the placing of a satellite into geostationary orbit in two stages by upgrading *Europa-I* with a so-called PAS (Perigee-Apogee System). In the first stage *Europa-I* would place a payload of about 1000 kg, comprising the satellite and a supplementary rocket, into a “parking” orbit 300 kms above the earth. Here a fourth stage (the perigee motor) would be fired, placing the satellite in an elliptical orbit with an apogee of 36,000 kms. As the 150 kg satellite passed through its apogee a second motor would be fired to place it into a circular geosynchronous orbit around the earth.

The British were not convinced. In February 1966 they circulated an Aide Mémoire to the ELDO member states expressing grave doubts about the financial, technical and commercial aspects of the initial programme. A first round of interministerial discussions in April, and the secretariat's proposal to upgrade *Europa-I* with a PAS, did nothing to allay their fears. In June 1966 they circulated a second Aide Mémoire threatening to leave the organization. As the British Minister of Aviation explained to his colleagues, Britain was not only perturbed by the spiralling costs of the *Europa* project and the delays in its realization. They also saw no commercial use for it, even in the

[62] For this section see De Maria and Krige (1992) and ELDO (1966).

applications field, particularly since the use of a geosynchronous orbit sharply reduced the number of telecommunications satellites necded for global coverage. Finally, anything that the Europeans could build would never compete with American launchers which were far more powerful and chcaper. Far better, thcn, to purchase launchers in the US for the European programme or, better still, try to get European firms linked up with American enterprises so that they could benefit from advances in spacc technology.

Britain's partners in ELDO shared her concerns about the cost and time overruns. However, they were fare more willing to put them down to a lack of experience, and to the decentralized, mcmber statc dominated structure of the organization, which effectively stripped the Secretary Genera1 of any executive authority. They also insisted that thc investment in a European launcher was never intended to be commercially rewarding in the short term. It was rather to be understood as pan of a long-term strategy to build up a European capability in the field. Finally, and crucially, Britain's partners disagreed that the USA could be countcd on to put a potentially competitive European telecommunications satellite into orbit using an American launcher. It was a fundamental mistake, they insisted, to embark on an applications programme on this side of the Atlantic without doing all one could to ensure an autonomous European launcher capability. At the same time Britain's partners made clcar their anger at her threat to leave ELDO, some of them going so far as to say that if the UK went ahead they would withdraw their support for her impending re-application for membership of the Common Market.

Faced with this opposition abroad, with Conservative scorn at home, and with considerable pressurc from industry, Britain's Labour govermnent judged it opportune to step down. After lengthy negotiations, ministers from the member states agreed on a new programme and new money for ELDO. By summer 1966 they had adopted, in addition to the initial programme, a supplementary programme comprising the PAS system, the development of an inertial guidance system for *Europa-I*, and the construction of a new near-cquatorial base at Kourou in French Guyana. Additional executive powers were vested in the hands of the secretariat. It was agreed that tendering and contracting for the supplementary programme should be as far as possible competitive, with the proviso that each member state would have a guaranteed minimum return of 80% of its contribution to both programmes. An overall budget ceiling for ELDO of 626 MMU ($626 million) up to 1971 was established, and annual budget ceilings within that figure were also laid down. In a concession to thc British, their share of the costs of the organization were reduced from some 39% to 27%, the bulk of the difference being absorbed by Germany (+ 5% to 27%) and the Low Countries (+ 3.5%, to 9% together). The voting rules on the annual budget, which required a double two-thirds majority (i.e., two-thirds of the member states in favour, including those who contributed a substantial percentage of the budget) were also revised so as to stop any one state from vetoing its approval. In the previous scheme any one of Britain, France or Germany could have single-handedly blocked the passage of ELDO's annual budget.

In addition to placing ELDO's programme and management on a new footing, the ministers of the countries concemed were determined to take positive steps towards harmonizing Europe's space activities. To this end they set up a Coordinating Committee of senior officials from ESRO, ELDO and CETS to facilitate closer liaison at the working leve1 between the three bodies. They also dccided that it was necessary for them to meet regularly at ministerial leve1 along with reprcsentatives from ESRO and CETS. A Committee of Altemates, chaired by E.A. Plate from the Dutch Ministry of Economic Affairs, was established to prepare these meetings. Its main tasks were to present recommendations to the ministerial conferences for a coordinated European space programme and to explore the most suitable measurcs for associating the telecommunications, broadcasting and television authorities in the different member states, along with national industries, in the commercial exploitation of space technology. The first of these more broadly based meetings at ministerial level, now labellcd the European Space Conference was held on 13 December 1966. Reprcsentatives from 14 member states, including all those from ELDO and ESRO and most members of the CETS, resolved that their first need was to take stock of the programmes under way or envisaged in Europe. This report was to be ready by the end of May 1967 in anticipation of another meeting of the Conference shortly thereafter.

* * *

One consideration above all led to the resolution of the ELDO crisis in 1965/66 in favour of a tcchnically and financially expandcd programme. It was the commercial potential of applications satellites, coupled with a conviction that European initiatives in this field should not be hostage to American policies. This was the only good reason Europeans had for building a heavy launcher. Defence needs were assurcd by sheltering under the American umbrella in NATO. Scientific needs were protccted by thc conviction that NASA would always be willing to launch research satellites. Certainly, thc American agency did sometimes impose unplcasant constraints (see section 3.4). But thesc were ncver so harsh as to justify Europe building its own rockets — and anyway the scientists could always turn to the other supcrpower for help if need be. Applications satellites, and telccommunications in particular, were a case apart. There were, it now seemed, real financial rewards to be gained in this field. After only eight months in orbit, *Early Bird* had rented out a third of its channels and had yielded more than $2 million. America could hardly be expected to rclinquish voluntarily its ncar-monopoly in this sector. The terms of the (interim) INTELSAT agrcemcnts, which had been drawn up in 1964, had reflected European backwardness at the time. Thcy were to be re-discussed in 1969. If Europe was to negotiate from a position of strength, many govcmments felt that shc had to be able freely to launch her satellites for herself. It did not matter, they said, that these launchers were less powerful or even more expensive than what the US had to offer. What was rcquired above all was that they worked, and so could serve as a bargaining chip in Europe's dealings with the USA. In sum, applications satellites were the saving of ELDO in the mid-

1960s. They also tollcd the death-knel1 of the conception of ESRO as a purely scientific organization which had imbued its founding fathcrs with their enthusiasm and euphoria only a few years before.

5.3. *Applications satellites are put on ESRO 's agenda*[63]

From what we have said, and knowing the importance which application satellites came to have in the European space effort, it is a short step to imbuing their emergence inside ESRO with an aura of inevitability, of necessity. Applications, however, were anything but a logical extension of ESRO's initial, purcly scicntific mission. Indccd when the CETS first formally invited ESRO at the end of 1965 to play a role in this area, cveryone was thinking of keeping the two sectors carefully separated and compartmentalized, with science remaining very much a priority. It was only towards the end of our pcriod that the thinking in some quarters began to change, and that the view began to gain ground that applications satellites provided the *raison d'être* for a European space programme. The sceds of the transformation of ESRO's character were sown in 1966/7. It was not "prefigured" in the carly contacts with the CETS, nor was it the only choice open to thc main decision-makers who shaped thc trajectory of the organization in the 1960s.

As we have already said (scction 5.1) at its meeting in Bonn in October 1964 the CETS established tcchnical planning staff (TPS) who were instructed to define a research and development programme for a satellite for long-distance point to point telephonic communication. A year later the TPS's report was ready in draft form. Its main recommendation was that an experimental communications satellite be built as a first step towards the development of a genera1 European capability in the field. The cstimatcd cost of the initial programme was 370 MFF. This draft was sent to thc chairmen of the ESRO and ELDO Councils at the end of October 1965. They were asked whether their organizations were interested in carrying out the programme defined by the TPS and, if so, how the project should be organized and when they could begin.[64]

The CETS offer was received positively by the ESRO Council at its meeting in November 1965 and in a subscqucnt meeting of the AFC.[65] The extension of ESRO's activities to include applications was coherent with its convention. It would avoid the need to establish a new organization for this purpose. It would, in the words of thc ESRO DG, "make the scientific effort more justiliable in the eyes of the public in the Member States".[66] And some of its technical aspects,

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63 See Russo (1993a).

64 See Collettc and Blassel (1968), ESRO/C/83, 20/11/64; ESRO/C/145, 8/11/65; and ESRO/C/225, Appendix 3, 6/9/66.

65 See ESRO Council, 9th session, 24-25/11/65, ESRO/C/MIN/9, 31/1/66; and ESRO/C/182, 14/3/66.

66 ESRO/C/182, 14/3/66.

notably those concerning telccommand and telemetry, would overlap with, and reinforce, ESRO's existing inhouse capabilities. It seemed quite reasonable then for "CETS to define a requirement for communications by satellite and for ESRO to undertake the development of the satellite."[67] There were two major problems though that had to be resolved. Firstly, there was the danger that it posed to the scientific programme. Secondly, there was the question of how the work was to be distributed between thc two organizations and above all who would carry the responsibility for the management of thc whole project.

The former question was discussed by the STC early in 1966. While the majority of the delegations favoured cooperation with CETS, it was emphasized that the "scientific purpose of ESRO, its programme and the management of the programme by ESRO must be fully safeguarded." They were reassured by several influential Council delegates in March that the timing and scope of the scientific programme would under no circumstances be jeopardized by any telecommunications activitics. The DG and his officers, for their part, were emphatic that applications should be paid for from additional outside funding, and that the work on the satcllite should be in the hands of an independent, small project team. Its main task would be to draw up the specifications of the satellite and to control the contracts in European industry. It would be based at ESTEC and it would use the services of the Noordwijk establishment in the same way as did project teams for scientific satellites.[68]

There were protracted discussions throughout 1966 on the management of the applications satellite programme. The main difficulty was to strike a balance between the conflicting wishes of the CETS to entrust the management of the project to ESRO while retaining control over certain key aspccts of it themselves — notably the distribution of contracts and the dissemination of scientific and technical information. The procedures they proposed, which were to be implemented by a Dircting Committce of representatives of CETS member states, not only differed from those in force in ESRO. They also raised important points of principle conceming the sharing of intellectual property with countrics which were not members of both organizations. No agreement could be reachcd on these issues. In September 1966 the ESRO Council decided to ask the Coordinating Committee of the thrce organizations which had been set up in July by the ELDO ministerial conference (see section 5.2) to look further into the matter.[69]

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67 ESRO/C/150, 13/11/65.

68 Sce ESRO/C/150, 13/11/65; ESRO/C/182, 14/3/66; and ESRO Council, 10th session, 24-25/3/66, ESRO/C/MIN/10, 10/6/66.

69 ESRO/C/221, 27/7/66; ESRO/C/221, Add. 1, 16/9/66 and Add. 2, 13/9/66; ESRO/C/225, 12/9/66; ESRO Council, 13th session, 29/9/66, ESRO/C/MIN/13, 13/10/66.

While ncgotiations were dragging on at the European level, France was planning her own national telecommunications programme. First she steered her partners in ELDO towards sharing the costs of a powerful launcher and an equatorial launch pad (to be built on French territory), both of which were needed to put a satellite into geosynchronous orbit. Then, at the Hague conference of the CETS in November 1966 France announced that she would be building her own experimental satellite. Named *Saros II* it would be used for telephonic and TV linkages, and it would be launched with the ELDO/PAS rocket. Shortly thereafter Germany, who was also developing her own tclecommunications satellite callcd *Olimpia*, announced that she would join France and that togcther they would develop an experimental telecommunications satellite to be named *Symphonie*.

The Haguc conference of the CETS also accepted a proposal from DG Auger — doubtless catalyzed by the French initiative — that ESRO propose designs for an experimental telecommunications satellite along the lines recommended in the TPS report, which had been on me table for almost a ycar. The study would cost the CETS 1.5MFF, it would start immediately, and would be ready by the end of May 1967.[70]

Two satellites emerged frorn this project, which was undcrtakcn by a team of 35 scientists and engineers at ESTEC. The first, CETS-A, was conservative in design and intended to place a European satellite into orbit as soon as possible (i.e., in less than four years), using alrcady available skills and resources. The second, CETS-B, was more adventurous and required more time and more advanccd technologies for its realization. The final report on the programme was submitted by ESRO to the CETS early in June 1967.[71] Thus in summer 1967 there were two proposals in the air for a European satellite, one from the broadly-based CETS, the other a bilateral venture financed by France and Germany.

Needless to say the Franco-German initiative was given a hostile reception by the ministers who gathered for the second European Space Conference (ESC) in Rome from 11-13 July 1967. The French, with German support, were asking their European partners to share the costs of the rocket and thc base needed — for them to launch their applications satellite. The Belgian delegate was particularly bitter. Questioning their reliability as partners, he challenged France and Germany to show that *Symphonie* was not an altemative to the first phase of the CETS project, and that they would be willing to contribute fully to the financing of both their national programmes and the CETS programme. More generally, the decision to build *Symphonie* was seen as symptomatic of Europe's inability to coordinate its space activities and, by extension, of the willingness of some countries to pursue selfishly their national interests at the expense of European collaboration. Adding their voices to that of the Bclgian dclegation, all the Scandinavians and the Dutch agreed that the

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[70] ESRO/C/245, 29/11/66.

[71] Blassel and Collettc (1968); Collctte (1992).

time was really not yet ripe for a fusion or amalgamation of the European space effort which lacked "coherent purpose" (Norway). As a first step towards giving it more shape, the ministers set up an Advisory Committee on Programmes chaired by J.-P. Causse, the then director of the French space centre at Brétigny. Basing itself on the results of the stock taking asked for at the first meeting of the ESC, Causse's committee were instructed to recommend how Europe could best distribute its resources between the three fields of science, applications and launchers. Their report was to be ready by the end of the year.[72]

The Franco-German initiative also caused a re-orientation of the CETS programmes. The CETS member states met immediately after the European Space Conference on 14 July 1967. There was considerable concern that, despite assurances by France and Germany to the contrary, *Symphonie* was similar in design to the planned first generation of European telecommunications satellites. Fortunately, however, a new "client" with new requirements emerged. The CETS meeting in midJuly was attended by the Director Genera1 of the European Broadcasting Union (EBU), a customer of the PTT's which dominated the CETS. The EBU was acutely aware of the limitations imposed on the distribution of its Eurovision television programmes by the PTT's network, which was difficult to use for transmission in real time and geographically restricted. To overcome these disadvantages the EBU presented their specifications for an operational TV satellite to the CETS conference. The body promptly authorized ESRO to spend a further 1MFF by the end of 1967 on design studies for a satellite meeting the needs of the Eurovision mission, and sufficiently different from *Symphonie* to avoid unnecessary duplication. The overall cost was to be held to 450 MFF.[73]

* * *

The way of thinking which emerged at the ESC in July 1967, and which informed the brief for Causse's committee, was indicative of a new attitude vis-à-vis the scientific programme. From 1961 the scientists (and politicians) who had founded ESRO had made a deliberate effort to keep it independent of ELDO. The same determination was visible a few years later when applications satellites emerged into the limelight. Now ministers were talking of "imbalances" between the fields and of developing a "harmonized" programme. Science, in other words, was no longer being treated as a case apart, but as one dimension of a three-pronged space effort involving launchers, scientific and applications satellites. If, or rather as, this thinking gained ground the scientists would find themselves having to defend funding for their programme within the framework of a global package, where their needs would be assessed along with those of activities which were far more important commercially and politically. The Belgian delegate to the ESC was particularly explicit on this point. His government, said Mr Spaey, "would not contemplate increasing its contribution to the

[72] European Space Conference, Ministerial Conference, Rome, 11-13/7/67, CSE/CM (July 67) PV/...

[73] Blassel and Collette (1968); Collette (1992); and ESRO/C/302, 26/7/67.

European space programme in any field whatsoever [...]" unless there was what he called "a more realistic distribution of resources, and setting aside from the outset an appropriate but significant share for [...] the development of a family of application satellites." At the meeting of the ESRO Council which preceded the ESC a dclegate from the same country went further. Belgium might be forced to withdraw from the organization, he threatened, unless application satellites were integrated into the programme, and unless the choice of scientific satellites was shaped by the possibilities of transferring their technical know-how to the applications sector. The science programme, in other words, risked becoming hostage to the applications programme. It was precisely the kind of situation that the scientists had always feared, the situation that they had wanted to avoid from the very start.[74]

It is not surprising that some of the small countries should have led the chorus of demands for an integrated space policy, and a single organization, at the cxpense of the science programme if necessary. Major states like France and Germany could build commercially exploitable satellites on their own, so reaping all thc benefits for themselves. Smaller countries could not hope to go it alone. They lackcd the financial, human and industrial resources required to do *so*. For them *Symphonie* raised the fear that their industries would be excluded from the first phase of development of a European telecommunications satellite, and would so be at a considerable disadvantage when it camc to competing for contracts later. The only way to "force" countries like France to share their know-how was to bind them into an organization which had the development of applications satellites as one of its primary goals. The CETS was too informal, and its brief too limited for this purposc. That lcft only ESRO.

ESRO, or more precisely some of the engineers at ESTEC, greeted this new development with enthusiasm. For almost five years now they had been sandwiched between the scientists in the membcr states and industry, interpreting the needs of the one to the other. They had hoped to have at least one major satellite which was essentially theirs to spccify, design and manage. The LAS was the prime candidate for that role, but the British had refused to relinquish control over the payload. Application satellites were a new opportunity for ESTEC, and an opportunity that was quickly seized by men like Pierre Blassel and René Collette. The scientists had always wanted to avoid having a strong inhouse staff at ESTEC which would compete with them for resources. Now that force was emerging and, worse stil1 for them, its main concern was not science.

74 European Space Conference, ministerial conference, Rome, 1 1-13/7/67, CSE/CM (July 67) PV/...; ESRO Council, 17th scssion, 6/6/67, ESRO/C/MIN/17, 6/7/67.

6. *Epilogue*

The first thrcc or four years of ESRO's official life were indeed sombre and difficult ones. The heady euphoria of the early sixties, fuelled by the relative ease and rapidity with which European govemments set up the organization, 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 secretariat by the member states' delegates, who judged it incompetent and irrcsponsible. By 1966 there was, as Bannier noted, a crisis of confidence throughout the organization. As if to confirm the malaise, first DG 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 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-11 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 Genera1 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 rolc in rebuilding confidence in the organization. He was helped of course by the lessons leamed during the Auger years, and by thc successful launch of first ESRO-1 and then HEOS-A soon after hc took office. By the end of 1968 the future of ESRO seemed secured. Indeed its success was one key factor counteracting the powerful ccntrifugal forces which threatened to tear apart the fabric of the European space effort as the 1970s dawned. It is to an overview of these developments that we shall mm in the next working paper in this series.

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