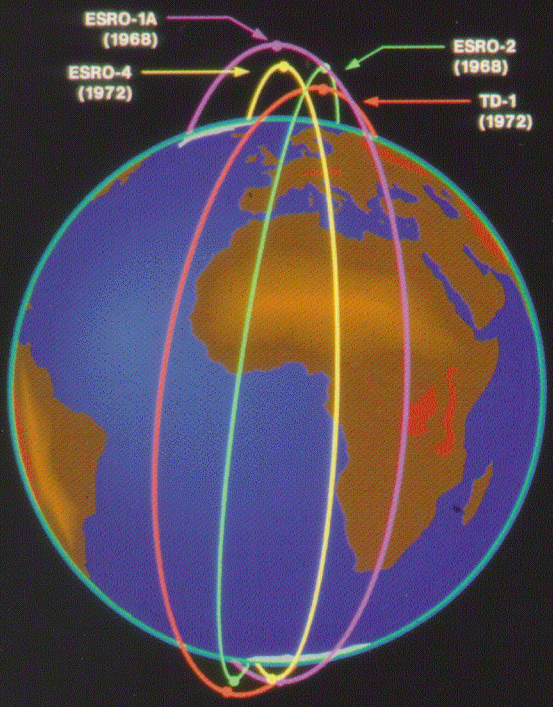
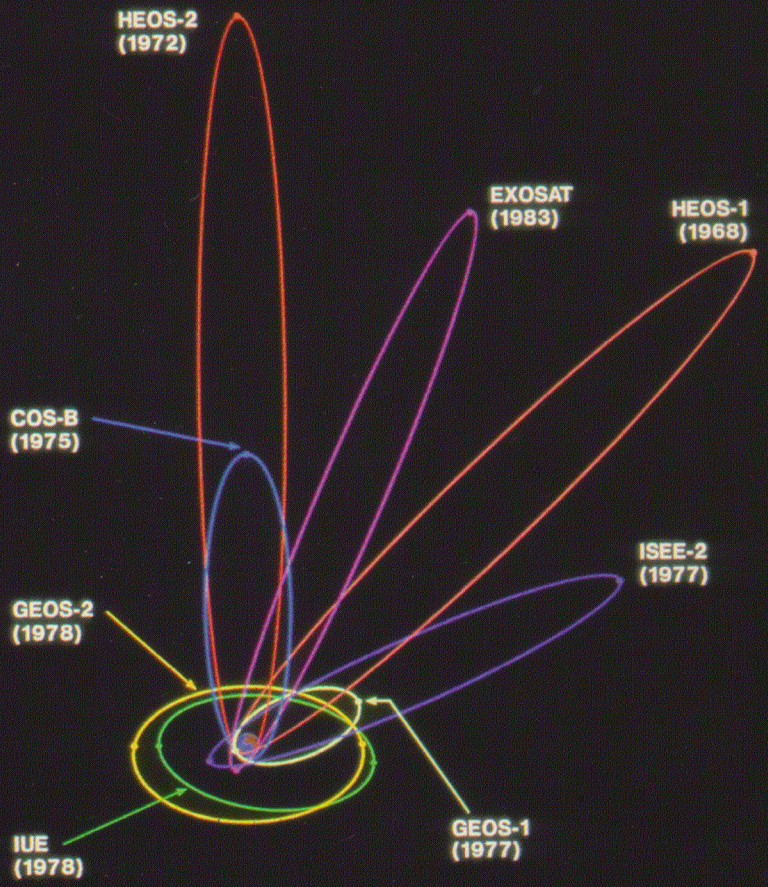
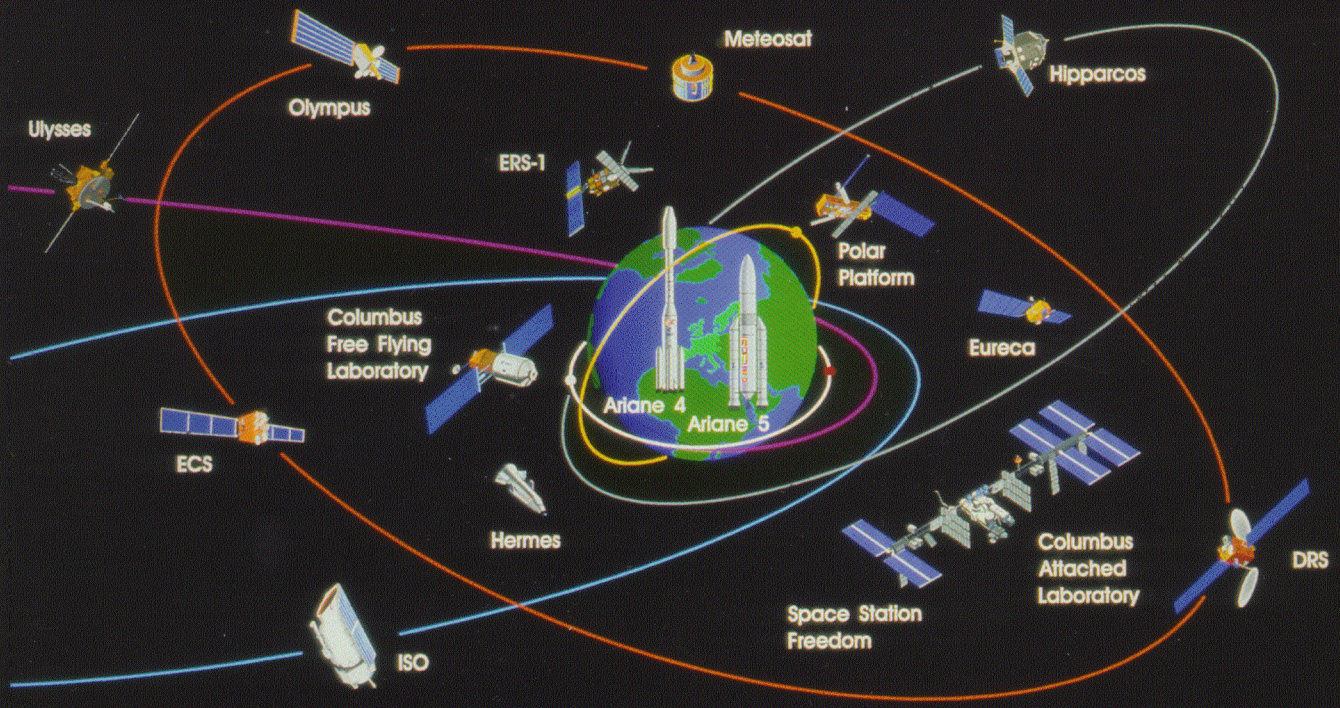
ESA HSR-2
October 1992





ESRO's First Scientific Satellite Programme 1961 - 1966

by Arturo Russo



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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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Published by: ESA Publications Division
ESTEC, Postbus 299
2200 AG Noordwijk
The Netherlands

THE DEFINITION OF ESRO'S FIRST SCIENTIFIC SATELLITE PROGRAMME (1961-1966) [1]

Arturo Russo

INTRODUCTION

The scientists who, in 1959-60, set up the first initiatives to create an European organization for space research had in mind the model of CERN. This was an example of a successful multinational organization of European countries dedicated to fundamental research in a field of science where real progress could only be realized by big and expensive technical equipment that no individual country could build by itself. Space research, however, is quite different from particle physics and if the CERN model could still provide evidence that European cooperation in a highly sophisticated scientific and technological domain could actually work, the institutional framework and the scientific programme of the new organization were to be significantly different. A rapid discussion of the main differences between these two examples of contemporary "big science" is useful to highlight the most significant aspects of the story we are about to tell.

The first difference lies in the organization of the research work. In the case of particle physics this is arranged around a large accelerator and supported by the facilities of a large laboratory. The laboratory and its "big machine" represent an intrinsic, stable and permanent component of the research organization, which sees different research groups sharing these facilities and alternating in performing experiments. Space research, on the contrary, is conducted by scientific instrumentation carried by rockets or satellites and eventually destined to be lost with the spacecraft. Space missions can be more or less sophisticated

[1] This paper is based on the large collection of documents from ESA files deposited in the historical archives of the European Communities at the European University Institute, Florence. Unless otherwise specified, all the documents cited can be found there, arranged in a master set by their original reference code and date, and we do not need to refer to them by box number.

and long lasting, from a simple sounding rocket to a complex space telescope, but each of them represents a definite and self-consistent element, involving at one and the same time the definition of a scientific aim, the building of the technical hardware, and the setting up of a specific managerial framework to link together scientific groups, technical teams, industrial firms, launching facilities, tracking and data handling facilities.

The second main difference between particle physics and space science regards their content. The former is a well defined research field, whose objectives and methods are continuously discussed and re-defined by a strongly homogeneous and influential sector of the scientific community. Space science, on the contrary, is defined by its technique rather than its objectives: it includes, in fact, any kind of scientific investigation conducted by the use of rockets, earth-orbiting satellites, and deep-space probes. In terms of established scientific disciplines, it covers fields as different as atmospheric physics and chemistry, ionospheric physics, geophysics, plasma physics, cosmic-ray physics, the various branches of astronomy (solar, stellar and planetary), and even biology and medicine. Each of these disciplines and sub-disciplines is characterized by its own aims and methods, by its own intellectual and institutional framework, by its own approach to the opportunities offered by space technologies.

Finally, one must mention the different roles of particle physics and space science in the general framework of national and international policies for scientific and technological development. Particle physics is undoubtedly pure research, with very limited, if any, possibilities of practical applications. Its large-scale development in the post-war period was mainly due to the prestige and influence that this sector of the physicists' community enjoyed thanks to their wartime work. The fortunes of the field depend not on the promises of economic profits or better human welfare but rather on the leading influence this community exerts within scientific and political circles. It is quite different for space research. In fact, the techniques that render this possible, rockets and satellites, have evident civil and military applications and their development largely depends on political choices based on extra-scientific considerations.

In analysing the process which led to the definition of ESRO's first scientific satellite programme all the aspects discussed above will come into consideration. The scientists who contributed to this process, whether in the capacity of national

delegates in the Organization's official bodies or as experts in advisory committees, were not members of one scientific community, with a well structured set of common cultural and professional values spread across national borders, whose task was to choose the best instrument or the most promising experiment proposal within the framework of a shared disciplinary paradigm. They represented instead various scientific and national interests, and were called to establish priorities and to make choices between competing scientific disciliplines and research programmes, between radically alternative technical options, and between different national policies. They were not members of an influential, international scientific elite who could confront the political decision-makers with the only arguments of their research goals. They were rather advocates of a variegated set of new research fields who had to negotiate among themselves and with national governments the place and fortunes of these fields in the wider framework of space activities.

This paper deals with the early development of ESRO's satellite programme (we will not deal with the sounding rocket programme) and it is organized in three main parts. In the first part the process which led to the definition of ESRO's eight-year scientific programme is analysed. This programme is described in the so-called *Blue Book*, approved by the *European Preparatory Commission for Space Research* in October 1961.[2] The second part describes the organizational structure by which proposals coming from the scientific community were discussed within ESRO in order to arrive at definite choices about mission objectives and satellite payloads. In this context, the decisions concerning the first phase of the Organization's operational programme are discussed. Finally, the third part deals with the painful process of revision of the original programme undertaken in the first three-year period of ESRO (1964-66), when the early ambitions had to confront the hard reality of scientific competition, technical difficulties and financial constraints.

In the paper, only the overall development programme will be discussed, with reference to the scientific missions of the approved satellites. In a subsequent

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[2] *Report of the Scientific and Technical Working Group to the European Preparatory Commission for Space Research*, 2nd edition, December 1961, herafter *Blue Book*.

paper the scientific objectives, payload compositions and scientific results of these satellites will be analysed.

WORKING OUT ESRO'S SCIENTIFIC PROGRAMME

The first steps

The origins of the *European Space Research Organization* (ESRO) can be traced back to the initiatives taken in 1959 and 1960 by a small group of scientists, catalysed by E. Amaldi and P. Auger, two physicists and scientific policymakers who had already had a major role in the creation of CERN.[3] Following preliminary discussions and informal meetings, in June 1960 a *Groupe d'Etudes Européen pour la Collaboration dans le Domaine des Recherches Spatiales* (GEERS) was created, anticipating the establishment of a Preparatory Commission called to set up an European organization for space research.

It was at a meeting of the GEERS' technical working group, held in London on 3-6 October 1960, that the broad outlines of the envisaged Organization's scientific programme were established, as well as the general principles of its organizational structure.[4] Here it was decided that ESRO's scientific programme should include both a vertical sounding rocket programme and a satellite programme. The scientific aims of the former were to be a synoptic study of the atmosphere from 30 to 200 km and the study of solar activity. The satellite programme was divided into three successive phases. In the first, lasting about three years, small satellites of the order of 100 kg would be developed and launched, carrying experiments in the fields of atmospheric physics, geodetic and time measurement problems, and cosmic rays. Subsequently, after about five years, satellites weighing between 500 and 1000 kg would be launched into near orbits and lighter spacecraft into the vicinity of the moon. Carried by this spacecraft, more sophisticated instruments would investigate ultra-violet and X-ray spectra from the sun and the stars, interplanetary and interstellar absorption, and cosmic rays in interplanetary space. Finally, in the third phase, to be

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[3] Krige (1992a).

[4] On this meeting see Krige (1992a) and Massey & Robins (1986), p. 114-117 and Annex 8.

developed in parallel with the first two, more advanced systems would be developed to allow soft landings of equipment on the moon, the exploration of other planets and the study of the sun's neighbourhood. In order to obtain the technical knowledge required for this kind of project, it was assumed that a vigorous programme of applied research would be developed in fields like propulsion, power sources, information storage, solid state physics, high-vacuum technology, materials science.

From the organizational point of view, the London meeting proposed that the main facility of the organization should be an Engineering Centre responsible for the engineering of satellites and large scientific payloads. It was also suggested that a main Data Analysis Centre should be established, in addition to the tracking and data facilities which would be required.[5] In the scheme of the Organization that Auger sketched on a blackboard chart at the meeting the most interesting feature is the equal status of the two main bodies controlling it: the Scientific Committee and the Council.[6] The former had the task to examine all proposals for research, whether from Universities and national scientific institutions or from within the organization itself, and to decide about the actual scientific programme of the Organization. The Council, made up of delegates of member states, would have overall control over policy and finance. It is evident that, by this time, the plans for ESRO were strongly affected by the scientists' determination to control the new Organization: they were thinking of an international agency, funded by governments, whose policy had to be defined by an independent scientific body on the basis of pure scientific considerations. No administrative and financial committee was foreseen which, as in the case of CERN, would be responsible for recommending the organization's budget and for advising the Council on financial matters.

The creation of COPERS and the first definition of the scientific programme

On the 1st December 1960, the official representatives of 11 European countries, convened by the Swiss Government in the amphitheatre of CERN,

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[5] The two centres became in the *Blue Book* the *European Space Technology Centre* (ESTEC) and the *European Space Data Centre* (ESDAC).

[6] Massey & Robins (1986), p. 116.

agreed on the so called *Meyrin Agreement* which established the *European Preparatory Commission for Space Research* (COPERS, from its French initials). By this Agreement, these nations expressed their interest "in studying the possibilities of European collaboration in research in space science and space technology" and assigned COPERS the task to prepare the documents and institutional settings for the future space organization. For this task COPERS was endowed with a budget of 935,000 FF (French francs), subscribed by member states according to the same scale of contributions in force at CERN.[7]

One of the assignments of COPERS was the preparation of the scientific programme of ESRO and for this the Commission, at its first session, created a Scientific and Technical Working Group (GTST, from the French initials) whose task was to draw a proposal for the scientific programme, with the proviso that it should consider "not only the scientific desirability of the proposed projects, but also the technological implications as well as the time, personnel and funds which such projects would require."[8] L. Hulthen, from the Royal Institute of Technology in Stockholm, was nominated chairman of the working group and R. Lüst, from the Max-Planck-Institut für Physik und Astrophysik in Garching, was its coordinating secretary.

The GTST met for the first time in Stockholm on 4-5 April 1961, with the participation of 23 people from all Member States including scientists, engineers and government officials.[9] Here, following the deliberations of the GEERS' London meeting, it was agreed to organize the scientific programme into three kinds of projects: short term projects, based on the use of sounding rockets; medium term projects, requiring small satellites and space probes; and long term projects, involving the use of larger and more complex spacecraft. This decision was not uncontroversial, however. Stimulated by some critical comments from the

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[7] Krige (1992a). The countries were Belgium, Denmark, France, (West) Germany, Italy, Netherlands, Norway, Sweden, Switzerland, United Kingdom. Eventually Austria also signed the Agreement and became the 12th member of COPERS. Norway did not join ESRO.

[8] COPERS, 1st session (13-14/3/61), COPERS/Min/1, undated, p. 3. At the same session a Bureau was elected, comprising the president H. Massey (UK), the vice-presidents L. Broglio (I) and H. van de Hulst (NL), and the executive secretary P. Auger (F). A Juridical, Administrative and Financial Working Group (AWG) was also created, under the chairmanship of A. Hocker (D).

[9] The draft minutes of this meeting, with 12 appendices, are in folder 1688, ESA papers, Florence. See also Massey & Robins (1986), p. 120-123, and Krige (1992c).

Italian engineer and space scientist L. Broglio, a lively discussion arose about the role and scope of the sounding rocket and small satellite programmes. According to Broglio, these two programmes had to be mainly performed on a national basis (sounding rockets) and in close cooperation with the NASA (small satellites), while ESRO should concentrate its efforts on more ambitious projects, well beyond national resources.[10] On the other hand, the majority of participants felt that sounding rockets and small satellites were necessary for three main reasons: (1) to involve the smaller countries more effectively in ESRO's cooperative activities; (2) to enable the European space science community to get significant results in a short time and independently from the American programmes; (3) to give the research groups and the new Organization useful experience in view of growing involvement in the more demanding satellite projects.

A coherent and well defined proposal on short term projects was presented by the Swedish physicist B. Hultqvist, from the Geophysical Observatory in Kiruna. This listed 13 experiments to measure upper atmosphere parameters in the auroral zone by means of rocket borne instrumentation and included cost estimates for rockets (six for each experiment), personnel and equipment.[11] The proposal reflected the interest and experience of Scandinavian scientists, and Hultqvist's in particular, in ionospheric studies in the auroral zone and over the polar cap. An interest in this kind of investigation also existed in Great Britain, where a rocket programme for ionospheric studies had started in 1953 with launchings going on since 1957. Therefore, Hultqvist's proposal was strongly supported at the meeting by the British physicist R. Boyd, of University College, London, in spite of some disagreement among the delegates "as to whether such a sounding rocket program was to be regarded as a true European cooperative project."[12]

Boyd himself, on behalf of the British delegation, presented a proposal for the long term programme.[13] This included two projects to be realized in 4-6 years, namely: (a) a series of satellite astronomical observatories based on a highly stabilized platform; and (b) a series of lunar satellites. Several scientific objectives

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[10] Broglio's statement is in appendix 8.

[11] Draft minutes, Appendix 9.

[12] Draft minutes, p. 4. British involvement in ionospheric research is described in Massey & Robins (1986).

[13] Draft minutes, Appendix 3.

were listed for the earth-orbiting observatories, with an emphasis on astronomical studies in the UV and X-ray bands, where atmospheric absorption hinders the use of ground based telescopes. In this respect it was mentioned that extensive preparatory work had been made in Great Britain for a satellite devoted to UV stellar spectroscopy with 1 Å resolution in the range 1250-3300 Å. The aims of the second project were the study of the physical properties of the moon and the provision of a long-life observatory for the study of solar corpuscular radiation, of interplanetary dust and of cosmic rays outside the terrestrial magnetic field. The lunar satellites were also considered a first step towards the direct study of planets.

While Hultqvist's and Boyd's proposals were eventually accepted as a basis for further elaboration for the short and long term programme respectively, no definite idea was discussed about the medium term projects. The participants at the meeting limited themselves to taking note of the French proposal for radioastronomical satellites and included among the projects to be studied a proposal from Lüst to create artificial comets from satellites and rockets. The meeting concluded with the creation of four subgroups of experts devoted respectively to: (i) *Scientific programmes*, under the chairmanship of Hultqvist; (ii) *Technology*, under the chairmanship of A.W. Lines, from the Royal Aircraft Establishment at Farnborough; (iii) *Tracking and data handling*, under the chairmanship of J.C. Pecker, from the Observatoire de Meudon, and later of C. de Jager, from the Utrecht Observatory; and (iv) *Vehicles and ranges*, under the chairmanship of J. Vandenkerckhove, from the Institute of Aeronautics of the University of Brussels. Eventually, these groups' reports were to become as many chapters in the GTST's final report to COPERS (the *Blue Book*).

After the GEERS' London meeting and with Boyd's and Hultqvist's proposals to hand, it was not a difficult task for the first of these subgroups to write down the outline of ESRO's future scientific programme. In fact, the first meeting of this subgroup, held in Kiruna on 27-29 April 1961, was attended only by Boyd and Hultqvist, by two other scientists from Sweden (E.A. Brunberg and J. Ortner) and one from Norway (B. Landmark). The French engineer P. Blassel was also present on behalf of the Secretariat. Of the other Member States, only Belgium and Germany had nominated representatives in the subgroup but they were unable

to attend.[14] At the meeting, the already agreed on three-phase programme was made just slightly richer. The short term programme included (with just a few additions) the auroral zone rocket experiments presented by Hultqvist, as well as similar studies of the upper atmosphere at medium and low latitudes, and rocket-borne astronomical experiments. A series of meteorological pilot studies was also included, to be performed by launching many small rockets (350 per year). This part of the programme, however, was not included in the *Blue Book.*[15] The long term programme included Boyd's projects of astronomical satellites and lunar satellites, as well as a project of geostationary satellites and a twin satellite project for radiointerferometric studies of the upper atmosphere. Eventually, however, only Boyd's proposals survived in the *Blue Book.* Finally, the list of the research fields in the medium term programme remained quite generic. It included topics like ionospheric, solar and geodetic studies; cosmic rays and Van Allen radiation; gravitational, electric and magnetic fields in the vicinity of the earth and in interplanetary space; solar wind, cometary evolution and interplanetary plasma. The list also included "study of fundamental problems in long distance communication by means of satellites" which eventually disappeared from the *Blue Book.*

From the organizational point of view, the meeting suggested that the scientific projects to be supported by ESRO should be divided into two groups:
a) pure ESRO experiments, totally funded and engineered by the Organization: these were to be primarily the long term, large satellite projects;
b) combined national and ESRO experiments, in which the scientific experiments were built by the laboratories proposing them and paid for by national funds while ESRO would take care of their integration in rocket or satellite payloads and would provide all technical facilities for engineering, testing and launching.

For both kinds of projects, however, it was stated that all the scientific work - planning the experiments, design and construction of the scientific instruments,

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[14] B. Hultqvist, *Report to the interim Scientific and Technical Working Group of the Preparatory Commission for European Space Research from the Subgroup for Scientific Projects,* 4 May 1961, folder 1688. J. Ortner was actually Austrian but he worked at Kiruna at that time.

[15] A project for rocket research in meteorology had been presented by the Swedish scientist B. Bolin at the first meeting of the GTST (appendix 10) and there it had been agreed that ESRO should initiate such a programme to be later taken over by meteorological service organizations.

interpretation of the results, etc. - had to be done by research groups in the member states and no in-house scientific laboratory was to be established.

Conflicting views about the role and aims of ESRO

At the second meeting of the GTST, held in London on 8-9 May 1961, the scheme worked out by the sub-committee was accepted and, on this basis, an outline of the launching programme, the facilities and the budget of ESRO was drafted.[16]

If the definition of a comprehensive programme in space research was not immediately controversial, it however put together different views about the role and aims of the future Organization. Two major areas of conflict can be identified. The first regards the relative priority to be given within ESRO's programme to projects involving small and medium-size satellites, on the one hand, and to those requiring larger and more complex spacecraft on the other. The first option met the interests of physicists involved in the various fields of space research: they would advocate a programme based on a large number of small and medium-size satellites, capable of meeting the needs of numerous research groups. The second option was to be supported by the astronomers, whose scientific interest was in the realization of a few space telescopes on highly stabilised, high-performance spacecraft.

The first option was more versatile and flexible but left ESRO mainly in the position of an agency providing managerial and technical facilities for a rather dispersed and fragmented set of activities. Moreover, this course of action left the financially limited operational programme of the organization to competition between the various sectors of the space science community. The second option was more in the line of the CERN model, establishing a principle of cooperation with the view of carrying out projects of interest to a large, multinational scientific community, whose realization required financial and technological means far beyond the capabilities of individual member states.[17]

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[16] COPERS/20, 11/5/61. This is the report issued by the GTST after the London meeting and presented at the second session of COPERS. A short draft by the co-ordinating secretary, with the list of participants, can be found in folder 1688, ESA papers, Florence.

[17] A discussion about this point is in Golay (1984).

The programme of ESRO, as it was worked out in that very early phase, did not establish priorities: neither between different kinds of projects nor between scientific fields. It came to be presented as an ambitious list of topics covering almost all fields of space science, except those involving manned flights. This was obviously the easiest course of action in a phase when space science in Europe was at its very beginning and no research group or disciplinary community had the experience and the prestige to advocate clear priority choices. As we shall see, a great deal of optimism about the technical and financial realities eventually led to gross overestimation of the number of spacecraft ESRO could actually realize, thus giving the illusion that this highly ambitious and unfocussed programme could be implemented.

The second area of controversy became explicit already at that time and regarded the question whether or not ESRO was to be endowed with its own research laboratory and to make in-house research. Following the recommendation of its subgroup for the scientific programme, the GTST's opinion was definitely on the negative. In fact, at the Group's London meeting it was agreed that ESRO should only be responsible for the engineering development of satellites and that it "should [not] compete with Universities and other Research Institutes in carrying out purely scientific research."[18] The whole of the scientific work would be under the responsibility of scientific groups outside the organization and the latter was called to provide for technical facilities such as engineering of satellites and complex payloads; general instrumentation like telemetering or stabilization; rockets, launching ranges and launching operations; tracking of satellites, data recording and reduction; etc. Moreover, no mention was made of the applied research programme which had been recommended at the GEERS' London meeting in October 1960.

The rationale "for ESRO not having its own scientific groups" was given by Hultqvist in the following terms:

> (a) if a central scientific establishment were set up it would drain the national scientific activity of scientists;
>
> (b) ESRO scientific groups will very easily become privileged groups, having the best staff, best laboratory facilities and most experience

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[18] COPERS/20, 11/5/61, p. 1.

> and might therefore be expected to have a tendency to take over the most sophisticated and interesting experiments;
> (c) if no purely scientific research groups [are to] exist, the scientific activity stimulated and supported by ESRO will certainly have to be distributed over the participating countries, which is regarded as being of great value for the organization.[19]

Hultqvist's position reflected the variegated character of space science as well as the weakness and lack of a common tradition within the space science community (a situation very different from that of particle physics). This community, in fact, could hardly accept a central research establishment when the power relations between its various sectors had not yet been tested and clear priorities had not yet been established.

This position, however, was not held unanimously among those involved in the discussion on the role and aims of the future organization. In fact, introducing the second session of COPERS, H. Massey invited the Delegations "[to] speak their minds quite frankly" on the suggestions contained in the GTST's report.[20] On his part, the latter's chairman, Hulthen, introduced this report recalling the specificity of space research and the various fields of research it involved. This, he argued, made ESRO quite different from an organization like CERN and justified both the lack of a detailed scientific programme and the suggested organization:

> Obviously the scientific planning and responsibility in such an enormous field of research could not be left entirely to a relatively small group of scientists at a central institute. In a European Space Research Organization, when it came to scientific initiative, ideas and planning, we would depend very much on the scientists all over Europe, not only those who were attached to the central establishments of ESRO.[21]

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[19] COPERS/GTST/I/l, 15/6/61, folder 1688. This is a letter from Hultqvist to Lines to be used in the discussion at the third meeting of the GTST.

[20] COPERS, 2nd session (17-18/5/61), COPERS/Min/2, 25/5/61, p. 1.

[21] COPERS/Min/2, p. 2.

Most delegations at COPERS did not agree, however, and shared the opinion expressed by the French that:

> It would be contrary to the Meyrin Agreement to consider that the sole aim of the European Space Research Organization was to put at the disposal of Member States a certain number of technical facilities, the initiation and execution of scientific experiments being left entirely to national institutions. If scientific research were only to be conducted in national institutions, there was a risk that some of the smaller countries which did not possess the necessary resources would feel themselves badly served.[22]

The vagueness of the scientific programme was also criticized and the Belgian Delegation blamed the GTST's report for not having "any mention of advanced scientific studies" and for limiting the role of ESRO "to the application of techniques already known."

In the event, the Preparatory Commission requested the GTST to perform more detailed studies about the objectives of the scientific programme and the way to implement it, and also requested to examine the desirability of establishing ESRO laboratories for pure and applied research.

When the GTST met again, on 12-13 June 1961, the case for an active role of ESRO in pursuing original research was advocated by J.A. Vanderkerckhove and by two astronomers: M. Golay, from the Observatoire de Genève, and J.C. Pecker, from the Observatoire de Meudon. According to the three scientists it was a serious mistake for ESRO "to keep outside the European programme the development of fundamental researches and new technologies as well as the exploitation of the results of this programme." On the contrary, ESRO had to play an important role in promoting and funding advanced research programmes both in pure and applied science and this could be done both by the establishment of new laboratories and research groups, partially or totally funded by ESRO, and by supporting already existing laboratories.[23]

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[22] COPERS/Min/2, p. 4.

[23] M. Golay, J.C. Pecker, J.A. Vanderkerchkhove, *Remarques sur le programme de la COPERS*, COPERS/GTST/6, 12/6/61. The quotation is our translation from the French original. GTST, 3rd meeting (12-13/6/61), COPERS/GTST/11, 14/6/61. A list of "arguments for and against the scientific laboratories of ESRO" was prepared by Pecker, COPERS/GTST/I/8, 20/6/61.

No conclusion could be reached at the meeting, however, and the GTST's subgroup on scientific programme was called to discuss the matter further and to suggest a new scheme. It in fact required two more meetings of this subgroup, a joint meeting of members of the Bureau of COPERS and the officers of the GTST, and a further meeting of the GTST, in order to reach what Hulthen presented as "the result of a long and difficult discussion and [...] a compromise between two opposing points of view."[24] This compromise, carefully worded in the *Blue Book*, stated that ESRO, besides providing technical facilities, would also provide "opportunities for original research beyond those which exist in individual countries." To meet this aim a small research group was envisaged, "at the same place as the European Space Technology Centre but not under the same direction", whose main functions were:

> To undertake theoretical studies and fundamental theoretical research of importance to space science [and] to provide experimental facilities to enable individuals and small institutions to undertake research in space science.[25]

The Research Group would have its own building and a small permanent staff (typically 1 scientific director, 2 assistants, and technical, administrative and secretarial staff) and facilities for some 50 research workers (fellows and guests). Its running budget was fixed at 1 MFF (million French francs), namely 0.4 % of ESRO's total budget. ESRO's scientific activity also included a fellowship programme, both at scientific institutions in member states and at ESRO establishments. The budget for these two kinds of fellowships amounted to 0.9 and 1.5 MFF respectively.

The *Blue Book* also established that ESRO had to perform applied research in space technology. In this respect a distinction was made between short-term research, whose aim was "to offer better facilities for a more advanced programme in space science", and long-term research, "associated with forward looking assessments of space missions, in order to indicate technical possibilities

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[24] COPERS, 3rd Session (24-25/10/61), COPERS/Min/3, 16/11/61, p. 2. GTST, 4th meeting (27-28/7/61), COPERS/GTST/22, 28/7/61. See also: *Report from Subgroup I to the Scientific and Technical Working Group*, COPERS/GTST/I/21-(rev. 1), 13/7/61.

[25] *Blue Book*, p. 24. ESRO's research laboratory came to be called ESLAB. Subsequently another research institute was created at Frascati, near Rome (ESRIN).

for space science." While it was clearly stated that short-term research had to be pursued at ESTEC, with close links with the technical development of the agreed scientific programme, the wording about the long-term programme reflected the laborious compromise:

> It is possible to envisage [long-term applied research] being carried out by some other means under ESRO control. [...] It is not considered desirable, at least in the initial period of build-up of ESRO, to set up separate institutes under ESRO control for carrying out long-term applied research. It is believed that such institutes would be less likely to produce results, which can form the basis of equipment development, than groups in contact with project work. However, it is considered that ESRO should support some applied research of a long-term nature for space application in universities and research institutes where work of an allied nature is already in progress.[26]

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

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[26] *Blue Book*, p. 38-39.

The Blue Book [27]

ESRO's scientific programme, as described in the *Blue Book*, extended over eight years and presented the usual division into short, medium and long term projects. The first category covered rocket experiments "which could be carried out using means which exist or which could be quickly developed." Three fields of study were included in the short term programme, for which some 75 experiments had been suggested by European research groups following a questionnaire circulated to COPERS member states. The first was essentially Hultqvist's original proposal to investigate upper atmosphere physics in the auroral zone. Fifteen experiments were listed and the main characteristics of the envisaged programme were discussed in terms of scientific objectives and apparatus. Moreover, the establishment of a northern launching range of the Organization, near the Kiruna Geophysical Observatory, was recommended (eventually called ESRANGE). The two other fields of study in the short term programme were far less detailed. The first consisted in the extension, where possibile, of the upper atmosphere physics programme to lower latitudes, using existing national ranges in Europe. The second was generically indicated as "astronomical studies", including solar ultraviolet and X-ray radiation; lunar and planetary ultraviolet and infrared radiation; solar corona, zodiacal light and albedo. As to time schedule and launching rate, the *Blue Book* considered that a small number of rockets could be launched in the first year of ESRO's existence, going up to about 40 rockets in the second year and reaching in the third year an annual launching rate of 65 "standard" rockets (50 kg payload to 150 km).

The medium term projects included experiments involving small satellites in near earth orbits and small deep space probes, each spacecraft carrying about five experiments. Here again about 75 experiments had been suggested by interested groups and the list of proposed fields of study included practically all fields of space science. No priority was given but it was underlined that, due to the limited

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[27] The *Blue Book* is a 77-page report prepared by the GTST and approved by COPERS at its third session, in October 1961. It represents the document where all the main features of the future European Organization from Space Research are established. The report is divided into 5 chapters, devoted respectively to a general outline of ESRO, the scientific programme, the technology centre, data handling, and the ranges and vehicles. Of this document only the aspects relevant to the subject of this paper will be discussed here.

time for preparation of the answers to the questionnaires, "the list must be regarded as a very preliminary one."[28] The time schedule and launching rate forecast for the medium term programme was rather ambitious: they envisaged the successful launching of two small satellites in the fourth year of ESRO and three small satellites or deep space probes per annum from the fifth year. It was assumed that the small satellites should be launched by the American *Scout* launcher while the space probes, as well as the large satellites of the long term projects, should be launched by a heavy launcher of the class of the forthcoming ELDO launcher based on *Blue Streak* or the American *Atlas-Agena B*.[29]

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

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

In conclusion, leaving aside the relatively simple and inexpensive sounding rocket programme, the *Blue Book* foresaw the successful development and launching of 17 satellites in the 8 years covered by the ESRO Convention, namely

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[28] *Blue Book*, p. 32.

[29] The *Blue Book* also took into consideration the possible use of the British *Black Knight* and the French *Diamant* as light launching vehicles. At that time, however, the adaptation of *Black Knight* for satellite launching was still under preliminary study and *Diamant* was still at the design stage. About the early development of ELDO (European Launcher Development Organization), see De Maria & Krige (1992).

11 small satellites, 4 space probes, and 2 large satellites (table 1). It must be noted, however, that it was assumed that 2 launchings would be required to obtain one successful spacecraft and thus the number of launchings actually budgeted was doubled.[30] The total cost of the satellite programme was estimated at 733.5 MFF, of which 450 MFF was for launchers and launchings and 283.5 MFF for spacecraft development.

Concluding this part two considerations are called for. The first regards the role and aims of the envisaged space organization. Conceived and advocated as an international organization solely devoted to space research, ESRO did not in fact come out as a scientific institution, with its own scientific staff, a scientific programme clearly defined according to established priorities and objectives, a recognised leadership role among other scientific institutions in member states, and a strong negotiating power *vis-à-vis* member states' governmental institutions. It eventually presented itself in the twofold aspect of a rather cumbersome multinational bureaucracy and a technical establishment conceived to use most of its operational budget for industrial contracts in member states according to the *juste retour* principle. It rapidly became a sort of battleground where difficult and complex negotiations among various interest groups were required in order to reach compromise and agreement.

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

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[30] See tables on p. 15 and 38 of the *Blue Book*. Also Krige (1992c).

The interim period

The *Meyrin Agreement* which created COPERS came into force on 27 February 1961 and was due to terminate one year later, when it was expected that the Convention establishing ESRO would be ready for signature by the new Organization's member states. As early as July 1961, at the 4th meeting of the GTST, it was decided to start an interim programme in order to lay the basis of the forthcoming organization, in terms of personnel and technical facilities.[31] In the event, due to delays in the preparation of the Convention, the Meyrin Agreement was duly prolonged and the interim period extended up to March 1964.

In spring 1962, with the ending of the preliminary planning, the preparation of the launching programme for the first phase of the forthcoming Organization became the most urgent task and it became clear that a new committee structure had to be defined for the interim period, modelled on that proposed for the permanent ESRO. The GTST then decided to dissolve the 4 sub-groups which had helped work out the *Blue Book* and to set up a *Launching Programme Sub-Committee* (LPSC) whose task was defined as follows:

> To propose the programme of payloads for sounding rockets and satellites to be submitted to the Scientific and Technical Working Group (later to the Scientific Committee which is expected to be set up by the Council of ESRO) for final approval. The task of [the LPSC] will be to combine proposals for experiments into a programme of integrated payloads, with tentative dates of firings and an indication of the ranges from which the launchings will take place."[32]

R. Lüst was chosen as the chairman of the LPSC, whose first membership included R. Boyd and O. Dahl (N) as well as the Head of the Programmes and

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[31] GTST, 4th meeting (27-28/7/61), COPERS/GTST/22, 28/7/61. See also COPERS/33 (rev. 1), 29/11/61.

[32] GTST, 6th meeting (9/5/62), COPERS/GTST/40, 17/5/62, p. 2. See also COPERS/GTST/37, 30/4/62.

Facilities Division and the Finance Officer of COPERS. Subsequently, the French physicist J.E. Blamont joined the membership of the LPSC.[33] To advise the LPSC in the consideration of the experiment proposals presented by research groups, a number of *ad hoc* working groups was created, whose members had to be chosen among European scientists expert in the different fields of space science (table 2a and 2b).[34] Finally, questionnaires concerning experiment proposals to be carried out with the first ESRO sounding rockets and satellites were sent out by the COPERS Secretariat.[35] The operational procedure to start the first European co-operative effort in space research was thus initiated.

The Launching Programme Sub-Committee

By the spring of 1963, 71 proposals for satellite and space probe experiments had been received and discussed by the various working groups (table 3). About 40 proposals were considered scientifically acceptable and were classified in three groups: those requiring simple unstabilized satellites, those requiring some kind of stabilization of the spacecraft and those requiring a highly eccentric orbit satellite or a deep space probe.[36] By the same time, it was decided that the first large astronomical satellites (LAS) of the long term programme should be devoted to high resolution (1 Å) stellar spectroscopy in the UV range, from the Lyman limit (912 Å) to about 3500 Å, on the basis of preliminary studies already performed in Great Britain.[37]

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[33] GTST, 7th meeting (29-30/10/62), COPERS/GTST/61, 10/12/62.

[34] The membership of the *ad hoc* groups is given in the series of documents COPERS/LPSC/5, in particular COPERS/LPSC/5 (rev. 2), 7/1/63 and COPERS/LPSC/5 (rev. 3), 15/2/64. For the evolution of the working groups see: LPSC, 6th meeting (29/4/63), COPERS/LPSC/84, 7/5/63; GTST, 9th meeting (30-31/5/63), COPERS/GTST/98, 20/6/63; 10th meeting (3-4/10/63), COPERS/GTST/126, 29/10/63.

[35] Letter of P. Auger, Executive Secretary of COPERS, 21/5/62. The questionnaire for sounding rocket experiments is COPERS/39; that for satellite experiments is COPERS/96. New versions of these questionnaires were prepared in 1963 and 1964.

[36] COPERS/LPSC/32, rev. 2, 7/5/63. An earlier version of this document, COPERS/LPSC/32, rev. 1, dated 21/1/63, lists 67 experiment proposals with no classification. The terms "highly eccentric orbit satellite" and "space probe" were used rather interchangeably in this phase. As a matter of fact, the former is a satellite whose orbit is a highly eccentric ellipse with apogee of more than 50,000 km; a space probe is a spacecraft injected into an escape orbit.

[37] The story of the LAS has been told in detail by Krige (1992b) and will be dealt with here only when necessary.

Following the discussions in the *ad hoc* working groups, the LPSC recommended that the first ESRO satellites should be two small unstabilized satellites devoted to the study of the polar ionosphere and to solar astronomy and cosmic rays respectively. These satellites were eventually called ESRO I and ESRO II.[38] A simple glance at table 3 explains this choice: it satisfied the interests of the largest fraction of the European space science community. The logic of numbers can be supplemented by the consideration that physicists involved in the study of ionospheric and auroral phenomena represented at that time the leading sector in the space science community, due to their established experience in rocket experiments. Moreover, most experiment proposals recommended by the ionospheric group did not require stabilization and the group itself had suggested an integrated payload containing experiments "for measurement of the ionizing agents, corpuscular and electromagnetic, as well as of the ionizations and excitations produced by those agents in the upper atmosphere."[39]

As to the experiment proposals requiring stabilized satellites, the LPSC limited itself to classifying them according to the proposing group and to the kind of stabilization required (i.e.: earth pointing, sun pointing and stabilization with respect to celestial co-ordinates). Subsequently, it was agreed to devote the first stabilized satellite to non-solar astronomy experiments, thus satisfying the interests of the second large sector of the astronomical community.[40]

Finally, the LPSC considered the proposals for highly eccentric orbit satellites (HEOS) and space probes (SP). Both the group on interplanetary medium and the cosmic ray group had stressed the great desirability of ESRO having a spacecraft journeying very far away from the earth as soon as possible and the LPSC invited the two groups to co-operate in order to define a good scientific mission for such a spacecraft. At the same time, the LPSC requested that a technical study be made

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[38] LPSC, 5th meeting (6-7/3/63), COPERS/LPSC/70, 2/4/63. See also COPERS/LPSC/80, 26/4/63 and COPERS/GTST/82, rev. 1, 14/6/63. In view of difficulties which arose in the preparation of the payload for the polar ionospheric satellite, it was eventually agreed to launch first the solar and cosmic ray satellite: LPSC, 7th meeting (26/8/63), COPERS/LPSC/95, 30/8/63. ESRO II thus became the first satellite launched by ESRO.

[39] *Ad hoc* group B, 5th meeting (14-15/2/63), COPERS/LPSC/59, 8/3/63, p. 9.

[40] LPSC, 8th meeting (7-8/2/64), COPERS/LPSC/123, 3/3/64; first meeting of the Interim LPSC (23/4/64), ESRO/ST/14, 4/6/64; second meeting of the Interim LPSC (30/7/64), ESRO/ST/60, 31/8/64.

on possible orbits and the associated tracking and telemetry problems.[41] Eventually, at its very last meeting, the LPSC agreed to recommend that the first ESRO highly eccentric orbit satellite (HEOS A) should be devoted to cosmic ray studies. It also recommended that a second HEOS or a space probe should be launched one year later and that primary consideration should be given to studies of the interplanetary medium.[42]

If we consider these first decisions and the work in progress on the LAS, we see that, thanks to the work of the LPSC and its advisory groups, the first phase of ESRO's satellite programme was reasonably well defined when the Organization came into being, with a fair balance among different scientific fields and technical options, and with about 20 research groups already involved in the preparation of the experiments. This was in line with the programme presented in the *Blue Book* and even though, owing to legal and financial reasons, the official life of ESRO was to start two years later than originally foreseen, scientists could feel confident that their optimistic plans could still be fulfilled.

ESRO's committees and advisory bodies

With the coming into force of ESRO's Convention, in March 1964, the GTST and the LPSC were dissolved and replaced by the Scientific and Technical Committee (STC) and its Launching Programme Advisory Committee (LPAC), respectively. The STC was made up of delegates from each Member State, preferably "competent scientists and technologists", with the task of advising the Council and ESRO's Director General on all scientific and technical matters affecting the work of the Organization. Among its terms of reference there was in particular:

> i) To recommend to the Council the scientific and technical programme of the Organization, having regard to the Organization's financial and other resources, and to keep under review the progress made in carrying out this programme.

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[41] LPSC, 6th meeting (29/4/63), COPERS/LPSC/84, 7/5/63; 8th meeting (7-8/2/64), COPERS/LPSC/123, 3/3/64.

[42] Second meeting of the Interim LPSC (20/7/64), ESRO/ST/60, 31/8/64.

ii) To examine proposals for space experiments and the composition of payloads, to approve where appropriate, and to make recommendations to the Council or the Director-General as appropriate regarding the timeliness and suitability of their inclusion in launching programmes.[43]

R. Lüst and the Danish physicist B. Peters, from the Niels Bohr Institute in Copenhagen, were unanimously elected chairman and vice-chairman of the STC.[44]

As to the LPAC, its terms of reference were defined as follows:

> The Launching Programme Advisory Committee (LPAC) shall prepare the scientific and technical programme of the Organization for submission to the Scientific and Technical Committee. In particular, the Committee shall combine proposals for space experiments into a programme of integrated payloads for sounding rockets, satellites and space probes. It shall also propose tentative dates of firings and indicate ranges from which the launchings will take place. In its work the LPAC shall take into account the financial, technical and scientific resources of the Organization.[45]

The membership of the LPAC consisted of four (eventually five) scientists nominated by the STC who were to be elected for a period of two years and were eligible for re-election. The initial membership was R. Lüst, R. Boyd, C. De Jager

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[43] Meeting of the Interim Scientific and Technical Working Group, 25-26/5/64, ESRO/ST/32, 11/6/64, p. 1-2. Document ESRO/ST/12, 6/5/64, contains the terms of reference proposed by ESRO's Secretariat that were eventually amended at the meeting. The most important differences are that the initial proposal considered that the STC should be composed of one delegate per Member State and that it should advise only the Council and not the Director General. At the meeting there was some discussion as to whether one or two delegates would be preferable and the matter was put to the vote: Sweden, Belgium, Spain and the United Kingdom voted in favour of two delegates and the other delegations abstained. Eventually, the Council decided that the number of delegates should not be limited. Council, 2nd session (15-17/6/64), ESRO/C/MIN/2, 8/7/64. Other tasks of the STC included to advising on technical facilities and on the recruitment of staff, and advising on the Organization's educational activities and co-operation with non-member states.

[44] STC, 1st meeting (10-11/9/64), ESRO/ST/MIN/1, 14/10/64.

[45] STC, 1st meeting (10-11/9/64), ESRO/ST/MIN/1, 14/10/64, p. 2. Also ESRO/C/75, 13/11/64. LPAC, 1st meeting (6/11/64), ESRO/ST/80, 20/11/64.

and J. Blamont and again Lüst was unanimously elected chairman of the committee.

Also carried over from COPERS was the system of *ad hoc* working groups called to assist the LPAC in its consideration of the proposals for experiments. The groups were identified by easily recognizable acronyms and their chairmen were appointed by the STC; their members were to be coopted by the chairmen as experts (table 4). The chairmen of the *ad hoc* groups were generally invited to the meetings of the LPAC, together with other persons such as the chairman and vice-chairman of the STC, the chairman of the Administrative and Finance Committee (AFC) and members of ESRO staff. Eventually, the LPAC decided that the number of members of a scientific working group should be between 9 and 12 and one third of the members should be replaced every year. The chairmen should act for a period of three years and they could not be members of the LPAC at the same time.[46]

Scientists and ESRO

The standard procedure to get an experiment included in one of ESRO's satellites provided that experiment proposals be presented by European scientific groups and discussed by the interested *ad hoc* group(s). If recommended from the scientific point of view, the proposal was submitted to the LPAC for eventual inclusion in a satellite payload, according to the agreed scientific programme and scientific mission of the satellite. In this phase, ESTEC engineers, in consultation with the proponents, were called to assess the various experiment proposals and their compatibility with each other and with the spacecraft from the technical point of view. Finally, the LPAC combined the various experiments into integrated payloads which were presented to the STC and then to the Council for final approval. The system thus worked along two lines: on the one hand, the STC and the LPAC discussed and approved, at political and scientific level

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[46] LPAC, 9th meeting (18/10/65), ESRO/ST/154, 9/11/65. The functions of the *ad hoc* working groups are described in ESRO/ST/40, 17/7/64, with rev. 1 (26/8/64) and rev. 2 (18/12/64). The initial membership of the groups is in ESRO/ST/88, 9/12/64. A partial renewal of the membership was approved at the 10th meeting of the LPAC (13/12/65), ESRO/ST/168, 4/1/66. In ESRO's annual *General Reports* one can find the membership of all ESRO's official bodies and advisory committees.

respectively, the overall programme of the Organization and the scientific missions of its satellites, within the financial limits imposed by the Council; on the other hand, the scientific community at large suggested scientific objectives and specific experiments in the various fields of space research.

The LPAC represented the place where the two lines eventually converged and a suitable compromise had to be worked out between the expectations of the scientific community and the political and economic constraints of ESRO's agreed policy. The members of the LPAC were at one and the same time scientists and scientific policymakers: representatives of the interests of the scientific community and guarantors of the technical and financial feasibility of the proposed experiments within ESRO's overall programme; authoritative spokesmen of national scientific communities and research fields and persons responsible for making choices on behalf of purely scientific interests in a multi-national, multi-disciplinary organization; strong personalities called to mediate between competing political, economic and scientific interests.

Above the LPAC, the STC was called to discuss and to recommend to the Council the overall scientific policy of the Organization. This regarded the launching programme and other matters such as: the applied research programme; the technical facilities required for the integration, engineering and testing of rocket and satellites, for the launching operations and for tracking and data handling; the research programmes of ESLAB and ESRIN; the relationship of ESRO with national space agencies in member states and with the NASA. In its membership, the essential tension between the members states' different interests, represented by the debates between national delegations, was interlaced with the several aspects of competition and cooperation between the different sectors of the space science community, expressed by the scientists present as delegates or advisers.

Under the LPAC, the discussions within the various *ad hoc* groups reflected the great variety of the scientific community interested in space research. For those scientists, the use of space technologies represented a new exciting frontier of experimental research. By instruments carried to the outer limit of the atmosphere and beyond, it became possible to study a wide range of otherwise inaccessible phenomena, such as the structure and properties of the ionosphere, the ultraviolet and X-ray components in the solar and stellar radiation, the

structure of the earth's magnetic field and its interaction with interplanetary plasma, primary cosmic radiation, the solar wind and the sun-earth relationship, the structure of the moon and other planets.

In order to understand the evolving debates within ESRO's committees and advisory groups, it may be useful to discuss a few aspects of the internal dynamics of this variegated scientific community. A first dividing line can be drawn between the disciplines interested in the earth's atmosphere and the sun-earth relationship and those interested in the study of celestial bodies (roughly speaking: geophysics and astrophysics). The most important research field in the first group concerns the study of the ionosphere and its modulation under the influence of solar radiation. The introduction of rockets and satellites radically changed the shape of this discipline, making it the first research field to come of age in space science. The use of satellites in this field required relatively small and simple spacecraft and one can easily understand the important role played in ESRO by the ION *ad hoc* group and by its influential chairman B. Hultqvist.

Within this first group one can also include the study of the earth's magnetosphere and associated phenomena. Several research fields and experimental techniques were involved in this kind of investigation whose range covered the solar wind, magnetic field measurements, trapped radiation, plasma processes, cosmic rays, and so on.

The other group of disciplines was the domain of astronomers, a far from homogeneous community, however, as their partition into three different *ad hoc* groups reveals. In this domain, the availability of space technology had opened up two new perspectives: the possibility to study the moon and the planets at close range, and the possibility to study electromagnetic radiation from celestial bodies in spectral regions where it is prevented from reaching the earth's surface by atmospheric absorption, in particular UV and X-radiation. While it appeared quite difficult for Europe to compete in the former field, in view of the vigorous programmes pursued by the two superpowers, the possibility to enter the fascinating field of UV astronomy was an obvious call for European astronomers, both those interested in solar physics, among whom the chairman of the SUN group C. De Jager was a recognised world spokesman, and those interested in stars. On the other hand, owing to the kind of detectors involved, X-ray and gamma-ray astronomy fell more into the domain of cosmic ray physicists.

By the early 1960s, cosmic ray physics was at a turning point. For about three decades the study of cosmic ray phenomena had been the experimental ground for the investigation of high energy particle interactions; the building of large accelerators in the 1950s had now shifted particle physicists to the new facilities and the interest in cosmic rays developed more and more in relation with other celestial phenomena. Here too a significant transformation was taking place. At the beginning of the space age, in fact, cosmic ray physics could be included in the domain of space geophysics. Cosmic ray physicists investigated the solar wind and its interaction with the earth's magnetic field and measured the composition and energy spectrum of non solar particles in the vicinity of the earth. Being charged, these particles are affected by interstellar magnetic fields and reach our planet having lost any memory about the position of the source. The emergence of the new fields of X-ray and gamma-ray astronomy, which required detecting techniques drawn from experimental physics, opened the domain of astrophysical research to cosmic ray physicists. X rays and gamma rays, in fact, propagate along straight lines from the sources and their investigation provides direct information on high energy processes in celestial bodies.[47] In this situation of rapid evolution of the discipline, which placed itself in a domain overlapping both geophysics and astrophysics, it is not surprising that the COS group became one of the most dynamic and successful.

THE REVISION OF THE 8-YEAR SATELLITE PROGRAMME

The first problem the LPAC had to face was the revision of the eight-year programme in the light of information acquired since the writing of the *Blue Book*. This was a difficult exercise, which brought into evidence the several problems and contradictions which affected the early development of ESRO as regards both its financial conditions and its scientific constituency.

We have seen that the programme approved by COPERS foresaw that most of ESRO's satellites had to be launched by *Scout* rockets. Subsequent discussions among scientists indicated an increasing interest in more sophisticated satellites than could be launched by the *Scout* vehicle. In particular, considerable interest

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[47] Hirsh (1983).

was expressed in the use of the *Thor Delta* as a medium launching vehicle, capable of launching larger and stabilized satellites. As a consequence, in the summer of 1963, the COPERS Secretariat was requested to make proposals for a possible programme based on a larger fraction of satellites and space probes of the *Thor Delta* (TD) type.[48] In the new proposal, the number of satellites to be launched was reduced to 14, namely 4 Scout-type satellites, 4 TD-type satellites, 4 highly eccentric orbit satellites or space probes, and 2 large satellites.[49] The total expenditure, budgeted over ten years, was estimated at 852 MFF, i.e. about 16 % higher than in the *Blue Book*. The cost breakdown was radically different, however, as the costs for launchers and launchings was now estimated at 317 MFF, including 11 backup launchings, while the expenditure on spacecraft development had risen to 535 MFF. A warning was added, however:

> By their very nature the above estimates are inexact since so far no technical studies have been conducted which will give more reliable figures.[50]

Some COPERS delegations, however, considered that the new operational programme and its budgetary version were rather optimistic and therefore they agreed to the proposal only for the first year of ESRO (1964). This year's budget was to be prepared accordingly, while the budget proposals for the two following years were to be considered only as a basis for planning.[51]

The LPAC plays its role

It was now up to the LPAC to discuss a sound scientific programme fitting this operational programme and to make a recommendation to the STC.[52] A "lengthy discussion" on this topic took place at the second meeting of the LPAC, in November 1964, and continued in the following three months. Eventually,

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[48] GTST, 9th meeting (30-31/5/63), COPERS/GTST/98, 20/6/63. See also, for the financial implications of using different launching vehicles, COPERS/GTST/91, 15/5/63.

[49] COPERS/GTST/116, 3/9/63; COPERS/GTST/117, 27/9/1963.

[50] COPERS/GTST/116, 3/9/63, p. 6.

[51] COPERS, 12th session (30-31/10/63), COPERS/MIN/12, 15/11/63.

[52] In November 1964, the ESRO Council officially asked the LPAC to review the 8-year programme and to submit its proposal to the STC and the Council itself: Council, 5th session (25-26/11/64), ESRO/C/MIN/5, 11/1/65.

definite conclusions were reached at an informal LPAC meeting, on 25 February 1965, and presented to the STC (table 5).[53] The first decision regarded the Scout-type satellites: on the basis of new information about the cost of the *Scout* and *Thor Delta* launchers, it was recognised that the latter was definitely to be preferred because of the lower cost per kilogram of payload. Therefore it was agreed not to start any further project of this type after ESRO I and ESRO II, both scheduled for launching in 1967. This freed resources for the TD-type satellites and, in fact, it was recommended to increase their number to six, on the assumption that they should be based on a common basic structure and stabilization system (the so-called "streetcar" concept). The scientific missions of the first four payloads were also agreed as follows:

TD-1, stellar astronomy (already fixed)
TD-2, solar astronomy
TD-3, ionospheric studies
TD-4, atmospheric studies

It was assumed the solar satellite TD-2 and the ionospheric satellite TD-3 were to be launched in time for the solar maximum in 1968/69 in order to study the relation between solar activity and ionospheric phenomena.

The new policy in favour of the *Thor Delta* launcher also affected the programme of highly eccentric orbit satellites. In fact, it was recommended that they too should all be launched by *Thor Delta* rockets into orbits extending out to 200,000 km (i.e. outside the magnetosphere) and that the telemetry network would be worked out on this basis. As to the scientific missions of this kind of satellites, following the first HEOS devoted to cosmic ray studies, it was agreed to devote the second to experiment proposals from the PLA group and the third to ionospheric studies. No choice was yet made for the fourth.

Finally, regarding the major projects, three large astronomical satellites (LASs) were proposed, the last to be launched in the 9th year. Preliminary studies

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[53] LPAC, 2nd meeting (24/11/64), ESRO/ST/89, 18/12/64. The February meeting was intended to be the fifth meeting of the LPAC, but as only two members of the Committee could attend (Lüst and Boyd), together with members of ESRO secretariat, it was not considered an LPAC meeting. The report on this meeting is in ESRO/ST/114, 16/3/65. The conclusions were presented in the report of the chairman of the LPAC to the 4th meeting of the STC: ESRO/ST/109, 3/3/65. Only the part of this document dealing with the satellite programme will be discussed here, leaving aside the part on the sounding rocket programme.

for the second major project were also under way, in particular on the feasibility of a fly-by mission to a comet and on a large solar satellite proposed by the SUN group. It was underlined, however, that "the necessary delays caused by the initial studies may result in the launching of [the cometary] mission outside the 8-year period", while the solar satellite "might, if accepted, be able to use the same basic vehicle as the LAS series."[54]

The expenditure estimate for this satellite programme was 455 MFF for spacecraft development and 225 MFF for launchings, both figures at 1962 prices. To this an amount of about 40 to 50 MF should be added for the realization of a deep space telemetry network. As we see, the total cost of the programme remained within the estimate in the *Blue Book*. It is remarkable, however, that in the three years since the writing of the *Blue Book*, the cost estimate for spacecraft development had doubled while the cost of launchings had been halved only by dropping all backup launchings. On the one hand this reflected the fact that now a larger number of more complex spacecraft were foreseen; on the other hand, the total number of satellites had also been reduced from 17 to 15 and industrial development work had actually started only for ESRO I and ESRO II, and therefore any cost estimate for the other projects still suffered from a large margin of uncertainty.

The STC fails to reach agreement on the LPAC'S recommendeations

When the LPAC's conclusions were presented to the STC, the chairman of the LPAC felt it necessary to put forward "a word of explanation [...] regarding the distribution of funds between the various projects":

> The policy has been to maintain a fair distribution in the scientific programme between the various fields of activity in space science. [...] In these various fields the cost of making worth-while observations varies considerably.[55]

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[54] ESRO/ST/109, 3/3/65, p. 4.

[55] Report of the chairman of the LPAC to the 4th meeting of the STC, ESRO/ST/109, 3/3/65, p. 2. Lüst, in fact, was the chairman of both the LPAC and the STC. However, he could not attend the STC meeting and the document was presented there by the Scientific Director of ESRO: STC, 4th meeting (10-11/3/65), ESRO/ST/MIN/4, 3/5/65.

Observations in the atmosphere and lower ionosphere could be made by relatively inexpensive rockets, argued Lüst, whereas a good astronomical programme required very expensive large satellites with high pointing accuracy and stability. Therefore, the attempt to keep a fair balance in scientific effort over the various fields of space science resulted in a disproportion in the distribution of money over the programme. He then concluded:

> Any apparent excess in emphasis towards astronomy does not, in fact, mean that more astronomical observations are being done, but follows from the fact that astronomical observations require very expensive instruments if they are to be done at all.

This argument, however, did not convince some members of the STC. Hultqvist, in particular, who was a Swedish delegate besides being the chairman of the ION group, argued that the balance of experiments was unfair since the proposed programme gave astronomers a much larger share in satellite space than what would be suggested on the basis of the interest of European scientists in the various disciplines of space science. According to him, in fact, satellite space appeared to be divided about fifty-fifty between astrophysical experiments and geophysical experiments, while:

> Of the total number of satellite experiments proposed (about 83 at present), those disciplines represented by the SUN and STAR groups submitted 24 % of experiments, whereas those represented by the groups such as ION and COS submitted 66 %.[56]

Hultqvist's arguments represented here more the opinions of the ION group than those of the Swedish Delegation. The former, in fact, had already claimed that "the proposed allocation [by the LPAC] of spacecraft to ionospheric and magnetospheric studies is totally inadequate to the needs" and they had proposed a "minimum programme" consisting of no fewer than 11 spacecraft of different kind in order to deal with the various scientific problems in the field and to match

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[56] STC, 4th meeting (10-11/3/65), ESRO/ST/MIN/4, 3/5/65, p. 2. Notice that cosmic ray studies were included by Hultqvist in the category of geophysical investigations because at that time they involved mainly the analysis of the solar wind and of the cosmic corpuscular radiation in the near earth environment.

the capacity of the scientific groups proposing experiments.[57] On the other hand, the other member of the Swedish Delegation, Y. Ohman, a veteran astrophysicist, underlined the need of pursuing most experiments in the astronomical field in order to gain experience before starting major projects. Astronomers, continued Ohman, "have been slow to see the advantages of space science", and they should not be discouraged, should the division of the programme be changed.[58]

Beyond the statistics, Hultqvist's arguments against the LPAC's proposed programme raised a question of scientific policy, namely whether to prefer a large number of small unstabilized satellites or a smaller number of large stabilized satellites. The first option was suitable for the study of the environment of the vehicle itself, i.e. the particles and the fields present in the regions of space visited by spacecraft; the second option was that of interest for astronomical and astrophysical studies, namely the study of distant objects. Connected to this question was the main controversial issue raised at the meeting, namely the idea of using streetcar type satellites for the TD series. Several delegations (the French and the German in particular) considered, in fact, that a streetcar satellite would have serious scientific limitations which would not be counterbalanced by financial and technical advantages. The reasons were explained by the president of the French *Centre National d'Études Spatiales* (CNES), J. Coulomb, in a document prepared for the following Council session:

> There is no justification for the development of a "standard", or "omnibus" or "tramway" vehicle for the Thor Delta satellites. If that method can provide good results in the USA for OSO [Orbiting Solar Observatory], OGO [Orbiting Geophysical Observatory] and POGO [Polar Orbit Geophysical Observatory] satellites, it is essentially because the experiments grouped in each type of satellite are of the same character and the satellites therefore carry out fairly similar experimental programmes; there is justification in this case for planning a vehicle in which the various scientific experiments can easily be accommodated. On the contrary, the ESRO Thor Delta series will include one solar, one stellar, one ionospheric and one geodetic

[57] SCI/WP/12, 25/1/65, p.1. See also Hultqvist's remarks at the 4th meeting of the LPAC (1/2/65), ESRO/ST/106, 17/2/65, p. 5.

satellite, and the experiments will be very different. It is in fact planned to develop a vehicle having the combined capacities of OSO and OGO, with severe limitations in size and weight. It is difficult to see how that can be done without introducing considerable limitations in the vehicle experimental programmes. There would be such great problems of adaptation that the final cost of the four vehicles may well be greater than that of the four *ad hoc* vehicles.[59]

Here again, behind the technical and financial uncertainties of the streetcar concept, an important issue of scientific policy was involved, namely whether to base ESRO's programme mainly on the realization of a number of specially designed satellites, in order to meet the requirements of very different scientific objectives, or to design a standard vehicle whose specifications (mechanical and electrical interfaces, attitude control, power, telemetry system, etc.) had to be met by the set of scientific experiments included in the payload. Obviously, these specifications were not "neutral" with respect to the kind of scientific mission the series of satellites was mainly called to accomplish: as the American case demonstrated, a geophysics standard satellite could be very different from an astrophysics standard satellite. Space scientists in the United States could profit by the bonanza of the Apollo project and then have independent programmes for the three main domains of space science (solar astronomy, stellar astronomy and geophysics); in Europe they had to fit everything in one.

Finally, at the STC meeting, technical and financial questions were put forward by ESRO's Technical Director A.W. Lines. He stressed that the concentration of launchings to meet the solar maximum in 1968/69 would run the Organisation into a peak of expenditure and pose a severe stress on ESTEC's resources. In order to implement successfully the envisaged programme a more rapid build-up of staff than planned was required. Lines also urged an immediate decision for endorsement of the programme and, in particular, an agreement on plans for the second year of the organisation as soon as possible (remark that this

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[58] STC, 4th meeting (10-11/3/65), ESRO/ST/MIN/4, 3/5/65, p. 3, 4.

[59] ESRO/C/114, 24/3/65, p. 2. To Coulomb's list of American standard satellites one should add the OAO (Orbiting Astronomical Satellites) series. A technical proposal for "A multi-purpose Thor Delta satellite" offering "a reasonable compromise between the requirements made by the experiments for solar, ionospheric and cosmic ray research" was discussed in SCI/WP/27, 23/4/65.

happened in March 1965, when the second year of the organisation was already in course!). In order to start investigating the possibilities of a basic design for a standard satellite, the Technical Director stressed, detailed information on at least two TD payloads was required, while, at that moment, only the payload of TD-1 had been agreed on.

The meeting closed without reaching agreement, much to the regret of Boyd who complained that "the STC was unable to agree a programme on which the LPAC had spent a great deal of time, and which it genuinely believed was the best possible solution." The Committee, nevertheless, agreed on the reduction in the number of Scout-type satellites and on the increase in the number of TD satellites, with the proviso, however, that the use of stabilized satellites would not exclude experiments not requiring stabilization from the launching programme. They also approved the LPAC's recommendation as to the scientific aims of TD-2 and TD-3, with the agreement that they should be known as solar maximum satellites and that the division of experiments between the various disciplines should remain flexible. Finally, after a long discussion, it was decided (with the abstention of Belgium and France who doubted the financial feasibility of the project) to recommend the payload already agreed on by the LPAC for the first highly eccentric orbit satellite. This decision, however, was subjected to the still controversial question of providing ESRO with a suitable deep space tracking and telemetry network.[60] No agreement, on the contrary, was reached about the principle of using a multi-purpose vehicle for the TD satellites, thus leaving still pending the core of the Organization's operational programme.

Before the Council session, the LPAC held a meeting in order to consider the comments of the STC on the proposed programme. Here again it came out that the controversial parts of the programme were: (a) the feasibility and the advisability of a standard spacecraft; (b) the necessity of a deep space telemetry network; and (c) the possible underestimation of the costs for the LAS project. In the event, the LPAC agreed that the realization of TD-3, TD-5 and of the second highly

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[60] The results of a preliminary study on a possible ESRO's tracking and telemetry network for highly eccentric orbit satellites and space probes are in ESRO/ST/111, 4/3/65. This paper was circulated at the meeting but not discussed because it had to be submitted first to the *ad hoc* groups. The French Delegation, however, expressed strong reservations about the opportunity of building a new deep space telemetry network.

eccentric orbit satellite "would depend finally on a review in two or three years' time when a more precise idea of the costing would be available." Therefore, the TD-2 satellite had to be regarded as a "solar, ionospheric and geophysical satellite" and the scientific *ad hoc* groups were invited to submit new proposals for its payload. Meanwhile ESTEC could start working on this spacecraft according to "probable specifications [...] based on present knowledge of experiments available."[61]

That was a poor compromise. When the realization of ionospheric satellite TD-3 actually proved impossible, the payload composition of TD-2 became a ground for harsh competition. It was bound to be a very hard job, in fact, to include in the same spacecraft experiments aimed at studying the sun as a star that happens to be near the earth (the way astronomers do) and experiments aimed at studying the influence of solar activity on the earth's near space environment (the way geophysicists do). Moreover, this task had to be accomplished by a set of experiments and a satellite design compatible with the already agreed payload of TD-1.

No decision taken on the 8-year satellite programme

In the presence of these divisions within the scientific community and lacking definite recommendations from its advisory bodies, the Council could only agree on the most conservative attitude, thus leaving any decision on the 8-year programme still pending. Provisional approval was given to the small satellite programme and to the TD programme "on the understanding that should costs prove much higher than anticipated, TD-3 and TD-5 might be abandoned." The Council also approved HEOS-A and its recommended payolad but it refused for the moment to endorse any extension of the existing ESRO tracking network (ESTRACK), in the hope that this, assisted by the French CNES stations, would make it possible "to obtain tracking and stored telemetry data sufficient for the proposed experiments." Finally, a lack of understanding was still registered about

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[61] LPAC, 5th meeting (19/3/65, ESRO/ST/116, 2/4/65, p. 6. The revised programme, with TD-3, TD-5 and the third HEOS listed in brackets and including new expenditure forecast, is presented in annex II to the minutes of the 6th Council session (24-25/3/65) ESRO/C/MIN/6, 14/6/65. See also ESRO/ST/128, 2/6/65.

the number of LASs to be included in the programme with regards to the availability of resources to start a new major project (the so called SLEP: Second Large ESRO Project). Several Delegations felt, however, that the costing of the major projects was unrealistic and it was agreed that the financial implications of the 8-year programme should be studied by the AFC before final proposals were submitted to the Council for approval.[62]

When the STC met again, in June 1965, only 5 projects plus the first LAS had been definitely approved (ESRO I and II, TD-1 and TD-2, and HEOS-A), and the whole operational programme was still under discussion. No step forward was taken at the meeting, in the presence of persisting uncertainties about expenditure forecasts and of different opinions among delegations.[63] The French Delegation insisted that ESRO should keep financial estimates within the limits laid down in the Convention, which implied, according to their estimates, that TD-3 and TD-5 had to be definitely abandoned as well as one HEOS (leaving only three) and one large satellite (leaving only two). The problem of the feasibility, scientific advisability, and cost of a single purpose vehicle for the TD series remained unsolved, because of the opposition of some who felt that this would impose too strict limitations to experiments aimed at different scientific objectives, and of others who advocated the use of small dedicated satellites against the inclusion of a large number of experiments with different scientific aims and technical requirements in one large payload.

The following STC meeting had no better success in finding an agreement. The main issues regarded the expenditure forecast, in particular the fact that an expenditure peak was going to occur in 1967/68 and the budget exceeded the ceiling imposed by the Financial Protocol annex to the Convention. The STC agreed to maintain the earlier recommendation that only the spacecraft projects already agreed on should go ahead and no new projects should be started for the time being.[64]

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[62] Council, 6th session (24-25/3/65), ESRO/ST/MIN/6, 14/6/65, p. 7-9.

[63] STC, 5th meeting (10-11/6/65), ESRO/ST/MIN/5, 13/8/65. The operational programme under discussion, with financial and budgetary implications, is in ESRO/ST/128, 2/6/65 (with annex ESRO/AF/246). See also the comments of the French Delegations in ESRO/ST/128, add. 1, 14/6/65.

[64] STC, 6th meeting (5-6/10/65), ESRO/ST/MIN/6, 26/10/65.

The 7th meeting of the STC was not even able to discuss the matter of the revision of the 8-year programme, owing to the budget problems raised by the fact that the AFC had placed a limit on expenditure in 1967 at 230 MFF while, according to the Technical Director, 270 MFF would be needed in order to carry out the agreed programme. The French Delegations argued that should the 1967 budget be restricted to 230 MFF, cuts should be made not in the operational programme but rather in the internal expenditure (buildings and personnel), which they felt was excessive. Waiting for more light about the financial problems, the STC concluded with a discouraging resolution:

> The STC does not yet feel in a position to determine whether [...] it will be possible to complete the adopted programme within the time envisaged as regards [the approved projects] ESRO I, ESRO II, TD-1, TD-2, HEOS and LAS.[65]

In fact, by the end of 1965, contracts had been signed and industrial development work had started only for the construction of ESRO I and II (in April 1965 and December 1964, respectively). Tender action had been concluded for HEOS-A and development work started in January 1966 on the basis of a preliminary letter of intent while the contract itself was signed only in November of that year. As to the TD-1/TD-2 project, the payload composition of the two satellites was approved by the Council in November 1965 but tender action was delayed and no definite information about the cost of the project was available. Finally, the LAS was still in the phase of design studies.

Thus, by the end of its second year (not considering the COPERS period), ESRO was still lacking a definite operational programme for its first 8-year lifetime, its management was still unable to make long-term plans on the basis of definite cost estimates and budgets, and European scientists had not even a certainty about the actual possibility of launching all satellites under development. The final blow to the optimistic hopes expressed in the *Blue Book* came when the member states refused to revise the ceilings which in 1961 the scientists had said that would be sufficient for an ambitious programme and which now proved dramatically insufficient to support even a much reduced programme.

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[65] STC, 7th meeting (5/11/65), ESRO/ST/MIN/7, 16/12/65. See ESRO/ST/161, 2/11/65, with attached FIN/WP/40, rev. 1, 29/10/65.

The 1966 crisis and the abandonement of LAS

The year 1966 was the last year of ESRO's first 3-year period (1964-1966), a period which was controlled by a financial ceiling of 385 MFF at 1962 prices, established by the Financial Protocol annex to the ESRO Convention. The Protocol also established a ceiling of 602 MFF for the second 3-year period (1967-1969), which left MFF 523 for the last two years of the initial 8-year programme to bring the total up to the ceiling of MF 1510 set for that period.

During 1966 it became evident that the Organization was unable to implement during the first three years all the capital investment and construction work for which the budget provided and in fact, after adjustment to 1965 prices, an underspending of 122 MFF was foreseen. In the spring of 1966, in view of the forthcoming Council session called to decide on the budget for the second 3-year period, the STC discussed again the revised 8-year programme and endorsed the proposal of the ESRO Secretariat that the unspent funds allocated to the first 3-year period would be carried forward to the second. On this basis a budget of 808 MFF (at 1965 prices) for the second 3-year period could be assumed, which implied that work could be begun on a pair of TD satellites roughly every 1.5-2 years and on a space probe at intervals of 2 years. The programme would be extended up to 1974 to complete all launchings.[66]

The Council, however, did not endorse this position and reaffirmed that the ceiling for the second 3-year period should be kept at MF 602 at 1962 prices, i.e. MF 686 at 1965 prices. The budget for 1967 was fixed at MF 230 at 1965 prices as against the MF 260 requested by the ESRO Secretariat.[67]

Facing this situation, a severe revision of the programme was required, based on the new figures about available resources. Assuming that work on the projects already started (ESRO I, ESRO II and HEOS-A) proceeded as planned, it was clear that "funds are not available to proceed with work on TD-1 and TD-2 and

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[66] STC, 9th meeting (2-3/5/66), ESRO/ST/MIN/9, 7/6/66, and 11th meeting (15/7/66), ESRO/ST/MIN/11, 24/8/66. See also ESRO/ST/201, 27/4/66. The financial situation and the budget proposal from the ESRO management are in ESRO/AF/476, 20/6/66.

[67] Council, 12th session (18-20/7/66), ESRO/C/MIN/12, 1/9/66. The Council went even beyond the recommendation of its AFC, which had proposed to carry forward about half of the unspent money and to set the budget level for the second 3-year period at 750 MFF: see ESRO/AF/549, 7/7/66, and rev.1, 8/7/66.

the LAS, even if no new satellites (TD 3/4 and HEOS-B) are started before about 1970." The conclusion:

> The launching of the LAS during the first 8-year period could therefore only be made possible by either abandoning the TD-1 and TD-2, or reducing the LAS aims and devoting only 160 MF to the spacecraft and 35-40 to the scientific package.[68]

Were neither of these alternatives to be accepted, it would probably be impossible to launch the LAS in 1971, within the 8-year period, and no new satellite project apart from TD-1 and TD-2 could be started before this date. In addition, owing to the approved budget for 1967, it was impossible to maintain the launching schedule for the TD satellites and therefore "some reduction of the aims of these satellites, or some delay, [was] necessary." This was not easy to do, however, for two main reasons: (a) TD-2 was closely linked to the occurrence of the solar maximum and then any delay implied that its payload had to be dramatically reconsidered; and (b) a tender for both TD satellites had been requested and any phasing out of them required a new tender action. Again, two alternatives were presented, both of which foresaw the launching of the LAS outside the 8-year period. In the first, the two TD satellites would be slightly simplified and the LAS programme would be slowed down in such a way as to launch it in 1973-74; in the second, one of the TD satellites would be cancelled from the programme, and the LAS would go ahead more rapidly, with an anticipated launch in 1972-73.

A dramatic discussion took place in the LPAC when they were called to give their advice; all aspects of ESRO's financial matters were analysed in order to avoid any reduction in the operational programme and to keep "the viability of ESRO as a reputable scientific organization." In the event, the LPAC recommended to reduce as much as possible the programme for capital investment and went as far as to propose the elimination of applied research contracts, the moving of ESRO's headquarters and ESDAC to ESTEC and the elimination of ESRIN. Even the possible abandonement of the sounding rocket programme was considered. As to the main issue, the LPAC strongly affirmed the highest priority of the TD-1/TD-2 programme and recommended that a ceiling of

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[68] SCI/WP/66, 19/8/66, p. 4. Also in ESRO/ST/215, 9/9/66.

300 MFF should be imposed on the LAS, of which no more than 200 MFF in the 8-year period. This would leave some money for starting new projects and the LPAC stressed that:

> ESRO should undertake medium satellites and space probe projects at such level as to ensure that two launchings take place on the average every year. This is considered a minimum programme.[69]

The LPAC's recommendations were endorsed by the STC after a long discussion that again dealt with all aspects of ESRO's activity and management.[70] This set of decisions probably represented the decisive blow to the LAS and, in fact, they showed the prevailing interest among European space scientists in a programme largely based on medium sized satellites, meeting the various scientific objectives and managerial capabilities of several groups, against a programme largely based on large and sophisticated spacecraft.[71]

By the end of 1966 ESRO's situation was dramatic and the budgetary difficulties seemed to jeopardize even the programmes already approved. In fact, in the operational programme the Secretariat presented to the STC in November no funds were available for the LAS in 1967 and only 1 MF could be allocated to the TD-1/TD-2 programme, with the possibility of allocating some 6 MF from the contingency fund.[72] This programme, however, had to start in early 1967 and the cost development plans for it submitted in the tenders foresaw payments of about 20 MFF for the first year: this was to be maintained if they wanted to launch TD-2 in the first half of 1970, in time for the solar maximum, and TD-1 six months later. Two alternatives existed in order to keep an acceptable launch date for TD-2, namely either to get at least 250 MF available for 1967 from the Council or to reach an agreement with the successful tenderer on a payment plan for 1967 with payments of about 5 MF.

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[69] LPAC, 13th meeting (27/8/66), ESRO/ST/218, rev. 1, 28/9/66, p. 6. The conclusions are also reported in ESRO/ST/215, 9/9/66. The draft budget for 1967 and the forecast estimate for the 1967-69 period based on this recommendation is presented in ESRO/AF/561, 7/9/66; also in ESRO/ST/216, 9/9/66.

[70] STC, 12th meeting (22-23/9/66), ESRO/ST/MIN/12, 2/11/66.

[71] Krige (1992b).

[72] ESRO/ST/229, 28/10/66.

A long and nervous discussion took place in the STC about the whole of ESRO's grim situation. The key issue was again the LAS, the large project which had been thought to be the main reason for ESRO's coming into existence but whose eventual realization also hampered any other project. Again, the STC agreed (with the only abstention of the United Kingdom) to accord absolute priority to the TD-1/TD-2 project while, by a few painful votes, it was substantially decided to halt the LAS until the Ministerial conference to be held the next year examined the new cost estimate and decide on the future of the project.[73]

The Council meeting in December could not find unanimous agreement (as required by the Convention) on the level of resources for the second 3-year period, thus preventing the Organization from planning ahead on a secure basis. Nevertheless it agreed on a 1967 budget of 240 MF and, endorsing the priorities established by the STC, requested the Secretariat to make proposals for savings in order to allow additional expenditure in the order of 4 to 7 MF for TD-1 and TD-2.[74] Thus, by the end of January 1967, a contract for the construction of TD-1 and TD-2 could finally be awarded.

Conclusion

By the end of ESRO's first 3-year period, and 5 years after the *Blue Book*, the comparison with the original plans was not exciting. Only five small and medium size satellites were under development and could be launched within the 8-year period covered by the Convention, no other project of this kind had been approved yet; the large astronomical satellite was definitely jeopardized and with it any hope to develop large space projects from which ESRO had mainly derived its *raison d'être*; financial difficulties and lack of confidence from member states made any long-term planning almost impossible.

Four main reasons can be given for this resounding set-back. The first regards the multinational character of ESRO and its institutional framework. The Convention had designed an organization on which tight control was to be kept by

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[73] STC, 13th meeting (8-9/11/66), ESRO/ST/MIN/13, 27/12/66. Also Krige (1992c).

[74] Council, 14th session (1-2/12/66), ESRO/C/MIN/14, 20/1/67.

member state delegation. This applied to the scope of its scientific programme, the extent of its facilities, and above all its budget, which was fixed over eight years and with fixed ceilings on expenditures at regular intervals.[75] Painful negotiations at several levels were required for most decisions and the executive branch of the Organization suffered from weakness and lack of autonomy. This was the malaise that J.H. Bannier so vividly described in March 1967, presenting his report on the structure and procedures of ESRO and on the changes deemed necessary.[76]

The second reason derives from the high fragmentation of space science, which implies a wide diversity of interests within the scientific community. The course chosen by the ESRO pioneers to respect this diversity in order to keep a united front in the early development of space research in Europe now collided inevitably with financial realities. When it started to become clear that not all research fields could be pursued and priorities had to be established, the competition among scientists became so fierce as to paralyse ESRO's advisory bodies. At the end of this phase one can already recognise one loser, namely the community of astronomers. Those interested in stars had lost the Large Astronomical Satellite and those interested in the sun were to compete for the TD-2 payload and they eventually lost. When, by the end of 1966, the LPAC started to discuss ESRO's new satellite projects, it was evident that the decisionmaking process would not be painless.[77]

Thirdly, one must mention the dramatic underestimation of the financial resources necessary to support the space research programme anticipated in the *Blue Book* and the glaring inability of ESRO to arrive at definite evaluation of the costs of projects. The lack of experience among engineers and industrialists in Europe about the requirements of space activities was certainly the main reason for this inability, to which one can add the illusory belief in the so-called "transatlantic factor", namely the idea that costs could be significantly lower in Europe than in the United States.

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[75] Krige (1992c).

[76] The *Bannier Report* is ESRO/C/APP/48, 29/3/67. This report and its implications will be discussed in another report in this series.

[77] LPAC, 15th meeting (13-14/12/66), ESRO/ST/237, 6/1/67. See Russo (1992a). The TD-2 crisis will be dealt with in Russo (1992b).

Finally, member states were not ready to support ESRO by itself. This Organization, in fact, was but an element in a complex framework which also included several others: the member states' national space programmes; the European launcher to be developed by ESRO's sister organization ELDO; the rising interest in application satellites and the commercial implication of space activities; the complex relationship of cooperation-competition between European countries and the United States; the ongoing process of European economic integration. It was in this framework that ESRO's crisis reached its peak. In fact, precisely in December 1966, following one year of negotiations among ESRO, ELDO and CETS (*Conférence Européenne des Télécommunications par Satellites*), the first European Space Conference (ESC) was convened in Paris, with the aim of defining a co-ordinated space policy in Europe. The task could not be accomplished easily, however, and it was only in November 1968 that the third session of the ESC was able to find a tentative solution, thus smoothing the way for the ESRO Council to agree finally on a level of resources for a new 3-year period (1969-71). Only then was ESRO allowed to make plans again.

TABLE 1

Number of satellites and space probes anticipated in the *Blue Book*

year	small satellites	space probes	large satellites
4	2	-	-
5	3	-	-
6	2	1	1
7	2	3	1
8	2		
total	11	4	2

It was assumed that two launchings would be required to obtain one successful spacecraft, therefore the number of launchings anticipated in the *Blue Book* was double the figures given in this table.

TABLE 2a

List of *ad hoc* working groups and their chairmen in 1962-1963

A	Atmospheric Structure	G.V. Groves (UK)*
B	Ionosphere and Auroral Phenomena	B. Hultqvist (S)
C	Meteorology	A. Nyberg (S)
D	Solar Astronomy and General Astronomy	J.-C. Pecker (F)
E	Interplanetary Medium	C. De Jager (NL)
F	Lunar and Planetary Astronomy	P. Swings (B)
G	Cosmic Rays and Trapped Radiation	G. Occhialini (I)
H	Geodetics, Relativity and Gravitation	W. Kertz (D)+

TABLE 2b

New distribution of atmospheric and astronomical groups

A, C	Atmospheric structure	R. Frith (UK)
D	Sun	C. De Jager (NL)
E	Moon, planets, comets and interplanetary space	L.F. Biermann (D)
F	Stars and stellar systems	P. Swings (B)

* M. Nicolet (F) had been initially proposed for the chairmanship of this group but he could not accept.

+ J. Bartels (D) had been initially proposed for the chairmanship of this group but he could not accept. This group was eventually dissolved.

TABLE 3

Satellite experiment proposals by early 1963 broken down according to disciplinary fields

A - Atmospheric Structure	3
B - Ionosphere and Auroral Phenomena	20
C - Meteorology	2
D - Solar Astronomy and General Astronomy	20
E - Interplanetary Medium	7
F - Lunar and Planetary Astronomy	--
G - Cosmic Rays and Trapped Radiation	18
H - Geodetics, Relativity and Gravitation	1
TOTAL	71

From: COPERS/LPSC/32, rev. 2, 7/5/63.

TABLE 4

Chairmen of *ad hoc* scientific groups in 1964/65

ATM	Atmospheric Structure	R. Frith (UK)
ION	Ionosphere and Auroral Phenomena	B. Hultqvist (S)
SUN	Solar Astronomy	C. De Jager (NL)
PLA	Moon, Planets, Comets and Interplanetary Medium	L. Biermann (D)
STAR	Stars and Stellar Systems	P. Swings (B)
COS	Cosmic Rays and Trapped Radiation	G. Occhialini (I)

From ESRO's *General Report* 1964-1965, p. 121-125. The membership of the groups is *ibidem.*

TABLE 5

Launching programme proposed by the LPAC in February 1965

Year	Small satellites (Scout type)	TD satellites (stabilised)	Highly eccentric orbit satell. or space probes	Major projects
1967	S1 S2			
1968				
1969		TD1 TD2	SP1	
1970		TD3 TD4	SP2	A1
1971		TD5 TD6	SP3 SP4	A2
1972				A3

It was assumed that *Thor Delta* rockets would be used for all TD- and SP-type satellites. For major projects the ELDO launcher was assumed.

From ESRO/ST/109, 3/3/65. p. 6. Also ESRO/ST/114, 16/3/65, p. 6.

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