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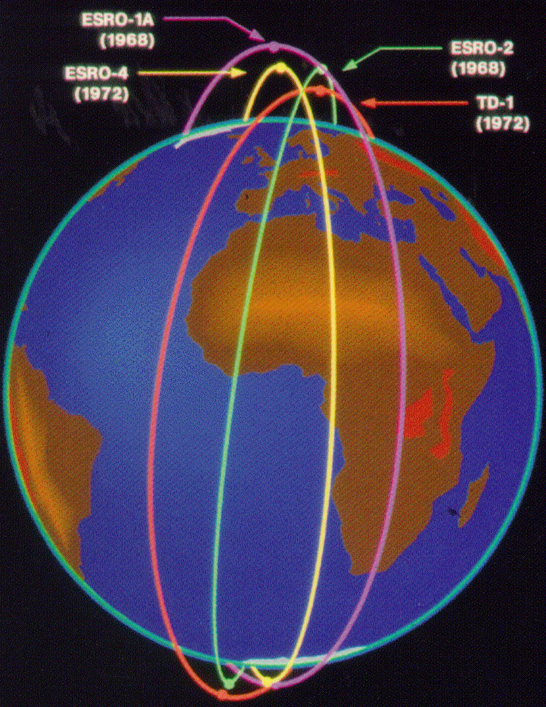
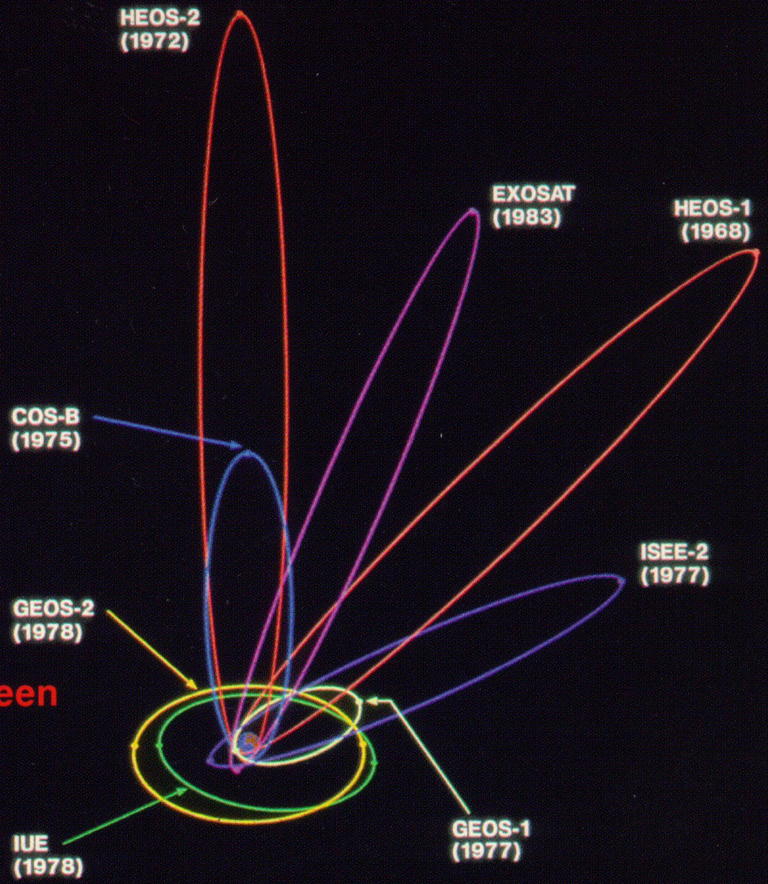
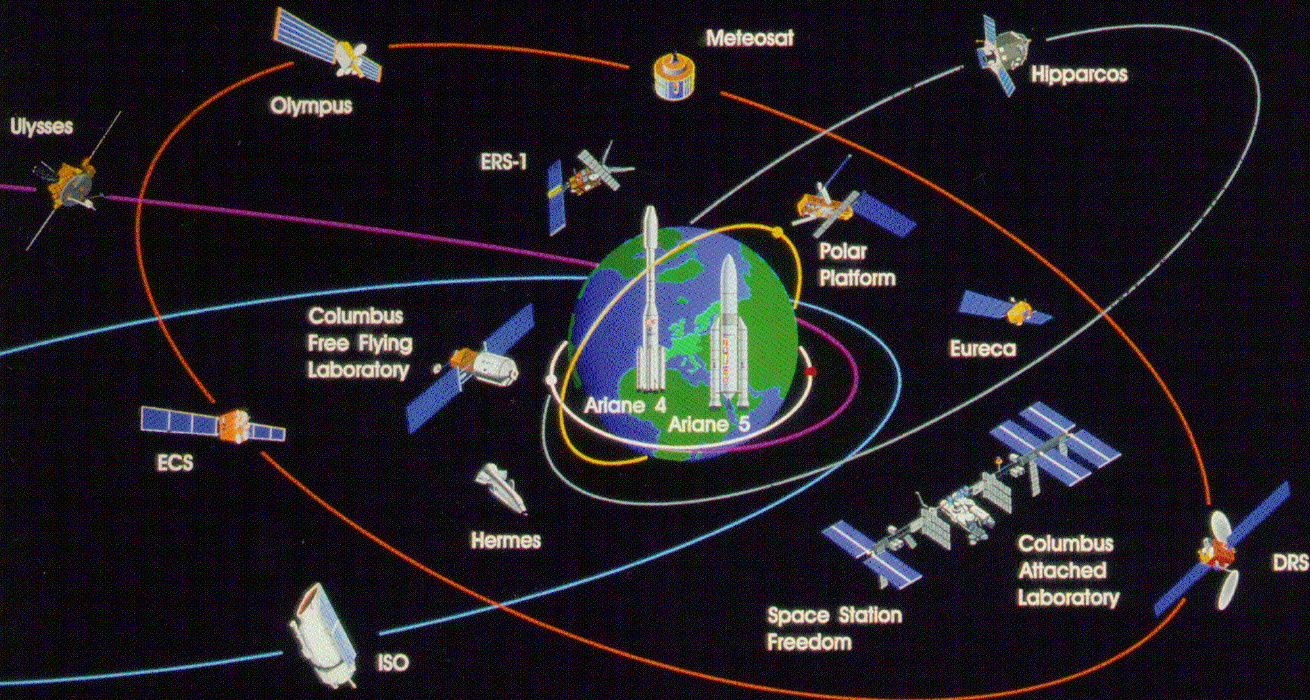




The scientific programme between ESRO and ESA: Choosing new projects (1973 – 1977)

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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THE SCIENTIFIC PROGRAMME BETWEEN ESRO AND ESA: CHOOSING NEW PROJECTS (1973–1977)

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Arturo Russo

> Scientific research is difficult. It is hard to do it alone; it is even harder to do it together.
>
> H. van de Hulst [1]

INTRODUCTION

In three previous reports in this series, we analysed the development of the scientific satellite programme of the European Space Research Organization (ESRO) in the first decade of its life.[2] Conceived in the early 1960s by a group of European physicists and astronomers, ESRO came officially into being in March 1964, when its Convention entered into force after ratification by the governments of its ten member states. The programme of the new Organization was written in a document, known as the *Blue Book*, prepared in 1961 by a Scientific and Technical Working Group and approved in October that year by the European Preparatory Commission for Space Research (COPERS, from its French initials).

In the following ten years, this programme was implemented amidst many difficulties of technical, financial and institutional character, which led to a drastic retrenchment of the founding fathers' early ambitions and expectations. By 1972 only seven small and medium-size satellites had been launched, roughly half the number planned, and no large satellite project had been realized. In spite of these difficulties and setbacks, however, ESRO could claim a very important role at the beginning of the new decade. Firstly, its satellites were working successfully and providing useful scientific data. For the European space science community, the most active, experienced and influential group of people involved in space activities in the Old Continent (at least in its western part), ESRO represented an

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[1] Van de Hulst (1961), p. 233.

[2] Russo (1992a), (1992b) and (1993b).

irreplaceable instrument for carrying on important research programmes in the various scientific fields that the advent of space technologies had opened up to experimental investigation.

Secondly, in the new framework of space activities, characterized by the growing importance of application satellites, ESRO provided Western European countries with a convenient institutional framework capable of guaranteeing their governments and industry an adequate presence in the new economic and commercial dimension of space. The Organization's managerial capability and technical expertise represented indeed a very firm basis for any joint European effort in such fields as satellite telecommunications, meteorology and earth resources surveying. The importance of this aspect is particularly evident when considered in the light of the failure of ESRO's sister organization ELDO (European Launcher Development Organization) and the inefficiency of the European Conference for Satellite Telecommunications (CETS, from its French initials).[3]

Finally, among the diverging economic interests and hard political conflicts which characterized the activity of the European Space Conference (ESC) in its effort to agree on a definite space policy at continental level, ESRO represented the only solid example of a possible cooperation. In December 1971, ESRO member states agreed on a "package deal" that defined the conditions for the Organization to continue its activity beyond the 8-year period covered by its Convention, not only in the field of space research but also in the new fields of application satellites. This agreement paved the way for a second package deal, agreed on by the ESC in July 1973, which laid down the institutional framework for a coherent European effort in all sectors of space, including the development of a European launcher (*Ariane*), a programme for a manned space laboratory in the framework of the NASA space shuttle programme (*Spacelab*) and the coordination of national space programmes. This second package deal was the corner-stone for the eventual creation in 1975 of the European Space Agency (ESA), whose organization was essentially based on ESRO's.[4]

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[3] Krige & Russo (1994b), Russo (1993c).

[4] Krige & Russo (1994b).

The ESA Convention was approved by a Ministerial Conference held in Brussels on 15 April 1975 and the new Agency came into *de facto* operation on 31 May. A few months later, on 9 August, the first ESA spacecraft was successfully launched and started providing a regular flow of important scientific data. This was the COS–B satellite, carrying a sophisticated instrument to study celestial gamma rays, whose mission had been approved by ESRO's decision-making bodies in 1969.[5] At that time, only one of ESRO's spacecraft was still in operation, the satellite HEOS–1 devoted to magnetospheric and solar wind studies. It re-entered the atmosphere two months later, on 18 October, after having completed 542 highly eccentric orbits in nearly seven years of successful operation. While COS–B was starting its orbital life, the ESA technical staff as well as a large fraction of the European space science community were implementing four scientific satellite projects approved in the days of ESRO. These were: (i) the geostationary satellite GEOS, approved with COS–B in 1969 and scheduled for launch in 1976 (later postponed to 1977), whose aim was the study of magnetospheric phenomena from the favourable position of the geostationary orbit; (ii) the space telescope IUE (International Ultraviolet Explorer), originally a joint undertaking by NASA and the UK Science Research Council in which ESRO had agreed to participate in 1971, whose launch was also scheduled for 1977; (iii) the ISEE–B satellite, ESA's contribution to the three-satellite International Sun–Earth Explorer programme developed in collaboration with NASA; and (iv) the X-ray space observatory EXOSAT. Both ISEE–B and EXOSAT had been approved in 1973 and were originally scheduled for launch in 1977 and 1979, respectively. Owing to budgetary revisions during the course of 1975, however, the EXOSAT project had been delayed and launch was now scheduled for 1980.[6]

The transformation of ESRO into ESA found the Organization's bodies involved in a new round of the decision-making process to select future scientific satellite projects. After the 1973 decision on ISEE–B and EXOSAT, a new decision was expected by 1976, when one or more projects would be approved for missions to be flown in the early 1980s. In preparation of this decision, the

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[5] Russo (1993a).

[6] Russo (1993b). In the event, EXOSAT could only be launched in May 1983.

European space science community was called upon to submit ideas and proposals and several mission definition and feasibility studies were performed by ESA, in consultation with the Agency's scientific advisory bodies. In the event, the decision was taken in two steps: in October 1976, the ESA Science Programme Committee (SPC) decided that ESA should participate in the NASA Space Telescope project; then, one year later, the SPC approved the Out-of-Ecliptic mission (later re-named International Solar Polar Mission), a joint ESA/NASA project consisting of two spacecraft flying over the North and South poles of the Sun, respectively, with the help of the gravitational pull during a Jupiter swing-by.

In this paper, we will discuss this decision-making process, which can be divided into three main phases. In the first, from June 1973 to April 1974, the European scientific community and their representatives in ESA's advisory committee structure were invited to agree on a set of space missions for which a definition study was recommended. The aim of this kind of study (mission definition or pre-Phase A studies, in ESA language) was to design a preliminary outline of the mission, to identify the various concepts and approaches for realizing it, and to assess the scientific importance of the results that could be achieved. At the end of this phase, thirteen missions were selected for such a definition study by ESRO's Scientific Programme Board (SPB).

The second phase covers the period from that decision up to March 1975, when a much more important decision was required, namely to select a restricted number of missions for which a feasibility (Phase A) study was to be performed. The aims of such feasibility studies were to establish the technical and financial feasibility of each project, to propose a well-defined project concept, to identify the research and technology effort required to support it, and to state a preliminary cost estimate to completion. We shall see that, on the basis of the results of the definition studies, five missions were selected for feasibility study by the SPB, following the recommendations of the scientific advisory bodies. Such a decision was one of ESRO's last legacies to the incoming ESA.

The third phase covers the first two years of the new Agency's life, and concluded with the selection of the projects to be adopted in ESA's scientific programme. As we have anticipated, two projects were pointed out by the scientific community as the most interesting, the Space Telescope and the Out-of–Ecliptic mission. In October 1976, the Science Policy Committee approved European participation in the former but reserved a decision on the latter because of uncertainties regarding the financial aspects of the programme. The decision was expected by May 1977 but it had to be postponed until November because of the crisis originated by the launch failure of the GEOS satellite in April that year.

The development of this decision–making process occurred in a transition period of which the transformation of ESRO into ESA was only one aspect. Three others should also be mentioned: (a) the new role of scientific research in the general framework of civilian space activities, which were more and more driven by economic rather than scientific interests; (b) the prospects opened up by the new space technologies under study in the post–Apollo era, i.e. re–usable transportation systems and manned space stations; (c) the new dimension of international cooperation in space, with the establisment of closer links both across the Atlantic and across the Iron Curtain. All these aspects will be dealt with, with more or less emphasis, in the following pages, making up the general background of the story we are about to analyse. We should stress, however, that the decision–making process we shall discuss in detail here is not the only relevant element in the history of ESRO's and ESA's scientific programme in the period from 1973 to 1977. Two others, at least, must be mentioned. Firstly, alongside the discussions on future scientific projects, ESA's decision–making bodies were also engaged in discussing the European contribution to the first Spacelab mission. The principal aim of this mission was the verification of the performance of Spacelab and its subsystems. However, taking into account the constraints imposed on the first payload by these system–test objectives, approximately half of the Spacelab resources were available for the accomplishment of scientific, application and technology objectives. These experimental objectives were planned jointly by ESRO and NASA, each agency taking about half of the available resources for European and US experiments, respectively. The discussions on the selection and financing of the European complement to the first Spacelab payload developed in parallel with those we are analysing below. They will be the object of a subsequent paper.

The second parallel story regards the problems and difficulties which affected the development of the GEOS and EXOSAT projects. The former suffered from a severe financial crisis in 1975, when it became evident that the accumulation of technical changes together with cost inflation would bring about a significant over–run of the budget allocation. After many negotiations with the industrial contractor, British Aircraft Corporation leading the STAR Consortium, a new cost–to–completion was agreed on and the launch date was postponed from August 1976 to April 1977. In order to meet this time schedule, however, it was necessary to forgo the qualification of the second flight model, a decision much to be regretted after the launch failure of the satellite.[7]

As to EXOSAT, it is important to recall that this was the first ESRO/ESA satellite for which the Organization was financing and managing the scientific payload. This was a consequence of the observatory nature of the mission and implied that its data should be made available to European observers outside the groups involved in the payload development programme. The design of the spacecraft passed through many modifications in the course of project development, both regarding the satellite and its scientific payload. The scientific objectives of EXOSAT also evolved, following the rapid evolution of X–ray astronomy, and in particular the lunar occultation mission no longer had the primary importance which it had when the project was first approved.[8] The most important change was due to the controversial decision to launch the satellite by Ariane instead of the originally foreseen Delta 2914. This implied a substantial increase in the cost of the project. Moreover, the ups and downs of the Ariane development and qualification programme resulted in delays which added to those imposed by budgetary restrictions. In the event, it was decided to revert to Delta and EXOSAT was finally launched by the American rocket in May 1983.[9]

THE SCIENTIFIC PROGRAMME IN THE NEW ESRO FRAMEWORK

When, in the spring of 1973, discussions started on ESRO's future scientific programme, a few important elements had to be taken into account. Firstly, there was a strong financial constraint. The 1971 package deal had fixed at 27 MAU (in 1971 prices) the annual level of resources for the scientific programme. Excluding

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7 ESRO/PB–S(75)10, add. 1, 22/5/75.

8 Russo (1993b).

9 Altmann et al. (1983).

adjustments for inflation, this figure was confirmed at the time of the second package deal, despite the dramatic increase in the financial resources made available to ESRO by its member states (from 75 in 1971 to 178 MAU in 1974). It remained unchanged after the birth of ESA, the total budget reaching 462.4 MAU in 1976. Indeed, while giving a level of stability to the scientific programme, the budget fixed by the 1971 package deal was rapidly becoming critically low when compared to the increasing size of the scientific community calling on ESA and to the demands for more ambitious research projects following the successes of the previous decade.[10]

The second element was the new relationship between ESRO/ESA and NASA. The participation of ESRO in the IUE project and the joint ISEE mission had already established good bases for effective collaboration in scientific projects of mutual interest. Moreover, the two agencies were jointly developing the Spacelab programme whose aims also included scientific objectives. Two reasons suggested fostering such a collaboration towards more ambitious goals. The first was a financial reason: ESRO/ESA could not hope to undertake important scientific projects without joining its meagre resources with those of its powerful American counterpart. The second was the lure of the new space technologies which would become available in the 1980s as a result of NASA's post–Apollo programmes. European scientists could not miss the opportunities offered by space shuttles, large space telescopes and manned space stations. NASA, for its part, had similar reasons. The American agency was struggling with the restrictions which followed the bonanza of the Apollo era and was keen to associate Europe in its scientific programmes. On the one hand, this helped from the financial point of view; on the other, the existence of international obligations partly eased the way

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[10] MAU stands for million accounting units, ESRO's conventional monetary unit. The Accounting Unit (AU) was originally defined in the ESRO Convention as 0.88867088 grams of fine gold and its value was roughly equivalent to one US $. After the 1971 crisis of the international monetary system based on the Bretton Woods agreement of 1944, a new concept had to be defined. After many discussions, in 1975 it was agreed to adopt the European Accounting Unit (EAU, later known as ECU) as the Accounting Unit for ESA. The EAU was made up of a "standard basket" of the nine European Community currencies weighted according to the average over five years of the gross national product and the intra–European trade of each state. In 1975 (1976) the value of the AU in terms of the main currencies was 1.27 (1.30) US$; 3.22 (3.05) DM; 6.21 (5.22) FF; 822 (815) LIT; 0.53 (0.57) GB£. See Frank (1976) and *ESA Annual Report 1975*, pp. 139–140.

towards approval of programmes and budgets from the federal government and Congress.

A third element affecting science policy discussions after 1973 was that future scientific missions could be carried out both by payloads borne by usual spacecraft and by instrumentation on board Spacelab. The ultimate aim of the Spacelab programme was to develop an Earth orbiting, re-usable manned laboratory that could be used by a wide community for scientific, application and technological objectives. European space scientists were thus confronted with a new facility that not only opened up new possibilities in the traditional space science disciplines, but also involved fields not covered by ESRO activities (e.g. medical and biological sciences and material sciences). In January 1973 a meeting of 250 scientists and technologists was convened by ESRO in Frascati, Italy, to discuss Spacelab utilization. Following the meeting, ESRO set up a number of "Spacelab payload groups" to study the possible utilization of this facility in the different scientific and application fields. In the United States, the National Academy of Sciences' Space Science Board organized in July at Woods Hole, Massachusetts, two study weeks devoted to the scientific utilization of the Space Shuttle and Spacelab (Figure 1).[11]

Finally, we must recall the changing institutional framework in which future scientific programmes were being discussed. Since the December 1971 package deal the very definition of "space research organization" no longer answered the programmes that ESRO was called to develop. Science, in fact, hardly provided the main rationale for the existence and functioning of ESRO in this new phase of its life, and covered only a small fraction of its total budget. Practical objectives such as commercial telecommunications, air traffic control and weather forecast had replaced scientific research as the principal aim of ESRO's undertaking. With the second package deal of 1973 and the eventual creation of ESA in 1975, science would become even less important within the overall programme of the new Agency. Economic and commercial interests, technological innovation and industrial policy were more and more the driving forces which shaped its activity,

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[11] Information on the scientific sessions at the Frascati meeting is in LPAC(73)4, 31/1/73. For ESRO's Spacelab payload groups, see ESRO/PB-S(73)14, 10/9/73. The NAS study weeks, held from 2 to 14 July 1973, were attended by a few European scientists and by the LPAC chairman who reported at the 49th meeting (4/10/73), LPAC(73)23, 26/10/73.

rather than the scientists' thirst for new knowledge on physical phenomena in outer space.

However marginal science might appear in ESRO's new charter, it nevertheless represented a key element in its overall programme. Firstly, it was the only part of the programme which was mandatory for all member states, and the one which for ten years had provided a successful ground for European cooperation in space. In the framework of the *à-la-carte* system that was to characterize the programme structure of the new Agency, the "special nature of the scientific programme" was explicitly recognised "as the common factor through which the whole Organization was held together."[12]

Secondly, the definition of the actual content of the scientific programme, i.e. the feasibility studies of possible missions, the adoption of specific projects and the selection of experimental payloads, always involved political issues of a different quality from that of application programmes. The latter, in fact, were characterized by well-defined objectives, these being the development of a commercially viable communication satellite system, a reliable meteorological satellite or any other technical device designed to operate in space for a specific application. Once the programme had been approved with its associate budget, users' specifications, technical options and industrial policy considerations were the important elements of all subsequent discussions and decisions. It was a different case for the scientific programme. As ESRO's Director of Programmes and Planning put it, "the scope of the scientific programme was decided by the financial envelope, within which the scientific committees endeavoured to follow a coherent scientific policy."[13] The definition of such a "coherent scientific policy" required continuous negotiations between the various sectors of a peculiar and very diverse community of users. It called into question the plans and expectations of the scientific groups active in many fields of space science, the relation between ESRO's scientific programme and its member states' national programmes, and the relation between these programmes and those of NASA and other non Western European space agencies (USSR, Canada, Japan).

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[12] SPB, 9th meeting (23/10/74), ESRO/PB-S/MIN/9, p. 10.

[13] J.A. Dinkespiler at the 1st SPB meeting, (17/10/72), ESRO/PB-S/MIN/1, 8/11/72, p. 12. See also Council, 46th meeting (9/5/72), ESRO/C/MIN/46, 23/5/72, p. 4.

A third element to point out is that scientists did in fact play an important role in the life of the Organization. Indeed, ESRO was born out of an initiative of the European space science community and its growth and success owed much to the perseverance and far-sightedness of this community. After a decade of active work in rocket and satellite experiments, physicists and astronomers involved in space research composed the most united, experienced and open-minded group of space users in Europe, who could adequately cope with the international dimension of the space effort and had the culture and intellectual authority to stand comparison with their American counterparts. Some influential scientists, like the former director general Hermann Bondi and Council chairman Giampiero Puppi, played a decisive role in the most delicate passages of ESRO's political life; many others held important advisory positions in national governments as regards space policy, and served in ESRO's legislative bodies.[14]

THE QUESTION OF SCIENTIFIC ADVICE AND THE ROLE OF THE LPAC

The peculiar political character of the scientific programme is displayed in the discussions about the status and role of the new Scientific Programme Board (SPB) and, above all, of the long-standing Launching Programme Advisory Committee (LPAC). With the approval of the December 1971 package deal, it became necessary to change the ESRO Convention in order to take into account the Organization's new involvement in the application fields and the requirements of the optional programme system. This issue absorbed much of the Council's time during 1972, the main question being how to reconcile the need for a unitary management, represented by the Council and the Executive, with the necessity of running several different programmes, with different groups of participating states and separate budgets. We shall not go into the detail of these discussions. It suffices to recall that for each programme approved by the Council a Programme Board was established, composed of delegates from the participating states, fully

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[14] The term "legislative" is used here to indicate the Council, the Programme Boards and all subordinate bodies composed of national delegates. The latter could either have decision-making authority or function as advisory bodies. The term Executive is used to indicate the ESRO/ESA Directorate and its staff. Advisory groups of experts (non-delegates) were also set up to report to legislative bodies or to the Executive (see Tables 1 and 9).

responsible for executing that programme (Table 1). The legal status of the Programme Boards was the same as that of the Council, its powers and functioning being defined by the special Arrangements between ESRO and the governments of participating states for the execution of each specific programme.

The Scientific Programme Board had been set up in order to place the various programmes on the same level. It thus replaced the Scientific and Technical Committee (STC) which, like the Administrative and Finance Committee (AFC), was a subordinate body of the Council. In this case, however, the role of the Board was not defined by any special arrangement between a group of member states. The activities referred to it, in fact, constituted nothing but those covered by the ESRO Convention and its functions were those that the Convention explicitly assigned to the Council. In other words, it was up to the Council to institute the SPB and delegate the necessary powers to it. Such considerations had caused some controversy when it came to decide whether to extend the programme board concept to the scientific programme too. In the event, the Council agreed to set up a Programme Board for the scientific programme alongside those for the application programmes but reserved the right to examine the scientific budget after approval by the Board.[15]

Within its terms of reference, the SPB was also given competence for "the selection and adoption of specific scientific projects within the overall programme and the ceiling approved by the Council." This was the most important element of the complex process which ultimately led to the launch of an ESRO satellite. It was not, however, the one that defined the Organization's scientific policy. While politically relevant, the adoption of a satellite project in the ESRO programme represented only the culminating point of a decision-making process which was largely driven by forces and interests outside the control of the legislative arm of ESRO. As we have described in our previous reports, it was the scientific community that liberally suggested space missions and experiments. These were discussed and refined by two groups of experts, the Astrophysics Working Group

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[15] Council, 52nd meeting (13–14/12/72), ESRO/C/MIN/52, 10/1/73. The SPB's terms of reference are reported in ESRO/PB-S(73)5, 12/3/73. Preliminary discussions were held at the first two meetings of the (provisional) SPB, on 17 October and 19 November 1972, respectively: ESRO/PB-S/MIN/1, 8/11/72, and ESRO/PB-S/MIN/2, 10/1/73. See also ESRO/PB-S(72)12, 28/9/72; ESRO/C(72)58, 6/11/72, and rev. 1, 20/11/72.

(AWG) and the Solar System Working Group (SSWG), and by the LPAC. Following these discussions, a few of them became the object of feasibility studies performed in ESTEC or in industry under ESTEC guidance. Finally it was the task of the LPAC to discuss the results of these studies and recommend one or more projects for final approval.[16]

In the whole process the LPAC played by far the most important role in shaping the Organization's scientific policy. It advised the ESRO Director General on the planning of future activities and defined scientific guidelines to orient the space science community in the making of their proposals; elected the members of the two Working Groups and nominated their chairmen and vice-chairmen (to be endorsed by the STC); instructed the ESRO Directorate of Programmes and Planning about mission definition and feasibility studies to be performed; discussed the scientific merit of the most interesting projects, assessing their technical and financial feasibility as well as the capability and competence of the groups called on to build the payload and analyse the data; and, finally, it selected the project to be recommended to the STC (later to the SPB) and the Council for adoption in the ESRO programme. At this final stage, of course, these projects had already passed through a severe process of progressive definition and refinement, and a strong scientific constituency had already committed itself to their eventual realization. The legislative bodies had a mere rubber stamp function.

In the ESRO framework, the LPAC consisted of a body of five independent experts whose task was to advise the Director General on all scientific matters, both regarding ongoing projects and the planning of future activities. Its members were appointed by the STC (later by the SPB) from a list of candidates submitted by the Director General after consultation with the scientific community, and they served for a period of three years. The chairman was elected by his colleagues. The LPAC was assisted in its work by the Director of Programmes and Planning and by the Director of ESTEC, as well as by the chairmen of the scientific working groups. By statute, its recommendations had to be based on purely scientific and technical considerations (Table 2).[17]

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16 Examples of such decision-making processes are discussed in Russo (1993a) and (1993b).

17 The status and functions of the LPAC as described above, in particular its becoming an advisory body to the Director General and no longer to the STC, were approved at the 20th

The special position of the LPAC as the key actor in the definition of ESRO's scientific policy and the fundamental link between the Executive and the European space science community reflected the peculiar *raison d'être* of the Organization in the 1960s, i.e. that of pursuing scientific research on behalf of the community itself. After the 1973 package deal, in the framework of discussions around the forthcoming new Space Agency, the status and role of the LPAC came to be reconsidered. In particular, it was felt that the SPB, which represented the interests of all member states, should have complete control over the definition of the Organization's only mandatory programme. A discussion on this question was prompted by the French delegation in the Council and developed in the second half of 1973, in the aftermath of the controversial decision to adopt ISEE–B and EXOSAT in the programme against the Venus orbiter. The French scientific community, in fact, had supported the planetary mission but had been defeated by the strong scientific constituency that had grown up around EXOSAT in the course of more than two years of studies on this project.[18]

Three arguments were pointed out in particular. Firstly, the new Agency was supposed to integrate in its programme a number of ongoing programmes in member states. This called for a more substantial participation of national scientific groups and space agencies in future planning, and the SPB delegations were certainly more appropriate than independent experts in designing ESRO/ESA's scientific policy. Secondly, budgetary restrictions limited the number of mission definition and feasibility studies that could be performed. Therefore the selection of such studies could actually become somewhat of a policy decision which should be reserved to the SPB. Finally, expert advice could never be and should not be completely independent and solely based on scientific arguments. "It was an illusion to think that scientists debated purely on scientific grounds," the French delegates claimed, "political elements were bound to cover their decisions, and this should be recognised in the composition of [the] working groups". And the Belgians argued that "the experts [...] had to be entirely familiar with the problems arising at the level of their national delegations. [...] The

Council meeting (29–30/11/67), after the conclusion of the Bannier report: ESRO/C/MIN/20, 14/12/67. See ESRO/C/306, add. 4, rev. 1, 14/12/67.

18 ESRO/C(72)70, 1/12/72; ESRO/C(73)19, 30/3/73, with add. 1 (30/5/73) and 2 (18/6/73); and ESRO/C(73)26, 10/4/73. For the EXOSAT decision see Russo (1993b).

appointment of the experts should therefore be a matter for the governments, through the Organization's legislative bodies." In the light of these considerations, and following the example of the other Programme Boards, it was argued that the SPB should control all stages of the decision–making process and that scientific advice should be conveyed directly to Board, either from an LPAC with enlarged membership, in order to include wider national representation, or from its own advisory body consisting of experts nominated by national scientific authorities.[19]

Facing this challenge, the LPAC and the Executive reacted by stressing the importance that the former kept its role as an advisory body of independent experts. In the words of the LPAC chairman, the Dutch astrophysicist Hendrik van de Hulst:

> An LPAC of the kind that already existed remained necessary and [...] the creation of another advisory body, namely a group with scientific experts from each member state to report to the SPB, would constitute an unnecessary further step in the Organization's committee structure.[20]

ESRO's Director of Programmes and Planning J. Dinkespiler, for his part, stressed that the advice of high–level scientists, "wise men" as he called them, was crucial for finding compromises between conflicting scientific interests:

> Experience had shown that, with regard to the scientific programme, it was extremely difficult to arrive at a decision unless the Director General was in a position to submit to the delegate bodies a programme proposal involving his responsibility; hence his need to have access to expert advice to help him to assume this responsibility.[21]

As a consequence of these discussions, a compromise was reached according to which the LPAC remained an advisory body to the Director General but should also provide advice to the SPB when requested, and keep the latter continuously informed of its activity. Moreover, it was decided that its membership should be

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[19] The two quotations are from SPB, 4th meeting (18/9/73), ESRO/PB–S/MIN/4, 22/10/73, p. 9; and from Council, 57th meeting (1/6/73), ESRO/C/MIN/57, 20/6/73, p. 13, respectively.

[20] LPAC, 48th meeting (21/6/73), LPAC(73)17, 17/7/73, p. 2.

[21] ESRO/C/MIN/57, cit., p. 14.

enlarged to include one expert in life sciences, concurrently with the envisaged establishment of a Life Science Working Group. While approving this compromise, however, the SPB reaffirmed its willingness to keep a firm control of the various stages of the selection process of future projects, stressing in particular that it would keep "a very close watch" over the selection and execution of feasibility studies. This was not the end of the story, however, as the forthcoming discussions about ESRO's scientific policy and future programmes would re-open the whole question of the LPAC and the other scientific advisory bodies.[22]

DISCUSSING FUTURE SCIENTIFIC PROGRAMMES

The LPAC started to discuss ESRO's future scientific programmes in early February 1973. Introducing the discussion, Dinkespiler reviewed the evolution of the Organization before and after the reform that was started in December 1971, pointing out two aspects in particular. Firstly, the fact that the scientific budget would remain unchanged against the dramatic increase of ESRO's total financial resources; secondly, that the development of the Shuttle/Spacelab system would offer space research new and interesting opportunities. In this light, Dinkespiler advised, it was necessary to adapt ESRO's advisory bodies to this broader field of possibilities and to revise the LPAC policy statement of June 1970. The latter, we should recall, had given priority to magnetospheric studies and high energy (i.e. X- and gamma-ray) astrophysics, and this had oriented the ESRO mission studies and, eventually, the LPAC recommendation of ISEE-2 and EXOSAT. Optical (including ultraviolet) astronomy, solar physics and planetary missions had been

[22] ESRO/PB-S(73)15, 17/10/73; SPB, 5th meeting (9/11/73), ESRO/PB-S/MIN/5, 12/12/73; 6th meeting (8/2/74), ESRO/PB-S/MIN/6, 25/3/74, p. 6. Preliminary activity for the creation of the Life Science Working Group (LSWG) developed in Spring 1974 by a 4-member "Nucleus" nominated by the ESRO Director General after a recommendation of the LPAC. This nucleus proposed names of specialists in the different areas and the LSWG members were eventually appointed by the ESRO Director General. The Working Group held its first meeting on 27 September 1974, and elected the Swede H. Bjurstedt as its chairman. A life science expert in the LPAC was never nominated but there was one in the ESA Science Advisory Committee (SAC), which replaced the LPAC in 1975. For detailed information, see: LPAC, 50th meeting (5/11/73), LPAC(73)27, 2/1/74; 51st meeting (LPAC, 14-16/1/74) LPAC(74)5, 14/2/74; 53rd meeting (29/3/74), LPAC(74)11, 7/5/74; and 55th meeting (13/9/74), LPAC(74)17, 15/11/74. See also LPAC(74)6, 14/2/74; ESRO/PB-S(74)16, 17/4/74; ESRO/PB-S(74)32, 4/10/74; and LSWG, 1st meeting (27/9/74), LIF(74)3, 1/10/74.

excluded from the programme, both for financial reasons and because of NASA's strong effort in these fields. In the new situation created by the forthcoming availability of the Shuttle/Spacelab system, and by the prospects of collaborative ventures with NASA, a new scientific policy was called for and new guidelines had to be established for scientific missions in the 1980s.[23]

The discussion was resumed in June, after the definitive approval of ISEE–B and EXOSAT, and the LPAC agreed that the European space science community should be invited to submit ideas and proposals. It asked the SSWG and AWG to prepare a report on the current trends in the research areas falling within their terms of reference. A special LPAC meeting was planned in January 1974 to discuss these reports and to define guidelines for ESRO scientific mission studies, in time for the ESRO/NASA programme review meeting scheduled in February 1974.[24]

The two Working Groups duly performed their task and by the end of 1973 their reports were submitted to the LPAC.[25] The SSWG identified eight priority research areas, with no explicit preference assigned to any of them (Table 3). Specific missions were also suggested for four of these areas: (a) a four–telescope cluster on board Spacelab to investigate solar physics phenomena; (b) a space probe to be launched into an out–of–ecliptic trajectory associated to an earth orbiting spacecraft for solar wind investigation and stereoscopic observations of the sun; (c) a space telescope for observing bodies of the solar system; and (d) an astrometry mission for precise measurements of the position and motion of stars. The first two involved cooperation with NASA, while the last two could be independent European projects, the latter in particular being already studied by the French Centre National d'Etudes Spatiales (CNES). A second group of research areas included magnetospheric, ionospheric and atmospheric studies. It was recommended that ESRO should ensure that European scientists had opportunities to fly experiments in these fields on board Spacelab when available. Finally, the

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[23] LPAC, 45th meeting (1/2/73), LPAC(73)9, 19/2/73. The LPAC policy statement of 1970 and its consequences are discussed in Russo (1993b).

[24] LPAC, 48th meeting (21/6/73), LPAC(73)17, 17/7/73; 49th meeting (4/10/73), LPAC(73)23, 26/10/73.

[25] The two reports are SOL(73)16, December 1973, and ASTRO(73)15, 18/1/74. See also SOL(73)7, 24/9/73.

SSWG recommended that ESRO should enter the field of solar system exploration by collaborating with NASA in developing deep space probes. Besides recalling the possibility of taking part in new missions to Mercury, Venus, and Jupiter, the SSWG also stressed its strong interest in the NASA plans for a Mars surface rover, and in a mission to comet Encke currently under study in Germany as a follow-up of the US/German HELIOS programme.[26]

The AWG presented 13 proposals for future missions, equally distributed between free-flyer spacecraft and Spacelab missions (Table 4). No priority was explicitly assigned between them but the Group provided the LPAC with an indication of the level of support that these missions had from its members. These were asked to select three preferred satellite missions and three preferred Spacelab missions and the result of this voting procedure was reported on a marking scale. The ensuing table showed that a strong interest existed in infrared astronomy, with two missions recommended for immediate consideration: a small satellite-borne telescope mainly devoted to the study of the cosmic background radiation, and a large infrared telescope on board Spacelab.[27] Other preferred missions were: a Spacelab payload for X-ray spectroscopy and polarimetric studies in the 0.5-8 KeV energy range; a satellite for low-energy gamma-ray astronomy; and a Spacelab telescope associated with a photon-counting system for ultraviolet stellar spectrophotometry.

The LPAC discussed the Working Groups' reports in a three-day meeting held from 14 to 16 January 1974 in a "quiet and secured place" in Argentières, at the foot of Mont Blanc. It then finalized its own report on 28 January. We have no record of these discussions and therefore we must limit ourselves to presenting their conclusions.[28] Two aspects must be pointed out. The first is that the LPAC did not formulate guidelines for future scientific policy, as it had done in 1970: it

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26 The joint ESRO/NASA comet Encke mission was officially proposed by the German Ministry of Scientific Research and Technology in a letter dated 12/12/73 and reported in ESRO/PB-S(74)9, 24/1/74. For the Mars Rover, see SOL(73)8, 2/10/73.

27 An infrared astronomy Spacelab payload had been studied by an ESRO mission definition group for a few months: ESRO/PB-S(73)19, 31/10/73.

28 The LPAC report is LPAC(74)4, January 1974. See also LPAC, 51st meeting (14-16/1/74), LPAC(74)5, 14/2/74, and 52nd meeting (28/1/74), LPAC(74)12, 12/4/74. The search for a "quiet and secured place" for this meeting was put forward to the ESRO Executive by the LPAC members at their 50th meeting (5/11/73), LPAC(73)27, 2/1/74, p. 9.

did not suggest priorities between the various research fields nor did it recommend specific kinds of mission (e.g. satellite or Spacelab mission, small or large spacecraft, purely European or co-operative projects). It rather suggested a procedure to arrive at a "responsible decision" on the selection of new scientific projects. This meant, in the words of the LPAC, a decision taken by the SPB on the basis of "factual information about the scientific aims to be achieved, the technical problems to be solved, and the legal arrangements to be made if the project involves interagency cooperation."

The LPAC suggested that the process for arriving at such a decision should be divided into two successive phases. The first should be devoted to definition studies of a rather large number of missions, singled out on the basis of the suggestions from the scientific community.

> During a mission definition study the type of instrumentation to be carried has to be specified in a preliminary fashion, but in sufficient detail to assess the scientific importance of the mission and the interest it may command in the European scientific community. However, many technological problems that may be involved must be left open and, consequently, the cost of the project can at this stage be guessed only very roughly.[29]

At the end of the first phase, and as a result of the definition studies, a small number of missions had to be singled out for more accurate feasibility studies, the aim of which was to collect the "factual information" referred to above, in order to eventually provide the SPB with all the important elements for making the final choice.

The second aspect of interest is, of course, the list of missions recommended by the LPAC for immediate definition studies (Table 5). This included 11 missions, essentially accepting most of the working groups' preferred projects with two important exceptions: the astrometry project and the cometary mission. The former, in the opinion of the LPAC, required preliminary discussions in order to assess "whether such a project would have sufficient scientific interest and support in the scientific community to compete with the projects recommended for further studies." As to the cometary mission, the LPAC considered that current

[29] LPAC(74)4, cit., p. 9.

injection techniques only allowed a simple fly-by mission with high relative velocities and this "appear[ed] to be a very expensive way of collecting about an hour's worth of data."

As a matter of fact, only the Jupiter orbiter survived in the LPAC list of the SSWG's ambitious plans in the field of planetary studies. Such a mission, however, was intended to study radiation belt and plasma physics rather than planetary physics. The Committee had discarded the solar system telescope as well as proposals for a visit to and sampling of one of the Mars satellites, and for participating in the American Mars landing programme. In the opinion of the LPAC, "any mission in this area, if at all financially feasible for Europe, would remain too much of an isolated and belated effort within ESRO's programme."[30]

The LPAC proposals were revised by the Executive after a joint ESRO/NASA meeting, held in ESTEC on 11 February 1974, where the two organizations' scientific programmes and plans were reviewed in order to highlight common interests and discuss possible cooperation. Eventually, after further discussion by the LPAC, the ESRO Executive identified 12 missions worthy of definition studies, eight of which in cooperation with NASA (Table 6). Three main changes must be pointed out. Firstly, the cancellation of the solar observatory, probably because NASA was not interested in such a project and ESRO could not afford to develop it alone. Secondly, the envisaged participation of ESRO in NASA's most ambitious scientific project, the Large Space Telescope (LST). ESRO, in particular, would contribute one of the instruments to be mounted on the focal plane of the telescope. Finally, the astrometry project was now included among the missions to be studied. This was a compromise negotiated with the French delegation in the SPB. ESRO, in fact, was not expected to perform any mission definition study on space astrometry projects, as they were actively being studied in France. Its activity would be limited to the organization of an international symposium to discuss proposals in this field and to appraise the degree of interest of the scientific community.[31]

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30 LPAC(74)4, cit., pp. 23 and 25. The poor consideration given to planetary studies by the LPAC was regretfully noted at the 9th meeting of the SSWG, (24–25/4/74), SOL(74)3, 3/9/74, pp. 2–3.

31 PB-S(74)15, 18/4/74. The conclusions of the ESRO/NASA programme review meeting are reported in ESRO/PB-S(74)12, 11/4/74. See also LPAC, 53rd meeting (29/3/74), LPAC(74)11, 7/5/74.

The Executive also suggested a time schedule for the decision-making process. Following the SPB's endorsement, all mission definition studies would be prepared during 1974 under the responsibility of the Directorate of Programmes and Planning's Space Mission Division. For each study a mission definition group would be set up, "comprising enough scientists to represent European interests properly".[32] The results of these studies would be discussed by the SSWG and AWG and then, on the basis of these discussions, the LPAC would indicate which projects it recommended for feasibility (Phase A) studies. The SPB would eventually take the final decision on such a recommendation by January 1975. It was expected that five feasibility studies would be approved and executed during 1975 by industrial contracts. Their results would eventually be discussed at a scientific symposium to be organized in early 1976. Finally, after examination of the two Working Groups, the LPAC would indicate the project(s) that it recommended for adoption in the ESA programme and the SPB would decide by March 1976.

THE SPB DECISION ON THE STUDY PROGRAMME FOR 1974

According to the framework emerging from the discusions on the prerogatives of the SPB, the mission definition studies had to be endorsed by the Board itself, on the basis of the LPAC report, the results of the ESRO/NASA programme review and the proposal of the ESRO Executive. The discussion was particularly lively and sometimes paradoxical, all contradictions about the scientific programme in the delicate transition period coming into dramatic evidence. These contradictions regarded in particular: the legitimation of the LPAC and its working groups as the bodies entitled to define ESRO's scientific policy; the poverty of the scientific budget *vis-à-vis* the expectations of scientists; the question of the scientific use of Spacelab; and the ever-present tension between the various disciplinary and national sectors of the space science community.[33]

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32 ESRO/PB-S(74)15, cit. p. 2.

33 SPB, 7th meeting (30/4/74), ESRO/PB-S/MIN/7, 30/5/74. At this meeting a few delegations presented their comments to the LPAC report in written documents: ESRO/PB-S(74)17, 11/4/74 (UK); ESRO/PB-S(74)18, 19/4/74 (Switzerland); ESRO/PB-S(74)19, 26/4/74 (Germany); ESRO/PB-S(74)20, 29/4/74 (Sweden); ESRO/PB-S(74)22, 30/4/74 (Italy). The issue

The discussion was opened with a long and provocative statement by the SPB chairman, the influential French scientist and scientific policymaker Maurice Lévy, who was also the chairman of the ESRO Council as well as Director of the CNES. Two aspects were pointed out in his statement: firstly, the way in which scientific opinions reached the Organization and a scientific policy was defined; secondly, the problem of funding. According to Lévy, there was "a need to transform the scientific space programme after its first ten years devoted to the exploration of the earth's near environment by sounding rockets and satellites." The new missions, he argued, should be much more ambitious, should require large instruments and be oriented towards astronomy and the study of planets. The whole machinery for selecting ESRO's scientific programme was put into question:

> Over the last ten years a large number of laboratories had built up both staff and equipment covering a number of areas and, at the same time, both for the selection of and performance of experiments, certain structures had emerged. Unfortunately, in some respect, these structures had features in common with the 'mandarin' system – young scientists were not consulted and they were unable to make their voices heard among the decision-makers. The fact that space projects were costly and that their development extended over a number of years at a time when science budgets were being cut back meant that there was keen competition between laboratories whose survival often depended on participation in a particular programme. Hence a certain blinkered view and lack of objectivity in the assessment of projects.[34]

The ESRO Executive, Lévy continued, was "subjected to constant pressure both from the delegations themselves and from various scientific groups [...] Therefore, it was all too frequently inclined to make the necessary political compromises instead of developing an ambitious and truly forward-looking programme." As a consequence, the LPAC and the Executive were now suggesting a programme which had "the semblance of a series of highly cautious

had been preliminarily discussed by the SPB at its 6th meeting (8/2/74), ESRO/PB-S/MIN/6, 25/3/74.

[34] ESRO/PB-S/MIN/7, cit., p. 3. All quotations from Lévy's statement are from this and the following two pages.

compromises" as compared to the "new impetus" of the American scientific programme, characterized by "a bold and energetic approach to large-scale planetary exploration programmes and wide usage of the Space Shuttle."

> Having agreed to expend 300 MAU or so on the development of Spacelab, in spite of the generous offer of American co-operation, Europe was unable to come up with any major programme for using the equipment.

Both in the member states and within ESRO itself, Levy concluded, there was "a fundamental need for renewal of the structures controlling the scientific space programmes." Only in this way, would it be possible to define a scientific policy based on a few ambitious projects, taking advantage of the co-operation with NASA and meeting the challenge of space research in the 1980s.

Where should the money for such ambitious plans come from? This was Lévy's second argument. Given the constraint of the scientific budget, only two or three out of the dozen projects on which the SPB was about to launch definition studies could be included in ESRO's programme. Moreover, there was a major financial problem related to Spacelab. When, in fact, the 1971 package deal had established the financial envelope for the scientific programme, Spacelab was not yet in sight. And when the project was approved in the 1973 package deal, no provision had been foreseen for financing any Spacelab payload agreed on in the framework of ESRO's scientific programme. It would be utopian, argued Lévy, to expect any increase in the mandatory scientific programme, for two main reasons. Firstly, because most member states had now reached a plateau as regards their contributions to ESRO; secondly, because of plain national egoisms. In Lévy's blunt words:

> The diverging views among the states as to the content of this programme were such that some states, particularly some of the biggest, would in fact refuse to support an increase in the budget of the mandatory programme if in doing so they ran the risk of having projects imposed on them which none of their laboratories was interested in.

The only possibility of fostering ambitious scientific projects was the adoption of the *à la carte* policy for the scientific programme too, thus providing means for supporting optional programmes complementing the mandatory one. These optional programmes would bring together those member states that were interested, possibly in close liaison with NASA.

Lévy's statement caused no little discomfiture among those present. The LPAC chairman, H. van de Hust, asked whether the Committee's report was really "useful or desired by the Scientific Programme Board in view of the very fundamental issues that had been raised by its chairman." The Belgian delegation concurred with Lévy's statement, arguing that "the criticsm it contained applied almost directly to the manner in which the LPAC had carried out its work [...] the distribution by subjects of the missions recommended by the Committee reflected too closely the composition of this body, which constantly tended to direct ESRO's policy along the same lines." The German delegation, on the contrary, "queried whether young scientists had in fact complained about the decision-making process with regard to the selection of new scientific projects." The Italian delegation, in Giuseppe Occhialini's characteristic tone, said that the chairman's remarks at the meeting would be given the same diffusion in the Italian scientific community as the LPAC report, "and for this it would be useful if there could be an unequivocal translation of the meaning the chairman gives to the term 'mandarinat' for which the interpretation in French dictionaries is varied."[35]

In the event, it was agreed to postpone the discussion on Lévy's statement to the following meeting and to deal now with the proposed missions. The SPB, in other words, chose the easiest path: it de-coupled the problem of ESRO's scientific policy from that of selecting mission definition studies. The former was temporarily removed and confined to the sphere of "general discussions", thus allowing the SPB to deal with the latter in the oecumenical way suggested by the LPAC's report. This course of action eased the way in this very preliminary phase of the decision-making process: why, in fact, should the SPB do what the LPAC had refrained from doing, i.e. set guidelines or establish priorities? why not approve as many mission definition studies as requested by the scientific community? On the other hand, everybody knew that such a large number of missions studied would raise expectations in the space science community which ultimately could not be fulfilled for financial reasons.

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[35] ESRO/PB-S/MIN/7, cit., pp. 5-7.

The outcome of the discussion made the paradox quite evident. The SPB, in fact, with the exception of Belgium, agreed with the LPAC proposals, supplemented by those of ESRO's Director General. At the same time, most delegations expressed their preference for one or the other project, or suggested new ones, according to national scientific interests. The German delegation, as was to be expected, requested the Executive and the LPAC to reconsider the cometary mission, arguing that "the short duration of the encounter with the comet cannot be taken as a measure of its scientific value."[36] The Swiss delegation, led by the planetologist Johannes Geiss, whose instruments had been included in the Apollo lunar missions, deplored the rejection of the planetary study projects and advocated a coordinated European effort in the field of planetary exploration in collaboration with NASA and the USSR Academy of Sciences. The cosmic ray physicist Bernard Peters, in his capacity as spokesman of the Danish delegation, regretted that the LPAC had been unable to recommend any experiment in the field of high energy cosmic-ray astrophysics and requested that mission studies in this field be undertaken, "in view of the remarkably high level achieved by certain laboratories specialising in this area in Europe." Peters himself was proposing an improved design for an experiment on cosmic-ray isotopic composition which had been rejected by the AWG.[37]

The French delegation expressed its satisfaction that the astrometric project, originally rejected, was now recommended. It also supported the planetology studies while manifesting doubts about the real interest of the proposed atmospheric, ionospheric and magnetospheric studies. The Swedes did not concur, which is hardly surprising given the long-standing tradition in that country of ionospheric and magnetospheric research. One of the Swedish delegates, the scientist Bengt Hultqvist, was an influential spokesman of this tradition as well as an ESRO pioneer. The delegation emphasized that a major fraction of the groups involved in ESRO's scientific programme were involved in these research fields. Europe should not follow NASA's attitude, they argued, but continue the work already undertaken and extend its knowledge of the cosmic plasma in the magnetosphere. Finally, the Italian delegation, among whom Occhialini did not

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36 ESRO/PB-S(74)19, cit., annex.

37 ESRO/PB-S/MIN/7, cit., p. 6-7.

like Spacelab, argued that, contrary to the LPAC decision, the X–ray survey satellite originally included in the AWG list should be preferred to the Spacelab X–ray instrument. A definition study of such an X–ray mission was also requested by the British delegation, which also supported Peters' cosmic–ray mission and suggested two new missions: an entry probe to Saturn's satellite Titan and a high energy gamma–ray astronomy mission.

To sum up the discussion, five new projects were put forward for immediate definition studies besides the twelve already selected, and the Director General warned that the available staff and finance would not permit the carrying out of 17 mission definition studies concurrently. It was eventually agreed that the cosmic–ray mission and the cometary mission should be added to the LPAC proposals; that the two British proposals could not lead to a project to be selected in early 1976 and therefore an immediate study was not necessary; that the out–of–ecliptic mission and the solar stereoscopic mission might be studied together as they could conceivably be combined; and, finally, that the AWG would be called to discuss the two X–ray missions again in order to eliminate one of them. In this way, there would be 12 missions remaining for ESRO definition studies, a 13th mission on astrometry being already under study by the CNES. Two days later, by a majority vote, the AWG confirmed the choice of the Spacelab X–ray spectropolarimeter (Table 7).[38]

THE SCIENTIFIC PROGRAMME IN TRANSITION

This conclusion of the first phase of the decision–making process calls for a few considerations. The first is that, unlike what had happened five years before, no clear scientific policy was defined in order to orient ESRO's forward–looking studies and the European space scientists' long–term plans. Neither the scientific working groups nor the LPAC, let alone the SPB, wanted to run the risk of discussing and establishing priorities between the various research fields (e.g. astronomy, planetary exploration, magnetospheric studies, etc.), between alternative technical options (e.g. Spacelab vs unmanned spacecraft, large telescopes vs multi–experiment satellites, etc.), and between different institutional

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38 AWG, 10th meeting (2/5/74), ASTRO(74)5, 15/7/74. See also ASTRO(74)4, 2/5/74.

frameworks (e.g. confining ESRO's scientific research to the mandatory programme or exploring the possibility of optional scientific programmes). This is in part justified by the rather uncertain perspectives of space research in the 1980s. On the one hand, the lure of new space technologies such as the space shuttle, cryogenic telescopes for infrared astronomy, large optical telescopes, electric propulsion, etc., stimulated plans for ambitious, large-scale projects. On the other hand, there were persisting uncertainties regarding technical and financial feasibility, political approval, co-operative ESRO/NASA arrangements and so on. Given the limitation of budgets and the uncertainties of congressional approval, it appeared risky to commit oneself at such an early stage to one or two big projects which could eventually fail. Moreover, not all space research fields required "big science." Medium-sized satellites and proven technologies could successfully be used for magnetospheric studies or X- and gamma-ray astronomy. The eclecticism of the set of missions studied by ESRO in 1974 reflected the fact that all sectors of the European space science community were now strong and skilled enough to advocate their pet projects. A choice had to be made anyway but only when all options had been given equal opportunities of being carefully studied.

A second consideration regards the role of the national scientific establishments *vis-à-vis* what Lévy had defined the "mandarin system" within the European space science community. We have seen how the French and German delegations succeeded in having their national projects – the astrometry satellite and the cometary missions, respectively – included in the list of missions to be studied for possible adoption in the ESRO programme. It is true that the second package deal had stipulated that the forthcoming European Space Agency would integrate national projects in its programme. But the fact is that the ESRO scientific advisory bodies had not recommended those particular projects. While a compromise could be accepted at the level of a mission definition study, the problem nevertheless remained: who was entitled to decide which national projects were worthy of consideration for inclusion in the ESRO/ESA programme, the national delegations in the SPB or the LPAC and its working groups?

This brings us to a third consideration, which regards the still hot question of ESRO/ESA's scientific advisory system. The close association of the ESRO Directorate of Programmes and Planning and the LPAC, as well as the presence in the latter of some of the most influential European space scientists and ESRO pioneers, had strongly determined the course of ESRO's scientific programme in the 1960s and early 1970s. However provocative the term "mandarin system" might be, it reflected a situation in which a small group of leading scientists and important laboratories did have a major role in orienting and shaping ESRO's scientific policy. The advent of a new generation of scientists and the growing political importance of space activities now put the "old citadel" in a state of siege. Scientific merit could no longer be the only aspect to be considered when selecting new projects and scientists could not be entirely independent of their governments, claimed most SPB delegations. The Italian delegation, advised by Occhialini, retorted:

> Throughout its long association with the Organization, and with the LPAC in particular, it could not recall one case where a scientist, called upon to give a recommendation on scientific grounds, had made this choice on a national basis. [...] It had never known of pressure being brought to bear on an LPAC member by his national authorities [...] most of the members were professors, who were in the course of their work, called upon to make very many important judgements, and who were well qualified to make recommendations concerning the scientific programme of ESRO.[39]

When, one year later, the French delegation urged changes in the scientific advisory system with "the stated aims of permitting a renewal of ideas and providing better guarantees of impartial choices," the LPAC chairman van de Hulst curtly commented that "there were plenty of ideas in Europe for space experiments, what was missing was the money to carry them out."[40]

Finally, our last consideration regards the role of Spacelab in ESRO's scientific programme. We have already pointed out that no extra funding had been granted for financing ESRO payloads for Spacelab missions. Therefore either Spacelab experiments had to be developed by groups of member states as special (optional) projects or funds had to come out of ESRO's scientific budget. In the former case,

[39] SPB, 4th meeting (18/9/73), ESRO/PB-S/MIN/4, 22/10/73, pp. 9-10. At this meeting Occhialini participated as an adviser of the Italian delegation.

[40] SPB, 9th meeting (23/10/74), ESRO/PB-S/MIN/9, 4/11/74, p. 5. We shall discuss the French proposal shortly.

the mandatory character of the scientific programme would be jeopardized; in the latter, new research fields and scientific groups would compete for funding with the traditional ones. The question was discussed by the LPAC and SPB in this period but no solution was agreed on, pending the definition work on Spacelab facilities and subsystems.[41] Underlying these discussions there was, however, a fundamental matter of controversy. The Spacelab programme was a very important political and technological enterprise – indeed it represented the start of a new era in US–European co–operation in space and Europe's ticket to manned spaceflight. However, most space scientists considered that such a facility was of very little scientific interest. Against the obvious advantages of return capability, large weight capability and the possibility of on–board adjustment of instruments, there were serious disadvantages such as the short duration of the experiments, restricted orbits, contamination caused by gases from the life–support equipment, and attitude instability caused by the crew. Scientists in the United States were very critical as regards the utilization of Spacelab in the science disciplines, as was evident at the National Academy of Science Summer Study in Woods Hole. In the words of the NASA Director of the Spacelab programme,

> The Sortie Lab [Spacelab's former name] was not the most popular programme presented to this group of scientists. With the exception of the life scientists present, most of the attendees felt their resources could be better placed on automated systems in the conventional space science disciplines. Once faced with the fact that a Sortie Lab would probably be provided by a European cooperative effort, they grudgingly conceded that there were some ways in which it could be useful to all disciplines.[42]

European scientists did not have better esteem of the scientific potentialities of Spacelab. Reporting to the LPAC on the Frascati symposium, G. Haerendel said that "there was scepticism [among scientists] regarding the Spacelab." At the symposium, in fact, critical comments had been made by important scientists like

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[41] LPAC, 45th meeting (1/2/73), LPAC(73)9, 19/2/73. SPB, 4th meeting (18/9/73), ESRO/PB–S/MIN/4, 22/10/73. See also ESRO/PB–S(73)14, 10/9/73.

[42] Lord (1987), p. 11. Logsdon (1986) has pointed out that the American space science community in 1970 and 1971 congressional hearing had been vocal in its opposition to the shuttle programme.

C. de Jager, H. van de Hulst, J. Geiss, and G. Occhialini, rapporteurs for solar astronomy, IR and UV astronomy, space and plasma physics, and high energy astrophysics, respectively.[43] Occhialini himself, retorting to Lévy's brutal statement about Europe being unable to propose any major programme for using Spacelab "having agreed to expend 300 MAU or so on its development", was equally brutal:

> Who 'agreed'? Certainly not the scientists. They were not consulted (neither the younger ones nor the older ones) on policy matters. If they had been, they would have said that there were very few solid scientific arguments in favour of the Space Shuttle programme as currently envisaged.[44]

To scientists it was clear that Spacelab should not significantly reduce, let alone exclude, other types of experimental activity in space. They were certainly not willing to subscribe to the French delegation's statement that "most of the funds for the scientific programme would be taken up by Spacelab for a long time to come, [therefore] it would be wiser to devote the funds for future studies to Spacelab experiments rather than automatic satellite experiments."[45] This was not the case, as we have seen, but the issue was only temporarily removed.

In conclusion, we can say that the decision on the 1974 study programme was typical of this transition period. The Old Guard of European space research was trying to keep its position under the impact of a new wave of political and technological novelties. They claimed skill and competence as well as the unique experience they had in Europe regarding space activities. And they tried to resist the growing political influence over ESRO's scientific affairs, the marginalization of science in the new framework of the European space effort, and the drift towards manned science missions. Their critics considered instead that the time was ripe to build a new European science policy in space, nurtured by transatlantic cooperation in the space shuttle programme and by strong national initiatives. In their opinion, the established leadership of the European space science community

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43 LPAC(73)9, cit., p. 6. LPAC(73)4, 31/1/73.

44 PBS, 8th meeting (13/6/74), ESRO/PB-S/MIN/8, 31/7/74, annex II, p. 1. Occhialini made this statement in his personal capacity, not on behalf of the Italian delegation.

45 ESRO/PB-S/MIN/4, cit., p. 7.

was not culturally prepared to design such a new policy; governments and science policymakers should do it. A compromise was agreed on in spring 1973 which left all options still open, but the real issues were still on the negotiating table: forthcoming discussions and decisions would hardly be peaceful.

Discussions, in facts, started soon, when the SPB was called to discuss the issues raised by its chairman, namely the opportunity of changing the scientific advisory system and the possibility of having special scientific projects outside the mandatory programme. We have already reported on Occhialini's arguing against Spacelab. In his long statement, Occhialini also opposed the idea of having optional scientific programmes. Here is an excerpt of his characteristic language:

> It may be easy for the "big" member states of ESRO to bear such expenditure, but it is much more difficult for the "small" one to contemplate. [...] The chairman, who also represents the powerful CNES, cannot adopt the same attitude as the scientists of other delegations, who represent countries in which the economic and structural problems do not allow of a large-scale scientific research effort. This being the situation, extension to the scientific field of the policy of "à la carte" programmes (what a frightful expression!) already adopted for the application programmes would mean the "small" countries participating on an ever smaller scale in the Organization's activity and the whole business becoming a nightmarish game of poker.[46]

The discussion, however, did not produce any significant result. Some delegations recognized that, notwithstanding their drawbacks, the "à la carte" programmes could provide the only realistic solution for increasing the resources devoted to science. Europe was not lacking in ambitious ideas, argued the chairman of the LPAC, "it was for want of funds that most of these proposals got no farther." And the German delegation pointed out that the dearth of new scientific ideas was due to the reduction of research activity in Europe:

> One could not expect young scientists to go on showing the necessary enterprise to embark on projects if they knew that their activities had little chance of leading to anything and that in any event they would

[46] ESRO/PB-S/MIN/8, cit., annex, p. 2.

have to pursue their research work for at least five years before they could carry out a space experiment.[47]

The discussion on the financial problem was concluded with the suggestion that the delegations should investigate at national level "how they might contribute financially to the new activities." As regards the delicate issue of the status of the LPAC and, more generally, of expert advice on future scientific programmes, the French delegation announced that it was preparing a document on this subject and it was agreed to discuss the question at a following meeting on the basis of this paper. Pending this document, which would bring up again for discussion the compromise agreed upon less than one year before, the relations between the SPB and the LPAC remained strained. This is reflected by the controversial replacement of two LPAC members, H. Elliot, whose term of office expired in March 1974, and G. Haerendel, who resigned in October for personal reasons. In both cases the SPB did not endorse the list of candidates the LPAC had suggested to the Director General and many negotiations were required before M. Rees and L. Houziaux were elected. The minutes do not make clear the reasons for this contrast but it seems that the main objection regarded the inclusion among the candidates of W.I. Axford, a long-time advocate of the Out-of-Ecliptic and the cometary missions, who had just assumed the directorship of the Max-Planck-Institute für Aeronomie in Katlenburg-Lindau after working for many years in the United States. It is significant that the two newly-elected members were not active in space research while the retiring members and Axford were.[48]

The French delegation's document was duly prepared and it prefigured a complete change in the system in force. The stated objective of the proposed new system was to comply with the SPB chairman's request that the present system of scientific advisory bodies be modified "in order to encourage adequate consideration of new ideas and avoid that these were blocked because of

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[47] ESRO/PB-S/MIN/8, cit., p. 9. The LPAC chairman's quotation is from p. 11. The conclusive remark quoted below is from p. 14.

[48] For the replacement of Elliot, the relevant meetings are: LPAC, 53th meeting (29/3/73), LPAC(74)11, 7/5/74, and 55th meeting (13/9/74), LPAC(74)17, 15/11/74; SPB, 8th meeting (13/6/74), ESRO/PB-S/MIN/8, 31/7/74, and 9th meeting (23/10/74), ESRO/PB-S/MIN/9, 4/11/74. For the replacement of Haerendel, the relevant meetings are: LPAC, 57th meeting (7/11/74), LPAC(74)20, 27/11/74, and SPB, 10th meeting (20/11/74), ESRO/PB-S/MIN/10, 20/1/75. For the role of Axford in the OOE mission, see Hufbauer (1993).

conservatism originating from the required effort of reconversion they impose on European space laboratories."[49] The suggested way to reach this objective was to detach the scientific advisory bodies both from the laboratories involved in space research and from the ESRO Executive, and to put them directly under the aegis of the SPB. The proposal was articulated in three points. Firstly, the number of working groups should be increased in order to take into account the variety of space disciplines. Both the chairmen and the members of the groups would be appointed by the SPB after nomination from the national delegations, the ESRO Director General being called only to give his advice on the nomination of chairmen. Secondly, the LPAC should be replaced by a scientific committee whose membership would include the chairmen of the working groups and up to six scientific personalities outside the working groups, three of whom should be "généralistes". Finally, the establishment was foreseen of a higher authority ("Comité d'Orientation") called to advise once a year on the general outline of the programme in the framework of the whole of scientific research in Europe.

The counter-offensive against the French proposal came from ESRO's acting Director General, Roy Gibson, following a nervous discussion in the LPAC.[50] His argument rested on two main points. Firstly, he recalled that it was the role of the Director General to make proposals and recommendations about future programmes and he could only accomplish this task with the assistance of a highly qualified scientific advisory body. The same kind of expert advice was required during the implementation of approved projects, owing to the continuous evolution of scientific knowledge and technical facilities. If the SPB established its own scientific advisory body there would be a risk of divergence and conflict which could jeopardise the very possibility of taking decisions. In this respect, Gibson recalled the agreement reached in November 1973, according to which there should not be in ESRO two possibly competing scientific advisory bodies, a wide circulation of information being however assured among the Executive, the LPAC and the SPB. The Director General did not tackle the delicate issue of impartiality, on which the LPAC had shown great sensitiveness: "Impartiality would certainly be no better guaranteed if the Scientific Committee members were

[49] ESRO/PB-S(74)35, 10/10/74, p. 1 (our translation from the original French text).

[50] LPAC, 57th meeting (7/11/74), LPAC(74)20, 27/11/74, pp. 3-5. Gibson's document is ESRO/PB-S(74)35, add. 1, 18/11/74.

nominated by delegations to the Scientific Programme Board," van de Hulst had commented in this respect, while the French LPAC member J. Steinberg had "very much regretted the implication in the French Delegation's proposals that the present LPAC was not impartial.[51]

Gibson's second point hit at the core of the argument of the French document, namely the role of the SPB. It was not the Board's task to plan future programmes, he argued, recalling that, according to its terms of reference, the SPB was a delegate body of the Council whose task included "the selection and adoption of *specific* scientific projects within *the overall programme* and the ceiling *approved by the Council*". Moreover, Gibson pointed out that the draft ESA Convention then under discussion stated that "the *Council* approves the *scientific programme* [...] and that a *Programme Board* is created to rule on the questions regarding the approved programme."[52] In other (and more brutal) words, you the SPB do your job of approving specific projects and controlling their execution, and leave to the Council, the ESRO Director General and the LPAC the task of defining a scientific policy and planning future programmes. In the event, pending the discussions in progress on the draft ESA Convention, the SPB agreed not to tackle the issue again and the whole matter was dropped.[53]

THE SELECTION OF FEASIBILITY STUDIES

The mission definition studies approved by the SPB were duly carried out from March to November 1974 by twelve groups of European scientists and ESRO staff members, under the supervision of the Directorate of Programmes and Planning's Space Missions Division (Table 7). Altogether, more than 50 external scientists were actively involved in different stages of the work, the LPAC and the SPB being called to discuss progress reports on ongoing studies. In addition, the Executive organized in October a symposium on Space Astrometry in order to ascertain the degree of interest and support in this field among the scientific

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51 LPAC(74)20, cit., p.4.

52 ESRO/PB-S(74)35, add. 1, cit., pp. 2-3. Our translation from the original French text. Emphasis in the original.

53 SPB, 10th meeting (20/11/74), ESRO/PB-S/MIN/10, 20/1/75, p. 7.

community.[54] On 4 to 5 February 1975, the Executive discussed with NASA officials those projects which had already been identified as candidates for possible cooperation, in order to review the respective positions and identify future actions after the preliminary study phase. Finally, later in February, the Astrophysics and Solar Physics Working Groups were requested to discuss the results of the studies and the Executive's conclusions, in order to assess the candidate missions from the scientific point of view and make recommendations to the LPAC on those missions which should be subjected to Phase A studies during 1975.[55]

Both Working Groups had closely followed the activity of the mission definition groups, discussing important issues about the scientific interest and technical feasibility of the various options emerging from the studies. Each Group discussed those missions that fell under its competence, the AWG also giving its advice about the astrometry project, the Out-of-Ecliptic and Stereoscopic mission, and the Solar Telescope Cluster, which fell within the competence of the SSWG. As financial reasons did not allow more than 5 Phase A studies to be performed in 1975, each Working Group was expected to recommend no more than three projects.[56]

The recommendations of the Solar System Working Group

The easy task for the SSWG was to recommend a phase A study on the AMPS (Atmosphere, Ionosphere and Plasmas in Space) programme; the difficult one was to successfully advocate missions in two fields alien to ESRO's tradition, namely solar physics and planetary studies. ESRO's participation in the Spacelab AMPS

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[54] The symposium was held in Frascati on 22–23/10/74, with the participation of about 40 astronomers and geophysicists: *ESRO Bulletin*, n. 26 (December 1974), p. 33.

[55] ESRO/PB-S(75)2, 7/3/75. See also LPAC(75)3, 18/2/75. The reports on the 13 projects studied in 1974 are MS(74)24 to MS(74)36.

[56] The AWG discussed the ongoing mission studies at its 11th meeting (7/9/74), ASTRO(74)9, 23/10/74, and 13th meeting (6/12/74), ASTRO(74)13, 21/1/75. The final recommendations were discussed at the 14th meeting (20–21/2/75), ASTRO(75)6, 27/5/75, and reported in ASTRO(75)3, 25/2/75. The SSWG discussed the ongoing mission studies at its 9th meeting (24–25/4/74), SOL(74)3, 3/9/74, and 10th meeting (19–20/9/74), SOL(74)9, 27/11/74. The final recommendations were discussed at the 12th meeting (17–18/2/75), SOL(75)4, 23/5/75, and reported in SOL(75)3, 20/2/75. The two Working Groups' recommendations are also reported in ESRO/PB-S(75)2, cit., annexes 3 and 4, respectively.

programme was definitely in line with the Organization's record of atmospheric and magnetospheric studies, and enjoyed the support of a well-established sector of the European space science community. The AMPS programme aimed at exploring the Earth's neutral and plasma environment by the use of sophisticated instrumentation on board Spacelab over a 5 to 10 year programme of flights. Besides the "core" devices or general-purpose instruments to be provided by NASA and ESRO, it was foreseen that the AMPS payload might also include instruments provided by independent scientific groups. The interest of European space scientists in such a programme was strong, as revealed by the fact that, in response to a NASA Announcement of Planning Opportunities, about 20 % of the proposals came from ESRO member states. Eleven European scientists were members of the AMPS Science Definition Working Group.[57] At the ESRO/NASA review meeting it was recognized that the technical and managerial interfaces were good and NASA stated that they hoped to effect a rapid build-up to a full AMPS payload in the early eighties. Therefore, despite some opposition from its chairman, the French astronomer A. Dollfus, the SSWG recommended that ESRO should participate in the AMPS programme, starting immediate feasibility studies on a laser facility for sounding the atmosphere in the region around 100 km altitude (Lidar) and on purpose-built subsatellites and launching devices. The possibility was also discussed that the Lidar might be included in the payload of the first Spacelab mission.

More controversial was the ESRO contribution to the Solar Telescope Cluster (STC) envisaged by NASA for a dedicated solar physics Spacelab flight. In a first phase, the European solar physics community and the SSWG had been unable to reach unanimous agreement on the choice of what kind of telescope should be contributed by ESRO. It was then suggested that the Executive should study the technical, managerial and cost aspects of the different options. In the event, following the results of this study, the SSWG had endorsed the Executive's proposal to build an X-ray grazing incidence telescope but emphasized the desirability of designing the STC mission as a truly collaborative venture in solar

[57] SOL(74)3, cit., p. 3. The NASA announcement was circulated in November 1973, as reported in ESRO/PB-S(74)8, 29/1/74.

physics, the scientific programming of all instruments being performed by the interested scientists on both sides of the Atlantic.

When the time came to decide on feasibility studies, however, no definite plans had been prepared by NASA for the build-up to a full STC payload. The Executive concluded therefore that "it was not clear what ESRO would be contributing to in 1980," and proposed that no phase A studies should be performed in 1975. The Working Group did not endorse this position. Two of its members, C. Jordan from the Culham Laboratory and M. Pick from the Paris-Meudon Observatory, strongly advocated the project, arguing that "the consequences [...] of a delay in the project of 2 to 5 years [...] would imply the loss of a healthy solar physics community in Europe." The discussion eventually led the Working Group to conclude that a phase A study of the grazing incidence telescope should be performed anyway, in consideration of the fact that "this telescope would yield excellent scientific results, even in the most pessimistic case that NASA's contribution [to the STC] was very modest."[58]

The other important project for which a phase A study was recommended by the SSWG was the Out-of-Ecliptic and Solar Stereoscopic Mission (OOE). The history of this project dated back to a suggestion made in 1965 by the leading German astrophysicist L. Biermann. A good scientific constituency had grown up since, both in Europe and the United States, and a dual-purpose mission was eventually envisaged: (a) the in-situ observation of the interplanetary environment outside the very thin disk close to the ecliptic within which all measurements had so far been confined; (b) the stereoscopic observation of the Sun by coordinated measurements from the out-of-ecliptic spacecraft and from the earth or near-earth orbit.[59] The study performed in 1974 by a joint ESRO/NASA team discussed two alternative OOE missions. The first foresaw a single spacecraft travelling out of the Ecliptic up to approximately 60^{o}, under the thrust of a Solar Electric Motor currently being studied at the Jet Propulsion Laboratory. In this so-called "Solar Electric Propulsion" (SEP) mission ESRO would provide the science module. The second mission foresaw the simultaneous launch of two spacecraft from the Shuttle towards Jupiter. The two probes would pass close to the planet and be

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58 SOL(75)4, cit., pp. 6-7; SOL(75)3, cit., p. 2.

59 Hufbauer (1993).

diverted by its gravitational field in such a way that one would pass over the North Pole of the Sun and the other over the South Pole. In this so-called "Jupiter Swing-By" (JSB) mission each space agency would provide one spacecraft. In both options, NASA would provide the launcher and ground support, while the scientific experiments would be shared by European and American scientists.

In this case too, however, the ESRO decisionmakers had to cope with the uncertainties regarding NASA's plans. In November 1974 the American space agency terminated its Jet Propulsion Laboratory's programme to develop ion propulsion for the OOE mission. As a consequence, the SEP mission would not be possible in early 1980s. This, according to the Executive, was a good reason for discarding this option, the other being that "ESRO did not wish to become involved in a project which was closely tied to a major development such as SEP, which was beyond its control."[60] By the time the SSWG was called to issue its recommendation, the dual spacecraft JSB mission was also jeopardized because of NASA's budgetary constraints. A possible fall-back JSB mission had been suggested during the ESRO/NASA programme review, namely that only the ESRO spacecraft be launched, NASA still providing the launcher and ground support. The SSWG discussed at length whether the one-spacecraft OOE mission was still attractive enough to pursue within the foreseen timescale, some of its members arguing that a new mission definition study was required in order to assess its real scientific interest. In the event, the Working Group recommended by a majority vote that a Phase A study on the ESRO spacecraft for the OOE mission should be performed anyway, even considering the possibility that it might fly alone if NASA decided not to proceed with the dual-spacecraft version.

Besides the three projects described above, for which a feasibility study was recommended, three others fell within the competence of the SSWG: the Jupiter orbiter and probe, the astrometry mission and the cometary mission. The first foresaw sending a NASA Pioneer spacecraft carrying American and European experiments to study the atmosphere and magnetosphere of the Solar System's biggest planet as well as the properties of some of the Jovian satellites. By February 1975, however, it was evident that such a mission could hardly be recommended. Firstly, as the ESRO Executive pointed out, "the proposed

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[60] SOL(75)4, cit., p. 11. See also Hufbauer (1993), p. 180.

hardware contribution was of less interest to the Organization than in other projects under study, [...] ESRO would prefer to offer more challenging work to European industry."[61] Secondly, the Pioneer Jupiter Orbiter (PJO) was in competition with other missions to Jupiter and Uranus that NASA was planning for the period 1979 to 1981. Therefore, the SSWG regretfully concluded that studies on the PJO mission should be interrupted and recommended that a real strategy for European planetary science be studied by ESRO in view of possible cooperation with NASA in other planetary missions beyond 1980.

As to the astrometry project, its objective was to measure stellar positions, proper motions and trigonometric parallaxes, with an accuracy at least 10 times better than that of present observations. The project, as we have anticipated, was discussed at a symposium organized by ESRO in October 1974 and three options were studied: an automatic satellite of the Thor–Delta (TD) class, a telescope to be mounted on Spacelab and an astrometry instrument in the focal plane of the Large Space Telescope. While not being particularly interested in such a mission, the SSWG recommended that a mission definition study should be initiated "in order to bring the definition of astrometry projects to the same level as the other 12 missions proposed." The Spacelab telescope, in particular, was considered worthy such a study.[62]

Finally, the SSWG took into consideration the probe to comet Encke, based on the German HELIOS spacecraft technology. Cooperation with NASA in this project proved impossible in view of the latter's plans to proceed independently with a study of a Mariner spacecraft mission to Encke. This was the first reason for the ESRO Executive's proposal not to proceed with further studies of such a project, the second being the high cost *vis-à-vis* the limited data return (approximately 30 hours observation time). The latter argument was strongly opposed by the German members of the Working Group, who argued that "it was not quite fair to judge a mission in terms of the volume of data provided," and that "the value of the mission should [not] be judged by the bit rate per accounting unit that would accrue."[63] In the event, the Working Group agreed on a proposal by J.

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61 SOL(75)4, cit., p. 9.

62 SOL(75)3, cit., p. 4.

63 SOL(75)4, cit., p. 17. The first quotation is from W.I. Axford, the director of the Max-Planck-Institut für Aeronomie in Lindau, the second from D. Offermann, of Bonn University.

Blamont to explore the possibility of a special project with the German authorities or, alternatively, to re-consider the cometary mission in cooperation with NASA, in the context of the envisaged strategy for planetary science.

The recommendations of the Astrophysics Working Group

The missions falling within the competence of the AWG had been thoroughly discussed by interested scientists in seminars held in ESTEC on 3 to 5 December 1974. The Working Group's task was essentially to make a choice between complementary projects in four research areas. Firstly, there were the two infrared astronomy projects LIRTS and CIRES. The AWG discussed at length these two options for entering this new and fascinating field of astronomy. Many doubts had been expressed both in the US and in Europe about the feasibility of useful IR astronomy measurements from Spacelab, both because of possible contamination problems and because of the short duration of Spacelab flights, and these doubts were echoed in the AWG discussions. Doubts were also expressed about the satellite project CIRES. This was intended to serve two scientific objectives, i.e. a complete and systematic exploration of the IR sky and a measurement of the spectrum and anisotropy of the diffuse background radiation. Opinions were divided about which of these objectives should be privileged, some preferring a dedicated survey satellite, others advocating a ground-based instrument or a Spacelab-borne specialized experiment to measure the diffuse background.

In the event, the AWG endorsed the Executive's proposal to perform a Phase A study of the LIRTS, defined as an infrared telescope of 2 to 3 metre diameter, operating at ambient temperature and mounted on a stabilized platform on board Spacelab. Two important qualifications, however, were attached to the AWG recommendation. First, that the size of the telescope should not be reduced below 2 metres; secondly, that a viable programme required a frequency of flights of one 7-day mission per year. Four such missions or, equivalently, two 30-day missions were required to make coverage of the whole celestial sphere. Should one of these conditions not be fulfilled, the AWG stressed, a reconsideration of the project and of its desirability would be necessary. As to the CIRES, the AWG acknowledged that NASA was studying an infrared satellite to be launched before 1980. As ESRO's financial constraints and Europe's technical expertise in the field of cryogenics did not allow for a timely launch of CIRES, the survey aspect of the mission was not worth pursuing. The AWG suggested studying a small Spacelab instrument for measurement of the background microwave radiation and stressed the importance of Europe developing expertise in the field of cryogenics for infrared and cosmic ray missions.

The second research area was that of optical and ultraviolet astronomy. Here little doubt existed about the great opportunity offered by the NASA Large Space Telescope (LST) project. In the AWG's opinion, "if [the LST] is realized in about its presently foreseen form, it will dominate astronomical progress in the 1980's." It was essential that such a facility should be accessible for European astronomers, and that all necessary steps should be taken to ensure a reasonable participation in the LST programme. The AWG acknowledged, however, "the uncertainty of NASA's plans regarding the mission and its latest ideas regarding the possible form an ESRO contribution could take."[64]

Following preliminary contacts between the two space agencies and after discussions within the AWG, ESRO had studied two focal-plane instruments for the LST, a High Resolution Camera (HRC) and a Faint Object Spectrograph (FOS), together with a photon counting system which could be applied to both. NASA had indicated its preference for ESRO to produce the HRC as it felt that the FOS should be assigned as a result of a competitive call for proposals. The reward for ESRO providing an instrument would be a certain guaranteed amount of observing time for European astronomers. This possible arrangement drew some criticism from U.S. astronomers, who felt that all LST instruments should be assigned on a competitive basis and did not like a fraction of the observing time being blocked off from their community. In Europe, too, some questioned why ESA should invest so much in the LST development programme in order to have access to what European astronomers could get anyway through normal competition, since NASA intended to open its Announcements of Opportunity to the entire scientific community. By early 1975 the LST Science Working Group in the U.S. had accepted the principle of the noncompetitive selection of one focal-plane instrument to be provided by ESRO/ESA. This opened the way to real negotiations between the two agencies, the outcome of which was however still

[64] ASTRO(75)3, cit., p. 2; ASTRO(75)6, cit., p. 11.

unpredictable owing to the complex scientific, technical and institutional problems involved.[65]

Equally unpredictable was whether the LST project could pass the formidable obstacle of Congressional approval, and if so in what form. In June 1974 the House had denied funds for continuing planning studies on the telescope in 1975. Only after strong lobbying and a joint House–Senate conference were $ 3 million appropriated of the $ 6.2 million originally requested by NASA. A new start in 1976 was out of the question, and no guarantee existed that the building of the LST in 1977 might eventually be approved. European participation in the LST programme was one element of NASA's strategy to win this approval; the other was to redesign the telescope in order to reduce its costs, and performance as well. By the end of 1974, the Science Working Group had reluctantly accepted a reduction of the telescope mirror to 2.4 metres from the planned 3 metres. NASA, however, was also studying the possibility of a further reduction to 1.8 metres, with only two scientific instruments, something that astronomers considered a real betrayal of their expectations from a "large" space telescope. Eventually, the 2.4–metre telescope was approved by the NASA Administrator and the struggle to win federal funding started again. It was expected that the situation on the LST and the ESRO–NASA collaboration would be clarified in June 1975.[66]

The relative uneasiness of the AWG *vis–à–vis* the uncertain LST situation is reflected by the discussion on the second UV astronomy project, the One–Metre Ultraviolet Spacelab Telescope (MUST). Should the LST go ahead there were good reasons for discontinuing studies on the MUST. In the event, however, that the NASA project should be jeopardized or the ESRO cooperation should not be pursued, Europe could not miss the opportunity to develop its own project. The AWG, in fact, recommended that the MUST should be kept under study anyway, noting that the photon counting detector being studied for the LST could be successfully used on the European telescope.

The third important choice was between the two high energy astrophysics projects, i.e. the Spacelab borne X–ray spectropolarimeter EXSPOS and the gamma–ray astronomy satellite LOGOS. The Working Group endorsed the

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65 Smith (1989), pp. 135–140. See also Bonnet & Manno (1994).

66 Smith (1989), pp. 121–135 and 143–154.

Executive's proposal that the former should be studied at Phase A level, as this mission was better defined as regards both the scientific objectives and the proper instruments to achieve these objectives. According to the AWG, EXPOS was "a typical Spacelab payload representative of a whole class of high energy astrophysics Spacelab payloads." It was assumed that one flight per year represented a reasonable timescale and that seven or eight flights would be required to cover all known X-ray sources.[67]

Finally, the AWG had to advise on the three proposals on cosmic rays. The mission definition group had concluded that a superconducting magnet on board Spacelab was the facility required to meet all important scientific objectives. This, however, could hardly be available in the 1980s and therefore two satellite payloads were proposed as possible alternatives: one for studies on the isotopic composition and another for investigating elemental abundances at high atomic weight. The AWG, however, did not recommend any of these satellite missions for a Phase A study but stressed the importance of keeping the superconducting magnet facility for Spacelab under study.

In conclusion, among the mission proposals falling under its competence, the AWG recommended the participation in the LST (with the MUST a subordinate option), the Spacelab infrared telescope LIRTS and the Spacelab X-ray facility EXPOS as scientific projects to be studied in 1975 at Phase A level. The Working Group also endorsed the SSWG's recommendations on the OOE and the astrometry missions but not that regarding the Solar Telescope Cluster. The AWG proposed, in fact, that a new mission definition study be carried out to re-define the project as a Spacelab "lone-flyer" independent on other STC elements.[68]

The LPAC makes its recommendation and the SPB endorses it

The results of the mission studies, together with the ESRO Executive's conclusions and the Working Groups' recommendations, were presented to the LPAC on 27 to 28 February 1975.[69] Introducing the discussion on behalf of the Executive, the acting Director of Planning and Future Programmes, A. Dattner,

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67 ASTRO(75)3, cit., p. 2; ASTRO(75)6, cit., p. 13.

68 ASTRO(75)2, cit., p. 2.

69 LPAC, 58th meeting (27-28/2/75), LPAC(75)5, 14/4/75.

stated that the resources available in 1975 would only permit the execution of 5 Phase A studies out of the 6 recommended by the SSWG and AWG. The ensuing discussion hardly added any new elements to what had been extensively discussed within the Working Groups. Their conclusions were essentially endorsed by the Committee, whose main task was now to decide which of the 6 recommended Phase A studies should be discarded. In the event, this was the X-ray telescope designed for the Solar Telescope Cluster, as was to be expected in the light of the Executive's position. The LPAC recognized that the uncertainty of the NASA planning was the main reason for not pursuing further studies of the envisaged ESRO instrument. It endorsed, however, the AWG's recommendation that the Spacelab grazing incidence telescope should be studied as a "lone-flyer" and stressed that such a study should be given "first priority" among the category of lower level studies to be performed in 1975. As regards the LST/MUST question, the Committee stated that ESRO should carry out further definition studies on the LST instruments until the end of June, pending a clarification of the LST situation. If at that time a decision to go ahead on LST were not reached in the U.S. or a suitable form of ESRO participation were not yet defined, Phase A studies on the MUST should be initiated. Moreover, it was agreed that a reconsideration of a possible cooperation on the LST would be called for if a mirror diameter of 2.4 m could not be achieved.[70]

Following the LPAC meeting, the ESRO Executive proposed that the SPB should endorse a study programme for 1975 which included the 5 Phase A studies recommended by the LPAC as well as some additional lower level (i.e. mission definition or technological) studies on projects which were not supposed to be candidates for ESRO's next scientific project but which might become candidates for subsequent projects. Among the latter, first priority was given to the Grazing Incidence Solar Telescope (GRIST), as recommended by the LPAC.[71]

The discussion at the SPB meeting did not touch on major issues. The Chairman recalled the "somewhat critical attitude that he had come to adopt, in recent meetings, of the process leading up to the preparation of the Organization's scientific programme," but now he wanted to state that "he was extremely satisfied

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[70] LPAC(75)5, cit., p. 5-6. The LPAC recommendations are reported in annex 1. See also ESRO/PB-S(75)2, cit., pp. 3-6.

[71] ESRO/PB-S(75)2, cit., pp. 7-8.

with the way in which the work had gone ahead within the Executive, the Working Groups and the LPAC to achieve the definition of the proposals which were about to be submitted to the Programme Board."[72] Delegations generally supported the LPAC's and Executive's proposals, although the German delegation regretted that the studies on a cometary probe had to be abandoned. In conclusion, the SPB approved without any further comment the proposed study programme for 1975 (Table 8).

OUTLINES FOR EUROPEAN SPACE RESEARCH IN THE 1980S

What comments can a historian make on the conclusion of this phase of the selection process of ESRO's next scientific project? The first regards the process itself, i.e. its peculiarity *vis-à-vis* that in use in the United States. Here NASA controlled the whole process of selecting both the missions to be developed and the scientists for a particular mission. In order to cope with the intense competition among scientists for access to space, "NASA created a strong Headquarters organization with a scientific and technical staff to establish policy, formulate the research programme, establish scientific missions, and select the scientists for those missions."[73] This was hardly the case for ESRO for which, as we have seen, it was the continuous negotiation within the European space science community that led to the progressive definition of the Organization's scientific programme. Out of the two dozen missions suggested by the scientific Working Groups in December 1973, five had survived by March 1975, after intensive study and discussions at various levels of the ESRO advisory system. And hardly more than one or two could eventually be adopted at the end of the process, by mid-1976. ESRO of course played an important role, by directing mission definition and feasibility studies, by keeping technical and institutional contacts with NASA, and by assuring circulation of ideas among scientific groups in Europe. Nevertheless, it was up to the scientific leadership in the various disciplines and national scientific communities to approve the studies, to endorse cooperative projects and to orient the circulation of ideas. This was what ESA's present

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[72] SPB, 11th meeting (26/3/75), ESRO/PB-S/MIN/11, 24/4/75, p. 2.

[73] Naugle (1991), p. 116.

Director of Science Roger Bonnet called "a *bottom-to-top* approach whereby the community is the only source of the ideas and of the concepts of missions, the Agency being there only to transform these ideas and concepts into reality".[74]

Our second comment regards the five projects selected for feasibility studies. How do they relate to ESRO's established scientific tradition? Firstly, we can point out that European solar physicists and planetary scientists had again failed to obtain proper consideration for a mission in their respective fields.[75] The "low level" study of an X-ray solar telescope could hardly satisfy the hopes and expectations raised by the envisaged Spacelab STC mission. As a matter of fact, the lure of such a mission proved doubly fallacious, as it also prevented the European solar physics community from designing an independent satellite project capable of competing successfully with the other proposals. As to planetary science, it confirmed itself as the weakest element in European space science. The high cost of launchers and deep space tracking and telemetry stations made planetary missions only feasible in cooperation with NASA, but the latter's vigorous programme in the field (the Pioneers and Mariners, and the forthcoming Voyagers) could only place Europe in a subordinate role that ESRO policymakers could hardly accept.

Secondly, we can underline the great importance of astronomical projects, certainly a novelty after the previous disappointments of the LAS and UVAS projects in the 1960s and the LPAC policy statement of 1970.[76] The envisaged participation in the Space Telescope appeared as one of the central elements in the Organisation's scientific planning for the 1980s while, with the LIRTS, European astronomers were given a chance to enter the field of infrared observations of celestial objects. Just as X-ray astronomy had marked in the 1970s a dramatic revolution in the scientific knowledge of the skies, so infrared astronomy promised to do in the 1980s. The Dutch IR-astronomy satellite IRAS, under development in collaboration with NASA, and the envisaged ESRO LIRTS promised to give Europe a forefront position in this new field (Figure 2).[77]

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[74] Bonnet (1993), p. 2.

[75] For previous cases see Russo (1992b) and (1993b).

[76] Krige (1993), Russo (1993a) and (1993b).

[77] Beckman (1977). The important role of Spacelab for infrared astronomy was very soon recognized. ESRO set up a study group to design a possible infrared astronomy payload for

Alongside the novelty of ambitious astronomical projects there was the confirmation of the important role of atmospheric and magnetospheric studies in the ESRO programme. The AMPS programme was in fact perfectly in line with previous (sounding rockets and ESRO-I) and ongoing (GEOS and ISEE-B) ESRO activities in this field. The same can be said of EXPOS, which met ESRO's ongoing effort in X-ray astronomy (EXOSAT), even though some scientists would have preferred the gamma-ray satellite LOGOS as a representative project in the field of high energy astrophysics.

Finally, we should underline the originality of the OOE project. For the first time in the history of astronautics, a spacecraft would be flung out of the ecliptic plane, i.e. the flat region around the Sun where all solar system bodies revolve, fulfilling scientific objectives which ran from solar physics to cosmic-ray studies and from solar wind measurements to studies of the interplanetary environment.[78] Science historian K. Hufbauer (1993) has told in detail how the idea of such a mission was born and eventually developed, first in Europe and then in the USA. As a matter of fact, this was a rather controversial project, whose scientific rationale was continuously negotiated because of the several changes in its concept (SEP vs JSB, single- vs dual-spacecraft, solar physics vs interplanetary medium studies, ESA/NASA collaboration vs pure ESA mission, etc.). The progressive definition and refinement of the project and its successful passing through ESRO/ESA's decision-making system, well represented, in our opinion, the characteristic "bottom-to-top" approach we discussed above.

Our third comment relates to the importance of the Shuttle/Spacelab system in ESRO's scientific planning in the mid-1970s. Three projects - AMPS, EXPOS and LIRTS - were designed for use with Spacelab, and indeed the fulfilment of their scientific objectives required many flights of the shuttle-borne laboratory spread over several years. The LST and the OOE mission required the Shuttle as launcher, except for the fall-back version of the latter, which required an Atlas-Centaur launcher for the one European spacecraft. We should recall that, in the case of EXPOS and LIRTS, alternative satellite projects had been discarded, i.e.

Spacelab in late summer 1973, i.e. soon after the approval of the Spacelab programme by the ESRO Council and before the first discussions in the AWG and the LPAC: ESRO/PB-S(73)19, 31/10/73. About IRAS, see ESRO/PB-S(75)6, 11/3/75.

[78] Page (1975).

LOGOS and CIRES. Both the latter had been defined as "high cost" projects by the Executive, as compared to the "low cost" and "medium cost" label assigned to EXPOS and LIRTS, respectively. This assessment, however, did not include recurring costs typical of Spacelab missions (e.g. maintenance, refurbishment and repeated launches and operations). Whatever good scientific reasons existed for preferring EXPOS and LIRTS to LOGOS and CIRES, respectively, the preference was also based upon highly optimistic expectations about the performance of the Shuttle/Spacelab system. Indeed, in the ESRO/ESA planning for Spacelab utilisation, it was envisaged that more than 20 NASA missions with European participation and seven fully European missions should be performed in the period 1980 to 1985.[79]

By the autumn of 1975, the Executive became well aware of the fact that this dependence on the Shuttle/Spacelab system was an "undesirable situation to be in because [...] the Shuttle could be subject to delays and modifications."[80] Sound planning demanded that alternate, Shuttle-independent scientific missions should be available to the Agency. The Director General addressed a letter to the space science community, urging proposals for "scientific missions which do not have to be launched with the Shuttle."[81] Following this consultation, it was decided that four new definition studies should be carried out in 1976 on Shuttle-independent contingency missions: a Sun-Earth Observatory and Climatology Satellite (SEOCS); a "Dumb-bell" mission, foreseeing two spacecraft linked by a wire or tether for magnetospheric studies; an Extreme Ultraviolet and X-ray Survey Satellite (EXUV); and a Transient X-ray Sources Satellite.[82]

Finally, our last comment regards the cooperation with NASA, which was to become more and more imperative because of the imposed ceiling on the scientific budget against the increasing sophistication and cost of space projects.[83] The two most important projects in ESRO/ESA planning, the LST and OOE missions,

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[79] *ESA Annual Report 1975*, p. 71. We should also recall that first priority among mission definition studies had been given to the GRIST, also a Spacelab payload. Regarding NASA's optimistic claims about the Shuttle performance and cost-effectiveness, see Logsdon (1986).

[80] ESTEC's G. Haskell at the 15th SSWG meeting (6-7/10/75), SOL(75)12, 1/2/76, p. 12.

[81] ESA/SPC(75)19, 5/12/75.

[82] ESA/SPC(76)6, 11/2/76, and Add. 1, 27/2/76.

[83] Manno (1980).

could be possible only with NASA, the former by definition and the latter, in either the twin– or the single–spacecraft version, because of the need of launching and deep space facilities. Of the three others, AMPS was essentially a NASA programme with European participation, and EXPOS and LIRTS were designed as pure ESRO/ESA ventures. These, however, required full availability of Spacelab facilities for several Shuttle missions, thus depending on some kind of agreement and/or cooperation with NASA. More generally, the foreseen use of the Space Shuttle in the 1980s as a unique means for carrying scientific experiments into space gave NASA great control over ESRO/ESA's scientific programme, as the use of Ariane would probably be too costly for the scientific budget. This circumstance was a cause of concern within the European space science community, which found an echo in the discussions of ESA's advisory bodies.[84]

In conclusion, in one way or another, in the 1970s a large part of ESRO/ESA's scientific planning depended on that of its American counterpart. The relations between the two space agencies became closer and closer at both technical and institutional level during the decade. Scientific contacts intensified, both for discussing ongoing joint projects and for future planning. European scientists were invited to participate in the NASA scientific advisory bodies and, conversely, representatives of NASA's scientific staff joined the Astrophysics and Solar Physics Working Groups. As ESRO pioneer Reimar Lüst would later state, the relationship between Europe and the United States in space cooperation was leaving the period of tutorship to enter that of junior partnership.[85] Although there were obvious advantages to be gained from cooperation with NASA, this also implied being subject yearly to the uncertainties of Congressional decisions which could strongly affect ongoing or future programmes and could result in unilateral postponement or cancellation of joint projects. The experience, in fact, often proved frustrating.[86]

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[84] SAC, 1st meeting (24/2/76), SAC(76)4, 7/4/76, p. 12.

[85] Lüst (1987).

[86] Bonnet & Manno (1994), chapters 4 and 5.

The approval of feasibility studies of possible future projects was one of ESRO's last legacies to ESA. In June 1975 the new Agency came into *de facto* operation and a new committee structure was set up. The SPB was replaced by a Science Programme Committee (SPC), whose formal status as a subordinate body of the Council was lower than that of a Programme Board (Table 9). In this period, as was to be expected, the question of scientific advice again came under discussion. In September the Director General proposed to replace the old–standing LPAC with a new Science Advisory Committee (SAC), reporting to him and responsible for providing advice on the whole of the Agency's scientific programme. According to his proposal, the members of the SAC and its chairman would be chosen by the Director General and the Committee would work in close contact with the Directorate of Planning and Future Programmes. Moreover, a number of scientific Working Groups would be set up, of which the chairmen and half the members would be nominated by the Director General, the other half being coopted by their colleagues. A main change in the status of these Working Groups was that they would henceforth report to the Director General and not to the SAC. Four Working Groups were eventually set up: Astronomy (AWG), Solar System (SSWG), Life Sciences (LSWG) and Material Sciences (MSWG).[87]

When called to comment on this proposal, which aimed at integrating the scientific advisory system within the Executive's activity, most SPC delegations expressed strong reservations. "The Science Programme Committee must be careful that it was not confronted with a ready–made programme which it was only requested to 'rubber–stamp'," the German delegation warned. The SPC should obtain direct advice from its own subordinate bodies, argued the Belgian delegation, adding: "The Director General [has] the right to consult whom he pleased, but he should not ask the SPC to consecrate his choice." Other delegations supported the view that the SPC should set up its own advisory body as other Programme Boards did, or at least appoint part of the SAC membership.[88] Reservations on the Director General's proposal were also expressed by the AWG,

87 ESA/SPC(75)8, 16/9/75; ESA/SPC(75)17, 27/11/75.

88 SPC, 1st meeting (9/10/75), 12/11/75, pp. 8–9.

whose members felt that the new structure would not be representative of the European scientific community. They argued that part of the membership of the Working Groups and the SAC should be appointed by external scientific bodies such as the European Science Foundation or the European Physical Society.[89] In the event, however, the Director General's position prevailed. The SPC agreed not to set up its own advisory body after being assured that all information resulting from the activity of the SAC and the advisory groups would be made available to it. The first membership of the SAC is reported in Table 10.

Summarizing, to the benefit of the new SPC, the schedule of main steps and decisions regarding future scientific projects, the Executive explained that five phase A studies were being conducted, the results of which would be available by spring 1976 (Table 8). As usual, these results would be discussed in a scientific symposium, presumably at the end of June, and then the scientific working groups and the SAC would be requested to issue their recommendations. By the end of July, the Director General would submit his proposals to the SPC, called to decide on the new project(s) to be adopted in the ESA scientific programme. Eventually, because of the limited funds available in 1976 and 1977, it was necessary to postpone the decision to early October.[90]

Discussing the new projects

Both Working Groups had being discussing ongoing feasibility studies, providing continuous advice on the best way to achieve the scientific goals assigned to the mission studied. The main concern regarded the status of the LST project, whose official name was now Space Telescope (ST), after the reduction of its diameter to 2.4 m. Following NASA's intimation that the Faint Object Spectrograph (FOS) would be assigned as a result of a competitive call for tenders, the Executive had decided not to enter into competition on the FOS but to concentrate study on a Faint Object Camera (FOC) with associated Imaging

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89 AWG, 16th meeting (28/10/75), ASTRO(75)13, 4/12/75. The AWG's criticism was reported by its chairman to the first SAC meeting (24/2/76), SAC(76)4, 7/4/76, pp. 2–5.

90 ESA/SPC(75)15, 1/12/75; ESA/SPC(76)10, 18/2/76; ESA/SPC(76)19, 17/5/76. Status reports on the various studies of scientific missions are ESA/SPC/(75)5, 19/9/75, and ESA/SPC/(76)5, 17/2/76.

Photon Counting System, i.e. the former High Resolution Camera (HRC) with the accent now on faint objects. Provision of this instrument was ESA's main contribution to the ST and the ticket for obtaining a fraction of observing time for European astronomers. It was envisaged that ESA should also provide the solar arrays and contribute to the ST operations. Negotiations between ESA and NASA were being pursued by a joint Working Group set up in June 1975.[91]

The situation remained however very uncertain at the political level. Early in October 1975, the U.S. President G. Ford announced cuts in the forthcoming federal budget and NASA had to shoulder its portion of the burden. The start of the ST project in 1977 was thus under serious threat.[92] As R. Bonnet put it, "The first thing to establish, in view of the budgetary restrictions imposed by NASA, [was] whether the LST would indeed fly."[93] The U.S. President was to present the federal budget to Congress at the end of January 1976, and only then would it be known whether the ST was included as a "new start" in the 1977 NASA budget. If it was not, one had to assume at least a one-year delay in the start of the ST. This was a rather embarassing situation for the AWG, which had to decide whether to start feasibility studies on the MUST or to keep supporting the Space Telescope. In early December 1975, it agreed to stick to the ST but reaffirmed that the MUST should be considered as a fall-back project should the former not be pursued.[94]

In January 1976 it appeared that the ST was not in the NASA budget for the fiscal year 1977, and funds were not even provided for further Phase B studies. This was bad news for ST supporters in the U.S. astronomical community as well as a matter of great concern for the AWG, whose members wondered "at what point a decision should be made to continue the study on the MUST."[95] A dramatic discussion on the ST programme and other ESA studies in ultraviolet astronomy developed at an AWG meeting in April, which exposed all the drawbacks of ESA's being so closely tied to the NASA programme. On the one hand, there was uncertainty about the future of the ST project. NASA had made it clear that the ST would have top priority in the 1978 budget, to be approved by

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91 ESA/SPC(75)6, 17/9/75.

92 Smith (1989), pp. 160–163.

93 AWG, 16th meeting (28/10/76), ASTRO(75)13, p. 11. 161.

94 ASTRO, 17th meeting (1–2/12/75); ASTRO(75)15, 23/2/76.

95 AWG, 18th meeting (28/1/76), ASTRO(76)4, 5/5/76, p. 5.

Congress in 1977. ESA, however, had to make a decision in 1976, i.e. prior to this hoped–for approval. On the other hand, despite the strong support given by the AWG to the MUST, the latter had the great disadvantage that, in order to achieve important results, it had to fly on many Spacelab missions. In fact, ten 30–day flights of the MUST would be required to achieve the equivalent observing time eventually available to ESA on the ST. While no cut–back had been made on the Shuttle main development programme, one could hardly be confident that budgetary constraints would not in the future negatively affect the Spacelab mission schedule. Moreover, the question of the cost of Shuttle/Spacelab missions was still open. Not surprisingly, some AWG members regretted that ESA had not considered a free flyer configuration for an ultraviolet telescope! In the event, the AWG had little choice but to reaffirm its support for the NASA project, and unanimously it did so.[96]

Late in June 1976, ESA's advisory bodies were called to recommend which project(s) should be adopted in the scientific programme. Apart from the uncertain situation of the ST project, two new elements had to be considered. Firstly, the AMPS programme was under critical review within NASA and it looked as if European scientists would not gain admittance to it for some years. Consequently, such a programme could no longer be proposed as a realistic context for use of the Lidar and the subsatellites. These facilities had now to be considered as independent projects within the framework of a possible European future programme of multidisciplinary Spacelab missions. Secondly, in addition to the projects for which a feasibility study had been prepared (Table 8), three others of minor importance were to be considered for possible adoption in the scientific programme. These were:

a) The ESA contribution to the experimental payload of the first Spacelab mission, in particular those instruments to be funded out of the scientific budget. Two facilities had been considered for possible inclusion in the first Spacelab payload (FSLP): the Lidar and a Sled device for studying the behaviour of the vestibular system of astronauts under weightless conditions.[97]

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[96] AWG, 19th meeting (13/4/76), ASTRO(76)6, 14/6/76, pp. 5–8.

[97] ESA/FSLP(75)3, 9/9/75; ESA/SPC(76)17, 18/5/76, and Add. 1, 16/7/76. The Sled fell within the province of life sciences and does not concern us here. Its inclusion in the FSLP was approved by the SPC after a positive recommendation of the SAC. For a general description of this

b) The extension of the COS–B mission beyond its planned lifetime of two years, as requested by the experimenters after the brilliant performance of the satellite.[98]

c) The passenger experiment for the Ariane qualification flight L02 (APEX–L02). Three options had been proposed: the COS–B second flight model (COS–B2), the GEOS second flight model (GEOSARI) and the COS–B spacecraft with a variety of experiments (COSARI).[99]

The results of all feasibility studies were presented to the scientific community during a symposium held on 28 to 30 June 1976. On July 1st the SSWG and AWG discussed the projects and issued their recommendations. The following day it was the turn of the SAC to do its job.[100]

The Working Groups' recommendations

Three projects fell within the field of interest of the SSWG: the Lidar, the sub–satellites, and the Out–of–Ecliptic mission. The first, as we have anticipated, was to be considered both with regards to its possible inclusion in the FSLP and in the framework of a possible future programme of Spacelab missions for atmospheric studies (four 7–day missions in one year had been recommended by the consultant group in order to gain significant scientific results). At a previous meeting, in April, the SSWG had accepted the principle of including the Lidar in the FSLP. This decision, which had been urged by the Executive because of the constraints of the Spacelab programme timetable, was taken with many reservations, both because the results of the Phase A study were not yet available and because it had to be taken outside the competitive framework scheduled for late June. Similar reservations were expressed by the SAC when called to endorse the SSWG's recommendation. Both the SSWG and the SAC had underlined that the decision to

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facility, see Steinz (1980). As anticipated, we will deal with the whole story of the FSLP in a following report and recall here only those aspects which are relevant in this context.

98 ESA/SPC(76)29, 19/7/76.

99 ESA/SPC(76)34, 22/9/76. For the Apex (Ariane Passenger Experiments) programme see Pfeiffer (1976).

100 SSWG, 19th meeting (1/7/76), SOL(76)14; AWG 21st meeting (1/7/76), ASTRO(76)10, 30/9/76; SAC 13rd meeting (2/7/76), SAC(76)11, 27/8/76. The recommendations of the working groups and the SAC are attached to ESA/SPC(76)25, 3/9/76.

fund the Lidar for the FSLP from the mandatory scientific budget should not in any way prejudice the chances of other missions or set a priority over any of them. Further development and re-flights of the Lidar had to be considered in the same way as other competitive projects.[101] When, in early July, the SSWG discussed again the possible inclusion of the Lidar in the FSLP, new information was available from the responses to the Call for Preliminary Proposals and from the discussions at the scientific symposium. The SSWG then reversed its April decision and concluded that a greater scientific return from the FSLP would be obtained by a passive sounding package than by the Lidar. The latter was not recommended for the FSLP, and its possible use in future Spacelab missions was not even discussed.[102]

The other project studied in the framework of the ill-fated AMPS programme was the development of sub-satellites to support Spacelab instruments. Several types of sub-satellites had been investigated, including the interesting class of tethered satellites. The SSWG recognized the interest of such sub-satellites but decided not to recommend the immediate adoption of this project in the ESA programme. In conclusion, failing the possibility of cooperating with NASA in the AMPS programme, ESA's plans in atmospheric and magnetospheric studies with Spacelab were definitely jeopardized.[103]

The OOE mission remained the only important project available to the space science community involved in Solar System research, and it was strongly supported by the SSWG. The Group considered it a "multi-disciplinary [and] truly exploratory mission", whose scientific interest involved many fields, from interplanetary science to solar physics, and from Jovian studies to astrophysics. The Group insisted that the dual-spacecraft mission was definitely to be preferred both to the single-spacecraft mission and to a new proposal advanced by the Italian physicist Giuseppe Colombo, namely to combine one out-of-ecliptic spacecraft with a solar probe.[104]

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[101] SSWG, 18th meeting (27-28/4/76), SOL(76)8, 2/7/76. SAC, 2nd meeting (28/4/76), SAC(76)8, 4/6/76. The final recommendations are reported in ESA/SPC(76)13, 18/5/76. For the scientific use of the Lidar, see SSWG, 16th meeting (16-17/12/75), SOL(76)1, 16/2/76.

[102] SOL(76)14, cit. See also ESA/SPC(76)13, Add. 1, 15/7/76.

[103] SOL (76)12, 1/7/76. Also attached to ESA/SPC(76)25, cit.

[104] SOL(76)12, cit., p. 1. About Colombo's proposal, see SSWG, 13th meeting (17-18/4/75), SOL(75)6, 13/6/75.

The three other projects pertained to the AWG, i.e the 2.4 metre Space Telescope (ST), the infrared telescope LIRTS and the X-ray spectropolarimeter EXPOS. The AWG reaffirmed its strong interest in the ST, "the most important development for astronomy in the 1980s." It was the unanimous opinion of the Working Group that "ESA should obtain guaranteed observing time for European astronomers so that they do not have to rely on 'hitch hikes'." Current negotiations with NASA foresaw that ESA would provide the Faint Object Camera with the associated Image Photon Counting System, the Solar Array and a contribution to the activities of the Space Telescope Science Istitute. The European contribution was envisaged at 15 % of the total cost and, in return for this contribution, 15 % observing time would be allocated to European astronomers.[105]

The LIRTS was considered by the AWG no less important than the ST. "An instrument such as the LIRTS," the Group claimed, "will be mandatory for the progress of infrared astronomy once the [Dutch satellite] IRAS has flown ($\approx$ 1981) [...] The instrument appears to be technically feasible, flexible and fast." The Group also stressed that the LIRTS was a totally European instrument, and this gave "a certain degree of independence *vis-à-vis* the United States space programme [to be balanced] with the strong dependence of the Space Telescope programme on approval by NASA and Congress."[106] The main problem with the LIRTS was the great uncertainty regarding the cost of reflights, since no official charging rates for Spacelab missions were as yet available from NASA. After the first 7-day mission, 28-day missions were recommended for economic reasons. The cost of each such mission was estimated by the Executive at about 23 MAU, as compared to the total cost of the project (including the first 7-day flight) of 40.3 MAU. That figure, the Executive warned, was not under ESA's control and might be inaccurate by rather large amounts.[107]

The third project within the AWG's field of interest was EXPOS. This was less expensive than the LIRTS (25.4 MAU, including the first 7-day mission), but

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[105] ASTRO(76)11, 13/7/76, p. 1. Also attached to ESA/SPC(76)25, cit. The principles for ESA/NASA collaboration on the ST project are presented in ESA/SPC(76)36, 7/9/76. It should be noted that the SSWG had also expressed interest in the ST because of its profitable use in solar system science.

[106] ASTRO(76)11, cit., pp. 1-2.

[107] ESA/SPC(76)33, 1/9/76, p. 14.

again its operation would be more costly than its development (an estimated 11 MAU for each of subsequent 28-day missions). The Working Group considered this instrument "of high scientific value and of great importance to X-ray astronomy [...] the logical step to aim at in the Shuttle era, because it will allow experimentation with various techniques designed to achieve high spectral resolution."[108]

Concluding the discussion on the three candidate projects, the AWG had to recommend priorities among them. Some advocated the ST, arguing that cooperation was the only "entrance ticket" to obtain a reasonable amount of observing time, and that its approval was urgent because of NASA's schedule. Others insisted that higher priority should be given to the LIRTS, while observing time on the ST should be negotiated through the guest observing programme or by granting the U.S. astronomers observing time on the LIRTS. The EXPOS was finally supported by those AWG members who were directly involved in high energy astrophysics: this discipline, they claimed, was entirely dependent upon space resources while optical and infrared astronomy could also take advantage from existing ground-based facilities. Finally, it was pointed out that "EXPOS, and to a minor degree LIRTS, were the two projects which were independent of the aleas of cooperation."[109]

In the event, a vote was taken. The outcome was that the ST and the LIRTS were both of prime importance for European astronomy and no relative priority could be assigned on scientific grounds. In case priorities had to be made in the financing schedule, the AWG agreed that the ST should take priority. It stated, however, that studies of focal plane instrumentation for the LIRTS should be pursued in any case and its mirror should be ordered as soon as possible. As to the EXPOS, the AWG decided by a majority vote that it should be given lower priority.[110]

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[108] ASTRO(76)11, cit., p. 2.

[109] ASTRO(76)10, cit., p. 5.

[110] ASTRO(76)9 and ASTRO(76)11, cit.

The SAC recommendation

On 2 July 1976, the SAC was called to discuss the recommendations of the SSWG and AWG and to issue the final recommendation on ESA's future scientific programme.[111] Two main questions were on the table. Firstly, the Committee had to assess the scientific merit of the projects which had been recommended by the Working Groups, namely the OOE, ST and LIRTS. Secondly, it had to assign a relative priority among them. On the former, the conclusions of the SSWG and AWG were fully endorsed by the SAC. On the latter, it could only agree that no priority could be assigned on scientific grounds.

The SAC considered the OOE, LIRTS and ST as "three outstanding projects", each of which could be submitted to ESA's decision-making bodies for possible adoption in the Agency's programme. Regarding the OOE mission, the SAC recognised that the two-spacecraft version offered "distinct scientific advantages." It recommended that the mission be approved and that ESA enter immediately into negotiations with NASA "with a view to determining a basis for collaboration so that an Announcement of Opportunity can be issued early in 1977." The SAC also endorsed the AWG's conclusion regarding the LIRTS, recommending that phase B studies be started immediately and that the mirror be ordered as soon as possible even if (for financial or other reasons) developments had to be slowed down.[112]

As to the ST, the SAC stressed that "all members of the SAC and Working Groups seem convinced that the ST is indeed the most outstanding and important project in space astronomy planned for the next decade; and we have no doubt that this view is widely echoed in the European scientific community." Against those who argued that personal contacts with American astronomers might be sufficient to ensure access to the ST, the Committee claimed that ESA should have a formal stake in the project.

> Guest-observer status may indeed prove adequate and satisfactory for some favoured individuals whose links with United States groups are

[111] SAC, 3rd meeting (2/7/76), SAC(76)11, 27/8/76. The minutes do not report on the discussions on this item of the agenda. A summary of the final recommendations is reported in SAC(76)10, 27/7/76, and a fuller report is in SAC(76)12, 1/9/76. Both documents are attached to SPC(76)25, cit.

> unusually close. But the SAC does *not* believe that the broad European astronomical community (with whose interest it should primarily concern itself) will have any real chance of fair and adequate accees, particularly during the early years of the ST's operation, *unless* ESA formally participates and, in return, gets a guaranteed share of observing time and participation in the proposed "ST Institute". Moreover, European groups certainly cannot, by mere "hitch-hiking", participate seriously in the definition and provision of ST instruments. We therefore regard the case for formal participation as a very strong one.[113]

The SAC supported the draft Memorandum of Understanding under discussion between ESA and NASA and, incidentally, recalled that even 15 % of the observing time would be invaluable to Europe, this amount exceeding, in terms of hours per year, "the *entire* clear dark time on a ground-based telescope."

Alongside the support to the three major projects, the SAC also expressed its opinion on the others whose Phase A studies were available. It concurred with the AWG in considering EXPOS "an instrument of high scientific value for X-ray astronomy [...] the logical step to aim at in the Shuttle era." Two elements, however, spoke against such a Spacelab facility when compared to the LIRTS. Firstly, the likelihood that the latter would obtain more data during Spacelab flights of limited duration; secondly, "the desirability of ensuring opportunities within ESA for infrared astronomers." As a consequence, the SAC recommended that only a minor effort should be devoted to study instrumentation for spectro-polarimetry suitable for use on Spacelab.[114]

Regarding the sub-satellites for AMPS studies, the SAC recognised that interesting experiments could be performed by such facilities. The feasibility study, however, had revealed a much higher cost for the various options than had been hoped for. Moreover, several technical aspects deserved more study, in particular regarding tethered satellites and the operational aspects of sub-satellite retrieval.

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112 SAC(76)12, cit., pp. 1 and 4; SAC(76)10, cit., p. 1.

113 SAC(76)12, cit., pp. 1-2 (emphasis in the original).

114 SAC(76)12, p. 6.

Finally, the SAC discussed the controversial question of the Lidar. This facility was strongly supported by SAC member G. Colombo, who emphasized the measurement accuracy which could be reached by laser techniques for geophysical studies. The other members did not concur, however. When assessed in comparison with other Spacelab facilities such as the LIRTS and EXPOS, the scientific case for the Lidar appeared much less definite, W. Axford argued, while R. Bonnet stated that the discussions at the recent scientific symposium had shown that better science could be done with passive techniques on board Spacelab. Concluding the discussion, chairman M. Rees stated that, in previous meetings, the SAC had assessed the Lidar outside of a competitive framework. Now the Committee had more information, both about the other opportunities that could be provided on Spacelab and about the kind of science that could be done on the FSLP. The conclusion, expressed in a diplomatic tone, definitely reversed the SAC's previous opinion:

> From this and from the scientific presentations made at the June symposium on the Lidar and the passive sounding techniques, the Lidar seemed to have a more negative position than it had at the last meeting when the SAC had recommended the funding of the Lidar for the FSLP from the mandatory scientific budget.[115]

Later in July, the SPC agreed to cancel the Lidar from the FSLP and asked the Executive to study in place of it the feasibility of a stabilized platform for passive sounding experiments (CAPS, Common Attitude Pointing System).[116]

In conclusion, the ESA scientific advisory bodies identified three outstanding projects (OOE, ST and LIRTS) among which they did not attempt to assign a relative priority on scientific grounds. Financial considerations, technical aspects, schedule constraints, and questions related to the collaboration with NASA would orient the Director General's proposals and the eventual decisions of the SPC. Before discussing these developments, however, we shall pause for a brief interlude.

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[115] SAC(76)10, cit., p. 6.

[116] SPC, 5th meeting (30/7/76), ESA/SPC/MIN/5, 30/8/76. This decision was taken against the strong opposition of the Italian delegation which supported the Lidar.

G. Colombo's dissenting opinion and the Spacelab question

The SAC's statement was not unanimous. A strong dissenting opinion was expressed by G. Colombo, an advocate of the Lidar and of tethered satellite projects. Colombo did not limit himself to conveying his ideas to the Italian delegation in the SPC but, after the latter had definitely cancelled the Lidar, he decided to circulate a written statement with a severe criticism of the whole of SAC's policy (and also ESA's). We will take advantage of this document in order to make a few considerations about the political aspects of the decisions ESA's policy-makers were about to take.[117]

Colombo's arguments started from a rather usual criticism (the "mandarin" argument), i.e. that a large number of young scientists felt "frustrated, totally neglected and unnecessarily deluded" because of ESA's scientific policy. Three main reasons were listed. Firstly, the poverty of the budget allocated to the scientific programmes, "even if it is clearly recognized that it is in these programmes that resides the most advanced technology." Secondly, the belief that more resources should be devoted to "the solution of problems more directly linked to the human environment." Finally, "the obvious fact that the programme is in reality under the control of a well established conservative group which has dictated the past ESRO activity and continues to do so with ESA." In Colombo's opinion, the negative decision on the Lidar was but "a further manifestation of the traditional conservative policy of ESRO, a further proof of the little imagination and the little courage that have characterised in the past the activity of our organization."

The core of the argument was the role of the Space Shuttle. The Shuttle, Colombo claimed, "is not an astronomical observatory but an element of the Space Transportation System." Its rationale was not to provide a platform for space telescopes but to make possible the construction of space stations where such telescopes could be installed in the future. The obvious implication was that ESA should drop all plans to develop telescope facilities for Spacelab (LIRTS, GRIST, EXSPOS) as well as its planned contribution to the Space Telescope. In the long-term, the only economic solution for astronomical observations from

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117 Colombo's document is reported in ESA/SPC(76)25, Add. 1, 13/9/76. Following quotations are from pp. 1-2.

space was the Astronomical Space Station exploiting the Shuttle servicing capability. ESA, Colombo concluded, should concentrate on studying telescope facilities suitable for such foreseeable developments. As regards the ST, he recommended a strong European participation in the ground support facilities and in the operation of the ST Science Institute. An obvious corollary, not explicitly stated here, was that the best use of Spacelab was for earth-oriented missions (i.e. looking at the "human environment"), such as those based on the Lidar facility or specialized sub-satellites.

Colombo's dissenting opinion also involved the OOE mission, which he had always opposed as a member of the SSWG. He criticized the proposed dual spacecraft mission to the Sun's poles and reiterated his proposal that one out-of-ecliptic spacecraft should be combined with a solar probe. The SSWG had discarded this option, as we have seen, expressing its preference for the dual spacecraft version. Colombo, on the contrary, recalled that several scientists participating in the June symposium had supported his proposal and argued that "such a solar probe would yield unique 'in situ' information on the origin of the solar wind and on the solar corona, would provide fundamental tests of general relativity, and would also provide a unique opportunity to obtain direct information on the Sun's interior structure."

How shall we appraise Colombo's arguments? What do they say about the policy choices the ESA decision-makers were about to make? Our answer will be based on three considerations. Firstly, we can safely dismiss the argument about the alleged conservatism and self-interest of ESA's scientific advisers. On the one hand, a certain degree of conservatism is unavoidable in all established communities, and it can also be convenient when important technical and financial aspects are at stake. On the other hand, it is usual for those whose expectations are not fulfilled to blame the "old generation" for frustrating and neglecting fresh new ideas coming from "young people". As a matter of fact, we have shown how the decision-making process for defining ESRO's and ESA's scientific programme was highly competitive and, at the same time, absolutely open. It involved the laborious development of scientific discussions at various levels (national communities, working groups, advisory committees, delegate bodies, etc.); mission definition and feasibility studies involving ESRO/ESA staff, outside scientists and industry; meetings and symposia whose proceedings were often edited and circulated; and continuous negotiations at high political level. In this process, strong interest groups and lobbies emerged and fought for success, whether for a general policy decision or the approval of a pet project. Success might be the outcome of good scientific arguments as well as of strong political influence. One can hardly claim, however, that all possible options were not carefully assessed, all opinions discussed, all controversies negotiated. The fact is that, at the end of this highly competitive process, there could only be winners and losers (sometimes by a strict majority vote); and since ESRO/ESA could only afford one major project every three or four years, the frustration of the losers was as deep as the satisfaction of the winners.

Our second consideration regards the actual result of the decision-making at this stage, with reference to the scientific fields involved. One can indeed hardly speak of conservatism. In the preceeding eight years, the ESRO/ESA scientific programme had been dominated by high energy astrophsyics (COS-B and EXOSAT) and magnetospheric physics (GEOS and ISEE-2). This tradition had been established mainly at the expense of optical astronomy (LAS and UVAS), solar physics (TD-2) and planetary science (Venus orbiter).[118] Now, the Agency was driven to direct its efforts towards infrared astronomy, a brand new discipline in astronomical space research; optical astronomy, in order to take advantage of the most ambitious space telescope ever conceived; and solar/interplanetary science, by a quite original space mission. Colombo could certainly claim that the dismissal of the solar probe as well as the earlier abandonment of planetary and cometary projects confirmed the poor status of solar physics and planetary science in ESRO/ESA's tradition. One can hardly claim, however, that following that path would have been less conservative.

Our third consideration touches what is, in our opinion, the most important of Colombo's arguments, namely the role of the Shuttle/Spacelab system in future space science activities. In Colombo's view, the future of space astronomy lay in manned space stations while automatic satellites and Spacelab facilities would mainly be directed towards the earth and its near environment. The Shuttle was the transportation system for the new era: it would be a low-cost device to put satellites in near earth orbits, it would make the building of space stations

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118 Russo (1992b), (1993a) and (1993b).

possible, and it would enable experimenters to work in space in a shirt–sleeves environment. With hindsight, one can consider this view as highly optimistic; no less optimistic however was the idea of flying the LIRTS once or twice a year for several years by 28–day long Shuttle/Spacelab missions, or planning a 5 to 10–year programme of flights of the AMPS payload. In other words, in order to be an effective research facility as was hoped for, Spacelab would have to perform as a space station, the difference being that the former would re–fly every one or two months with different configurations and payloads while the latter could continuously orbit around the Earth.

Here is the deep ambiguity of the Spacelab programme. ESRO/ESA's policy–makers had embarked on the undertaking for essentially political reasons. On the one hand, Spacelab was a key element of the second package deal which had made the birth of the new European Space Agency actually possible. On the other, it was Europe's only ticket to enter the American Space Shuttle programme. Alongside its political importance, the Spacelab programme was also of great technological interest, as for the first time it posed to ESRO/ESA and the European industry the challenge of manned space flight. The perspective, however, was much hazier when considered from the point of view of the utilization of Spacelab. Most scientists, as we know, did not like it and did not miss the opportunity to stress that manned flights should not jeopardize the use of automatic spacecraft in space research. Regarding applications, the use of Spacelab could only make sense in the perspective of future large space stations, a very uncertain future indeed. With the obvious exception of Germany and in part France, ESRO member states were very reluctant to commit themselves to invest resources in Spacelab utilization. In a sense, however optimistic some ESRO planners were regarding the Shuttle/Spacelab system, Spacelab appeared similar to the original ELDO rocket: a technical facility in search of meaningful use and adequate funding.

The optimistic vision of Spacelab performance had driven ESRO's scientific advisory bodies to discard CIRES and LOGOS in favour of LIRTS and EXSPOS, and the astrometry and cometary missions in favour of AMPS and GRIST. In conclusion, it was not a conservative approach which affected the choices of ESRO's and ESA's scientific advisory bodies in 1974–76 but, on the one hand, the American vision that the Shuttle/Spacelab system would be the main and most profitable facility available for every space research discipline in the 1980s and, on the other hand, the European vision that they would have a high status in the ESA/NASA relationship as regards the exploitation of the facility. Some doubts existed in the scientific community regarding both visions. The political importance of Spacelab, and the hopes that the Shuttle and Spacelab would be in the 1980s what the Saturn launcher and the Apollo spaceship had been in the 1960s overcame these doubts and shaped ESA's scientific planning by the mid 1970s.

THE APPROVAL OF THE ESA PARTICIPATION IN THE SPACE TELESCOPE PROGRAMME

In September 1976 the Director General submitted his proposal on new scientific projects to the SPC.[119] The proposal, covering the period 1977 to 1983, was supported by a detailed presentation of the financial aspects, which we have summarized in Table 11. Taking into consideration a fixed ceiling for the scientific programme of 59.7 MAU (at mid–1976 price levels, corresponding to the 1971 package deal ceiling of 27.0 MAU), and the financial requirements of ongoing programmes and in–house scientific activity, the availability of funds for new programmes increased from 3 MAU in 1977 to 53.3 MAU in 1983. The total availability in the 1977–1983 period was 221.5 MAU.

In order to elaborate his proposal, the Director General took into consideration only the three major projects recommended by the scientific advisory groups, namely ST, OOE and LIRTS. This resulted in a list of six possible combinations, each consisting of a different set of (1 to 3) projects approved. We should note that of the seven mathematically possible combinations one was not taken into consideration, namely that including the ST and LIRTS. No explanation was explicitly given for this exclusion which, however, can easily be understood. Approving the ST and LIRTS at the expense of the OOE mission, in fact, would have strongly unbalanced the ESA scientific programme towards astronomy, unduly mortifying solar system science. In other words, if two projects were to be approved, one had to be the OOE mission. In addition to these six combinations, a seventh was included which foresaw all three projects approved but with the

119 ESA/SPC(76)33, 1/9/76; ESA/SPC(76)34, 22/9/76.

development phase (Phase C/D) of the LIRTS delayed at least two years after the completion of the Phase B study.

For each of these seven combinations of the three major projects, four variants were considered, each consisting in incorporating from all to none of the three minor projects, namely the CAPS facility for the FSLP, the passenger experiment for the L02 Ariane test flight and the prolongation of COS–B.[120] The estimated development costs of each of the resulting 28 combinations were then compared with the available resources in order to ascertain which combinations were feasible from the financial point of view. The Director General's proposal eventually stemmed from the results of this exercise, supplemented by considerations on the schedule constraints and the prospects of ESA/NASA co-operative projects ST and OOE. The proposal was articulated in the following points:

a) The SPC was invited to approve at once the ESA participation in the ST project. Phase B studies would start immediately but further developments would be subject to the final approval of the project by the U.S. authorities and to the favourable conclusion of the negotiations with NASA.

b) A decision on the OOE mission could be delayed to Spring 1977, when more information would be available on the status of the project in the U.S as well as on a number of financial uncertainties regarding ongoing programmes (in particular EXOSAT). The launch window of January 1983 could still be met provided that an Announcement of Opportunity be released soon in order to allow a quick start of Phase B, should the mission be approved.

c) The LIRTS project could not be approved at this stage. A Phase B study of the project was recommended, however, because the results of this study were needed in case neither the ST nor the OOE were approved by the U.S. authorities.

d) The SPC was finally invited to approve the APEX–L02 project, endorsing the SAC recommendation that the GEOSARI mission should be selected. A

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[120] To be precise, the first variant foresaw all minor projects approved, the second only APEX–L02, the third the CAPS and the COS–B prolongation, and the fourth none.

decision on the CAPS and the COS–B prolongation could be reserved for early 1977.[121]

Before going to the SPC, the Executive's proposal was discussed by the SAC.[122] The main issue was whether the SAC endorsed its implied priorities (ST, OOE and LIRTS in sequence), in consideration of the fact that it had not assigned any relative priorities to the three major projects. In fact, the SAC reaffirmed that the ST and OOE should be assigned equal priority and "both projects [should] have equal opportunity for realisation." Such a statement was urged in particular by W.I. Axford, a long–time advocate of the OOE mission, and by the SSWG chairman, J. Geiss. In response to this concern, the Director General stated that "it was his intention to proceed with obtaining approval for both projects," and that different schedules had been suggested for the two projects only because of constraints depending on NASA's plans. As regards the LIRTS, the SAC recalled that the AWG had recommended the ST and LIRTS with equal priority. It acknowledged, however, that ESA could not commit itself beyond Phase B in view of the uncertainties about the flight costs of Spacelab and the duration and frequency of flights. Finally, the Committee stressed that the inclusion of GEOSARI on the APEX–L02 should not jeopardize the 1983 launch of the OOE mission or delay a Phase B study of the LIRTS.

In conclusion, the proposal which the Director General submitted to the SPC for approval definitely committed the Agency to the Space Telescope and the Out–of–Ecliptic mission, provided that the ESA/NASA collaboration could be successfully implemented. Its rationale essentially derived from three main elements. Firstly, financial considerations prevented the approval of all three major projects. Secondly, in spite of the uncertainties of cooperation, the realization of the ST project seemed less problematic than that of an ambitious Spacelab facility like the LIRTS (indeed, none of the many Spacelab projects originally proposed survived the screening process). Thirdly, as we have already pointed out, it was hardly possible to propose two astronomy projects, while the Space Telescope and the Out–of–Ecliptic mission would satisfy two different sectors of the space science community. The contextual approval of GEOSARI, a

121 The recommendation of the SAC, SSWG and AWG on APEX–L02 are attached to ESA/SPC(76)34, cit. On GEOSARI, see Knott (1977).

122 SAC, 4th meeting (15/9/76), SAC(76)15, 4/11/76. Following quotation from p. 6.

mission devoted to magnetospheric research, consolidated the balanced equilibrium in the scientific programme: the earth's space environment with GEOSARI, the sun and interplanetary medium with OOE, and the stars and possibly the planets with ST, were open to investigation to European space scientists in the 1980s.

The SPC was called to take its decision on 4 and 5 October 1976, three years after the decision-making process had started. The Director General's proposal was generally well received, even though some delegations expressed doubts about the financial feasibility of the three projects. It was generally agreed that the ST should have priority over the OOE mission for the time being, and all endorsed the GEOSARI mission, with the exception of the UK delegation, which feared that this might compromise a favourable decision on the OOE the following spring. Only two delegations expressed open criticism towards the proposal. One was the Italian delegation, as to be expected. They recalled Colombo's reservations on the OOE mission and his plea for environmental research, and argued that the Space Telescope did not present as much interest for Europe from the technological point of view. The other was the German delegation, which recognized the very great scientific value of the ST project but considered it relatively too costly. The German scientific community, in fact, had opted in favour of the OOE and LIRTS projects, a choice which also had the advantage of leaving some budget resources available for smaller missions to be undertaken alongside major projects.

In spite of these reservations, the Executive's proposal was eventually unanimously approved. ESA participation in the ST project was thus officially endorsed by the legislative arm of the Organization and the Director General was invited to start Phase B studies and continue negotiations with NASA in order to arrive at a Memorandum of Understanding. The funding of the GEOSARI project for the Ariane L02 test flight on the ESA scientific programme was also approved. A decision on the OOE mission was reserved for spring 1977, after consideration of an updated statement of the financial situation. Meanwhile, the Executive was authorized to continue negotiations with NASA on this mission, and eventually to issue an Announcement of Opportunity if judged necessary. A decision on the

Phase B study of the LIRTS and the prolongation of the COS–B mission was also reserved to spring 1977.[123]

Before concluding this section, a word must be said about the CAPS, for which a decision was reserved pending the conclusion of the feasibility study. The results of the study showed that its cost would be of the order of 8 MAU, i.e. twice as much as estimated. Moreover, in order to develop the CAPS in time for the FSLP, an exceptionally fast procurement procedure had to be authorized and the delivery date had to postponed by 4 to 6 months.[124] On this basis, the SSWG and the SAC recommended that the CAPS should not be included in the FSLP and the SPC eventually cancelled it.[125]

THE APPROVAL OF THE OUT–OF–ECLIPTIC MISSION

The decision on the OOE mission was the last to be taken in the selection process started in 1973. By spring 1977 the Executive had performed a thorough reassessment of the OOE and ST programme costs, concluding that it might be possible to accommodate the OOE project within the science ceiling. The Director General then proposed to approve the project, the SSWG and SAC having re–affirmed their previous positive recommendation. At the same time, he also proposed to approve the extension of the COS–B mission, while studies of the LIRTS should be continued at Phase A level.[126]

When, late in May, the SPC was called to discuss the Executive's proposal, the situation had dramatically changed owing to the failure of the GEOS mission. The satellite had been launched on 20 April from Cape Canaveral, Florida, by a Delta 2914 launcher but, because of malfunctioning of the launcher, it was impossible to put the satellite into the foreseen geostationary position. After three days of

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123 SPC, 6th meeting (4–5/10/76), ESA/SPC/MIN/6, 17/11/76. The final resolution is reported in Annex II.

124 ESA/SPC(76)46, 6/12/76.

125 SPC, 9th meeting (14/12/76), ESA/SPC/MIN/9, 24/1/76, pp. 12–13. The SSWG and SAC recommendations are in SOL(76)20, 9/12/76, and SAC(76)23, 13/12/76, respectively. Both documents are attached to ESA/SPC(76)50, 13/12/76.

126 ESA/SPC(77)12, 29/4/77. SSWG, 22nd meeting (2/3/77), SSWG(77)2, 10/5/77; SAC, 7th meeting (2/5/77), SAC(77)8, 7/7/77. At the SAC meeting, G. Colombo re–affirmed his opposition to the OOE project and his statement is reported in the Annex to SAC(77)8.

intensive mission analysis, it was decided to use GEOS' apogee motor to place the satellite into a rescue orbit with an apogee of about 38,000 km and a perigee of about 2100 km. Having achieved this complex orbital manoeuvre, the experiments were switched on and some useful data could be obtained.[127] In spite of this partial rescue, however, it was clear that the original scientific objectives of the mission could not be met. The idea then emerged that the qualification model of GEOS, intended for the GEOSARI mission with Ariane in 1979, could be brought to flight standard as soon as possible, so that it could be launched around February 1978 on a Delta vehicle (GEOS-2). The idea was warmly supported by the GEOS experimenters and eventually endorsed by the SAC.[128] The main problem regarding the GEOS-2 mission was the cost of the launcher, which could not be borne by the scientific budget without jeopardizing the programme. The SPC, in the event, agreed to the accelerated refurbishment of the second GEOS flight model but excluded any provision for the launch costs. In the words of the Swiss delegation, "the effect of the accident to the GEOS launcher should be the responsibility of the Agency as a whole, and not merely of the scientific programme".[129]

In the aftermath of the failure of the GEOS launch, pending a decision on the financial aspects of the envisaged GEOS-2 mission, the SPC could not discuss the proposal the Director General had prepared for concluding the decision-making process on new scientific projects. A decision on the OOE had to be reserved for a later time, when a complete reassessment of the financial situation would be available. The SPC, however, was now requested to approve the COS-B prolongation up to end 1978, the start of experiment selection for the OOE mission, and some Phase A studies on LIRTS instruments. The SPC agreed to these decisions, that on the LIRTS being approved by a majority vote.[130]

An updated version of the Director General's proposal was prepared in October, to be submitted to the SPC meeting of 8 November. This document

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127 ESA/SPC(7)13, 16/5/77; GEOS (1977).

128 SAC, 7th meeting (2/5/77), SAC(77)8, 7/7/77.

129 SPC, 11th meeting (27/5/77), ESA/SPC/MIN/11, 18/7/77, p. 4.

130 ESA/SPC/MIN/11, cit., pp. 7-8. The proposal on the LIRTS was approved by 5 votes in favour (B, F, S, CH, UK), to 2 votes against (I, SP) and 4 abstentions (DK, FRG, IRL, NL). The case for the COS-B mission extension was presented in ESA/SPC(77)12, Add. 2, 6/5/77.

presented an exercise similar to that performed one year earlier, i.e. the estimated costs of the approved programmes and in-house scientific activity in the period 1977–1983 were compared with the available budgets, in order to demonstrate the financial feasibility of both the GEOS-2 and OOE missions. The former would be launched in 1978 by a Delta rocket, the latter in 1983 as foreseen. The feasibility of this programme rested on two important conditions regarding the funding of the GEOS-2 mission, namely: (a) that the Council agreed that the 3 MAU savings in the 1977 budget might be used as a contribution to the cost of the launcher, and (b) that NASA accepted an *ad hoc* payment schedule which would deviate substantially from that normally used for reimbursable launches. Under these conditions, the cost of the GEOS-2 mission could be covered by the Science Programme budget.[131]

The discussion in the SPC on the Director General's proposal was animated by the opposition of the Belgian and French delegations, both arguing that the combination of OOE and GEOS-2 would lead to severe budgetary difficulties. The former claimed that GEOS-2 was a new programme whose scientific merit still had to be assessed in the light of the limited resources of the scientific budget. Arguing that most of the groups involved in GEOS would also participate in OOE, the Belgian delegation proposed that the SPC should take an immediate decision in favour of OOE, "which seemed to be a well constituted and appealing new mission," and ask the scientific advisory groups and the Executive to put forward a list of other new projects instead of GEOS-2. The French, on the contrary, suggested that only the latter should be approved while a decision on OOE should be delayed until new information was available in mid-1978. These arguments were strongly opposed by other delegations. The German delegation was particularly sanguine in defending the OOE, any delay in which would be, in its opinion, "absolutely unacceptable." The Swedish and the Swiss delegations, for their part, strongly contested the idea that GEOS-2 should be regarded as a new programme, the former arguing that its cost should be considered as an insurance matter, the latter recalling that "the general scientific community in the member states had sacrified important funds for developing the experiments in GEOS."[132]

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131 ESA/SPC(77)30, 18/10/77, with add. 1, 7/11/77. See also ESA/C(77)66, 19/7/77. The cost of the launcher was estimated at $ 17.4 million, equivalent to 15.4 MAU.

132 SPC, 14th meeting (8/11/77), ESA/SPC/MIN/14, 6/12/77, p. 6, and Add. 1, 11/1/78.

Scientific and financial aspects as well as personal interests were at stake in this discussion. Several national delegates, in fact, were scientists directly involved, or whose institutes were involved, in GEOS experiments: Denmark's B. Peters, Germany's K. Pinkau, Sweden's B. Hultqvist and Switzerland's J. Geiss, the latter also being the chairman of the SSWG. And the Belgians were not wrong when foreseeing that they would presumably be involved in the OOE mission as well.

The real reason for this nervous discussion was the controversial issue of the launcher for EXOSAT. Let us step back one year. In late 1976, the Executive had suggested that EXOSAT might be launched by Ariane instead of the foreseen Delta 2914 rocket. The Council accepted this suggestion and the Executive had eventually studied the technical and financial implications of the Ariane option.[133] When, in June 1977, the SPC was called to give its advice, several delegations criticized the Executive's proposal, both on technical grounds and because it required an 11 MAU increase in the EXOSAT programme. In the event, "as a gesture of solidarity" in consideration of the political importance of promoting the use of Ariane for launching European scientific satellites, the SPC approved a resolution, with the German, Italian and U.K. delegations voting against, which stated that the Ariane solution could be accepted, provided that no more than 4 MAU should be debited to the scientific programme. This figure corresponded to the cost of adaptation of the spacecraft and its payload to the new launcher, the remaining 7 MAU being the cost difference between Ariane and Delta launching.[134] In early July, the Council finally approved the Ariane solution, the Italian and U.K. delegations reiterating their negative vote, but it could not find an agreement on the attribution of the additional cost. Opinions were divided, in fact, about whether this should be covered with a GNP-based contributions scale, as advocated by a majority of delegations including France, Belgium and the Netherlands, or in accordance with the contribution scale of the Ariane production

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133 ESA/C(76)88, 20/9/76; ESA/C(76)129, 9/12/76. Council, 13th meeting (16-17/12/76), ESA/C/MIN/13, 8/2/77. The Executive's study is reported in ESA/C(77)49, 15/6/77, also attached to ESA/SPC(77)20, 15/6/77.

134 SPC, 12th (extraordinary) meeting (28/6/77), ESA/SPC/MIN/12, 8/8/77, and ESA/SPC/XII/Res. 1, 29/6/77. The German delegation said it would be able to accept the Ariane launcher provided that no charge was made to the science programme budget. The Italian and U.K. delegations said that they would only be able to accept it if this resulted in a payment to the science programme budget.

programme, as proposed in particular by Germany and Italy. As a consequence, the question of funding the GEOS-2 mission also remained pending, as France opposed the allocation of the 3 MAU 1977 savings as a contribution to this mission. The whole matter then re-emerged at the SPC meeting we were discussing above.[135]

According to the French delegation, both the cost of the GEOS-2 launcher, and the extra costs incurred for adaption of EXOSAT to Ariane, should be imputed to the scientific budget. The German delegation strongly disagreed, recalling that "the Scientific programme had made a sacrifice by making available 4 MAU for adaptation of the EXOSAT satellite for launch on Ariane [...] If this contribution of 4 MAU was insufficient, then the decision to adapt EXOSAT should be reconsidered, but the decision on GEOS-2 and OOE should not be subjected to uncertainties resulting from the EXOSAT/Ariane situation." No less sanguine was the Swedish delegation: "It did not oppose the use of Ariane, it was opposed to these costs, which were associated with the developments of a launcher for future commercial projects, being an extra burden for the scientific programme." In the event, a vote was called on a resolution which endorsed the Executive's proposal to approve the GEOS-2 and OOE and, at the same time, reaffirmed that the scientific budget would not contribute more than 4 MAU towards the costs related to launching EXOSAT on Ariane. The resolution was adopted by 5 votes in favour (Denmark, Germany, Netherlands, Sweden and Switzerland), 2 votes *ad referendum* (Italy and United Kingdom) and 3 abstentions (Belgium, France and Spain).[136] One month later, and after many negotiations, the Council finally agreed to de-couple the question of EXOSAT/Ariane funding from the GEOS-2 mission and approved the financial arrangements for the launch of the latter as suggested in the Director General's proposal. The OOE and GEOS-2 missions were thus finally adopted in the ESA programme alongside the Space Telescope. The EXOSAT/Ariane funding remained pending but the Council agreed that the Scientific Programme should

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135 Council, 18th meeting (30/6-1/7/77), ESA/C/MIN/18, 18/7/77, and add. 3, 19/9/77; 19th meeting (26-27/7/77), ESA/C/MIN/19, 3/8/77; 20th meeting (3-4/10/77), ESA/C/MIN/20, 17/10/77. See also ESA/C/(77)79, 19/8/77.

136 ESA/SPC/MIN/14, cit., pp. 5 and 7, and ESA/SPC/XIV/Res. 1, 8/11/77.

not contribute more than 4 MAU for the adaptation of EXOSAT for launch on Ariane.[137]

EPILOGUE

By the end of 1977 the decision-making process for the choice of ESA's new scientific projects came to a conclusion. This process had started in June 1973, its final goal being to select one or two space missions from which interesting results could be obtained in the first half of the 1980s. ESRO's and ESA's scientific advisory bodies had to guide this process taking into account, on the one hand, the rigid financial constraints imposed on the scientific budget and, on the other, the expectations of their large, variegated and often conflictual scientific constituency. Their discussions were affected by ESRO's scientific heritage as well as by the lure of new research fields and revolutionary technical facilities; their planning also reflected a characteristic ambivalent feeling *vis-à-vis* NASA, the need for cooperation always being balanced by the determination to remain independent.

More than four years after the LPAC's first discussion, the process ended with the final adoption of the Space Telescope project and the Out-of-Ecliptic mission, the former eventually called Hubble Space Telescope, in honour of the American astronomer Edwin P. Hubble, and the latter being renamed, after a suggestion from NASA, International Solar Polar Mission (ISPM). ESA's participation in both projects was subjected to their approval by the United States authorities and to a favourable outcome of negotiations with NASA. Both missions depended on the successful development of the Space Shuttle programme. In fact, as regards the political conditions, things soon turned out favourably. The Space Telescope was finally approved by the U.S. Congress in July 1977 and the Memorandum of Understanding (MOU) between ESA and NASA was signed in October that year.[138] In the course of 1978 the political framework of the ISPM mission was also settled: in February, following a joint ESA/NASA selection process, the scientific payloads were selected for the two

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[137] Council, 22 meeting (12-14/12/77), ESA/C/MIN/22, 4/1/78, with attached ESA/C/XXII/Res. 6, and Res. 7. See also ESA/C(77)103, 17/11/77, and add. 1, 24/11/77.

[138] Smith (1989), pp.175-186; Laurance (1990).

spacecraft; in September, after harsh congressional debates and an intense lobbying effort, the mission was finally approved by the U.S. authorities. The MOU between the two agencies was formally signed by ESA's Director General and the NASA Administrator in March 1979.[139]

This was not the end of the story, however, at either the technical or the political level. In 1980, in fact, as a result of difficulties with the development of the Space Shuttle, NASA announced a delay of two years in the ISPM launch. At the same time, also because of budgetary limitations, it became evident that NASA would not be able to maintain the first launch date of the Space Telescope in December 1983. This was bad news, in particular for the ISPM whose scientific objectives could be achieved at their best if the two spacecraft were launched, as planned, during the very restricted window in early February 1983. As work on the ESA spacecraft was already well advanced, it was agreed to continue with its development and integration up to completion and then to store the spacecraft until the new launch date.[140]

The following year was much more frustrating. NASA announced that it would not continue with development of its ISPM spacecraft and delayed the launch of the ESA spacecraft by another year. The announcement was completely unexpected and was strongly contested by ESA. In fact, as a result of NASA's unilateral decision, the concept of a two–spacecraft mission was destroyed and the fulfillment of the mission's scientific objectives severely impaired. Apart from the impossibility of performing stereoscopic and imaging observations, only possible from the NASA spacecraft, about one half of the instruments to be flown on the mission would not be used, and about 80 U.S. and European investigators were eliminated right away from the project.[141]

Strong political and diplomatic actions were undertaken by the ESA Executive as well as by member state representatives, in order to reverse the NASA decision. These, however, came to nothing and therefore, partly in view of the large expenditure already incurred on ISPM in Europe, it was agreed that ESA should proceed with a single spacecraft mission, eventually renamed Ulysses. A "build–

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139 Hufbauer (1993); Wenzel & Eaton (1980).

140 Wenzel & Eaton (1990).

141 Bonnet & Manno (1994).

and–store" philosophy was adopted, i.e. the project would be developed according to the previously defined schedule until the completion of the flight acceptance testing by mid–1983. The flight spacecraft would then be placed into storage until late 1985 when it would be recommissioned for launch on the Space Shuttle Challenger in May 1986. The tragic disaster of 28 January that year, when Challenger exploded soon after lift–off killing its crew, abruptly terminated the final testing and preparation for launch that Ulysses was undergoing at Kennedy Space Center, Florida. Pending the re–establishing of the Space Shuttle programme, the spacecraft was brought back to Europe and placed into storage for the second time. It was finally launched by the Shuttle Discovery on 6 October 1990.[142]

The Challenger disaster also affected the launch schedule of the Hubble Space Telescope. Owing to a series of financial and technical difficulties, the original launch date of December 1983 had been put back several times, resulting in a three–year delay overall. Finally, Hubble was being prepared for a launch in October 1986 when the Challenger disaster occurred. This caused a further delay of about three and half years. The Telescope was finally launched by the Shuttle Discovery on 24 April 1990 and successfully deployed from the Orbiter cargo bay the following day.[143]

In the light of the history we have been analysing here, it is extremely significant that when Ulysses and Hubble started their challenging scientific missions, two other ESA spacecraft were already performing their task in the sky: the cometary probe Giotto and the astrometry satellite Hipparcos. Our patient reader will certainly recall that both a cometary and an astrometry mission had been discussed by the SSWG in 1973 and discarded by the LPAC. Both missions survived however at study level and were eventually selected in 1980, at the end of a new round of feasibility studies and decision–making. Giotto and Hipparcos were pure ESA projects and both were launched by the ESA launcher Ariane, the former in 1985 and the latter in 1989. In March 1986, while Ulysses was being placed into storage after the Challenger disaster, Giotto heralded its successful historic encounter with the comet Halley. Most instruments survived the dramatic

142 Wenzel & Eaton (1990).

143 Laurance (1980).

impact with the comet atmosphere and the spacecraft was then targeted to a new encounter with the comet Grigg–Skjellerup in July 1992. It is worth recalling that Giotto, like Ulysses, had originally been conceived as the ESA contribution to a joint ESA/NASA cometary mission to be launched on the Space Shuttle. At the end of 1979, however, with the cost of the shuttle programme soaring, the American cometary project was cancelled. Annoyed by this betrayal of their expectations, the European scientists already involved in the joint project proposed that ESA should adopt the Halley mission in its own programme. They also suggested that the spacecraft could be launched by Ariane, which in December of that year had successfully performed its first test launch. Their lobbying succeeded in having the project approved and accommodated in the budget together with Hipparcos.[144]

As we see, very little survived in the early 1990s of the ambitious plans for scientific cooperation which ESA and NASA had been discussing about fifteen years earlier. Nor had the expectations regarding Spacelab been met. The first launch of the European-built laboratory took place on 28 November 1983 with the Shuttle Columbia on the 9th Shuttle flight. This 10–day mission was mainly devoted to verification test objectives but it also carried many experiment facilities from both European and U.S. scientists.[145] By this time, the ambitious flight schedule planned three years before was being drastically retrenched. In September 1980, in fact, the Space Transportation Systems Operations Office had forecast two Spacelab missions in 1983, three in 1984, and two each year beyond that time, with occasional isolated pallet opportunities in between. By June 1984, only one mission had been performed and nine were scheduled: four in 1985, one in 1986 and 1987, and three in 1988. Moreover, several discipline–oriented Shuttle missions carrying Spacelab pallet elements were planned in the same period.[146] In the event, after the 1983 mission only three other Spacelab missions were launched, all in 1985, the last one being the all–German project D–1 sponsored by the Germany Ministry of Research and Technology. The Spacelab 2 mission carried the 1265–kg Instrument Pointing System (IPS), developed in

[144] Calder (1992); Logsdon (1989); Russo (1994).

[145] Bolton *et al.* (1984); Knott (1984); Shapland & Rycroft (1984), pp. 117–152; Lord (1987), pp. 343–364.

[146] Lord (1987), pp. 364–365; Shapland & Rycroft (1984), pp. 153–165.

Europe as part of the Spacelab Programme and provided as a service for Spacelab users.[147] None of these missions carried a joint ESA/NASA payload, and barely a handful of European principal investigators could hitch-hike on the two NASA missions. Indeed, as anticipated by many scientists, Spacelab was a very poor deal for European space science. Spacelab was not a good deal for European space industry either. NASA, in fact, purchased only one additional facility, barely complying with the requirements of the MOU. Indeed the Spacelab programme was criticized in Europe as being a 1 billion dollar gift to the U.S. Space Shuttle programme, "Europe's most expensive gift to the people of the United States since the statue of Liberty," the head of the German delegation in the ESA Council remarked.[148]

In conclusion, looking back with hindsight, one can hardly avoid noting the error of perspective which affected the discussions that ESA scientific advisors and decisionmakers held in mid-1970s on the future of space science. We shall recall here the two factors which, in our opinion, contributed to this erroneous vision. The first was the highly optimistic consideration of the scientific potentialities of the Shuttle/Spacelab system. The optimism, we should point out, was less harboured by the scientific community than by the political decision-makers. Nevertheless, in the wake of the spectacular Apollo moon landings, it was genuinely felt that a new era of big science in space was opening up in the 1980s. The great versatility of the Space Shuttle and the large capacity of its cargo bay made many dreams feasible. As a matter of fact, well before the Challenger accident it became evident, firstly, that the financial and technical difficulties of the Shuttle development programme would severely harm NASA's science programmes and, secondly, that the Shuttle operation was much too expensive for this facility being used in scientific missions, the commercial and military interests being a better trade off.[149]

The second factor was the lure of ESA/NASA scientific cooperation. Both space agencies needed this cooperation, as a consequence of the budgetary limitations of the seventies. In 1974, the U.S. Congress stated that collaboration

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147 Sahm & Jansen (1985); Heusmann & Wolf (1985); Lord (1987), pp. 374–388.

148 W. Finke, quoted in McCurdy (1990), p. 102. See also Lord (1987), p. 396; Gibson (1992), p. 42.

149 Nature (1979) and (1982). See also Logsdon (1986).

with ESA was a *sine qua non* for it eventually to approve NASA's Space Telescope. And ESA scientific advisory bodies could hardly design ambitious scientific missions which could dispense with NASA participation. However, in spite of the good scientific and technical relations established in that period, too many differences existed between the two agencies as regards their institutional and political framework. The difference in the budget procedures was the most striking one. Decision-making could be very long for ESA, as we have seen, because of its multinational constituency, but once a project had been approved its financial allocations were also approved in terms of a certain cost-to-completion. In a way, provided no cost escalation occurred, the project became legally binding for member states and there was no threat of cancellation. NASA, on the contrary, was a national agency whose overall programme and budget had to be yearly negotiated with the Federal Government and Congress. Funds could always be shifted from one programme to another on the basis of political considerations, congressional lobbying or national security priorities.

The case of the joint ISPM (former OOE) mission is particularly revealing. The ESA/NASA Memorandum of Understanding, in fact, included the (obvious) statement that its applicability was always subject to the availability of funds for both parties, according to their "respective funding procedures". This condition applied with near certainty to ESA, after the mission had been approved in November 1977. It was different on the U.S. side, however. Here the final go-ahead was given by the Congress in early 1978 with the inclusion of ISPM in the fiscal year 1979 budget. Two years later, as a consequence of President J. Carter's budget cuts, NASA's research budget was dramatically reduced in order to protect the escalating Space Shuttle programme, and the mission had to be delayed two years. The election of R. Reagan as Carter's successor brought about fundamental changes in the budget process, which led to a further decrease of the space science budget and, ultimately, to the unilateral cancellation of the ISPM spacecraft. Here is the comment of two protagonists of ESA's scientific history:

> The outrage and incredulity in Europe were great [...] incredulity that an international agreement would be be cancelled at all. This reflected ESA's stunned realization of the fundamental difference in attitude between the two organizations about the sanctity of a Memorandum of Understanding. In Europe [...] the MOU was considered as legally

> binding on its Member States, while it became painfully clear that this was not the case for the U.S. Administration.[150]

This was a severe lessons for ESA policymakers, which deeply affected future relations with their American counterparts: "Europe would no longer accept being considered a subordinate participant."[151]

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150 Bonnet & Manno (1994), p. 102.

151 *Ibidem*, p. 106.

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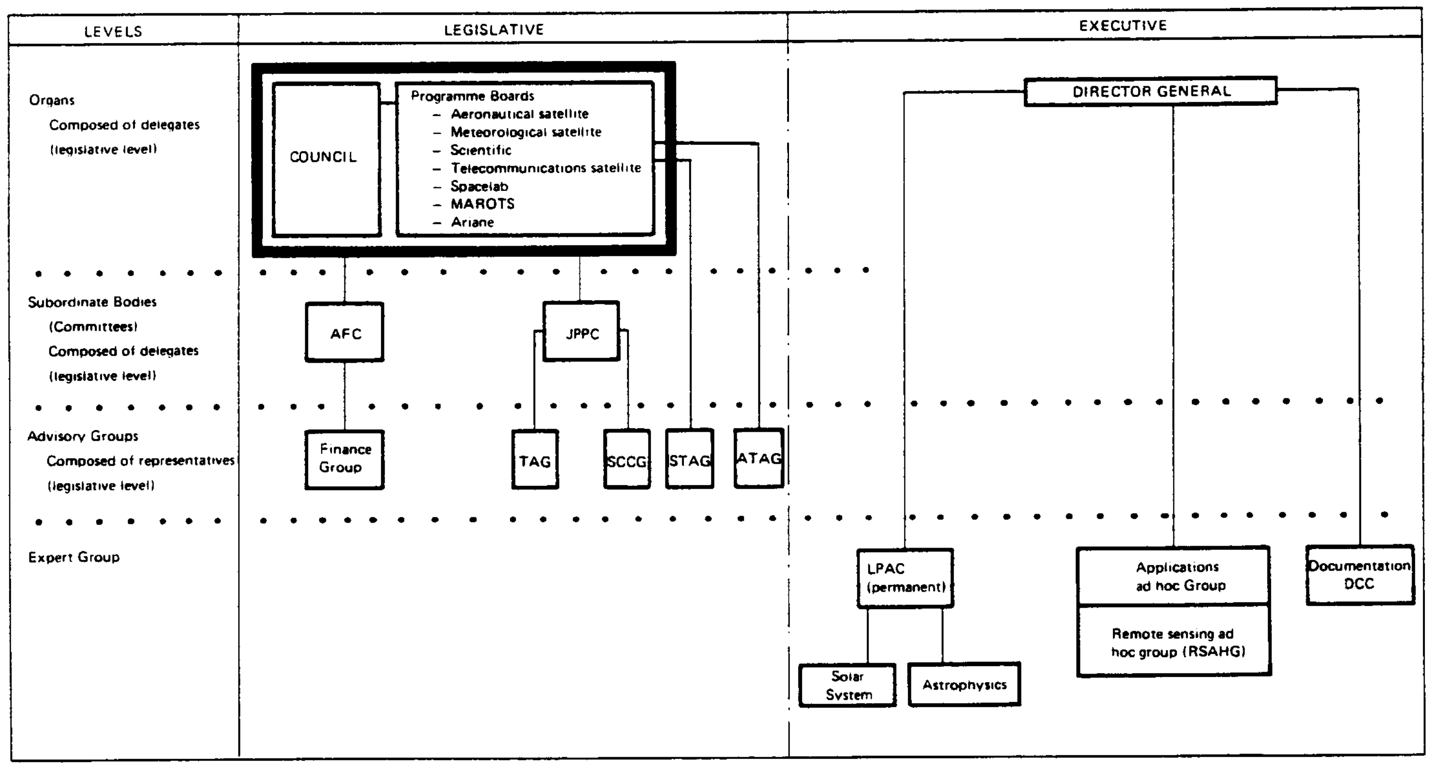
Tables and Figures

TABLE 1

ESRO's committee structure in 1973



The AFC (Administrative and Finance Committee) and JPPC (Joint Programmes and Policy Committee) were subordinate bodies of the Council. The JPPC was advised on technical matters by the Technology Advisory Group (TAG, formerly ARAC) and the Space Components Co-ordination Group (SCCG). The STAG (Science and Technology Advisory Group) and the ATAG (Aeronautical Technical Advisory Group) advised the Meteorological and the the Aeronautical Programme Boards, respectively.

TABLE 2

The Launching Programme Advisory Committee (1973 - 1975)

	February 1973 - October 1974	November 1974 - May 1975
Restricted membership	H.C. van de Hulst, *Sterrewacht te Leiden (chair)* H. Elliot, *Imperial College, London* (up to May 1974) G. Haerendel, *Max-Planck-Institut, Garching* G. Pizzella, *Lab. Plasma Spazio, Frascati* J.L. Steinberg, *Observatoire de Paris, Meudon*	H.C. van de Hulst, *Sterrewacht te Leiden (chair)* L. Houziaux, *Université de Mons* (since February 1975) G. Pizzella, *Università di Lecce* M.J. Rees, *Cambridge University* J.L. Steinberg, *Observatoire de Paris, Meudon*
Astrophysics Working Group	C. de Jager, *Sterrekundig Instituut, Utrecht (chair)* L. Scarsi, *Università di Palermo (deputy)*	C. de Jager, *Sterrekundig Instituut, Utrecht (chair)* L. Scarsi, *Università di Palermo (deputy)*
Solar System Working Group	A. Dollfus, *Observatoire de Paris, Meudon (chair)* C. Fälthammar, *R. Inst. Technology, Stockholm (dep.)*	A. Dollfus, *Observatoire de Paris, Meudon (chair)* C. Fälthammar, *R. Inst. Technology, Stockholm (dep.)*
Life Sciences Working Group		H. Bjurstedt, *Karolinska Institutet, Stockholm (chair)* H. Bücker, *Arb. Biophys. Raumfors., Frankfurt (deputy)*

TABLE 3

Priority areas selected by the Solar System Working Group (December 1973)

Research fields	Proposed missions	Remarks
Solar physics	Cluster of 4 telescopes on board Spacelab, with broad spectral resolution (visible to X rays) and high resolution	ESRO should build one of the 4 telescopes
Solar/Interplanetary physics	Out–of–ecliptic spacecraft plus near earth spacecraft for solar wind studies and stereoscopic observations of the sun	Deep space tracking network required. High launch cost
Solar system astronomy	Telescope on shuttle–visited spacecraft dedicated to observations of planets, comets and asteroids	Could be independent European project
Astrometry	Astrometry instruments carried in Spacelab or satellite	Could be independent European project
Solar system exploration	Spacecraft missions to Mercury, Venus or Jupiter; cometary missions (Encke, Halley); Mars surface rover	Collaboration necessary
Magnetospheric research	Plasma physics experiments in Spacelab	Possible coordination of magnetospheric, ionospheric and atmospheric experiments in Spacelab
Ionospheric research	Experimental ionospheric physics in Spacelab	
Atmospheric research	Active sounding (in particular by laser), passive remote sensing and mass spectrometry in Spacelab	

TABLE 4

Proposals for future missions recommended by the Astrophysics Working Group (December 1973)

Research fields	Proposed missions or payloads	Marking	Remarks
Infrared astronomy	Satellite–borne telescope for IR background and sky survey	12/14	
	Large IR telescope in Spacelab	13/14	
	IR interferometer for high resolution studies on board Spacelab	–	At a later date
Ultraviolet astronomy	1–meter stellar spectrophotometer on board Spacelab	9/14	
X–ray astronomy	Low energy (< 0.3 keV) sky survey satellite	8/14	
	Spacelab instrument for spectroscopy and polarimetry in the 0.5–8 keV energy range	11/14	Early SL mission to correlate with EXOSAT
Gamma–ray astronomy	Low energy gamma–ray satellite	11/14	
Cosmic rays	Isotopic composition at energies between 2 and 15 GeV/n	–	Requiring further studies
Solar physics	European Space Solar Observatory	7/14	
	High resolution telescope on board Spacelab	5/14	
	X–ray telescope on board Spacelab	3/14	
Fundamental physics	SOREL satellite project to test gravitation theories	3/14	Requiring further studies
	Mercury orbiter to test gravitation theories	–	Requiring further studies

TABLE 5

Missions recommended for immediate studies by the LPAC (January 1974)

Mission	Primary scientific objectives	Spacelab/free flyer
Infrared background and sky survey	Spectrum and polarization of IR radiation between 100 μm and 2 mm and sky survey of sources between 50 and 500 μm	free flyer
Large infrared telescope	Infrared exploration of stars, sun, planets and interstellar medium	spacelab
Stellar ultraviolet spectrophotometry	Exploration of stellar evolution and interstellar medium	spacelab
X–ray spectropolarimetry	Investigation of X–ray sources in the 0.5 – 8 keV energy range	spacelab
Low energy gamma–ray survey	Study of gamma–ray emissions from supernovae and galactic plane in the energy range below 10 MeV	free flyer
Solar telescope cluster	Simultaneous high resolution study of the sun in all wavelength regions	spacelab
Solar observatory	Study of the solar atmosphere with high spectral, spatial and time resolution	free flyer
Solar stereoscopic mission	Stereoscopic study of solar features	free flyer
Out–of–Ecliptic mission	Study of the solar wind, interplanetary magnetic field and the cosmic radiation	free flyer
Jupiter orbiter	Study of the plasma physics regime in the Jupiter environment	free flyer
Magnetospheric, ionospheric and atmospheric research	Dedicated Spacelab payload to study plasma physics and the coupling between the magnetosphere, ionosphere and atmosphere	spacelab

TABLE 6

Missions recommended for immediate studies by the ESRO Executive (April 1974)

Spacelab payloads in collaboration with NASA	Large infrared telescope for IR study of stars, sun, planets and interstellar medium 1–meter ultraviolet telescope for UV stellar spectroscopy Solar telescope cluster for high resolution study of the sun in all wavelengths Payload for the study of the atmosphere, magnetosphere and plasmas in space (AMPS)
Automatic satellites and space probes in collaboration with NASA	Infrared satellite for the study of the infrared background and sky survey of IR sources Out–of–Ecliptic mission for the study of the solar wind, interplanetary fields and cosmic rays Jupiter orbiter for the study of fields and plasmas in the Jupiter environment
NASA Large Space Telescope	ESRO instrument at the focal plane of the LST
ESRO payload for Spacelab	X–ray spectropolarimeter for the study of sources in the 0.5– 8 keV energy range
ESRO projects for automatic satellites and space probes	Solar probe for stereoscopic study of the Sun (in association with NASA spacecraft) Low energy gamma–ray satellite Astrometry mission (automatic satellite or Spacelab)

TABLE 7

Mission definition studies carried out in 1974

Large Infrared Telescope for Spacelab (LIRTS)

The telescope would permit observation of the planets and other celestial objects with large spatial and spectral resolution. It consisted of an ambient-temperature telescope with a diameter of 2–3 metres mounted on a stabilized platform on board Spacelab. Fitted with different focal-plane instruments (photometer, polarimeter, interferometer, heterodyne receiver), it would operate in the 30 to 1000 μm range and would have a pointing accuracy of 2 arc sec (for 1000 seconds).

Cryogenic Infrared European Telescope (CIRES)

This satellite would serve two scientific objectives: (a) to undertake a systematic exploration of the sky in the 10 to 1000 μm range and (b) to measure the spectrum and anisotropy of the diffuse background radiation. The instrument consisted of a 50 cm aperture telescope cooled to a temperature below 20 ^{0}K by means of liquid helium. The satellite, weighing approximately 300 kg, would be three-axis stabilised with a precision of about one arc min.

Low Energy Gamma-Ray Observatory (LOGOS)

The scientific aim of this space observatory was to measure the celestial diffuse background and to detect sources of line and continuum emission. The proposed payload consisted of four germanium/lithium detectors, with a total sensitive area of 120 cm^2, cooled to a temperature below 90 ^{0}K. The payload was expected to weigh 220 kg and the whole satellite 450 kg. It would be placed in either a highly eccentric or a geostationary orbit.

Focal Plane Instrumentation for the Large Space Telescope (LST)

The LST to be developed by NASA was a wide-aperture telescope (2 to 3 m) with an angular resolution of better than 0.1 arc seconds. It would be placed in low orbit and periodically visited by the Shuttle. Its lifetime would be not less than 15 years. The envisaged ESRO contribution to the project was the supply of scientific instruments mounted on the focal plane of the telescope, such as a spectrograph for faint objects and/or a high-resolution camera as well as a photon counting detector. In addition, the supply of the solar array was also envisaged.

One-Metre Ultraviolet Spacelab Telescope (MUST)

The scientific objectives of this telescope were complementary to those of the LST. It would have a very high spectral resolution and its angular resolution was about 0.5 minutes of arc. The telescope would be mounted on a stabilized platform on board Spacelab and several instruments could be accommodated on the focal plane: e.g. a high- or low-resolution spectrograph, a photometer grating and a high-resolution camera.

Cosmic-ray Astrophysics Projects

Three projects were studied in this field:

a) A Spacelab instrument including a superconducting magnet. This would permit measurement of the isotopic composition in a wide range charge composition (20 to 50 GeV per nucleon) as a function of energy and electron/positron spectra.

b) A satellite experiment designed to study the isotopic composition from nickel to neon at energies between 1 and 2 GeV per nucleon. The satellite, three-axis stabilized and weighing about 900 kg, would be placed in low orbit.

c) A satellite experiment designed to measure the charge spectrum as a function of energy, particularly at energies in excess of 100 GeV per nucleon. The satellite, spin stabilized and weighing about 350 kg, would be placed in either a highly eccentric orbit or a geostationary orbit.

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X-ray Spectropolarimetry on board Spacelab (EXSPOS)

The experiment was intended for studies of the spectra of cosmic X-ray sources and for the detection of polarized X-ray emission. It consisted of a number of Bragg crystal spectrometers operating in the 2 to 10 keV energy range, enabling the study of variable sources with good time resolution and high sensitivity.

Study of the Atmosphere, Magnetosphere and Plasmas in Space (AMPS)

NASA's AMPS programme foresaw the use of Spacelab to perform active or passive sounding of the atmosphere, to make *in-situ* measurements and, with the aid of sub-satellites, to study plasma physics by means of ion and electron accelerators, plasma generators, radio transmitters and antennae. The envisaged ESRO contribution to such a programme was a laser facility for sounding the atmosphere in the relatively unknown region between 35 and 120 km altitude. Moreover, ESRO could also build certain sub-satellites.

Solar Telescope Cluster on board Spacelab (STC)

In the framework of a dedicated solar physics Spacelab payload, including a cluster of telescopes for co-ordinated and simultaneous measurements over a wide range of wavelengths, ESRO would provide a grazing-incidence telescope for use in the X-ray region.

Pioneer Jupiter Orbiter and Probe

In the framework of NASA's Pioneer programme it was envisaged to develop a Jupiter orbiter and a probe penetrating the atmosphere of the planet. The defined mission's objectives were to investigate Jupiter's atmosphere and magnetosphere, to study Galilean satellites and to analyse the planet/satellite system from the point of view of celestial mechanics.

Out-of-Ecliptic and Solar Stereoscopic Mission (OOE)

This combined mission comprised two scientific objectives: (a) *in situ* measurement of the interplanetary environment outside the ecliptic plane; (b) observation of the Sun from a position away from the Earth/Sun line, in order to obtain a stereoscopic view of certain solar structures. Two completely different missions were studied for the achievement of these objectives:

a) A three-axis stabilized probe, injected into an orbit with a radius of one astronomic unit and bearing a set of electric thrusters powered by solar cells (solar electric propulsion, SEP) capable of gradually shifting the orbital inclination to approximately 60^0 with respect to the ecliptic by the end of three years. In this option ESRO would be responsible for the module containing the scientific instruments;

b) a set of two space probes, spin stabilized and launched towards Jupiter by a single launch vehicle. Taking advantage of the planet's gravitational pull, one of the probes would pass over the North Pole of the Sun at about 1.5 astronomical units and the other over the South Pole. In this option ESRO would be responsible for the provision of one of these spacecraft.

Interception of Comet Encke

This mission for a ballistic interception of the comet Encke in 1980 was intended to study the physical and chemical properties of the comet and its nucleus, the nature of the solar-wind/coma interactions, the dynamics of dust particles in the vicinity of the comet, and others. The fly-by velocity at the moment of meeting the comet would be around 7 km/s and the useful observation time was estimated at 30 hours at least.

Space Astrometry

Three projects for a space astrometry mission were discussed at an international symposium organized by ESRO: an automatic satellite, a telescope on board Spacelab and a focal-plane instrument for the LST. The foreseen performance would represent an improvement by a factor of 10 in the state of knowledge of positions, proper motions and trigonometric parallaxes of stars. This progress was considered of great scientific importance for a number of fields, such as astrophysics, astronomy of double stars, stellar kinematics, solar-system mechanics, geodynamics.

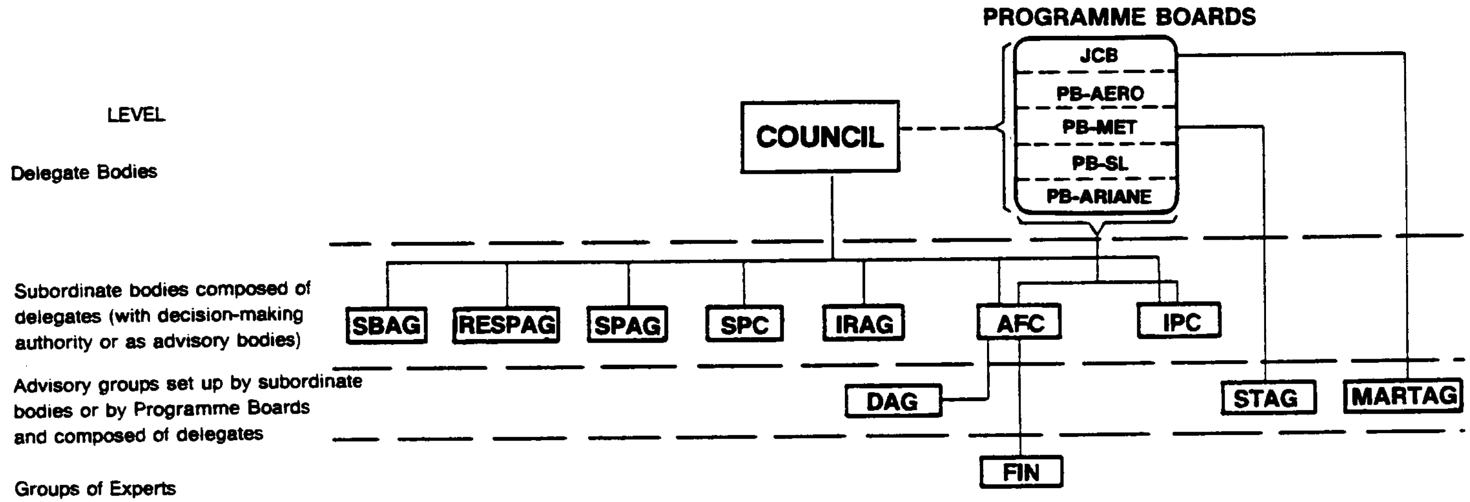
TABLE 8

ESA study programme for 1975 – 1976

	Projects	Remarks
Phase A studies of candidate projects among which a selection would be made in 1976 of ESRO's next scientific project(s) following Exosat	LIRTS	An IR telescope with a 2 to 3 m mirror and pointing accuracy of about 2 arc sec.
	LST / MUST	Further studies of the LST focal plane instrument (Faint Object Camera and photon counting detector). Depending on the LST status, either Phase B studies would be initiated or Phase A studies on MUST would be carried out.
	EXSPOS	A Spacelab instrument to study spectra and polarization of X–ray sources in the 2 to 10 keV energy range.
	AMPS	NASA's Spacelab programme for atmospheric, magnetospheric and plasma studies
	Lidar	A laser facility for active atmospheric sounding in AMPS missions
	Subsatell.	Subsatellites for use with AMPS missions
	OOE / Stereo	A medium–cost spacecraft as contribution to co–operative dual–spacecraft project. Study of implications of launching ESRO spacecraft alone.
Mission definition studies (including studies on Shuttle–independent contingency missions)	GRIST	A grazing–incidence X–ray solar telescope for Spacelab.
	Others	Astrometry mission, Infrared Diffuse Background Satellite (IRSAT), Solar Probe, Extreme UV and X–ray Satellite (EXUV), Dumb–bell mission, Sun–Earth Observatory and Climatology Satellite (SEOCS), Transient X–ray Sources Satellite.

Table 9

ESA's legislative bodies in 1976



JCB	:	Joint Board on Communication Satellites Programmes	RESPAG	:	Remote-Sensing Programme Advisory Group
PB-AERO	:	Aeronautical Satellite Programme Board	SBAG	:	Satellite Broadcasting Advisory Group
PB-MET	:	Meteorological Satellite Programme Board	SPAG	:	Spacelab Payloads Advisory Group
PB-SL	:	Spacelab Programme Board	SPC	:	Science Programme Committee
PB-ARIANE	:	Ariane Launcher Programme Board	DAG	:	Documentation Advisory Group
AFC	:	Administrative and Finance Committee	STAG	:	Scientific and Technical Advisory Group
IPC	:	Industrial Policy Committee	MARTAG	:	Maritime Technical Advisory Group
IRAG	:	International Relations Advisory Group	FIN	:	Finance Group

Note: There also exists a Programme Advisory Committee on the ESRANGE Special Project which is not included in the above structure.

TABLE 10

The Science Advisory Committee (1975–1977)

Restricted membership	M.J. Rees	*University of Cambridge (chair)*
	W.I. Axford	*Max-Planck-Inst., Lindau*
	R. Bonnet	*Lab. Phys. Stell. Planet., Verrières-le-B.*
	G. Colombo	*Università di Padova*
	L. Houziaux	*Université de Mons*
	H.S. Wolff	*Clinical Research Centre, Harrow*
AWG chair	L. Scarsi	*Università di Palermo (up to February 1976)*
	H.J. Habing	*Huygens Laboratorium, Leiden (Feb - Sept 1976)*
	G. Setti	*Università di Bologna (since October 1976)*
SSWG chair	J. Geiss	*Universität Bern*
LSWG chair	H. Bjurstedt	*Karolinska Institutet, Stockholm*

TABLE 11

Summary table of financial aspects of new projects (1977–1983)
(in MAU at mid–1976 price levels and 1977 exchange rates) *

Project	Total cost	Remarks
Space Telescope	60.1	ESA contribution until 1983. Post–1983 costs estimated at ± 20 MAU.
OOE	71.0	Complete ESA contribution until launch (1983).
LIRTS	40.3	Including launch and costs for a first 7–day mission. Following missions estimated at about 23 MAU each.
EXSPOS	25.4	Including launch and costs for a first 7–day mission. 1981. Following missions estimated at about 11 MAU.
Lidar	11.7	Including launch and costs for a first 7–day mission in 1981. Following missions estimated at about 3 MAU.
Sub–satellites	39.3	Series of 5 sub–satellites with orbit and attitude control up to 1984.
Pointing platform in first Spacelab payload (CAPS)	4.0	Development costs in the period 1977–1980.
APEX–L02	8.5 - 9.3	Development and operation costs (1977–1981) depending on option chosen.
COS–B prolongation	1.3	Operation costs (1977–1978).

* ESA/SPC(76)33, 1/9/76. The figures for APEX–L02 are from ESA/SPC(76)34, 22/9/76.

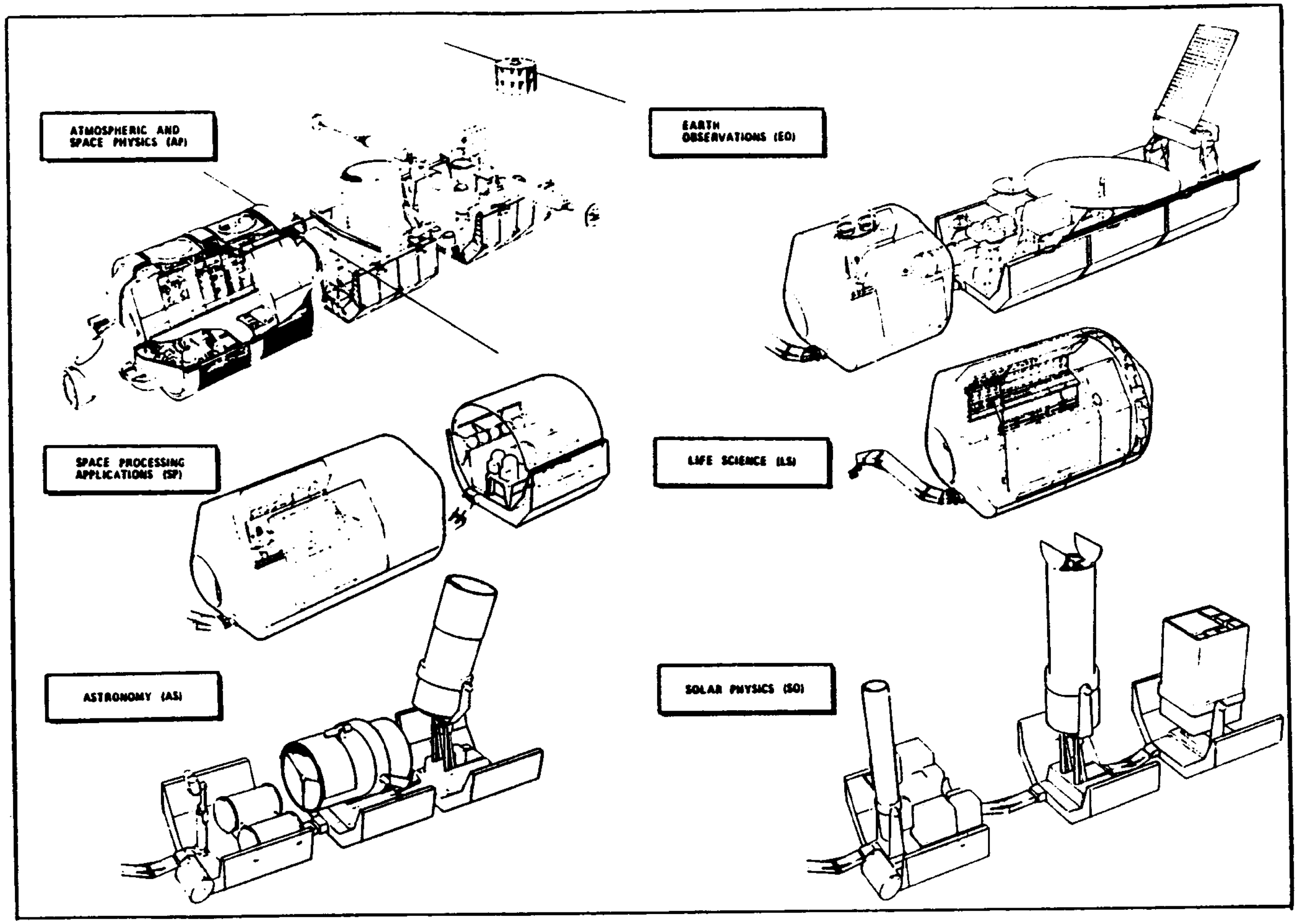


FIGURE 1

Scientific and applications areas for Spacelab utilization (*ESA Annual Report 1974*, p. 143)

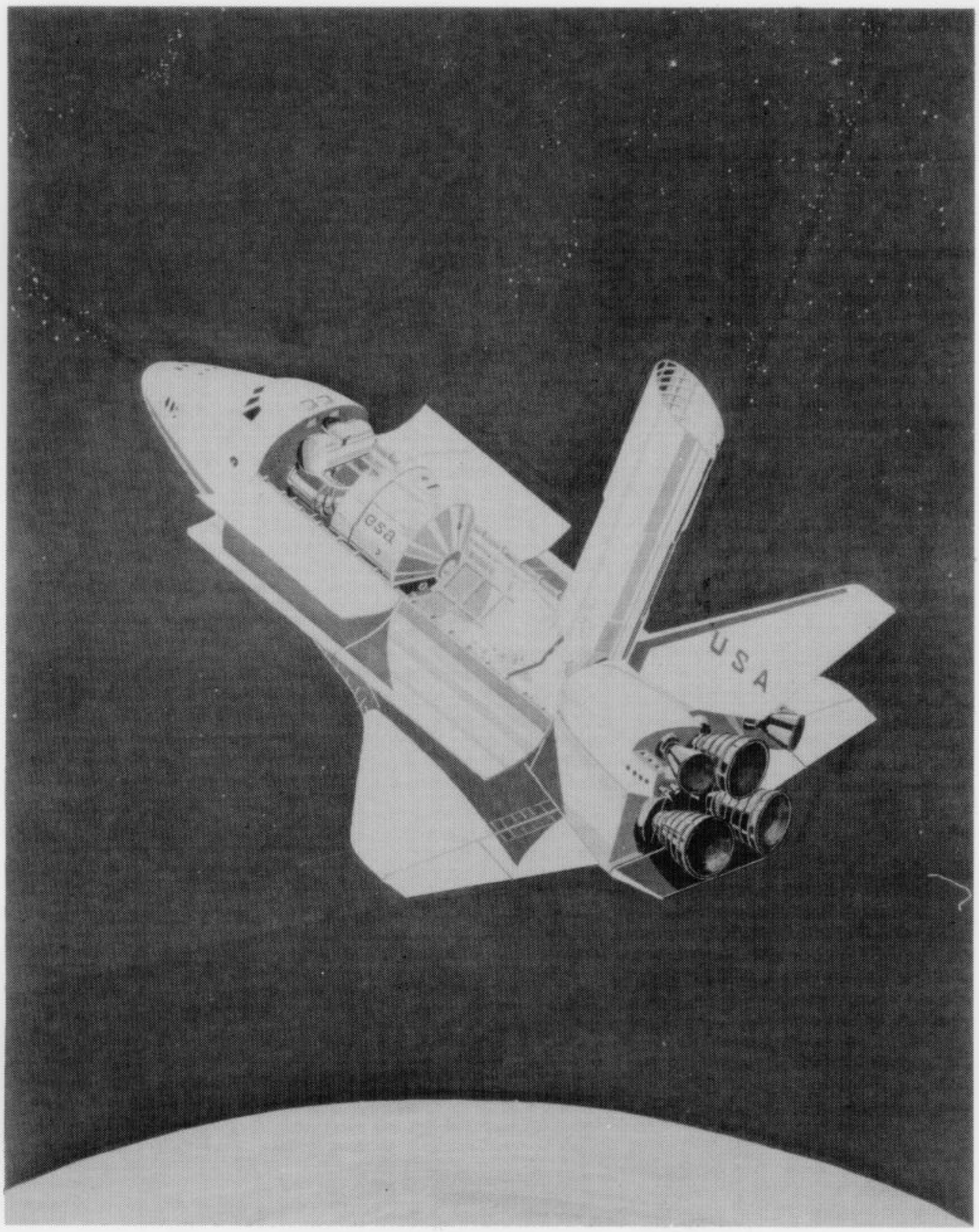


FIGURE 2

Artist's impression of the Large Infrared Telescope for Spacelab (LIRTS), in operational mode aboard the Shuttle (Beckman, 1977)

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