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by

J. Krige, A. Russo and L. Sebesta

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Chapter 4:
The Definition of ESA's Scientific Programme for the 1980s

A. Russo

Introducing the European Space Agency's Annual Report for 1975, the Chairman of the ESA Council, Wolfgang Finke, did not hide the difficulties that the newly created Agency had to face up to in the future: "If the eleven-year marriage of Europe and space under ESRO was occasionally stormy, the lusty cry of its progeny ESA after a long-anticipated and difficult birth did not signify the end of the problems". One of ESA's biggest problems, Finke wrote, was its very size – more precisely, the size of its programme and the budgetary consequences:

Deciding what to put into the greatly enlarged programme of space activities to be undertaken by the new Agency had itself been difficult, given the different priorities of the ten Member States. Working out how these activities were to be financed in the mid-1970s – a period of peak expenditure for several of the biggest programmes which had been started virtually simultaneously – was bound to be intractable.[354]

The dramatic increase of the volume of financial resources to be managed was the first aspect of the budgetary problems the new Agency had to cope with. The funds managed by ESA in 1975 amounted to 342.4 MAU, with an increase of 73.6% and 180% over ESRO's funds in 1974 (197.2 MAU) and 1973 (122.1 MAU), respectively.[355] A second aspect derived from the complexity of the optional programme structure of ESA's activities. The Agency had to manage several independent budgets, each corresponding to a different programme, supported by a specific set of Member States, with a specific contribution scale. Only two budgets were mandatory, i.e. supported by all Member States according to a gross national product (GNP) contribution scale. These were the General Budget, covering the basic and support activities, and the Science Budget, covering all scientific satellite projects and the research activities of ESTEC's Space Science Department (SSD). The other budgets covered the various optional programmes approved by the ESA Council, each of them being financed by the participating Member States according to a contribution scale mutually agreed upon. In the first phase of its life, the Agency ran six optional programmes: Telecommunications, Spacelab, Ariane, Marots, Aerosat and Meteosat.

Besides the contribution scales, another important difference existed between the science programme, on the one hand, and the optional programmes, on the other. The former consisted of a succession of individual projects within an overall financial envelope, the various projects being selected by a competitive procedure mainly based on scientific merit. Each optional programme, on the contrary, comprised one clearly specified project, mainly defined on political grounds and to be completed within an agreed fixed cost. The management of this complex budgetary structure was made more difficult by the need to comply with the so-called "fair return" principle, requiring that, for each programme, the participating Member States should receive a share of industrial contracts as far as possible equal to their financial contribution.

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354 W. Finke's "Foreword" to ESA *Annual Report 1975*, p. 4. The new Agency began to function "de facto" on 31 May 1975 but, pending formal ratification and entry into force of its Convention, the ESRO Convention remained the legal basis of its activities and programmes. ESA's first Member States were the same as ESRO's, namely Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom. By the end of 1975, Ireland had also signed the ESA Convention, but it formally became a Member State in 1980, when the Convention came into force. Meanwhile, that country was associated in the Agency's activities under the terms of a special Agreement of Cooperation and Association.

355 ESA, *Annual Report 1975*, p. 137; ESRO, *Annual Report 1974*, p. 197; ESRO, *General Report 1973*, p. 169. A further increase of 35.8% was realised in 1976, when the funds managed by ESA amounted to 465 MAU: ESA, *Annual Report 1976*, p. 164.

A complicating factor in the administration of ESA's various budgets was the peculiar economic climate in Europe in the 1970s, characterised by a high rate of inflation and large monetary fluctuations. The weighted average price increase within the Member States was 14.6% over the period mid-1974 to mid-1975, but the inflation rates were very different in the various countries, ranging from 7.1% in Germany to 24.8% in the United Kingdom.[356] The different inflation rates and the large fluctuations in the exchange rates between national currencies and ESA's Accounting Unit called for a serious revision of the Agency's financial regulations, in particular regarding the procedures for calculating financial contributions and industrial returns. Failing to reach a general agreement on this matter, in December 1977 the Council called on the International Monetary Fund (IMF) for an expert analysis of the economic and monetary situation, and asked it to provide recommendations on how to change ESA's financial system accordingly. The IMF duly prepared its report by June 1978, but the diverging interests of those Member States with strong currencies and low inflation rates and those Member States with weak currencies and high inflation rates made any substantive agreement impossible. As a consequence, the triennial level of resources for 1978-1980 could not be approved, and the mandatory budgets for 1978 and 1979 were not adopted because the required unanimous agreement was not achieved. As a consequence, mandatory activities, including the Scientific Programme, were developed by the recurrent application of the system of *provisional twelfths* approved by the Council on a provisional basis.

Return to normality was realised in 1980, when the Council decided to maintain unchanged the existing financial system, but to provide for some ad hoc compensation to take into account the most negative effects of inflation and exchange-rate variations. This compromise eased the way to the formal entry into force of the ESA Convention, which occurred after the French government deposited its instrument of ratification on 30 October that year. In February 1984, after ten years of discussions, the Council finally approved the new Financial Regulations, thus replacing a financial system whose substance went back to the first ESRO Financial Rules of November 1964.

It is against this historical background that we will discuss in this chapter the evolution of ESA's Scientific Programme in the late 1970s and early 1980s, dealing in particular with two main topics: (a) the definition of a general strategy for European space science in the 1980s; (b) the decision-making process that led to the selection of the Agency's next scientific projects: the cometary mission Giotto and the astrometry satellite Hipparcos.

4.1 Discussing a long-term strategy for ESA's scientific activities

In early 1977, the ESA Director of Planning and Future Programmes, André Lebeau, asked the Science Advisory Committee (SAC) to undertake a discussion on a long-range strategy for ESA's scientific activities.[357] At that time, the Agency's first scientific satellite, the gamma-ray observatory COS-B, was in the second year of its orbital life, providing a continuous flux of valuable data; two other satellites, GEOS and ISEE-2, both devoted to magnetospheric studies, were scheduled for launch later that year and a third one, the X-ray satellite Exosat, was under development; finally, a new run of the decision-making process had just been concluded with the decision to undertake two new projects in collaboration with NASA, the Hubble Space Telescope and the International Solar Polar Mission (ISPM).[358]

The main reason for the SAC to undertake the new long-term planning exercise, which followed that made in 1970 by the SAC's forerunner of the ESRO period, the Launching Programme Advisory

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356 ESA, *Annual Report 1975*, p. 138.

357 "Medium-term orientation of the activities of the European Space Agency (1977-1983)", ESA/EXEC(76)1; SAC, 6th meeting (28 January 1977), SAC(77)3, 22 March 1977.

358 In the event, the launch of GEOSin April 1977 failed because of malfunctioning of the Delta launcher. The second GEOSflight model was successfully launched in July 1978. The ISEE-2 satellite, launched in October 1977, was the European contribution to the ESRO/NASA International Sun-Earth Explorers mission.

Committee (LPAC), was to make a case for a substantial increase in the level of resources for the science programme, established with the 1971 "first package deal".[359] That agreement had fixed the target annual level of the mandatory science budget at 28 MAU (including 1 MAU for contingency) at mid-1971 prices, corresponding to 69 MAU at mid-1976 prices.[360] The available funds for scientific activities were lower in ESA than in NASA by a factor of ten, the SAC noted, while the number of active research groups at European universities and research institutions had kept growing steadily since the beginning of the space age. Moreover, the technical complexity and financial cost of scientific space projects had significantly increased in this period, evolving from small multidisciplinary spacecraft with an exploratory character to large dedicated missions, and new research fields had added to the traditional space sciences, in particular those related to Earth observation from space platforms.

Finally, important developments had occurred since 1971, notably the decision of ESRO/ESA Member States to build the Spacelab facility within the framework of the US Space Shuttle programme, and to undertake the construction of the heavy satellite launcher Ariane. The advent of Spacelab, on the one hand, opened up the "microgravity" space environment to experimental activity in the fields of materials science (crystal growth, tribology, fluid dynamics, surface phenomena, materials processing, etc.) and life sciences (human physiology, cellular biology, plant growth, vaccine research, etc.). On the other hand, the availability of Ariane would have the consequence that European space missions will preferably be launched by this launcher, and therefore "the ESA Scientific Programme would require a higher level of funding in order to satisfy the potential claims that would be made for its use".[361]

After some preliminary discussions, the SAC decided to hold an extraordinary meeting exclusively devoted to long-range planning of ESA's Scientific Programme. This meeting was to be carefully prepared by the SAC members, the Working Groups and the ESA Executive, in consultation with national delegations in the Science Programme Committee (SPC) and the scientific community at large.[362] The chairman of the SAC, the British astronomer Martin J. Rees, set the agenda for the discussions in an informal document he circulated in early October, following a meeting of the Committee on Space Science of the European Science Foundation (ESF) in which he had been invited to participate.[363]

Rees identified two broad classes of issues. The first included topics of specific interest of the SAC, such as the question of scientific priorities, the role of free flyers vs Spacelabs, the equilibrium between "classical" and "new" space science disciplines, the relationship between scientific and application programmes, the ways to reduce the costs of spacecraft and launches. The second regarded areas "where the ESF could usefully take the lead", i.e. the optimum feasible level of activity in European space science and the relation between the ESA programme and the national programmes. The problem, according to Rees, was to define a scientific policy tailored to Europe's needs and resources:

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359 The LPAC policy statement of June 1970 is discussed in chapter 8 of Volume 1.

360 ESA/C(76)33, rev. 3, 17 November 1976, Annex. Besides the effects of inflation, the new figure also took into account the changes in the budget structure introduced after the second package deal and the setting up of ESA. Eventually, the science budget for 1977 was approved by the Science Programme Committee (SPC) at the level of 67.3 MAU: SPC, 9th meeting (14 December 1976), ESA/SPC/MIN/9, 24 January 1977, pp. 11-12.

361 SAC(77)3, *cit.*, p. 8.

362 SAC, 7th meeting (2 May 1977), SAC(77)8, 7 July 1977.

363 M.J. Rees, "Long range planning studies. Some preliminary ideas on what the SAC might do", SAC(77)12 [10 October 1977]. The following quotation is from p. 2. The ESF Space Science Committee was chaired by H. Massey, a pioneer of space research in Europe, and included other eminent space scientists (and ESRO founding fathers), such as R. Boyd, H. Elliot, H. van de Hulst, C. de Jager, R. Lüst, B. Peters. The ESA Director General, R. Gibson, and A. Lebeau were also members of the Committee. The meeting attended by Rees was held on 5 October 1977, and a copy of the minutes is available in *D/Sci archives*.

There is little point in discussing scientific priorities in a completely "abstract" way [...] We ought instead to focus on what Europe should do, taking full cognisance of what has already been achieved, the existing expertise (and limitations), and the wishes and plans of the major established European institutes. In the light of such considerations, we can maybe suggest some hypothetical launching programmes for major projects in the 1980s which, taken as a whole, could [...] provide a balanced scientific return, and give each member country a fair share of the action. This cannot be done without making a careful choice of subfields within each discipline, and accepting that some fields must be left entirely to NASA and the USSR.

Rees also suggested a procedure to proceed with a thorough study of the European space policy for the 1980s. An extraordinary meeting of the SAC should be organised in early 1978, to be attended by incoming and outgoing SAC members, the chairmen of the Working Groups, top ESA officials and some invited experts and ESF members, "to discuss priorities in general and to decide what individual scientists or institutions might be invited to contribute opinions, papers on scientific topics, or information about plans and preferences". A further extended meeting would be held some months later "to digest the material and prepare a report".[364]

The extraordinary SAC meeting was duly held on 25 February 1978, chaired by the newly elected SAC chairman Roger Bonnet (Table 4-1).[365] The key question discussed at the meeting was the definition of a proper framework for ESA's Scientific Programme, i.e. the content of the activities to be supported by the Agency's mandatory science budget. This essentially meant a distinction between those disciplines, research fields and technologies that could be accommodated within the programme and those that could not, for either financial reasons or lack of relevant interest and experience in Europe. The LPAC's policy statement of 1970 had excluded from the ESRO programme such important fields as optical astronomy, solar physics and planetary exploration; at the same time, it had given priority to high energy astrophysics and magnetospheric studies. It was likely that a similar list of "negative and positive priorities" would be necessary in the new phase too.

This exercise involved two different aspects. The first was a careful appreciation of the long-term scientific potential of the various research fields, and the role Europe could play *vis-à-vis* the parallel efforts in the USA and the Soviet Union. As was pointed out at the meeting, "[one] should be cautious about giving priorities for missions to be carried out ten years hence [and] it would be a mistake to close off areas of science at this stage".[366] The second involved the question of the kind and size of projects to be done by ESA. On the one hand, large, observatory-type missions seemed most appropriate for cooperative undertakings, but, owing to the necessarily limited number of such projects, there would have been large fluctuations in the activity of any individual research group, with young scientists having a chance to carry out experiments only every six to eight years and being otherwise left with routine work. On the other hand, small projects and multi-experiment satellites could more easily cater for the scientific community at large and facilitate a balance among disciplines, but many felt that confining ESA to small-size projects would betray the ambitions of European space scientists and the very meaning of their collaborative effort.

4.1.1 "Classical" and "new" space science disciplines

The balance between the various disciplines and between large and small projects was only part of the problem, however. The SAC had to establish also what criteria allowed a "new" discipline to be included in ESA's mandatory Scientific Programme. Since the early ESRO period, this had traditionally included two broad research areas, covered by the Solar System Working Group (SSWG)

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[364] SAC, 8th meeting (18 November 1977), SAC(77)15, 15 December 1977, p. 10. This procedure as well as the agenda for discussions were eventually detailed by the Executive in SAC(78)1, 8 February 1978, and SAC(78)4, 17 February 1978.

[365] SAC, "Extraordinary meeting on long-term planning" (25 February 1978), SAC/78)6, 11 April 1978.

[366] SAC(78)6, *cit.*, p. 6.

Table 4-1: Participants in the SAC extraordinary meetings on long-term planning (25 February and 26-27 September 1978)

Members of the SAC:	R. Bonnet (chairman)
	W. Axford
	G. Colombo *
	K. Pinkau
	A. Wiin-Nielsen
	H. Wolff
Outgoing members of the SAC:	M. Rees *
	L. Houziaux **
Chairmen of Working Groups:	
Astronomy	G. Setti
Solar System	M. Petit
Solar Telescope	F. Pacini
Life Sciences	(H. Wolff)
Material Sciences	H. Weiss
Outgoing Chairmen of Working Groups:	
Solar System	J. Geiss *
Life Sciences	H. Bjurstedt
Chairman of the SPC:	H. Curien
European Science Foundation:	
Chairman, Space Science Committee	H. Massey (R. Boyd) ***
Chairman, Astronomy Committee	R. Lüst
Invited Expert	H. van de Hulst
ESA:	
Director General	R. Gibson
Dir. of Planning and Future Programmes	A. Lebeau
Dir. of Scientific and Meteorological Progrs.	E. Trendelenburg
Deputy Director of Planning	A. Dattner
Head of Future Scientific Programmes Dept.	E. Peytremann
Head of Space Science Dept.	D. Page
	V. Manno

and the Astronomy Working Group (AWG), respectively. The former included solar physics, planetary science, solar-terrestrial relations, ionospheric and magnetospheric studies; the latter included astronomy and astrophysics, and cosmic-ray physics. All these fields had been covered to some extent by ESRO's first satellites, while in the late 1960s and early 1970s priority had been given to magnetospheric research (ISEE-2 and GEOS) and high-energy astrophysics (COS-B and Exosat). In the new decade, Spacelab would open up interesting opportunities for "science in space" in a variety of disciplines outside the traditional domain of "space science". Microgravity research in life sciences and material sciences was only possible on Spacelab missions, and could extend the European space expertise in a domain of great importance in view of future manned space stations. In fact, two new

* Only attending the February meeting.

** Only attending the September meeting.

*** Massey was unable to attend the September meeting but was represented by Boyd.

working groups had been set up by ESA in order to deal with the new scientific prospects, the Life Sciences Working Group (LSWG) and the Material Sciences Working Group (MSWG).

Should biomedical research on Spacelab be considered as space science in the ESA framework, and then supported by the mandatory science budget? The answer tended to be positive, and in fact the SAC had recommended (and the SPC approved) the funding of a Sled facility for vestibular studies in the payload of the first Spacelab flight out of the science programme budget.[367] If, however, this programme should cater for the further development of life sciences in space, a revision of the "package deal" level of resources could hardly be avoided.

The situation was different in the case of materials science, also represented in the first Spacelab payload by a general experimental facility under development with national funding. There was an evident potential economic interest in this research field on the borderline between science and applications, and it was expected that governments and industry would support its development in the framework of an envisaged optional programme on Spacelab utilisation. The problem remained, however, about the role of the SAC and the SPC in the definition of a scientific policy for this field. In the words of the chairman of the MSWG, H. Weiss:

> *The distinction between science and applications was academic. All our techniques were derived from scientific studies. In the field of material sciences, the physical and chemical behaviour of fluids and gases in space was still a mystery to a large extent and many years of exploration of materials in space would be required before the setting up of a space factory would be feasible. This field was indeed a scientific one and belonged to the science programme.*[368]

If there was a scientific content as well as an economic interest in materials science, and if this field was to share Spacelab facilities with "traditional" space science disciplines, how could the European scientific community represented in ESA's advisory and decision-making bodies be involved in the selection of experiments? How could the principle of scientific merit, adopted within the framework of the mandatory science programme, be safeguarded within the framework of an optional programme funded according to national economic interests? If, on the contrary, material sciences were included in the science programme (and the budget increased accordingly), how could one prevent the new application-oriented disciplines from being unduly privileged against "classical" research fields?

Alongside the new Spacelab sciences, a similar problem arose regarding Earth-oriented research, a field which was coming to the forefront of space research in the wave of the new interest for environmental sciences in the 1970s, but was not covered by ESA activities. Earth sciences included a wide spectrum of disciplines on the borderline between science and applications, from oceanography to climatology, from geodynamics to atmospheric physics, from geodesy to remote sensing. Lebeau, was a convinced advocate of the Agency's involvement in this field:

> *This complex of disciplines forms a single whole, with a unity of its own, and one must not seek to divide it up artificially. It is founded on a set of homogeneous space techniques and means. It relates to a clearly identified, homogeneous scientific community and one which, moreover, as things stand at present is virtually excluded from the European programme.*[369]

According to the Director of Planning and Future Programmes, an optional science programme should be set up for the study of the Earth and its atmosphere. Such a programme, he said, "would constitute, alongside the mandatory Scientific Programme and the [optional] application programmes, a new category of activities".

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[367] See chapter 14 in this volume.

[368] SAC(78)6, *cit.*, p. 4.

[369] SAC(78)3, 16 February 1978, p. 4. The following quotation is from p. 1.

The proposal was not well received by the spokesmen of the European space science community. All recognised that a way was needed of including new branches of science in the ESA programme, either by enlarging the mandatory programme or establishing optional Scientific Programmes, but they did not like that any area of science should be granted a preferential position on the basis of its potential value for applications. The founding fathers of European space science were particularly resolute in this respect. "The study of the Earth and its atmosphere [is] also of a scientific nature", Reimar Lüst argued: "While a programme such as proposed might be more applications oriented than others and therefore more easily accepted politically, this would be at the expense of recognising the significance of the science to be done by ESA". Supporting Lüst's arguments, Hendrik van de Hulst, Martin Rees and Johannes Geiss recalled that the field of atmospheric research was covered by the SSWG and had not been neglected either in the past or in future planning. The latter added: "While new programmes might understandably be introduced into the Agency's structure, if these were imposed there might be criticism from other disciplines. Therefore care should be taken to select only first rate scientific objectives".[370]

Behind principles there were, of course, financial considerations and disciplinary allegiances. As the total funds that national governments allocated to space would presumably not increase in the future, all money going to application-oriented projects would be lost for pure-science projects, both within the ESA framework and in national space programmes. Facing the pressure of new disciplines and new research fields which claimed access to space, Lüst and his peers wanted to protect the "traditional" fields by preserving the original character of ESRO's Scientific Programme, i.e. one driven by the established European space science community. They advocated more resources for space science, either by increasing the mandatory budget or in the form of optional programmes, but insisted that all research fields should be dealt with on equal footing, and that ESA's scientific policy should be defined on purely scientific grounds.

The discussion about the role of the new disciplines in the ESA programmes was complicated by two factors. Firstly, the SAC was split on this issue, with one of its members, Giuseppe Colombo, strongly arguing that priorities should also be based on "possible economic return", and that ESA should preferably undertake projects aimed at geophysical problems.[371] Secondly, a dramatic difference of opinion existed within the ESA Directorate, setting Lebeau, on the one hand, in opposition to the Director of Scientific Programmes, Ernst Trendelenburg, on the other. The former advocated an important European effort in Spacelab utilisation and Earth-oriented research within the framework of ESA's activities. The latter shared his fellow space scientists' distrust of Spacelab and was resolutely against the inclusion of application-oriented disciplines in the mandatory Scientific Programme. The present level of the scientific budget was highly unsatisfactory, he argued, and one could hardly expect that it could be significantly raised in the near future: "In this situation, the inclusion in the Scientific Programme of 'new' disciplines [...] would be inadvisable, in that it would no doubt alienate our traditional customers without necessarily generating any 'new' friends".[372] The contrast between the two men led in this period to an important modification in ESA's directorate structure, essentially complying with Trendelenburg's vision: responsibility for studies of future scientific projects, with the significant exception of studies related to life sciences and material sciences, was transferred from Lebeau's Directorate of Planning and Future Programmes to Trendelenburg's Directorate of Scientific Programmes. Moreover, the latter ceased to be responsible for the meteorological programmes, which were placed under the responsibility of the newly created Directorate of Applications Programmes (en enlargement of the former Directorate of Communications Satellites Programmes).This change enabled Trendelenburg to guide ESA's scientific policy more efficiently according to his own orientations.

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370 SAC/78)6, *cit.*, pp. 3-4.

371 SAC(78)6, add. 1, 20 April 1978. Colombo's strong criticism of SAC's scientific policy is discussed in the previous chapter. cf. also Bonnet (1985).

372 SAC(78)4, 17 February 1978. cf. also Lebeau (1997).

Coming back to the extraordinary SAC meeting, two other important questions discussed by the participants were the role of the Ariane launcher and the aims of technological research within ESA. Ariane was much too big and expensive for the launch requirements of most scientific missions. Therefore, either scientific satellites had to go into orbit on shared launches, which would imply technical and schedule restrictions for the Scientific Programme, or a reduced version of Ariane had to be studied in order to meet the launch requirements of the programme itself. The issue of ESA's technological research touched a recurring controversial theme, i.e. the diverging interests of larger countries with important national space programmes and technological capability, on the one hand, and smaller countries which were dependent on ESA for supporting their research groups and training their engineers, on the other. The former, notably France and Germany, argued that the technological research programme at ESTEC should be kept at a minimum and mainly developed in relation to specific projects. This position was spelled out at the meeting by Klaus Pinkau and supported by Lüst. The interests of smaller Member States, which obviously converged with ESA's, were defended by Lebeau who insisted that "the technological research programme [should be] oriented towards basic space technology rather than specific projects".[373]

Concluding the meeting, a list of activities and task assignments was identified, and a Steering and Editorial Board (STEB) was set up, comprising R.M. Bonnet, K. Pinkau, H. Wolff and A. Wiin-Nielsen, with the task of preparing the final report. The on-going work was discussed at the ordinary SAC meeting of 9-10 May and a draft report was then discussed on 26-27 September at a new extraordinary meeting with essentially the same attendance as the previous one (Table 4-1).[374] The final version of the report was eventually approved by the SAC on 19 December and then printed and circulated by ESA.[375] We will review its content in the following section.

4.2 The SAC's vision of European space science in the 1980s

"In the SAC's view, a case can – and should be made – to recover the support for space science which was lost in 1972": this sentence we find in the introduction of the report.[376] That year, we should recall, the provisions of the first package deal started to be implemented, rapidly transforming the former "space research organisation" into an organisation mainly devoted to application satellites (Figure 4-1). The budget for scientific projects was dramatically reduced from about 60 MAU to the target figure of 27 MAU plus 1 MAU contingency per year (at 1971 price levels).[377] At that time, this was meant to be a minimal funding level required for maintaining a viable Scientific Programme; in fact, it became a maximum level as Member States refused to increase their mandatory contributions to the science budget above the required minimum. After price level adjustments and new budgetary procedures, the annual level for science amounted to 76 MAU in 1978, to which one could add a *pro-rata* share of the general budget and a small amount for the scientific part of the first Spacelab mission, thus bringing the total to approximately 85 MAU. This figure, the SAC commented, "is about

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373 SAC(78)6, *cit.*, p. 10.

374 SAC, 11th meeting (9-10 May 1978), SAC(78)11, 9 June 1978; SAC, Extraordinary meeting on long-term planning (26-27 September 1978), SAC(78)20, 20 November 1978.

375 SAC, *Recommendations on the development of space science in the 1980s*, ESA SP-1015, December 1978. The report was also referenced as SAC(78)17 and circulated under cover SA/SPC(79)12, 3 January 1979.

376 ESA SP-1015, *cit.*, p. 11.

377 It is worth recalling that in 1971 the LPAC had estimated that "the minimum level of funding required for a truly viable scientific satellite programme lies between 45 and 47 MAU": LPAC, 36th meeting (28-29 April 1971), LPAC/110, p. 3 (restricted session). A recommendation for an increase of the science budget had been made by the LPAC in its 1974 guidelines for new mission studies: LPAC(74)4, January 1974. cf. chapter 8 in Volume 1 and chapter 3 in this volume.

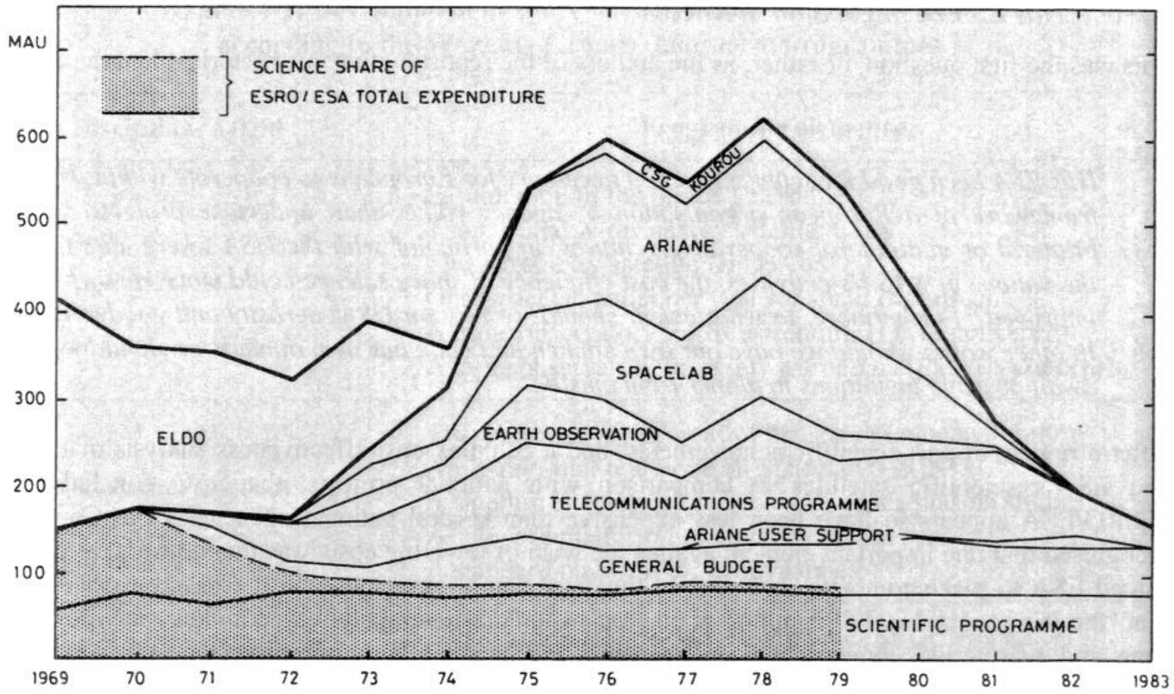

Figure 4-1: Expenditure of ESRO, ELDO and ESA, normalised to mid-1978 price levels (ESA SP-1015, p. 9)

three times smaller than CERN's 1978 budget (approximately 260 MAU) [and] very low compared to the space-science effort in the USA".[378]

The second package deal (1973) and the ensuing creation of ESA (1975) had brought an important new element into the framework of the European space effort, i.e. the decision to build the Ariane launcher and Spacelab. This had two particular consequences: firstly, that future European space missions were preferably to rely on Ariane and the Shuttle/Spacelab system for launch, at a cost presumably higher than "traditional" launch vehicles; secondly, that new scientific disciplines wished to be included into ESA's science programme in addition to the "classical" space sciences.

This situation justified the SAC's claim for a significant increase in the science budget in the coming decade, and a quick analysis of the graph reported in Figure 4-1 showed that this was indeed possible and even necessary. It indicated in fact that, owing to the completion of the Ariane and Spacelab programmes, the ESA funding requirements were undergoing a dramatic reduction in the near future. Supplementary support for space activities was then required, in order to "avoid Europe falling further behind the United States in terms of level of effort, and to enable European scientists to play a role compatible with Europe's historical and political importance in the World".[379] An increasing support to space research, in other words, was to be considered as a key element of a sound space policy for Europe *vis-à-vis* the United States, and also Japan, whose space effort was already comparable to that of ESA Member States as a whole. It was the SAC's task to show that the new resources made available for space activities in Europe could profitably be spent within the framework of ESA's Scientific Programme.

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378 ESA SP-1015, *cit.*, p. 9. The comparison between space science and high energy physics was suggested by Trendelenburg on the basis of the CERN report *Resources given to high energy physics in 1976 in the CERN Member States*, prepared by C. Roche, DIR/CPO/153/Rev., January 1978. cf. Trendelenburg's letter to STEB members, 27 July 1978, in *D/Sci archives*.

379 ESA SP-1015, *cit.*, p. 15.

4.2.1 *"Has ESA been good for science?"*

This was the first question, or rather, as the authors of the report, with some rhetorical lengthiness, put it:

> *Has ESA been good for science and is it necessary for Europeans to cooperate within the framework of a European organisation or agency rather than undertake projects as bilateral or multilateral cooperative ventures, in particular with the USA where, due to the volume of NASA's activities, the cost efficiency of space science could more easily be improved? Furthermore, to what extent should we rely on US generosity and goodwill? In other words, should we have our own kitchen and cook our own dinners, or should we await possible invitations to dinner from outside?*[380]

After a review of past scientific achievements, and a complex cost-effectiveness analysis of ESRO's and ESA's scientific satellites in comparison with national projects, the SAC concluded that "ESRO/ESA appears to have been less expensive than several national agencies". The Committee recognised that one important element against the wish of lowering costs was the industrial policy that forced ESA to place contracts according to the "just return" principle, and it strongly recommended that "the fair geographical distribution of contracts should be averaged over more than one project at a time, and over periods longer than those necessary for the completion of a project". As an example of such a relaxed policy, the SAC presented the case of hardware experiments contributed by national scientific groups to the various ESRO/ESA satellites, where a fair geographical distribution had been achieved over a ten-year period, "without the imposition of a forced policy towards this end".[381]

In conclusion, answering the foregoing question, the spokesmen of the European space science community insisted that Europe should keep a cooperative effort "on a European scale", in addition to any possible bilateral or multilateral undertakings. Three main reasons were given. Firstly, in a context in which the increasing complexity of spacecraft and experiments reduced the number of flight opportunities, and made the competition between scientists fiercer, the European programme increased the possibilities for the space science community to fly experiments, and offered more "security, stability and continuity" than cooperative ventures with a "one-off character". Secondly, the spectrum of scientific interests in Europe differed in many areas from that of American scientists, "and the European community at large feels the need for an independent programme in which its particular interests can be safeguarded and represented". In this respect, a clear guideline for future European programmes could be identified, i.e. "to exploit those fields of science of which the originality is well recognised, and which can be undertaken earlier in Europe than in the USA or USSR". Finally, the concept of free cooperation between European nations was an ideal that extended beyond the scope of space research alone: "The furtherance of this ideal may in itself be worth some small cost penalty", the SAC argued.[382]

4.2.2 *The content and dimension of ESA's Scientific Programme*

The next step was to discuss an overall programme for the development of space sciences within ESA in the 1980s, including both the "classical" disciplines (astronomy and solar system science), and the new fields of microgravity research and Earth sciences. In Table 4-2, we present the plans elaborated between 1976 and 1978 by ESA's four Working Groups, which the SAC laid at the foundation of its

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380 ESA SP-1015, *cit.*, p. 26.

381 ESA SP-1015, *cit.*, pp. 24-25.

382 ESA SP-1015, *cit.*, p. 26.

Table 4-2: Development of space science within ESA in the 1980s according to the Working Groups' long-term programmes

Disciplinary field	Programme elements
Astronomy and astrophysics	Exploitation of the Space Telescope The UV and X-ray survey satellite EXUV The astrometry satellite Hipparcos One Spacelab pallet per year for small experiments A large observatory for IR astronomy (LIRTS concept) A large observatory for X-ray astronomy (EXSPOS concept)
Solar System sciences	Two missions in the areas of planets or comets An X-ray solar telescope on Spacelab (GRIST) A satellite or Spacelab facilities for space plasma studies A standard platform for atmospheric sciences A standard platform for geodynamics
Earth sciences	Participation in the GARP programme (SEOCS satellite) An ocean and ice programme A solid-Earth physics satellite
Material sciences	Participation in one Spacelab mission per year
Life sciences	Studies of the human vestibular system by the Sled facility Biorack facility for the study of plants, cells and bacteria

analysis.[383] Two aspects were to be discussed: firstly, the size and content of the ESA Scientific Programme; secondly, the institutional framework in which the programme itself could be implemented. The first aspect was related to the place of the new disciplines *vis-à-vis* the classical ones and to the financial resources required to develop a viable programme in the various research fields. The second was related to the various mechanisms that the ESA Convention provided for the implementation of the Scientific Programme, namely the mandatory programme, the optional programmes and the internationalisation of national programmes (either within the mandatory programme framework or as an optional programme).

As regards the first aspect, the SAC refrained from establishing negative priorities, and recommended that "Europe [should] follow a policy in which all the fields of European scientific excellence in space are developed and supported, and in which the space science budget is not so small that entire fields must vanish". Three considerations supported this statement: firstly, the potential of the various research fields in Europe, as resulted from the Working Groups' discussions with the scientific community at large; secondly, the need to have a fair balance between the various (old and new) disciplines; thirdly, the role of space science in the political environment within which Europe would develop its overall space effort. As the SAC put it:

[383] AWG, *Report on long-term planning, 1980-1990*, ASTRO(76)13, August 1976; *Summary and conclusions of astronomy long-term planning*, ASTRO(78)12, August 1978. SSG, *An approach to long range planning 1980-1990*, vol. I, SOL(76)9, September 1976, and vol. II, SOL(78)12, June 1978. SSWG, *Report of the Ad Hoc Panel on Earth Sciences*, SOL(78)16, August 1978. MSWG, *Long-term planning in material science*, MAT(78)10, March 1979. LSWG, *Long-term planning in life sciences*, LIFE(79)1, 1979.

> *In space science, Europe should accept and be equal to the position that it has economically and politically in the World. Europe should move into the next decade attempting to meet the challenge deriving from its scientific and cultural heritage.*[384]

This ecumenical space policy implied the achievement of an event rate of about one satellite launch per year and about half a Spacelab every two years, so that existing groups would be granted a minimum level of continuity in hardware-building activity and an evenly spaced event rate of experiments in microgravity research. The obvious implication was a strong plea for a significant increase in the resources devoted to science in the ESA budget: "If such an increase is not achieved, it will not be possible to continue supporting the different branches of science in a reasonable way and it will be necessary to kill entire fields. [...] The reductions occurring in the 1970 to 1972 time frame have cut too deeply into the possibilities of space science, and [...] an upward correction must now occur".[385]

As regards the institutional framework, the SAC agreed to take "a pragmatic approach", recognising that in order to meet the demands of the classical and new disciplines, a combination of all three funding mechanisms should be used, "while at the same time maintaining the scientific standard irrespective of the way in which a particular programme is funded".[386] The case of Earth sciences was exemplary in this respect. Earth-oriented space projects were justified both for their purely scientific value (e.g. the understanding of the relations between the atmosphere, the oceans and the polar ices, or the study of the global motion of the Earth's crust) and because of their potential for easily identified applications (e.g., the description and prediction of the climatic system, or the possibility of Earthquake predictions). After a discussion in a restricted meeting which is not reported in the minutes, the SAC "unanimously agreed that Earth Sciences should be recognised as a discipline within ESA and be treated on an equal footing with the other scientific disciplines".[387] It, however, recommended that Earth-oriented missions should be supported within the framework of an optional programme, and that an Earth-Oriented Research Working Group be established "within the ESA's advisory structure, in order to guarantee a competitive selection procedure similar in every respect to that used in the field of 'classical' space disciplines".[388]

According to the SAC, the mandatory programme should continue to provide the backbone of ESA's scientific activity, but it was too small to support the long-term plans in the classical disciplines, and certainly it had no margin to provide for the new microgravity sciences. The Committee noted that, as a result of the tight financial constraints, both the AWG and the SSWG had undertaken a frustrating procedure of killing mission proposals and reducing the programme to the minimum level required to maintain the scientific community in the disciplines within their purview. Despite this exercise, the long-term programmes elaborated by the working groups required expenditures in the range of 120 MAU per year in the 1980s, i.e. about 30% of ESA's total expenditure, "assuming a constant annual expenditure of 400 MAU (Figure 4-1)". The SAC, however, agreed to refrain from identifying particular fields for which support should be stopped in the future should the level of the science budget not be increased. On the contrary, it recalled that ESRO/ESA had never undertaken a pure solar physics or planetary mission, and considered that this situation had to be rectified.[389]

A cautious attitude was adopted as regards life and material sciences:

> *The basic question is whether the microgravity research [...] will prove important or not. The SAC believes that there is need for a cautious but adequate investment here, much of which will have to be used to fund an exploration phase [...] This phase may last until the*

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384 ESA SP-1015, *cit.*, p. 33.
385 ESA SP-1015, *cit.*, p. 38.
386 ESA SP-1015, *cit.*, p. 39.
387 SAC, 14th meeting (28 September 1978), SAC(78)21, 20 November 1978, p. 2.
388 ESA SP-1015, *cit.*, p. 34.
389 ESA SP-1015, *cit.*, p. 32.

middle of the next decade, when it will be possible to review the situation and decide which of the investigations are ripe for in-depth study and scientific evaluation.[390]

The Committee recommended that the exploration phase be supported by "a modest but continuous supply of Spacelab flight facilities", but insisted that additional funding had to be found and that the missions had to be "of high scientific value". The level of resources required during the exploration phase was estimated at 120 MAU for ten years, which could be accommodated within the framework of the mandatory Scientific Programme, "if its present very low level were increased".

4.3 The role of Spacelab (and Ariane)

Two considerations can be made regarding the role of microgravity sciences in the SAC's report. Firstly, it reflects the long-standing distrust of space scientists towards man-in-space programmes. Since the glamorous times of the Apollo programme, they knew that scientific objectives were hardly the main motivation for sending human beings into orbit, while political, military and ideological considerations were the real driving force for manned space missions. As the former NASA director for the space science programme put it:

Underlying the prevailing discontent in the scientific community regarding the [manned spaceflight] programme was a rather general conviction that virtually everything that men could do in the investigation of space, including the moon and planets, automated spacecraft could also do and at a much lower cost.[391]

European space scientists, for their part, did not like being obliged to follow their American colleagues in the trap of manned spaceflight: i.e. being obliged to search for a scientific rationale for an essentially political decision such as the "second package deal" decision to build Spacelab in Europe.[392] The SAC then insisted that the new disciplines should be developed within ESA "according to the same scientific principles" as the classical ones; that a competitive selection procedure should be introduced, "making use also of advice that is not *a priori* space-oriented"; and that the new Working Groups for life, material and Earth-oriented sciences "should include scientists of high repute not committed to space investigations".[393]

The second consideration concerns the actual prospects of Spacelab utilisation. When the SAC was preparing its report, the Spacelab programme was suffering a dramatic crisis, with development costs estimated to be about 50% higher than the approved budget; the first mission delayed from spring 1980 to mid-1981, and then again to spring 1982; the cost of the European contribution to the first Spacelab payload estimated at about twice the level approved two years earlier; and the two envisaged ESA demonstration missions almost definitely jeopardised. It was becoming more and more clear that it was not only scientists who did not like Spacelab, but ESA Member State governments as well were reluctant in committing resources in the future utilisation of Spacelab, with the obvious exception of Germany.[394]

Within this framework, the SAC felt it should make clear its opinion about the role of the Scientific Programme in the future exploitation of Spacelab and Ariane, being aware that a strong pressure would be exerted on the European space science community in the future to design ESA scientific missions in such a way as to make fullest possible use of these made-in-Europe space transportation

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390 ESA SP-1015, *cit.*, p. 35.

391 Newell (1980), p. 290. Cf. also pp. 389-392, about the negative attitude of American space scientists towards the Space Shuttle programme. Logsdon (1970), Lord (1987) and McCurdy (1990) devote several pages to the lukewarm (say often negative) attitude of American scientists to the Apollo, Spacelab and Space Station programmes, respectively.

392 See chapters 11-14 in Volume 1. cf. also Schwarz (1979).

393 ESA SP-1015, *cit.*, p. 47.

394 See chapter 14 in this volume.

systems. This could not be accepted. Spacelab was not competitive with conventional satellites for classical sciences on a cost/observation-day basis, and the high cost of the launch would gravely endanger the development of microgravity sciences for which Spacelab was the only opportunity for experiments. Here is the SAC's conclusion,

> *The scientific community should consider itself as a potential user of this means of transportation, and not a promoter of it. In no way should the community and the Working Groups themselves undertake the task of programming the utilisation of Spacelab.*

A similar argument was made for Ariane. This rocket had been conceived and developed mainly for launching heavy telecommunications satellites into geostationary orbit, and it was oversized for most scientific missions. Double launches could not offer a general solution because of the constraints in terms of interface, orbits and launch windows. In conclusion:

> *The SAC wishes to express clearly its concern that neither Spacelab nor Ariane is adapted to the financial state of the Scientific Programme and to the majority of its needs. If ESA wishes to promote the use of Ariane or Spacelab for science, then the mandatory programme must be put in a position to buy the launches by an increase in the funds available to the programme; alternatively, "free" launches could be provided in the form of an optional programme (which would allow the participating Member States to choose their respective contributions).*[395]

In a later statement, the SAC clarified that, in its recommendation to increase the mandatory budget to the level of 120 MAU/year, it was not intended that this should cover increased launch costs: "If the Member States agreed to grant 120 MAU/year as recommended, but stipulated that exaggerated launch costs (Ariane and Spacelab) should be charged to the mandatory programme, this would not improve the current situation for science".[396]

A new occasion for the SAC to express its opinion about the issue of Spacelab utilisation occurred in May 1979, when the rising costs of the programme and the diverging interests between Member States made the prospects of European use of this facility appear more and more uncertain. No firm commitment had been made from Member States, apart from Germany, for supporting the proposed experiments on the two demonstration missions planned by ESA; no long-term plan for Spacelab use in the microgravity field had been worked out; and all the important Spacelab instruments studied in depth within the science programme (the infrared telescope LIRTS, the X-ray solar telescope GRIST and the laser instrument for atmospheric studies LIDAR) had had to be abandoned because of their poor scientific profitability.[397] In this situation, the SAC was called to put the question of Spacelab utilisation and the plans for its follow-on development on its agenda. "The SAC is well aware that the future of space programmes depends to a large extent on the results of these discussions [...], as Spacelab is one the major components of the Agency's transportation systems development programme", Bonnet wrote to the Director General.[398]

In view of the SAC meeting, the Executive (i.e. Lebeau's Directorate in this case) prepared a report on the costs of the utilisation of Spacelab for scientific investigations, whose aim it was to answer the criticism which had often been made with respect to the high costs of Spacelab missions and the high cost to develop Spacelab experiments and equipment. The key argument was the comparison of launch costs per kg of experiment for Shuttle/Spacelab and conventional launchers/spacecraft, respectively

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395 ESA SP-1015, *cit.*, pp. 48-49. The possiblity of optional programmes for launching scientific missions on Ariane or Spacelab referred to the obvious interest of France and Germany to support their utilisation after the development phase.

396 SAC, 17th meeting (16 March 1979), SAC(79)10, 3 May 1979, p. 4.

397 See chapters 3 and 14 in this volume.

398 R. Bonnet, letter to R. Gibson, 30 Mars 1979, *D/Sci archives*.

(Tables 4-3 to 4-5). These cost figures, the Executive argued, were "strongly favourable for Spacelab when compared to conventional satellite payloads". While recognising that Spacelab was not a vehicle tailored for traditional space disciplines, in particular those fields of astronomy and space physics requiring long-term observations or measurements, the document insisted that "the large mass and volume capabilities of Spacelab offer better possibilities for some areas of traditional space sciences like infrared astronomy (cryogenic cooling) and multi-spectral solar observations, large instruments for astrophysical observations, etc".[399]

Table 4-3: Comparison of launch costs per kg of experiment for Shuttle/Spacelab, conventional launchers and sounding rockets [SAC(79)12]

Project	Experiment Mass	Mission implementation costs (excl. experiment costs)	Cost/ kg of experiment (kAU/ kg)
13 ESRO/ESA scientific satellites	672.5 kg (51.7 average)	1111 MAU	1650
First Spacelab Mission (FSLP)	1392 kg (European share)	21.7 MAU (excl. Shuttle launch costs)	15.6
Spacelab mission DM2 (5 pallets)	5960 kg	60 MAU (incl. 25 MAU for launch services)	10
Spacelab mission DM1 (Module-only)	3900 kg	54.6 MAU (incl. 25.6 MAU for launch services)	14
Sounding rockets (e.g. Texus II)	240 kg	1.7 MAU	7

The SAC definitely disagreed with these arguments. The comparison of launch costs per kg of experiment for the Shuttle/Spacelab system and conventional launchers was not the most significant way of reviewing the matter, as the total cost of Spacelab experiments was as high as those of comparable experiments on unmanned satellites. Given the present situation of the Scientific Programme, they argued, there is no way of planning Spacelab utilisation, let alone endorsing any follow-on development, until the costs of Spacelab missions are significantly reduced. The first priority was to increase the funding of European space science rather than to make further expenditure on transportation systems.[400] The latter argument was made more explicit by K. Pinkau in a letter to Bonnet just after the meeting:

Table 4-4: Specific launch costs of various launch vehicles [SAC(79)12]

Launch vehicle		Costs per kg of bare experiment mass (only launcher costs involved)
Spacelab	(4000-6000 kg experiment, 25 MAU for NASA Shuttle/Spacelab services)	4.2 - 6.3 kAU/ kg
Thor Delta (2914)	(low orbit, 15 MAU, 25% experiments of 1950 kg payload)	30.8 kAU/ kg
Ariane	(low orbit, 32 MAU, 25% experiments of 4500 kg payload)	28.4 kAU/ kg
Scout	(UK 6, 625 km orbit, 62 kg experiments)	64.8 kAU/ kg

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399 SAC(79)12, 26 April 1979, p. 9.

400 SAC, 18th meeting (9-10 May 1979), SAC(79)16, 25 June 1979. The SAC's views were supported by the ESF Space Science Committee, represented at the meeting by its chairman J. Geiss. See also 19th meeting (26 September 1979), SAC(79)25, 8 November 1979.

Table 4-5: Comparison of experiment development costs for some free-flyers and the FSLP [SAC(79)12]

Free-flyers	**Experiment original cost/ kg (kAU/ kg)**	**Cost/ kg (1978 price level) (kAU/ kg)**
Meteosat (experiment only, 1973)	273	382
Several small (5 kg) experiments on ESRO I and ESRO II	200	279
COS-B (experiment only, 1971)	165	264
HEOS A2 (experiment only, 1968)	250	488
ESRO IV (experiment only, 1969)	193	354
Spacelab experiments (FSLP)	**Mass (kg)**	**Cost/ kg (1978 price level) (kAU/ kg)**
Charged particle beams (ES020)	41.5	27.9
Solar constant (ES021)	5.5	18.6
X-ray astronomy (ES023)	20.5	29.0
Sled (ES200)	165.0	26.5
Material science double rack (ES300)	467.0	33.8
Grille spectrometer (ES013)	137.0	42.7
Microwave remote sensing exp.	153.0	38.9

> *If you look at the German expenditures, [...] you see that expenditure between 1971 and 1976 rose by only 10% (which is less than inflation) although they accepted the entire Spacelab plus applications programme plus Ariane and Kourou into their funding. [...] They achieved this by killing the national scientific space programme. In our view it is entirely fair to say that the Spacelab development in the past has been paid essentially from within the Scientific Programme in Germany.*[401]

The SAC could not endorse any follow-on programme, Pinkau continued, without having previously received a firm assurance that the mandatory Scientific Programme will be increased, and that it will not be charged for the launch costs of Spacelab and Ariane. In a following letter, Pinkau, who was to succeed Bonnet to SAC chairmanship, directly challenged the Executive's argument with an irreverent metaphor:

> *The considerations on the cost of any approach cannot be restricted to comparison, [...] an absolute yardstick exists. It is the size of the financial envelope available for that part of the activity which is to be served by this system. In our case, it is the size of the mandatory programme. [...] Systems have to come in practical sizes to be used. It may be much cheaper for me, per roll of toilet paper, to buy it by the truck-load, but I may not be able to afford to invest so much money in this venture and it may be not practical. Thus I may still decide to buy single rolls (Thor Deltas, for example) although they may be more expensive per roll, since this is compatible with my income and with a practical solution.*[402]

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401 Pinkau, letter to Bonnet, 19 June 1979, *D/Sci archives*.

402 Pinkau, letter to Bonnet, 28 September 1979, *D/Sci archives*. Lebeau's comments, attached to a letter to Bonnet of 17 October 1979, are *ibid*.

Pinkau made a similar argument regarding Ariane. "Scientists are led to believe that their proposals are doomed to failure from the outset if they do not propose Ariane missions", he wrote to Bonnet, and then continued:

> *It thus appears that we are victims of a feedback cycle which from the outset is reducing the scientific usefulness of our limited mandatory budget, because we are being presented with mammoth missions only. The mortality rate of these mammoth missions must be very high due to the financial situation, [...] and the time and enthusiasm of the proposing scientists, and much money, is being wasted.*[403]

More money for science is needed, this was again the general conclusion, not only for the sake of space science, but for making the rate of usage of Ariane and Spacelab proportionate to the level of resources Europe had invested in these new space transportation systems. The SAC, for its part, made it clear that it "would assess proposals on their scientific interest and associated costs irrespective of the launching and space transportation systems that might be used".[404]

4.4 More money for science?

The report on the development of space science in Europe in the 1980s was definitely approved by the SAC at its meeting of 19 December 1978, and eventually published by ESA. It was also agreed that a summary of the report should be prepared for the Council, listing the SAC's main recommendations and the actions required for their implementation.[405] The first and most urgent set of recommendations, on which all other arguments about the future development of space science in Europe depended, regarded of course the increase in the level of resources. These recommendations are summarised in the following three statements:

> *The support for space science which was lost at the time of the 1971 first package deal should be recovered as soon as possible through an increase in the level of the mandatory programme and the creation of optional programmes (in particular for Earth sciences).;*
>
> *The level of the mandatory programme should be increased to 120 MAU/year for astronomy and solar-system sciences, plus 12 MAU/year for microgravity sciences, i.e. about 33% of an assumed 400 MAU total level of resources for ESA in the 1980s.*
>
> *The launch costs with Ariane and Spacelab (or part of them) should not be charged to the mandatory budget.*

There was nothing the SPC could do regarding the problem of funding, but to discuss the SAC's report and advise the Council, the only body entitled to decide on this crucial question, to give "its urgent attention" to the fact that:

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403 Pinkau, letter to Bonnet, 18 October 1979, *D/Sci archives*. cf. also Trendelenburg to Bonnet, 25 October 1979, and Bonnet to Trendelenburg, 6 November 1979.

404 SAC, 20th meeting (5-6 December 1979), SAC(79)35, p. 2. It must be noted that this meeting was held after a SAC mission to the USA, on 23-25 October, where they visited the NASA Johnson and Kennedy Space Centers. Following this visit, concern about the lack of any firm plan for Spacelab utilisation in Europe was expressed by Bonnet in a letter to Gibson, 26 October 1979, *D/Sci archives*.

405 SAC, 15th meeting (19 December 1978, SAC(78)23, 8 January 1979; 16th meeting (22-23 January 1979), SAC(79)4, 9 March 1979. The summary report for the Council is ESA/C(79)14, 11 June 1979. Preliminary versions of this document, for discussion in the SPC, are attached to ESA/SPC(79)7, rev. 1, 8 May 1979, and ESA/SPC(79)7, rev. 1, corr. 1, 15 May 1979.

> *The present level of the mandatory programme, if not increased or complemented by optional programmes or otherwise, leads to a serious situation for European space science, in which groups that have gained world renown by their present work may face the problem of survival and where work in the new fields of space science may not get a fair chance of development.*[406]

A few aspects of the SPC discussions, however, are worth mentioning as they are evidence of the attitudes of Member States towards the main questions. Most delegations were in favour of a general increase in the funds devoted to space sciences, but opinions diverged about how this could be achieved. The French delegation opposed the idea of increasing the mandatory budget, and stated that their authorities would anyway not approve participation in new optional programmes in the near future. Additional French money, in other words, would eventually go to the national programme. Moreover, the delegation could not agree with the SAC's arguments regarding the launcher question. France being the main sponsor of Ariane, its position is easily understood:

> *It was up to scientists to adapt their missions to the launchers which existed. [...] The primordial [political] question was whether ESA considered its Scientific Programme as a separate entity, in which case there would be no need for it to accept the imposed launcher, or whether it represented an essential part of a coherent whole. In the latter case, every attempt should be made to make the maximum use of the investments already made, and the use of Ariane was not a constraint but an objective.*[407]

Contrary to France, Germany was in favour of increasing the science programme budget, in consideration of its political importance as ESA's only mandatory programme. The German delegation argued that, "in order to avoid a decomposition of the fundamental activity of the Agency", the scientific mandatory programme should be restored to the level it enjoyed before the 1971 package deal, and insisted that the transfer of individual scientific projects to optional programmes should be resisted. Only the new Earth-oriented sciences and material sciences could be regrouped as optional programmes, each with their own budgets.[408] The delegation also believed that the Scientific Programme should use as far as possible the Shuttle/Spacelab system and Ariane, but the Council should find ways of subsidising their use.

Similar concern about the high costs of the new space transportation system was also expressed by the Swiss, Swedish and British delegations. The latter, however, was adamantly against any increase in the mandatory budget which, in its opinion, should anyway provide for the classical disciplines only. Equally against any increase in the mandatory budget was Spain, which, however, argued that new disciplines should be considered within the Scientific Programme. Italy and the smaller Member States were in general in favour of a global increase in expenditure on space sciences, but they could not give any firm information about the rate of increase (if any) their authorities would eventually agree to, or their financial participation (if any) in new optional programmes.

In view of the important Council discussion on the SAC report and the future of the Scientific Programme, the Executive prepared a document to present its own case for an increase in the level of the mandatory budget and a proposal for the practical implementation of the SAC's recommendations.[409] The starting point was again the crucial divide of the 1971 package deal. In the period between 1967 and 1971, the ESRO annual budget showed an overall increase of about 20% for

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406 SPC, 19th meeting (22-23 March 1979), ESA/SPC/MIN/19, 26 April 1979. The quotation is from the attached resolution ESA/SPC/XIX/Res. 1, 23 March 1979.

407 SPC, 18th meeting (23-24 January 1979), ESA/SPC/MIN/18, 22 February 1979, p. 4.

408 The quotation is from a draft resolution presented by the German delegation which, however, was not put to the vote: ESA/SPC(79)15, 26 April 1979. Cf. ESA/SPC/MIN/19, *cit.*, p. 7, and SPC, 20th meeting (22-23 May 1979), ESA/SPC/MIN/20, 25 June 1979, p. 6.

409 ESA/C/Bur.(79) 3, 29 May 1979, attached to ESA/SPC(79)27, 12 September 1979. Following quotations from pp. 4- 6

satellites and sounding rockets and of about 50% for satellites alone, the Executive recalled, while in the following period, the envelope for space science in ESRO/ESA was dramatically reduced and strictly maintained at the level established with the first package deal. As a consequence, the Executive concluded, "there has been no evolution in the European scientific activity in space but, at best, stagnation". Four main arguments were then given for an increase in the scientific budget. Firstly, the intellectual challenge presented by advanced space missions which required international collaborations: "a simple return to purely national programmes would represent scientifically a step backwards". Secondly, the high scientific interest of the European space science community in ESA's programme, as demonstrated by the number and quality of proposals addressed to the Agency: "ideas and proposals abound, only money is scarce". Thirdly, the low level of the ESA science budget in comparison with other international scientific activities, in particular particle physics at CERN. Finally, the non-competitive position of the ESA science programme in relation to NASA: "the NASA science budget is about 9 times as high as that of ESA [while] the GNP of the US is about equal to that of the ESA Member States". In conclusion, the Executive fully endorsed the SAC's main recommendation that, from 1982 onwards, "the pure science programme of ESA should receive a substantial boost and recover the momentum that was severely reduced in 1971".

The Executive (i.e. Trendelenburg's Directorate in this case) went even further, however. It presented its own estimate of the financial requirements for space science within ESA and suggested a possible scenario to implement the proposed new budget level. In fact, the 120 MAU/year level recommended by the SAC for astronomy and solar system sciences could only be assumed as a baseline of the science budget, as it allowed the launch of a medium-size satellite per year.[410] These disciplines had now evolved from an exploratory phase to a phase which required larger systems of higher performance and higher cost. In the astronomy field, projects such as a large infrared telescope or an X-ray facility fell into the 250-300 MAU class. In the solar system area, where single spacecraft were cheaper, the new scientific objectives required groups of spacecraft simultaneously operating at different sites, therefore "the global costs of such programmes again falls into the above brackets". Finally, if the European scientific community wanted ESA to get involved in planetary missions in cooperation with another agency, the European contribution was again estimated at about 250 MAU. Assuming that at least three such large projects were developed during a decade, the Executive concluded, then the total annual budget for space science should be set at the level of 200 MAU/year, which would also include a fixed provision (of the order of 5%) for microgravity sciences. The new level could be achieved at the beginning of the 1990s by progressive increases of around 10% per year as from 1982 (Figure 4-2).

4.4.1 *The Council's answer is no*

The Council discussed the "deplorable status of the science budget" at its meeting of 28-29 June 1979.[411] Most delegations accepted in principle the possibility of an increase in the mandatory science budget, but the required majority could not be achieved and the Executive was then invited to make its plans on the basis of the package deal funding level. We are not surprised by this result. At that time, in fact, the Member States had not yet settled the financial questions related to the bad economic conditions in some of them, as well as the questions related to ESA's complex budgetary structure. The mandatory budget for 1979 had not been approved in due time and the meeting itself was still unable to find an agreement; consequently, the Council had to authorise continuation of the *provisional twelfths* system with regard to the general budget and the Scientific Programme budget beyond 30 June.[412] In this situation, it was hardly conceivable to secure the requested unanimous agreement to an increase in the mandatory budget.

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410 This figure, the Executive noted, corresponded to that recommended by the LPAC in 1971, when actualised to 1979 price levels (see fn. 177).

411 ESA/SPC(79)27, *cit.*, p. 1. Council, 32nd meeting (28-29 June 1979), ESA/C/MIN/32, 19 July 1979.

412 ESA/C/XXXII/Res. 7., 28 June 1979.

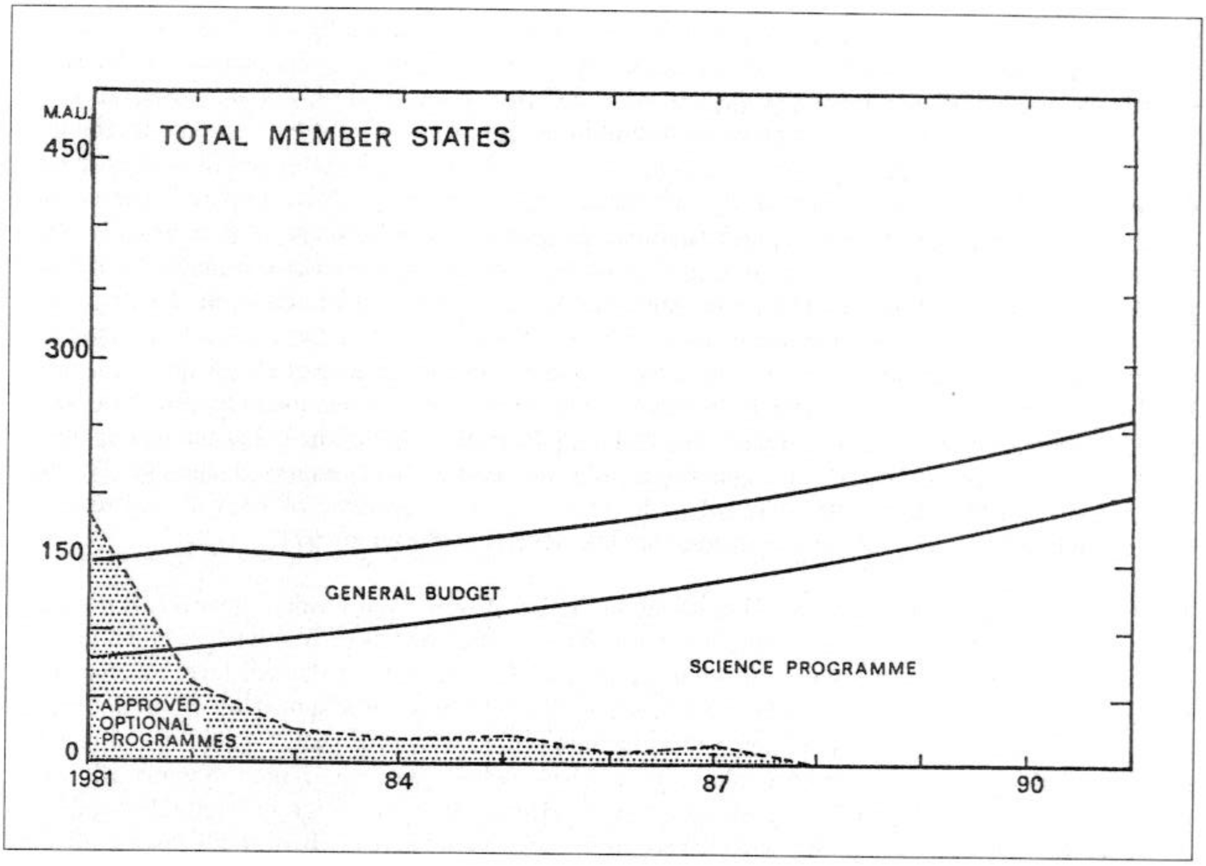

Figure 4-2: Contribution of Member States to the Mandatory Budgets, assuming an increase of 10% in the Science Budget from 1982 onwards: (ESA/SPC(79)27)

The strongest opposition against the idea of reinforcing and extending the Scientific Programme came from France and the UK. The former had always been very luke-warm towards ESA's mandatory Scientific Programme. As early as during the discussions on the first package deal, in 1971, the French delegation had insisted that the Scientific Programme should be made optional like the application programmes, and only with a drastic reduction of funds had it been finally agreed to keep it mandatory. The French space science community had never been a big user of the ESRO/ESA Scientific Programme, its efforts being developed rather within the framework of France's strong national space programme and by co-operative ventures with scientific groups in Europe, the USA and the Soviet Union.

Contrary to France, the UK had always been in favour of a cooperative European Scientific Programme funded according to a GNP contribution scale. It considered, however, that the level of the science budget could not be increased, both because of the difficult economic situation in Europe and in order to prevent its national programme from being reduced accordingly. The high inflation rate in Britain had resulted in a dramatic increase in the contributions to ESA in national currency, and all pounds given to ESA meant less funds available for national scientific activities.[413] Moreover, the British delegation argued that the cost-effectiveness ratio of ESA's science programme was unduly low compared to national programmes, and insisted that measures had to be taken to improve this ratio before speaking of increasing the budget level. Finally, the delegation opposed the funding of microgravity sciences from the envelope of the Scientific Programme.

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413 Long negotiations had been developed in 1976-1978 among ESA Member States in order to find ways to compensate the negative effects of high inflation rates in the contributions of the UK and Italy: Council, 14th meeting (28 January 19789), ESA/C/MIN/14, 17 February 1977, with attached resolution ESA/C/XIV/Res.; 23rd meeting (Part II, 6-7 April 1978), ESA/C/MIN/23(II), 20 April 1978, with attached resolution ESA/C/XXIII/Res. 5.

The two other big Member States, Germany and Italy, were generally in favour of an increase in the mandatory budget, but while the former "wanted the Scientific Programme to be effectively reinforced and extended in the medium-term", the latter stated that "in view of the financial situation it was unable to enter into any new commitments".[414] The difference is easily understood. Germany's economic strength, low inflation rate and ambitious space programme (including Spacelab utilisation) allowed its political authorities to commit themselves to support ESA activities, being aware that the country's industrial system would certainly take advantage of the Agency's contracts. Italy, on the contrary, suffered from severe economic problems and a high inflation rate; its contributions to ESA were escalating because of the changes in the conversion rates. and its industrial system was not able to keep pace with the "just return" principle.[415]

The most convinced advocates of the SAC arguments for an increase in the mandatory science budget were the smaller Member States whose scientific groups had benefited most from the ESRO/ESA programmes, i.e. Belgium, Denmark, the Netherlands, Sweden and Switzerland. "The Agency [should] remain faithful to its first calling, which was that of a scientific organisation", the Dutch argued, suggesting that ESA's overall funding should be split into three equal parts, one third going to science, one third to applications and one third to space transportation systems. The Swiss and Danes concurred, while the Belgians and the Swedes qualified their statements: the former arguing that it would be difficult to secure approval of national authorities, "if the Belgian scientific community could not be directly associated with the work done under the programme, from which during recent years it had been excluded by circumstances"; the latter observing that "financial considerations currently militated against an increase in the programme's budget envelope".[416] Finally, the Irish and Spanish delegations stated there was no way for their governments to approve additional resources to the mandatory budget.

While frustrating the SAC's and Executive's plea for a reinforcement of the mandatory Scientific Programme (and *a fortiori* rejecting the proposal that Ariane and Spacelab launches of scientific payloads be financed from outside the science budget), the Council agreed to the principle of setting up optional programmes in scientific areas connected with future applications, in particular in the field of Earth sciences. It also invited the Executive to produce a programme proposal with respect to microgravity sciences, to be eventually implemented within the framework of a Spacelab utilisation programme.

The outcome of the Council meeting was bad news for the space science community. The SAC chairman advised the SPC that during the presentation of candidate projects for ESA's future Scientific Programme, scheduled for November 1979 (see next section), "the scientific community should be informed of the fact that certain disciplines will have to be eliminated from the Agency's activities".[417] The SAC itself could only endorse the initiative of the Life Sciences and Material Sciences Working Groups to elaborate a joint research programme in microgravity sciences to be submitted to the Council outside the framework of the mandatory Scientific Programme, and put on the record that "one of its main tasks in the coming years, together with the Executive, would be to maintain efforts to convince the national delegations of the need to increase the mandatory budget".[418] These efforts, as we shall discuss in the following chapter, will be crowned with success in January 1985, when the ESA Council meeting at ministerial level in Rome endorsed the *Horizon 2000* long-term Scientific Programme, worked out by the European space science community during the previous year, and agreed that the Agency's mandatory Space Science Programme should be increased by 5% a year until 1989.

414 ESA/C/MIN/32, *cit.*, p. 5.

415 Italy's poor position with regard to the geographical distribution of ESRO/ESA industrial contracts between 1972 and 1989 is reported in *ESA Annual Report 1979*, p. 164.

416 ESA/C/MIN/32, *cit.*, pp. 5-6.

417 SPC, 21st meeting (8-9 October 1979), ESA/SPC/MIN/21, 25 October 1979, p. 7.

418 SAC, 12th meeting (5-6 December 1979), SAC(79)35, 3 March 1980, p. 9.

While failing in its aim of increasing the mandatory science budget, the SAC planning exercise of 1978 had however important consequences in shaping the future development of ESA scientific activities. The most important was the Council decision to exclude the new space science disciplines, i.e. Earth sciences and microgravity research, from the mandatory programme as well as from the terms of reference of the Science Directorate. An Earth Observation Programme and a Microgravity Programme were eventually set up to support activities in these fields, funded on an optional basis and managed by other Directorates. This did not help the case for an increase in the mandatory budget but, on the other hand, kept the ESA scientific programme well under the control of the established European space science community. By preserving the "traditional" pure-science character of the mandatory Scientific Programme in a phase of financial difficulties, the SAC and the Science Directorate wanted in fact to protect those research fields in which most of its constituency was actively involved at that time. If the support for space science of the ESRO period could not be recovered, and the SAC could not have many hopes in this respect, the ESRO spirit could however be safeguarded within the stronghold of a mandatory Scientific Programme including only the "classical" space science disciplines.

4.5 Studying future scientific projects

While discussing the long-term strategy for European space science, the ESA scientific advisory bodies were also involved in the selection process for the new project(s) to be adopted in the Agency's programme for launch in the mid-1980s. Taking into account the financial constraints imposed by the ongoing projects, the Executive estimated that a new project could be started in 1980 and a second one in 1981, and the SPC would be called on to take decisions by the end of 1979 and 1980, respectively.[419] As usual, the decision-making process had started a few years earlier, back in the ESRO times. In March 1975, in fact, ESRO's Scientific Programme Board had approved a few mission definition studies to be performed during that year.[420] First priority was given to the Grazing Incidence Solar Telescope (GRIST), a facility originally designed as the European contribution to a dedicated solar physics Spacelab mission in collaboration with NASA. After NASA had failed to confirm its commitment to this cooperative project, the LPAC had recommended that the possibility of flying the GRIST alone should be studied, in order to fill a long-standing European gap in the field of solar physics.[421] In addition, the Executive was requested to undertake preliminary studies on three topics: i.e. an astrometry mission for accurate measurements of positions and proper motions of stars; small "throw away" satellites for infrared astronomy to be launched from Spacelab; and the development in Europe of cryogenic technology for infrared astronomy missions and of superconducting magnets for cosmic-ray missions. Two other studies were undertaken in the following months, after recommendations from the SSWG and the AWG, respectively. The first was of a solar probe to be directed towards the centre of the Sun after a Jupiter fly-by; the mission objectives included the determination of the gravitational quadrupole moment of the Sun, tests of the relativity theory, and *in situ* measurements of the interplanetary medium. The second study was of an exploratory astronomy mission in the extreme ultraviolet and soft X-ray spectral region.[422]

A further extension of the Executive's study programme was agreed on in early 1976, after the Director General had urged the European space science community to suggest proposals for "scientific missions which do not have to be launched with the Shuttle". At that time, in fact, all five candidates for the next scientific project(s) to be selected in October that year depended on the availability of the

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419 ESA/SPC(78)5, 16 May 1978.

420 SPB, 11th meeting (26 March 1975), ESRO/PB-S/MIN/11, 24 April 1975. See also ESRO/PB-S(75)2, 7 March 1975.

421 See previous chapter. The GRIST was to be one of a cluster of four telescopes for simultaneous measurements of the solar radiation over a wide range of wavelengths.

422 ESA/SPC(75)5, 19 September 1975. cf. SSWG, 14th meeting (21-22 May 1975), SOL(75)9, 1 September 1975, and SOL(75)8, 28 May 1975; AWG, 15th meeting (10-11 June 1975), ASTRO(75)10, 18 September 1975. The solar probe had been originally suggested by G. Colombo (cf. SOL(75)6, 13 June 1975, annex 1).

Shuttle, either as launcher or as Spacelab's carrier. "Although we have no grounds to believe that the Shuttle might not be available at the required time", the Director General advised, "sound planning demands that alternate, Shuttle-independent scientific missions be available to the Agency".[423] In other words, the Executive wanted establish a set of contingency scientific missions in order to fill a possible gap of one or two years in the Scientific Programme, should the Shuttle be delayed. Many mission proposals were discussed by the SSWG and AWG, and four new studies were eventually approved by the SAC: a Sun-Earth Observatory and Climatology Satellite (SEOCS); a "Dumb-bell" mission, foreseeing two spacecraft linked by a wire for geophysical and magnetospheric studies; a satellite for studying variable X-ray sources; and the Extreme Ultraviolet and X-ray Survey satellite (EXUV), already recommended by the AWG and now endorsed with first priority.[424]

The complete list of the eight mission definition studies undertaken by ESA in 1975-1976 is provided in Table 4-6. According to the usual ESA procedure, it was foreseen that, following these preliminary (mission definition) studies, four missions would have been selected in Autumn 1976 for feasibility (Phase-A) studies, whose results would be the foundation for the final selection of the Agency's next scientific project(s).

Table 4-6: ESA mission definition studies in 1975-1976

Mission	Scientific objectives
Space Astrometry	Accurate measurements of positions, proper motions and parallaxes of celestial objects.
Sun-Earth Observatory and Climatology Satellite (SEOCS)	Measurement, monitoring and mapping of the Earth's radiation budget (incoming solar flux and radiation fluxes leaving the Earth to space).
Grazing Incidence Solar Telescope (GRIST)	An X-ray telescope carried by Spacelab, using the Instrument Pointing System, to observe the Sun in the 10-170 nm wavelength range, with high spatial and spectral resolution.
Extreme Ultraviolet and soft X-ray Survey Satellite (EXUV)	Astronomical observations in the 1-100 nm spectral band to study the interstellar medium, stellar atmospheres and stellar evolution.
Solar Probe	A spacecraft directed to "graze" the Sun (at a few solar radii) using a swing-by around Jupiter, to study the solar quadrupole moment, parameters related to gravitational theory (general relativity tests), and the Sun's immediate surroundings.
Infrared Satellite (IRSAT)	A satellite carrying a telescope cooled to the temperature of liquid helium to measure, in the far infrared, the spectrum and spatial distribution of the infrared diffuse flux.
Dumb-bell	Two spacecraft linked by a wire to measure the Earth's gravitational field in order to get information on plate tectonics and convective motions in the Earth's interior. Also magnetospheric and plasma studies
Transient X-ray Sources Satellite	Sky survey in order to detect, observe and monitor variable X-ray sources.

423 ESA/SPC(75)19, 5 December 1975. The candidate Spacelab projects were a laser facility for atmospheric studies (LIDAR), an infrared telescope (LIRTS) and an X-ray instrument (EXSPOS); the two other candidate projects, designed to be launched on the Shuttle, were the Out-of-Ecliptic (OOE) mission and the Hubble Space Telescope. See previous chapter.

424 SSWG, 17th meeting (29 January 1976), SOL(76)5, 1 March 1976; AWG, 18th meeting (28 January 1976), ASTRO(76)4, 5 May 1976; SAC, 1st meeting (24 February 1976), SAC(76)4, 7 April 1976. The SPC endorsed the SAC recommendations at its 3rd meeting (11 March 1976), ESA/SPC/MIN/3, 13 April 1976. The Executive's reference document, with a list of all mission proposals received, is SAC(76)1, 15 January 1976. The working groups' and SAC's recommendations are reported in SOL(76)4, 9 February 1976; ASTRO(76)3, 5 February 1976, and SAC(76)3, 27 February 1976, respectively. All of these documents are also attached to ESA/SPC(76)6, 11 February 1976, and Add. 1, 27 February 1976.

The reports on the eight mission definition studies were discussed during a symposium held in Paris on 28 to 30 June 1976. Following the symposium, on 1 July, the AWG and SSWG discussed those projects which fell within their respective competencies and issued their recommendations about which projects should be studied at Phase-A level. The following day it was the turn of the SAC to do its job.[425]

Four projects were in the field of interest of the AWG, i.e. the astrometry mission and the three projects dedicated to astronomical observations in three different regions of theelectromagnetic spectrum, respectively: the infrared (IRSAT), the extreme ultraviolet (EXUV) and the X-rays (variable sources). The first had originated within the French scientific community (the very first proposal was presented by P. Lacroute as early as March 1966), and preliminary studies had been performed during 1974 by the Centre National d'Etudes Spatiales (CNES).[426] The AWG recognised that the astrometry satellite would have "a very fundamental impact on astronomy [as] it will overcome basic problems in the fundamental system of stellar positions that have plagued astronomy for more than a century, and that have stopped developments in possibly very fruitful fields such as galactic dynamics". The Group then highly recommended a Phase-A study, whose main objective should be the technical feasibility of the required accuracy. As regards the three astronomical satellites, the AWG recommended a Phase-A study on the EXUV project: "This satellite will [...] make a survey in a spectral region that hitherto has been largely unknown [and], as in all new surveys, completely unexpected results may be obtained".[427] Two main reasons were given for discarding the IRSAT project as presently designed. Firstly, it was felt that its objectives should be redirected towards measurements of the fluctuations of the microwave background; secondly, some of its scientific goals would be resolved by the Dutch infrared satellite IRAS under development. Finally, the X-ray satellite was not regarded as being extremely fundamental.

The four other projects listed in Table 4-6 fell within the aegis of the SSWG, i.e. the Spacelab solar telescope GRIST, the climatology satellite SEOCS, the solar probe and the "dumb-bell". GRIST, if eventually adopted in the ESA programme, would have met the long-standing expectations of European solar physicists to have a dedicated European mission in their field of interest. Therefore the group advocated the scientific interest of the X-ray solar telescope and recommended the start of a Phase-A study on this instrument. The SEOCS was the second project recommended by the SSWG for a feasibility study. This satellite, the Group argued, "responds to the urgent need to obtain a better understanding of the Earth's atmosphere-surface-ocean system", a need which was recognised by the international Global Atmospheric Research Programme (GARP). The SSWG also underlined that the proposed SEOCS mission was "basically a *scientific* mission", indeed the first ESA spacecraft devoted to atmospheric science, but it recognised that, in the long run, "practical climatology and meteorology will benefit from the results".[428] While recommending these two projects for immediate Phase-A study, the SSWG did not discard the other two. Both the solar probe and the dumb-bell were considered scientifically very interesting projects, and the Group recommended that some complementary studies should be undertaken on a few critical aspects, in preparation for eventual Phase-A studies to be undertaken in the future.

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425 SSWG, 19th meeting (1 July 1976), SOL(76)14, 15 September 1976; AWG, 21st meeting (1 July 1976), ASTRO(76)10), 30 September 1976; SAC, 13th meeting (2 July 1976), SAC(76)11, 27 August 1976. The SSWG's recommendations are reported in SOL(76)12, 1 July 1976, and SOL(76)13, 5 August 1976; the AWG's recommendations are reported in ASTRO(76)9, 1 July 1976, and ASTRO(76)11, 13 July 1976; The SAC's recommendations are reported in SAC(76)10, 2 July 1976, and SAC(76)12, 1 September 1976. All of these documents are attached to ESA/SPC(76)25, 3 September 1976. These were the same meetings where the LIRTS, the Space Telescope project and the OOE mission were recommended for adoption in the ESA Scientific Programme at the end of the previous selection process (previous chapter).

426 Perryman & Hassan (1989).

427 ASTRO(76)11, *cit.*, p. 3.

428 SOL(76)13, *cit.*, p. 4, emphasis in the original.

The SAC endorsed the Working Groups' recommendations. The endorsement of GRIST, as recalled above, was a kind of a moral obligation towards the solar physics community which had strongly advocated keeping the project alive after the abandonment of the joint ESA/NASA Solar Telescope Cluster. Moreover, it was also the only important scientific project on Spacelab, after financial considerations had forced the abandonment of the infrared telescope LIRTS and the X-ray facility EXSPOS. The SAC then recognised the scientific importance of the exploratory mission to be accomplished by the EXUV satellite in a new field of astronomy, which bridged the gap between the "traditional" UV band and the medium-energy X-ray region already studied in some detail from space. Observations in the 10-1000 Å band, they stressed, would provide information on the interstellar medium, stellar atmospheres and stellar evolution. As regards SEOCS and the astrometry mission, both these projects were a novelty within the ESA scientific tradition, the former reflecting the new interest of atmospheric scientists and geophysicists in the complex phenomena which affect the Earth's climatic system, the latter involving a sector of the astronomy community hitherto alien to space technologies. The Committee, in particular, recognised the great scientific value of the SEOCS project ("an outstanding opportunity [...] to study the interactions between the Sun and the Earth up to the level of the upper atmosphere", in the words of R. Bonnet), as well as its interest in the future meteorology programme. As to the astrometry mission, the SAC considered that its technical feasibility deserved careful investigation and that the astrometry community should be encouraged to address the problems related to the required instrumentation.[429]

The feasibility studies on these four candidate projects were carried out during 1977 and early 1978 by four different teams of scientists, who defined in detail the scientific objectives and justifications, as well as the instrumental and mission requirements, while the technical, operational and managerial aspects were taken care of by ESA staff and by study contracts with industry.[430] They were reviewed by the AWG and SSWG, which confirmed their interest in these projects and suggested complementary studies in view of the final decision scheduled for the end of 1979.[431]

Two important aspects can be pointed out. Firstly, the fact that the three satellite missions (astrometry, SEOCS and EXUV) were designed for launch with Ariane, a consequence of the decision to use the European launcher for future ESA missions. This, in particular, caused an important change in the design of the astrometry mission, now renamed Hipparcos after the name of the Greek astronomer of the second century B.C. who discovered the precession of the equinoxes and prepared the first stellar catalogue based on accurate observations of star positions. The previous concept of a near-Earth spacecraft in polar Sun-synchronous orbit was abandoned and the spacecraft was designed for being operated in geostationary orbit, thus improving the chance of sharing an Ariane launch with another (presumably application) satellite. The main change regarded the attitude control system: in fact the original idea of passive stabilisation by the Earth's gravity field had to be abandoned because the gravitational stabilising force is too small at the geostationary distance from Earth, and an active attitude control was adopted, based on the use of reaction wheels in the spacecraft. This system, however, posed severe technical problems because the small disturbances from the mechanical bearings (the so-called "attitude jitters") might have jeopardised the astrometric goal of achieving angular measurements in the range of 2 milliarcsec. It was only in 1982, two years after the mission had definitely been adopted in the ESA programme, that the problem of "attitude jitters" could be solved via the introduction of the attitude control by cold-gas jets by the satellite prime contractors.[432]

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429 SAC(76)11, *cit.*, p. 8.

430 ESA/SPC(78)4, 12 May 1978.

431 AWG, 31st meeting (9 May 1978), ASTRO(78)7, 2 August 1978; SSWG, 27th meeting (8-9 May 1978), SOL(78)6, 13 June 1978. Also ASTRO(78)8, 31 May 1978, and SOL(78)8, 8 June 1978, both attached to SAC(78)12, 8 June 1978.

432 Perryman & Hassan (1989), p. 81. The EXUV spacecraft, whose planned orbit was highly eccentric (apogee about 120,000 km), was also originally designed for a tandem launch on Ariane with an application spacecraft aimed at geostationary orbit, but eventually a dedicated Ariane launch was envisaged and the spacecraft design parameters were established accordingly.

The second aspect is the recognised high operational costs for GRIST. It was evident that the development costs of the instrument plus the costs for a minimum programme of three Spacelab flights would be disastrously high, and it became necessary for the SAC to reappraise the mission, unless an agreement could be reached with NASA for a free flight in exchange for data, "which was however not considered likely". Following a suggestion from W. Axford, the SAC recommended that the possibility of a "descoped" GRIST be studied, "in view of the importance of including solar physics in the ESA programme and the fact that NASA still considered GRIST to be part of the Solar Telescope Cluster".[433] The study was eventually undertaken, but after NASA had confirmed that it was not interested in a cooperative mission, it was definitely removed from the list of candidate missions.[434]

4.5.1 The comets and the Moon

In the second half of 1978, an important new element was introduced into the decision-making process. Within the framework of a general re-organisation of the planning and selection procedures for scientific projects, the Executive informed the Working Groups and the SAC that it was possible to undertake Phase-A studies for two new projects to be added to the list of candidate missions for the end-1979 selection.[435] The AWG and the SSWG were then requested to make their recommendations for potential new candidates, on the basis of the pool of mission proposals already discussed within the framework of their long-term planning. The former decided to maintain its emphasis on the two projects within its competence already under study, i.e. Hipparcos and EXUV, and recommended that the Executive should perform complementary studies on these rather than study any further project at Phase-A level.[436] The SSWG, on the contrary, found itself in the embarrassing situation of setting *a priori*ty among three mission proposals which it had already considered equally interesting: a cometary mission, an orbiting lunar observatory and an oceanography satellite.

The idea of a cometary mission had been discussed in the early days of ESRO as the second large project after the ill-fated Large Astronomical Satellite (LAS). Subsequently, the SSWG had recommended such a mission in its 1973 report to the LPAC on long-term priorities in the areas within its competence. The Working Group, in particular, expressed at that time its interest in a mission to comet Encke currently under study in Germany as a follow-up the US/German HELIOS programme. At the insistence of the German delegation in the Scientific Programme Board, the cometary mission to Encke was submitted to a mission definition study during 1974, but it was eventually abandoned because of its high cost.[437] After the creation of ESA, the SSWG made a case for Europe to undertake deep space missions in its 1976 report on long-term scientific strategy. In this framework, two possibilities for a cometary mission were suggested: firstly, a cooperative mission with NASA, e.g. a dual spacecraft mission in which ESA would provide a simpler daughter spacecraft; secondly, a purely ESA mission to several comets, using the Earth or Venus to make the required trajectory changes.[438] By mid-1978 the first possibility became a concrete option when NASA proposed to Europe to

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433 SAC, 12th meeting, 19 June 1978, SAC(78)15, 21 July 1978, p. 6.

434 ESA/SPC(78)25, 27 October 1978; SPC, 18th meeting (23-24 January 1979), ESA/SPC/MIN/18, 22 February 1979, p. 6. As a matter of fact, new hope of including GRIST again in the selection process arose during the SAC mission to NASA in October 1979 (fn. 52), when the American space agency informed that there was a possibility of flying in the same Spacelab payload (without charge to ESA) the GRIST and an American Solar Optical Telescope (SOT). This possibility, however, did not materialise. Cf. SAC(79)24, 11 September 1979, SAC(79)32, 29 November 1979, and SAC(79)34, 7 December 1979.

435 The new procedures, which aimed at shortening the period between conception and approval of new projects, are described in ESA/SPC(78)17, 9 October 1978, reproduced with two minor changes in ESA/SPC(78)17, rev. 1, 16 November 1978. They reflected the change in the ESA Directorate structure which gave responsibility for studying future scientific projects to the Directorate of Scientific Programmes, as discussed above.

436 AWG, 32nd meeting (13 June 1978), ASTRO(78)11, 5 July 1978. Cf. also ESA/SPC(78)24, 18 October 1978.

437 See previous chapter. Cf. SSWG, *Priorities for the Eighties*, SOL(73)16, December 1973. The possibility of a special project mainly funded by Germany was also discussed but could not be realised.

438 SSWG, *An approach to long range planning 1980-1990*, Vol. I, SOL(76)9, September 1976.

cooperate in a mission to comet Tempel-2 to be launched in 1985. The NASA project foresaw a large spacecraft driven by a solar-electric propulsion system (SEPS) to a rendezvous with the comet during its 1988 apparition; a passive probe provided by ESA would be released from the main spacecraft to meet comet Halley at the end of 1985.

A workshop on cometary missions was held in April 1978 in Darmstadt, which was attended by more than 60 European scientists and whose results were summarised as follows:

> *From this meeting, it was clear that the European cometary community is growing very fast, because space scientists not previously involved in cometary studies realised that they could exercise their expertise in one of the many aspects of a cometary mission. [...] It was clear that a good deal of instrumental expertise does exist in Europe, in all domains addressed [...] It was concluded that a cometary mission is mature enough to drive in Europe a tremendous interest among many scientists of various fields.*[439]

The advocates of the cometary mission insisted that, in the event that the NASA rendezvous mission should be postponed, ESA should anyway undertake a purely European ballistic mission, using Ariane to launch a space probe aiming at flying-by two comets (or a comet and an asteroid) with the help of an Earth-gravity assist.

Their plans, however, were opposed by those scientists who argued that Europe should enter the field of planetary exploration via a mission to the Moon, more precisely a Polar Orbiting Lunar Observatory (POLO) aimed at "geochemical and geophysical mapping of the whole surface of the Moon, including the far-side and the polar regions". The report of a meeting held in Paris in April 1978 goes on as follows:

> *There exists a broad well-defined scientific community in Europe which has already been involved in NASA lunar programs and therefore is acquainted with problems of lunar research. About 30 laboratories in Europe have been involved in lunar sample analysis, lunar data interpretation and synthesis, or even directly participating as investigators in various missions to the Moon. [...] Thinking of future planetary missions, a POLO could be the ideal precursor [as] its instrumentation could be adapted to other planetary orbiters, like a Mars or Mercury polar orbiter and precursor for future lunar exploration and utilisation. [...] It is a mission that can be done within the budgetary constraints of ESA in the next decade as a fully European enterprise but not excluding co-operation with NASA.*[440]

The third mission had been recommended by the SSWG's Panel on Earth Sciences, following a workshop on Space Oceanography, Navigation and Geodynamics (SONG) organised at Schloss Elmau in January 1978. This was a three-axis-stabilised Long-Life Oceanographic and Ice Dynamics Satellite (LLOIDS), to be launched by the end of 1985 into a near-polar orbit with an altitude of about 1000 km. The general objectives of this mission were to provide global information on ocean surface phenomena (general dynamics of the oceans, tidal dissipation, interaction between the oceans and the atmosphere) and to measure the bulk change of ice caps.[441]

As we have anticipated, the SSWG did not award any priority among these three projects, all being considered of comparable scientific value and each of them being supported by an important constituency. In June 1978, however, the Group was requested to indicate which of the three project studies should be started first, and performed at an accelerated pace (Phase-A level) in order that it might be included as a candidate in the decision cycle for selecting ESA's next scientific project at end-1979. The two other studies would normally be performed at mission definition level, on a time

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439 SOL(78)8, 8 June 1978, annex 5, p. 3.
440 SOL(78)8, *cit.*, annex 6, p. 2.
441 SOL(78)8, *cit.*, annex 7.

schedule compatible with the following decision point at the end of 1980.[442] The real contest, actually, was between the POLO project and the cometary mission, as the LLOIDS was not presented as a candidate for such a quick study. While, in fact, the Earth sciences were already covered by the SEOCS in the list of candidate projects, an exploratory mission to a solar system body, either the Moon or a comet, was a real first in the history of Europe in space. Here is a summary of the main arguments presented by the supporters of the two options, as recorded in the final resolution.[443] The first two are from the comet supporters, the following three are from the moon-lovers:

The exploration of the comets is an entirely new and very appealing scientific subject and, moreover, a cometary mission would look attractive for the general public.

A decision in favour of POLO would automatically exclude the possibility of participating in the Halley/Tempel-2 mission because of the tight time schedule imposed by the launch window in 1985; on the contrary, giving priority to the cometary mission would not exclude the lunar mission for which a decision would be delayed by one year and that, in any case, was not constrained by a launch window.

The foregoing argument is hardly convincing; in fact, owing to the overall constraints of the ESA programme, it is very unlikely that a second project in planetary exploration would be selected one year after the selection of the cometary mission.

The lunar polar orbiter is scientifically very good, it can easily be launched by Ariane, and the technical risks are very limited; on the contrary, several managerial problems are to be expected for the joint ESA/NASA cometary mission, while a purely European fly-by mission would have a poor scientific return because of the short duration of the encounter.

A cooperative venture with NASA would have a twofold disadvantage: firstly, coming after the Space Telescope and the Out of Ecliptic mission, the joint cometary mission would make the ESA Scientific Programme dangerously dependent on the US space policy; secondly, because of the limited contribution of ESA to a common project (estimated at 20 to 25%), the participation of European scientists to the mission's scientific harvest would be limited as well.

After two days of lively discussion, a general consensus could not be reached and a vote had to be taken. The result showed dramatically the discord within the Working Group, reflecting the existence of substantial communities supporting both planetary missions: six votes were in favour of the lunar polar orbiter, four in favour of the cometary mission, two members abstained. As a consequence, this was the obvious conclusion — if only one mission could regretfully be studied within the time frame of the decision cycle ending in late 1979, then the POLO mission should have priority. Halley's comet was definitely lost.

The minutes do not inform us about the votes expressed by the twelve SSWG members participating in the meeting, but J.-L. Bertaux, from the French CNRS' Service d'Aéronomie in Verrière-le-Buisson, and U. Fahleson, from the Royal Institute of Technology in Stockholm, asked that their dissent from the majority opinion be explicitly reported. A third vote in favour of the cometary mission can be ascribed to H. Fechtig, from the Max-Planck-Institut für Kernphysik in Heidelberg, a

442 SSWG, 28th meeting (21-22 June 1978), SOL(78)11, 10 August 1978.
443 SOL(78)10, 22 June 1978.

specialist in mass spectrometry of meteoritic material and interplanetary dust, and an ardent advocate of cometary studies.[444]

This was not the end of the story, however. The supporters of the comets, in fact, had a powerful ally in ESA, namely E. Trendelenburg, and an influential advocate in the SAC, namely W. Ian Axford, the Director of the Max-Planck-Institut für Aeronomie in Lindau, where several research groups were already designing instruments for the envisaged cometary mission. They succeeded in convincing the SAC chairman R. Bonnet that the matter deserved further discussion, and thus the issue of priorities for future studies was put on the agenda of the SAC meeting scheduled for 28 September. The timing was quite appropriate: NASA had confirmed its plans for its 1985 cometary rendezvous mission, and a European team was expected in Washington on 11-12 October to discuss the technical and managerial aspects of the envisaged Tempel-2/Halley dual-spacecraft mission.[445]

At the SAC meeting, Trendelenburg pointed out that "letters had been received from European scientists expressing disappointment at the outcome of the study priority set up by the SSWG", and invited the Committee to "act as an arbitrator in this case and to express a view as to whether the priority set by the SSWG should be maintained". After extensive discussion, the SAC reversed the SSWG priority and recommended that a study on the joint ESA/NASA cometary mission be started immediately, "with the goal of being ready for a decision by the end of 1979". At the same time, it definitely excluded the possibility of studying a purely European fly-by mission.[446]

In the following days the protests of the supporters of the lunar mission could not prevent Trendelenburg's Directorate from undertaking intensive studies in-house and with the Americans on the Halley probe to be carried on NASA's mother spacecraft to Tempel-2, for what was now called the International Cometary Mission (ICM). Several members of the SSWG blamed the SAC for acting "in an undemocratic manner", some explicitly challenging its right to give advice "independent of and even in contradiction of Working Groups' recommendations". These arguments, however, could not change the situation. Bonnet claimed that the SAC had in fact acted in accordance with its procedures in making its recommendation to the Executive, "which the Executive had thought it correct to pursue". Trendelenburg, for his part, stated that "the Executive could if it deemed it necessary, or had any grounds for disagreement with the Working Groups' views, seek the advice of the SAC, as the senior scientific advisory body".[447]

4.6 The selection of ESA's next scientific mission

The decision on ESA's next scientific mission was eventually postponed to February 1980 in order to fit within the American policy-making. In the USA, in fact, the cometary mission was in competition with a Venus Orbiter mission, both of them being launch-window dependent, and the probability of the former being approved by NASA and the Congress was hardly higher than 50%. A first indication as to whether the ICM would receive a positive response was expected by January 1980, if in the NASA budget presented by the President to the Congress there would have been a request for the development of the SEPS technique required to drive the spacecraft towards its rendezvous with Tempel-2. At the same time, in order to comply with the NASA selection procedures for the instruments to be included in the payload of scientific satellites, the SAC agreed to deviate from the

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444 Calder (1992), p. 21-22. Calder's lively book is essentially based on personal interviews with the main protagonists of the history of the Giotto mission. He informs us that the main lobbying for POLO came from the British scientists.

445 The ESA/NASA October meeting is reported on in ESA/SPC(78)25, *cit.*, p. 3. cf. also Calder (1992), p. 20.

446 SAC, 14th meeting (28 September 1978), SAC(78)21, 20 November 1978, pp. 3-4. Only four members of the SAC attended the meeting, namely Bonnet, Axford, Pinkau and Wiin-Nielsen, together with the chairmen of the AWG (Setti), SSWG (Petit) and MSWG (Weiss). The two other members, Colombo and Wolff, were unable to attend.

447 SAC, 15th meeting (19 December 1978), SAC(78)23, 8 January 1979, pp. 2-3.

usual ESA policy of issuing an Announcement of Opportunity (AO) to the scientific community only after project approval. NASA, in fact, planned to release an AO for the ICM in late Spring 1979; therefore, either ESA would have to issue a joint AO with NASA at that time, or the European scientific community would be unduly penalised in the final definition of the payload. There was no choice but to accept the first option, even though "experimenters wishing to bid for space on other candidate ESA satellites might feel themselves being at a disadvantage".[448] The SPC endorsed the SAC decision but made it clear that "[this] did not imply that the SPC accorded priority to the cometary mission, [and] the issuing of the AO should not be invoked as a reason for giving the cometary mission priority over other candidates".[449] This was quite fair; nevertheless the preparation of experiment proposals in view of the forthcoming AO (eventually issued in October) did reinforce the cometary scientific constituency already established in Europe.

After the dismissal of GRIST and the addition of the ICM, three other changes occurred in the list of candidate projects for the February-1980 selection. Firstly, the elimination of SEOCS from the list, as it was agreed that this project should be considered as part of the optional Earth-observation programme, and then funded from outside the mandatory science budget. Secondly, the addition of a general Spacelab facility for life-sciences experiments, called Biorack. This was a set of holding units and incubators for plants, cells and tissues, and lower vertebrates, similar to those widely used in standard laboratory research. The Biorack, whose cost was estimated at less than 5 MAU, had been strongly recommended by the LSWG and endorsed by the SAC, and the SPC had eventually agreed that it be included in the list of candidate projects for the mandatory programme.[450] Finally, the SAC and the SPC endorsed the Executive's proposal to consider for inclusion in the programme the utilisation of the GEOS spacecraft for a bold scientific mission to be launched at no or very low cost on one of the Ariane test flight. This so-called GEOS-3 mission would aim at exploring the Earth's magnetospheric tail (i.e. the magnetospheric region in opposition to the Sun) beyond the orbit of the Moon, at about 230 to 260 Earth radii from the Earth.[451]

The list of candidate projects at end-1979 is reported in Table 4-7.[452] According to the usual ESA procedure for the selection of new scientific project(s), the results of the Phase-A studies were to be presented to the scientific community and discussed at a symposium scheduled for 22 January 1980 in ESTEC. Following this presentation, the Working Groups would be called to discuss the projects within their competence and issue their recommendations. Subsequently, it was up to the SAC to make its recommendation to the SPC, whose final decision was scheduled for 4-5 March.

4.6.1 The comet and the stars: telex lobbying

When the ESTEC symposium was being prepared, it was announced in the USA that the required funding for the SEPS had not been included the President's budget. As solar electric propulsion was an essential element of the Tempel-2/Halley mission, it had to be acknowledged that the basis for the cooperative cometary mission no longer existed.[453] Facing the new situation, the Executive decided to resume a proposal, originally made in early 1979 by G. Colombo, which combined the GEOS-3 project and a mission to Halley. This mission, called HAPPEN (Halley Post-Perihelion Encounter), foresaw that the GEOS-3 spacecraft, instrumented for Earth-magnetotail research but suitably

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448 SAC, 16th meeting (22-23 January 1979), SAC(79)4, 9 March 1979, p. 6.

449 SPC, 18th meeting (23-24 January 1979), ESA/SPC/MIN/18, 22 February 1979, p. 6.

450 SAC, 14th meeting (28 September 1978), SAC(78)21, 20 November 1978; SPC, 17th meeting (14 November 1978), ESA/SPC/MIN/17, 5 December 1978. Cf. ESA/SPC(78)19, 16 October 1978.

451 The GEOS-3 concept was first presented in ESA/SPC(78)26, 6 November 1978, and add. 1, 10 November 1978. Several mission profiles were studied in the following months in consultation with the SSWG. Cf. SAC, 6th meeting (22-23 January 1979), SAC(79)1, 9 March 1979, pp. 6-7; SSWG, 31st meeting (3-4 May 1979), SOL(79)10, 25 June 1979.

452 The reports on the Phase-A studies for the classical science projects, all dated December 1979 and coded SCI(79)9 to 12, are available in *D/Sci archives*. The report on the Phase-A study for Biorack, prepared under the responsibility of the Directorate of Future Programmes, is coded DP/ST(80)1.

453 The history of US plans for a cometary mission are discussed by Logsdon (1989).

Table 4-7: Candidate projects for adoption in the ESA Science Programme (February 1980)

Mission	Scientific objectives and technical characteristics
Space Astrometry (Hipparcos)	Accurate measurements of parallaxes, proper motions and positions of about 100,000 selected stars. The scientific payload, including a 25 cm Baker-Schmidt telescope, would be mounted on a three-axis-stabilised spacecraft launched by Ariane into a circular geosynchronous orbit.
Extreme Ultraviolet and Soft X-ray Survey Satellite (EXUV)	Search for extreme UV points and nebular sources in the band 100-1000 Å, and mapping of the diffuse emission in the band 10-250 Å. Two telescopes mounted on a three-axis-stabilised spacecraft launched by Ariane into a highly eccentric (apogee 120,000 km), low inclination orbit.
International Cometary Mission (ICM)	A joint NASA/ESA mission to rendezvous with comet Tempel-2 in 1988 and to fly-by comet Halley in 1985. A main spacecraft provided by NASA and a Halley probe provided by ESA launched together from the Shuttle, using an Inertial Upper Stage, and driven by an SEP system. At Halley encounter, the probe is released from the spacecraft and targeted to approach to within a few hundred kilometres of the comet's nucleus.
Earth's Magnetospheric Tail Explorer (EMTEX, formerly GEOS-3)	Exploration of the Earth's magnetotail beyond the orbit of the Moon, perhaps as far as 260 Earth radii from the Earth. A spacecraft based on the GEOS-1 and -2 design, and using a certain amount of hardware remaining from the GEOS programme, would be launched by Ariane into the geomagnetic tail. Two orbit options were foreseen.
Biorack	A Spacelab multi-user facility for research in the areas of developmental and genetics studies in biology, with accommodation for cells, tissue, micro-organisms, small insects, etc., and enabling these specimens to be exposed to weightlessness and cosmic radiation.

reconfigured, could be targeted to intercept the tail of comet Halley at the end of its magnetotail mission. The encounter with Halley would occur in March 1986, after it had rounded the Sun, instead of the pre-perihelion encounter in November 1985 foreseen in the ESA/NASA mission.[454]

The GEOS-3/Happen mission proposal was discussed at the ESTEC symposium in January, and it was supported by the GEOS experimenters: "The HAPPEN proposal would, after the likely cancellation of the ESA/NASA comet mission, present a unique opportunity for cometary plasma research", they recommended to the SSWG.[455] The Working Group, however, did not agree. At their meeting of 24 January, the SSWG strongly recommended GEOS-3 for selection for the new ESA scientific project, but rejected the HAPPEN extension: "Opinions were somewhat divided", the SSWG concluded, "but, on balance, [...] the probable science to be achieved by this mission did not justify the estimated [additional] expenditure of 30 MAU".[456] The comet was thus lost again. The minutes of the meeting do not give details of the discussion, but several members regretted that, after the loss of

[454] The HAPPEN mission had been discussed by the SSWG at its 31st meeting (3-4 May 1979), SOL(79)10, 25 June 1979, but it had been discarded in view of the on-going planning for the ESA/NASA (Tempel-2/Halley) cometary mission. Cf. the SSWG's recommendation reported in SOL(79)9, 4 May 1979. The GEOS-3/HAPPEN mission as proposed by the Executive is described in SCI(80)2, January 1980.

[455] Copy of this recommendation, dated 24 January 1980, typewritten and signed by nine GEOS experimenters, is in *D/Sci archives*.

[456] SOL(80)3, 29 January 1980.

POLO, the crisis of the cometary mission had caused again a situation in which no planetary mission was left for decision, and the Working Group had to continue to recommend only projects in the same discipline of magnetospheric research.[457]

Opinions were also divided within the AWG, whose task it was to award priority to one of the two projects under its competence, the astrometry satellite Hipparcos and the EXUV mission. Of the 13 members attending the meeting, 8 voted in favour of Hipparcos and 5 in favour of its competitor. While both missions were considered as promising good scientific return, two main arguments were raised against EXUV. Firstly, the controversial combination of two experiments in the same payload; secondly, the fact that the scientific objectives of this mission were being covered by two different missions planned by NASA and Germany, respectively. In support of Hipparcos there was a large constituency, including both the astronomer community (a resolution supporting the astrometry mission had been adopted in August 1979 by the International Astronomical Union's General Assembly) and the scientific community interested in geodesy (precise astrometric data are required for measuring the Earth's rotation and the shape of its surface).[458]

Given the results of this formal consultation, the task for the SAC was now to decide on two main questions. Firstly, whether to recommend GEOS-3 or Hipparcos for immediate adoption in the ESA Scientific Programme; both projects, in fact, could not be accommodated in the 1980 budget, but the loser would anyway remain in the list of candidate projects for the next selection in early 1981. Secondly, whether to recommend Biorack for funding out of the science budget. The latter had been strongly recommended by the LSWG, and its scientific interest was not questioned, but its inclusion in the mandatory budget was not politically innocent *vis-à-vis* the on-going debates about Spacelab utilisation.[459]

The SAC meeting was scheduled for 6-7 February, with the German physicist Klaus Pinkau replacing Bonnet in the chair (Table 4-8).[460] There were ten days for the supporters of the cometary mission to rescue their project. Insisting on the GEOS-3/HAPPEN concept was out of the question, after the SSWG resolution. In fact, the combination of two different objectives within one mission could be criticised both from the scientific and the technical points of view: The GEOS-3 spacecraft could not be instrumented appropriately for studying the comet without detracting substantially from the effectiveness of the magnetotail mission, and important instruments for cometary studies such as a camera, a neutral mass spectrometer and an instrument for measuring dust composition could not be included in the payload. Moreover, the cometary mission had a definite launch window in 1985, which could only be achieved if it was adopted now. As a consequence, the adoption of Hipparcos would definitely have killed GEOS-3/HAPPEN, while, on the contrary, GEOS-3 alone could still remain in the list of candidate projects for the early-1981 selection, which the magnetospheric scientists certainly preferred. In conclusion, a new proposal for a cometary mission was required.

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457 SSWG, 33rd meeting (24 January 1980), SOL(80)4, 7 May 1980. An explicit criticism to the Executive for introducing GEOS-3 in the decision process instead of concentrating its efforts on assessment studies of POLO in order to have this project ready for a decision at the same time as the cometary mission was made by G. Neukum in a letter to G. Haskell (SSWG Secretary), 20 February 1980, *D/Sci archives*.

458 ASTRO(80)2, 30 January 1980. Cf. AWG, 39th meeting (24 January 1980), ASTRO(80)3, 21 March 1980.

459 The various financial implications arising from the selection of any of the candidate projects (including EXUV) were described by the Executive in SAC(80)5, 31 January 1980. The LSWG recommendation on Biorack is reported in LIFE(80)1, 30 January 1980.

460 SAC, 21st meeting (6-7 February 1980), ESA/SAC/MIN/21, 17 April 1980.

Table 4-8: SAC membership and Working Group Chairmen in 1980

Members of the SAC:	K. Pinkau (chairman)
	A. Egidi
	H. Elliot
	J. Kovalevsky
	G. Tammann
	H. Weiss
Chairmen of Working Groups:	
Astronomy	C. de Jager
Solar System	A. Gabriel
Life Sciences	H. Wolff
Material Sciences	Y. Malmejac
Earth Observation	E. Raschke
Space Telescope	F. Pacini

The proposal came in a telex to Trendelenburg from an impressive group of German physicists, many of whom were already involved in designing experiments for the ill-fated ESA/NASA mission. "Comet Halley will be the only comet in this century that is active enough to make it an outstanding target for a flyby mission", they wrote, and then made their proposal as follows:

> *A separate spacecraft, such as of GEOS type, solely dedicated to cometary science is much more adequate. This spacecraft could be launched together with GEOS-3 in its original version. The production of two similar spacecraft and their simultaneous launch will probably be only slightly more expensive than the figure (60 + 30 MAU) quoted for the HAPPEN mission. The extra cost over GEOS-3 should be comparable to that of the probe (50 MAU) for the NASA/ESA mission.*[461]

There were several advantages in launching a pure comet probe jointly with GEOS-3, they argued. Firstly, the use of two similar (existing) spacecraft for the magnetotail and the comet reduced the cost of each spacecraft; secondly, a dual launch would use the full capability of Ariane, help optimising mission planning, and cause no extra launch costs for the cometary mission; last but not least, ESA would fly its first interplanetary mission, a purely European cometary mission, for the extra cost of an inexpensive satellite.

Trendelenburg was delighted to receive this telex, but his staff had just one week to work out a credible technical proposal to be presented at the forthcoming SAC meeting. Only a rough outline could be prepared, which could hardly win approval against Hipparcos. The latter had a convinced advocate in the SAC, the French scientist J. Kovalevsky, who had contributed to the Phase-A study. The crucial question was whether the scientific appeal of the cometary mission was sufficient to justify a delay in taking a decision on the next project, i.e. until the technical and scientific feasibility

[461] The telex, dated 29 January 1980, was signed by 19 physicists, including H.U. Keller, W.I. Axford, L. Biermann, H. Fechtig, R. Lüst, F. Neubauer and U. von Zahn. A copy of this telex, as well as a few others sent by other scientists to protest against the SSWG negative decision on the GEOS-3/HAPPEN proposal, are in *D/Sci archives*. cf. Calder (1992), pp. 32-34.

of this new proposal could be established beyond doubt. Another three-month study was required, Trendelenburg told the SAC.[462]

After presentations of all candidate projects (including EXUV) and some general discussion, it took two restricted sessions for the SAC to reach agreement on the final resolution, ... and the comet mission was rescued. The SAC, in fact, unanimously recommended that the proposed Comet/GEOS-3 dual mission be selected as the next scientific project, provided that, within a period of three months, the scientific value of the project could be confirmed, its technical feasibility demonstrated, and the estimated cost not be higher than 120 MAU.[463] The engineers hurried to work, and the cometary mission acquired a charming name: Giotto. This was motivated by the fact that the earliest realistic portrait of Halley's comet was painted by the great Italian artist in one of the beautiful frescoes in the chapel of the Scrovegni family in Padua. The star of Bethlehem in the painting of the Adoration of the Magi, in fact, is but a faithful representation of the famous comet, as Giotto saw it during its sensational appearance in 1301.

There are three main reasons for the SAC decision. The first is obviously the firm commitment of Trendelenburg's Scientific Directorate to undertake the cometary mission. While the SAC was formally independent in making its recommendations, nevertheless it was the Directorate which provided the necessary inputs in terms of technical assessments and financial estimates of mission proposals. Had Trendelenburg not decided to hurry studies on the GEOS-3/Happen project and then on the purely cometary mission, and had he not insisted on submitting both projects to the SSWG and the SAC, the Halley comet mission would definitely have been lost to ESA. Public relations considerations seem to have had a major role in Trendelenburg's efforts in supporting the cometary mission. Visiting a famous comet and sending close-up images of its nucleus to TV screens on Earth was certainly more appealing to popular eyes than accurately measuring star positions, and would add glamour to the European space effort which lacked space walks and footsteps on the Moon. If, after all, the ESA programme depended on taxpayers' money, why not offer them a colourful vision of the wonders of nature in addition to esoteric papers in scientific journals?[464]

The second reason was the strong interest of the magnetospheric physics community, in particular the GEOS-3 experimenters, in linking their pet project to an independent cometary mission. From the scientific standpoint, during Giotto's long journey to its encounter with Halley, important data on the interplanetary medium could be obtained that would enhance the scientific value of GEOS-3. This was not the only element, however. The GEOS-3 constituency, in fact, could hardly win a competition against the powerful astronomy community supporting Hipparcos, but their chances would certainly be higher if the magnetospheric mission could be coupled to such a stimulating objective as studying a comet *in situ*,. Facing the challenge of a technically sophisticated astronomical mission, the old tradition of ESA magnetospheric studies would be dramatically reinforced by its association with Europe's first interplanetary mission.

Last but not least, there was some weakness in the Hipparcos project itself. Some technical uncertainties regarding its feasibility had been expressed in the Phase-A report; the question of the complex data handling had not yet been settled; and the high costs of the project had been recognised, in particular because it was suggested that the payload should be financed by ESA. No unanimous consensus, as we know, had been expressed by the AWG on awarding priority to Hipparcos against EXUV, and an influential SAC member, the British physicist H. Elliot, argued that "a definite decision

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462 SAC, 21st meeting (6-7 February 1980), ESA/SAC/MIN/21, 17 April 1980.

463 SAC(80)7, 11 February 1980. No minutes of the restricted sessions are available, but Kovalevsky asked that its doubts that in-depth studies on the combined Comet/Geos-3 mission could be done in a three-month period be recorded.

464 Calder (1992), p. 23. It is worth recalling here that the public relations aspect of the Giotto mission was very badly managed by ESA and the scientists involved in the experiments. On "the night of the comet", while everybody was expecting to see beautiful colour pictures of the comet nucleus, what was shown on several hundred million television screens was a series of coded isophotes totally incomprehensible to the public.

to go ahead with Hipparcos could not yet be taken because of the absence of complete confidence in the technology".[465] These doubts were reflected in the SAC resolution, which requested that the three-months period should also be used for further technical studies on the astrometry mission, and to find ways and means whereby the payload could be funded nationally. The SAC clearly stated that, in case the comet mission should not be feasible, Hipparcos should then be the first choice (against EXUV and GEOS-3 alone) only provided that the payload was funded outside the mandatory budget. The resolution then concluded:

> *In the event that the Hipparcos payload would need to be funded within the mandatory programme, the SAC was divided as to whether Hipparcos should then remain the Agency's choice or if EXUV should be carried out because this mission was considered by some members to be just as interesting.*[466]

A last word must be said regarding Biorack. The SAC did not endorse this project at this stage but requested the Executive to undertake a further study to firm up the estimated cost of the facility, and to issue an Announcement of Opportunity in order to establish a possible payload for the first Biorack mission: "The recommendation whether to go ahead with the funding of Biorack and its ancillary equipment would be made following evaluation of the science proposed".[467] In the event, Biorack was included in the optional Microgravity Programme, established in February 1982.

The SAC decision came as a bombshell in the scientific community. Pinkau and Trendelenburg, as well as the SPC chairman and the ESA Director General, were flooded by telexes and letters from all over Europe, blaming, on the one hand, the unusual and "arbitrary" procedure of recommending a project not supported by technical studies and not previously discussed by the SSWG, and claiming, on the other, the great support that Hipparcos enjoyed within the scientific community. The chairman of the Hipparcos Consortium, P.L. Bernacca, wrote that 170 research proposals for the astrometry mission had been presented by 125 astronomers from 12 countries, recalling that 24 institutes from 8 countries were available to put manpower into hardware and software activities, and 5 were already working on aspects of hardware and software using their own funds. The cometary lobby was just as active, however, and many telexes arrived expressing satisfaction with the SAC decision and whole-hearted support for Giotto, "which is a once in a lifetime opportunity".[468]

4.6.2 The SPC decision

It was up to the Science Programme Committee, whose meeting was scheduled for 4-5 March under the chairmanship of the Italian physicist Edoardo Amaldi, to say the last word on the selection of ESA's next scientific project. In this political body, made up of national delegations and where senior scientists and space policymakers sat side by side, even an appealing scientific idea could not do without sound technical and financial credentials, all the more so as the idea was so controversial. Pending the results of the on-going study, the information Trendelenburg could provide in support of the Director General's formal proposal to select the combined Giotto/GEOS-3 mission was rather poor.[469] In fact, the lack of information and the hurried decision which the SPC had to confront was

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465 ESA/SAC/MIN/21, *cit.*, p. 4.

466 SAC(80)7, 11 February 1980, p. 2.

467 *Ibid.*

468 All telexes are in *D/Sci archives*. The last quotation is from one signed by a group of physicists of the M.P.I. für Kernphysik in Heidelberg and the universities of Bochum and Bonn. The "arbitrariness" of the SAC action was blamed by SSWG members A. Brahic and A. Cazenave, from Toulouse. "Great enthusiasm" was expressed, on the contrary, by the original proponents of the dual Comet/GEOS-3 mission. The rationale for the SAC decision is expressed in a letter sent by Pinkau to the AWG chairman C. de Jager, dated 17 March 1980, a copy of which is in *D/Sci archives*.

469 The Working Groups and the SAC acted as advisory bodies to the DG, and it was the latter who formally made proposals to the policymaking SPC. The terms of reference of the ESA scientific advisory structure are described in ESA/ADMIN(79)10, 22 May 1979. The DG's proposal to the SPC is in ESA/SPC(80)4, 13 February 1980.

regretted by most SPC delegations, and the French explicitly questioned the Executive for presenting a proposal which was not "politically advisable since it had not met with a general consensus in the scientific community and could possibly lead to a complete split in the Committee".[470] Only Germany and Sweden advocated the dual Giotto/GEOS-3 mission, as was to be expected given the involvement of German and Swedish scientists in the former NASA/ESA cometary project and magnetospheric studies, respectively. France (of course), Belgium, the Netherlands, Denmark, Italy, Switzerland and Spain supported Hipparcos. The British delegation requested that the decision be deferred until more information was available on both Hipparcos and the combined Giotto/GEOS-3 mission; and the Irish said that among Irish scientists there was an equal interest in both projects.

The long discussion in the SPC brought into evidence two elements: firstly, that if a vote had been taken, then Hipparcos would have been chosen as ESA's next scientific project; secondly, that such a decision would anyway have left several delegations and a large fraction of the scientific community deeply dissatisfied. Apart from Germany and Sweden, Italy did not want to abandon GEOS-3, as only "a slight preference" had been expressed for Hipparcos within its scientific community; Switzerland anyway wanted GEOS-3 or Giotto (both being impossible) in addition to the astrometry mission; an "important minority" of the Belgian scientific community had expressed interest in the cometary mission; and even France suggested exploring the possibility of undertaking a mission to comet Halley in cooperation with NASA.

In the event, a compromise agreement was reached: Hipparcos was reinstated as the next scientific project, with the provision that ESA should also take responsibility for the payload development, but the Executive was instructed to pursue the study of the Halley mission until the end of June, definitely discarding GEOS-3. If Giotto proved to be scientifically interesting and technically feasible within a cost envelope of 80 MAU, then it would be included in the ESA programme, "on the understanding that the Hipparcos project could be stretched to accommodate the cometary mission". The stars could wait, while the comet could not be stopped in its journey through the solar system, and the two-week launch window of July 1985 could not be missed.[471]

The compromise did not make the SAC happy, at least not its chairman who went as far as offering his resignation to Trendelenburg. "It apparently is true that comets are a bad omen", Pinkau wrote to his fellow SAC members.[472] Firstly, facing the grim financial situation of the science programme, he did not like the SPC decision to finance the Hipparcos payload out of the mandatory budget. It was customary for ESA scientific satellites that the payloads be financed nationally, but Hipparcos was now the third astronomy project, after Exosat and the Space Telescope, for which the SPC had voted in favour of paying also for the payload: "Thus [it] is beginning to establish a policy", Pinkau remarked, and such a policy implied of course that less funds would be available for new projects. Secondly, according to the SAC chairman. the ESA decision-making process favoured "big science" projects, the main determining factors being financial feasibility and Ariane launch, rather than the "value for money" of the proposed missions. The dual Giotto/GEOS-3 mission would have supported "a very large community with very good science at low cost", Pinkau argued, but the SPC had not considered the magnetotail mission worth the price difference between the financial frame of the cometary mission (80 MAU) and the combined Giotto/GEOS-3 mission (120 MAU). This difference was roughly equal to the price of the Hipparcos payload. Finally, Pinkau remarked on the unfair distribution of resources between astronomy and solar system science, the former taking by far a larger fraction of the available funds for the 1980s.

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470 SPC, 23rd meeting (4-5 March 1980), ESA/SPC/MIN/23, 3 April 1980, p. 3.

471 ESA/SPC/XXIII/Res. 1, 7 March 1980. The resolution was approved with the only abstension by the Netherlands delegation.

472 Pinkau, letter to the SAC members, 14 March 1980, copy in *D/Sci archives*. cf. also Pinkau's letter to M. Rees, also dated 14 March 1980, and Bonnet's letter to Pinkau, 21 April 1980, *ibid*.

4.6.3 *Giotto and Hipparcos adopted*

The Giotto study was duly prepared by mid-May and the final report discussed at a meeting of the interested scientific community on 30 May. It foresaw a flyby mission launched in July 1985 either by Ariane in association with an application satellite or by a Thor-Delta rocket, a significant involvement of American scientists in the scientific investigations being foreseen in the latter case in exchange for a free ride. The Halley encounter was scheduled for March 1986 (four weeks after perihelion) with a flyby velocity of 68 km/sec, active trajectory control and adequate shielding guaranteeing spacecraft operations up to a few hundred km from the comet's nucleus. The model payload, with a total mass of 53 kg, included: an imaging camera; neutral, ion and dust mass spectrometers; a dust impact detector; a plasma analyser; a magnetometer; and a UV-spectrometer. The estimated cost was 85 MAU, plus 2 MAU for the use of the large antenna at the Parkes Radio Observatory in Australia for tracking and data acquisition during the short encounter phase. The inclusion of Giotto in the programme implied a delay in the Hipparcos project by about 6 months and a delay in the selection of the next scientific project by about one year. An immediate decision had to be taken in order to respect the 1985 launch date.[473]

On the basis of the results of the study, the SSWG unanimously expressed its enthusiastic support for the Giotto project, which it considered "an exciting and cost-effective scientific opportunity", and recommended its inclusion in the ESA programme as a purely European mission launched by Ariane.[474] Two weeks later, the SAC fully endorsed this recommendation.[475]

When, however, the matter came up for discussion, and final decision, at the SPC, two clouds hindered the conclusion of the selection process. Firstly, there was the request byf Germany to re-discuss the issue of the ESA funding of the Hipparcos payload. If Giotto and Hipparcos (payload included) were approved, the German Minister for Research and Technology warned, the science budget would be blocked for a long period, making it impossible to support other areas of space science. The suggestion was that the Hipparcos payload should be funded in the form of an optional programme by the Member States interested in the astrometry mission.[476] The second cloud derived from the French request that the cometary mission should anyway be open to American investigators, even if the mission was launched by Ariane. The collaboration with the USA was considered indispensable, "both from the point of view of the scientific results to be obtained and from the point of view of the security of the mission itself". This was an important policy question which could only

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473 The report, coded SCI(80)4, 14 May 1980, is in *D/Sci archives*. Cf. also ESA/SPC(80)13, 6 June 1980. Negotiations with NASA about the possible use of a Thor-Delta launcher were still ongoing. The possibility of using the Parkes facility at such a good price compared to NASA's Deep Space Network (4 to 10 MAU) materialised only after the completion of the report, but, to Trendelenburg's relief, before the SPC meeting (*infra*). Calder (1992), p. 37, writes that Parkes' request was 200,000 dollars (about 0.14 MAU), which is obviously incorrect.

474 SOL(80)6, 30 May 1980. Cf. SOL, 34th meeting (30 May 1980), SOL(80)7, 30 June 1980.

475 SAC, 22nd meeting (16-17 June 1980), ESA/SAC/MIN/22, 5 September 1980. The SAC resolution is reported in SAC(80)15, 17 June 1980.

476 W. Finke's letter to the Director General, dated 25 March 1980, was circulated under cover ESA/SPC(80)10, 9 April 1980. Finke's arguments echoed Pinkau's and one can reasonably guess that the latter, who was an influential scientific adviser to the German government on space matters and a former SPC delegate, exerted some influence.

be decided upon by the Council, but the French delegation insisted that the SPC resolution should include a statement to this effect and be referred to the Council in the form of a recommendation.[477]

After a long discussion, the German delegation agreed to withdraw its request regarding the funding of the Hipparcos payload, in order to remove "a major obstacle for the approval by some delegations of the Giotto mission". France, on the contrary, formally stated that, unless the resolution explicitly indicated that the call for experiment proposals would be open to US experimenters, it would vote against it, which it eventually did. Giotto was thus adopted in the ESA programme with ten votes in favour and one against. The last word was Trendelenburg's:

> *The Director of the Scientific Programme underlined the importance of the decision taken; he stressed that the Giotto project was certainly more risky than any other project undertaken by the Agency to date, but believed that ESA had demonstrated that it was technically able to undertake such a project and hoped delegations would fully support the Executive in its endeavours to carry out the mission successfully.*[478]

4.7 Epilogue

The Giotto spacecraft was successfully launched by an Ariane 1 vehicle on 2 July 1985, carrying on board a 59 kg scientific payload including ten experiments. The following day, its solid-propellant Transfer Propulsion System was fired as planned and put the spacecraft right on course for its rendezvous with Halley's comet.[479] Giotto was to act as a sort of *kamikaze* mission, approaching the comet at about 600 km in order to get a close-up view of the nucleus and its atmosphere. Passing at a speed of about 70 km per second through the thick cloud of dust and gas surrounding the cometary nucleus, there was very little chance of survival for the spacecraft and its scientific instruments. The Giotto mission, which had required two years for decision-making (including the preparation of the ill-fated NASA/ESA mission), five years for building the spacecraft, and eight months of cruising in space, was to collect all its relevant data in the very last hour of its lifetime.[480]

The encounter phase started at about 6 p.m. GMT on 13 March 1986 and Giotto's closest approach to the comet occurred at 00:11:0.5 GMT on 14 March, at a distance of about 596 km from the comet's nucleus and 144 million km from the Earth. Although the encounter was formally over 15 minutes after that moment, payload operations continued until 02:40 GMT on 15 March when the scientific mission was terminated and the payload switched off.[481] As the spacecraft and several instruments survived the dramatic encounter with Halley, it was eventually decided to extend the mission and to redirect Giotto to encounter comet Grigg-Skjellerup by means of an Earth-swing-by manoeuvre. The latter encounter took place on 10 July 1992, with the spacecraft passing within approximately 200 km of the cometary nucleus, 214 million km from the Earth.[482]

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477 SPC, 24th meeting (8-9 July 1980), ESA/SPC/MIN/24, rev. 1, 13 August 1980, p. 3. There is no explicit reason given for the French insistence on having the Giotto payload open to US investigators. Most probably this was due to the fact that the French space policymakers did not believe that the most important Giotto instrument, the imaging camera, could be built in Europe and wanted to secure the experience of the Jet Propulsion Laboratory's group which had built the camera for the Voyager spacecraft. At that time, in fact, one of the most influential French advisers for space policy matters, Jacques Blamont, was visiting JPL, trying to convince them to devise a camera for Giotto. cf. Calder (1992), p. 40.

478 ESA/SPC/MIN/24, *cit.*, p. 5. The final resolution is reported in ESA/SPC/XXIV/Res. 1, 9 July 1980.

479 Wilkins (1985).

480 Russo (1994).

481 "Giotto special issue", *ESA Bulletin*, No. 46 (May 1986). A lively account of the "night of the comet" is in Calder (1992).

482 Schwehm (1992).

Hipparcos was launched on 8 August 1989 by an Ariane-4 vehicle, one year later than originally scheduled because of various delays in the Ariane launch schedule. The launch was successful and the spacecraft was injected into the elliptical transfer orbit (210 km perigee and 36,000 km apogee) with high precision. About 36 hours after launch, the apogee boost motor was due to be fired to put the satellite into its final geostationary orbit. However, the firing attempt failed, as did several subsequent attempts to ignite the motor, and it became clear that an irrecoverable on board hardware failure had occurred. A recovery mission was then designed for Hipparcos, with the satellite remaining in a highly eccentric orbit (500 km perigee and 36,000 km apogee) and orbital coverage being carried out by ground stations in Odenwald (Germany), Perth (Australia) and Kourou (French Guiana). The implementation of the recovery mission was completed in early November and then the satellite was commissioned for scientific use. Targeted for an operational lifetime of three years, Hipparcos lived one year longer, performing accurate astrometric measurements of about 120,000 stars until 15 August 1993, when the mission was terminated.

A discussion of the important scientific results obtained by these two ESA missions is outside the scope of this chapter. It is worth recalling, however, that both represented a striking novelty in space science, Giotto offering for the first time the possibility of studying cometary phenomena by close-up imaging and *in situ* measurements, and Hipparcos providing a space platform for the most ancient branch of astronomy. Moreover, Giotto's glamorous encounter with Halley's comet, broadcast to television viewers all over the world, finally gave the European Space Agency a place in the public's imagination regarding space exploration. From the historical point of view, however, the great scientific interest of Giotto and Hipparcos, as well as their successful performances, should not make one forget the political factors which led to their adoption into the ESA programme against POLO and EXUV, respectively. Had Germany and France not strongly supported the cometary mission and the astrometry mission, respectively, these would probably not have passed the selection process, perhaps not even started it.[483] In the event, it was a compromise between ESA's two biggest Member States which ended the decision-making process: Germany agreed that ESA funded the Hipparcos payload, and France accepted a delay in the astrometry mission in order to have Giotto launched on time.

Both missions were purely European projects, launched by Ariane: this prompts our second historical consideration. In the early 1980s, in fact, all ambitious plans for scientific cooperation between ESA and NASA fell apart. We have discussed above the end of the envisaged joint cometary mission in January 1980. Later that year, as a result of technical and financial difficulties with the Space Shuttle development programme, NASA announced a two-year delay in the launch of the ESA/NASA dual-spacecraft International Solar Polar Mission (ISPM). This meant, firstly, that the launch window of February 1983 could not be met, thus jeopardising the mission's main scientific objectives, and, secondly, that the ESA spacecraft, whose development was near completion, had to be stored until the new launch date. Things went even worse the following year, as NASA unilaterally announced that it would not continue with development of its ISPM spacecraft, and that the launch of the ESA spacecraft would be further delayed. All efforts to reverse the American decision were frustrated, and ESA Member States eventually agreed to proceed with a single spacecraft mission, named *Ulysses*.[484] The spacecraft was scheduled for launch on the Shuttle Challenger in May 1986, but the tragic accident of 28 January that year, when Challenger exploded soon after lift-off killing its crew, put a brake on the Shuttle programme. Thus, when Giotto was heralding its historic encounter with Halley, Ulysses was sadly being placed into storage for a long period. It was eventually launched by the Shuttle Discovery on 6 October 1990, as much as seven years after the construction of the spacecraft had been completed.

After the Tempel-2/Halley cometary project was aborted, the joint ISPM mission abandoned, and the plans for cooperative utilisation of the Shuttle/Spacelab system frustrated, the Hubble Space Telescope remained the only ESA/NASA cooperative project, with ESA acting as a junior partner. Hubble was originally scheduled for launch on the Space Shuttle in December 1983 but the launch date had been

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[483] See previous chapter.

[484] Bonnet & Manno (1994), pp. 98-108. Cf. also Johnson-Freese (1990), pp. 35-44.

put back several times, resulting in a three-year delay overall. Its launch was eventually scheduled for October 1986 but the Challenger accident caused a further delay. The telescope was finally launched by the Shuttle Discovery on 24 April 1990, thus joining Hipparcos to the benefit of the astronomy community at large. By this time, Europe could rightly claim to have overcome a period of junior partnership with the United States and entered a new period of equal partnership and competition in many areas of space activities: strong competition in the launcher domain, with Ariane taking up a larger and larger share of the market, and "real partnership" claimed as the necessary foundation for cooperating in the future development of the Space Station.[485]

The dramatic problems of the science budget could not be solved in the period covered here. In spite of the many arguments put forward by the SAC in its 1978 report, the bad economic conditions of the 1970s prevented the ESA Member States from approving an increase in the mandatory budget, as requested by the spokesmen of the space science community. The consequences were rather severe, as demonstrated by the evolution of the launch rate of scientific satellites. Seven satellites were launched by ESRO in the 1968-72 period, i.e. before the impact of the first package deal. A three-year standstill followed, then three satellites were successfully launched by ESA between 1975 and 1978 (COS-B, ISEE-2 and GEOS). The next ESA satellite, EXOSAT, originally scheduled for launch in 1979, suffered from many delays because of budgetary problems and was eventually launched four years later, in 1983. Then Giotto came in 1985 and Hipparcos in 1989, certainly a far cry from the event rate of about one satellite launch per year that the SAC had considered necessary in order to keep a viable space science activity in Europe in the 1980s.

Facing this situation, which was the cause of much frustration and disappointment within the European space science community, ESA's scientific policymakers could no longer avoid the difficult task of establishing a general framework for a long-term programme in which a proper balance could be maintained between large and smaller projects, between purely European and cooperative projects, and between the various research fields. ESA's scientific missions could no longer be selected on an ad hoc basis, through a competitive procedure driven by incidental power relations within the advisory bodies, as and when funds became available in Europe or the United States. The future space science programme had to be put into perspective, so that hundreds of scientists in Europe who were making use of space investigations could feel confident that a flight opportunity would be provided in a definite time framework, and plan their work accordingly. The battle for more money in the 1980s had been lost; the next effort was to work out a plan to the year 2000.

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485 Lüst (1987). This is the text of an address the ESA Director General presented in Washington on 4 April 1987. For Europe's "hard negotiating line" regarding future cooperation in the Space Station programme, cf. Bonnet & Manno (1994), pp. 108-119. A detailed discussion can be found in Chapter 15 of this volume. See also Johnson-Freese (1990).