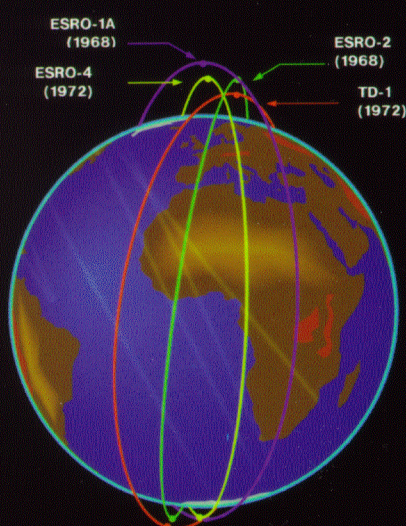
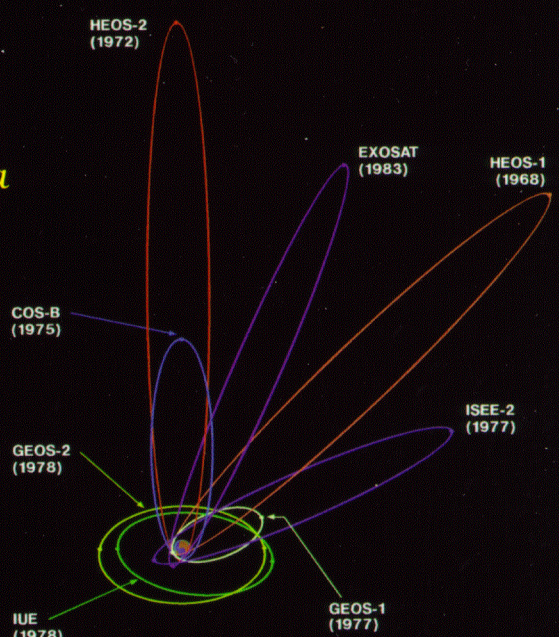
HSR-21
October 1997

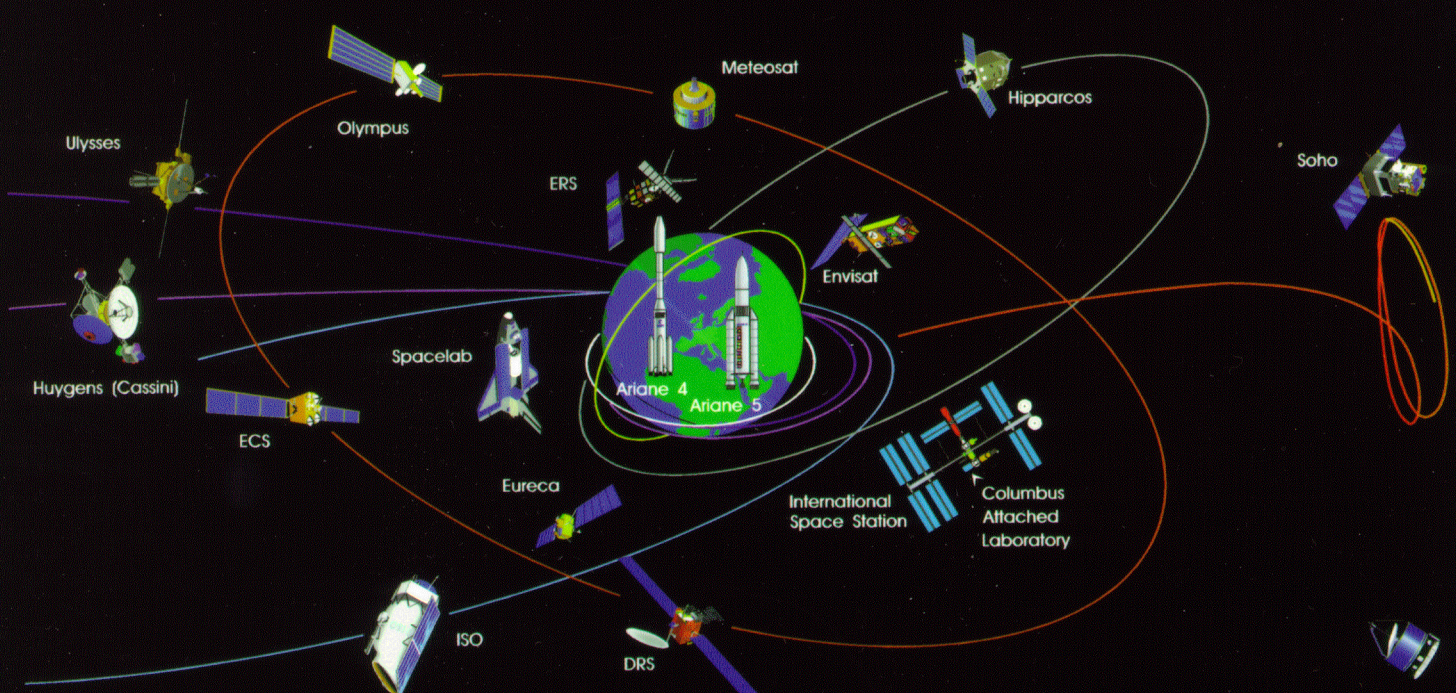
Spacelab in Context

by

Lorenza Sebesta







European Space Agency
Agence spatiale européenne

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The ESA History Study Reports are preliminary reports of studies carried out within the framework of an ESA Contract. As such, they will form the basis of a comprehensive study of European space activities covering the period 1958-1987. The authors would welcome comments and criticism, which should be sent to them at the appropriate address below.

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

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Table of Contents

1: The first phase, 1969-1973 1
1.1. Introduction 1
1.2. Early European-US contacts 4
1.3. Spacelab in the European context 8
1.4. The legal instruments 10

2: The implementation of the programme, 1973-1983 17
2.1 Introduction 17
2.2. The early involvement of industry 19
2.3. General guidelines for payload selection and the institutional framework of the programme 23
2.4. The management: early challenges and creative solutions 26
2.5. Beyond the "sacred limit" of 120% 31
2.6. Duplication avoidance 35
2.7. Follow-on production (FOP): the second Spacelab 36
2.8. The Spacelab follow-on development (FOD) programme: Spacelab improvements and the start of Eureca 38

3: Conclusions 43

Annex 1: Arrangement Between ESRO and its Member States 47
Annex 2: Agreement Between the USA and ESRO Member States 63
Annex 3: MOU Between NASA and ESRO 77
Annex 4: Development and Breakdown by Programme, of ESRO and ELDO Budgets 101
Annex 5: Spacelab Flights 105

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1: The first phase, 1969-1973 [1]

1.1. Introduction

Spacelab basically consists of two types of payload carrier elements: a pressurised manned laboratory module and a series of external unpressurised instrument platforms or pallets, suitable for conducting research and application activities on Shuttle sortie missions lasting seven to thirty days. Modules and pallets are conceived to be flown separately or in various configurations, depending on mission requirements. Basic subsystem elements are accommodated in the forward end of the module (subsystem train) or, for pallet-only missions, in an igloo[2].

Spacelab has the flexibility to accommodate both multidisciplinary experiments and complements devoted to a single scientific or applications discipline. The laboratory module hosts experimental devices, data processing and electrical power equipment, an environmental control system and crew control stations. The staff of up to six scientists relies on the Shuttle orbiter for living quarters, for communications and data transmissions and other related functions, but carries out its experimental activities in the laboratory module. Pallet experiment equipment can be remotely controlled from the laboratory or, eventually, from the orbiter[3]. This system has some special features which cannot be offered by traditional scientific satellites, such as the immediate recovery of data and samples, the re-use of equipment and material, the adaptability of a single system to very diverse missions, the reduction of the time interval between proposing an idea for an experiment and obtaining the results, flexibility during the flight, since the experimenter can take decisions while the experiment is in progress, and the lower instrument reliability required, because of the presence of the experimenter.

That is why pallet and module configurations were welcomed by those scientists whose disciplines, such as material sciences (alloys, optical and electronic components, composites), Earth-survey (geophysics, ecology, meteorology), biology and medicine (including embryology, physiology, cellular biology, vaccine research), would benefit from its 'microgravity' environment and/or the possibility to host scientists for the performance of certain tasks[4]. It has to be noted that these were

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1 I am deeply grateful to all the participants in the workshop on Spacelab which took place at ESTEC, Noordwijk, The Netherlands, on 22 and 23 April 1997 - the proceedings of which have been published with the editorial assistance of Bruce Battrick, whose help I greatly appreciated. The perceptive and sharp comments by the audience for my original paper and their generosity and open-mindedness in answering my questions, gave me the possibility to gain a much better understanding of the project. The documents gathered at the archives began, with their help, to fall into discernible patterns. My gratitude goes also to my colleagues John Krige, a source of encouragement and steady intellectual support and Arturo Russo for insightful reading of my text. A special thank you to Michel Bignier for his unfailing help during the crucial phases of my study. Finally, I thank Karl Reuter, who made the workshop possible and Johann Oberlechner for the organisational setting. I partly re-worked the text presented to the Spacelab Workshop, in order to take account of some of the many comments received. This text is, of course, my complete responsibility.

2 For a technical description of the Spacelab as flown in its first mission, Spacelab-1 (28 November-8 December 1983) see A.Thirkettle, F. Di Mauro and R. Stephens, "Spacelab - From Early Integration to First Flight: Part 1", ESA Bulletin, no.38, May 1984, pp. 70-79 and A.Thirkettle, F.Di Mauro and R.Stephens, "Spacelab - From Early Integration to First Flight: Part 2, ESA Bulletin, no.39, August 1984, pp.70-84.

3 Historical Archives, European University Institute, Florence, Italy (HAEUI), ESRO/C(73)45, rev.1, Memorandum of Understanding between the NASA and the European Space Research Organisation for a Co-operative Programme Concerning Development, Procurement and Use of a Space Laboratory in conjunction with the Space Shuttle System, 26/7/1973 (approved at the 59th Meeting of the Council on 1 August 1973), Preamble and Article II; reprinted in its entirety in Douglas Lord, Spacelab, An International Success Story (Washington: NASA) 1987.

4 HAEUI, ESA, dep.2, 52053, ESRO News Release, ESRO to undertake Sortie Lab project definition phase, Background Document, 10/11/1972.

disciplines which entered the "space dimension" for the first time and had not previously been represented in the classic scientific decision-making groups of ESRO and, later, ESA. Their legitimacy as "pure space sciences" was therefore not unchallenged among the traditional space science community who, in a context of "conservative" science budgets, perceived these disciplines as potential competitors for limited resources. They preferred to consider at least some of the research areas dealing with microgravity, those concerned with material sciences for example, as applied sciences, bordering on technology. The senior staff of ESA's highest level scientific structures, such as Ernst Trendelenburg, Director of Scientific and Meteorological Programmes, not infrequently shared this point of view.

The elements which were considered as advantages by these new disciplines were not greeted with the same degree of interest by others which did not specifically need them, such as space physics, astronomy, astrophysics. Since the fifties, these scientists had been tuning their instruments and research to the then-existing space vehicles (sounding rockets and satellites launched by small launchers); the adoption of Spacelab would mean a complete re-orientation toward a new vehicle, yet undefined in terms of costs, time schedules and technical characteristics. Moreover, human presence would interfere with the precision of the scientific instruments; instead of perceiving it as an asset, it seemed therefore plausible to them to think about it as a dangerous and expensive nuisance. Pallet-only configurations were therefore originally conceived to accommodate the requirements of classical space scientists and reduce their objections to short-duration manned science flights, which did not fit with the requirements of their scientific culture, experience, and experiments[5].

The objective of the Spacelab programme, however, was not restricted to its final use. For European governments, engineers and industrialists, its biggest challenge was to be found more in the construction of the technological object *per se*, and in its integration with the major system, the Space Shuttle, than in the functions it could help to perform.

First of all, Spacelab represented the first joint European effort in manned space exploration through a general support capability to be flown in low orbit for a potential multi-disciplinary user community (scientists and engineers without the need of a full astronaut training). It was a far more expensive and complex enterprise than any previous one associated with the building of European satellites. Secondly and not less relevant, Spacelab was conceived as a major US-European co-operative programme concerning the development, procurement and use of the laboratory in conjunction with the Shuttle. Since 1970, there had been, on the European side, a conscious attempt to proceed from a project-oriented co-operation, limited to one specific project at a time, as had been the co-operative projects of the sixties, to an activity-oriented co-operation whose aim was "to develop an expertise in a whole activity through a succession of initially undefined projects"[6]; the Spacelab programme was the embodiment of this new willingness. It is interesting to remark here that as early as 1976 the ESA Council, considering NASA's Space Station study programme and "noting the impact of, and relationship between" the Spacelab and the future Space Station, drew the attention of Member States to the importance of giving an early assessment of the opportunity to participate in the project[7].

Furthermore, the Federal Republic of Germany, as the main contractor, and even though in lesser degree the other European participants, were eager to strengthen the industrial and technological links with the USA with regard to all aspects of such a new expertise, to be extended from support capabilities for manned space exploration in low orbit to the Space Transportation System (STS) as a whole. After a decade of debates and recriminations on the "technological gap" between the USA and

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5 For a deeper reflection on this point see Arturo Russo, "Big Technology, Little Science: the European Use of Spacelab", ESA History Study Report HSR-19. On the scientific aspects of Spacelab, see D.Shapland and M. Rycroft, Spacelab. Research in Earth Orbit (Cambridge, Cambridge University Press) 1984; for Shapland, the book is the outcome of many scientific articles and papers produced on the topic during the previous years.

6 HAEUI, ESRO/C/469, Director General's Policy Statement, 18/11/1970.

7 HAEUI, ESA/C/MIN/X, Res. 2, 8/10/1976.

Europe, the time was ripe for Europe to be directly exposed, through a common enterprise, to an industrial "savoir faire", which seemed to be embodied more in the organisation and management of complex programmes than in technical specifications[8].

Spacelab was in fact envisaged as "an integral part of the US programme in the post-Apollo period", and a major one, if we consider that in June 1972, when presenting the then current US mission model for the period 1973 through 1986, NASA expected an average of 25 mission per year (once the Shuttle was operational) and the same number of missions for DOD. Among NASA missions, approximately 8 per year would be sortie missions "in the fields of life science, space technology, and materials science, communication and navigation, earth observation, astronomy, and space physics". It is interesting to remember that, since that time no more sortie missions were planned for the first three areas after 1985, when the Space Station was supposed to accommodate experiments in those areas [9].

Spacelab was constrained by the performance capabilities of the Orbiter and, more generally, by the Shuttle, in more than one respect. First of all, it was constrained by the technical features of the Shuttle, which influenced such relevant characteristics as the mass and electric power available for subsystems and instruments, the flight schedule, the duration of the mission and the presence of additional elements such as the instrument pointing system (IPS)[10]. Secondly, Spacelab needed the Shuttle to get to orbit, perform its duties and come back to earth. It would be carried into orbit in the payload bay of the Shuttle Orbiter, and would remain attached to the Shuttle throughout the mission. During this time, the Orbiter would provide such important services as safety monitoring and control over payload elements. The crew members were supposed to work in the Spacelab, but, as already noted, sleep in the Shuttle Orbiter. Access to the module would be by means of a tunnel. At the end of each mission, the Orbiter would make a runway landing and the laboratory would be retrieved from the bay.

Co-operation with the USA was sanctioned by two diplomatic agreements signed in 1973. The demarcation of obligations as specified thereby left to the European partner the whole financial and industrial responsibility of defining, designing, developing, qualifying and delivering to NASA one prototype Engineering Model (EM), one Flight Unit (FU), ground engineering support for the first two flights and spares/documentation. NASA was to support the European effort, provide general managerial and technical information, monitor ESRO's technical progress, specify interfaces, develop the tunnel, operate Spacelab within the Shuttle Programme and procure a second Spacelab if the first met its design and price requirements[11]. The development of Spacelab as an ESRO special project was ruled by an Arrangement between certain ESRO Member States and ESRO. It was in the discharge of the complex duties linked to this process, in its co-ordination with the other major European project, Ariane and in the implementation of the tasks and co-operation with the US, from the design to the day-to-day management of the production phase, that the newly born ESA tested-out its new institutional structures and managerial and industrial capacities as well as its political willingness to grow more influential in space affairs. As such, policy-making about Spacelab helps us to clarify not

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8 Cfr. L.Sebesta, "A new political tool for the sixties: the technological gap". Paper presented at the conference "Beyond the Cold War: the United States and the renewal of Europe", Florence/Bologna, 16-19 October 1994.

9 HAEUI, CSE/CS(72)15, Report of the ESA Delegation on discussions held with the US Delegation on European participation in the post-Apollo programme (14-16/6/1972), 22/6/1972. A more generous estimate, regarding the STS mission model for the period 1980-1990, seems to have been offered to the Europeans one year later. It forecast that about 40% of the Shuttle flights would be devoted to sortie missions. ESRO/C (73)49, 13/7/73, Director General's recommendation on the Spacelab programme; see also "Europe and Post-Apollo", no author, ESRO/ELDO Bulletin, n.22, August 1973, p.13.

10 A very accurate pointing device for experiments, to be flown on a stabilised platform, IPS was not mentioned in the legal instruments (MOU and IGA). However, as we shall see, it was eventually developed, under a separate contract, by Dornier as an integral part of the Spacelab programme. HAEUI, 4865, Internal communication: Reinhold to DG, 6/9/1976.

11 A.Thirkettle, F.Di Mauro, R.Stephens, "Spacelab. From Early Integration to First Flight. Part 1", ESA Bulletin, May 1984, p.70. Parts 1 and 2 of this article deal with the engineering model and Spacelab-1 test programmes at ERNO and the ground processing at KSC between April 1978 and December 1985.

only the story of a remarkable European technological and scientific endeavour in the field of human space exploration, but some major features of the European space effort as it emerged during the sweeping renovation of the seventies.

At the same time, because of the necessity to solve the problem of interfaces between Spacelab and the Shuttle, because of the changes in the schedules and technical features of the Shuttle, because of American leadership in managing complex technological programmes and because of the specific know-how of the consultants put to work with European firms, US-European co-operation on Spacelab was lengthy, complex and deep in character. NASA not only provided technical support and advice in management and programme control, it was also there to become familiar with Spacelab in view of its ultimate responsibility for its operation[12]. Despite divergences and discussions during the negotiations of the agreements and their implementation, the Spacelab programme was generally perceived, by the actors involved and the public at large, as a conspicuously good example of international collaboration.

The aim of this paper is to reconstruct the phases of negotiations and signature of the legal instruments governing the co-operation, as well as the implementation of the agreement, in order to capture the decision-making strategies followed at the political and industrial levels. These strategies will be placed in the broader context of US-European relationships, European activities in space and the international economic setting[13].

1.2. Early European-US contacts

The evolution of the US-European negotiations on the post-Apollo programme from 1969 onwards has been discussed in another ESA History Study Report [14]. The American programme changed over time and its originally very ambitious scope was reduced, due to a severe limitation of American funds. Finally, by January 1972, the American President approved NASA's Space Shuttle programme, the pillar of the new programme: the Space Station was delayed for an undetermined period, while the tug's future was uncertain. Offers of collaboration to the Europeans were in parallel restricted: in June 1972, talks on European participation in the post-Apollo programme were focused on sortie modules, one of their many names at the time, intended to help in performing space science, applications and technology activities.

In US eyes this choice respected some of the traditional concerns of NASA in co-operation with foreign countries: the space laboratory had to be self-funded (by Europe), essentially separable from the Shuttle, even if it was an integral part of the post-Apollo programme as a whole, it didn't require the transfer of highly advanced technical information. The laboratory as conceived by NASA in mid-1972 could be built in Europe. The US felt confident that "the tasks entrusted to Europe (were) those for which European firms (had) a capability". This implied that US assistance would be "limited": "if found necessary and appropriate Europe would be allowed to buy existing American equipment ('black boxes')"[15]. From the preliminary discussions held in June 1972, it emerged that no firm

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12 For this last point, see Michel Bignier, "Spacelab Development", ESA Bulletin, n.36, November 1983, p. 9.

13 A complete account of the European industrial effort, centred on the experience of ERNO, can be found in Klaus Berge, Spacelab. Aufbruch in den achten Kontinent (no place: no publisher) 1988 - Chapter 2 of the book, dealing with the period 1973/74, is written by Heinz Stöwer; for a complementary version, more focused on the Italian participation, see Ernesto Vallerani, Italy and Space. Habitat Modules (Milano: McGraw-Hill Libri Italia srl) 1995, especially pp. 1-80. Douglas Lord's book cited in footnote 2 gives an account of the design and development phases as well as of the planning of Spacelab use, as seen from the American side.

14 L.Sebesta, "United States-European space co-operation in the post-Apollo programme", ESA HSR-15 (Noordwijk: ESA) 1995; see also, by the same author, "The politics of technological co-operation in space: US-European negotiations on the post-Apollo programme", History and Technology, vol. XI, n.3, 1994, pp. 317-341.

15 HAEUI, CSE/CS(72)15, Report of the ESC Delegation on discussions held with the US delegation on European participation in the post-Apollo programme (14-16/6/1972), 22/6/1972. As already stated in informal discussions in April

commitment as to the number of modules the US would eventually procure could be taken, nor was it clear which relationship would exist between the sortie module and the advanced experiment module which would be attached to the Space station after 1985; it would not imply the application of any special pricing policy for the use of the Space Transportation System (European users would be charged on the same basis as comparable non-US government domestic users) and it would not change the conditions of access by Europe to launching systems as settled in President Johnson's letter to Lefèvre of September 1971[16]. The motivations behind American offer "were purely political and commercial or technical factors had practically no influence" [17].

For Europe, the choice to accept the American invitation had a much broader meaning. The Spacelab, as it would be called by Europeans from 1973, would inaugurate a new approach to the utilisation of space, whose underlying principle was to support life in space for a long duration. In the words of ESRO Director General, Alexander Hocker, Spacelab was "the indispensable element to transform the Shuttle into a first generation Space Station"[18]. This principle implied the need for the utmost reliability of the technology used and for a fail-safe philosophy for the essential subsystem functions. In the fulfilment of their task, the Europeans had to achieve a major goal, i.e., to build a low cost space research facility in terms of both development and operations, available to as wide a range of experimenters as possible, with some features which made it more attractive than automated systems, at least for some disciplines.

More precisely:

1 they had to meet a range of users' needs and therefore guarantee the versatility, i.e. they should offer various configuration of the laboratory;

2 they had to offer flexibility to the users, since the experimenters should be able to take decisions on the spot, while the experiment was in progress, and offer immediate recovery of data;

3 they had to limit the final costs and offer an affordable service to scientists by guaranteeing:
   - multiple re-uses of the same module and pallet;
   - the use of ground laboratory equipment on board (an objective only partially fulfilled) versus specific type of instruments;
   - to keep to a minimum experiment and orbiter interface changes for the different configurations[19].

1972, in the most "sensitive" cases of classified technology, if the basic technology could not be transferred, the US would undertake, if necessary, to sell the hardware itself; CSE/CS(72)13,Neuilly, 8 May 1972, Report by the Secretary General of the ESC on the informal discussions with American officials regarding participation in the post Apollo programme. It is maybe of some interest to note that, revising the minutes of the June meeting (originally transcribed in Europe), Pollack objected to the wording of the mentioned sentence, suggesting a more equitable "(...)Europe would be assisted perhaps through the sale of existing American 'black boxes', or in other ways". HAEUI, CSE/CS(72)15 add.1, Letter from M.Pollack to the ESC Secretary General (30/6/1972), 3/7/1972

16 When the post-Apollo programme was originally presented to the Europeans, it seemed that their participation would contribute to induce a liberalisation of US policy as far as the availability of launchers for telecommunications satellites was concerned. Johnson's letter of September 1971 clarified that the availability of US launchers for telecommunications satellites would not be conditioned on European participation in the post-Apollo programme, but would depend on a positive vote by a two-thirds majority of the INTELSAT Assembly. For an analysis of this point, see L. Sebesta, "The availability of American launchers and Europe's decisions 'to go it alone'", HSR-18 (Noordwijk: ESA) 1996.

17 HAEUI, CSE/CS(72)15, Report of the ESA Delegation on discussions held with the US Delegation on European participation in the post-Apollo programme (14-16/6/1972), 22/6/1972.

18 ESRO/C (73)49, Director General's recommendation on the Spacelab programme, 13/7/73.

19 HAEUI, CSE/CS (72) WP/5 rev.1, Report by the Secretary General of the ESC on the discussions between Europe and the United States on participation in the Post-Apollo programme, September 1972.

At the same time, specifications were linked to Shuttle interfaces, timetables and needs. Decisions on feasibility should therefore entail trade-off studies between performance, cost and schedule. It was clear, moreover, that some technological areas would have to be advanced, if the programme was to be 100% European. In fact, a certain number of "off-the-shelf" items (available from stock or to be obtained from a running production line in the most extreme definition) would be available with little or no development in Europe. A few of them however, involved such long term and costly development and production in the USA that their development in Europe would represent a major undertaking, not commensurate with the Sortie Laboratory time scale and cost envelope[20]. Europeans, who were participating in their first manned space programme, hoped to be able to draw some information from US sources on those areas such as:

1 reliability and safety, crew protection and life-support systems characteristic of manned spacecraft, in which Europe had no experience at all;

2 construction of large-diameter pressurised structures with a very low leakage rate;

3 development of active thermal control, to keep the temperature inside the laboratory at a constant level;

4 development of a complex data processing system in view of the large volume of information to be handled and of the necessary flexibility of use, because of the variety of experiments hosted and the diversity of missions;

5 provision of electric power supply by means of systems (without solar panels) entirely new to Europe [21].

Vallerani reports in his book that "the greatest need was felt in certain aspects of programme control and the organisation of the various activities". The USA had the opportunity to develop such an expertise in both military programmes (the Polaris missiles for example) and civilian space-related undertakings, such as the Apollo programme[22].

European activities were at first directed:

1 to set up industrial feasibility studies for concept definitions and to acquire the technical and managerial capabilities to build the laboratory;

2 to devise a collaborative European-American institutional framework for its development and its integration with the Shuttle;

3 to match the project to the ongoing European space programme.

After the decision to limit US-European collaboration to a Sortie Laboratory, a NASA technical team visited ESTEC in Noordwijk between 26 and 30 June 1972, at the invitation of the European Space Conference, to share information acquired through previous NASA studies. This would help ESA to assess what financial and technical resources would be required for Europe to develop the Sortie Laboratory. At the conclusion of the team visit, Jean Lagarde, ESTEC lead systems engineer (and formerly ESC Liaison Representative in Washington) prepared a summary report for ESRO. The

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20 Ibidem.

21 HAEUI, ESA, dep.2, ESRO News Release (on the ESRO Council meeting of 9 November 1972), ESRO to undertake Sortie Lab definition phase, 10/11/1972.

22 E.Vallerani, op. cit., p.17. We will come back to this aspect when dealing with the industrial implementation of the programme.

financial estimate included in this report was $250 million (in 1972 dollars), which included development costs of a prototype and the delivery of the first flight model[23].

In the meantime, diplomatic contacts started in order to agree on common grounds for co-operation. On 17-18 August 1972 a meeting between the ESC Secretariat and NASA officials was held in NASA Headquarters, Washington D.C. Discussions focused on the form and content of possible agreements on the Sortie Laboratory (in the US version), Space Laboratory (in the European version) or SL (in a neutral one)[24]. It was agreed that the laboratory was an essential part of the US Space Transportation System and that, according to European requests, it would not be developed in parallel in the US, should the Europeans take up the responsibility for its production. However, NASA was adamant in sustaining that the construction of the Spacelab would not guarantee any preferential treatment in the use of the Shuttle; countries participating in the development of the Sortie Laboratory would only enjoy a priority right in its use and would be entitled to appoint crew members for its flights.

NASA was to retain overall responsibility for the total programme and the last word in such vital areas as Shuttle/Sortie Laboratory interfaces, quality control and safety. In particular NASA would wish to be in a position to assess the efficiency of the management plan proposed by the European agency for the Spacelab and stressed the necessity for a "unitary management agency" on the European side. On the other hand, NASA offered arrangements to let the European agency participate in the Shuttle interface control activity, defining user requirements and in the regular review of the Shuttle programme. Moreover, a wide range of NASA assistance would be available free or at marginal cost, including provision of US designs and technology (except where specific considerations from the security and proprietary rights point of view prevented this), quality control, acceptance testing, cost control, audit and use of US facilities. The USA would favour a "government agreement", albeit very "slender". This kind of highly visible political agreement had been avoided by NASA since the inception of US-European co-operation and the (prudent) willingness to frame Spacelab in such a form was a proof of the high stakes involved[25].

In September 1972, the Department of State informed ESC of an amendment to the overall system planning: NASA would not need to embark on actual development work for the Sortie Laboratory, if left alone, before 15 August 1973 (it was considered that it would take the US one year less than Europe to build a space laboratory)[26]. It was proposed that European commitment in principle be made at the September Conference of 1972 and formal agreements concluded by end-October. This commitment would lead Europe to immediately start a thorough definition phase (full-scale project definition effort). Should the cost established by this study unacceptably exceed the financial ceiling agreed by the ESC Ministerial Conference, the Europeans would be allowed, through an escape clause, to withdraw from their commitment at any time before August 15 1973. This clause was later introduced into the ESRO-Member States agreement of February 1973.

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23 The team comprised nine people, led by Robert Lohman, director of Program Integration in the Sortie Lab Task Force. Dale Myers, NASA Associate Administrator for Manned Space Flight, joined the team for an executive session with Hammerstroem, ESTEC Director; HAEUI, CSE/CS(72)18, att.annex I, Report on the technical discussions between NASA and ESRO (26-29/6/1972), 4/7/1972; CSE/CSWP/5 rev.1, Report by the Secretary General of the ESC on the discussions between Europe and the United States on participation in the Post-Apollo programme, September 1972; see also D.Lord, op. cit., p.18 et pp.23-24.

24 CSE/CS(72)25 and ANNEX I to VI, Report on discussions between ESC Secretariat and NASA officials in Washington on 17-18 August 1972 regarding the form and content of agreements necessary in the event of European participation in the post-Apollo programme, 28/8/1972. See this document for the following discussion. The US designation makes reference to the functions performed in relation to the Shuttle (sortie missions), while the European denomination captures the innovative gist of the space laboratory per se, as compared with the traditional laboratories at work on Earth.

25 D.Lord, op. cit., p. 24.

26 ESRO/C(72)48, Annex I, US Aide Memoire (21/8/1972), 13/9/1972.

This temporary accommodation was essential to leave the Europeans the time to introduce the programme in a broader package deal - which would be finally approved in July 1973. By the end of 1972, Europe decided to "freeze" the name of the laboratory. From now onwards it would be Spacelab; this decision was transmitted to the American partners during the meeting of the NASA/ESRO Sortie Laboratory Working Group on 12 January 1973 [27].

1.3. Spacelab in the European context

The approval of a co-operative Spacelab programme was the last stage of long and complex negotiations on European participation in the American post-Apollo programme. Originally very ambitious, these negotiations had been progressively restricted in scope[28]. The limitation of co-operation to Spacelab, and thus the limitations of the costs of co-operation[29], only partially solved the problems that Europe had to confront in the same period, since interest in Spacelab had to be balanced not only against its own costs, but in the context of a series of uncertainties relative to the European space programme as a whole[30].

Spacelab was but one of the three major concerns of the member states, the other two being:

1 the future organisational nature of Europe in space, in the context of two concerns: from the tactical point of view, the disruptive power of the impending liquidation of ELDO had to be neutralised; from the strategic point of view, the new European concerns linked to the application capabilities of satellites (first of all in telecommunications) could not be coped with by an organisation set up for mainly scientific purposes, ESRO.

2 the new configuration of a launcher capable of meeting all the new European needs in the field of application satellites [31].

The apparent irreconcilability of French and British positions over these points came to the forefront during the informal meeting of ESC Ministers and representatives of participating states (8 November 1972) called to organise the subsequent December CSE meeting[32].

Attention was focused on a difficult dilemma; what should have been given priority, the institutional framework or the programme toward which this framework would orient its work? Charbonnel, the French representative, subordinated the solution of the European space institutional problems to the "definition of a programme worthy of Europe", i.e. a common programme of heavy launchers capable of orbiting the payloads which Europe would develop for its needs in the field of space applications (in the three main fields of telecommunications, air navigation control and meteorology) and which would even enable it to export commercially viable complete systems. Faced with the reluctance of certain states to join in the Europa III programme of ELDO, France was prepared to carry out, on a

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27 HAEUI, ESA, dep.2, 52054, NASA/ESRO Sortie Lab Working Group, Minutes for the Meeting (12/1/1973), no author, no date; Ibidem, ESA, dep.2, 5606, "Spacelab Guidelines and Constraints for Program Definition", by Douglas Lord and Jean-Pierre Causse, 23/3/1973. However, the first document on "Spacelab Guidelines and Constraints for Program Definition" (March 1973) mentioned the fact that Sortie Lab was still in use in the US. However, Spacelab was always used, from there on, every time the programme was mentioned in coordinated documents.

28 See footnote n. 13.

29 The cost of Spacelab was then estimated at $ 200-250 million, against an estimated cost for (the abandoned) tug of about $ 500 million. This difference has been considered by the literature an important element in favouring the positive resolution of the launcher-versus-post-Apollo dilemma, since it freed relevant European financial contributions in favour of Ariane. See John Logsdon, "International involvement in the US space station program", in Space Policy, February 1985, p.24.

30 CSE/CS(72)WP/5,rev.1, cit.

31 For a broader analysis of these aspects of the ESRO-ELDO crisis, see J.Krige, A.Russo, Europe in Space, 1960-1972, ESA SP-1172, September 1994.

32 CSE/CM(Nov.72)4, Meeting of Ministers in Paris on 8th November 1972 under the Chairmanship of Theo Lefèvre, plus Annexes, 17/11/1972; see also J.Krige, A.Russo, op. cit.

different technical and institutional basis, a programme meeting the same objective, i.e. L III S, the future Ariane.

Considering the organisational question as one which would have implied a great loss of time and energy, France was more prone to begin by solving the problem which, in its opinion, was most urgent for the future, the one of launchers. Why this choice?

1 because dismissing the programme would be seen by public opinion in European countries as an unacceptable abdication of a political responsibility;

2 because the funding needed to complete the programme was minimal compared with the sums European had so far invested. As recalled by Chairman Lefèvre during his opening remarks, this would have implied not only a loss of technology, but also a loss of markets;

3 because the absence of a European launcher would deprive the Symphonie project of some of its meaning, the value of which as an example was paramount at a time when Europe was undertaking important application programmes.

On the other hand, taking into primary consideration the financial constraints under which the Conservatives (back in power since 1970) found themselves, the UK representative, Heseltine, subordinated any decision on the programme to the prior solution of the institutional framework. In view of what was thought to be poor cost-effectiveness, European performance in space during the previous decade (whose results "do not measure up to a financial commitment of this proportion"), the UK singled out the organisational problem and the duplication between national and European space programmes as the causes of this ("we are spending enough money to achieve results but we are not spending it in the way it ought to be spent").

Moreover, neither France nor the UK seemed enthusiastic about joining the US in the post-Apollo programme. France, noting that while the Spacelab "would enable Europe to take an interest for the first time in the problems of manned flight, ...none of the economic needs of the next decade would be met by the development in Europe of a Sortie Laboratory, which can in no case be considered a substitute for a launchers programme", stated it was ready to participate to the programme only if all the measures were taken to satisfy Europe's requirements particularly with regard to launchers. The UK stated that, for the time being, the UK would not participate to the Post-Apollo programme and thought it could change this position only if progress were made in the creation of a single European Agency.

Only Germany seemed to be ready to accept the US invitation. Despite this continuing divergence, some countries agreed, under certain conditions, to finance the Phase B studies for the Sortie Laboratory (reduced to a single approach selected from the alternatives identified in the first phase, Phase A) The Committee of Alternates gave its political blessing and invited the ESRO Council to comply. The ESRO Council accepted this request and authorised its Director General, Alexander Hocker, to take the necessary implementing steps [33].

Reports on the activities of ESRO and ELDO and on the Post-Apollo programme were offered at the start of the ESC Ministerial conference of December 1972. Each of the three areas had its specific sets of unsolved problems. In spite of the dilatory position of the UK - whose delegates stressed how the "Government did not believe in the need for a European launcher programme" and how the arguments in favour of the post-Apollo were not considered "overwhelming"- and some incertitude of the Italian side - who subordinated participation in the launcher programme to fruitful co-operation in the post-Apollo programme and asked for the acceptance of the rule of "juste retour" for the common

33 CSE/CM(Dec.72)5, 7/12/1972.

programmes - the resolution of the Ministerial Conference registered an important agreement on some points which had been objects of intense debate:

1 the setting up of a new organisation, ESA, if possible by January 1974, formed out of ELDO and ESRO

2 The Sortie Laboratory and the French launcher proposal (L III S) to be managed within a common European framework (Europa III being dropped)

3 there should be a rationalisation of the various satellite programmes, including GTS (the geostationary technology satellite programme had been initiated by the UK as a national project; originally intended for telecommunications purposes, it was subsequently reoriented to meet requirements for aiding maritime navigation and was later merged with Marots)[34].

The first element of the far reaching decisions arrived at in the meeting was the decision to set up a new unique European Space Agency (ESA), whose programme would consist of a compulsory "basic" programme - science, general activities and facilities- with GNP related contributions and an "optional" programme -including Spacelab, launcher and applications satellites - in which the Member States were free to decide on their participation and financial contribution [35].

One element that greatly contributed to convince uncertain states to comply with the second decision was the suggestion put forward by France and Germany about the financing of the launching programme - a fixed amount for European countries other than France rather than a fixed percentage for every state. The other one was represented by the technical features of L III S, nearly as powerful as Europa III, but not requiring such a large and sophisticated cryogenic stage [36].

A compromise was being worked out between two projects which had seemed for a long time mutually exclusive, mainly for economic reasons: the European launcher and participation in the post-Apollo programme. The UK re-entered the game, introducing Marots into the bargain. This equilibrium was reached mainly thanks to an agreement between France and the FRG on a reciprocal participation in the launcher and Space Laboratory projects, where the two countries would respectively provide the majority of funds for the two projects. This compromise was eventually finalised in July 1973, after a series of sometimes harsh discussions and horse-trading among European partners[37]. It was in the context of this rather perturbed diplomatic setting that European-US negotiations on the Spacelab agreements took place.

1.4. The legal instruments

Albeit provisional in kind, the ESC December (1972) decision gave the green light to the opening of the last stage of US-European negotiations. At the end of the Brussels meeting, Minister Lefèvre

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34 CSE/CM(Dec.72)8, 20/12/1972; CSE/CM(Dec.72)PV/2, plus Annexes, 10/1/1973.

35 J.Krige, A.Russo, op. cit.

36 CSE/CM (Dec.72)PV/2, Minutes of the Afternoon Session of the ESC held in Brussels on 20 December 1972, Statement by Charbonnel, Ministre du Développement Industriel et Scientifique, France, 10/1/1973. The L III S rocket would be able of putting payloads of 1500 kg into transfer orbit, or of 750 kg into geostationary orbit with the aid of an apogee motor. The French government was willing to assume 60% of the expenses of the development phase (estimated at 550 MAU by Charbonnel) which was due to start on 1 January 1974 and to end with qualification of the launcher in 1980. L III S should be assured a suitable priority of use in Europe compared with means of launching developed outside Europe. The technical and financial management of the L III S would be entrusted to CNES; CNES would define the industrial arrangements and place contracts with industry on behalf of the programme participants; there would be a Programme Board to monitor the distribution of work among the various participants and act as the appeals body for a participant with respect to the choice of firms made by CNES.

37 J.Krige, A.Russo, op. cit., pp.111-112.

wrote to Secretary of State William Rogers to inform him about the European decision and, with a resolution of January 1973, ESRO's Council authorised its Director General to negotiate with NASA and the participating countries the legal framework for the programme, pending the arrangements between ESRO and the member states [38].

Meanwhile, Europe had to study how it might participate in the Post-Apollo programme on the basis of the American offer. The Federal Republic of Germany proposed to undertake the development of Spacelab under Art. VIII of the ESRO convention, as a special project. An Arrangement between certain ESRO member states and ESRO was therefore drafted and approved by the ESRO Council in February 1973. Open for signature from 1 March to 23 September, it entered into force on 10 August 1973[39].

It determined the objectives and the main elements of the programme, together with the conditions for its execution. It called for the creation of a Spacelab Programme Board (which had already been set up in an interim form) to be responsible for the programme and ensure its implementation, keeping the Director General informed and ensuring close links between ESRO and future users.

The fair return rule was applied, though in a generic form: the geographical distribution of contracts should "correspond to the percentage contribution of participants" (Art.8). Although optional, all ESA Member States except Sweden eventually funded it (Belgium, Denmark, the Federal Republic of Germany, France, Italy, the Netherlands, Spain, Switzerland, the United Kingdom), plus Austria which voluntary associated itself to the programme at a later stage. The countries decided to establish a financial envelope of 308 MAU at mid-1973 prices (1 MAU = approximately 1,2 US dollars) divided over Phase-B (the definition phase), the main design, development and construction contract, ESRO internal costs including overhead, and finally contingencies including space technology and modifications resulting from the Shuttle programme [40].

Germany was due to pay the largest share of the cost during phases C/D (52.55%), the other main contributions coming from Italy (18.00%), France (10.00%) and the United Kingdom (6,30%) [41]. The percentages would be slightly revised in October[42]. The arrangements provided for a review of the overall amount at the end of sub-phase B 2 of the definition phase (end July 1973). If the financial hypothesis were not confirmed, but significantly exceeded, those participants who so wished could withdraw. At the same time, it was anticipated that members should bear up to 20% overruns on the estimated cost to completion (and the Programme Board should decide on the additional expenditure by a two-thirds majority); should this percentage be exceeded, everyone had the right to withdraw from the project (Art 6).

The early months of 1973 were devoted to the drawing up of the final text of the US/European diplomatic instruments, with meetings, drafts, phone calls and aides memoire going back and forth between the US and Europe. As a normal procedure, each European revision was submitted for approval to the Spacelab Interim Board, chaired by Massimo Trella, and then forwarded as an aide memoire to the US government via the German chargé d'affaires, on behalf of the European participating members[43]. It had been agreed June 1972 that two instruments would be worked out, i.e. an executive agreement between agencies of both sides and a governmental agreement between the

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38 HAEUI, ESRO/C/LIII/Res. 1 (Final), Resolution on the Spacelab programme, 18/1/1973.

39 See Basic Texts of the European Space Agency, Vol. II, Spacelab, Columbus (Paris: ESA) 1988, note p. AI a/2.

40 "Europe and Post-Apollo", no author, ESRO/ELDO Bulletin, n.22, August 1973, p.12.

41 HAEUI, ESRO C(73)2 rev. 3, Arrangement between certain member states of the European Space Research Organisation and the European Space Research Organisation concerning the execution of the Spacelab programme, approved at the 54th meeting of the Council on 15/2/1973, Annex B.

42 HAEUI, ESRO IB-Spacelab(73) 26, 3/10/1973.

43 HAEUI, see the series of documents under ESA/IB-SL.

US government and the participating European governments to reinforce the political commitment of both parties [44].

The Director General, Hocker, skilfully handled the delicate balance between the need to respect the national sovereignty of the Member States and therefore leaving them the final say on each revision and the need to expedite the sometimes extended discussions. The State Department represented only one government; ESRO's Director General represented nine countries with their not always converging interests. Legally speaking, as we have seen, he was given special powers by the agreement between ESRO and Member States for the execution of the programme. Politically, however, national views needed to be respected, at least for some major decisions.

In a way, the need to confront the American partner with a single voice forced European members to smooth their differences and devise new mechanisms for harmonising their views, thereby leading to stronger bindings. On the other hand, it can be said that the attainment of a single European voice on such delicate topics as ownership, management and a follow-on development programme, was a good proof of the flexibility of Member States, especially those with a high financial stake in the project, of the diplomatic skills of policy-makers, liaison personnel and managers involved and last but not least, of the shared willingness to find viable compromises in the light of a prominent political goal at the time, i.e. European integration. It has to be remembered that, after protracted negotiations, British membership to the European Community was formalised in January 1973, at the very moment at which ESRO was defining the text of the legal instruments for the Spacelab programme [45].

The legal framework for co-operation on Spacelab was set out in two documents:

1 an intergovernmental agreement negotiated between certain ESRO Member States and the US Government, dealing with the political commitment of the member states with regard to carrying out the programme. It placed this endeavour in the general context of co-operation between the USA and Europe and in relation to the Space Shuttle system [46].

2 a Memorandum of Understanding negotiated between ESRO and NASA to define the tasks and responsibilities of each organisation in carrying out this co-operative programme [47].

From 14 August to 24 September 1973, the Intergovernmental Agreement was opened for signature in Paris. It entered into force at different times, depending on the date of ratification. To implement this agreement, the NASA-ESRO Memorandum of Understanding, marking "the beginning of a new era", was signed [48]. Some of the articles deserve special attention, not only for their objective importance in

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44 HAEUI, CSE/CS(72)15, Report of the ESC Delegation on discussions held with the US Delegation on European participation in the post-Apollo programme (14-16/6/1972), 22/6/1972.

45 Great Britain entered the European Community along with Ireland and Denmark.

46 HAEUI, Agreement between the Government of the United States of America and certain Governments, Members of the European Space Research Organisation, for a Co-operative Programme Concerning Development, Procurement and Use of a Space Laboratory in Conjunction with the Space Shuttle System, ESRO/C(73)46, rev.1, approved at the 10th Meeting of the Spacelab Programme Interim Board (SPIB)(31/7/1973), 26/7/1973.

47 HAEUI, Memorandum of Understanding between NASA and the European Space Research Organisation for a Cooperative Programme Concerning Development, Procurement and Use of a Space Laboratory in conjunction with the Space Shuttle System, ESRO/C(73)45, rev.1, 26/7/1973 -approved at the 59th Meeting of the Council (1/8/1973). It is to be stressed that articles of the MOU were in roman numbers, while the inter-governmental agreement used arabic numeration.

48 This is a excerpt from the declaration signed during the ceremony of the American signature of the ESRO/NASA MOU, at Washington, on 24 September 1973; cit. in n.a., "Spacelab Memorandum of Understanding Signed in Washington", ESRO/ELDO Bulletin, n.23, November 1973, p. 18 (pp. 18-19 for the whole article). The MOU had been approved at the 59th meeting of the ESRO Council on 1 August 1973 and signed on 14 August, thereby entering into force on that date; see Basic Texts of the European Space Agency, cit., note p. AI c/2.

defining the rationale of the programme, but because they were much debated before being approved and would be the focus of future debates.

As already mentioned in the introduction, according to article I, ESRO would undertake to **design, develop, manufacture and deliver the first flight unit of Spacelab,** and other materials described in the Memorandum. Spacelab would be used as an element to be integrated with the Space Shuttle. ESRO would design, develop and manufacture such elements as ESRO and NASA might agree to be necessary for the programme in addition to those listed in the document (Art. V.1.c)[49] Phasing, scheduling and working arrangements would be worked out jointly in the Joint Programme Plan (whose preliminary version had been produced in July 1973). The plan would be based on the results of the preliminary design studies in progress in Europe and in the US, on the user requirements and on the final definition of the Shuttle (Art. IV). NASA would provide managerial consultation and technical interface information. It would monitor the implementation of ESRO activities, develop selected peripheral components and manage all operational activities after the delivery of the Spacelab (Art. V.2).

The first operational Shuttle flight was scheduled for late 1979 which meant that the Spacelab flight unit should be delivered to NASA at least one year before, to enable the Agency to integrate experiments into Spacelab and Spacelab into the Shuttle orbiter. European preoccupations during the opening stages of negotiations revolved around the concept of ownership: they hoped to be able to assure for themselves the development **and ownership** of the Spacelab, while they were ready to guarantee free and unrestricted use and control of the first Spacelab unit to their partners. It became rather clear, though, that NASA would never agree to this. Due to the integration of Spacelab into the Shuttle system, reference to European ownership of Spacelab, they stated, would be perceived in the USA as implying a shared ownership of the Space Transportation System as a whole. To overcome this difficulty, no mention of the question was made in the final text [50] In practical terms, this silence would not favour Europe: the US would make "unrestricted use of the first Spacelab unit free of costs" (Art. IX and Art. 7) and would have "full control of the first Spacelab unit", including the right to make any modification it desired (Art.XI and Art.7), but Spacelab would remain the property of ESA after delivery and ESA would be liable "for damage occurring in connection with a Space Shuttle launch, flight or descent" during the first Spacelab unit mission (Art.11), while sharing liability for subsequent missions [51].

As for the **scope** of Spacelab, it would "support a wide spectrum of missions for peaceful purposes" and "would accept readily the addition of special equipment for particular mission requirements" (Art. II). NASA had the overall responsibility for the total programme and the last say in such vital areas as Shuttle/Spacelab interfaces, quality control and safety, "including the right to make final determination as to its use for peaceful purposes" , Art. 7 and Art.XI). However, "the experimental objectives of the first flight will be jointly planned on a co-operative basis" (Art. XI).

As far as the **commercial use** was concerned, the European request for the establishment of "mutually agreeable standards and conditions" was converted, in the final text, into the search for "the maximum practicable harmonisation of the respective policies" (Art.7), whereby each country was free to adopt

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49 On the basis of this article, it was decided in March 1976 by the NASA/ESA Joint Spacelab Working Group that ESA would develop IPS; HAEUI, Communication interne, Reinhold to DG, 6/9/1976.

50 HAEUI, ESA, dep.2, 52055, Communication interne on NASA/ESRO Spacelab Agreement, Gibson to Kaltenecker, 29/1/1973; Ibidem, ESA, dep.2, 52055, Communication interne on Agency to Agency agreement, Spacelab, from Gibson to Director General, 1/3/1973; HAEUI, ESA, dep.2, 52049, European text (proposed), US text (revision), 25/4/1973; HAEUI, ESA, dep.2, 52055, Note pour le dossier, Propriété du premier Spacelab, by Lafferranderie, 4/11/1974.

51 HAEUI, ESA, dep.2, 52055, Note pour le dossier, Propriété du premier Spacelab, by Lafferranderie, 4/11/1974; see also the retrospective comments in ibidem, ESA/IRAC (82)R/2, Annex III, Report on possible extension and/or expansion of the cooperation established between Europe and the United States of America in the Spacelab Programme, prepared by J.Arets, J.L.Collette, F.Emiliani, C.Reinhold, G.Seibert, June 1981.

such standards and conditions as it deemed more pertinent[52]. Construction of the Spacelab would not guarantee any preferential treatment in the **use of the Shuttle system, nor in the access for scientists to subsequent flights of Spacelab**. European request of "a formal commitment to have unconditional access and use of the Shuttle at least when it is used for a European Space mission" was denied[53]. Art. 7 thereby stated that the US would "make the Space Shuttle available for Spacelab missions (experiments and applications) of the European Partners and their nationals on either a co-operative or cost-reimbursable basis". Pricing policy was left undecided; actually, NASA was unable to anticipate what the Shuttle charging policy would be until 1977.

Although the first flight of the first Spacelab unit would be "jointly planned on a co-operative basis" (Art. XI) (which meant, in the language of the agreement, non-cost for Europe as far as the launching services were concerned), the definition of the nature of subsequent flights remained open to question. This elusive aspect of the agreements (and the fact that Shuttle pricing policy would be constantly revised upwards after 1977), though understandable on technical grounds, because the Shuttle development was still in its infancy at the time, would greatly weaken the consistency of the Spacelab project, preventing any long term cost-benefit analysis between European investments, flight costs, and flight objectives[54]. Because the instrumentation originally foreseen for the inclusion in the First Spacelab Payload (FSLP) needed to be repeatedly taken into space in order to give significant results, the uncertainty about the Shuttle charging policy frustrated the possibility of rational planning of the scientific uses of Spacelab[55].

NASA's guarantee to European scientists was limited to providing access to Spacelab for experiments or applications proposed for reimbursable flights by Governments participating in the Spacelab programme, in preference to those of third countries. Selection on co-operative (i.e. non-cost) flights should follow normal NASA policy, with European proposals given preference over the proposals of third countries only if they were at least equal in merit to the third country's proposals (Art.XI).On the other hand, countries participating in the development of the Spacelab would be entitled **to appoint European crew members** for its flights -"It is contemplated that there will be a European member of the flight crew of the first Spacelab flight" (Art.XI).

The question of **commonality** between Spacelab and the Shuttle, one which would pose serious financial problems for Europe during the development phase, was repeatedly debated during the negotiations. It was difficult to establish, in theory, whether integration should follow the criteria to minimise development and operational costs of the Spacelab or whether reliability and Shuttle requirements should be prioritised. Whereas the USA was in favour of a provision which specified that an effort should be made "for Spacelab to optimise commonality with Shuttle components", faced with resolute European resistance, the compromise formula adopted made reference to the more balanced need "to optimise commonality between Spacelab and Shuttle components" (Art. II)[56]. Choices on modifications would actually be done, as we shall see, on an *ad hoc* basis.

NASA was resolute in refusing to give guarantees about the effects on Spacelab of design changes to the Shuttle. Although recognising "the desirability of avoiding **changes** resulting in a disproportionate

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52 For the European view, HAEUI, ESA, dep. 2, 52055, Communication interne on Spacelab Agreements, from Gibson to Director General, 5/7/1973.

53 HAEUI, ESA, Dep. 2, 52050, Aide Memoire on Spacelab Government/Government Agreement, attached to Letter Gibson to Knörich, 1/6/1973.

54 For pricing policy, see Papers of James Fletcher, Manuscript Division, University of Utah Marriot Library, Salt Lake City, box 43, Letter Gibson to Fletcher, STS Charging Policy, 12/7/1976; see also, A Report to the Committee on Appropriations, US House of Representatives, on the Cost Comparisons and related issues of operating the Space Shuttle and various foreign and US expendable launch vehicles, by the Surveys and Investigations Staff, April 1985.

55 See, for example, the case of Lidar cited in A. Russo, HSR-19, cit.

56 For the US-European debate, HAEUI, ESA, dep. 2, 52055, Communication interne on Spacelab Agreements, from Gibson to Director General, 5/7/1973.

impact on the Spacelab programme", the Agency reserved to itself "the right to require changes affecting the interfaces or operational interactions between the Shuttle and the Spacelab". In the case of changes to the Shuttle affecting Spacelab "to the extent that changes affect the Shuttle and Spacelab programme, NASA and ESRO will bear the increases in the costs of their respective Shuttle and Spacelab development costs" (Art.IX). The formula endorsed was the one proposed by NASA since January[57]. During the implementation of the agreement, the meaning of "disproportionate" would be subject to different interpretations

As for **technology**, while both partners believed that the Spacelab could be developed within the existing European capabilities, it was recognised that some commercial procurements of components and services from the US were likely (Art.6)[58]. Data processing systems had been singled out, as we have seen, as one of the areas in which US help would be most needed. A contract ($ 12 million) for the software components of the data system was eventually placed by ESA with TRW [59]. On the other hand, to the great disappointment of ESRO, the USA resolutely refused any access to technology not directly linked to the development of Spacelab[60]. The major reason for European interest in the collaboration, as we have already noted, seemed to stem from hopes of gaining "programme management and systems engineering experience (...) rather than in specific technical know-how or direct commercial benefits"[61].

NASA agreed to procure from ESRO "whatever **additional items** [Spacelab] of this type it may require for programmatic reasons, provided that they are available to the agreed specifications and schedules and at reasonable prices to be agreed"(Art.VIII). "NASA should give an initial procurement order **of at least one Spacelab at the latest two years before the delivery" of the first Spacelab unit**. (Art. VIII). On the other hand, the article introduced an element of ambiguity concerning the timing of future procurement orders, recognising, in the following paragraph, "the desirability of gaining operational experience with the first flight unit before ordering additional units" and the parallel (and contradictory) need to maintain continuing production capability. NASA's commitment to buy at least one Spacelab was a compromise between the European desire for a long-term commitment to procure Spacelab from Europe and financial constraints and economic interests of the USA[62]. As in the case of the formula "substantial duplication", the wording "at reasonable prices to be agreed" seems to have given rise to some problems because it was later difficult to find a cost basis for "reasonable prices" proposed by European industry[63]. Article VII specified that the financial commitments of ESRO and NASA to carry out the programme were subject to their respective funding procedures which meant, in the case of the US, the yearly approval of the Congress. NASA also agreed to refrain from "separate and **independent development** on any Spacelab substantially duplicating the design and capabilities of the first Spacelab unless ESRO fails to produce such Spacelab" (Art.VIII). This element was represented as a sine qua non condition by European

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57 HAEUI, ESA, dep. 2, 52055, Communication interne on NASA/ESRO Spacelab Agreement, Gibson to Kaltenecker, 29/1/1973.

58 CSE/CS(72)15, Report of the ESC Delegation on discussions held with the US delegation on European participation in the post-Apollo programme, 22/6/1972. As already stated in informal discussions in April 1972, in the most "sensitive" cases of classified technology, if the basic technology could not be transferred, the US would undertake, if necessary, to sell the hardware itself;CSE/CS(72)13, Report by the Secretary General of the ESC on the informal discussions with American officials regarding participation in the post Apollo programme, 8/5/1972.

59 It was the only direct ESA contract to the US, the others being signed on an industry-to-industry basis; see interview M.Bignier, 6/12/1996, Paris.

60 HAEUI, ESA, Dep. 2, 52050, Aide Memoire on Spacelab Government/Government Agreement, 1/6/1973.

61 D.Lord, op.c it.,p.59; see also E.Vallerani, op. cit., p.17.

62 For the European position, HAEUI, ESA, Dep. 2, 52050, Aide Memoire on Spacelab Government/Government Agreement, attached to Letter Gibson to Knörich, 1/6/1973.

63 HAEUI, ESA/IRAC (82)R/2, Annex III, Report on possible extension and/or expansion of the cooperation established between Europe and the United States of America in the Spacelab Programme, prepared by J.Arets, J.L.Collette, F.Emiliani, C.Reinhold, G.Seibert, June 1981.

negotiators since 1972. In view of the fact that the Marshall Space Center had accumulated extensive knowledge about Sortie Cans since the inception of the post-Apollo programme and was involved in concept analysis within Phase-B of the current programme, the relevance of the conciliatory US attitude cannot be underrated[64]. The application of the clause, unfortunately, would be under dispute for many years and "the dividing lines between duplication, substantial duplication and substantial modification very difficult to draw"[65].

It must be stressed that, whereas the USA considered Spacelab as a sort of revised and expanded Helios project - and originally made reference to the German-American agreement of 1969 on Helios as a possible base for the new one - Europeans argued that this agreement should represent the first phase of a long-term co-operation in space exploration by orbital systems. For this reason they insisted in having a provision introduced in Art. 1 of the IGA whereby the programme would provide "for consideration of the timely expansion and extension of this co-operation as their mutual interests warrant" (Art.1). This was in line with the call made by the Director General since 1970, in favour of orienting co-operation towards an area of activities, rather than *ad hoc* projects. Probably, however, the US representatives took some time to understand the underlying importance of such a change in European attitude[66].

Finally, the expiration date was set at 1 January 1985 and, in any case, at least five years after the date of the first flight unit of the Spacelab (Art.16). If no notice of termination were given prior to the expiration date, the agreement would be automatically extended for three years.

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64 HAEUI, ESA, dep.2, 52054, Minutes of the NASA/ESRO Meeting on the Technical and Managerial Problems related to Phase B of the Space Laboratory Programme, 22/11/1972. See also E. Vallerani, op. cit., p. 12.

65 HAEUI, ESA/IRAC (82)R/2, Annex III, Report on possible extension and/or expansion of the cooperation established between Europe and the United States of America in the Spacelab Programme, prepared by J.Arets, J.L.Collette, F.Emiliani, C.Reinhold, G.Seibert, June 1981.

66 Aide Memoire on Spacelab Government/Government Agreement, no date, cited in footnote 53.

2: The implementation of the programme, 1973-1983

2.1 Introduction

Agreements, like law in general, have meaning only in their implementation. Studying the implementation of a programme such as Spacelab is always a delicate task for the historian. Official documents tend to downplay divergences. With some exceptions, personal memories and published accounts emphasise good relationships rather than problems, especially when sponsored by one of the operating agencies. Last but not least, during co-operative ventures it is sometimes preferable to communicate dissent by voice, e.g. telephone calls, rather than by a written document. Written formalisation polarises positions and forces the partner "to retaliate" with an answer of the same formal quality. To force a showdown can be counter-productive if the negotiating partner is in a weak position relative to other political actors at home (for example NASA vis-à-vis the Congress!).

Gibson gives evidence of such a danger, reporting about one of his meetings with high level NASA officials, among whom its Administrator Robert Frosch, subsequent to a letter of strong protest on Spacelab programme implementation, sent by him to NASA in June 1978. "It quickly became apparent" reports Gibson in a note for the record "that their main concern was concentrated on the fact that I had written rather than telephoned. There were repeated references to the embarrassment of having such a letter on the record, the difficulty of even being able to reply in writing, and the fact that Congress may become aware of its existence". "My attitude" reports Gibson "was to say that the contents of the letter represented the minimum compatible with the complaints of Member States, and that these had reached the point where they could not be explained by telephone calls"[67]. We do not want to expand on this particular issue here: the example was just taken to show how much the use of phone calls, and private (not recorded) conversations, can influence the actual outcome of international negotiations and joint programmes, without leaving a tangible trace for the historian.

It is equally important to understand that the position taken by a given individual during the negotiating process has to be viewed in the context of the place occupied by that person in his own hierarchy. Frequently, officials in lower positions can be less flexible if they perceive that this can strengthen their position within their own organisation. Bignier reflected on this point after his first mission to the US as Spacelab Programme Director, stressing how staff at the lowest levels in the power hierarchies tended to be stiffer on certain points [68]. Equally important, a hard initial position was not necessarily a negative sign: it could simply be used to gain space for flexibility during the negotiations, and to be able to appear generous towards the partner[69].

Another major problem arises from the use that is subsequently made by policy makers of old agreements to influence new agreements. What are, in retrospect, considered as weak points of the old agreement are emphasised in order to legitimise requests that are aimed at repairing what is presented as being a misapplication, or in more extreme terms, an abuse of the agreement by the partner. The Spacelab agreement was used during the Space Station negotiations to alert Europeans about *what not to do this time* and to clarify to the US partner what would not be acceptable. In this context, old negotiations acquire a very strong political significance, which can bias later judgements.

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67 HAEUI, ESA, dep.2, 5506, Note for the Record, Meeting with Dr. Frosch in Washington (14/7/1978), by R.Gibson, 17/7/1978.

68 He was referring to the discussions on the integration programme to be executed at the NASA Marshall Space Flight Center, mainly by the MCDAC.

69 HAEUI, ESA, dep.2, 5596, Compte rendu de la mission de D/SL B Washington du 21 au 23 mars 1977, by M.Bignier, 25/3/1977.

The historian is therefore required to draw a delicate balance between what is not said in official documents and (some) oral interviews and what is overstated in more "politicised" sources. It must be stressed that because one of our purposes, underlying even if seldom specified, is to overcome future problems through knowledge of past experience, it is precisely the experiences which caused most trouble that attract the attention of historians. Last but not least, the analysis of conflict situations during co-operative ventures (as is true of crises in international relations), helps to open up the black box of decision-making, revealing the interests at stake[70].

Implementation, especially in such long-term enterprises, has two facets. On the one hand we have the day-to-day work of the men striving to attain a goal, to co-ordinate their tasks, to solve technical and managerial problems, to respect schedules and financial estimates and to monitor the development programme. This is an activity partly recorded in committees such as the ESA/NASA Joint Spacelab Working Group (JSLWG) or the Spacelab Programme Board (PB-SL) reporting to the ESA Council, and in programme evaluations and reviews - but it mainly takes place in the firms involved and at ESTEC. On the other hand, the goal as finally attained is seldom identical to the one set out at the beginning. Financial pressures, political and technical constraints constantly force its redefinition. A continuous feed-back process is required between the political and the technical echelons as well as frequent bargains at the higher political level, to define rules and clauses that have deliberately been left open during the drafting of the legal instruments. This is even more true in the cases, such as Spacelab, in which changes are frequent. They can be imposed by European necessities in terms of savings or users needs, or by outside decisions, such as the restriction of funds by the US Congress which imply changes in the Shuttle design, or by technical accidents which generate slips in its schedules.

The technical competence of one partner, Europe in this case, may be a prerequisite but is not a sufficient guarantee for the happy ending of the story. A successful co-operation requires political willingness, which depends on internal and international interests at stake and bargaining capacities, which increase with each partner's knowledge of the other. They imply a common recognition of national goals, good communication channels, flexibility and mutual trust. Co-operation is something that goes against the well-rooted concept of national sovereignty: its main difficulties lie precisely in the need to keep to it formally and yet, to circumvent it in practice. In the implementation of these tasks lies the core of a co-operative programme.

The prospect of a repetition of co-operation eases the whole process. During the Spacelab negotiations, as we have already seen, Europeans insisted on introducing into the text of the legal instruments a formula whereby the partners anticipated the extension of co-operation beyond Spacelab; policy-makers were probably (and quite rightly) expecting that the prospect of a long-term co-operation based on reciprocity would reduce the risk of arrangements which penalised one of the partners excessively. In the case of repetition and in the absence of a superior juridical authority, this approach is normally met with a tit-for-tat behaviour which leads to a fatal deterioration of co-operation. It is in nobody's interest, therefore, to disavow commitments.

As the industrial work proceeded on the Spacelab programme, arguments started between ESA and NASA "on the precise definitions of the commitments and responsibilities undertaken in the existing agreements". What had been considered a skilfully termed diplomatic formula such as "reasonable prices", "disproportionate impact" or "substantial duplication" needed to be given a specific content, while the arguments that had been deliberately left unsaid, to avert conflict, especially with regard to the contents of the deliverable items and the post-delivery phase, came to the forefront as topics of dispute[71]. If the actors are working on the base of a loose agreement, the more work progresses

70 For this last point of reflection, I am indebted to John Krige.

71 HAEUI, ESA/IRAC (82)R/2, Annex III Report on possible extension and/or expansion of the co-operation established between Europe and the United States of America in the Spacelab Programme, prepared by J.Arets, J.L.Collette, F.Emiliani, C.Reinhold, G.Seibert, June 1981.

towards the attainment of the goal, the more it becomes necessary to resolve the ambiguities which originally made the agreement possible. Friction arises between partners and bargaining can be tough, especially if, as in the case of Spacelab, partners are confronted with rises in costs and changes in design over a very long time. It is, however, a basic premise that the knowledge of each other acquired during the first phases of the co-operation, and the increased mutual interest developed during the attainment of the final goal, should favour compromises on *ad hoc* points that would be difficult to handle at the outset of co-operation. As we shall see, this is what happened most frequently during the Spacelab experience. Whenever a co-operation is invested with strong political significance, the credibility of both partners is equally at stake and the risk of losing it is a great cement for the enterprise.

In order to facilitate bargaining and mutual agreement between the two agencies and to clarify any eventual misunderstandings, an Annual Review was foreseen in Article VI, to be conducted and discussed by the NASA Administrator and the ESA Director General. The first meeting between Hocker and Fletcher was held on 20 May 1974. These discussions actually played a very important role in resolving misunderstandings and interpreting those clauses which had been left vague in the agreements whenever it was deemed necessary to do so. This was done at the highest level in the agencies and in the quickest way, while reaffirming each time the political importance of the co-operation [72]. Good communication between Europe and the US was further pursued through the setting up of a network of joint working groups and the diplomatic skills of the people in charge of the programme.

2.2. The early involvement of industry[73]

By June 1974 ESRO had passed over four thousand industrial contracts worth about $ 900 million [74]. The total cost of the Spacelab programme alone was originally expected to be $ 250 (or 308 MAU), but ended up much higher. The challenge for European industry was a major one.

While early American studies on modules such as RAMS (research and applications modules) were performed in close connection with studies on the original Space Station, later studies were more focused on manned laboratories in the context of a broader modular space station, such as the sortie cans; they had to be hosted in the Shuttle cargo bay and devoted to short term missions[75]. In 1970 the European Space Conference authorised the first studies related to the Space Transportation System[76]. From June to November 1972, three European consortia, COSMOS, STAR and MESH, concentrated on a modular orbital system to be flown by the Shuttle. They named it Sortie Laboratory or Space Laboratory and proceeded to three preliminary definition Phase A studies. The COSMOS team was led by MBB (Messerschmitt-Bölkow-Blohm), which had participated as contractor to the Convair studies on RAM, and included SNIAS (FR), MSDS (UK), Selenia (I), ETCA (B), CASA (Spain) and CIR (CH). The MESH team was lead by the ERNO division of the VFW-Fokker Corporation, which had also participated in Convair studies and included Battelle (CH), BTM (B), Aeritalia (I), HSD (UK), INTA (S), MATRA (FR) and Philips (NL). The STAR team was lead by the British Aircraft Corporation (BAC) and included Dornier (FRG), Contraves (CH), Thomson-CSF (F), GSE-FIAR(I) and Montedel (I) [77].

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72 Ibidem.

73 On this point, see the insightful accounts in K. Berge, op. cit., pp.1-19.

74 R.Gibson, "Space Development - Europe or how the octopus learned to dance" (Transcript of a speech made at the Financial Times World Aerospace Conference, San Francisco, 15 October 1974), ESRO/ELDO Bulletin, nr.26, December 1974, p.9.

75 D.Lord, op. cit., pp.35-48.

76 See L. Sebesta, ESA HSR 15, cit., pp. 8-9; where reference in note is omitted, we refer to M.Bignier, "Spacelab Development", ESA Bulletin, n.36, November 1983, pp. 6-11.

77 E.Vallerani, op. cit., p.14; D.Lord, op. cit., pp.48-52.

As the Phase-A studies were approaching their end, the Council of ESRO authorised, in November 1972, the Director General to carry out the detailed definition (Phase-B) studies, to arrive at a firm costing on which states could make their final decision. Belgium, the Federal Republic of Germany, Italy and Spain indicated their intention to finance this work. Soon afterwards, at the Ministerial meeting of ESC on 20 December 1972, ESRO was entrusted with the task of implementing the programme. During the ESRO Council meeting of January 1973, the German delegation stated that "since each of the three European space consortia had a very flexible structure, changes could be made to adopt their composition to the requirements of the new programme". This was achieved during the following months[78].

By January 1973 it was decided by the Interim Spacelab Programme Board, chaired by Professor Massimo Trella, that the distribution of work for Phase-B was to be organised, to the maximum extent possible, so as to ensure return to those states which, by the following month, would engage themselves in these studies. A provision was added whereby states could withdraw during 1973 if the results of the Phase-B studies should indicate that the original financial estimate of 308 MAU would be significantly exceeded. This tactic persuaded states other than the four original ones to get involved in the project, leaving an escape clause for them to withdraw at a later time. Politically, it was much easier for a Minister to gain approval for the commitment of a limited amount of funds, especially if, as it happened in the case of the UK, it could be made explicit that the government was free to withdraw after completion of Phase-B studies. Nine states engaged, at different times, in these studies. By the end of Phase-B the original financial estimate was confirmed and the division of costs among states was clarified (ESC Council of July 1973). None of them, eventually, withdrew from the enterprise - and Austria later joined the team.

Because of the higher percentage of expenses borne by the Federal Republic of Germany, and the existence of the fair return principle, the prime contract was to be awarded to a German prime contractor. This consideration, along with the special technical requirements of Spacelab (the composition of the consortia, which were created to build unmanned satellites such as ESRO I and ESRO II and which were not suitable for performing all the tasks required for this new undertaking) as well as the magnitude of the contract that would enable the participation of more firms than those usually required for earlier ESRO contracts, forced a total redirection of the previous three-consortia scheme. In fact it seemed appropriate:

> *that Phase B2/3 contracts be awarded to ERNO and Messerschmitt-Bölkow-Blohm, the two firms that had led the MESH and COSMOS consortia respectively in the phase A studies, with the provision that these firms, in selecting their co-contractors and sub-contractors, must give serious consideration to a complete restructuring of their groups, bearing in mind the points previously raised [technical requirements of firms and magnitude of the contract], and also taking in consideration the STAR consortium firms that had taken part in the earlier work, as well as the fact that geographical allocation of the work at subsystem level must bear a close resemblance to the percentage contributions of the participating States. In other words, the selection of ERNO and MBB as prime contractors did not necessarily imply the selection of the MESH and COSMOS consortia, but that there should be a re-grouping around the prime contractors of as many as possible of the qualified industrial firms in the participating countries* [79].

The three initial consortia were therefore recombined in two by February 1973.

Early in 1974, the ESRO project team at ESTEC issued to industry a Request for Proposals (RFP) for the design and development contract (Phase C/D) and, as a result of subsequent evaluation, the

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78 HAEUI, ESRO/C/MIN/53 (18/1/1973), 29/1/1973.

79 "Europe and Post-Apollo", no author, ESRO/ELDO Bulletin, n.22, August 1973, p.10; on the influence of Spacelab on the dissolution of the three original consortia, see also: Interview George van Reeth, by John Krige and Lorenza Sebesta, San Vincente, Italy, 11 July 1996.

Director General recommended to the Administration and Finance Committee the choice of the industrial consortium lead by VFW-Fokker/ERNO against its rival MBB. This was not an easy choice. Generally speaking, MBB, which had accumulated more experience in aerospace production in previous years, appeared to many the favourite to win. The Tender Evaluation Board, however, after setting up ten panels to carry out the detailed evaluation, considered both proposals technically and financially acceptable and felt unable to recommend a choice between the two in view of the closeness of the final markings (approximately 1% difference). In accordance with standard practice, the Board's report was submitted to the ESRO's Adjudication Committee, under the chairmanship of the Director General, and finally chose ERNO on the following grounds:

1 "superior technical concept;

2 higher state of technical preparedness and depth of design for immediate implementation of Phase C/D;

3 greater suitability of concept to user's wishes;

4 particular strength of top management aspects;

5 shortcomings of the proposals more easily 'repairable' both because of their nature and because some would come to bear only later on in the project"[80].

The trade-off between quality, price, geographical distribution and political concerns is something whose complexity our sources cannot help us to grasp. It is however interesting to locate the geopolitical realities that it reproduced [81]. The North, where Bremen was located, was the place where the Social-democrat Premier Willy Brandt had built up his political career as the major of Berlin, before becoming Chancellor in 1969, at the head of a Social-democrat/Liberal coalition, succeeding the long-established Christian-democrat government[82]. The South, and Munich, where MBB was located, had in contrast benefited from governmental policies and industrial orders in the past. In fact the development of a strong technological region in Bavaria had been always high on the agenda of the Christian-democrat Minister of Defence Franz Joseph Strauss.

Notwithstanding, "the choice" recalled Roy Gibson, Acting Director General of ESRO, in October 1974 "was made after extended discussions within the Secretariat, and without any political pressure (from Germany or elsewhere)". Quoting again Gibson, the trade-off complied with the following steps: "Inside the Secretariat we have for many years taken steps to isolate the technicians from the need in their evaluation to attempt to quantify the importance of geographical distribution. The Tender Evaluation Board makes its recommendations in the light of quality, cost and availability. The Board also notes those offers which are technically unacceptable. A separate committee -often meeting at Director level- adds geographical distribution considerations where this is necessary (relatively rarely). The most important contracts (around 30 per year) go to a delegate body, the Administrative and Finance Committee. This committee has two or three times reversed the

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80 No author., "Spacelab", ESRO/ELDO Bulletin, n.25, July 1974, p.22.

81 Douglas Lord hints at the "political overtones" of the choice; D.Lord, op. cit., p.73. Vallerani describes how "the ESRO TEB tried to work in isolation, ignoring political pressures and concentrating on the technical aspects"; E.Vallerani, op. cit., p.26. For a general introduction (in English) to the development of space policy and industries in the Federal Republic of Germany, see Johannes Weyer, European Star Wars: the emergence of space technology through the interaction of military and civilian interest-groups, in Everett Mendelssohn, Merrit Roe Smith, Peter Weingart (eds), Science, technology and the military (Dordrecht: Kluwer Academic Publishers) 1988, pp. 243-288.

82 It is interesting to note that at the national election (November 1972) which had taken place after the sweeping international economic crises of 1971, the CDU-CSU lost its majority in Parliament for the first time in its history (44.9% against 45.8% for the SPD). Willy Brandt was succeeded as Chancellor by Helmut Schmidt in May 1974.

recommendation of the Secretariat, but in no case was the Secretariat instructed to award a contract which it considered to be technically unacceptable"[83].

The first Annual review between ESRO Director General, Alexander Hocker and NASA Administrator, James Fletcher, took place some days after the Director General's recommendation in favour of VFW-Fokker-ERNO, and before proceeding to Phase C/D. The discussion soon focused on the failure of both contractors to satisfy the target payload masses for the various configurations of Spacelab, by significant amounts. Adjustments in design and goals, and a reduction in the mass growth margins, arrived at with American assistance, contributed to solving the problem. Mass reduction needs, on the other hand, forced a revision of the original design, inducing a higher level of sophistication than initially envisaged[84].

In June 1974 the European industrial team led by VFW-Fokker/ERNO was awarded the 6-year, 180 MAU ($ 216 million) Spacelab design and development contract whereby the programme entered the design and development phase. The contract specified the deadline for the first unit, fully qualified and ready for installation of experiments, as April 1979 - the first launch being expected for early 1980. Two engineering models (one for ESRO and one for NASA), three sets of ground support equipment and spares were included in the contract. Commitment for the Instrument Pointing System (IPS) was postponed because the design and cost details were considered inadequate for development commitment. After protracted discussions with the US side and as a result of a tender action in October 1975, the programme for the development of the IPS was initiated in December 1976 and a contract was awarded to Dornier in June 1977 for IPS Phase C/D, for a total value of 19 MAU (at December 1976 price)[85].

During the Summer, ESRO and industry representatives of the Spacelab team visited the USA to discuss design details, operations and interfaces. They were led by Heinz Stöwer, acting Programme Director for ESRO and Hans Hoffmann, ERNO Project Manager[86]. Hans Hoffmann, with the administrative help of Kappler and Bernard Kosegarten, Commercial and Financial Directors, and the support of his deputy Klaus Berge and later, Ants Kutzer (previously Project Leader of the German satellites Azur and Helios), would guarantee the continuity of management within ERNO during the whole project[87]. The first NASA/ESRO Joint Programme Plan was produced in September 1974 in conformity with Article IV of the MOU. In order to clarify the working arrangements between the two agencies, it also amplified the overall description of the programme and of the phasing and scheduling mentioned in Articles II and III of the MOU[88]. The production was divided into various sub-systems, many of which were manufactured by subcontractors. VFW-FOKKER/ERNO was responsible for the development, integration and test of the total system and ten European co-contractors, supported by

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83 R.Gibson, "Space Development - Europe or how the octopus learned to dance" (Transcript of a speech made at the Financial Times World Aerospace Conference, San Francisco, 15 October 1974), ESRO/ELDO Bulletin, n.26, December 1974, p.9 (pp.8-11).

84 Papers of James Fletcher, Manuscript Division, University of Utah Marriot Library, Salt Lake City, box 20, note Frutkin to Fletcher, 2/6/1974; E.Vallerani, op. cit., p. 26.; D.Lord, op. cit., pp. 74-75.

85 HAEUI, ESA/PB-SL(77)13, 8/9/1977, Status of the IPS Development; a summary of IPS contractual history can be found in HAEUI, 6124, ESA/IPC(81)72, 5/11/1981, Industrial Policy Committee proposal to place a rider. The funding constraints and technical problems linked to the software used to control the various operational steps of the IPS, as well as the need to redesign it in order to comply with the Shuttle-Orbiter-induced load requirements after 1980, caused extended redesign and difficulties throughout the programme. Despite these inconveniences, IPS was finally loaded on Spacelab-2 in July-August 1985. The full IPS story still remains to be told. For a preliminary assessment, see H.Heusmann and P. Wolf, "The Spacelab Instrument Pointing System (IPS) and its First Flight", ESA Bulletin, n.44, November 1985, pp. 75-79.

86 D.Lord, op. cit., pp. 86-87.

87 For a complete scheme of the ERNO organisation, See K.Berge, op. cit., p.10. See also E. Vallerani, op. cit., p. 39.

88 NASA-ESRO Joint Programme Plan for Spacelab, by Douglas Lord, Director, Spacelab Program, NASA and Heinz Stöwer, Acting Head of Spacelab Programme, ESRO, 26 September 1974; reproduced in D.Lord, op. cit., pp. 461-467.

36 subcontractors, collaborated. At the height of the development phase, about 2000 people were employed in European industry to perform tasks related to the programme[89].

One of the more complex and debated tasks was performed by the Command and Data Management sub system, which contained three computers, one to handle the subsystems, one for experimenters' needs and one as a backup. After some resistance from the US, which intended to use IBM machines, it was handed over to Engins MATRA (France)[90]. Other important tasks were performed by the other nine co-contractors: Aeritalia (Italy) responsible for one whole subsystem, the module structure, and part of the environmental control device (i.e. the thermal control); Dornier Systems (Germany) which built the environmental control and life support system and, later, the IPS; Hawker-Siddeley Dynamics, later part of the nationalised British Aerospace (UK), responsible for the pallet structure; AEG-Telefunken (Germany), which built the electrical power system; Bell Telephone Manufacturing (Belgium), INTA (Spain), Fokker (The Netherlands), SABCA (Belgium) and Kampsax (Denmark). Other European firms, as well as ERNO itself, were involved with the production of other subsystems, as subcontractors[91].

US firms were involved from the beginning in Spacelab. They worked either directly for ESA (as in the case of the TWR for the software system) or, more frequently, through agreements with private industries. Eventually, the technology passed over to European partners was in the form of know-how, not of black boxes[92]. McDonnell Douglas, one of the first American companies to be deeply involved in man-in-orbit activities, which had contributed to NASA-funded studies on sortie cans for the Marshall Space Flight Center (and which had lost the bid for the Shuttle), welcomed the approaches by ERNO and provided up to 35 consultants to the firm, 5 to Aeritalia and 2 to Fokker. As recalled by Vallerani, "it went so as far as to set up a European branch, with head offices in Bremen" to manage its consultancy contracts [93]. At the same time, suffering from what was perceived as an undue loss of industrial procurement opportunities in a time of need, it critically scrutinised European firms in the opening stages of collaboration[94]. Martin Marietta joined the MBB team. Consultants provided an important input during Phase-B studies and stayed on until the engineering model was delivered to NASA in 1980. The contribution of TRW consultants to ERNO, MATRA and BTM was important in easing problems related to payloads and avionics [95].

2.3. General guidelines for payload selection and the institutional framework of the programme

The objectives of Spacelab, which had been defined in concise terms in the MOU as being "peaceful", were among the most relevant topics discussed during the first annual review of Spacelab programme (20 May 1974), where Fletcher and Hocker met to discuss its future development. In the guidelines set

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89 M.Bignier, "Spacelab Development", cit., p.8.

90 D.Lord, op. cit., pp. 93-95. The then Programme Director Jean-Pierre Causse played an important role in ensuring that the computers and aluminium for the module were procured from European sources; Intervention K.Berge, Spacelab Workshop, Noordwijk, 22/4/1997.

91 Switzerland and Austria were only represented by sub-contractors, with CIR and VMW respectively; see A.Thirkettle, F.Di Mauro, R.Stephens, Art. cit , part 1, p.71; K.Berge, op. cit., p. 11; D.Lord, op. cit., p.85 and pp. 175-205.

92 Intervention K.Berge, Spacelab Workshop, Noordwijk, 22/4/1997.

93 E. Vallerani, op. cit., p. 18.

94 On this point, see the intervention of L.Tedeman, Spacelab Workshop, Noordwijk, 23/4/1997.

95 D.Lord, op. cit., pp. 85-86; for schedule extension of TRW support personnel at ERNO due to the unavailability of experienced ERNO personnel, see HAEUI, ESA, dep.2, n. 5580, Letter Pfeiffer, Project Manager, Spacelab, ESTEC, to Berge, ERNO, 6 February 1979. Aviation Week and Space Technology estimated in 1973 "that 20% of Spacelab's $ 300-million total cost (would) be spent in the US to buy technology, systems skills and hardware": "Space Technology. US to Extend Export Dominance", May 28, 1973, Aviation Week and Space Technology, pp. 222-229, p. 222 for quotation. For a broader reference to the role of US consultants, see intervention of K. Berge, H. Hoffmann and R.Pfeiffer, Spacelab Workshop, Noordwijk, 22-23 April 1997.

out by NASA for the discussion, the payload was said to be "open to science, applications, and technology experiments"; it should not, however, "carry experiments where the results will not be freely disseminated or where the main purpose [would be] for direct commercial exploitation". We already saw how the topic of commercialisation had given rise to debates during the negotiations, the Europeans being prone to establish common codes of conduct, the USA to "harmonise" the respective ones. The will to preserve their freedom in such a delicate domain probably prompted the USA to abandon the prospect of co-operation in commercial areas altogether. This limitation, which was not in the original text of the MOU, was a proof of the persisting difficulties in co-operating when financial returns were anticipated and, therefore, competition envisioned. The guidelines and procedures for selection of the first Spacelab payload, proposed by the NASA/ESRO JPG were approved. The principal objective of the first payload would be the verification of the main Spacelab design aspects and capabilities and the performance of a series of scientific experiments [96].

As far as the organisation is concerned, Spacelab development would be managed by Europeans, with the assistance of the USA. While France, in the Ariane programme, had made the assumption of the largest financial share conditional on the acceptance by the other partners of CNES management, the Spacelab programme, pending the establishment of ESA, was managed by ESRO and later ESA. This reality was reflected in the numbers of ESA personnel involved in the two projects: 120 for Spacelab and 25 for Ariane[97].

The Federal Republic of Germany, though being by far the most important contributor, was not entrusted with the predominant institutional role it claimed[98]; as a matter of fact, after the nomination of Jean-Pierre Causse as first Programme Director in March 1973, the role of the Director of the programme was always entrusted to a French citizen, except for the period during which Heinz Stöwer was Acting Programme Director.

The programme was supervised by the **Spacelab Programme Board** (PB-SL), as indicated by Article 4 of the agreement between ESRO and its members in 1973 and by US/European agreements. The Board, composed of representatives of the participants, provided the Director General with all the necessary instructions regarding the interfaces of the programme with the Shuttle and ensured links with the user community. After existing as an interim board (the Spacelab Interim Board), the PB-SL had its first meeting on 30 September 1975, under the chairmanship of the Italian aeronautical engineer Luigi Broglio.

Generally speaking, the structural changes introduced after the birth of ESA favoured increased independence of the Agency from its Member States. Three programme directorates were created - Communications Programmes, Science and Meteorological Programmes and Spacelab Programme. Whereas in ESRO the responsibility for implementation rested ultimately on the Council, the more focused ESA Directorates, reporting directly to the Director General, permitted direct action and less dependence on national inclinations. This relative autonomy during the implementation, was further enhanced in the case of Spacelab by the existence of the ESRO Member States Agreement whereby members had delegated the Organisation the power to take practical steps for the implementation of the agreement.

The implementation of the programme was ascribed to two Heads of Programme, or **Spacelab Programme Directors**, since it had been established that there would not be joint management responsibility of the programme: one for ESRO (originally, Jean-Pierre Causse) and one for NASA (Douglas Lord). While Lord kept his post until 1980, to be replaced by James Harrington, there were

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96 Papers of James Fletcher, Manuscript Division, University of Utah Marriot Library, Salt Lake City, box 20, Diary Note by Frutkin, First Spacelab Payload Selection: Guidelines, Procedures, Constraints and Timetable, 10/5/1974.For more details on this point, see A.Russo, HSR-19. cit.

97 Interview M.Bignier by L.Sebesta, 6/12/1996, Paris.

98 Intervention J-P. Causse, Spacelab Workshop, Noordwijk, 22/4/1997.

several replacements on the European side. Causse left his post in April 1974 to become Director of Research of the firm Saint-Gobain and after that Heinz Stöwer took up the delicate double cap of Acting Programme Director and Project Manager. Stöwer left the first post in March 1975, when Bernard Deloffre (French chief executive of the Symphonie satellite programme and former Director of the Space Launch Centre of Kourou in Guiana) was nominated Programme Director. Deloffre left his post in June 1976 and, after an interim of four months covered by Gibson and Trella, Michel Bignier (ex Director General of CNES) took up his task in November.

Two **Project Managers** were responsible for day-to-day and more technical co-ordination. The ESRO Project Manager at ESTEC was Heinz Stöwer and the NASA Project Manager at the Marshall Space Flight Center was Thomas (Jack) Lee. Stöwer was substituted as Project Manager in March 1977 by Robert Pfeiffer (who had directed the Franco-German experimental telecommunication satellite Symphonie). Franco Emiliani, number two to both Stöwer and Pfeiffer, assured management continuity. In 1983, Pfeiffer was replaced by G. Altmann. Despite the split of management along geopolitical and industrial lines, co-operation was achieved through many consultative joint groups. At the end of November 1972 the **ESRO/NASA Joint Sortie Laboratory Working Group** jointly chaired by Johannes Ortner (ESRO Assistant Director for Space Missions) and Douglas Lord (Director of the NASA Sortie Laboratory Task Force) met in Washington. The same committee had been working to co-ordinate technical activities on orbital system studies for the two previous years. From now onwards it was to monitor the exchange of technical information, interface questions between Spacelab and the Shuttle, to co-ordinate changes in requirements or contents and settle cost issues[99]. By the third meeting Jean-Pierre Causse, named Head of the Spacelab Programme, replaced Ortner as ESRO committee chairman. The name of the group was changed into the **ESRO/NASA Joint Spacelab Working Group (JSLWG)** after the decision to use Spacelab as the official name of the project. Constraints originating from the Shuttle's technical and financial features were to be matched against users' requirements for Spacelab design and operations, which were solicited from 1973 onwards, through the **Joint ESRO/NASA User Requirements Group (JURG).** This was initially co-chaired by Gerald Sharp (NASA) and Johannes Ortner (ESRO) and eventually revived in 1978 to report on users requirements vis-à-vis improvements of Spacelab within the Follow-on Development programme. Both co-chairmen of JURG were therefore full members of JSLWG[100].

One cannot fail to notice the importance of the procedure set up by the MOU whereby the two heads of ESRO (later ESA) and NASA would meet regularly to solve major problems arising in the implementation of the programme. These meetings were indeed extremely useful in showing to the public how Spacelab was identified by both NASA and ESA among their top political priorities, and in reinforcing the authority of the Director General vis-à-vis industry, when he had to force it towards some special requirements in terms of time or financial schedules. There was a remarkable stability in contacts between Gibson (Acting Director General of ESRO from July 1974 to April 1975 and thereafter Director General of ESA until May 1980, when he was replaced by Quistgaard) and Fletcher, NASA Administrator, who left the agency in May 1977 to be replaced by Frosch[101]. Gibson himself was always in close and direct contact with the senior managers of Spacelab throughout the programme.

On the industrial side, a structure was soon created to co-ordinate the work of the co-contractors, to increase the effectiveness of leadership to be played by ERNO, to solve interface problems and to transmit, without excessive loss of time and energy, changes in design and in time schedules. This

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99 Article VI of the Memorandum of Understanding; see also M.Bignier, "Spacelab Development", cit.

100 HAEUI, ESA, 4876, Inter-office Memorandum, Charter for JURG, by Bignier, 23/3/1978. Other joint working groups were created to manage specific aspects, such as the Spacelab Operations Working Group, the Software Co-ordination Group and the Avionics Ad Hoc Group; see D. Lord, op. cit., p. 100. Other groups discussed the scientific aspects of Spacelab, such as the NASA/ESRO Joint Planning Group co-chaired by Gerald Sharp (NASA) and Jacques Collet (ESRO). For more details, see A.Russo, op. cit.

101 Robert Frosch would be eventually replaced, in June 1981, by James Beggs.

was the **Board of Directors of the Spacelab Consortium**, which met every three months. Sessions were held at different locations, to increase everybody's sense of participating in a "common mission"[102]. Bignier used the Board to be kept informed of progress in industrial work in a delicate period of the programme, participating in the last part of these meetings. This gave the firms a sense of being in touch with the latest political development of the programme, enabling the Director, at the same time, to be in close touch with the problems on the production side in order, if necessary, to solve them quickly and informally[103]. Finally, mention should be made of ESA's representative in Washington, Wilfred Mellors, and NASA's representative in Paris, P.Murphy (initially); they were the channels that filtered political information pertaining to the country where they were based, giving the officials back at home an invaluable framework for decisions and behaviour at high-level diplomatic meetings. This complex institutional framework was put on the credit side of the programme by both US and European observers [104].

2.4. The management: early challenges and creative solutions

The implementation of the programme can be considered as a story whose main scenes took place in a somehow segregated context, mainly in ESA/ESTEC (where the overall project direction, control and co-ordination with NASA was performed) and in ERNO and its co and sub-contractors firms. Yet, the development of this story was closely linked to the external environment through concentric circles: the most general of these was the economic system of the seventies, which deeply influenced the financial aspects of the project: at an intermediate level there was the Shuttle system, in which Spacelab was deeply embedded and on which it was totally dependent: finally, there were all the questions related to the implementation of the programme, the main actors here being on the one side ESA/ESTEC, ERNO and the other firms involved and on the other NASA. The intertwined relationships between these three circles created the extraordinarily intricate basic pattern of the Spacelab programme.

Economically, the seventies were a critical period. They started with the crumbling of the fixed currency exchange system that had guaranteed, since 1945, the stability of international commerce. The exceptionally high level of industrial production attained by the developed countries by 1972-73, was soon counter-balanced by the oil crisis, and subsequent oil price increases, which struck Western countries in the last months of 1973. In four months the price of a barrel of oil increased by a factor of four (from 3 to 12 dollars). This was paralleled by a sustained increase in the prices on the international markets, of primary commodities such as cereals. Due to this economic and financial turmoil, inflation rates, which had been increasing since 1968, exploded and reached their highest levels since the war. From 1974 to 1980, inflation rates rose to 9.2% in the US, 11.1% in France, 15.9% in the UK and 16.8% in Italy. The Federal Republic of Germany was the only exception to this general increase: however, it scored a remarkable (for its post-war standards) 4.7% [105]. Spacelab, whose original price of 308 MAU was calculated in 1973 prices, was severely hit by these circumstances (much more than Ariane, whose reference price was in 1974 currency)[106]. And, among participating states, those with the highest rate of inflation, such as Italy, were obviously exposed to the greatest increase in production costs. The upgrades of the first two years, which brought the

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102 See the observations by H. Hoffmann, Spacelab Workshop, Noordwijk, 23/4/1997; also E.Vallerani, op. cit., p.30.

103 Interview M.Bignier, 6/12/1996, Paris.

104 HAEUI, ESA/IRAC (82)R/2, Annex III, Report on possible extension and/or expansion of the co-operation established between Europe and the United States of America in the Spacelab Programme, prepared by J.Arets, J.L.Collette, F.Emiliani, C.Reinhold, G.Seibert, June 1981; see also D.Lord, op. cit.

105 Pierre Milza, Serge Bernstein, Histoire du XXe siècle. 1973 À nos jours, la recherche d'un nouveau monde (Paris:Hatier) 1993, p. 13; Alan Milward, L'Europa in formazione, in AAVV, L'Europa oggi (Torino:Einaudi) 1993, pp.211-219.

106 This important consideration was suggested to the author by M.Bignier, Interview M.Bignier, 6/12/1996, Paris.

original estimate up to 369 MAU by the end of 1975, seem actually to have been totally due to the rates of inflation[107].

Within this economically unfavourable context, Europeans were confronted with yet another, more practical, problem. Spacelab and Shuttle development proceeded in parallel throughout the seventies. Both projects had technical difficulties, delays and cost overruns. As far as Spacelab was concerned, this meant that it had to be integrated into a system whose parameters were open to refinement until the very end, whose timetable for launch was repeatedly postponed and whose pricing policy was highly uncertain. Commonality, which had been one of the focuses of discussions during the drafting of the legal instruments, had to be negotiated on an *ad hoc* basis. Discussions ranged from the prosaic choice of the measurement system (Europeans struggled to keep their metric system for Spacelab specifications, while US units (feet, pounds etc.) were kept for the Shuttle and its interfaces) to the delicate decision on the possibility of taking a docking module on board (for emergencies), which would imply a great loss of mass for Spacelab[108]. Refinements of specifications and schedules of the Shuttle affected the cost-to-completion of the whole Spacelab[109]. It is difficult to quantify the impact of this on the Spacelab cost overrun[110]. Anyway, several Shuttle/Spacelab hardware and programmatic interface issues, before and after the delivery of Spacelab to the US, were still open during the integration and test phase at the end of the seventies. NASA expected ESA to fund all make-work changes to Spacelab, including those originating from the Shuttle, up to the second Spacelab flight, while ESA was trying to limit its funding responsibility to a funding ceiling and a precise cut-off date for the new NASA requirements[111].

This problem was tackled using a two-way approach. On the one hand the initial ESA approach whereby any contractor in the consortium could raise an engineering change proposal and start working on it (being sure to be funded by ESA if the change required extra payments) was terminated. Changes subsequently needed prior approval by ESA. On the other hand, a "Risk Assessment Working Group" (J.Harrington & R.Pfeiffer) was set up to define ESA/NASA responsibilities as far as the post-delivery support phase was concerned[112]. Spacelab was required to meet essential technical and scientific requirements and, at the same time, to stay within the programme constraints of schedules and funds. While ERNO, a private firm, its co and sub-contractors, were more interested in the technical success of the enterprise, with less regard for fund limitations and time constraints, ESA/ESTEC, by definition, appeared to emphasise time and financial schedules. The reconciliation of these different if not divergent aims was the challenge that Spacelab managers had to confront for a decade. The formalisation introduced by the ESA management in order to reduce the price of changes, for example, was perceived by industry as an obstacle to quick changes and efficiency in the production process[113]. The flexibility of the structure (the Spacelab would be available in more than

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107 HAEUI, ESA, 4876, Letter, Deloffre to Lord, 28/11/1975; the exchange rate of AU into dollars changed to 1 AU being equivalent to $ 1.3.

108 The idea was eventually discarded. See J.-P. Causse's intervention, Spacelab Workshop, Noordwijk, 22/4/1997.

109 See, for example, D.Lord, op. cit., p.102.

110 During a presentation given in 1982, Robert Pfeiffer tried to assess the causes for Spacelab cost overrun (40%)up to that date, indicating approximately the following percentage: 33% due to consortium make-work changes and higher cost for work in industry already committed, 30% due to the fact that some MOU commitments were not part of industrial baseline contracts (logistic support, depot maintenance and sustaining engineering support), 20% due to new user requirements and inadequate design, and 17% due to Spacelab/orbiter interface changes, including flight and ground operations. See R.Pfeiffer, Le programme Spacelab. La gestion du programme, les problèmes rencontrés et les solutions adoptées, Paper presented at the Course on Space technology/The management of Large Space Programmes, CNES, Toulouse, 3-14 May 1982.

111 HAEUI, ESA, 4860, Memorandum W.Brado to J.Stiernstedt, 5/10/1979.

112 Intervention of R.Pfeiffer, Spacelab Workshop, Noordwijk, 23/4/1997. ESA Washington Office, Internal communication. Inter-office Memorandum, de D/SL(Bignier) to Mellors, 11/4/1979, Action decidée lors de la réunion DG/A du 29/3/1979; ibidem, Letter Frosch to Gibson, 7/5/1979; ibidem, Letter Gibson to Frosch, 17/5/1979.

113 For the industrial point of view, see K.Berge's intervention, Spacelab Workshop, Noordwijk, 23/4/1997.

one configuration), the constraints imposed by the Shuttle features and their changes and the number of companies involved caused many different concerns to managers and constructors during the programme. Spacelab characteristics such as mass, subsystems, interfaces, and its programmatic features such as operations and user requirements, changed over time and gradually diverged from those in the first document "Spacelab Guidelines and Constraints for Programme Definition, Level I"[114], produced in March 1973 by the programme directors, Jean-Pierre Causse and Douglas Lord. The complexity of these changes has been analysed elsewhere[115]. Progress in the programme was monitored at major milestone reviews, the list of which (see below) we take from an article by a qualified eye-witness. These reviews were catalysing milestones of the project, an essential part of the project management. There, not only was industrial performance scrutinised; but young engineers also had the opportunity to become familiar with a US managerial style developed from a need for accountability and the demands associated with the production of complex technical systems.

Some US suggestions were gladly incorporated into the practices of European engineers, such as the formalised procedures for presenting reports and proposals, implying the extensive use of graphs and tables [116]. On the other hand, the need for written specifications down to the smallest detail was sometimes resented as an implied criticism of the personal capabilities of European engineers and technicians, who were used to operating with more autonomy.[117]. Other procedures, such as the "award fee system", were introduced and then later discarded because they were not tuned to the uncertain schedules and continuous changes of the programme[118]. The "managerial gap" of the late sixties between the US and Europe was (also) being filled up through day-to-day exposure of European engineers to US procedures, through the creative appropriation and selective rejection of the proposed models.

The major milestone reviews were the following:

1 The Preliminary Requirements Review (PRR) in 1974 established a conceptual baseline for subsequent reviews and gave preliminary approval to higher level system specifications and plans[119].

2 The System Requirements Review (SRR) in 1975 updated the system requirements and served as a start for the final subsystem definition and design phase.

3 The Preliminary Design Review (PDR) in 1976 was a technical review of the basic design approach, to assess design versus requirement and adequacy of design in order to lead to authorisation for Engineering Model design and manufacture[120].

4 The Critical Design Review (CDR) in 1978 formally established the production baseline for the first flight unit.

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114 HAEUI, ESA, dep. 2, 5606, "Spacelab Guidelines and Constraints for Program Definition, Level I", by Douglas Lord and Jean-Pierre Causse, 23/3/1973; see also D.Lord, op. cit., pp. 87-88 for the first document, p.91 for the last.

115 K.Berge, op. cit., pp. 20-37; E.Vallerani, op. cit., pp. 31-40. Douglas Lord's book follows these milestones step by step; D.Lord, op. cit.

116 See H.Hoffmann's intervention, Spacelab Workshop, Noordwijk, 23/4/1997; K.Berge, op. cit., pp.20-21; E.Vallerani, op. cit., p.17.

117 For similar considerations, see K.Berge's intervention, Spacelab workshop, Noordwijk, 23/4/1997.

118 R.Pfeiffer's intervention, Spacelab workshop, Noordwijk, 23/4/1997; see also K.Berge, op. cit., pp. 15-16.

119 See also: "Spacelab", ESRO/ELDO Bulletin, nr.27, April 1975, p.17.

120 HAEUI, ESA, dep.2, 5596, Spacelab Preliminary Design Review PDR-B, Minutes of ESA/ERNO Board (part II) held at ERNO, Bremen (8/12/1976), by M.Bignier and H.Hoffmann.

5 The Final Acceptance Review (FAR) in 1981, at which ESA formally accepted the Spacelab Module flight unit from ERNO and NASA accepted it from ESA.

6 The Final Acceptance Review (FAR) in 1982, at which ESA formally accepted the flight units of the Spacelab igloo and pallets from ERNO and NASA accepted them from ESA[121].

By 1976, technical and managerial problems became serious[122]. This was all the more disturbing because, by 1977, the emphasis within the Spacelab project team should have been changing from one of system and sub-system design to hardware manufacture, assembly and test. The most difficult managerial task involved in the Spacelab programme would be to find the right procedures to deal with two problems:

1 the implementation of technical changes;

2 the enforcement of cost-reducing steps.

This would imply quick contractual adjustments, quick communication and effectiveness of authority. The bigger the project and the greater the distribution of tasks among the co and sub-contractors, the bigger was the need for an efficient managerial control by the prime contractor. All this required stringent controls by ESA on ERNO, ERNO's improved authority over co-contractors and co-ordination between co-contractors having subsystem interfaces. This meant continuous supervision, co-ordination, flexibility, and charismatic leadership[123].

Among the managerial changes realised during this period, it is worth mentioning at least two which attempted to come to terms with the problem of implementing changes:

1 a special joint ESA/ERNO-NASA/Rockwell group was created to address the question of changes impacting the Shuttle-Spacelab interfaces. This group met twice a year and tried to establish some basic criteria to reduce changes and their financial impact[124].

2 the backlog of changes to be negotiated with industry was enforced through "bulk" negotiations, referred to by Gibson as "a commando type exercise aimed at dealing with the change notices in the pipeline"[125].

Pessimism was expressed by the Americans during the PDR of December 1976[126]. ESA's own assessment was equally critical: design deficits (that is weaknesses in design) could only be solved "without major cost or schedule impacts if correct management action (was) taken and full co-contractor co-operation achieved". Management authority and delegation of authority were considered

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121 M.Bignier, "Spacelab Development", cit., p. 9.

122 HAEUI, ESA, dep. 2, 4860, Memorandum Reinhold, Meeting ESA/Spacelab Board of Directors (2/3/1976), 11/3/1976; see also E.Vallerani, op. cit., pp. 37-39.

123 For the difficulties in the management of the programme in the mid-seventies, see HAEUI, ESA, dep.2, 5596, Fourth Report of Adelbert O.Tischler to ESA on the Spacelab Programme, based on observations made during the period May 8-21, 1976.

124 Among the criteria cited by Pfeiffer in his intervention (Spacelab Workshop, Noordwijk, 23/4/1997), two seem of special interest: "Each change would be studied on both sides of the interface to find the most economical and appropriate solution; the change would be implemented on the side of interface where it was cheapest. The cost incurred was borne by the party responsible".

125 Ibidem. See also Papers of James Fletcher, Manuscript Division, University of Utah Marriot Library, Salt Lake City, box 43, Letter Gibson to Fletcher, 8/7/1976.

126 Papers of James Fletcher, Manuscript Division, University of Utah Marriot Library, Salt Lake City, box 43, Letter Fletcher to Gibson, 16/8/1976; "Documentation was inadequate, schedules were slipping, the budget could not be held, the contractor team was out of control, and the team morale was at an all-time low": D.Lord, op. cit., p. 143.

"mandatory" to solve the problem which should be confronted "immediately"[127]. Despite these weaknesses, Gibson hoped that through modest delays, severe cuts in the deliverable hardware, disciplined resistance to future changes and continued dedicated effort by all participants the programme should be accomplished within the 120% margins[128].

Michel Bignier, as new Director of the Programme since November 1976, began a major analysis of the primary flaws of the programme, which he found in its growing costs and in low industrial productivity. The programme seemed to have been defined with "over-optimistic planning". Engineering changes required in the PDR were handled (in terms of costs) by reductions and cuts in the programme. A severe "scrubbing" (or "descoping") was approved by the SB Programme Board in January 1977. Cuts affected the areas of logistics, maintenance and spare parts, and the pallet-only mode[129]. Due to the strong German support (and French backing), IPS, a potential candidate for the "descoping" exercise, was kept within the general Spacelab budget, despite the opposition of five delegations[130]. The mood of the time was captured by Bignier's comment on this decision. "I have accepted the constraints imposed by them (the Delegations) on the Programme" he wrote to Douglas Lord "in the spirit of the TV programme 'Mission Impossible' in which the actors always succeed in carrying out their impossible task (...)"[131].

With "new blood"[132] injected in the management of Spacelab, both at the Director level and at the programme manager level (Stöwer, as we have seen, was replaced by Pfeiffer), a continued presence of ESA at ERNO, to provide, in the Director General's words "the daily guidance, encouragement and firm orders which they need"[133] and, finally with a tightened contact between ERNO and its co-contractors through the Board of Directors, the project could confront the crucial transition between the "paper" phase dedicated to the drawing up of specifications, schedules and contracts and the hardware phase of manufacture, assembly, test, verification and check-out.

In the meantime, new areas of possible disagreement between European members, and between them and the US, had to be confronted. The integration contract was given, through the Marshall Space Flight Center, to McDonnell Douglas (MCDAC): it amounted to $ 43.5 million in 1977 prices [134]. The Wall Street Journal of 11 March 1977 reported the letting by NASA of the contract for "a scientific unit of the Space Shuttle", avoiding any reference to either Spacelab or Europe [135].

In the Summer 1977, under German pressure, the Council was confronted with the problem of the financing of the first payload. Its updated cost (13.9 MAU in 1976 prices) compared to the charge of

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127 HAEUI, ESA, dep.2, 5596, Spacelab Preliminary Design Review PDR-B, Minutes of ESA/ERNO Board (part II) held at ERNO, Bremen (8/12/1976), by M.Bignier and H.Hoffmann.

128 HAEUI, ESA, dep.2, 5596, Spacelab Preliminary Design Review PDR-B, Minutes of ESA/ERNO Board (part II) held at ERNO, Bremen (8/12/1976), by M.Bignier and H.Hoffmann.

129 E.Vallerani, op. cit., pp. 39-40.

130 From Belgium, Denmark, Italy, The Netherlands and Spain; for a summary of IPS evolution in this period, see HAEUI, ESA/PB-SL(77)8, 26/5/1977, Status of the Development Project; see also HAEUI, ESA/PB-SL/MIN/10, 9/3/1977. Dornier contract for IPS C/D phases would be finally signed in June 1977 for a total of 19 MAU (at December 1976 prices -that was a fixed price plus incentive with a price escalation clause in order to limit costs overruns); HAEUI, ESA/PB-SL(77)13, 8/9/1977.

131 HAEUI, ESA, 4872, Letter Bignier to Lord, 18/3/1977.

132 HAEUI, ESA, dep.2, 5580, Letter M.Bignier to J.Yardley (Associate Administrator for Space Flight, NASA), 22/12/1976.

133 HAEUI, ESA, dep.2, 5580, Letter R.Gibson to J.Fletcher, 2/2/1977.

134 HAEUI, ESA, dep.2, 5596, Compte rendu de la mission de D/SL à Washington du 21 au 23 mars 1977, 25/3/1977.

135 As press briefings and TV broadcasts began to be programmed in the US, ESA Spacelab representative at NASA wrote an alarmed report to his HQ on what he perceived as a tendency, albeit not extendable to all sectors of NASA, to Americanise the programme; HAEUI, ESA, dep. 2, 5580, Rapifax message from Jan Bijvoet (ESA Spacelab Representative at NASA) to Pfeiffer, 14/3/1977.

the Spacelab development was forecast to be low [136]. Considering the difficulties Bignier was trying to overcome in order to remain below the ceiling of 120%, however, it was difficult to think that it could be funded out of the development programme [137]. A general resolution on the willingness to adopt a new optional programme called the Spacelab Utilisation Programme, including the FSLP and two demonstration missions, was eventually approved in October[138].

At the same time, in order keep below the 120% ceiling, Bignier obtained from the Americans an extension of their financial responsibility in order to cover the whole tunnel being built by a NASA contractor and originally financed partly under the Shuttle development effort and partly under the Spacelab programme[139]. Soon after, in the Summer of 1977, it was the USA's time to ask for a co-operative behaviour. It then became clear that NASA wished to postpone the Spacelab-1 flight, which should originally be flown in the first operational Shuttle, because of their wish to launch the Tracking and Data Relay Satellite System (TDRSS) 1 + 2 with the Shuttle before Spacelab-1 [140]. Fortunately, slippage in production and flight plans of the Shuttle, despite having some bad repercussions on the cost side of Spacelab, matched the European need for expanded production time: it would in fact have been nearly impossible for Europe to produce Spacelab in time for the 1980 launch which had been planned in 1977.

During the ESA Council of July 1978 it became clear that there would be difficulties in keeping the development costs within the 120% limit. The German delegation explained the need to increase national contributions for Spacelab with the fact "that the programme had not been originally sufficiently precisely defined and that major design modifications had to be made, while appreciable technical difficulties subsisted". Everything should be done, in Germany's view, to avoid a further cost overrun "which meant that the Agency should in particular adopt an extremely firm attitude towards NASA's demands, at the risk of accepting some deterioration of the good relations with NASA". Both the Director General and the Spacelab Programme director pointed to the inevitability of overruns, due to the early stages of design of both Spacelab and the Shuttle when the MOU was signed, to the novelty of the task for European industries, to the number of firms involved and to the constraints affecting the distribution of work. However, in front of the Member States, they defended their position vis-à-vis NASA, a position that, in the Spacelab Programme Directors' words "could never have been regarded as 'easy-going', but rather the opposite"[141].

2.5. Beyond the "sacred limit" of 120%[142]

Actually, in June 1978, just few weeks before the Council, Gibson had sent to NASA a diplomatic yet firm assessment of the Spacelab programme as seen from Europe. The price for a Shuttle flight (which had been finally communicated by NASA the year before) seemed to go well beyond the first tentative American forecast of 1973; no convenient solution for Europe was in sight as far as the procurement of a second Spacelab was concerned (discussions being focused at the time on the "barter agreement"[143]); suggestions were being aired about a possible development by the USA of a sortie system which would substantially duplicate Spacelab. On the other hand, the Spacelab programme had demanded from Europe much more than initially foreseen and "the large number of

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136 HAEUI, ESA/SPAG (77)23 (27/6/1977), Annex III, Project de declaration des participants au programme d'utilisation du Spacelab.

137 HAEUI, ESA/C/MIN/18 (30/6 to 1/7/1977), 18/7/1977.

138 HAEUI, ECA/C/XX/Rcs.1, 4/10/1977; for more information on the FSLP, see A.Russo, HSR-19 cit.

139 Interview M.Bignier, 6/12/1996, Paris. For the original setting, see Papers of James Fletcher, Manuscript Division, University of Utah Marriot Library, Salt Lake City, box 43, Spacelab issue paper, by Douglas Lord, 23/5/1975.

140 HAEUI, ESA, 4876, Letter Bignier to Yardley, 13/6/1977; HAEUI, ESA, 5580, Telex M.Bignier to W.Mellors, 22/7/1977.

141 HAEUI, ESA/C/MIN/26 (26-27/7/1978), 14/9/1978.

142 The expression is used in Gibson's letter we refer to in the text; HAEUI, ESA, 4876, Letter Gibson to Frosch, 28/6/1978.

143 See the section on FOP.

interface modifications needed and the delivery to NASA of more hardware than initially foreseen, greatly contributed to this increase in expenditures"[144].

Gibson's letter was received with what he later described as "hurt incomprehension". Frosch being out of the country, it was Lovelace, as Deputy Administrator, who harshly retorted to Gibson that "many of the complaints cited reflected misunderstandings, both of the current situation and of the basic Spacelab agreements"[145]. We already hinted in the introduction to this part of the paper, how Lovelace's attitude could have been affected by his hierarchical position within NASA; Gibson's letter, on the other hand, was probably linked to the necessity to rebuke the critics of Spacelab and on what was increasingly interpreted by European members as a "soft" attitude vis-à-vis NASA, in parallel with the prospect of yet another rise in national contributions. One substantial result of Gibson's move was the US decision to proceed with the procurement of a second Spacelab, a decision we will soon examine in depth[146].

In the following autumn, during the annual review between the agencies' directors, Gibson "pointed out that in its approach to Member States ESA (had) to assume end-1981 as termination date for European funding of the sustaining engineering support. ESA (would) not be able to provide funding beyond that date". NASA's Administrator retorted that, as with all development programmes, the indicated target dates should be refined "as they are affected by technical progress and the availability of necessary funding"[147]. NASA expected ESA to fund all changes of Spacelab including those originating from the Space Shuttle, up to the second Spacelab flight which was then scheduled for October 1982. ESA tried to limit its funding responsibility to a ceiling value and to a precise cut-off date for new NASA requirements [148]. NASA's European representative James Morrison, writing to Michel Bignier in May 1979, saw "a clear inconsistency in ESA's strongly held position of not wanting to be treated like a contractor by NASA but as a partner in a development programme and then, on the other hand, wanting to set a date, the sooner the better, after which all programmatic risk is assumed by NASA. In my view" commented Morrison "the latter position does not admit the former. Risk is a natural part of the business and he who does not wish to share the risk cannot really be called a partner. It seems to me" he further went on "that, once the step is taken of setting such a date, ESA is giving NASA a fundamental message which NASA would have difficulty in ignoring in future discussions involving international co-operation"[149]. Morrison's zeal to defend the US position seems to be a typical case of the tendency, in lower echelons of NASA, to assume stiffer positions vis-à-vis international partners, for internal purposes, which Bignier had so aptly stigmatised since 1977[150]. Yet, due to the heavy financial situation of the programme, Europe resented the fact that NASA expected "ESA to fund all make-work Spacelab changes, including those originating from the Space Shuttle up to the second Spacelab flight"[151].

As far as the post delivery support responsibility was concerned, the solution was arrived at by the turn of the decade. Gibson and Frosch, meeting in March 1979, decided to create a special joint ESA/NASA "Risk Assessment Working Group", to which we already referred, in order to set

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144 HAEUI, ESA, 4876, Letter Gibson to Frosch, 28/6/1978.

145 HAEUI, ESA, 4876, Letter Lovelace to Gibson, 10/7/1978

146 HAEUI, ESA, 5580, Letter Frosch to Gibson, 4/12/1978.

147 ESA Washington Office, 020-2C DG/A, Meeting of ESA Director General and NASA Administrator, 7/10/ 1978.

148 HAEUI, ESA, 4860, Inter-office Memorandum, W.Brado to Stiernstedt, 5/10/1979; see also ESA Washington Office, 020-2B. Communication interne, Inter-office Memorandum, de D/SL (Bignier) to Mellors, 11 avril 1979, Actions décidée lors de la réunion DG/A du 29 mars 1979; ibidem DG/A, Letter Frosch to Gibson, 7/5/1979; ibidem, Letter Gibson to Frosch 17/5/1979.

149 HAEUI, ESA, dep.2, 5580, Letter J.Morrison, to M.Bignier, 8/5/1979.

150 HAEUI, ESA, dep.2, 5596, Compte rendu de la mission de D/SL B Washington du 21 au 23 mars 1977, by M.Bignier, 25/3/1977.

151 HAEUI, CAB/INT/I-31/VH/EP/13188, Communication Interne, from H/CAB to J.Stiernstedt, 5/10/1979; HAEUI, PB-SL(79)31, 6/9/1979.

mutually agreed ESA and NASA responsibilities. By the beginning of 1980, ESA's Director-General and NASA's Administrator accepted the final report of the group, with the understanding that ESA would "be responsible for correction of all obvious and hidden deficiencies necessary to meet the Spacelab requirements" as they existed on September 30, 1979. These responsibilities would continue throughout the first flight of a component, but no later than completion of the second Spacelab flight[152].

Not until 1980, could the decision to go beyond the upward limit, as originally anticipated in ESRO-member states arrangement of 1973, be formalised. Continuation of the programme beyond the original 120% schedule (i.e. beyond 369.6 MAU at 1973 price levels) was enforced through the adoption of an appropriate resolution at the 30th meeting of the SPB, in March 1980. The new increase brought the total cost to 140% of the original price (431.2 MAU at 1973 price levels). Every participant waived the use of the right to withdraw ex Article 6 of the original arrangement. The part of the programme above the 120% of the overall financial envelope would be funded in accordance with a scale of contribution in which Italy's share was significantly reduced (from the 18% of the original agreement to 1%) and the German share significantly increased (from 52.55% to 64.40%). Small adjustments also occurred in the contributions of the other countries -notably the French raised their contribution from 10% to 12.07% [153].

The diminution of the Italian share needs some explanation: at the opening of the production phase, Italy began to protest against the poor geographical return to Italian industry within the development programme, which it considered to have been settled by the Spacelab Arrangement between ESRO and Member States at 100% of the contribution. Many explanations could be found for the low Italian industrial return. First of all, it had appeared that the cost increase of the programme had a limited impact on the Italian share because the changes only partly affected the fields in which Italy was working. In other words, the "correspondence" between contributions and contracts mentioned in the Arrangement worked for the industrial proposal which, as we have seen in the chapter on industrial involvement, only applied to about 70% of the work, allowances being made for technical contingencies. The imbalance in Italy's position arose in connection with the remaining 30%, as well as with the work which had necessitated commitment of the 20% margin (above the original 100%)[154]. Exchange rates were also objectively unfavourable to the Italian currency[155] and its firms, which were working in a fixed price environment, in a much less favourable situation, therefore, than those working under costs plus contracts. The Italian share, fixed in 1973 MAU, was in the meanwhile increasing due to the devaluation of the lira vis-à-vis the European currency. On the other hand, a certain "lack of aggressivity and the poor competitiveness of Italian firms leading to the transfer of work to other countries (windows/viewport,...)" had been noted[156].

Among the many question raised by the Italian protest, at least one needs to be remembered, because it would take so long to settle; it was in this context that the Director General commissioned the Council to decide whether the problem posed by an industrial return shortfall of a participant should be dealt with exclusively within the framework of that programme or whether this should be examined in the context of the geographical distribution in respect of the Agency's programmes as a whole[157]. Other discussions were raised by a German proposal to solve the Italian problem in either of two ways: to forego certain contributions due from Italy or make efforts, on the occasion of staring up a new programme, to redress the Italian shortfall.

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152 ESA Washington Office, Minutes of the meeting of ESA DG and NASA Administrator, 14/2/1980.

153 HAEUI, ESA/PB-SL/XXVIII/Res.1 adopted at the 30th meeting of the SPB (12/3/1980).

154 HAEUI, ESA/C/MIN/35 (10-11/10/1979), Intervention Bignier, 6/11/1979.

155 Italy had to pay in 1973 MAU and, the Lira being strongly devaluated, had to pay what resulted to be a much larger amount of money than expected.

156 HAEUI, ESA, dep.2, 5580, Letter M.Bignier to ERNO, 13/7/1978.

157 HAEUI, ESA/C/MIN/32 (28-29/6/1979), 19/7/1979.

By 1980, Spacelab had entered the system qualification tests of the Engineering Model and integration (assembly) and testing of the Flight Unit[158]. These phases involved more technical difficulties and took more time than anticipated. According to ERNO, although "it would be self appraisal to say that there were no problems, this impacted mainly in a negative way on schedule and costs, not on the technical content and quality"[159]. ERNO's technical competence was unanimously recognised, as the absence of major programmatic technical issues. Despite the absence of major technical problems, ERNO had experienced "many detail and interface problems, causing one part of past schedule delay versus plan"[160].

In 1981 a further delay was announced in the launch of Spacelab, from September 1983 to the beginning of 1984. This delay would imply both an overrun of ESA's cost-to-completion ceiling for the two Spacelab developments and a bad psychological impact on experimenters and members who would refrain to take any decision regarding future utilisation of Spacelab and its follow-on development programme. The Spacelab Programme Board sadly defined its "mood" as being "tempered by the many postponements already suffered by the Spacelab-1 experimenters". The shadow of the ISPM affair loomed large: the Board expressed concern about the long-term impact of this unfortunate decision on US-European relations in general[161].

Another development related to the Shuttle would impact on Spacelab in 1982. As we have seen at the very beginning, a first Shuttle Reimbursement Policy for commercial and foreign customers had been published by NASA in 1977. It established a fixed flat rate for the first three operational years (FY 1983-84-85) based on best estimates of the number of flights available in that year. The standard price for a dedicated Shuttle mission was established at $18 million (FY 1975 dollars). Due to cost increases in Shuttle operations, significant reductions in projected flight rates and the effects of inflation, NASA had to revise the previous estimate upwards. In June 1982, the new price for a dedicated launch performed during the period 1986 to 1988 amounted to $71 million (FY 1982 dollars). When compared on an equal basis (using FY 1982 rates), the new price amounted to a 85% increase. That was indeed higher that the charging price of most American expendable launch vehicles[162]. This escalation, to be followed by yet another (smaller) one in 1984, had obvious repercussions on Spacelab, because a non-negligible percentage of the cost of each mission was determined by the price of the launch.

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158 ESA Washington office, 020, Spacelab, VFW-Fokker/ERNO, Spacelab. Presentation, by Ants Kutzer, Spacelab Project Manager, to W.Mellors, ESA Representatives at NASA, 15/2/1980.

159 Ibidem.

160 Ibidem.

161 HAEUI, ESA, dep.2, 5580, Telegram J.Ortner, chairman SL-PB, to J.Beggs, NASA Administrator, 5/5/1981; ibidem, dep.2, 5580, Inter-office memorandum M.Bignier to DG, 7/3/1981. The International Solar Polar mission (ISPM) was a dual scientific solar mission, to be carried out by two spacecraft, one from NASA and the other from ESA, with different technical characteristics, hosting scientific experiments, of European or American origin, to be accomodated impartially after competitive selection. The two spacecraft should be launched in 1983 by the Shuttle, and subsequently inserted into an interplanetary orbit by an inertial upper stage. An MOU with the classic escape clause making reference to the availibility of appropriate funds was signed in 1979. Early in 1981 however, the Europeans were informed that NASA had to cancel the mission due to budgetary constraints imposed by the incoming Reagan administration. See Joan Johnson-Freese, "Cancelling the US solar-polar spacecraft", in Space Policy, vol. 3, n.1, February 1984, pp. 24-37; see also Roger Bonnet and Vittorio Manno, International Cooperation in space (Cambridge: Harvard University Press) 1994, pp.98-108.

162 ESA Washington Office, A Report to the Committee on Appropriations, US House of Representatives on the Cost Comparison and related issues of operating the Space Shuttle and various foreign and US expendable launch vehicles, Surveys and Investigations Staff, April 1985.

2.6. Duplication avoidance

After the signature of the Spacelab agreements, ESA became aware of certain development activities in the USA, of systems which could be installed in the Shuttle Orbiter cargo bay[163]. Could they be considered duplications of the ESA Spacelab? The Memorandum of Understanding and the Intergovernmental Agreement both required the USA to refrain from separate and independent development of any Spacelab "substantially duplicating" the design and capabilities of the first Spacelab, unless Europe were to fail to produce such Spacelab components in accordance with agreed specifications and schedules at reasonable prices. From the formal point of view, the adverb "substantially" left much room for subjective definition. New ideas for Shuttle utilisation emerged during the decade, leading to changed technological requirements which could not be met by Spacelab. That is why Gibson, ESA Director General and Frosch, NASA Administrator, at their meeting of 29 March 1979 decided to establish a working group, the Duplication Avoidance Working Group (DAWG), to give technical form to what the diplomatic agreements had purposefully left vague, i.e. to examine in practical terms what "substantially duplicating" meant[164]. The first meeting of ESA/NASA Duplication avoidance WG (DAWG) took place in Washington on July 18/19 1979: Michel Bignier, Director Spacelab Programme, ESA and Philip E.Culbertson, Deputy Associate Administrator, NASA Headquarters chaired the delegations.

The cases discussed included the Rack Integration Aids, Pallet of Opportunity, DOD pallet and pointing systems. One of the systems under scrutiny by the group was the "Sortie Support System" (SSS), a pallet-type structure to support DOD payloads. In ESA's opinion, several components of the SSS substantially duplicated the design and capabilities of Spacelab pallet-only configuration. NASA partly agreed and asked for a detailed clarification from DOD. "where and if substantial duplication in the design and capabilities of components exists" noted the WG, Article 5 of the IGA reserved to the European partner the first opportunity (a prior right to bid) to produce the components subject to availability, schedules and reasonable prices [165]. A meeting was held with ESA, NASA , USAF and the Department of State to discuss the SSS RFQ and the applicability of the Spacelab IGA. The US position was that procurement laws, i.e. the DOD Appropriation Act of 1973 (known as the Bayh Amendment) prevented the award of research and development contracts outside the US if a satisfactory US source was available at a lower cost. The problem could be solved, in the USAF's view, by choosing an American prime contractor procuring from European sources.

In December of the same year a guideline was approved by the WG whereby it would be the responsibility of NASA to communicate to ESA any new requirement which might possibly lead to a system to be considered as substantially duplicating Spacelab. The Joint NASA/ESA Spacelab Working Group would discuss NASA requirements and how to satisfy them and would determine if that was a case of duplication. A system would be deemed to duplicate Spacelab if Spacelab hardware and/or software:

1 had similar capabilities to the proposed system;

2 were of a similar design or had similar interfaces to the proposed system;

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163 W.M.Thiebaut, "Legal Status of Memoranda of Understanding in the United States", *ESA Bulletin*, nr.38, May 1984, pp. 99-104: Thiebaut indicates that ESA was first informed of the Air Force desire to procure a SSS in 1973; the documents we have found, as we shall see from the text, refer to a later date.

164 ESA Washington Office, 020-2B. Communication interne, Inter-office Memorandum, de D/SL (Bignier) to Mellors, Actions décidées lors de la réunion DG/A du 29 mars 1979, 11/4/1979; Ibidem, Letter Frosch to Gibson, 7/5/1979; ibidem, Letter Gibson to Frosch 17/5/1979.

165 ESA Washington Office, 021-2, Spacelab MOU Compliance, ESA/NASA Duplication Avoidance Working Group, Minutes of Meeting, (18-19/7/1979) and attachments; HAEUI, CAB/INT/I-31/VH/EP/13188, Communication Interne, from H/CAB to J.Stiernstedt, 5/10/1979.

3 could, with minor modifications, if necessary, substitute for the proposed system or its components.

If the JSLWG determined such a duplication, NASA should refrain from the development and procure the system in Europe unless it could not be made available in accordance with the agreed schedules and at reasonable prices. If not, NASA should provide, upon ESA request, an opportunity to make proposals and NASA would treat European and US proposals on an equal basis[166]. A directive was then written by Frosch on avoiding duplication. It stated that all NASA studies and plans envisioning development of new Spacelab-type systems should be made known to NASA HQ in sufficient time that an effective decision on ESA involvement could be made. This included possible or planned development of any multi-use payload carrier systems that would be used in the Shuttle, whether such developments were done in-house or under NASA contract[167]. As stressed by C.Reinhold from Spacelab, ESA HQ, what became apparent in the discussions was that "two specific interests would govern the shaping of these criteria and procedures. ESA's emphasis on protecting the investment and technical know-how of its European industry in the development of the Spacelab system for future co-operative projects and NASA's emphasis on cost-effective, efficient utilisation of the STS"[168]. The problem was later solved, after pressure put by Wilfred Mellors, Head of the ESA Washington Office from 1973 to 1983, on Philip Culbertson and by him "at fairly high level within the USAF by general Frank Simokaitis" (NASA's Director of DOD Affairs). DOD accepted to send RFP's directly (without letting US private firms do it privately) to interested European firms[169].

2.7. Follow-on production (FOP)[170]: the second Spacelab

The ESRO/NASA MOU of 1973 provided for the procurement by NASA of at least one further Spacelab, no later than two years before the delivery of the first, provided that it was "available to the agreed specifications and schedules and at reasonable prices to be agreed" (Art.VIII). NASA's Administrator later argued, however, that NASA would not consider substantial follow-on activity for the second Spacelab until the usefulness of the first Spacelab had been demonstrated. This echoed a paragraph of the article we have already analysed, whereby "the desirability of gaining operational experience with the first flight unit before ordering additional units" (Art.VIII) was clearly expressed - but originally intended to be the criterion whereby Spacelab units beyond the second one would be ordered. European requirements diverged, quite understandably, from the American ones: they were linked to the major aim of preventing costly gaps in industrial production or unsuitable overlaps between the first and the second Spacelab[171]. Europeans also experienced a major difficulty in providing to NASA reliable financial estimates about the cost of a laboratory whose technical requirements were subject to frequent modifications. On the other hand, an early starting date for the industrial work would be of the utmost importance, especially for costs reasons, and ESA needed for that purpose a sufficient commitment to go to Member States for the FOP activity approval[172].

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166 ESA Washington Office, 021-2. Spacelab MOU Compliance, Procedure for Disposing of Future Cases which may Imply Substantial Duplication of the design and Capabilities of the First Spacelab, 6/12/1979 (revised on 21/12/1979 and agreed by DAWG chairmen).

167 ESA Washington Office, 021-2. Spacelab MOU Compliance, From Administrator for distribution, on NASA Development of Spacelab - Type Equipment, 14/5/1980.

168 ESA Washington Office, 021-2. Spacelab MOU Compliance, From C.Reinhold to James Harrington, NASA Headquarters, 31/1/1980.

169 ESA Washington Office, 021-2B. SSS, telex Mellors for D/SL, 15/4/1980; for Mellors's pressure on Philip Culbertson (NASA HQ), Ibidem, Letter Mellors to Culbertson, 10/4/1980.

170 The second Spacelab was defined as "follow-on procurement" by the US: the use of the acronym FOP solved the discrepancy in terminology.

171 HAEUI, ESA/PB-SL/MIN/14 (23/11/1977), Programme Director Intervention, 22/12/1977; in general, see J.Marchant, "The Spacelab Production Programme", ESA Bulletin, August 1980, n.23, pp. 55-57.

172 ESA Washington Office, 020-2C DG/A, Meeting of ESA Director General and NASA Administrator, 7/10/1978.

Because of these conflicting aims, a start on the FOP was made in 1976, but it was not until the end of the decade, after eliminating alternative solutions, that ESA negotiations, with NASA on the one side and ERNO (as the prime contractor) on the other, were completed. Of special interest is the fact that discussions had initially been focused on a "barter agreement", i.e. the marginal cost of the second Spacelab to be credited to ESA for the purchase of Shuttle flights: after the escalation of the Spacelab costs above the 120% ceiling in mid 1978, the Europeans asked and obtained from NASA the acceptance of an alternative solution, which implied a real payment by NASA[173].

Even from the strictly legal point of view, one major obstacle stood in the way of a fruitful agreement. In accordance with American procurement practices, the contract between ESA and NASA should commit the US agency for the then-current fiscal year and should contain a "subject to availability of funds" clause for the following fiscal years. The US budgetary system provides mainly for yearly appropriations and no governmental agency is allowed to commit funds in absence of a specific Congressional authority or appropriation. This had been recognised in the Spacelab agreements where the need to respect "the respective funding procedures" had been incorporated (Art.8 and Art.VII). The amount required by industry and ESA and the sum provided for in NASA's 1980 budget and earmarked in the financial planning for future years left a cash flow deficit in 1980-81 and 1981-82 which could be covered only in 1983-84. The difference needed therefore to be covered temporarily by a commercial bank loan. The ESA Council initially guaranteed the commercial loan necessary to fill up this gap. But NASA, even if it did not have, in principle, the equivalent of ESA contract authority, made special arrangements with the Congress and thereby assured ESA that it would take over this guarantee by the end of 1981.

The Director General was therefore entitled to take out such loans as might be necessary to cover the shortfall then existing in the NASA budgets during the years from 1980 to 1983, on the understanding that the cost of the loans and their reimbursement should be borne exclusively by NASA and entail no commitment by Member States [174]. In other words, the Agency was entitled to act as a contractor vis-à-vis NASA and would contract the necessary loans, it being understood that all the financial charges and costs of the commercial bank loan would be covered by NASA only. NASA's "political commitment" to arrive at a full legal guarantee of repayment at the earliest date was considered as a "sufficient guarantee" to activate the project[175]. In January 1980, therefore, the procurement contracts between NASA and ESA on the one hand, and ESA and European industry represented by ERNO (the prime contractor) on the other were signed, with an agreement on the price, the clauses and conditions applicable to both NASA/ESA and the ESA/ERNO contract and the work statement[176]. The NASA/ESA contract covered the costs of the industrial effort necessary to manufacture, assemble, test and deliver to NASA a second Spacelab flight unit plus the reimbursement of ESA's management costs; it amounted to a total of 117.1 MAU (at mid-1979 prices) for the industrial element (95% of which was fixed-price with an escalation clause) and an estimated 12.2 MAU to cover the Agency's internal costs, to which the financial charges for the loan should be added. The contract was established in the national currencies of the participating firms [177].

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173 HAEUI, ESA, 4876, Letter Gibson to Frutkin, 20/9/1978.

174 HAEUI, ESA/C/XXXV, Res. 3 (Final), Council Resolution concerning the supply to NASA of a second Spacelab, 11/10/1979; HAEUI, ESA/C (79)112, add.1, 14/12/1979, Supply of a Second Spacelab to NASA;HAEUI, ESA/C(80) 6,Bridging financing for the Spacelab Follow-on Production, 9/1/1980.

175 HAEUI, ESA/C/MIN/39 (23-24/1/1980), 31/1/1980.

176 HAEUI, ESA/C/XXXV/Res.3 (final), Council Resolution concerning the supply to NASA of a second Spacelab, adopted on 11/10/1979.

177 J.Marchal, "The Spacelab Production Programme", cit., p.57; no author, "Spacelab", ESA Bulletin, May 1980, p.57. ESA decided to make the contracts payable in local currencies, considering that devaluation of the dollar would be the most plausible scenario for the future. The European choice was made at a moment of high instability in exchange rates, which made any kind of forecast extremely difficult. By the eighties, the dollar actually begun recovering until 1985, when it devalued again until 1992.Giuseppe Mammarella, Imparare l'Europa (Bologna: Il Mulino) 1994, p.52. See also interview M.Bignier, 6/12/1996, Paris.

If we cannot fail to notice the difference between how much ESA paid for the development and production of the first unit, to be given for "unrestricted use" to the NASA "free of cost" (Art. 7 MOU and IX IGA), and how NASA was charged for the procurement of the second, we have to stress that NASA did fulfil its promises. Political willingness, associated to practical and legal flexibility and imagination, allowed the FOP to survive the problems that would, early in 1981, have forced the cancellation of NASA's participation in ISPM -which was equally subject to the "availability of appropriate funds" escape clause. A duplicate of the first flight unit, including the IPS and operational spares, was provided under the 1980 arrangement. By the mid-eighties almost everything was delivered to the US; the German D-1 mission was the first to use FOP materials[178]. By January 1986, NASA, ESA and MBB/ERNO agreed to convert the remaining FOP commitments under the NASA/ESA FOP contract into a direct agreement between NASA and MBB/ERNO[179].

2.8. The Spacelab follow-on development (FOD) programme: Spacelab improvements and the start of Eureca

Judgements on the future of Spacelab were far from uniform at the end of the decade. In June 1978 the Executive submitted to the Spacelab Programme Board and the Council an overall concept of a Spacelab Follow-on Development Programme and, some months later, a detailed proposal for the first phase of the programme. No positive reaction to this proposal was received from delegations. Definition studies, financed under the General Studies budget, were soon completed in 1979 and the matter seemed to have reached a dead end. In September, the Executive vigorously underlined the negative consequences of this uncertain attitude. Discontinuing "the most important co-operative programme with the US" would be harmful to the political interests of Europe; besides, public opinion would interpret this unwillingness as an evidence of the abandonment of any European effort in manned space systems[180]. The momentum created with the future first Spacelab would be inevitably lost. Many reasons lay behind Europe's hesitation. The decision on FOD activities was to be framed within the broader question of European priorities in space for the future decade. Ariane and Spacelab were on the verge of being operational; telecommunication satellites and Space Station seemed to be the two pillars around which to construct the future of European activities in space. Yet it was still unclear if Ariane and Spacelab would and could be the focuses around which to expand European activities in these two fields[181]. Not least, it was still impossible for Europe to divine US future pricing policy for the Space Shuttle and its potential evolution (upwards, as we have seen, by 1982), with a view to expanding co-operation beyond the Spacelab agreement and to giving Europe the opportunity to make proposals to meet new requirements [182]. Moreover, it was difficult to go beyond the study phase of any future programme without knowing how the first Spacelab users had fared and without having exploited the results of the first flight[183]. Before taking any definite step, initial utilisation experience had to be acquired and the system flight testing successfully concluded. In the meantime, the user community was consulted and its views filtered through the ESA/NASA Joint User Requirements Group (JURG), which suggested some possible improvements to increase:

1 the electrical power;

2 the mission duration;

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178 Rapport Annuel de l'ESA, 1985, p.66; see also D.Lord, op. cit., p.105.

179 ESA Bulletin, n.46, May 1986; the last IPS activities to be undertaken by ESA under the MOU with NASA were concluded by the beginning of 1988; see ESA Bulletin, n.52, November 1987, p.53.

180 HAEUI, ESA/C(79)109, Annex, Analysis of the consequences of the absence of a decision to undertake the Spacelab Follow-on Development Programme, 4/9/1979.

181 Ariane had prospective customers, but the Shuttle was deemed to be operational very soon, changing the terms of competition in the launchers fields.

182 Ex Art. VIII of ESA/NASA MOU and Art. 5 of US/European IGA.

183 As pointed out repeatedly by the German delegation; see HAEUI, ESA/C/MIN/39 (23-24/1/1980), 31/1/1980; ibidem, ESA/C/MIN/41 (20/5/1980), 6/6/1980..

3 the size of the on board computer memory[184].

Despite these efforts, the Council, while approving the execution of the initial phase of the programme within the framework of the Agency, could only invite the interested members to commit themselves towards supporting studies[185]. The threshold of 80% decided for starting-up the work was not reached, Italy being unable to put a figure on its level of participation[186]. In general terms, by the end of 1981, it appeared clear that there was a widespread preference among European delegations to divide the FOD programme in two parts:

1 the limited improvement of Spacelab to make it better matched to users' requirements, to achieve greater cost-effectiveness of Spacelab utilisation and to adapt it to Shuttle developments;

2 the definition and development of a retrievable instrument carrier, or free flyer, (to be called Eureca, from the initials of EUropean REtrievable CArrier).

The importance of this last element within the global STS programme was becoming increasingly important and discussions on the FOD programme came to be more and more focused on the opportunity to extend European competence in the field of platforms[187]. After a protracted discussion in which the Federal Republic of Germany was the main promoter, Italy and the UK the least favourable, this last "in view of the doubts, stemming from NASA's uncertainty, that still surround the form of the programme and its interfaces with the other programme", the ESA Council accepted the resolution with nine votes to one (Italy) and one abstention (the Netherlands)[188]. ESA would create, an optional programme for "Spacelab improvements and for developments and experiments on retrievable orbital systems".

Eureca was conceived as a reusable payload carrier, or "free flyer", to weigh approximately 4000 kg at launch including 1000 kg of payload. It would optimise the length-to-mass ratio (4000 kg, not more than 2.5 m length) in order to minimise the launch charges and maximise the mounting flexibility - it could fit comfortably into the 4.6 m diameter cargo bay. It would provide essential services for its payload, including high electrical power, heat-rejection capabilities, attitude control and data handling. After being deployed in space, an on-board propulsion unit would move the carrier to a higher orbit of about 500 km altitude, where the drag on its large solar arrays would be low and it would be therefore easier to reduce gravitational accelerations to near zero, offering a perfect environment for microgravity experiments involving fluids. The high altitude would also help minimise the use of fuel for altitude control. Once in its operational orbit, the payload would be switched on and operated by remote control. The experiments, though highly automated, would be monitored on ground. Its low gravity disturbance level would make it especially suitable for microgravity research. At the end of each mission Eureca would return to low orbit, recovered by the Shuttle orbiter and brought back to earth. After refurbishing and re-equipping, it could be re-used, up to five times in ten years, its expected lifetime[189]. The new system should be more economical to build and operate than the classical non-recoverable satellite systems in low orbit and should offer to users a flight duration beyond the 7 to 10 days of Spacelab. It would incorporate, at the same time, the most attractive features of Spacelab, such as high mass and power capability and recovery. It should enable

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184 HAEUI, ESA/C(79) 109, Annex I, Description of the initial steps of the Spacelab FOD programme, 11/9/1979; see also E.Vallerani, op. cit., p.113.

185 HAEUI, ESA/C/XXXIX/Res.4, 24/1/1980.

186 HAEUI, ESA/C(81)101, Spacelab Follow-on Development Programme, 7/12/1981.

187 HAEUI, ESA/PB-SL/XXXVII/Dec. (Final), Annex A., Programme de développement ultérieur du Spacelab. Déclaration relative à un programme d'amélioration du Spacelab, de développement et d'expérimentation de systèmes orbitaux récupérables, 10/12/1981; HAEUI, ESA/c/MIN/50(27-28/10/1981), Intervention German delegation, 10/12/1981.

188 HAEUI, ESA/C/MIN/50 (27-28/10/1981), 30/11/1981; Ibidem, ESA/C/L/Res. 6 (Final), 30/10/1981

189 "Eureca", ESA Bulletin, n.31, August 1982, p.73; W.Nellessen (Columbus System and Projects Department, ESA Space Station and Platform Directorate, ESTEC), "The Eureca Design Concept", ESA Bulletin, n.47, August 1986, pp. 7-14.

Europe to accumulate the technological and operational experience needed to develop and operate large, autonomous European retrievable platform systems for both commercial and scientific experiments[190]. It should be user friendly by providing standardised structural attachments as well as standardised power and data interfaces; based on the "ship and shoot" concept, it could be shipped as a fully integrated system, requiring only a minimum of Shuttle interface and safety check at the launch site[191].

At the same time, Eureca had growth capabilities "either because existing designs and hardware could be re-used or because the design of existing hardware would be flexible enough to allow increases in performance without major redesign". That is why Eureca was also conceived as contributing eventually, in several ways, to the future Space Station scenario.

1 once qualified on Eureca flights, the capabilities in terms of support operations (power generation, heat rejection, orbit-to-ground communication, attitude control, orbital transfer, data handling) could be applied, with the necessary scaling factors, to space-station elements;

2 Eureca represented an ideal test bed for demonstrating, in-flight, essential technologies for a future space station, such as assembly, inter-orbit communication, rendez-vous and docking, in-orbit servicing and maintenance of systems in space;

3 it could represent a demonstration mission in the field of ground processing of data, launch, retrieval, in-orbit operations, all of which would be needed for the space station;

4 Eureca was conceived as being the first step of a future co-orbiting Space Station element, able to provide the advantages of an unmanned automatic platform[192] .

Commenting on the broader strategic goals of Eureca, the Spacelab Programme Board suggested in 1981:

> *"En particulier, il permettra de poursuivre la coopération avec les Etats-Unis dans le domaine de l'évolution de la navette et du Spacelab, ce qui facilitera l'accès de l'Europe aux missions de pointe, élargira son expérience des vols spatiaux habités et lui permettra d'obtenir une compensation partielle sous forme de services de lancement. Ce programme permettra de répondre en outre à l'évolution des besoins de l'Europe dans les domains de la microgravité (fabrication de matériaux, sciences de la vie); d'autres expériences ne demandant pas un changement des spécifications peuvent être embarquées à titre accessoire".*

The envisioned cost was 118.8 MAU (mid-1980 price level), 101.6 MAU of which were to be devoted to "external" expenditures, i.e., mainly, expenses for development, personnel and operations. After the definition phase and the definition of instruments to be carried, a review should be executed before beginning the development phase of the retrievable platform [193]. By April 1982 contributions reached

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190 W.Nellessen (Columbus System and Projects Department, ESA Space Station and Platform Directorate, ESTEC), "The Eureca Design Concept", ESA Bulletin, nr.47, August 1986, pp. 7-14; R.Mory, "Spacelab and Eureca as a Basis for European Involvement in the Space Station", ESA Bulletin, n. 42, May 1985, pp. 30-38.

191 R.D. Andresen and W. Nellessen, "The Eureca concept and its importance in preparing the Columbus programme", ESA Bulletin, n.52, November 1987, pp. 57-67.

192 R.Mory, "Spacelab and Eurcca as a Basis for European Involvement in the Space Station", ESA Bulletin, n. 42, May 1985, pp. 30-38.

193 HAEUI, ESA/PB-SL/XXXVII/Dec. (Final), Programme de développement ultérieur du Spacelab. Déclaration relative à un programme d'amélioration du Spacelab, de développement et d'expérimentation de systèmes orbitaux récupérables, 10/12/1981, Annex A.

80.8% of the above mentioned envelope, - 80% having being considered, under German pressure, as a minimum for the start of the programme[194]. Therefore, the programme could start immediately[195].

194 HAEUI, ESA/C/MIN/51 (9-10/12/1981), Intervention German delegation, 18/1/1982.

195 HAEUI, ESA/C (81) 101, add.4, 16/4/1982.

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3: Conclusions

As soberly explained by the Spacelab European resident team members at Kennedy Space Center, Florida, Spacelab was a "complicated" device and took "a lot of understanding"[196]. This was always clear to all people involved in the programme, and became ever more evident in the post-delivery phase, i.e. when the Engineering Model and, later, the Flight Unit (in the two configurations) were brought to the United States to be tested at subsystem and system level, to be checked for Spacelab/payload compatibility and to be finally integrated with the Shuttle Orbiter. The Spacelab Engineering Model reached the Kennedy Space Center in December 1980. Post-delivery organisation, assembly and testing were established and performed[197]. The first Flight Unit configuration I (a long module and one pallet) was accepted by NASA in February 1982 at a ceremony held at the Kennedy Space Center and attended by George Bush, then Vice-President of the USA[198]. Problems encountered during this period were faced and solved within the deadlines. The most dramatic appears to have been the major design deficiency and box failures of the Command and Data Management System, discovered after the test performed in September 1982. Despite the quick remedies provided for this, the computers (along with the pointing system) were considered by some US engineers as being "of marginal, if not obsolete, technology compared to what they used on board American missions"[199]. Problems due to NASA's need to postpone the launch were also resolved [200].

Spacelab-1 was launched on board the Shuttle Columbia, from the Kennedy Space Center, Florida, on 28 November 1983. The mission lasted until 8 December 1983. Six astronauts were on board: John Young (commander), Brewster Shaw (pilot), Owen Garriott and Robert Parker (mission specialists), Ulf Merbold and Byron Lichtenberg (payload specialists). One of the three ESA astronauts trained for the mission, the German citizen Ulf Merbold, was the first non-American to fly on the Shuttle and the second European citizen to fly in space - the first being J.L.Chrétien flying on Soyouz in 1982. This "outsized thermos bottle", as popularly characterised by Time magazine at the time, performed its tasks remarkably well. The Verification Flight Instrumentation (VFI, housed in the core segment at the front end of the module) consisting of 264 environmental, mechanical and electrical sensors and the associated control, monitoring and recording system, showed the high engineering and functional quality of Spacelab. Some 72 investigations in different scientific disciplines were performed, the results of which have been evaluated elsewhere[201]. "The mission" in the words of the Spacelab European resident team members at Kennedy Space Center "showed not only that the requirements were met but also that there [was] an inherent in-orbit operational flexibility built into Spacelab which [had] only just begun to be understood"[202].

Spacelab was conceived, developed and produced in a period of high inflation. Inflation, together with technical changes and deadlines slippages, had a large impact on its price, as they did on the Shuttle programme as a whole and, what was more devastating for European partners, on the Shuttle pricing policy. Despite some weaknesses in the area of management co-ordination in the initial period of the manufacture phase and despite an overrun of 140% of the original price and the problems experienced during the post-delivery phase, the Spacelab programme was a remarkable co-operative endeavour, achieved by Europeans in close collaboration with the US. Spacelab-1, however, was to be the only

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196 A.Thirkettle, F.Di Mauro and R.Stephens, "Spacelab - From Early Integration to First Flight: Part 2" cit., p. 84.

197 Ibidem, pp. 70-73.

198 M.Bignier, "Spacelab Development", cit., p.10.. Flight Unit configuration II (an igloo and pallets) was delivered in the Summer of the same year.

199 As Bonnet and Manno put it; Roger Bonnet and Vittorio Manno, op. cit., p.79.

200 See A.Thirkettle, F.Di Mauro and R.Stephens, "Spacelab - From Early Integration to First Flight: Part 2", cit., pp. 70-84.

201 D.Shapland and M.Rycroft, op cit.

202A.Thirkettle, F.Di Mauro and R.Stephens, "Spacelab - From Early Integration to First Flight: Part 2", cit., p.82.

flight programmed in common by ESA and NASA. There would not be any *a priori* sharing of space in subsequent Spacelab payloads (Spacelab-2, 29 July to 6 August, 1985, when the Igloo-Pallet-IPS configuration was flown; Spacelab-3, 29 April to 6 May 1985), while D-1 and D-2 would be German flights paid by the German Ministry of Research and Technology, although they hosted experiments from other ESA members and from NASA [203].

"By the time Spacelab was ready for use" noticed a disenchanted American scholar some years ago "its development costs had risen to almost $1 billion [at the then current rate], rather than that the approximately $ 250 million originally estimated. Projections on Shuttle usage had dramatically shrunk, and the United States decided to purchase only the one additional Spacelab it was obligated to buy, at a cost of $ 128 million. Any chance for ESA to recoup some of its development costs through Spacelab production thus vanished. The agreement provided for one joint US-ESA Spacelab mission at no launch cost to ESA. After that, ESA would have to pay launch costs for any Spacelab missions it wanted to undertake. By the early 1980s, the combined costs of preparing the experiments for a Spacelab mission and paying Shuttle launch fees, exceeded ESA's resources, and the Agency was left in a position of not being able to afford the use of the system it had developed (...)"[204].

Criticism was occasionally aired of the principle whereby the first unit of Spacelab was handed over to NASA with no tangible return in terms of privileged access for Europeans in subsequent payloads. This eventually led to its partial abandonment by the Agency -although this did not prevent national German missions and an extended number of US missions, with or without European participation, from being performed [205]. This criticism, albeit in a diplomatic form, was officially expressed by ESA Director General Reimar Lüst in 1987, in a crucial phase of Space Station negotiations. More recently, it has been revived by Roger Bonnet and Vittorio Manno in their book on ESA[206]. Some years after his 1987 speech, Lüst completed his previous comment with some considerations of realpolitik. The Director General declared that:

1 "international co-operation does indeed depend a lot on the actual balance of power"

2 due to the limited European expertise, Europe had to pay an entrance fee (the first Spacelab) to acquire "the basics of manned spaceflight"[207].

Manno and Bonnet also agreed on that, as they concurred in Lüst's emphasis on previous American generosity (in co-operation during the 60s), interpreting Spacelab as a way to reciprocate it[208]. Another point made by European officials, dealt with the unwillingness of the US to share technology. Fréderic d'Allest, then Director General of CNES, talking in 1985 about the prospective agreement on Space Station, declared:

> *"the bitter experience of...co-operation in the Spacelab programme and finally the declared policy of limiting transfers of technology and technical information to the*

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203 D.Shapland & M.Rycroft, op. cit.; D.Shapland, "Spacelab" in Le Grand Atlas de l'Espace (Paris:Encyclopaedia Universalis) 1987, pp. 278-281.

204 John Logsdon, "Together in Orbit: The Origins of International Participation in Space Station Freedom", NASA Contract NASW-4237, December 1991, pp.12-13.

205 R.Fraysse (Bureau de Co-ordination et de Contrôle des Projets), "Retour sur le passé: la décision de l'Europe de participer au programme Post-Apollo", ESA Bulletin, n.40, November 1984, pp. 61-65;
Reimar Lüst, "Co-operation between Europe and the United States in Space", [The Fulbright 40th Anniversary Lecture, 6 April 1987, Washington DC] ESA Bulletin, n.50, May 1987, pp. 98-104, spec. p.101. For Spacelab missions, see Annex 5.

206 R. Bonnet and V. Manno, op. cit., pp. 78-80.

207 R. Lüst, "US Cooperation in Space", European Affairs, 3,1989, quoted in R.Bonnet & V.Manno, op. Cit., p 79.

208 R.Bonnet and V.Manno, op. cit., pp. 78-80.

minimum needed to ensure compatibility of peripheral European elements, demonstrates unambiguously the limits of co-operation with the USA in a strategic sector"[209].

Despite numerous dispersed European texts about Spacelab, the comprehensive Spacelab story was first told to the public in 1983, by Douglas Lord, who wrote a rather detailed account of his experience as NASA's Director of Spacelab throughout the programme. There, he candidly admitted: "it was as if NASA had hired a development contractor, only in this case the contractor was in Europe and would use its own money"[210]. Yet, the simple existence of this book, a book written by an American about a European developed programme, whose title is about a dignified "success story" in international co-operation, seems to prove, on the contrary, that there was indeed something more than a contractual agreement in the Spacelab story. The reasons for this apparent inconsistency are probably to be found in the American mentality, more than in a deliberately "patronising" attitude. In order to find its roots, we have to sympathise for a moment with an entire generation of US officials who had come to adulthood after the second world war. They had seen the USA go to the rescue of Europe against Nazism, help Europe to recover from war damage through an impressive programme of economic aid and help it to set up a common defence through NATO. They had later witnessed Europe stand on its own feet again and become prosperous; they had further observed the successes of the European Communities, created in 1957 with their own strong encouragement, and the gradual transformation of Europe into a dangerous competitor on the international market by the end of the sixties and into a recalcitrant ally in the military field (failure of the Multilateral Force and the exit of France from NATO in 1966). This assertiveness, translated into the space field, had contributed to the European decision in 1973 to try to develop an independent expendable launcher.

At the same time the USA had been busy, among other things, in preparing one of the (if not the) most legendary adventures in space, the 1969 human landing of the Moon, which had consecrated what was generally perceived as a "victory" over their cold war enemy, the USSR. It goes without saying that the effort in terms of financial and human resources, emotional and political commitment put into this enterprise, and the sense of pride built around it, were unique and in no way comparable to what was happening on this side of the Atlantic in space policy. American behaviour vis-à-vis their European partners can only be understood against this rather complex historical background of extraordinary achievements in space and a yet undefined but growing anxiety about future European competition in space.

An assessment of the programme, beyond the successful, purely technical and scientific, aspects can only be political and will inevitably change with time. During the negotiating phases of the Space Station, when the Europeans struggled to earn the status of "equal partners", what were perceived as weak aspects of the Spacelab Agreements were emphasised in order to reinforce European requests, to accentuate what was presented as US bad will in previous times and on the other hand, to stress the supposed European generosity.

Politicians have the freedom "to use" history as a tool, as they frequently do, but we, as historians, must try to make clear what are the assumptions underlying our work, what are the real facts throughout and what are our opinions. In this case, our assumption has been that co-operation is, under certain circumstances, indeed advantageous for all - i.e. it is not a zero-sum game. It is not an "either or" game in which there is only one disputed prize. Many different advantages are on the table and, through negotiations, these advantages are distributed. A good deal, must be a good deal for every partner: their aims must not only be compatible but, possibly, mutually reinforcing. The bargain must fulfil two requirements. It has to be "feasible" in the short term and it has to create a long-standing attitude conducive to a continuity in effective co-operation. Mutual trust is the base for a healthy partnership.

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209 Interavia, December 1985.

210 D.Lord, op. cit., p. 31.

Beyond these general assumptions, which were satisfied during the Spacelab programme, one major flaw must be noticed. Due to the early stage of both the Spacelab and the Shuttle design, European assessment was based on poor estimates on future costs of both the laboratory and the Shuttle flights. Inflation did the rest. In this situation it was very difficult to produce a reliable cost/benefit analysis between European investment and future technological and scientific returns, as it was difficult for users to judge the real opportunities which Spacelab offered them. Spacelab became a sort of political challenge to test the efficiency of ESA managerial and industrial capacities in confronting this major hindrance. Flexibility and imagination helped ESA to confront this challenge [211]. Actors could thereby find their way out of the most apparently insoluble problems: for example, partners had to keep to the US procurement practice whereby any contract stipulated by a US agency is only committing for the running fiscal year and contains a "subject to availability of funds" clause for the following fiscal years - expressed in the Spacelab agreements by the need to comply to the "respective funding procedures" (Art. 8 and Art.VII). Yet, despite budget difficulties, the US honoured its obligations through the 1980 contract for a second Spacelab (FOP) - although it was on this basis that NASA's participation to ISPM was unilaterally cancelled in early 1981.

Creative behaviour was also found, on the European industrial and ESA side, during the solution of the crises which affected the main development contract during the years 1976-77 and in 1980. Regaining the control of the situation (that is, of the performance and changes introduced by industry) and restoring the morale of the groups involved, was a delicate task. It implied, as we have seen, innovative measures as far as the staff and the practices were concerned, but it also required to maintain a sense of continuity with the past, in order to save the global credibility of the management - vis-à-vis the subordinates and vis-à-vis the American partner. In 1980, when the Member States were requested to support yet another augmentation in the Spacelab budget, they had to be reassured against indefinite extension of ESA financial responsibility; they also had to be reassured about the reliability of the US partner as far as the order of the second Spacelab was concerned. It is not by coincidence that these problems were worked out, as we have seen, in the same time-frame, as a sort of informal package-deal.

It is through the analysis of these kinds of past circumstances and of the successes and failures encountered, that it will be possible to establish for the future, more realistic patterns of open or tacit rules for allocating the advantages of co-operation. Here we stop, having tried to establish a plausible, yet surely uncompleted, plot of this extraordinarily complex and fascinating technical, scientific and human collaborative venture in space.

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211 We obviously cannot assess the technical and scientific aspects, which we leave to more expert judges.

Annex 1: Arrangement Between ESRO and its Member States

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AIa. ARRANGEMENT BETWEEN CERTAIN MEMBER STATES OF THE EUROPEAN SPACE RESEARCH ORGANISATION AND THE EUROPEAN SPACE RESEARCH ORGANISATION CONCERNING THE EXECUTION OF THE SPACELAB PROGRAMME

NOTES

Ref. ESRO C(73)2. rev. 3. Approved at the 54th Meeting of the Council on 15 February 1973. the Arrangement was opened for signature from 1 March 1973 to 23 September 1973 and entered into force on 10 August 1973.

Annex B (cf. ESRO IB-SL(73)26) was revised by a decision of the Programme Board during its 11th Meeting on 3 October 1973.

PREAMBLE

The Governments signatories of this Arrangement (hereinafter referred to as " the Participants "), being Governments of States parties to the Convention for the establishment of a European Space Research Organisation opened for signature on 14 June 1962 (hereinafter referred to as " the Convention "),

and

the European Space Research Organisation (hereinafter referred to as " the Organisation "),

HAVING REGARD to the United States Authorities' offer to Europe to take part in the post-Apollo programme by developing one or more research and application modules and by making use of the shuttle and orbital system,

RECALLING Resolution No. 3 of 24 July 1970 of the European Space Conference on cooperation in the post-Apollo programme, and the agreement reached by the European Space Conference at its meeting in Brussels on 20 December 1972, concerning the execution of the Spacelab programme, which has been notified to the United States Authorities, and under which this programme shall be executed in the first instance by the Organisation and be pursued later on by the future European Space Agency,

CONSIDERING the advantage to international cooperation from an active contribution from Europe towards the execution of the most important space programme currently developed and the advantage to Europe from developing its space technology through participation in this programme,

RECALLING the authority already granted by the Council of the Organisation at its 50th Session (ESRO/C/MIN/50), on the basis of which the Director General has initiated the project definition phase of the Spacelab programme,

CONSIDERING the draft Memorandum of Understanding (ESRO/C(73)2, rev. 1 - Annex III) between the Organisation and the National Aeronautics and Space Administration (NASA) of the United States Government (hereinafter referred to as the " Memorandum of Understanding "),

HAVING REGARD to the Resolution adopted by the Council of the Organisation at its 53rd Session, concerning the approval to execute the Spacelab programme within the framework of the Organisation (ESRO/C/LIII/Res. 1 [Final]),

HAVE AGREED AS FOLLOWS :

ARTICLE 1

1. The Participants shall, under the provisions of the present Arrangement and in particular of article 5 thereof, undertake in close cooperation with the United States Authorities a programme having as its objective the definition, design, development and construction of the Spacelab as a technically integrated part of the United States' shuttle and orbital system and Europe's contribution to the post-Apollo programme with which it is to be used.

2. The objectives and elements of the Spacelab programme are described in annex A to the present Arrangement.

ARTICLE 2

The programme referred to in article 1 above shall be broken down into two phases, a definition phase which has already been started and a design, development and construction phase.

1. The purpose of the definition phase (sub-phases B 1-B 3) of the Spacelab programme is to establish the configuration of the Spacelab in the light of the requirements of the users and to define the corresponding sub-systems. The results available at the end of sub-phase B 2 will serve as a basis for the preparation of a technical proposal and a development plan, together with a detailed cost analysis and an estimate of the cost of the design, development and construction phase.

2. The elements for the detailed analysis referred to in paragraph 1 of the present article shall be available to the Participants by 1 August 1973 and will also be notified to the other member States of the Organisation.

3. The decision to proceed to the design, development and construction phase shall be taken in conformity with the provisions of article 5 below.

ARTICLE 3

1. The Organisation shall, under article VIII of the Convention, execute the Spacelab programme in conformity with the timetable and other provisions set out in annex A to this Arrangement.

2. Except where otherwise provided in this Arrangement, the Organisation shall execute the programme in conformity with the rules and procedures in force in the Organisation.

3. For the purpose of the cooperation with NASA referred to in article 1 above and in order to ensure close integration of the Spacelab with the other elements of the shuttle and orbital system, particularly with the development of the space shuttle, the Organisation shall set up, on the basis of the Memorandum of Understanding, a structure for cooperation and coordination with NASA. The European scientific and technical users shall be associated with the work of the Organisation and NASA.

ARTICLE 4

1. A Programme Board, composed of representatives of the Participants, shall be responsible for the programme and shall take all decisions relating to it in conformity with the provisions of this Arrangement.

2. For matters affecting more than one programme of the Organisation, the Programme Board shall be advisory to the Council of the Organisation, to which it will on such matters make all necessary recommendations.

3. The Programme Board shall in particular :

a. provide the Director General of the Organisation with all necessary instructions concerning the execution of the programme, in particular regarding the interfaces of the programme with the other elements of the shuttle and orbital system of the United States;

b. ensure that close links are established by the Organisation with the future European users of the Spacelab system;

c. ensure implementation of the Memorandum of Understanding and any other relevant legal documents as far as the rights and obligations of the Participants are concerned;

d. study, if possible at least three years before the end of the development of Spacelab, the rules for implementing the principles referred to in article 10 of this Arrangement.

4. The Programme Board may establish such advisory bodies as it may deem necessary for the proper execution of the programme.

5. Except where otherwise provided in this Arrangement, the decisions of the Programme Board shall be taken in accordance with the rules of procedure for the Organisation's Council which shall apply *mutadis mutandis*.

ARTICLE 5

1. The financial envelope of the programme on the date of opening the present Arrangement for signature is estimated at 308 millions of accounting units at mid-1973 prices, on the basis of the elements described in annex B to the present Arrangement. This amount will be reviewed at the end of sub-phase B 2 of the definition phase.

The Participants agree that, should this review confirm the overall financial assumptions, they will continue the programme and initiate sub-phase B 3 of the definition phase, as well as the design, development and construction phase. Should it appear that the estimates will be significantly exceeded, the Participants who so wish may withdraw from the programme; however, those Participants that wish to continue with the programme shall consult among themselves and determine arrangements for such continuation.

2. The Participants fix a financial envelope of 10 millions of accounting units for the definition phase studies due to be completed by the end of 1973. The Participants agree to contribute to the financing of these studies in accordance with the scale set out in annexe B of the present Arrangement, but only up to the amounts required for the execution of sub-phases B 1 and B 2 due to be completed by the end

of July 1973. When the review referred to in paragraph 1 of the present article is carried out, the Participants will decide whether to unblock the amount of the envelope that relates to sub-phase B 3.

3. When fixing the overall financial envelope of this programme in accordance with the provisions of paragraph 1 of the present article, the Participants shall determine by unanimous agreement, their individual percentage contributions.

4. The relevant annual budgets shall be subject to the approval of the Programme Board by a two-thirds majority within the relevant financial envelope.

Article 6

1. The Participants agree, in order that the overall financial envelope of the programme referred to in article 5, paragraph 3 of the present Arrangement may be revised in the event of changes in price levels, to apply the procedure in force in the Organisation at that time.

2. If the overall financial envelope needs to be revised for reasons other than changes in price levels, the following provisions shall apply:

a. If the cumulative overruns of estimated costs to completion do not exceed 20 % of the amount of the overall financial envelope of the programme, no Participant shall be entitled to withdraw from the programme and the Programme Board shall decide on the additional expenditure by a two-thirds majority;

b. If the cumulative overruns of estimated costs to completion exceed 20 % of the amount of the overall financial envelope, the Participants who so wish may withdraw from the programme subject to the provisions of article 17. Those Participants that wish to continue the programme shall consult among themselves and determine the arrangements for such continuation. They shall report accordingly to the Council of the Organisation which will take any necessary decision.

Article 7

Intellectual property rights arising from the execution of the programme, as well as access to and use of technical information so arising, shall be reserved to the Participants in so far as this is consistent with the relevant terms of the Memorandum of Understanding, but the Organisation shall have the right to make use of them free of charge for its activities as a whole.

ARTICLE 8

1. The Participants authorise the Organisation to conclude the necessary contracts for the execution of the programme in conformity with the Organisation's rules and procedures. However, in placing contracts and sub-contracts for the execution of the programme, first preference shall be given, wherever possible, to having the work executed in the territories of the Participants and second preference to having it done in the territories of other member States of the Organisation, taking into consideration the decisions of the Council of the Organisation in the matter of contractual policy and distribution of work.

2. For this purpose the geographical distribution of contracts among the Participants concerning the Spacelab programme shall correspond to the percentage contributions of the Participants. Since the percentage of work to be performed in non-member States either by direct contracts from the Organisation or by sub-contracts issued by the industrial prime contractor, will probably in this programme be unusually high, the Organisation shall keep the amount of such contracts and sub-contracts under review and ensure that they are excluded from the preparation of statistics on the geographical distribution of contracts amongst Participants.

ARTICLE 9

1. The Organisation, acting on behalf of the Participants, shall be the owner of the Spacelab elements developed under the programme, as well as of the facilities and equipment acquired for its execution.

2. The terms and conditions for making available to NASA the elements developed under this Arrangement, as defined in annex A, shall be fixed by the Memorandum of Understanding between the Organisation and NASA and, as appropriate, by the intergovernmental Agreement between the Participants and the Government of the United States, referred to in article 10 below.

Any transfer of facilities and equipment acquired shall be decided on by the Programme Board, in consultation with the Council of the Organisation.

ARTICLE 10

The Participants intend to define, in consultation with the Council of the Organisation, in an Agreement with the Government of the United States, the principles relating to the use of the Spacelab and the other parts of the shuttle and orbital system, in particular the space shuttle, access to United States technology, and all other questions appropriate to such an Agreement.

ARTICLE 11

1. The Participants shall indemnify the Organisation in respect of any obligation it may incur should its international liability be involved as a result of the execution of the programme.

2. Any compensation for damage received by the Organisation with respect to the programme shall be credited to the annual programme budgets referred to in article 5, paragraph 4.

ARTICLE 12

The Participants have noted the provisions of the proposed Memorandum of Understanding with NASA and their rights and obligations arising therefrom, and they agree to the Council of the Organisation authorising the Director General to sign the text as approved by the Programme Board and the Council. Should this Memorandum not enter into force, or should it be modified substantially, the Participants will consult among themselves with a view to determine the appropriate measures to be taken.

ARTICLE 13

1. Any dispute which arises between two or more of the Participants, or between any of them and the Organisation, concerning the interpretation or application of this Arrangement, and which cannot be settled by mutual consent, shall be submitted at the request of any party to the dispute to a single arbitrator to be appointed by the President of the International Court of Justice. The arbitrator may not be a national of a State which is party to the dispute, nor be permanently resident in that State.

2. Those parties to the Arrangement which are not parties to the dispute shall have the right to join in the proceedings and the arbitrator's decision shall be binding on all the Participants and the Organisation, whether or not they have joined in the proceedings.

ARTICLE 14

1. This Arrangement shall be open for signature by the Member States of the Organisation from 1 March 1973 to 10 August 1973. If, on this date, the Arrangement has entered into force in accordance with the provisions of paragraph 3 of this article, it shall remain open for signature until 23 September 1973.

2. The States shall become parties to this Arrangement :

— either by signature not subject to ratification or approval,

— or by depositing an instrument of ratification or approval with the Government of the French Republic if the Arrangement has been signed subject to ratification or approval.

3. This Arrangement shall come into force when it has been signed by the Organisation and when the aggregate contributions payable, on the basis of the scale set out in annex B, by the States that have become parties to this Arrangement, in accordance with paragraph 2 of this article, amount to two-thirds of the total contributions payable, for the sub-phase B 2.

4. For the purpose of paragraph 3 of this article, the deposit, with the depositary Government, of a declaration of intent to apply the Arrangement provisionally and to seek ratification or approval as soon as possible shall be considered as the deposit of an instrument of ratification or approval.

5. The Government of any member State of the Organisation which has not signed the Arrangement by 10 August 1973 may become party to it after that date, provided the other Governments parties to the Arrangement agree. In such case, the Government in question must deposit an instrument of accession with the Government of the French Republic; it may also apply the provisions of paragraph 4 of this article in order to become a party to this Arrangement.

6. Unless the Programme Board unanimously decides otherwise, a Government that becomes a party to this Arrangement under the terms of paragraph 5 of the present article, shall pay a contribution equal to that which it would have paid if it had been a party to the Arrangement at the moment of its entry into force, which shall also cover a contribution to the expenses for the defition phase, and this contribution shall be credited to the other Participants pro rata to their contributions to the programme budget.

ARTICLE 15

The Government of a State that is not a member of the Organisation may present a request to the Council of the Organisation to accede to the programme; a Council decision to grant such a request shall require unanimity and must be taken in agreement with the Programme Board, which shall unanimously determine the detailed terms of accession.

ARTICLE 16

The Organisation shall notify the Participants, after consultation with the Programme Board, when the programme has been duly completed in accordance with the provisions of this Arrangement and this Arrangement shall expire upon receipt of such notification.

ARTICLE 17

1. A Participant wishing to withdraw under the terms of article 6, paragraph 2, shall notify its withdrawal to the Organisation. This withdrawal shall take effect at the date of the notification, subject to the following provisions :

a. The withdrawing Participant shall be bound to pay in the manner agreed its contributions adopted under the current or previous annual budget(s);

b. The withdrawing Participant shall remain bound to pay its share of the payment appropriations corresponding to approved contract authority used under the budget for the current or previous financial year(s') and relating to the design, development and construction phase;

c. The withdrawing Participant shall remain a member of the Programme Board until its obligations under *a* and *b* above have been fulfilled. It shall only have a right to vote on matters which are directly related to these obligations.

2. The withdrawing Participant shall retain the rights acquired up to the date on which its withdrawal takes effect. As regards actions and developments decided upon after its withdrawal, no further right or obligation shall arise in respect of that part of the programme to which it no longer contributes, unless and to the extent agreed otherwise between the remaining Participants and the withdrawing Participant. The provisions of article XVII of the Convention of the Organisation shall apply *mutatis mutandis*.

3. Should a non-member State which has acceded to the programme in accordance with the provisions of article 15 wish to withdraw from the programme, the provisions of this article shall apply *mutatis mutandis*.

Article 18

Annexes A and B to this Arrangement form an integral part of it.

Article 19

1. Without prejudice to the relevant provisions of the Memorandum of Understanding, this Arrangement may be amended at the request of a Participant or of the Organisation. Any amendment shall come into force when all parties have notified their approval to the depositary Government.

2. Without prejudice to the relevant provisions of the Memorandum of Understanding, the annexes to the Arrangement may be revised by the Programme Board in accordance with the special provisions contained in the revision clauses of those annexes.

ARTICLE 20

Upon entry into force of the Arrangement, the Government of the French Republic shall register it with the Secretariat of the United Nations, in accordance with article 102 of the United Nations Charter.

ARTICLE 21

The Government of the French Republic shall be the depositary of this Arrangement and shall notify the Participants and the Organisation of the date of entry into force of this Arrangement and any amendments thereto, and of the deposit of all instruments of ratification, approval, accession and declaration of intent to apply the Arrangement provisionally.

IN WITNESS WHEREOF, the undersigned representatives, having been duly authorised thereto, have signed this arrrangement,

DONE IN NEUILLY-SUR-SEINE, THIS FIFTEENTH DAY OF FEBRUARY NINETEEN HUNDRED AND SEVENTY-THREE,

in the English, French and German languages, the three texts being equally authoritative, in a single copy, which shall be deposited in the archives of the Government of the French Republic, which shall transmit certified copies to each of the Participants and to the Organisation.

For the Government of the Federal Republic of Germany

H. BLOMEYER F. R. GÜNTSCH

For the Government of the Kingdom of Belgium

J. BOUHA

For the Government of Spain

P. CORTINA

For the Government of the French Republic

G. de BOISGELIN

For the Government of the Italian Republic

Ugo MORABITO

For the Government of the Kingdom of the Netherlands

A. van der WILLIGEN

For the Government of the United Kingdom of Great Britain and Northern Ireland

Christopher EWART-BIGGS

For the Government of the Swiss Confederation

Pierre DUPONT

For the Government of the Kingdom of Danemark

Paul FISCHER

For the European Space Research Organisation

A. HOCKER

ANNEX A

1. OBJECTIVES OF THE SPACELAB PROGRAMME

The Spacelab programme includes the definition, design, development and construction of mannable pressurised laboratory modules and unpressurised instrument platforms (pallets) suitable for conducting research and application activities on shuttle sortie missions. The laboratory module and the pallet, either separately or together, will be transported to and from earth orbit in the shuttle payload bay and will be attached to and supported by the shuttle orbiter stage throughout the mission. The laboratory module will be characterised by a pressurised (shirt-sleeve) environment, a versatile capability for accomodating laboratory and observatory equipment at minimum cost to users, rapid access for users, and minimum interference with shuttle orbiter ground turnaround operations. The pallet, supporting telescopes, antennas and other instruments and equipment requiring direct space exposure, will normally be attached to the laboratory module with its experiments remotely operated from the laboratory module, but can also be attached directly to the shuttle orbiter and operated from the orbiter cabin. Additional descriptive material of the concept will be included in the Preliminary Project Plan drawn up jointly with NASA.

2. DESCRIPTION OF THE PROGRAMME

2.1. Definition phase (Phase B)

Sub-phase B 1 :

— continuation of the study on the selected concept;

— identification of those sub-systems that are critical from the cost viewpoint;

— possible adaptation of the industrial structures.

Sub-phase B 2 :

Production of a technical proposal leading to the choice of a system and a corresponding development plan, together with a cost analysis, and of an estimate, to be prepared by the Organisation, of a cost proposal for the design, development and construction phase.

Sub-phase B 3 :

On the basis of the system selected at the end of sub-phase B 2, the following action will be taken:

— preliminary project study of the corresponding sub-system,

— analysis of operations;

— establishment of a firm proposition for the design, development and construction phase.

This sub-phase will be completed by the selection of the main contractor for the following phase.

2.2. Design, development and construction phase.

— Preparation of the detailed specification of, and construction plans for, the different Spacelab elements.

— Development of the Spacelab elements.

— Testing, assembling and checkout of the complete Spacelab.

The following elements are planned for delivery to NASA: one Spacelab flight unit, one Spacelab functional mock-up and two series of Spacelab ground support equipment, possibly together with the necessary spares and relevant documentation.

3. TIMETABLE

The timetable currently envisaged is as follows:

— Definition phase (Phase B):

— *Sub-phase B 1 :* mid-November 1972-end-January 1973,

— *Sub-phase B 2 :* start-February 1973-end-July 1973,

— *Sub-phase B 3 :* beginning-August 1973-end-1973;

— Design, development and construction phase.

The first Spacelab flight is planned for 1979.

4. REVISION CLAUSE

The provisions of this annex may be revised by a unanimous decision of the Programme Board.

ANNEX B

1. COST OF THE PROGRAMME.

The overall financial envelope is estimated at 308 millions of accounting units (MAU) at mid-1973 prices and is composed of the following elements:

— Definition phase : the financial envelope for this phase is fixed at 10 MAU, and divided as follows:

— sub-phase B 2 : 7 MAU,

— sub-phase B 3 : 3 MAU.

— Design, development and construction phase: the financial envelope shall be determined in accordance with the provisions of article 5, paragraph 1 of the Arrangement. The cost of the main development contract is estimated at 175 MAU.

— Internal expenditure (estimated at 30 MAU) and share of commun and support costs (estimated at 33 MAU).

— Contingency, including space technology, fixed at 15 MAU, and modifications resulting from the shuttle programme, not covered by the main development contract, estimated at 45 MAU.

2. SCALE OF CONTRIBUTIONS.

a. Subject to the provisions of article 5, paragraph 2 of the present Arrangement, each Participant shall, in accordance with the following scale applicable for 1973, contribute to the expenditure resulting from the execution by the Organisation, under the terms of this Arrangement, of the sub-phase B 2 of the definition phase.

States	Share of contributions
	%
Federal Republic of Germany	52.55
Belgium	4.20
Denmark	1.50
Spain	2.80
France	10.00
Italy	18.00
Netherlands	2.10
United Kingdom	6.30
Switzerland	1.00
Other countries (*)	1.55

(*) Weight of vote to be attributed to the Federal Republic of Germany as long as the provisions of (c) below are applicable.

b. The scale for the execution of the sub-phase B 3 and the design, development and construction phase will be fixed by the States parties to the Arrangement on the completion of sub-phase B 2 (see article 5 of the present Arrangement).

c. The Government of the Federal Republic of Germany guarantees the payment of any sums shown under the heading "Other countries" in the above table until such time as they are otherwise covered.

3. REPORTS BY THE ORGANISATION ON THE FINANCIAL AND CONTRACTUAL SITUATION

The Director General of the Organisation shall issue the necessary instructions for the presentation of reports on the progress and geographical distribution of the work, on the call-up of contributions, the expenditures to date and the latest estimates of cost-to-completion of the programme, in accordance with the relevant provisions of the Organisation's financial rules and with the provisions adopted by the Council of the Organisation concerning the periodical reports to be presented (document ESRO/C/306, add. 2,rev. 1).

4. FINANCIAL RULES

The direct expenditure resulting from the execution of the programme by the Organisation under the foregoing Arrangement shall be charged to a programme budget which shall be established and administered by the Organisation in accordance with the relevant provisions of its financial rules. The programme's share of the Organisation's common and support costs shall be established and allocated to the programme budget in accordance with the relevant principles and procedures adopted by the Organisation.

5. REVISION CLAUSE

The provisions of paragraphs 1 and 2 of this annex may be revised by a unanimous decision of the Programme Board. The provisions of paragraphs 3 and 4 of this annex may be revised by a two-thirds majority decision of the Programme Board.

Annex 2: Agreement Between the USA and ESRO Member States

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AIb. AGREEMENT BETWEEN THE GOVERNMENT OF THE UNITED STATES OF AMERICA AND CERTAIN GOVERNMENTS, MEMBERS OF THE EUROPEAN SPACE RESEARCH ORGANISATION, FOR A COOPERATIVE PROGRAMME CONCERNING DEVELOPMENT, PROCUREMENT AND USE OF A SPACE LABORATORY IN CONJUNCTION WITH THE SPACE SHUTTLE SYSTEM

NOTES

Ref. ESRO C(73)46, rev. 1. Approved at the 10th Meeting of the Spacelab Programme Interim Board on 31 July 1973, the Agreement was opened for signature from 14 August to 24 September 1973.

It entered into force on 14 August 1973 for the United States, Germany and the United Kingdom, on 18 August for Spain, and was temporarily applied for Belgium, Denmark, Italy, The Netherlands and Switzerland for which it will enter into force on the date of deposit of their instrument of ratification or of approbation with the Government of the French Republic.

PREAMBLE

The Government of the United States of America

and

the Governments of the Federal Republic of Germany, the Kingdom of Belgium, the Kingdom of Danemark, Spain, the French Republic, the Italian Republic, the Kingdom of the Netherlands, the United Kingdom of Great Britain and Northern Ireland, the Swiss Confederation, parties to the Arrangement between certain Member States of the European Space Research Organisation and the European Space Research Organisation concerning the execution of the Spacelab Programme, opened for signature on 1 March 1973 (the above European Governments and such other Governments as adhere to this Agreement being referred to hereinafter as the " European Partners "),

CONSCIOUS of the challenge and potential of space exploration and convinced that international cooperation in the development and use of new mechanisms for space exploration will further strengthen the bonds of friendship between the countries involved and will in general contribute to world peace;

RECALLING with satisfaction the considerable amount of cooperation in the space field already conducted and now in progress between the countries involved;

DESIRING to extend and expand cooperation already conducted in the space field between the countries involved;

CONVINCED also that such cooperation will result in scientific, technological and economic advantages to their mutual benefit as well as the benefit of all mankind;

RECALLING the invitation extended by the Government of the United States of America to Europe to cooperate in the United States post-Apollo programme;

CONSIDERING that the Government of the United States of America has established policies to make available to other nations launch assistance for scientific and applications space missions for peaceful purposes;

NOTING the decision of the European Space Conference to participate in the post-Apollo programme as expressed in the Resolution adopted in Brussels on December 20, 1972;

CONSIDERING that the European Partners have entrusted to the European Space Research Organisation (hereinafter referred to as " ESRO ") to undertake, as a special project, the development of a Space Laboratory (hereinafter referred to as " SL ");

CONSIDERING that the Government of the United States of America has entrusted to the National Aeronautics and Space Administration (hereinafter referred to as "NASA") the development of the Space Shuttle;

CONSIDERING that the SL concept is essential for the full exploitation of the Space Shuttle potential;

HAVING NOTED the Memorandum of Understanding between NASA and ESRO drawn up for the purpose of implementing a cooperative programme concerning the development, procurement and use of an SL in conjunction with the Space Shuttle system;

HAVE AGREED AS FOLLOWS :

ARTICLE 1

Purposes and objectives

The Government of the United States of America and the European Partners shall engage in a cooperative programme concerning an integrated space transportation and orbital system to provide : 1° for the design, development, manufacture and delivery of the first flight unit of the SL as an element to be integrated with the Space Shuttle; 2° for the use of the Space Shuttle and SL systems for peaceful purposes; 3° for the production and procurement of additional SLs; 4° for appropriate exchanges and interaction in the development and use of the Space Shuttle and SL systems; and 5° for consideration of the timely expansion and extension of this cooperation as their mutual interest warrants.

ARTICLE 2

General description of the Space Shuttle and SL programmes

A. The Space Shuttle programme refers essentially: to the definition, design and development of a Space Shuttle which will: serve in missions to deliver payloads to earth orbit; maintain station on orbit for mission durations in the order of seven days or more; provide safety monitoring and control over payload elements throughout missions; and provide seating and complete habitability for crews, including free movement between the Shuttle and SL.

B. The SL programme provides for the definition, design, development and procurement of mannable laboratory modules and unpressurised instrument platforms (pallets) attached to and integral with the Shuttle and suitable for conducting research and applications activities on Shuttle sortie missions.

ARTICLE 3

Cooperating agencies and implementation

A. NASA is designated as the cooperating agency of the Government of the United States of America to implement its side of the cooperative programme. ESRO, or its successor organisation, is designated as the cooperating agency of the European Partners to implement their side of the cooperative programme.

B. Detailed provisions for the implementation of this cooperative programme are set forth in the Memorandum of Understanding between NASA and ESRO, dated 14 August 1973, confirmed herewith. Upon formation of a successor organisation to ESRO, the Memorandum of Understanding will be considered as being between NASA and that organisation.

ARTICLE 4

Obligations of the European Partners

As their part of the cooperative programme the European Partners shall have among their obligations the following:

1° to design, develop, manufacture and deliver an SL and associated equipment according to mutually agreed specifications and time schedule;

2° to establish the necessary means and infrastructure in Europe in order to ensure the possibility of the procurement at reasonable prices by the Governement of the United States of America of additional such SLs, components and spares as the Government of the United States of America may need;

3° to ensure the availability of a sustaining engineering capability for the SL to meet the mission operating requirements of the Government of the United States of America; and

4° to provide for the necessary contingency arrangements to enable the production in the United States of SLs, components and spares in the event that the European Partners fail to complete the first SL or to produce subsequent SLs for procurement by the Government of the United States of America in accordance with agreed specifications and schedules at reasonable prices.

ARTICLE 5

Obligations of the Government of the United States of America

As its part of the cooperative programme the Government of the United States

of America shall have among its obligations the following: 1° to provide relevant information and advice; 2° to provide, subject to its availability and applicable United States laws and regulations, such assistance and for export of such technology, including know-how and hardware, as may be mutually agreed is required for the development and manufacture of the SL; 3° to procure only from the European Parnters such additional SLs, components and spares as substantially duplicate the design and capabilities of the first SL, as are needed by the Governement of the United States of America, including needs arising from its international programmes, and as are available in accordance with agreed schedules and at reasonable prices; 4° to refrain from separate and independent development of any SL substantially duplicating the design and capabilities of the first SL unless the European Partners fail to produce such SLs, components and spares in accordance with agreed specifications and schedules and at reasonable prices; 5° to use the first SL developed in Europe as an element integrated with the Space Shuttle system for the peaceful exploration and use of outer space; and 6° to keep the European Partners informed of its plans for future use of the Space Shuttle system, and, in particular, of future concepts which may lead to modifications of the present SL concept, with a view to expanding and extending this cooperation beyond the present Agreement.

ARTICLE 6

Access to technology and information

A. The European Partners will have access to that technology, including know-how, which is available to the Government of the United States of America and is needed in order to accomplish succesfully their tasks under this cooperative programme; for the same purposes the Government of the United States of America will have access to technology, including know-how, available to the European Partners.

B. The technology, including know-how, which the Governent of the United States of America and the European Partners will require from the other for the successful accomplishment of tasks under this cooperative programme will be jointly defined. However, the Government of the United States of America and the European Partners each reserve the right in exceptional cases to arrange for their respective technology so defined to be made available in the form of hard-ware, rather than know-how.

C. The technology, including know-how, so identified and transferred under this cooperative programme and normally subject to licensing and proprietary control will not be made available beyond the European Partners, their nationals and ESRO acting in their behalf in the SL programme without the express prior approval of the Government of the United States of America. If the European Partners, their nationals or ESRO wish to use this technology, including know-how, for purposes other than the development and production tasks under the cooperative programme and other than in connection with their use of the Space Shuttle and SL, such uses may be arranged on a case-by-case basis in accordance with normal commercial practice and the applicable United States laws and regulations.

D. The Governement of the United States of America will give consideration on a case-by-case basis to requests for access to United States technology, including know-how, beyond that which is directly necessary for the execution of the SL programme.

E. Any technology, including know-how, transferred under this cooperative programme to the Government of the United States of America or its nationals by the European Partners will be subject to similar conditions as to availability and use.

F. The access to technology, including know-how, referred to above will be effected in such a way as not to infringe any existing proprietary rights of any person or body in the United States or Europe.

G. The Governement of the United States of America will make available to the European Partners general information related to the design, development, and use of the Space Shuttle and orbital system, particularly that required for the understanding of that system.

H. In those cases where the information requested can be made readily available by agencies of the Government of the United states od America, it will be made available free of charge; in other cases, the Government of the United States of America will use its best efforts to facilitate its availability on favourable conditions.

I. While the Government of the United States of America and the European Partners believe that the SL can be developed within existing European capabilities,it is recognised that some commercial procurement of components and services in the United States is likely. In consideration thereof, the Government of the United States of America shall, in procurement of commercially available components and services related to the development of the Shuttle, follow the principle of giving full recognition to advantages offered in Europe in cost, quality or availability.

J. The provisions of this Article shall be subject to applicable laws and regulations.

Article 7

Use of the Space Shuttle and SL

A. The Governement of the United States of America shall, consistent with international agreements and arrangements, make the Space Shuttle available for SL missions (experiments and applications) of the European Partners and their nationals on either a cooperative or cost-reimbursable basis.

B. In regard to space missions of the European Partners, the Government of the United States of America shall provide access for use of SLs developed under this cooperative programme for experiments or applications proposed for reimbursable flight by the European Partners, in preference to those of third countries considering, in recognition of the participation of the European Partners in this cooperative programme, that this will be equitable in the event of payload limitation or scheduling conflicts.

Experiments or applications proposed for cooperative flight will be selected on the basis of the merit of each proposal in accordance with continuing United States policy; such proposals of the European Partners will be given preference over the proposals of third countries provided their merit is at least equal to the merit of the proposals of third countries. The European Partners will have an opportunity to express their views with respect to the judgement of merit regarding their cooperactive proposals.

C. The commercial use of Space Shuttles and SLs will be on a non-discriminatory basis. The establishment by the Government of the United States of America or by the European Partners of standards and conditions for the commercial use of SL units will be the subject of prior exchange of views on such standards and conditions, looking toward the maximum practicable harmonisation of the respective policies. In exceptional circumstances, should this prove impossible, the exchange of views will take place at the first opportunity thereafter.

D. In order to assure the integrity of operation and management by the Government of the United States of America of the Space Shuttle system, this Government shall have full control over the first SL unit, after its delivery to the Government of the United States of America, including the right to make final determination as to its use for peaceful purposes. The Government of the United States of America may make any modifications to the first SL unit it desires. However, in the case of intended major modifications, the European Partners will be given advance notification to permit the opportunity for them to express their views and to provide modification kits.

E. With regard to the first flight of the first SL unit, the system test objectives will be the responsibility of the Government of the United States of America. The experimental objectives of this first flight will be jointly planned on a cooperative basis. Thereafter, the cooperative use of this first SL unit by the European Partners and ESRO will be encouraged throughout its useful life, although not to the exclusion of cost reimbursable use by them. The Government of the United States of America will otherwise have unrestricted use of the first SL unit free of cost.

F. The Government of the United States of America will provide SL flight crew opportunities to nationals of the European Partners in connection with their space missions involving an SL. It is contemplated that a European crew member will be included in the flight crew of the first SL flight.

G. The results of NASA and ESRO experiments on cooperative SL missions shall be made freely available to the Parties to this Agreement, subject to any proprietary rights and to the usual priorities to be granted to individual experimenters for the purpose of advance exploitation and publication of the data obtained.

H. The use of Space Shuttles and SLs by European nationals may be arranged through ESRO or by the appropriate European Partner.

ARTICLE 8

Costs

A. The Government of the United States of America and the European Partners

shall bear the costs of their respective participation in the cooperative programme under this Agreement.

B. Neither the Government of the United States of America nor the European Partners will seek to recover government research and development costs incurred in the development of items procured from the other in connection with this cooperative programme.

C. With respect to the financial conditions for reimbursable launch services from United States launch sites, European Partners, their nationals and ESRO will be charged on the same basis as comparable non-government United States domestic users.

D. The obligations of the Government of the United States of America and of the European Partners shall be subject to their respective funding procedures.

ARTICLE 9

Consultation and planning

A. The Parties agree to consult with a view to facilitating a continuing and expanding cooperation in the use of outer space.

B. In order to enhance the opportunities for the European Partners to determine and express their interest in the planning and use of the Space Shuttle system, and particularly the SL, the Government of the United States of America will associate representatives of the European Partners, through consultation and as observers, with mission definition planning for use of the system as well as with planning and management of the overall development of the system.

C. The Government of the United States of America will consult with the European Partners on the appropriate measures to be taken in the event the Space Shuttle programme is not continued, and will, consistent with United States policy and the objectives of Articles 7 and 8, make available to the European Partners or ESRO existing alternative launchers for missions of the European Partners being developed for SL flights.

ARTICLE 10

Movement of persons and materials

A. The Government of the United States of America and the European Partners shall facilitate the movement of persons and materials involved in the cooperative programme under this Agreement into and out of their territories.

B. The Government of the United States of America and the European Partners shall use their best efforts to accord, to such material as may be government-owned, entry free of customs duties and other charges.

C. The Government of the United States of America and the European Partners shall use their best efforts to accord to non-government-owned material : 1° entry free of customs duties and other charges; and 2° purchase free of national and other taxes.

ARTICLE 11

Liability

A. The Government of the United States of America shall have full responsibility for damage to its nationals and to its governmental property arising in the course of implementation of this Agreement. The European Partners shall have full responsibility for damage to their nationals, to their governmental property, and, through ESRO, to employees of ESRO and to ESRO property, arising in the course of implementation of this Agreement.

B. In the event of damage, arising from the launch, flight or descent of the Shuttle carrying the SL, to nationals of countries which are not parties to this Agreement, for wich damage there is joint liability of the Government of the United States of America and the European Partners under the principles of international law or of the Convention on International Liability for Damage Caused by Space Objects, the Government of the United States of America and the European Partners agree to consult promptly on an equitable sharing of the payment for any settlement required. If agreement is not reached within 180 days, the Government of the United States of America and the European Partners will act promptly to arrange for early arbitration to settle the sharing of such claims following the 1958 model rules on arbitral procedure of the International Law Commission.

C. In the event of damage to nationals of countries not parties to this Agreement, arising from the implementation of this Agreement and not covered by Paragraph B above, such damage shall be the responsibility of the Government of the United States of America and/or the European Partners depending on where the responsibility falls under applicable law.

D. Notwithstanding Paragraph A above, with respect to the first SL to be provided by the European Partners, the Government of the United States of America shall be responsible for damage to such first SL after its acceptance by the Government of the United States of America, but shall not be liable for damage occurring in connection with a Space Shuttle launch, flight or descent.

ARTICLE 12

Disputes

The resolution of any dispute as to the implementation of the cooperative programme will be the responsibility of the agencies referred to in Article 3 of this Agree-

ment. Only a dispute which, in the view of the Government of the United States of America or the European Partners, seriously and substantially prejudices the execution of the cooperative programme may be referred for resolution to a representative of the Government of the United States of America and to a representative of the European Partners. If these representatives are unable to resolve the dispute, it may be submitted for such arbitration as may be agreed.

ARTICLE 13

Amendments

The present Agreement may, on the initiative of the Government of the United States of America or of the European Partners, be amended by consent of the Parties. An amendment will enter into force when the Government of the United States of America an the European Partners have notified their approval to the depositary Government.

ARTICLE 14

Entry into force and depositary

A. This Agreement shall be signed on August 14, 1973 by the Government of the United States of America and European Partners. The Agreement shall enter into force on this date for the Government of the United States of America and those European Partners which sign not subject to ratification or approval.

B. The Agreement shall remain open for signature for European Partners, not signing on August 14, 1973, for the period from August 15, 1973 to September 24, 1973. The Agreement shall enter into force for a European Partner which signs the Agreement in this period not subject to ratification or approval, on the date of its signature.

C. For those European Partners which sign this Agreement subject to ratification or approval under Paragraph A or Paragraph B above, the Agreement shall have provisional application upon signature. The Agreement shall enter into force for such a European Partners on the date of the deposit of its instrument of ratification or approval with the depositary Government.

D. After September 24, 1973 participation in the cooperative programme may be effected only in accordance with the provisions of Article 15.

E. The Government of the French Republic shall be the depositary Government.

ARTICLE 15

Adherence of other governments

A. With the consent of the Parties, and subject to such terms as may be agreed by the Parties, other governments may adhere to the present Agreement as European Partners. However, the consent of the Government of the United States of America is not required for the adherence of a present member Government of ESRO.

B. Adherence of a Government may be deposited after the appropriate Parties under Paragraph A above have notified the depositary Government of their consent and shall become effective on the date of deposit of the instrument of adherence.

ARTICLE 16

Duration

This Agreement shall remain in force until January 1, 1985, but at least for five years from the date of the first flight of the SL. This Agreement shall be extended for three years unless eithers the Government of the United States of America or the European Partners give notice of termination prior to January 1, 1985 or prior to the expiration of the five years, whichever is applicable. There after, the Agreement shall be extended for such further periode as the Partics may agree.

ARTICLE 17

Registration

A. The depositary Government shall notify the signatories and adhering Governments of the signatures, ratifications or approvals and adherences.

B. The present Agreement shall be registered by the depositary Government pursuant to Article 102 of the Charter of the United Nations.

IN WITNESS WHEREOF the undersigned, duly authorised thereto by their respective governments, have signed this agreement.

DONE IN NEUILLY-SUR-SEINE, THIS FOURTEENTH DAY OF AUGUST NINETEEN HUNDRED AND SEVENTY-THREE,

in the English, French and German languages, each version being equally authentic, in a single original which shall be deposited in the archives of the Government of the French Republic which shall transmit duly certified copies thereof to the Government of the signatory and adhering States.

For the Government of the Federal Republic of Germany
H. BLOMEYER V. KNOERICH

For the Government of the Kingdom of Belgium
J. BOUHA
Sous réserve de ratification

For the Government of the Kingdom of Denmark
Paul FISCHER
Sous réserve de ratification

For the Government of Spain
P. CORTINA

For the Government of the French Republic
G. DE BOISGELIN
Sous réserve d'approbation

For the Government of the Italian Republic
Ugo MORABITO
Sous réserve de ratification

For the Government of the Kingdom of the Netherlands
J. A. DE RANITZ
Sous réserve de ratification

For the Government of the United Kingdom of Great Britain and Northern Ireland
Christopher EWART-BIGGS

For the Government of the Swiss Confederation
Ernest BAUERMEISTER

For the Government of the United States of America
Galen L. STONE

Annex 3: MOU Between NASA and ESRO

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AIc. MEMORANDUM OF UNDERSTANDING BETWEEN THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND THE EUROPEAN SPACE RESEARCH ORGANISATION FOR A COOPERATIVE PROGRAMME CONCERNING DEVELOPMENT, PROCUREMENT AND USE OF A SPACE LABORATORY IN CONJUNCTION WITH THE SPACE SHUTTLE SYSTEM

NOTE

Ref. ESRO C(73)45 (rev. 1). Approved at the 59th Meeting of the Council on 1 August 1973, the Memorandum of Understanding was signed on 14 August 1973 and entered into force on that date.

PREAMBLE

Pursuant to the offer of the Government of the United States of America to Europe to participate in the major US space programme which follows the Apollo programme, and in particular in the development of a new space transportation system (Space Shuttle), the execution of which has been entrusted by the Government of the United States of America to the National Aeronautics and Space Administration (NASA), European States, members of the European Space Research Organisation (ESRO), have manifested their desire to develop a Space Laboratory, hereinafter referred to as "SL", in the form of a Special Project within ESRO, for the purpose of participation in the Space Shuttle programme. These States, by means of an international Arrangement have charged ESRO or its successor organisation with the execution of the SL programme. In order to provide for appropriate association of the two Agencies in the execution of both programmes and in order to assure the necessary coordination between them, NASA, acting for and on behalf of the Government of the United States of America, and ESRO, acting for and on behalf of the Governments of those States participating in this Special Project, have drawn up this Memorandum of Understanding which sets out the particular terms and conditions under which such association and coordination will be effected. This Memorandum of Understanding will be subject to provisions of the Agreement between the Governments of the above participating States and the Government of the United States of America concerning this cooperative programme.

ARTICLE I

OBJECTIVES

The purpose of this Memorandum of Understanding is to

provide for the implementation of a cooperative programme in which ESRO undertakes to design, develop, manufacture and deliver the first flight unit of an SL, and other materials described in this Memorandum. This flight unit will be used as an element to be integrated with the Space Shuttle. This Memorandum sets out furthermore the provisions for ESRO access for use of the SL and for the procurement by NASA of additional SLs, and establishes the cooperative structure between NASA and ESRO for dealing with all questions concerning interface between the Shuttle and SL programmes and concerning the missions to be defined.

ARTICLE II

GENERAL DESCRIPTION OF THE SL PROGRAMME, ITS INTERFACE WITH THE SPACE SHUTTLE, AND ITS USES

1. Summary description of the SL programme

The SL programme provides for the definition, design and development of mannable laboratory modules and unpressurised instrument platforms (pallets) suitable for accommodating instrumentation for conducting research and applications activities on Shuttle sortie missions. The SL module and SL pallet will be transported, either separately or together to and from orbit in the Shuttle payload bay and will be attached to and supported by the Shuttle orbiter throughout the mission. The module will be characterised by a pressurised environment (permitting the crew to work in shirt sleeves), a versatile capability for accommodating laboratory and observatory equipment at minimum cost to users, and rapid access for users. The pallet, supporting telescopes, antennae and other instruments and equipments requiring direct space exposure, will normally be attached to the module with its experiments remotely operated from the module, but can also be attached directly to the Shuttle orbiter and operated from the orbiter cabin or the ground. Both the module and the pallet will assure minimum interference with Shuttle orbiter ground turnaround operations.

2. Interface with Shuttle

The Shuttle will : serve in missions to deliver payloads to earth orbit; maintain station on orbit for mission durations in the order of seven days or more; provide safety monitoring and control over payload elements throughout the missions; and provide seating and complete habitability for crews, including free movement between the SL module and the Shuttle. In the interest of minimising developmental and operational costs, and maximising reliability, an effort will be made to optimise commonality between SL and Shuttle components.

3. Use objectives

The SL will support a wide spectrum of missions for peaceful purposes and will accept readily the addition of special equipment for particular mission requirements. The SL will facilitate maximum user involvement and accessibility. The flight equipment complement will be capable of augmentation as appropriate to satisfy approved programme needs. It will be possible for users to utilise the SL with or without supplementary equipment for a single experiment or, in the alternative, to utilise only a small portion of the SL in combination with other experiments. The standard resources of the SL may be utilised to any degree appropriate by an experimenter adhering to standardised interfaces which are to be defined and procedures which are to be set forth. Considerable flexibility in equipment and mission structuring shall be available to the user for effective mission operation.

ARTICLE III

PHASING AND SCHEDULING

1. Phase B studies

Based on present schedules, the Phase B (preliminary design) studies of the SL are expected to be completed around the end of 1973.

2. Phases C & D

At the completion of the Phase B studies, the parties will mutually agree on a design for immediate implementation and development by ESRO in Phases C & D (final design and hardware development and manufacture).

3. Completion schedules

It is currently planned that the first operational space flight of the Shuttle will occur in late 1979. To permit adequate time for experiment integration, check-out and compatibility testing, the SL flight unit shall be delivered to NASA about one year before the first operational Shuttle flight.

4. Schedule changes

Each party will keep the other fully and currently informed of factors affecting the schedules of the Shuttle and the SL respectively and their potential effects on flight readiness.

ARTICLE IV

PROGRAMME PLANS

The foregoing gross descriptions of the SL programme and of the phasing, scheduling and working arrangements are amplified in greater detail in the preliminary version, dated 30 July 1973, of the Joint Programme Plan. The parties recognise that many issues remain to be resolved in the Joint Programme Plan, which is to be developed and updated as appropriate by the Programme Heads. This plan is to be based on the results of preliminary design studies now in progress in both Europe and the United States, on the results of independent and joint studies of user requirements, and on the final definition of, and the requirements for integration with, the Shuttle.

ARTICLE V

RESPECTIVE RESPONSIBILITIES

1. ESRO responsibilities

Among ESRO's responsibilities are the following :

(a) design, develop and manufacture one SL flight unit (consisting of one set of module and pallet sections), one SL engineering model, two sets of SL ground support equipment, initial SL spares, along with relevant drawings and documentation; and qualify and test for acceptance this equipment according to NASA specifications and requirements;

(b) deliver to NASA the items listed above;

(c) design, develop and manufacture such elements as ESRO and NASA may agree to be necessary for the programme in addition to those listed in (a) above;

(d) establish in the US and accommodate in Europe agreed liaison personnel;

(e) provide all necessary technical interface information;

(f) provide agreed progress and status information;

(g) following delivery of the above flight unit, maintain and fund an SL sustaining engineering capability through the first two SL flight missions, and ensure for NASA's account the future availability to NASA of such engineering capability to meet NASA's operating requirements, on the same conditions as would apply to ESRO;

(h) ensure the production in Europe and possibility of procurement by NASA of subsequent flight units, components and spares; and

(i) provide for preliminary integration of experiments which ESRO supports, as well as acquire the corresponding data, within the overall responsibilities of NASA described in paragraph 2 (j) of this Article, and process it.

2. NASA responsibilities

Among NASA's responsibilities are the following :

(a) establish in Europe and accommodate in the US agreed liaison personnel;

(b) provide general technical and managerial consultation;

(c) provide all necessary technical interface information;

(d) provide agreed progress and status information;

(e) monitor ESRO technical progress in selected areas as defined in the Programme Plans;

(f) review and concur in the implementation of ESRO activities critical to the NASA programmatic requirements for the SL as defined in the Programme Plans;

(g) specify, in order to assure successful operation of the SL in the Shuttle system, operational plans, and hardware and operational interfaces as defined in the Programme Plans;

(h) conduct systems analyses for development of operational concepts and utilisation plans, and assess the impact of changes at all SL external interfaces;

(i) develop selected peripheral components, not part of, but necessary to the successful operation of the SL (e.g. access tunnel, docking ports); and

(j) manage all operational activities subsequent to the delivery of the SL, including experiment integration, crew training, check-out, flight operations, refurbishment, data acquisition, preliminary processing and distribution of data.

3. By agreement of the NASA Administrator and the Director General of ESRO, changes may be made in the above responsibilities, as may be desirable for the implementation of this cooperative programme.

ARTICLE VI

COORDINATION - LIAISON - REVIEWS

1. Programme Heads

Each of the parties has designated in their respective Headquarters an SL Programme Head. They will be responsible for the implementation of this cooperative programme and they will meet and communicate as they require.

2. Project Managers

In addition, each of the parties will designate an SL Project Manager responsible for day-to-day coordination in the implementation of this cooperative programme.

3. Joint SL Working Group (JSLWG)

The two Programme Heads will together establish a Joint SL Working Group with appropriate technical representation from each party. The Programme Heads will be co-chairmen of the JSLWG. The JSLWG will be the principal mechanism for :

(a) the exchange of information necessary to inform both parties fully of the status of both the Shuttle and the SL;

(b) monitoring interface items, problems and solutions;

(c) early identification of issues or problems of either party which may affect the other; and

(d) assuring early action with respect to any problems or requirements.

4. Liaison

The parties shall each provide and accommodate liaison representation at levels as mutually agreed. The representation will be such as to assure each party adequate visibility of the other's progress especially with regard to interfaces and their control. ESRO shall have representation on appropriate Shuttle change control boards to assure adequate

opportunity to present the views and interests of ESRO with respect to any change. The ESRO representatives on the boards will have a voice but will not vote. NASA will have similar representation on the comparable ESRO SL board. ESRO and NASA will enable and arrange for visits to their respective contractors as required.

5. Progress reviews

Each party shall schedule progress reviews of its work in the Shuttle and SL programmes and shall provide access to the other to such reviews. Annual reviews will be conducted by the NASA Administrator and the ESRO Director General.

ARTICLE VII

FUNDING

1. Costs

NASA and ESRO will each bear the full costs of discharging their respective responsibilities arising from this cooperative programme, including travel and subsistence of their own personnel and transportation charges for all equipment for which they are responsible.

2. Availability of funds

The commitments by NASA and ESRO to carry out this cooperative programme are subject to their respective funding procedures.

3. Principle on pricing

Neither party will seek to recover government research and development costs incurred in the development of items procured from the other in connection with this cooperative programme.

ARTICLE VIII

NASA PROCUREMENT OF SLs

1. Principle

Subsequent to the delivery by ESRO of the SL unit and other items referred to in Article V,1 (a), NASA agrees to procure from ESRO whatever additional items of this type it may require for programmatic reasons, provided that they are available to the agreed specifications and schedules and at reasonable prices to be agreed. NASA should give an initial procurement order of at least one SL at the latest two years before the delivery of the SL unit referred to above. Recognising the desirability of gaining operational experience with the first flight unit before ordering additional units, but that the price and availability of production units will be dependent on the maintenance of a continuing production capability, NASA will endeavour to provide significant lead time for any subsequent procurement order.

2. NASA abstention from SL development

NASA will refrain from separate and independent development of any SL substantially duplicating the design and capabilities of the first SL unless ESRO fails to produce such SLs, components and spares in accordance with agreed specifications and schedules and at reasonable prices to be agreed. For any NASA SL programme requirements which are not met by SLs developed under this cooperative programme, NASA will have the right to meet such requirements either by making the necessary modifications to the SLs developed under this cooperative programme, or by manufacturing or procuring another SL meeting such NASA requirements.

3. Notice of prospective requirements

NASA will endeavour to give ESRO advance notice of any prospective requirements for substantially modified or entirely new SLs so as to provide ESRO

with an opportunity to make proposals which might meet such requirements.

ARTICLE IX

CONTINGENCIES

1. Non-completion of first SL or failure to meet specifications

NASA's obligations with respect to the SL shall lapse and ESRO will turn over to NASA without charge and without delay all drawings, hardware and documentation relating to the SL if ESRO abandons the development of the SL for any reasons, or ESRO is otherwise unable to deliver the SL flight unit prior to the first operational Shuttle flight, or the completed SL does not meet agreed specifications and development schedules. The right of NASA to use the said drawings, hardware and documentation shall be limited to the completion and operation of the SL programme. ESRO shall ensure that it will be in a position to provide as hardware any proprietary item for which it does not hold transmissible rights of reproduction.

2. Non-availability of subsequent SLs

If SLs, components and spares required by NASA after the first flight unit are not available to NASA in accordance with agreed specifications and schedules and at reasonable prices to be agreed, NASA shall be free to produce such units in the United States. For this purpose, ESRO will arrange in advance on a contingency basis any necessary licensing arrangements.

3. Design changes

While it is understood that ESRO will be represented on the Shuttle change control boards, NASA reserves the right to require changes affecting the interfaces or operational interactions between the Shuttle and the SL after hearing and considering ESRO's views with respect to the prospective effect of such changes on the SL design or cost. NASA recognises the

desirability of avoiding changes resulting in a disproportionate impact on the SL programme. To the extent that changes affect the Shuttle and SL programmes, NASA and ESRO will bear the increases in the costs of their respective Shuttle and SL development contracts.

ARTICLE X

ACCESS TO TECHNOLOGY AND ASSISTANCE BY NASA

1. Principles

(a) ESRO will have access to technology, including know-how, available to NASA and needed to accomplish successfully its tasks under this cooperative programme; for the same purposes, NASA will have access to technology, including know-how, available to ESRO. NASA will do its best to arrange for such technical assistance as ESRO and its contractors may require for the satisfactory completion of the SL programme. Access to technology and arrangements for technical assistance shall be consistent with applicable US laws and regulations.

(b) NASA will make available to ESRO general information related to the design, development, and use of the Shuttle and orbital system, particularly that required for the understanding of that system.

(c) Requests for use of technology, including know-how, in other than SL development and production tasks will be considered on a case-by-case basis.

(d) To the extent that NASA can make the required information readily available, it will do so without charge; in other cases, NASA will use its best efforts to facilitate its availability on favourable conditions.

(e) The access to technology, including know-how, referred to above will be effected in such a

way as not to infringe any existing proprietary rights of any person or body in the United States or Europe.

2. Joint definition of areas

The two parties shall provide for the earliest possible joint definition of areas in which help in the procurement of hardware and technical assistance from US Government Agencies or nationals may be required.

3. Form of assistance

In providing such help to ESRO as may be agreed, NASA may respond on an in-house basis or may refer ESRO and/or its contractors to US contractors. NASA reserves the right to arrange for such assistance in the form of hardware, rather than know-how.

4. Quality control and acceptance

Where ESRO needs to procure US hardware, NASA agrees to use its good offices in connection with arranging the services of US quality control and acceptance and cost control and auditing personnel in US plants where available and appropriate.

5. Facilitation of export licenses

Early advance notification of contemplated ESRO procurements of US hardware or technology, including know-how, will facilitate assistance by NASA in connection with arrangements for export licenses consistent with applicable US laws and regulations.

6. Use of US facilities

Where it is jointly determined that it is appropriate and necessary for the conduct of the cooperative programme, NASA will use its good offices in connection with arranging for the use of US Government or contractors' facilities by ESRO and/or its contractors.

ARTICLE XI

PRINCIPLES CONCERNING ACCESS TO
AND USE OF SHUTTLE/SL

1. Planning

There shall be adequate European participation in NASA planning for Shuttle and SL user requirements, with a view to providing for inputs relevant to both the SL design and to European use of the SL. Appropriate representation and relevant procedures are being jointly prepared and will be subject to agreement by NASA and ESRO.

2. Flight crews

Flight crew opportunities will be provided in conjunction with flight projects sponsored by ESRO or by Governments participating in the SL programme and utilising the SL. It is contemplated that there will be a European member of the flight crew of the first SL flight.

3. Special provisions for the use of the first SL flight unit

(a) In order to assure the integrity of operation and management of the Shuttle system, NASA shall have full control over the first SL unit after its delivery, including the right to make final determination as to its use for peaceful purposes.

(b) With regard to the first flight of the first SL unit, the system test objectives will be the responsibility of NASA. The experimental objectives of this first flight will be jointly planned on a cooperative basis. Thereafter, the cooperative use of this first SL unit will be encouraged throughout its useful life although not to the exclusion of cost reimbursable use. NASA will otherwise have unrestricted use of the first SL unit free of cost.

(c) NASA may make any modifications to the first SL which it desires. Should NASA find it

desirable to effect major modifications to this unit, these shall be discussed with ESRO which will be given the opportunity to provide modification kits. With respect to minor modifications, the normal procedures for configuration control will be relied on to provide adequate information on changes.

4. Subsequent availability and preferred access to participants

While it is premature to define the ultimate terms and conditions for operation and use of the Shuttle with the SL after the first SL mission, it is expected that the following principles will apply :

(a) NASA will make available the Shuttle for SL missions on either a cooperative (non-cost) or a cost-reimbursable basis. In the latter case, costs which may be charged include, but are not limited to, integration, check-out, crew training and data reduction, processing and distribution, as well as the costs of the launching services provided.

(b) In regard to space missions of ESRO and Governments participating in the SL programme, NASA shall provide access for use of SLs developed under this cooperative programme for experiments or applications proposed for reimbursable flight by ESRO and Governments participating in the SL programme, in preference to those of third countries considering, in recognition of ESRO's participation in this cooperative programme, that this will be equitable in the event of payload limitation or scheduling conflicts. Experiments or applications proposed for cooperative flight will be selected on the basis of merit in accordance with continuing NASA policy; such proposals of ESRO and Governments participating in the SL programme will be given preference over the proposals of third countries provided their merit is at least equal to the merit of the proposals of third countries. ESRO and the Governments participating in the SL pro-

gramme will have an opportunity to express their views with respect to the judgement of merit regarding their cooperative proposals.

ARTICLE XII

PUBLIC INFORMATION

Each party is free to release public information regarding its own efforts in connection with this cooperative programme. However, it undertakes to coordinate in advance any public information activities which relate to the other party's responsibilities or performance.

ARTICLE XIII

PATENTS AND PROPRIETARY INFORMATION

Each of the parties and their contractors shall retain unaffected all rights which they may have with respect to any patents and/or proprietary information, whether or not they antedate this Memorandum of Understanding. Where it is mutually determined that patentable or proprietary information should be transferred in the interest of successfully implementing this cooperative programme, this may be done under arrangements which fully recognise and protect the rights involved. In addition, each of the parties shall secure from its contractors the rights necessary to discharge the obligations contained in this Memorandum of Understanding in accordance with its internal rules.

ARTICLE XIV

SETTLEMENT OF DISPUTES

1. Any disputes in the interpretation or implementation of the terms of this cooperative programme shall be referred to the NASA Administrator and the Director General of ESRO for settlement.

2. Should the NASA Administrator and the Director

General of ESRO be unable to resolve such disputes, they may be submitted to such other form of resolution or arbitration as may be agreed.

ARTICLE XV

DURATION

This Memorandum of Understanding shall remain in force until 1 January 1985, but at least for five years from the date of the first flight of the SL. This Memorandum shall be extended for three years unless either NASA or ESRO gives notice of termination prior to 1 January 1985, or prior to the expiration of the five years, whichever is applicable. Thereafter, the Memorandum of Understanding shall be extended for such further periods as the parties may agree.

ARTICLE XVI

ENTRY INTO FORCE

This Memorandum of Understanding shall enter into force when both the NASA Administrator and the Director General of ESRO have signed it and it has been confirmed under the terms of the Agreement between the Governments of the participating European States and the Government of the United States of America concerning this cooperative programme.

Dated 14 August 1973

A. Hocker

For the
European Space
Research Organisation
A. Hocker

James C. Fletcher

For the
National Aeronautics and
Space Administration
J.C. Fletcher

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AIf3. CONTINUATION OF THE SPACELAB PROGRAMME BEYOND THE 120% OF ITS OVERALL FINANCIAL ENVELOPE

NOTE

Ref. ESA/PB-SL/XXVIII/Res. 1. Adopted at the 30th meeting of the Spacelab Programme Board (12 March 1980).

The representatives of the Participants in the Spacelab programme, meeting in the Spacelab Programme Board,

CONSIDERING the present status of the programme and the most recent estimate of the overall cost to completion, which is not exceeding 431.2 MAU at the 1973 price level (ESA/PB-SL(79)3, rev.1);

RECALLING the Resolution adopted by the Spacelab Programme Board on 7 April 1978 (ESA/PB-SL/XVI/Res.1) and noting that the Participants have unanimously reaffirmed their will to complete the programme;

HAVING REGARD TO the letter from the Italian Delegation concerning the conditions for its participation in the programme beyond the 120% ceiling (ESA/PB-SL(79)12);

HAVING REGARD TO Articles 6.2(b), 17 and 19 of the Spacelab Arrangement and to Annex B thereto:

I. NOTE that each Participant in the Spacelab Arrangement explicitly declares that it will not use the right to withdraw from the programme which it could exercise under Article 6.2(b) of the Spacelab Arrangement in view of the fact that the estimated cost-to-completion exceeds 369.6 MAU (1973 price level) representing 120% of the overall financial envelope referred to in Article 5 of the afore-mentioned Arrangement;

II. NOTE Italy's intention to limit to 1% its participation in the costs of the programme beyond the 120% of the overall financial envelope;

III. AGREE, pursuant to Article 6.2 of the Arrangement, that the following specific provisions shall apply to the continuance of the programme;

(a) the waiving of use of the right to withdraw from the programme referred to in paragraph I above applies only as long as the cost-to-completion does not exceed the present estimate (431.2 MAU) given in the preamble, subject to Article 17 of the Spacelab Arrangement;

(b) the part of the programme over and above 120% of the overall financial envelope shall be funded by the Participants in accordance with the following scale of contributions which was established taking into account the contributions scale contained in Annex B of the Spacelab Arrangement:

Participants	%
Germany	64.40
Austria	0.76
Belgium	5.07
Denmark	1.81
Spain	3.38
France	12.07
Italy	1.00
Netherlands	2.53
United Kingdom	7.60
Switzerland	1.00
Other means of funding*	0.38
	100.00

* Germany guarantees the funding of this part so long as it is not covered otherwise.

IV. FIND that in view of the specific provisions referred to above the execution of the programme is continuing in accordance with the provisions of the Spacelab Arrangement and its Annexes;

V. INVITE the Director General to bring the present Resolution to the attention of the Council.

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Annex 4: Development and Breakdown by Programme, of ESRO and ELDO Budgets

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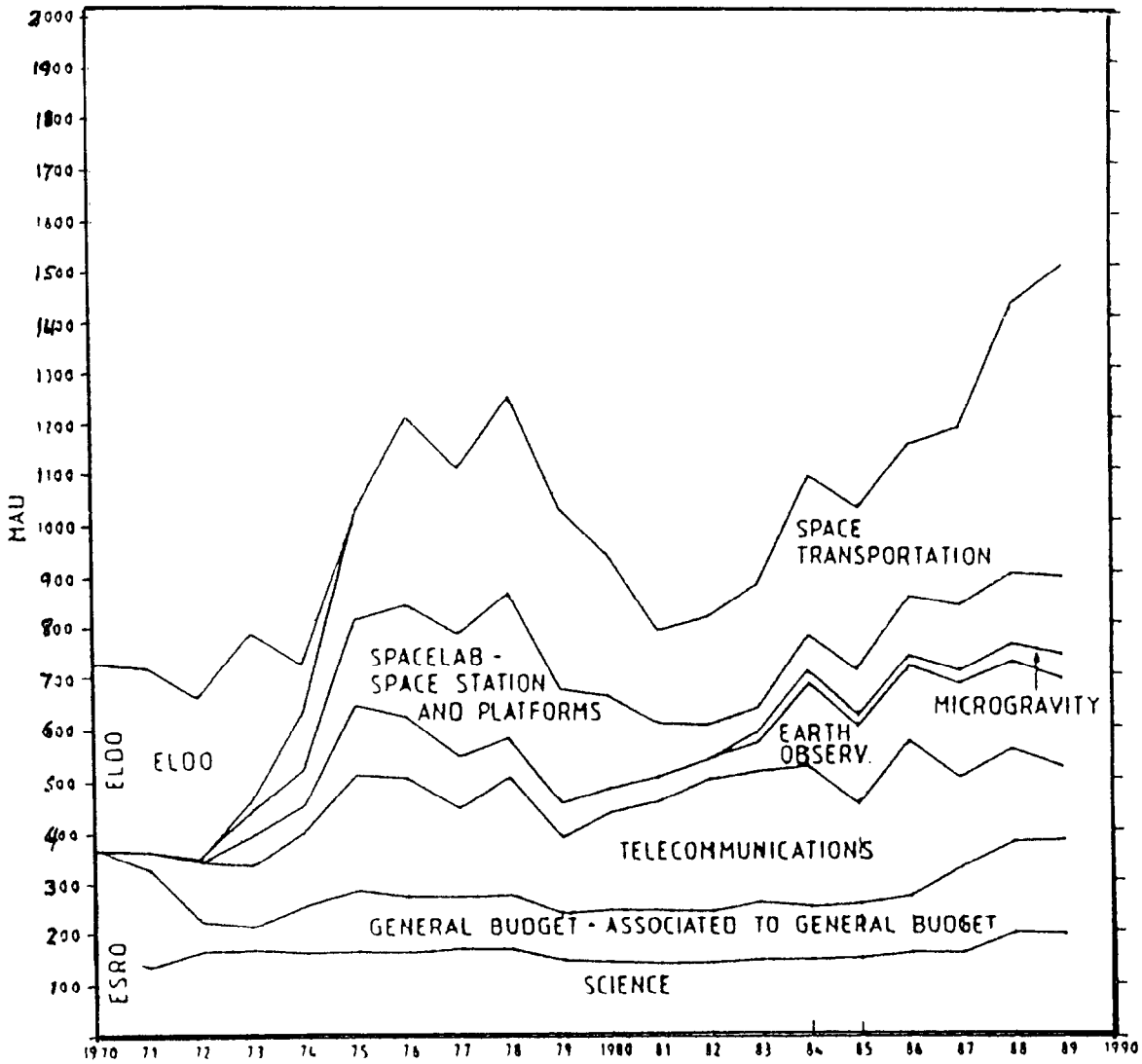

[5] The figure is from G. Lafferanderie, "Les Programmes Facultatifs," *The Implementation of the ESA Convention. Lessons from the Past*, Proceedings of the ESA/EUI International Colloquium, Florence, 25 and 26 October, 1993, pp. 21-40, at p. 40.

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Annex 5: Spacelab Flights

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STS Carrier	Launch Date & Duration	Orbit Incl. & Alt.	Mission	Config-uration	Discipline	European User Participation		European Astronaut
						Major	Partial	
STS 9 Columbia	28 Nov. 83 10 days	57° 250 km	SL-01 FSLP	LM + 1P	Multidiscipl.	x		U.Merbold
STS 51B Challenger	29 Apr. 85 7 days	57° 360 km	SL-03	LM + MPESS	Mat. Science			
STS 51F Challenger	29 Jul. 85 8 days	50° 320 km	SL-02	IG + 3P + IPS	Solar Astron.		x	
STS 61A Challenger	30 Oct. 85 7 days	57° 330 km	SL-D1	LM + MPESS	Mat. Science Life Science	x		R.Furrer E.Messer-schmid W.Ockels
STS 35 Columbia	2 Dec. 90 9 days	28° 350 km	ASTRO-1	IG + 2P + IPS	Astronomy			
STS 40 Columbia	5 Jun. 91 9 days	39° 300 km	SLS-01	LM	Life Science			
STS 42 Discovery	22 Jan. 92 8 days	57° 300 km	IML-01	LM	Mat. Science Life Science		x	U.Merbold
STS 45 Atlantis	24 Mar. 92 9 days	57° 300 km	ATLAS-1	IG + 2P	Atm. Physics Solar Astron.		x	D.Frimout
STS 50 Columbia	25 Jun. 92 14 days	28° 300 km	USML-01	LM + EDO	Mat. Science			
STS 47 Endeavour	12 Sep. 92 8 days	57° 300 km	SL-J	LM	Mat. Science Life Science			
STS 56 Discovery	8 Apr. 93 9 days	57° 300 km	ATLAS-2	IG + 1P	Atm. Physics		x	
STS 55 Columbia	26 Apr. 93 10 days	28° 300 km	SL-D2	LM + USS	Multidiscipl.	x		M.Schlegel U.Walter
STS 58 Columbia	18 Oct. 93 14 days	39° 280 km	SLS-02	LM + EDO	Life Science			
STS 65 Columbia	8 Jul. 94 15 days	28° 300 km	IML-02	LM + EDO	Life Science Mat. Science	x		
STS 66 Atlantis	3 Nov. 94 11 days	57° 300 km	ATLAS-3	IG + IP	Atm. Physics		x	Clervoy
STS 67 Endeavour	2 Mar. 95 17 days	28° 350 km	ASTRO-2	IG + 2P +EDO	Astronomy			
STS 71 Atlantis	27 Jun. 95 10 days	52° 300 km	SL-M	LM				
STS 73 Columbia	20 Oct. 95 16 days	39° 300 km	USML-02	LM + EDO	Mat. Science		x	
STS 78 Columbia	20 Jun. 96 17 days	39° 280 km	LMS	LM + EDO	Life Science Mat. Science	x		Favier
STS 83 Columbia	4 Apr. 97 4 days	28° 300 km	MSL-01	LM + EDO	Mat. Science		x	
STS 94 Columbia	1 Jul. 97 16 days	28° 300 km	MSL-01R	LM + EDO	Mat. Science		x	
STS 90 Columbia	2 Apr. 98 16 days	28° 300 km	NEURO-LAB	LM + EDO	Life Science		x	

STS Carrier	Launch Date & Duration	Spacelab Pallet & Purpose
STS-2 Columbia	12 Nov. 81 2 days	1 Pallet / OSTA-01 - Shuttle Imaging Radar SIR - A
STS-3 Columbia	22 Mar. 82 8 days	1 Pallet / OSS-01 - NASA Office of Space Science
STS-41G Challenger	5 Oct. 84 8 days	1 Pallet / OSTA-03 - Photographic and radar images of Earth
STS-51A Discovery	8 Nov. 84 8 days	2 Pallets / Retrieval of Palapa and Westar communication satellites
STS-39 Discovery	28 Apr. 91 8 days	1 Pallet / AFP-675 - Air Force Program 675
STS-46 Atlantis	31 Jul. 92 8 days	1 Pallet / TSS-01 - Tethered satellite
STS-59 Endeavour	9 Apr. 94 11 days	1 Pallet / SRL-01 - Space Radar Laboratory
STS-64 Discovery	9 Sept. 94 11 days	1 Pallet / LITE - Lidar In-Space Technology
STS-68 Endeavour	30 Sept. 94 11 days	1 Pallet / SRL-02 - Space Radar Laboratory
STS-75 Columbia	22 Feb. 96 16 days	1 Pallet / TSS-1R - Tethered satellite reflight

European Space Agency
Agence spatiale européenne

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