International Collaboration in

Advanced Technology:

The Case of the European Communication

Satellite Programme

by

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ABSTRACT

International Collaboration in Advanced Technology: The Case of the European Communication Satellite Programme

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Governments have funded the development and production of advanced technology in order to establish supply security and/or to achieve economic growth. The policy of government funding includes three alternatives: the two basic options of maintaining a national project or participating in international collaboration involving a number of sovereign states, and the third option of doing both in parallel. The study examines international collaboration in such a way as to assist in the selection of the appropriate policy option. Particular attention is paid to the perspective of small and large, advanced and less advanced European countries.

The research problem is addressed by focusing exclusively on those results which distinguish international collaboration from a national project, summarised under the concepts of collaborative sharing and collaborative efficiency. The former identifies the sharing of funding and technology not to be found in a national project. The latter identifies the difference in efficiency between international collaboration and a national project. Efficiency, indicated by cost, quality and time, is examined under the headings of policy-making, executive management, industrial rationalisation and production volume. Furthermore, collaborative sharing and efficiency are examined in the context of parallel national projects. This focus on the differences between the policy options provides the basis for selecting the appropriate one.

Previous studies fail to give convincing answers to the research problem: they concentrate on collaborative efficiency while neglecting collaborative sharing, and they disagree over whether international collaboration or a national project is more efficient. This study attempts to overcome these shortcomings by examining a major case study of international collaboration, namely the European Communication Satellite Programme.

The following conclusions are established. To achieve supply security, the collaborative option is considered appropriate for the large, advanced European country, and the parallel option for the large, less advanced countries. To achieve economic growth, the national option is appropriate for the advanced European countries. The smaller, less advanced countries are seen to play only a limited role in government funding of advanced technology.

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LIST OF ABBREVIATIONS

AFC	Administration and Finance Committee
ASTP	Advanced System and Technology Programme
AU	accounting unit (for value, see appendix A, table 4)
B	Belgium
BAC	British Aircraft Corporation
BADG	British Aerospace Dynamics Group
BMFT	Bundesministerium für Forschung und Technologie
BTM	Bell Telephone Manufacturing Company
C	Council
CASA	Construcciones Aeronauticas
CEPT	Conférence Européenne des Administrations des Postes et des Télécommunications
CETS	Conférence Européenne des Télécommunications par Satellite
CH	Switzerland
CIR	Compagnie Industrielle Radio Electrique
CNES	Centre National d'Etudes Spatiales
CNS	Compania Nazionale Satelliti
COMSAT	Communication Satellite Organisation
CSEE	Compagnie de Signaux et d'Entreprises Electriques
CTC	cost-to-completion
CTL	Computer Technology Limited
D	West Germany
DFVLR	Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt
DG	Director-General
DK	Denmark
E	Spain
EBU	European Broadcasting Union
ECS	European Communication Satellite
ELDO	European Launcher Development Organisation
ESA	European Space Agency
ESC	European Space Conference
ESOC	European Space Operations Centre
ESRANGE	European Sounding Rocket Range
ESRIN	European Space Research Institute
ESRO	European Space Research Organisation
ESTEC	European Space Technology Centre
ETCA	Etudes Techniques et Constructions Aérospatiales
EURATOM	European Atomic Energy Community
EUTELSAT	European Telecommunication Satellite Organisation
F	France
FIAR	Fabbrica Italiana Apparecchiature
GHz	giga hertz
GNP	gross national product
GTE	General Telephone and Electronics Group
GTS	geostationary technology satellite
HSA	Hollandse Signaal Apparaten
H-SAT	heavy satellite
HSD	Hawker Siddely Dynamics

I	Italy
IAPC	Interim Application Programme Committee
INMARSAT	Interim Maritime Satellite Organisation
INTA	Instituto Nacional de Técnica Aerospacial
INTELSAT	International Telecommunication Satellite Organisation
IPC	Industrial Policy Committee
ICL	International Computer Ltd
JCB	Joint Board on Communications Satellite Programme
JPPC	Joint Programme and Policy Committee
LCT	Laboratoire Central de Télécommunications
LME	Ericcson
L-SAT	Large Satellite
MARECS	Maritime European Communication Satellite
MARISAT	Maritime Satellite
MAROTS	Maritime Orbital Test Satellite
MAU	million accounting units (for value, see appendix A, table 4)
MBB	Messerschmidt-Bölkow-Blohm
MSDS	Marconi Space and Defence Systems
NASA	National Aeronautics and Space Administration
OEEC	Organisation for European Economic Cooperation
ONERA	Office National d'Etudes et de Recherches Aérospatiales
OTS	Orbital Test Satellite
PB	Programme Board
PB-MAR	Maritime Satellite Programme Board
PB-TEL	Telecommunication Satellite Programme Board
PTT	Postal, Telegraph and Telephone Administration
R&D	research and development
S	Sweden
SAFT	Société des Accumulateurs Fixes et de Traction
SAT	Société Anonyme de Télécommunications
SCTS	Satellite Control and Test Station
SBAG	Satellite Broadcasting Advisory Group
SEEE	Société Européenne d'Etudes et d'Essais d'Environnement
SEL	Standard Elektrik Lorenz
SEP	Société Européenne de Propulsion
SNIAS	Société Nationale Industrielle Aérospatiale
SODERN	Société Anonyme d'Etudes et de Realisations Nucleaires
SODETEG	Société d'Etudes Techniques et d'Entreprises Générales
SPC	Scientific Programme Committee
STC	Scientific and Technical Committee
STS	Consorzio per Sistemidi
TAU	thousand accounting units (for value, see appendix A, table 4)
TELECOM	Telecommunication Satellite Programme
TPO	Technisch Physische Dienst
TV-SAT	television satellite
TWTA	travelling-wave tube amplifier
UK	United Kingdom
UKATS	United Kingdom Advanced Technology Satellite
VFW	Vereinigte Flugtechnische Werke

INTRODUCTION

This study examines international collaboration in advanced technology. As an introduction to the study, a short outline of the thesis chapters is given below.

In chapter 1 the theoretical framework is described. First, the research problem is identified by outlining the origins, objectives and policy options for government funding of advanced technology. Two objectives, namely supply security and economic growth, are identified, and three policy options can be distinguished: the two basic options of maintaining a national project or participating in international collaboration involving a number of sovereign countries, and the third option of doing both in parallel. The study examines international collaboration in such a way as to assist in the selection of the appropriate policy option. Particular attention is paid to the perspective of small and large, advanced and less advanced European countries. The research problem is addressed by focusing exclusively on those results which distinguish participation in international collaboration from a national project; those results are summarised under the concepts of collaborative sharing and collaborative efficiency. The former identifies the sharing of funding and technology not to be found in a national project. The latter identifies the difference in efficiency between international collaboration and a national project. Furthermore, collaborative sharing and efficiency are examined in the context of parallel national projects. The focus on the differences between the policy options provides the basis for selecting the appropriate one.

Previous studies fail to give convincing answers to the research problem, since they fail to establish an adequate understanding of the two research concepts. A new effort is pursued here with the aim of resolving the debate and differences while contributing a new perspective.

This study attempts to overcome the shortcomings of past research by examining a major case study of international collaboration, namely the European Communication Satellite Programme. It is a joint effort of nine European countries, spanning more than ten years and costing more than $400 million. The TELECOM programme is studied in relation to national and bilateral efforts. In the final part of chapter 1, the research concept, which takes into account the exploratory nature of the research, is described.

In chapter 2, a brief account is given of the early developments in communication satellite system technology starting in the late 1950s. This is followed by a description of the first initiatives for a European communication satellite system in the early 1960s in the context of national initiatives and the European space policy. These European efforts are known as the CETS A/B/C projects. In addition, the national European space policy is described and particular emphasis is given to the development of launchers required for orbiting communication satellites. The chapter ends with the decision to embark on phase I of the TELECOM programme in 1970.

In chapter 3, a detailed description is given of the European Space Research Organisation (ESRO), which implemented the TELECOM programme, as it shifted its activity from scientific space research to space technology application. Details are provided on ESRO's policy towards industry and its project management system. In addition, chapter 3 covers policy-making in the TELECOM programme and the implementation of phase I. It ends with the decision to embark on phase II at the end of 1971.

Chapter 4 is devoted to an analysis of policy-making and industrial implementation under phase II of the programme. Its main purpose is to describe the OTS project and identify the industrial results. The chapter ends with a short overview of the status of the OTS project at the end of 1975.

Chapter 5 begins with an account of the amalgamation of the European space organisations and the creation of the European Space Agency (ESA). This is followed by a description of the planning and implementation of phase III of the TELECOM programme, the key parts of which are the ECS and H-SAT projects. Subsequently, the break-up of joint European space activity on communication satellites and the abandonment of the H-SAT project are described. The chapter ends with a summary of subsequent activities and the characteristics of two new projects carried out in parallel, namely the limited European project L-SAT (later renamed OLYMPUS) and the Franco-German project TV-SAT/Tdf. In addition, a brief outline is given of the market potential of European industry in communication satellite technology.

In chapter 6, the major findings of the case study are reviewed by returning to the research questions outlined in chapter 1, and a number of hypotheses on the appropriate policy option are developed.

The thesis contains two appendices. Appendix A includes tables and graphs on European space expenditure and programmes. For those readers unfamiliar with communication satellite systems and technology, appendix B provides a brief description of their characteristics.

CHAPTER 1

THEORETICAL FRAMEWORK

1.1 Government funding of advanced technology: origins, objectives and policy options

During the early 1950s, European countries, still struggling with post-war reconstruction, were forced to acknowledge their new position in world affairs. The USA had emerged as the leading political, industrial and military power of the western world. Its prosperity was on the one hand the motor for European recovery and on the other hand the illustration of European decline in political and industrial leadership. The Soviet Union demanded a recognition of parity with the United States. A massive arms and space race between the new superpowers had reduced European countries to mere observers.

The economic and political results of this development were perceived in Europe as a threat to its political independence and economic growth. The 'American challenge', the 'technology gap' and the 'Atlantic imbalance' were common phrases used to describe the emerging lead of American industry in sectors such as communications, computers, aerospace and nuclear energy.1/

These industrial sectors had something in common. Their products were expensive, had high research-and-development costs, became rapidly obsolete and required a lengthy development. Such are the characteristics of advanced

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1/ There exists a host of publications which refer to the 'technology gap' issue. For selected reading, see J. Servan-Schreiber, The American Challenge (Harmondsworth, Pelican Books, 1969); T. Schaerf, 'The Technological Gap: Issues, Politics and Trade Offs', Orbis, III (1968), 852-72; H. Nau, 'A Political Interpretation of the Technololgy Gap Dispute', Orbis, VI (1971), 507-27; R. Nelson, 'World Leadership, the Technological Gap and National Science Policy', Minerva, IX (1971), 386-99; J. Quinn, 'Technological Competition: Europe vs. U.S.', Harvard Business Review, XLIV (July/Aug. 1966), 113-30.

technology.1/

As a result of the perceived technology gap between the United States and Europe, there was a widespread belief among European governments, industrialists and academics that industry was unable to achieve the desirable level of progress in the advanced technology sector without government assistance.

In fact, government involvement in industry and technology was nothing new. Education, tariffs, corporate and patent laws are only a few examples of the long tradition of government attempts to guide industry in the national interest. In addition, government agencies had financed basic research in university institutes, government laboratories and establishments, and industry. For the most part, there was no intention of using the technological advances immediately in end-products or for commercial gain.

Now, however, government funding was demanded and granted for applied industrial research and development (R&D) in the advanced technology sector, aimed at creating new products. The rationale for such government funding was manifold, but two objectives were considered to be most important: supply security and economic growth. Whereas the former relates to the establishment or maintenance of a domestic industrial base for the supply of strategic products required to fulfil important government functions such as defence,

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1/ Technology is understood as procedures, experience, physical devices and equipment. It is described in terms of its functional properties, e.g., power to weight ratio or fuel consumption efficiency. In other words, technology is described in terms of what it does. For a discussion of the concept of technology, see D. Sahal, 'Alternative Conception of Technology', Research Policy, X (1981), 2-21. For a description of advanced technology development activity, see C. Freeman, Industrial Innovation (Harmondsworth, Penguin Books, 1974); H. Lane, R. Beddons, P. Lawrence, Managing Large Research and Development Programmes (Albany, State University of New York Press, 1981).

the latter relates to the creation of commercial opportunities for domestic industry.1/

Government funding of advanced technology was first implemented within a national framework, primarily through government contracting or procurement agencies. It quickly spread from military aerospace programmes to nuclear energy, communications, computers and space. This national approach had been taken by all the major European countries, including France, Italy, the United Kingdom and West Germany, from the early 1950s to the late 1960s. The results, however, were not very encouraging. As Layton notes, all the national programmes in Europe experienced the same problem - rising government expenditure, resulting in costly and uncompetitive products.2/

The perceived technology gap between Europe and America seemed to widen, as European industry was unable to become competitive, particularly in those industries which received massive government funding. In searching for the causes of this disappointing development, and in studying the American experience, the Europeans found one essential lesson - the need for size. Small projects implemented in parallel in a number of European countries did not pose a sufficient challenge to advanced industrial competence. The limited requirements of national government procurement did not provide for long production runs which could keep unit production costs low. Industrial competition confined within national borders did not provide the required motivation for efficient research and development. Finally, national European companies were considered to be too small to maintain an internationally

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1/ For a detailed discussion of the funding objectives, see section 1.2.2.

2/ C. Layton, European Advanced Technology - Programme for Integration (London, George Allen & Unwin, 1969), pp. 51-82.

competitive capability in advanced technology.1/

In fact, the characteristics of advanced technology seemed to require a size which was seen to be larger than that of the European national state, and there was a growing belief that the imperative of modern technology had made the European national state obsolete.2/ An alternative to national projects was envisaged: international collaboration characterised by the involvement of a number of sovereign states. Such collaboration included international agreements to fund, develop and produce advanced technology products, work-sharing arrangements and the creation of transnational administrative structures and decision-making procedures. International collaboration seemed to hold a number of advantages over a national project. First, the sharing of funding would limit the financial burden on each participating country and provide for more demanding projects. Second, it was thought that the efficiency of the collaborative project might exceed that of a national project. Efficiency, here, relates to the classical criteria in product

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1/ The perceived technology gap is relevant for this study in so far as it is seen to have been the major incentive for European countries to move towards technological collaboration. From the perspective of the seventies, however, it has been noted that those fears were unfounded. The technology gap, which only existed in a number of selected sectors, did narrow or even reverse with European companies creating an internationally competitive R&D capability. See K. Pavitt, 'Technology in Europe's Future', Research Policy, I (1971), 210-73; O. Keck, Fast Breeder Reactor Development in West Germany: An Analysis of Government Policy (Brighton, University of Sussex, Ph.D. Thesis, 1977); Gaps in Technology: Analytical Report (Paris, OECD, 1971).

2/ Layton, op.cit.; R. Gilpin, 'European Discussion and the Technology Gap', Public Interest, III (1968), 43-54; Lord Bessborough, Industry and the Common Market (London, Federal Trust, 1971); R. Foch, Europe and Technology: A Political View (Paris, Atlantic Institute, 1970).

development, namely cost, quality and time.1/ Joint funding would result in joint procurement. The resulting large production volume would reduce the cost of each production unit. In addition, collaboration would result in industrial rationalisation, which signifies the optimisation of industry to create new industrial structures of increased efficiencies, such as larger industrial entities, enhanced specialisation and increased competition.2/

Based on the disappointing results of national projects and supported by an emerging spirit of European cooperation, the first attempts at international collaboration were made in the early 1950s. One of the efforts of that time was EURATOM, a research programme for the peaceful exploitation of nuclear power financed jointly by five European countries. ENEA, less ambitious than EURATOM, was formed by a larger number of OEEC countries for a similar purpose.

In aerospace, international collaboration in Europe started with military projects like TRANSVALL and ATLANTIQUE. ATLANTIQUE, a naval-recognition and anti-submarine aircraft, was initiated in 1959 and built by four countries: Belgium, France, the Netherlands and West Germany. TRANSVALL, a military transport aircraft, was built and procured by France and West Germany. A technologically more ambitious project was JAGUAR, an Anglo-French fighter plane. There were many small military projects in the following years, such as the Anglo-French development of the LYNX and PUMA helicopters and the

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1/ Cost, quality and time are the main criteria according to which project success is evaluated. For further discussion, see T. DeCotiis, L. Dyer, 'Defining and Measuring Project Performance', Research Management, XXII (1969), 17-22; A. Martyn, 'Some Problems in Managing Complex Development Projects', Long Range Planning, VIII (1975), 13-26; L. Rogers, 'Guidelines for Project Management Teams', Industrial Engineering, VI (1974), 12-9.

2/ For a detailed discussion of sharing of funding, industrial rationalisation and production volume, see section 1.2.3.

Anglo-French project to build the MARTEL air-launched guided missile. In recent years, one of the biggest military projects was the TORNADO multi-role combat aircraft, developed and built by Italy, the United Kingdom and West Germany.

International collaboration spread from military aerospace to the civilian sector. The Anglo-French CONCORDE project and the multinational AIRBUS project are well-known cases. For international collaboration in space, European countries had formed two organisations. One, the European Space Research Organisation (ESRO), was set up by nine European countries and originally devoted to the construction of scientific satellites. The other, the European Launcher Development Organisation (ELDO), was concerned with the development of launchers for civilian use. In 1975, the two space organisations were joined to form the European Space Agency (ESA).

Besides those mentioned, there have been many other examples of international collaboration and an even larger number of attempts which never led to any agreement or failed to reach the production stage. Those which did involved a varying number of European countries and utilised a multitude of organisational and managerial arrangements; in some cases, they were established for a single project, and in others, for a long-term programme.1/

International collaboration, however, seems not to have fulfilled its initial promise. It was noted that the sharing of funding implied the sharing of the benefits derived from the collaborative programme, which some countries were not prepared to accept. Since funding objectives such as supply security and economic growth are achieved through the development of advanced

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1/ L. Bölkow, 'A Future for European Aerospace', New Scientist and Science Journal, XLI (1971), 352-3.

technology, sharing of benefits in international collaboration is associated with the sharing of technology. Furthermore, not only did the expected efficiency associated with industrial rationalisation and production volume fail to materialize, but international collaboration exhibited inefficiencies such as cumbersome policy-making and inadequate executive management.1/

Policy-making in international collaboration was the responsibility of the national funding organisations and/or national policy bodies and took place in multinational steering committees or boards of directors. These organisations represented the national participants in international collaboration. Policy-making in international collaboration was seen to result in delay of decisions and extra costs. The executive management in international collaboration translated the basic policies into project activities. Its prime task was the initiation, implementation and supervision of the industrial work, a key issue being the awarding of industrial contracts.2/ The executive management level was in some cases a multinational body, responsible not to national entities but to the multinational policy level. In others, no single contracting agency was established; instead, national contracting agencies were represented on an executive management

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1/ For a detailed discussion of sharing of technology, policy-making and executive management, see section 1.2.3.

2/ In fact, the organisational framework of international collaboration exhibits, within limitations, some similarities with multinational companies, where the policy level would correspond to the board of directors, the executive management level to the companies' executives and the industrial level to subcontractors. The industrial level of international collaboration comprises those companies which carry out the development and production of advanced technology under a contract from the executive management level. There are a number of arrangements which differ in the responsibility and liability of the companies and in profit-sharing schemes. In some cases, a group of subcontractors work for a prime contractor; in others, there are international consortia or joint subsidiaries.

board consisting only of a small secretariat. Executive management in international collaboration was seen to result in additional overhead, delays and lack of leadership.

On the basis of the results of international collaboration, only the early military aerospace projects are seen as successes. EURATOM and ELDO, however, are regarded as failures, CONCORDE as a commercial failure and technical success, TORNADO as marked by huge cost overruns and AIRBUS as a financial burden which required substantial government subsidies to penetrate the world market for civilian aircraft. While these are rather general conclusions with regard to the outcome of specific projects, past experience suggests that the success of participating in international collaboration is viewed quite differently from the perspective of small and large, advanced and less advanced European countries. In addition, the success of international collaboration may differ with regard to the achievement of different funding objectives such as supply security and/or economic growth.

So far, however, previous experience in government funding of advanced technology has not established a marked preference for one of the two basic policy options: international collaboration involving a number of sovereign states, and national projects confined to single countries. In addition, governments have increasingly pursued a third option, namely participating in international collaboration in parallel to maintaining a national project.

This study examines international collaboration in such a way as to assist in the selection of the appropriate policy option. The research problem will be elaborated in the following section, which includes a review of previous research.

1.2 Examining the three policy options from the perspective of international collaboration

1.2.1 Research problem and approach for the review of previous research

This study aims to examine international collaboration in such a way as to assist in the selection of the appropriate policy option for government funding of advanced technology. Three options can be distinguished: the two basic options of participating in international collaboration or maintaining a national project and the third option of doing both in parallel. The appropriate policy option is considered to be the one that best achieves the funding objectives, such as supply security and/or economic growth. In particular, the research problem is examined from the perspective of small and large, advanced and less advanced European countries.

The introduction has highlighted a number of issues which are seen to influence the success of international collaboration. In addition, they focus exclusively on those results which distinguish international collaboration from a national project. The research problem is addressed by examining these differences between the policy options as the basis for selecting the appropriate one. In order to do so, the issues are categorised into a set of organised concepts. First, the concept of collaborative sharing includes the sharing of funding and the sharing of technology not to be found in a national project. The concept of collaborative efficiency identifies the difference in efficiency between international collaboration and a national project. Efficiency, indicated by cost, quality and time, includes the issues of policy-making, executive management, industrial rationalisation and production volume. Where the results achieved under the concept of collaborative sharing and efficiency contribute to the achievement of the funding objectives, international collaboration would be the appropriate option; where the results hinder the achievement of those objectives, a national project would be the appropriate option.1/ In order to address the third option, the study examines the impact of a parallel national project on the results of collaborative sharing and efficiency, and vice-versa. Where these results contribute to the achievement of the funding objectives, the parallel option should be preferred and both single options ruled out.

Based on this concept, the review of past research will proceed according to three steps. First, the funding objectives of supply security and economic growth introduced in section 1.1 are described. This will not only provide the information required for the subsequent step of the review, but also shed light on the relationship between the research problem of this study and another field of research: the controversy over the justification for government funding. Second, based on the understanding of the funding objectives, the findings of previous research are summarised under the concept of collaborative sharing and collaborative efficiency. Particular attention is paid to the impact of parallel national projects on the results of collaborative sharing and efficiency, and vice-versa. In addition, the perspective of small and large, advanced and less advanced European countries are examined. Third, the findings of previous studies on the research question are recalled. This will be done with reference to the preceding examination of collaborative sharing and efficiency.

1/ Examining the relevance of collaborative sharing to the achievement of the funding objectives means examining the relevance of having only a piece of the pie (collaborative share) instead of the whole pie (national project). Examining the relevance of collaborative efficiency means examining the relevance of that piece (collaborative share) coming from a larger or smaller pie (collaborative efficiency).

1.2.2 Funding objectives and the controversy over the justification of government funding

Two main government objectives for funding advanced technology - supply security and economic growth - are discussed here in detail. The discussion recalls some common justifications relating to these objectives and the criticism thereof.

Supply security: Government funding of advanced technology has been justified by the need to create domestic sources of supply. This is based on the belief that dependence on foreign technology implies dependence on the policy of the supplier government, which might restrict the international dissemination of technology if it considered such action to be in the national interest. Gilpin cites a number of cases in which the United States has used

> '...its scientific, technological, and economic power to punish France for challenging American leadership and to force American foreign policy objectives on the French. French officials note that France has been denied nuclear technology and information which the United States has made available to Great Britain. The French also point out that American firms have been prevented by the US Government from cooperating with French firms in missile development. The US, they argue, also reneged on agreements to supply France with enriched uranium needed to develop a submarine propulsion reactor.'1/

Layton notes that the US refused to sell France computer technology in the mid-1960s in order to control European computer sales to Eastern European countries.2/ Another case in point is the Franco-German request to provide US launcher service for the SYMPHONIE communication satellite. Here, the US government restricted access to US-based technology in order to protect the long-term commercial interests of US industry. The request was finally

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1/ R. Gilpin, France in the Age of the Scientific State (Princeton, Princeton University, 1968), pp. 53-4.

2/ Layton, op.cit., p. 17.

granted on the condition that the satellite would not be used operationally but only experimentally. Finally, Williams emphasises the danger for Europe as a whole of becoming dependent on American nuclear fuel. He points out that the US had already gently but firmly made use of its fuel monopoly in the 1960s to obtain other advantages. For example, plutonium was sold to the German fast-breeder programme only on the condition that there was an exchange of information on the programme.1/ Williams feels that America might use a possible monopoly in fuel supplies to prevent European manufacturers of nuclear reactors from competing with the United States in third markets.

These cases support government reluctance to rely completely on foreign supply of military or civilian technology considered essential for such functions of the national economy as energy or communications. Moreover, Pavitt shows that the distinction between military and civilian needs is difficult to make in advanced technology. Both needs are often met by the same technology and even by the same industrial company. In addition, the speed of development of military technology is often dependent on the speed of development of civilian technology and vice versa.2/

While government funding has been granted to avoid dependence on foreign supply, it has also been justified as a means of avoiding dependence on foreign-controlled national supply. Vernon points out that multinational companies are much more flexible in switching their operations between countries than may be the case for national firms.3/ Multinational companies

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1/ R. Williams, European Technology - The Politics of Collaboration (London, Croom Helm, 1973), p. 87.

2/ K. Pavitt, 'Technology, International Competition, and Economic Growth: Some Lessons and Perspectives', World Politics, XXV (1973), 183-206.

3/ R. Vernon, Sovereignty at Bay (New York, Basic Book, 1971).

may also be used to apply political pressure across boundaries. Vernon shows that the US government had in some cases reached through the US parent to influence the foreign subsidiary in ways which might be considered a challenge to the policies of the host government. Moreover, Germidis has found that foreign subsidiaries do not tend to build up an industrial capability in advanced technology. Technology transfer is often limited to production technology and does not include any major R&D activity.1/ In fact, Pavitt notes that relative factor costs support the spread of production technology but not of R&D, which tends to be concentrated in those countries which are already more advanced.2/ As a result, the subsidiaries of multinational companies are considered to establish 'subcontracting economies' or 'branch plants' in less developed industries and not to create an overall industrial capability in order to maintain supply security.

The need to maintain national ownership not only limits the role of the multinational subsidiary in establishing supply security but can also be used to make a case against transnational merger or international takeover. Goldberg has shown that European governments actively intervened in negotiations between private companies in order to prevent merger with or takeover by a foreign firm.3/ Williams notes that such a nationalistic attitude is less potent in Belgium, the Netherlands and Italy than in Britain, France or West Germany, arguing that

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1/ D. Germidis (ed), International Subcontracting - A New Form of Investment (Paris, Development Centre of the OECD, 1980); see also M. Sharpsten, 'International Sub-Contracting', Oxford Economic Papers, XXVII (1975), 94-135.

2/ Pavitt, 'Technology in Europe's Future'.

3/ P. Goldberg, The Evolution of Transnational Companies in Europe (Cambridge, Massachusetts Institute of Technology, Ph.D. Thesis, 1971), p. 89.

> '...when it comes to foreign ownership, or indeed to partnership with other major industries, the citizens of the smaller countries have fewer sensibilities than the ex-great powers'.1/

Finally, Vernon identifies what can be seen as an additional justification of government support for the creation of supply security in advanced technology, namely a

> '...powerful psychic and social need on the part of the élite groups...to avoid a sense of dependence on outsiders.'2/.

In any review of the justification for government funding of advanced technology, it must be acknowledged that market mechanisms do not accommodate the motivation to establish supply security. It appears, however, there is full justification for such a motivation only if there is a foreign monopoly supplier of a technology considered to be of major military or economic importance. Where a number of suppliers are available, it appears unlikely that access to the technology would be prohibited. Even where a foreign monopoly exists, Zysman argues against a full-scale development effort, instead favouring a defence strategy based on exploratory activities and the maintenance of a stand-by capability.3/ If access to the technology should become restricted, such a capability should enable a timely response for the creation of national supply.

Economic growth: The development of advanced technology is seen as a major stimulus of economic growth, creating, among otherthings, profit opportunities for industry, employment and benefits for consumers. Industry,

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1/ Williams, op.cit., p. 251.

2/ R. Vernon, 'The Multinational Enterprise: Power versus Sovereignty', Foreign Affairs, XCIX (1971), 736-51.

3/ J. Zysmann, 'Between the Market and the State: Dilemmas of French Policy for the Electronics Industry', Research Policy, III (1975), 312-36.

however, is not considered capable of generating an optimum rate of development but rather tends to underinvest in advanced technology for two major reasons: the imperfection of the market and the risk aversion.

Schonfield argues that the private rate of return on investment in advanced technology is lower than the social rate of return.1/ In other words, profit opportunity created through the development of advanced technology does not reflect the benefit of this activity for society as a whole. Closely linked to this issue is the question of patenting and licensing. Weidenbaum argues that companies tend to underinvest in R&D because the results of such efforts are often not patentable.2/ As a result, if society wants the benefits of advanced technology which are not reflected in the private rate of return, it is up to government to fund its development in industry. In fact, Pavitt argues in favour of supporting 'bridgehead technology', which may benefit industry as a whole, on a temporary basis, whereas Hollomon is in favour of direct government support of broadly applicable technology which is of importance to industry.3/

A second reason for underinvestment is seen in the risk aversion of

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1/ A. Schonfield, 'Innovation: Does Government have a Role', in C. Carter (ed), Industrial Policy and Innovation (London, Heinemann Education Books, 1981), p. 16. Schonfield cites an investigation of US innovations by Mansfield, who compared the private rate of return (profit) with the social rate of return (added consumer surplus, resources saved). Mansfield concluded that the private benefits in general were less than the social benefits. See E. Mansfield, 'Measuring the Social and Private Rates of Return on Innovation', in Economic Effects of Space and Other Advanced Technologies (Strasbourg, Council of Europe, 1980).

2/ M. Weidenbaum, 'Government Spending and Innovation', Astronautics and Aeronautics, XI (1973), No. 1, 32-43.

3/ Pavitt, 'Technology, International Competition and Economic Growth: Some Lessons and Perspectives'; J. Holloman, 'Government and the Innovation Process', Technology Review, LXXXII (Feb. 1979), 30-41.

private industry. As noted above, the time span between product design and first output is comparatively long for advanced technology. In addition, advanced technologies such as aircraft, space vehicles and nuclear power involve large research-and-development efforts. Uncertainties in technical problem-solving increase the risk for the company. Finally, the financial commitment to the production process is higher as a result of specialised machinery, materials and manpower. Whereas Marshall recognises that such resource requirements might be beyond the capabilities of even large companies, Galbraith attributes underinvestment to a basic conservatism and risk avoidance in large companies.1/ Managers of large enterprises are seen to strive for survival and growth rather than profit. Smaller enterpreneurs tend to avoid the down-side risk of long-term investments in R&D which might jeopardise the company's existence. Others have attributed such risk aversion rather to educational practices, describing it as the 'MBA syndrome'.2/ Neglecting the benefits of externalities is seen to be the result of risk avoidance. Such externalities are known as by-products, spin-offs or fall-outs which are not part of the main development interest.3/ They are often disregarded since they cannot be quantified adequately in advance. Finally, risk avoidance is seen to discourage, in particular, investments in

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1/ W. Marshall, 'Interaction between Government and Industry: Lessons from Harwell's experience', Atom, XIX (1974), 75-81; K. Galbraith, The New Industrial State (Hammondsworth, Penguin Books, 1974).

2/ N. Valéry, 'The Declining Power of American Technology', New Scientist, XCVI (1976), 729.

3/ J. Welles, R. Waterman, 'Space Technology: Pay-off from Spin-off', Harvard Business Review, XLII (July/Aug. 1964), 106; P. Piganiol, 'Scientific Policy and the European Community', Minerva, VI (1968), 354-65; Economic Effects of Space and other Advanced Technologies, op.cit.; G. Niderau, 'Economic Benefits of ESA Contracts', ESA Bulletin, V (1979), No. 18, 48-58.

'infant' industries or industries with high entry barriers despite long-term potential for profitability. With regard to the latter point, Maddock argues that the 'entrance fee' to new generations of technology is sometimes beyond the resources of even very large companies.1/ Schnee has found that government funding has played an essential role in establishing new high technology industries, citing US experience in semiconductors and computers.2/ Consequently, Stine argues, governments should accept the role of 'explorer' in advanced technology.3/ In this regard, the Japanese experience is cited as an example of the fact that the international division of labour need not be accepted. In fact, the Japanese government has helped Japanese industry overcome the entrance barrier in a number of advanced technology sectors and thereby contributed to its success in markets previously dominated by foreign competitors.4/ In this approach, it is not assumed that market mechanisms would lead towards convergence of technology capabilities if they started from different levels of strength, but that a

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1/ I. Maddock, 'Beyond the Protestant Ethic', New Scientist, XCVIII (1978), 592-5.

2/ J. Schnee, 'Government Programmes and Growth of High-Technology Industries', Research Policy, VII (1978), 2-24. According to the same argument a European effort is demanded in European Society Faced with the Challenge of New Information Technologies: A Community Response (Brussels, Commission of the European Commmunities, COM(79)650 Final, 1979); Proposal for a Council Regulation EEC Concerning Community Actions in the Field of Microelectronic Technology (Brussels, Commission of the European Communities, COM(80)421 Final, 1980); G. Dosi, 'Institutions and Markets in High Technology: Government Support for Microelectronics in Europe', in Carter (ed), op.cit.

3/ H. Stine, Government and Industrial Roles in the Initiation of Space Industrialisation (San Francisco, Proceedings of the 23rd AAS Annual Meeting, Oct. 1977).

4/ C. Allen, 'Industrial Policy and Innovation in Japan', in Carter (ed), op.cit., p. 75.

laissez-faire approach would suit the winner rather than the late-comer.

Government funding of advanced technology for the sake of economic growth is criticised on a number of counts. Eads and Nelson argue that the resource requirements for the development of advanced technology are not beyond the capability of private industry. They recall the example of IBM, which invested $5 billion to develop the 360 computer family.1/ Whereas Eads and Nelson recognise that private profit opportunities in advanced technology might not reflect the social benefits, they do not support direct government funding to achieve those benefits, but rather favour a more cost-effective approach, such as exploratory developments, loans or risk-sharing schemes instead of subsidies. In this connection, Bradbury emphasises the need for the government to sponsor research on the context in which advanced technology is developed and marketed rather than to fund the development of technology itself.2/ Such research should be concerned with the whole legislative and regulatory context and general environment in which industry operates. Abernathy and Chakravarthy take a different approach; they suggest improving the effectiveness of direct government funding of industrial R&D (technology push) by combining it with product characteristics intervention and market modification (technology pull).3/ The latter approach reflects an understanding of technical progress in which the funding of R&D is only one

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1/ O. Eads, R. Nelson, 'Government Support of Advanced Civilian Technology: Power Reacators and the Supersonic Transport', Public Policy, XIX (1971), 405-27.

2/ F. Bradbury, B. Bodroghy, F. Clark, P. Jervis, Community Industrial Research Priorities for the early 1980's - Final Report (Oxford, Oxford Centre for Management Studies, Sept. 1980).

3/ J. Abernathy, B. Chakravarthy, 'Government Intervention and Innovation in Industry: A Policy Framework', Sloan Management Review, XIX (Spring 1979), 3-18.

element. Whereas R&D may result the solution of technical problems, it does not reduce market uncertainties. Keck emphasises that the risk avoidance of industry is the result of commercial rather than technological problems.1/ In addition, he sees technical progress as the outcome of a highly complex process including issues of organisation, management and training. This notion is supported by Pavitt and Wald, who conclude that there is no relationship between government R&D and industrial performance.2/ They cite the experience of Switzerland, which is a highly developed industrial country but does not engage in direct government funding. In addition, analysing the perception of industry, Rubenstein finds that government action to stimulate innovations is generally perceived as not being salient in industrial R&D and innovation decision-making.3/ Based on this understanding, Jewkes argues that using the argument of social benefit to justify government funding is pseudo-scientific language.4/ In fact, he states that the risk avoidance of industry is appropriate and government is left subsidizing products with poor market prospects which industry does not consider worthy of support.5/ Instead, as Jewkes points out, government tends to take risks because there is

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1/ Keck, op.cit., p. 24.

2/ K. Pavitt, S. Wald, The Conditions for Success in Technological Innovation (Paris, OECD, 1971), p. 126.

3/ A. Rubenstein, 'Management Perceptions of Goernment Incentives to Technological Innovation in England, France, West Germany and Japan', Research Policy, VI (1977), 324-57.

4/ J. Jewkes, Government and High Technology (London, The Insitute of Economic Affairs for the Wincott Foundation, Occasional Paper 37, 1972), p. 21.

5/ See also P. Henderson, 'Two British Errors: Their Possible Size and Some Possible Lessons', Oxford Economic Paper, XXIX (1977), 159-205; G. Eads, 'U.S. Government Support for Civilian Technology: Economic Theory versus Political Practice', Research Policy, III (1974), 2-16.

no sanction for failure. Critics generally tend to doubt that bureaucratic government organisations are more capable and competent than industry in responding to market signals. In fact, government attempts to identify what is worth supporting pay little attention to comparative advantage and opportunity costs. With regard to the latter point, Eads and Nelson point out that the benefit of government funding should be limited to a time/cost trade-off.1/ Government funding is seen merely to speed up the development of products which industry would have developed at a later stage, when sufficient technical and market knowledge had been accumulated to warrant the investment. Furthermore, the contribution of indigenous R&D capability to economic growth is seen to be overvalued since technology easily flows across national borders through direct imports, licensing and foreign investment.2/ Finally, with regard to externalities and spin-offs, Keck recalls that those would also occur in industrial R&D and are only put forward as justifications for government funding when a particular project comes under criticism.3/

Concluding remarks on funding objectives and the relationship between the main research problem and the controversy over the justification of government funding

Two major motives for government funding have been summarised, namely supply security and economic growth. This illustration is certainly not exhaustive. There are many other possible motives, such as government

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1/ Eads, Nelson, op.cit., 419.

2/ Nelson, op.cit.

3/ Keck, op.cit., p. 60.

attempts to guide industrial restructuring,1/ to create jobs in distressed areas in times of high unemployment, to improve the balance of payments,2/ to increase the 'social return' on technology for environmenal protection or product safety 3/ and to achieve national prestige.

The intention of the illustration is twofold. First, it creates an understanding of the funding objectives for the subsequent exploration of collaborative benefits and shortcomings. Second, it lays the groundwork for an examination of the relationship between the main research problem and the controversy over the justification for government funding of advanced technology. Supporters and critics alike see government funding channeled to advanced technology projects of high technological and market risks and agree that private industry is unlikely to fund these projects itself. Supporters view such projects as beneficial to society as a whole and industry in particular and argue that those projects are not undertaken by industry as a result of imperfections in the market-place and company investment-making. The critics, however, see government funding as a waste of resources, as it transfers resources from productive to unproductive sectors. In fact, Eads and Nelson argue that while industry carries out the profitable projects, government is left to fund the 'second best' projects.4/ Comparing

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1/ W. Corden, 'Conclusions on the Logic of Government Intervention', in W. Corden, G. Fels (eds), Public Assistance to Industry (London, The Mcmillan Press, 1976), pp. 215-29.

2/ Hollomon, op.cit.

3/ J. Logsdon, 'Towards a New Policy for Technology: The Outlines Emerge', Technology Review, LXXV (Oct./Nov. 1972), 36-42; J. Hollomon, 'Technology in the United States: Issues for the 1980's', Technology Review, LXXVII (June 1974), 10-70.

4/ Eads, Nelson, op.cit.

international collaboration and national projects. Pavitt pursues this argument by stating that while governments fund 'second best' projects nationally, they seek the collaborative framework for 'third best' projects. In particular, he notes that European governments have a

> '...temptation to offload on to a "European" budget R&D projects which have a low, national priority'.1/

A similar observation is made by Foch when examining the EURATOM organisation:

> 'The various countries include in their own programmes the easiest projects from the technical point of view, or those which appear most promising, and assign the less promising, more difficult or adventurous projects to the international community.'2/

As an example, Foch recalls that whereas France, Italy and West Germany individually decided to develop nuclear reactors cooled respectively by gas, steam and heavy water, they entrusted EURATOM with the less promising task of studying cooling by organic liquid. Although EURATOM came up with a perfect technical solution after spending $150 million, none of the countries showed any interest in this cooling method.

Assuming a project is not undertaken because it is considered third best in a national framework, one could argue, however, that this project might become justified in a collaborative framework as a result of the effective utilisation of government funding associated with international collaboration. In addition, national characteristics such as the advanced state of industry or the financial resources available might make it advantageous for a particular country to select one option since it produces the best results, whereas different characteristics would make an alternative

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1/ Pavitt, 'Technology in Europe's Future', 254.

2/ Foch, op.cit., p. 31.

option more appropriate.

This difference in explanation highlights the relationship between the research problem and the controversy over the justification for government funding. This relationship has to be examined in order to gain an adequate understanding of the research problem; it will be addressed in the subsequent review of previous research according to the categories of collaborative sharing and efficiency and in the description of the new research effort.

1.2.3 Collaborative sharing

On the basis of the discussion of the funding objectives in the previous section, it is possible to review the findings of previous research under the categories of collaborative sharing and collaborative efficiency according to the concept outlined in section 1.2.1. This section is confined to the former category, including the sharing of funding and the sharing of technology. The issues are explored by examining, on the one hand, their contribution to the achievement of the funding objectives of the participating governments and, on the other hand, the causes which explain their occurrence. Particular attention is paid to the perspective of funding organisations from small and large, advanced and less advanced European countries. Finally, reference is made to the impact of parallel national projects on the results of collaborative sharing, and vice-versa.

Sharing of funding: The huge financial requirements of developing advanced technology are often seen to be beyond the resources which European governments are able or willing to spend. Sharing the funding of such development efforts through international collaboration could not only limit the financial burden on the participating governments, but also allow those countries which were not able to maintain a national project on their own to participate in the advanced technology sector. In addition, the sharing of funding is likely to make larger sums available for the technology programme than the national project. Hence, more demanding projects could be implemented, enabling industry to create and maintain a higher level of competence.

The need to spread R&D and production costs while keeping total annual expenditure within acceptable limits has been seen as the main impetus for defence collaboration.1/ Britain's ambitious defence programme in the late 1950s and early 1960s is an illustration that soaring development costs are far beyond the means of a medium-sized European power.2/ At that time, the United Kingdom initiated projects to develop nuclear weapons, ballistic missiles, supersonic bombers, interceptor aircraft and a range of missiles. If these projects had been carried out, double the resouces actually available would have been required. Instead, a series of cancellations followed in order to stay within the financial limits, estimated at $700 million annually. The ballistic missile project was canceled and replaced by the American Thor missile and later by Polaris. In addition, none of the aviation developments initiated between 1950 and 1955 reached service. In order to spread the available funds, the United Kingdom established collaborative ventures with its European neighbours on all projects initiated after 1967.

Participation in international collaboration limits the financial burden of the funding organisations in comparison to national projects.3/ The claim, however, that the financial burden of a project is beyond the reach of a national budget could be misleading. As noted in the preceding section, the reluctance to finance the project nationally might be attributed to its low priority. In addition, the benefit of sharing the funding is limited in cases where the cost of the collaborative project is not spread equally among a large number of participating countries. France, for example, funded over 60%

1/ Williams, op.cit., p. 158.

2/ Layton, op.cit., p. 53.

3/ The possible increase in the financial burden as a result of collaborative inefficiencies will be covered under those concepts of benefits and shortcomings which illustrate inefficiencies.

of the ARIANE launcher project, which was carried out by the 13-member ESA.1/ West Germany covered 70% of the costs of a four-country project to develop a prototype nuclear reactor.2/

Sharing of technology: Sharing the funding of an advanced technology programme implies the sharing of its benefits among the participating countries. Since government objectives such as supply security and economic growth are achieved by supporting the development of advanced technology, sharing the benefits of international collaboration is associated with the sharing of this technology. In fact, it has become a cardinal principle of international collaboration that national industry is expected to receive a 'fair share' of the industrial effort.3/ This principle of 'fair share' or 'fair return' is widely understood as the sharing of industrial contracts among the national industries according to the financial contribution of the participating governments. In the Anglo-French CONCORDE project, for example, the distribution of development contracts and subcontracts reflected equal sharing of costs by the two countries. Specifically, the work on the airframe was divided on a 60/40 basis, with the French company, Sud Aviation, having the lead over the British company, BAC. For the engine, the British company, Bristol Siddeley Engines, received a share of 60% compared with 40% for the French company, SNECMA.4/

1/ M. Schwarz, 'European Policies on Space Science and Technology 1960-1978', Research Policy, VIII (1979), 204-43.

2/ H. Nau, 'The Practice of Interdependence in the Research and Development Sector: Fast Reactor Cooperation in Western Europe', International Organisation, XXVI (1977), 517.

3/ Williams, op.cit., p. 104.

4/ Layton, op.cit., p. 136.

In addition to the quantitative comparison of participation in industrial activity, the principle of 'fair return' also has a qualitative aspect, since some contract shares are considered more attractive than others. Long battles have been fought, for example, between national delegations about which national industry gets the design leadership or prime contractorship. Similar to the sharing of development contracts, a 'fair return' policy is also applied to the production stage. Governments expect that the sharing out of production contracts will result in a workload for national industry equivalent to the national funds provided for the procurment of the collaborative product.

Even where a qualitative and quantitative 'fair share' has been achieved by each participating country, this result is still considered to fall short of benefits derived from national projects. Whereas a national project could achieve domestic supply security, participation in international collaboration may only result in participation in an interdependent network of supply security. As for achieving economic growth, international collaboration might result in sharing the economic benefits which otherwise would have remained in domestic industry under a national project.

The shortcomings associated with the sharing of technology have been outlined on the assumption that each country was able to secure a 'fair return' from the collaborative venture. This assumption is often violated, as some countries benefit at the expense of others. Such an unequal distribution of industrial participation is seen to be the result of a capability gap between the collaborating countries. Where national industries are allowed to compete freely for collaborative funding, obviously those countries which already possess an advanced technological capability will receive the major share of the contracts. This was the case in the EURATOM programme, where member countries exhibited different levels of development.1/ EURATOM's subsequent practice of concentrating industrial activities in the advanced countries was seen by the less advanced countries, such as Italy

> '...as a means to make the rich European countries richer and the poor poorer'. He concluded '...just as France or West Germany may worry about the gap between themselves and the United States, the lesser developed Western European countries such as Italy worry about the gap between themselves and the more developed of their partners.'2/

Pavitt doubts that such an intra-European gap can be overcome by international collaboration and rather favours national projects, arguing that

> 'Centrally-financed R&D inevitably creates the problem of 'fair return', whilst nationally-financed R&D eliminates this problem, and allows the technologically weaker countries the option of making an energetic effort to catch up.'3/

Such national projects, however, are not maintained by the weaker countries but by the larger, more advanced ones and even in parallel to their participation in international collaboration. France and West Germany, for example, maintained national programmes in civilian nuclear energy in parallel to their participation in EURATOM. As noted by Nau,

> 'The Germans followed a general rule...which required that whatever was done internationally must be done at home on at least twice the scale. Later the ratio became more like 1:4 in favour of national programmes'.4/

This policy is seen to vary with the size of a country. Foch notes that small European countries tend to cut back on national projects in favour of participation in international collaboration.5/ Luxembourg is said to have even discontinued national projects entirely. France and West Germany, on the

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1/ Gilpin, op.cit., p. 406.

2/ Ibid., p. 429.

3/ Pavitt, op.cit., 255.

4/ Nau, op.cit., 508.

5/ Foch, op.cit., p. 18.

other hand, continue to maintain large national programmes. Pavitt makes a similar point when he concludes that smaller countries are keen to pool resources whereas larger countries are not likely to give up their prerogative to finance national developments in the advanced technology sector.1/ This difference in attitude could also be the result of economic reality. Whereas the small countries do not like to see all their key industries controlled by foreigners, they do not have the financial resources to control all of them themselves. They strongly favour international collaboration in which policies and control are exercised jointly. As a result, the two groups of countries have different attitudes towards international collaboration. While the smaller countries have a clear interest in the success of international collaboration, larger countries tend to judge international collaboration in terms of its effect on their national plans. In fact, international collaboration can even be viewed to be complementary to national activities, supplementing national programmes and augmenting limited national resources. Gilpin notes that the success of France's national efforts in space and atomic energy ultimately depended on complementary international programmes. He concludes, therefore,

> '...that French science policy is totally chauvinistic, paradoxically her policy is most internationalistic, as well as the most nationalist science policy pursued by any European government'.2/

The argument that collaboration complements national projects can also be reversed: in this case, the national project creates a technology gap between the collaborating countries, as already discussed above under the issue of 'fair return'. Referring to this point, Foch recalls the observation of the

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1/ Pavitt, op.cit.

2/ Gilpin, op.cit., p. 382.

Director-General of the French space organisation that

> 'To abandon our national space effort altogether and concentrate on a European programme would be the worst solution of all...our industry would lose its present lead and we should merely be financing foreign industry'.1/

Foch describes this as a 'position-of-strength complex'. Even after the idea of international collaboration is accepted, participating countries attempt to manoeuvre themselves into a position from which they can dominate the collaborative venture. Other countries soon follow, however, which leads to a proliferation of national projects, as was the case in EURATOM.2/

Despite a technology gap and the existence of parallel national projects, it is possible to achieve a 'fair return' for all countries participating in international collaboration. This, however, will limit the benefit of industrial rationalisation.3/

The policy of 'fair return' is most important for sharing out the R&D activity of the collaborative project. This activity creates the industrial competence which sets the stage for production. In fact, the flexibility to arrange for the sharing of work during the production stage is often confined

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1/ Foch, op.cit., p. 31.

2/ Ibid., p. 30. Furthermore, the tendency to maintain national projects in parallel to participation in international collaboration is seen by Layton as an insurance policy which governments take out in case international collaboration is not considered satisfactory. Foch, on the other hand, believes that the distribution of funding between collaborative and national projects is rather the result of vested interests. Whereas he believes that the funding of national projects should be reduced in favour of joint projects, he points out the political reality that '...the latter is most likely to be cut back for the simple reason that it is drawn up by the people who administer the national programmes' (Ibid., p. 31).

3/ This issue is discussed under the concept 'benefit: industrial rationalisation'. The policy of 'fair return' and its implications for 'sharing of technology' and 'industrial rationalisation' will be elaborated further in section 1.2.4, which examines the potential and limits of international collaboration in reference to national projects.

to work arrangements established for the development of the product. As it does to R&D activity, the policy of 'fair return' also applies to production. Hence, the procurement plans of the countries participating in a collaborative arrangement are already taken into account for the sharing of R&D activities. Quite often, however, these initial procurement plans are not binding and change during the course of the collaborative venture. Walker notes that at the beginning of the TORNADO project, the British, German and Italian governments declared their intention to purchase 380, 600 and 200 aircraft respectively.1/ After the project was well under way, the Germans reduced their forecast to 320 and the Italians to 100; only the British stuck to their original intentions at that time. Quite clearly, in light of such volatile procurement plans, it appears difficult to maintain a 'fair return' balance of contracts at the production stage, as the flexibility of sharing has already been considerably limited by the arrangement agreed and implemented for the development stage.

In addition to getting a 'fair return' from international collaboration, governments and industry are often eager to protect the national industrial capability which the companies possess before they enter into collaboration. The Society of British Aerospace Companies describes the 'surrender of expertise' as a main shortcoming of international collaboration.2/ Aked and Gummett even identify 'jealousies', as each country guards its investment in advanced technology.3/

1/ W. Walker, 'The Multi-Role Combat Aircraft (MRCA): A Case Study in European Collaboration', Research Policy, III (1974), 296.

2/ Williams, op.cit., p. 109.

3/ N. Aked, R. Gummett, 'Science and Technology in the European Communities: The History of the Cost Project', Research Policy, V (1976), 270-94.

1.2.4 Collaborative efficiency

As outlined in the section 1.2.1, collaborative efficiency identifies the difference in efficiency between international collaboration and a national project. The concept includes the issues of policy-making, executive management, industrial rationalisation and production volume. As in the case of collaborative sharing, these issues are explored by examining, on the one hand, their contribution to the achievement of funding objectives of participating government and, on the other hand, the causes which explain their occurrence. The review of the collaborative benefits and shortcomings will highlight the disagreement over whether international collaboration or a national project is more efficient. It is not the prime intention of this review to reconcile this disagreement but rather to reveal the spectrum of opinion. In fact, the reconciliation of this disagreement will be the subject of the new research effort outlined in section 1.3.

Policy-Making: A number of shortcomings are attributed to the collaborative machinery for decision-making at the intergovernmental level. One of the major issues is the procedure for reaching a decision: majority, weighted majority or unanimity vote. The voting procedure reflects a compromise between the interests of the individual member state and those of the collaborative venture. In the case of the two European space organisations ESRO and ELDO, the convention contained provisions for simple majority, for two-thirds majority and for unanimity in specified instances. Whereas for the approval of ELDO's annual budget, a 'special two-thirds' majority was required, including two thirds of the member states providing at least 85% of the funds, the ESRO budget could be settled by a straight two-thirds majority. In fact, the ELDO budget could be vetoed by one major contributing country.1/ In the case of ELDO, it has been noted that

> '...the attainment of intergovernmental consensus on the desirability of a specific technological effort, not to speak of agreement on the details of the R&D programme, lengthened the process of development.'2/

Obviously, the taking of decisions at the policy level will be eased by limiting the requirements for agreement. Layton notes, for example, that the prolonged wrangling over the EURATOM research programme could have been avoided if decisions had been taken by qualified majority vote instead of by majority vote. On the other hand, majority vote implies the surrender of national sovereignty; countries might be forced to participate in a project which they find unacceptable. In fact, international collaboration must strike a fair compromise between the two requirements, including the appropriate provisions for terminating participation in case the project assumptions prove drastically wrong.

Whereas procedures are important in producing smooth decision-making, the subject about decisions are made may be even more important. In fact, it has been argued that decisions in international collaboration can be made in reasonable time. This implies, however, unity of purpose and a whole-hearted, mutual and complementary interest in the project.3/ International collaboration involving a large number of governments is not likely to achieve this condition.

In addition to the voting procedures, the unwieldiness resulting from the size and number of the government committees has been seen to contribute to

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1/ Williams, op.cit., p. 101.

2/ R. Pfaltzgraff, J. Deghand, 'European Technological Collaboration: The Experience of the European Launcher Development Organisation (ELDO)', Journal of Common Market Studies, VIII (1969), 22-34.

3/ Williams, op.cit., p. 74.

the length of time taken to reach decisions. Greenwood describes the top-heavy government decision-making machinery established for the CONCORDE project: the CONCORDE Directing Committee of senior governmental officials in charge of policy and programme; the Management Committee; an Aircraft Committee of Directors consisting of representatives of BAC (UK) and Sud Aviation (F); a Committee of Engine Directors consisting of representatives of Rolls Royce (UK) and SNECMA (F); and a series of specialist committees for engineering, design, production, sales etc., also including government specialists.1/ Effective liaison between all the officials concerned becomes a daunting task.2/ The setting up of excessive numbers of subsidiary bodies whose sole object is to check on other bodies has been described as 'over-organisation' or 'over-management'.3/ Quite often, these bodies, set up in an attempt to control and reduce project costs, merely increase those costs.

Decision-making at the policy level is held up by what has been called the 'uncorrelated periods of paralysis'.4/ Based on his experience as Director-General of ESRO, Bondi notes that

> 'The government of every country is paralysed overall for perhaps 15 to 20 per cent of the time because of impending elections, a ministerial reshuffle, or a currency or language crisis...when there are ten governments with uncorrelated periods of paralysis, the days when all are in a position to take decisions are rather few'.5/

As a utopian solution, Bondi suggests that the elections of all

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1/ A. Greenwood, 'Co-operation in Aerospace Projects', 4-22, in Bessborough (ed.), op.cit.

2/ D. Willson, JET: A European Experience (Bristol, Adam Hilger, 1981), p. 53.

3/ A. Cleaver, 'Over-Management', Raumfahrtforschung, XIII (1972), No. 2, 54-6.

4/ Williams, op.cit., p. 153.

5/ H. Bondi, 'International Collaboration in Advanced Technology', The World Today, XXIX (1973), 20.

governments participating in international collaboration should be synchronised.

The discussion at the policy level is hindered by the limited discretion of government representatives. Before collaborative meetings, national cabinets often instruct their representatives, with the result that there is limited flexibility to find a compromise decision.1/ Layton therefore argues that the policy level should be staffed with distinguished representatives, capable of exercising leadership.2/ Hochmuth, on the other hand, argues that governmental representatives should not be of high level, since their premises for decisions necessarily encompass far more than the collaborative project alone.3/

In order to avoid dead-locks at the policy level during the implementation, Foch argues that projects should be clearly defined and agreed in advance. In fact, he states that it is important to fix the technical and operational boundaries of the project prior to determining the administrative and political mechanisms needed to carry it out.4/ The same issue is raised by Williams, who stresses the need for an explicit and comprehensive collaborative agreement setting out the relationship of the national participants in order to avoid conflicts during programme implementation.5/ Ropelewski, however, has shown that the definition of such an agreement in

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1/ Williams, op.cit., p. 65.

2/ Layton, op.cit., p. 113.

3/ M. Hochmuth, Organising the Transnationals: The Experience with Transnational Enterprises in Advanced Technology (Leiden, A.W. Sijthoff, 1974).

4/ Foch, op.cit., pp. 133-4.

5/ Williams, op.cit., p. 154.

terms of selecting a specific programme and defining specific cost and work-sharing formulas is likely to take considerable time.1/

With regard to overcoming dead-locks in decision-making, an interesting observation by Hochmuth should be mentioned. He notes that the representatives of smaller countries on the ELDO Board of Directors often played the role of arbitrators or conciliators during particularly difficult debates between the larger countries.2/

Finally, with regard to style, Darth finds that decision-making at the governmental level can be characterised as incremental, whereas Walker notes that the strain of formality and excessive politeness between national representatives discourages constructive internal criticism.3/

Executive management: Executive management acts as the link between the policy level and industry. It is concerned with the management activities associated with the international character of the project as well as with technical matters. Whereas some collaborative ventures have created independent organisations solely devoted to providing this link, such as full-time engineering agencies of international civil servants responsible to the policy-making machinery or joint industry/government committees, other collaborative ventures rely instead on industry for guidance and direction. It should be noted that such a distinction can also be made for national projects. Hochmuth notes, for example, that US government contracting depends

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1/ R. Ropelewski, 'European/U.S. Cooperation Weighed', Aviation Week and Space Technology, LXI (Feb. 1976), 19.

2/ Hochmuth, op.cit., p. 47.

3/ L. Darth, M. Gibbons, J. Ronagne, 'The European Molecular Biology Organisation: A Case-Study of Decision Making in Science Policy', Research Policy, IV (1975), 56-78; Walker, op.cit., 291.

on government engineering agencies to provide day-to-day direction and timely guidance to the industrial companies after the contracts are awarded. For the German contractual system, such a full-time agency is not essential and contractors are relatively free to 'lead' the government.1/

For space collaboration, European governments established the independent executive management organisation ESRO.2/ The Director-General of ESRO was responsible to the Council of member states. He was given real authority, in view of the number and types of problems and decisions he had to submit to the Council and its finance, technical and administrative committees.3/ In the case of ESRO, authority was matched by competence. ESRO built joint installations: a central laboratory (ESTEC) in the Netherlands, including large test equipment such as vacuum chambers and shake tables; a computing centre (ESOC) in West Germany; and a tracking and telemetry network. Not long after it had been established, ESRO had a staff of 800 employees. Despite problems during the early stage of its existence, ESRO is generally considered to have been successful in implementing scientific satellite projects. In fact, Hochmuth points out that

> 'Authority to manage, power to contract, a full and competent in-house administrative and technical capability combined ...[gave]...ESRO's directorate the elements of success.'4/

Quite clearly, ESRO's capability also had a price, and Layton, for

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1/ Hochmuth, op.cit., p. 112.

2/ A case in which governments decided to allocate the executive management resposibility to the industrial level was the TORNADO project, which will be described under the concept of industrial rationalisation. In that case, executive management responsibility was entrusted to the joint company Panavia.

3/ Hochmuth, op.cit., p. 87.

4/ Ibid., p. 177.

example, expressed doubts that full use was made of the facilities, arguing that underutilisation limited the cost-effectiveness of ESRO.1/

In the case of the European launcher organisation ELDO, European governments had opted not to establish a strong, independent executive management body. National government departments placed contracts on ELDO's behalf with national industries, denying ELDO management and technical authority. Consequently, the industries addressed themselves to their national government departments and not to ELDO, which seriously inhibited coordination and overall technical integration of, for example, the electrical interfaces.2/ In fact, the technical failures of ELDO's launch attempts have mainly been attributed to a lack of centralised competence and authority. In contrast to ELDO, the history of ESRO, the second European space organisation, is generally regarded as successful. This success has been ascribed to the fact that management authority was entrusted to ESRO's centralised management body, which had the requisite in-house capability in administrative and technical matters.3/ The same applies to CERN, which had been established with extensive authority appropriate to fulfil its functions.4/

The question of management authority and competence has been linked to what is considered a major shortcoming of international collaboration: cost escalation. Cost estimates for the Anglo-French CONCORDE project, for example, increased from 70 million pounds Sterling in 1962 to 1,500 million by 1976, and even the latter figure was still substantially short of the final

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1/ Layton, op.cit., p. 168.

2/ Williams, op.cit., pp. 100-1; Hochmuth, op.cit., p. 65.

3/ Schwarz, op.cit., 211; Hochmuth, op.cit., p. 176.

4/ Layton, op.cit., pp. 92-3.

cost.1/ Cost control in ELDO was 'one of the worst features', with programme costs increasing from $196 million in 1961 to $770 million in 1968.2/ The cost schedule of the technically less ambitious ATLANTIQUE aircraft project, on the other hand, has been met.3/

Cost increases for the CONCORDE and ELDO programme were attributed to such factors as underestimation of costs, design changes and inadequate contract control. Contracts did not provide for cost contributions by the contractor, incentive provisions or fixed price ceilings, but were mainly on a cost-plus-profit basis.4/ Reliable cost estimates and effective cost control, in particular for advanced technology projects, are seen to require a competent management body entrusted with appropriate authority.5/

Whereas the management authority of the collaborative body has been described in reference to industry, it is also relevant for the policy-making organs. Analysing the impact of the policy level on the management level, Layton shows that the policy level actively intervenes in management responsibilities, resulting in what he calls a 'hotch-potch' of politics and management. As a case in point, he argues that in the CONCORDE project, too much contract placing had to be approved by government representatives; subcontracts for equipment worth more than $56,000 - from electronic

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1/ Williams, op.cit., p. 117; Henderson, op.cit., 196.

2/ Williams, op.cit., p. 125; Schwarz, op.cit., 211.

3/ Williams, op.cit., p. 123.

4/ A cost-plus type of contract is seen to be more economical where accurate pre-estimates of the amount of work involved are difficult to determine, in particular, because of technical uncertainties. For such advanced technology work, a contractor is likely to insist on too high a contingency in a fixed price contract to cover himself against the risks involved.

5/ Hochmuth, op.cit., p. 12.

navigation systems to toilet mechanisms - had to be approved by governments.1/ Consequently, Goldberg argues against too much supervision of the management level by the policy level.2/

The final point relates to staff policy at the management level. Collaborative projects sometimes employ their own staff, or the partners second staff to the joint venture while they remain employed with the parent organisations. Under the first option, staff might face unemployment should the collaborative project come to an end. Under the second option, the authority of the collaborative management body is diluted, since staff see better career prospects with the parent organisation than in the collaborative project. In fact, when analysing the HAWK air defence missile project, Hochmuth found that staff members assigned to the collaborative venture feared for their career prospects, since they were taken out of the mainstream of their parent companies.3/ Hochmuth also points out that care must be taken in balancing the nationalities of the top executives of the collaborative organisation.4/ In the HAWK project, where this was not achieved, he found that the management body was stamped by national dominance and favoritism.5/ In contrast to this opinion, it is considered desirable to oppose pressure from member states to choose staff according to nationality.6/ CERN, for example, appointed staff on the basis of merit.

1/ Layton, op.cit., p. 138.

2/ Goldberg, op.cit., p. 244.

3/ Hochmuth, op.cit., p. 41.

4/ Ibid., p. 184.

5/ Ibid., p. 43.

6/ Layton, op.cit., p. 92.

With regard to language differences of multinational staff, there is considerable evidence that this does not pose a major obstacle. Language differences were not considered a great problem, for example, at ESRO or in the HAWK programme.

Industrial rationalisation: The rationalisation of industry in international collaboration is seen to create new industrial structures of increased efficiency. As a result of these efficiency gains, fewer resources are required to develop and produce advanced technology products. Industrial rationalisation is understood as a process of optimising industrial capabilities and interface costs; both will be outlined in detail below.

The development and production of advanced technology in a collaborative framework can be based on a wider range of existing industrial capabilities compared to a national project. One company may be particularly advanced in the development of a specific key technology; another company may possess outstanding experience in managing complex advanced technology projects; there may be a cost advantage due to low labour cost for producing standard equipment, etc. Where each country possesses a capability not found in the partner countries, the industries of these countries would complement each other in a joint framework and could be considered interdependent. In fact, the possibility of optimising interdependent systems is seen as a major advantage of international collaboration. Country A may have capability X, which country B does not possess, while the latter can offer capability Y, which is not available in country A. Joining capabilities X and Y in a collaborative framework between A and B will result in an efficiency gain vis-a-vis a national project; in a national project, additional funds would be required to catch up with the know-how already available in the partner countries. Optimising an industrial structure characterised by interdependence would determine the industrial participation of all collaborating countries in accordance with their national capabilities.1/ In summary, the benefit described above includes two assumptions. First, it assumes the existence of industrial interdependence. Second, it assumes that the collaborative arrangement provides for the optimisation of this industrial structure, a 'gathering together of collaborative expertise'.2/

Optimising industrial capabilities is not sufficient to rationalise industry. Rationalisation must include the optimisation of interface costs associated with bringing together companies of different countries. This is not limited to reducing the costs of, for example, communication or travel which occur when collaborating countries are geographically separated. It also includes the issues of optimal company size, industrial specialisation and industrial competition as outlined below.

Layton argues that the faster technology advances, the more important size becomes.3/ Large companies are seen to be able to devote the required resources for the development of advanced technology - skilled manpower, expensive instruments and computer installations. Outspending competitors is seen to shorten the development process and enable the company to get to the

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1/ This example illustrates optimisation of a collaborative structure characterised by interdependence. Here collaborative capability XY is superior to capabililty X of country A and capability Y of country B. This should be distinguished from an industrial structure characterised by a technology gap. In a technology gap, XY would, e.g., be superior to X but equal to Y. Optimisation in international collaboration would result in efficiency gains vis-a-vis a national project from the perspective of the less advanced country (A), but there would be no efficiency gain from the perspective of the advanced country (B). Optimisation, however, would also allocate the industrial activity to the advanced country (B) and exclude companies from the less advanced country (A).

2/ Walker, op.cit., 290.

3/ Layton, op.cit., p. 25.

market-place first. In fact, Layton identifies the availability of resources as the main reason why American aircraft companies take less time to develop a prototype than European companies. Rather than creating the bigger industrial structures required by advanced technology, national projects result in an excess of small units. One example is the solar cell industry, in which a large number of small manufacturers sprang up as a result of national projects. Whereas Europe's total expenditure on space did not amount to a tenth of the American effort, there were even more solar cell manufacturers in Europe than in the United States.1/ International collaboration is seen to optimise the collaborative industrial structure and create large international companies which possess the minimum optimum level for production, research and development.

Advanced technology projects also call for specialisation between companies. Such projects are often carried out by a network of companies, with the major company concentrating on system design, integration and management and specialised subcontractors carrying out parts of the development and research. International collaboration is seen to enhance such specialisation, since it could provide an adequate level of work-load for individual companies as an incentive to build up highly specialised know-how.

Finally, optimisation of interface costs includes the issue of industrial competition for government funding. In fact, competition is generally regarded as supporting the development of 'good technology' by sharpening 'the businessman's mind wonderfully'.2/ In a national framework, however, competition is often limited to the small number of companies with adequate

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1/ Bondi, op.cit., 18.

2/ Pavitt, 'Technology in Europe's Future', 229.

size and experience to carry out advanced technology work. Mergers, often supported by government with the aim of creating companies of sufficient size, sometimes result in only one or two main national industrial units. In fact, the limited competition between the small number of national suppliers is seen as limiting the efficiency of R&D, and a larger number of competent companies in a collaborative framework is seen to enhance competition.1/ Whereas Pavitt argues that a case can be made in the advanced industrial countries for a policy of specialisation within a framework of international competition and exchange, Layton suggests, for example, promoting the development of at least two major European computer groups, in competition with the Americans.2/

International collaboration, however, has often failed to realise the potential of industrial rationalisation. In general, no joint multinational companies emerge from international collaboration. For the CONCORDE project, for example, no joint industrial company was established; instead, the French and British companies were made separately responsible, and their work was coordinated through a number of joint committees of company and government representatives.3/ A similar set-up was established for the American-German MBT-70 tank project, and decision-making at the industrial level was diluted by shared authority and shared responsibility. Since there was no boss, there were only negotiated decisions, which left the door open to national pressures and prejudices.4/

1/ Pavitt, 'Technology, International Competition, and Economic Growth: Some Lessons and Perspectives', 190; Layton, op.cit., p. 200.

2/ Pavitt, op.cit., 194; Layton, op.cit., p. 200.

3/ Williams, op.cit., p. 96.

4/ Hochmuth, op.cit., pp. 118-9.

A common feature of international collaboration is the establishment of a joint company. In the TORNADO project, for example, industry established two joint companies: Panavia, registered in West Germany and owned by Aeritalia (I), BAC (UK) and MBB (D); and Turbo-Union, registered in the United Kingdom and owned by Aeritalia (I), MTU (D) and Rolls-Royce (UK). Whereas Panavia was responsible primarily for the airframe activity, Turbo-Union was concerned with the development of the engines. Panavia was a flexible organisation in the sense that the shares held by the companies changed in accordance with their participation in project implementation. Panavia had its own management and felt competent enough to announce in 1970 the initiation of private venture studies for future military aircraft.1/

Analysing the procedure for adopting design changes, Walker argues, however, that the Panavia solution exhibits three major disadvantages:

> 'It is clumsy: the organisation is bureaucratic, ridden with paper-work, and slow in taking decisions - irritating for those accustomed to more dynamic forms of management. It is expensive: a large staff has to be employed with high overheads (telephones, air-fares - the expense of communicating over large distances). And it adds an undesirable degree of inflexibility to the development procedure'.2/

With regard to the latter point, Walker points out the difficulties of making changes in the direction of the programme necessitated by external influences or internal design problems which seriously weakened design leadership and hampered the choice of the 'development strategy'. Whereas Walker acknowledges that inflexibility of development procedures is the result of centralised controlling bureaucracy also to be found in national projects,

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1/ Williams, op.cit., p. 98. European governments entrusted the industrial organisation Panavia with the executive management responsibility. In other cases, as outlined for the ESRO organisation above, an independent executive management body was established.

2/ Walker, op.cit., 293.

he argues that these shortcomings are amplified by international collaboration. With reference to the issue of geographical separation, Bondi does not consider this a relevant problem, since American industry appears to have no trouble with national distances, which are larger than distances within Europe.1/

Another form of industrial set-up is the international consortium, characterised by the prime contractor/subcontractor relationship. A system of competing international consortia was established, for example, to implement the industrial work of ESRO and ESA. Similar to the argument used in the discussion of the joint company Panavia, Pavitt argues that effective R&D requires unified management and the flexibility to adjust the technical direction as new knowledge accumulates. This, however, is seen to be restricted when development contracts are shared among a number of companies of different nationalities within a consortium system.2/ Finally, Williams considers consortia ill-equipped to support the development of advanced technology. He regards such consortia as merely machines for sharing out work.3/ The centrifugal tendencies are considered to be predominant in such struggling consortia.4/

A step towards close integration of collaborating companies is the establishment of joint industrial entities such as the French 'Groupement d'Intérêt Economique' (GIE). This structure provides for financial responsibility of member companies in proportion to their share in the

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1/ Williams, op.cit., p. 153.

2/ Pavitt, 'Technology in Europe's Future', 231.

3/ Williams, op.cit., p. 254.

4/ Layton, op.cit., p. 156.

project, joint decision-making and apportioning of profits and losses. An example is the AIRBUS programme, in which the collaborating companies set up a joint GIE organisation. In the case of AIRBUS, the GIE structure illustrated the feasibility of establishing an organisation which not only can be a vehicle for collaboration across national frontiers but is also acceptable to the funding governments.1/

The failure of international collaboration to optimise industry has also been identified with regard to optimising complementary industries. Walker, for example, points out that the industries of the collaborating countries in the TORNADO project were far from complementary; rather, they were characterised by a capability gap in aircraft development, with the experienced industry of the United Kingdom on one side and the less experienced industry of West Germany and Italy on the other side.2/ Whereas the British industry had little to gain from its partners, this was not the case for the less advanced industries of West Germany and Italy, which only existed at a rudimentary level. From their national perspectives, a national product might have been more expensive: outside the collaborative framework, they would not have been able to rely on British capability.

Even where there is an industrial structure characterised by complementary capabilities, the collaborative arrangement often fails to optimise the existing capabilities. With a 'fair return' policy, the technology share of a participating country quite often does not correspond to

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1/ Williams, op.cit., p. 96-7.

2/ Walker, op.cit., 290.

its industrial capability.1/ If the share is too low, competent companies of this country are excluded from participating in the collaborative project; if the share is too high, industrial work has to be given to 'second best' companies. It it is assumed that the 'fair return' policy is a principle of limited flexibility, the failure to optimise complementary industries can then be attributed to the failure to share the funding of the collaborative project according to the industrial strength of the participating countries.

The policy of 'fair return' indicated that European governments were not willing to let the market operate, often promoting national industries without paying attention to the needs of the joint project.2/ As already mentioned under the 'sharing of technology' shortcoming, government representatives press for agreements which guarantee the participation of their national industries in the joint project. Quite clearly, any 'guarantees' of participation or any policy of 'fair return' is likely not to enhance industrial competition.

International collaboration may not only have failed to enhance industrial competition, it may even have limited it. In comparison to a scenario of competing alternative development efforts established by parallel national efforts, international collaboration, in general, limits the scenario of alternative development to a single technical solution. Consequently, Pavitt argues that

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1/ This issue is discussed under the 'sharing of technology' shortcoming. The policy of 'fair return' and its implications for 'industrial rationalisation' and 'sharing of technology' will be elaborated further in section 1.2.4, which examines the potential and limits of international collaboration in relation to national efforts.

2/ Layton, op.cit., pp. 238-9.

> 'Centrally-financed R&D increases the danger of rigidity in pursuing either too few technical options, or the wrong ones for too long, whilst nationally-financed R&D will retain competition amongst a larger number of technical options.'1/

In fact, he takes a critical stance towards 'centralised planning', 'coordination' or 'control' of R&D and hence only attributes limited benefit to the elimination of duplication or overlap.2/

So far, a number of 'interface' costs have been described in relation to the results achieved under industrial optimisation, such as expenses associated with geographical distribution or inflexibility of development procedures. Additional examples of such costs are mentioned below.

International collaboration in Europe is hampered by differences in language and technical conventions. Feld argues that this is especially bothersome at the highest management level, where prestige and precision of expression are important considerations. This problem is considered less important for the middle managers concerned with the day-to-day operation of international collaboration, since they are often chosen for this task because of their linguistic capabilities.3/

Companies which work together in a consortium or a joint entity may not always have compatible objectives. In fact, they may be competitors, not necessarily in the market for which government funding was provided but, for example, in consumer electronics. Such rivalries could hinder far-reaching

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1/ Pavitt, op.cit., 255.

2/ Ibid., 228.

3/ W. Feld, Transnational Business Collaboration Among Common Market Countries - Its Implication for Political Integration (London, Praeger Publisher, 1970), pp. 401-42.

collaboration.1/ Gilpin refers to a similar point when arguing that collaboration among European companies is difficult because of commerical secrecy and the worry that the present partner could be the future competitor.2/ Greenwood notes, however, that companies from different countries can work amicably together in collaborative projects while competing in other markets. In the JAGUAR project, for example, BAC (UK) worked very compatibly with Brequet/Dassault (F), while attempting to sell its LIGHTNING plane throughout the world in fierce competition with Dassault's MIRAGE.3/ With reference to incompatible company objectives, Bondi stresses that industries should not be forced to work together by government diktat, but must be able to arrange international industrial structure as they see fit and based on mutual benefits.4/ In order to provide stability for the creation of multinational entities, Doina points out that international collaboration should not be 'ad hoc', i.e., temporary and limited in scope.5/ Referring to a similar point, Williams argues in favour of programme organisations instead of project organisations.6/

Apart from the centrifugal forces resulting from the different interests of collaborating companies, government itself might prohibit far-reaching collaboration. Whereas Hayward and Russett argue that international collaboration has increased interdependence and international specialisation,

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1/ Hochmuth, op.cit., p. 33.

2/ Gilpin, op.cit., p. 401.

3/ Greenwood, op.cit.

4/ Bondi, op.cit., 23.

5/ T. Doina, 'Europe Calls for Combines', Management Today, IV (1969), 82-5.

6/ Williams, op.cit., p. 157.

Layton points out that European countries have attempted to maintain the national character of domestic industry and have been reluctant to favour transnational mergers in advanced technology industries.1/ In addition, taking the aircraft industry as an example, Layton argues that the creation of permanent European industrial groups has been thwarted by the attempts of European governments to reshape their national industries without regard to the needs of collaborative patterns, thus disrupting the partnership.2/

The creation of multinational industrial entities can also be hindered by the different government/industry relationships in European countries. In the EURATOM programme, for example, government funding was channeled to private industry in West Germany, whereas in France, R&D contracts were awarded to public authorities, which prevented far-reaching collaboration between the two countries at the level of programme implementation.3/

Other problems which might generate 'interface' costs should be mentioned. Williams argues that the harmonisation of European countries' legal and tax systems would enhance collaboration at the industrial level.4/ Layton stresses the need to create a European patent and corporate law.5/ DeHoghton and Feld highlight the problem of culture, which could hinder

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1/ K. Hayward, 'Politics and European Aerospace Collaboration: The A 300 Airbus', Journal of Common Markets Studies, XIV (June 1976), 354-71; B. Russett, 'Interdependence and Capabilities for European Cooperation', Journal of Common Market Studies, IX (Dec. 1970), 143-50; Layton, op.cit., p. 252.

2/ Layton, op.cit., p. 153.

3/ Nau, op.cit., 511.

4/ Williams, op.cit., pp. 96-8.

5/ Layton, op.cit., pp. 236-7.

collaboration.1/ Finally, Feld argues that cultural and business concepts occupy a very significant place among the difficulties which companies experience in transnational ventures. Whereas the former point includes issues like 'culture shock' experienced by staff during extended stays at the location of the transnational partner, the latter point relates to misunderstandings caused by differences in methods of doing business. He recalls a survey of Dutch enterprises engaged in transnational ventures which revealed that these problems were experienced most frequently with partners in France, somewhat less often with those in Belgium and Italy and least often with companies in West Germany.

Experience has shown that international collaboration has often failed to realise industrial rationalisation. In fact, interface costs can even turn the potential benefit into a burden, with collaborative efficiency falling short of the results achieved in a national project.

Production volume: As noted above, advanced technology is costly to develop and to produce. In order to bring down the unit cost of production, it is important to establish long production runs. First, unit costs are reduced as a result of learning.2/ That is, direct labour hours per production unit decline as production experience increases. Second, this

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1/ C. DeHoghton, Cross-Channel Collaboration - A Study of Agreements Between British and Continental Firms (London, PEP, 1978), pp. 22-4; Feld, op.cit., pp. 401-2.

2/ The effect of learning can be expressed in terms of a learning curve. An 80 per cent learning curve, for example, means that each time production is doubled, the direct labour input per unit is reduced by 20 per cent. Hence, direct labour costs for the first unit may amount to 100 hours, for the second 80 hours, the fourth 64 hours, etc. The concept of the 'learning curve' has been criticised by arguing that it is not possible to assure a constant rate of learning, e.g. 80 per cent, or to consider the occurrence of steady-state phases early in the production. See W. Walker, 'MRCA: Reply to Professor Saul', Research Policy, III (1974), 375-8.

enables development costs and production facilities to be spread over a larger number of products. Companies are likely to be able to establish long production runs if they can serve large markets. Government objectives of supply security or economic growth are often limited to markets where government-owned/influenced organisations are a major or even the dominant customer, as in the areas of defence, communication, transportation and energy. These organisations are often guided by a 'buy national' policy. National procurement is not only seen to enable the maintenance of the technological competence, but also to provide economic benefits in terms of profit opportunities, employment and support for domestic or export sales. As a result of national procurement policies, the market for advanced technology products is often defined by national borders.1/ The consequences of market fragmentation, however, are more serious in Europe than in the USA.2/ The Powden Report on the British aircraft industry in 1965 pointed out the importance of the large market size to US industry. This market accounted for approximately 75 per cent of world military and space purchases and half of civil aviation purchases. Whereas the average production run for British military aircraft was 177 between 1955 and 1961, it was 530 in the USA.3/

As a result of the limited size of national markets, European countries were facing two major disadvantages vis-a-vis the USA. First, European governments had to procure costly products to fulfil, for example, their

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1/ In fact, it became illegal in January 1970 for members of the European Community to reserve government contracts for their own national industry. The practice has continued, however, mainly because this rule is difficult to police. See Williams, op.cit., p. 48.

2/ Pavitt, op.cit., 229.

3/ Williams, op.cit., p. 130.

defence obligations. Second, since domestic procurement did not provide for a considerable reduction in unit costs, European companies were unable to secure major export deals. International collaboration was seen to be able to overcome those disadvantages by providing a larger market on the assumption that those countries which shared in the funding and the development of the technology would be likely to procure the product. In fact, international collaboration was considered to make larger production runs possible by combining national procurements and substituting the 'buy national' with a 'buy collaboration' policy. Here, an important incentive to 'buy collaboration' is the national technology share in the production of the joint product.1/ Where countries do not maintain an independent national supply in parallel to the collaborative effort, the 'buy collaboration' policy would be the second best option, still more attractive than buying foreign technology.

The benefits of joint procurement were expected to be considerable. Combining the procurement levels of the major European countries for a military fighter plane, for example, is seen to lead to a reduction of the production cost per unit by 30 per cent. The benefits of longer production runs are only achieved, however, if a single production line is established to supply the collaborative product. In the case of the CONCORDE, for example, there were two final assembly lines, one at Bristol (UK) and one at Toulouse (F). As Williams notes,

> '...this duplication, and the toing and froing of parts which it involves, plainly means extra costs'.2/

1/ It should be recalled that similar to sharing the development contracts, such a 'buy collaboration' policy is guided by the 'fair return' principle. For further discussion, see above: 'shortcoming: sharing of technology'.

2/ Williams, op.cit., p. 138.

The same point is made by Walker regarding the TORNADO project, for which separate assembly lines were established in different countries. While appreciating that

> '...each country should expect a portion of the production as part of the collaborative agreement, and in return for R&D expenditure, giving employment within the aircraft industry...' he states that 'The proliferation of assembly lines adds considerably to the cost of production. It requires duplication of machinery, and of the organisations required to manage the production'.1/

Not only are parallel production facilities more costly than single ones, but the reduction of unit costs as a result of learning will also be smaller: parallel production lines imply shorter production runs for each single production line.

While duplication of production lines can reduce the benefits of the larger market associated with collaboration, this market has often been overestimated at the beginning of collaborative ventures. During the early stage of the TORNADO project, the participating governments announced their intention to purchase a total of 1,180 aircraft. This figure was later revised to 800, as the German government bought the PHANTOM aircaft from the USA and therefore reduced its initial procurement plan for the TORNADO.2/ After the collaborative project for the development and production of the HAWK air defence missile was already well under way, France decided to reduce its procurement plans by two thirds. This has been viewed as a pre-planned move in order to insure French dominance at the initial stage of the project by overestimating the procurement requirements.3/ Initial procurement plans

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1/ Walker, 'The Multi-Role Combat Aircraft (MRCA): A Case Study in European Collaboration', 297.

2/ Ibid., 296.

3/ Hochmuth, op.cit., pp. 38-9.

were not realised for NATO's ATLANTIQUE and FIAT G91 aircraft. After a French company received management responsibility for ATLANTIQUE, Canada, the United Kingdom and the United States refused to buy the aircraft. After an Italian company was chosen for the FIAT G91, France declined to take the fighter.1/ In other cases, Belgium decided not to purchase the MERCURE plane despite having participated in its development. The French navy refused to buy the JAGUAR fighter, a Franco-British project.2/ Cost considerations (e.g. buy American under licence) and national policy (e.g. 'buy national') outweighed the attractiveness of 'buy collaboration'. In light of this experience, it has been argued that international collaboration should include arrangements which provide for the payment of substantial penalties in case the original procurement commitments are not honoured by the participating governments.3/

Even assuming that the cost benefits of longer production runs can be realised in international collaboration, these benefits might be reduced by an issue inherent in joint procurement, namely the need to define joint specifications. Talks between France and the United Kingdom on a joint variable-geometry aircraft highlighted the difficulties of designing a single aircraft which could meet the different requirements of the partners.4/ Whereas the French wanted an intercepter for national air defence, the British pressed for a strike reconnaissance aircraft with the range to operate in the Pacific and Indian Oceans. In order to reconcile these different requirements, the initial estimates of the development costs were increased

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1/ Williams, op.cit., p. 61.

2/ Walker, op.cit., 300.

3/ Williams, op.cit., p. 61.

4/ Ibid., p. 145.

from $560 million to $840 million. In the case of the German-American MBT-70 tank project, the German side gave highest priority to tank mobility whereas the Americans emphasised protection.1/ As a result, not only did the cost estimate increase with each component compromise, but the potential German user also lost interest in the tank because of the compromise characteristics. In order to persuade West Germany to participate in the TORNADO programme, the United Kingdom agreed to build a multi-role aircraft even though its own airforce only needed a single-role aircraft to fill the gap in strategic requirements.2/

The need to compromise for the benefit of longer production runs appears to result in overspecification. Goldberg refers to a similar point when arguing that cooperative efforts produce lowest-common-dominator products that fit the needs of the cooperative partners.3/ It has been argued that in order to avoid the problem of overspecification, collaboration must take place at the level at which, for example, defence policy is defined.4/ In fact, Layton states that a '...common weapons-buying policy means a common defense policy'.5/

1/ Hochmuth, op.cit., pp. 19-21.

2/ Walker, op.cit., 284-5.

3/ Goldberg, op.cit., p. 160.

4/ Williams, op.cit., p. 61; Gilpin, op.cit., p. 434.

5/ C. Layton, Trans-Atlantic Investment (London, The Atlantic Institut, 1966), p. 166.

1.2.5 Conclusions on the appropriate policy option

A large number of selected findings have been recalled under the concept of collaborative sharing and collaborative efficiency. With regard to collaborative sharing, the policy of 'fair return' has been highlighted as a cardinal principle of international collaboration. It mandates the balancing of financial contribution and industrial share for each participating country. This is widely regarded as an equitable solution for distributing the shortcoming associated with the sharing of technology and the benefit associated with the sharing of funding. Maintaining a 'fair return' policy despite the existence of a technology gap between the participating countries is seen to stifle industrial rationalisation and reduce efficiency by limiting industrial optimisation and competition. Consequently, Schwarz argues that collaborating countries should cease to press for a 'fair return' in order to make international collaboration more efficient. While abolishing the principle of 'fair return' might lead to increased efficiency, it might also result in an unequal distribution of the shortcoming associated with the sharing of technology: those countries which are already ahead in technology will receive the lion's share of contracts, while others will be excluded from industrial participation. For the latter countries, international collaboration would result in dependence on the collaborative partners for supply security and the exclusion of national industry from economic growth. Quite clearly, this is not acceptable to those countries.

The relevance of collaborative sharing for the achievement of the funding objectives, however, has received little attention in previous studies. Collaborative sharing was mainly examined in terms of its impact on collaborative efficiency, which was seen as crucial to the achievement of the funding objectives. A national project maintains the technology within national boundaries and therefore exploit nationally the economic growth potential of the entire product technology or establish national independence in supply security. Quite clearly, such results cannot be achieved when technology is shared between countries participating in international collaboration. The issue of collaborative sharing is therefore seen to be of prime importance for the achievement of the funding objectives and should receive adequate attention in comparisons of the policy options.

The review of collaborative efficiency has revealed a wide spectrum of opinion with regard to specific issues. For example, it has been argued that executive management of international collaboration involves long delays and results in extra overhead costs. Others have argued that executive management can be efficient, establishing central control and project expertise which keep project costs down and permit adherence to a tight project schedule.1/ The spectrum of disagreement identified for specific issues such as policy-making, executive management, industrial rationalisation and production volume can be summarised in two principle positions, outlined below.

Considering the experience of joint aerospace projects, Williams recalls that research-and-development costs are likely to increase by a third and production costs by five per cent in international collaboration as compared with national efforts.2/ Those surplus costs, however, could be offset by longer production runs as a result of joint procurement. After having recovered those costs, every additional production unit resulting from joint procurement would make participation in international collaboration the

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1/ It should be recalled that it was not the aim of the review to reconcile this disagreement but to show the spectrum of opinion. The new research effort will attempt to contribute to the reconciliation.

2/ Williams, op.cit., p. 116.

appropriate option for government funding of advanced technology. Hence, a national project should be preferred when the savings of joint procurement do not offset the increase in development and production costs.

Evaluating international collaboration according to a similar concept, Walker takes a different view.1/ He argues that the estimates of surplus costs understate the actual costs. In addition, he has doubts about the benefit of joint procurement described above. Finally, Walker concludes that advanced technology products developed in international collaboration would be less competitive than products developed in national projects. Hence, the possibility that technology developed in international collaboration will gain a share of non-government-controlled markets is seen to be remote, with production volume staying small.

Williams takes a more positive view of international collaboration, outlining the conditions under which this option might be more efficient than a national project. Walker takes a more positive view of national projects, arguing that they are likely to be more efficient than international collaboration. On the basis of their conclusions with regard to the specific issues outlined under collaborative efficiency, Layton and Hochmuth might associate themselves with the position expressed by Williams, whereas Pavitt and Schwarz might tend to agree with the position emphasised by Walker.

Whereas these are general categorisations, some specific points of view should be recalled. Pavitt, for example, argues that international collaboration could be more efficient if not restricted to a single, isolated effort. International collaboration could be arranged in such a way as to allow each country to specialise in a particular technology sector, such as

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1/ Walker, op.cit., 299-300.

atomic energy, space transportation, etc. Such an interdependent system of specialised competence is seen to avoid the cost penalties inherent in international collaboration confined to a single effort.1/ As a major precondition for any successful international collaboration in advanced technology, Layton prescribes 'agreement on political objectives'2/ and the 'willingness to accept greater technological interdependence amongst the European powers'.3/ Referring to a similar issue, Walker goes further, arguing that political and economic unity is a prerequisite for successful technology development.4/ He therefore rules out participation in international collaboration as a viable option for government funding of advanced technology, since this alternative implies collaboration between sovereign states.

Whereas previous research differs on the level of collaborative efficiency that can be achieved, all writers attach great importance to collaborative efficiency for the achievement of the funding objectives, such as supply security and/or economic growth, and neglect, as noted above, the relevance of collaborative sharing. The option which produces the best results in terms of cost, time and quality is considered to be the appropriate option. This emphasis on collaborative efficiency might be the result of different research interests. Although the research problem of this study has been addressed in the final conclusions, previous researchers often chose not to examine the appropriate option for government funding as their central

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1/ Pavitt, op.cit., 239-40.

2/ Layton, op.cit., p. 190.

3/ Ibid., p. 266.

4/ Walker, op.cit., 305.

concern, but the justification for government funding.

This observation may also explain why past studies have concentrated on the comparison between the national and collaborative options when addressing the research problem, but paid little attention to the third, parallel option as a valid alternative. In fact, previous research viewed the existence of such parallel efforts rather as an indication that international collaboration had failed. Nevertheless, the review of past research has identified the following selected findings on the parallel option, which could serve as the basis of a new research effort.

It has been noted that parallel efforts often resulted in the establishment of an independent national capability as well as a technology gap between these countries and those which do not maintain national efforts. Based on this technology gap, the advanced countries were able to dominate the collaborative effort and secure, for example, a large share of the collaborative contracts. The independent capability gave governments a choice of leaving the joint framework if considered appropriate. In that case, the collaborative effort was disrupted and the efforts of those countries without a national project seriously hampered.

In examining the research question, the review has focused so far on determining which results are considered important for achieving the funding objectives. The relevance of these results, however, might vary depending on the funding objectives. Previous research has already indicated that there appears to be a shift in the importance of collaborative results where there is a shift in funding objectives. Layton, for example, recalls a proposal made by Mr. Gueron, a French director of research for EURATOM, regarding how to proceed from what he described as the research phase to the industrial phase.1/ Gueron proposed the development of a range of prototype reactors during the research phase so that European industry could select and market whatever reactor won the race during the industrial phase. Layton notes, however:

> 'Once the stakes rise and national interests and the hopes of gain from commercial exploitation come into the game, separate interests begin to triumph'.2/

> Williams criticises EURATOM for remaining confined

> '...to the R&D side of an effort whose gravity quickly became industrial'.3/

This is seen as the main reason why EURATOM failed to maintain a collaborative approach during the commercial exploitation of reactor development. Finally, Schwarz foresees a political crisis at ESA during the coming years as a result of a move from previous R&D activities to the commercial production of European space systems.4/ In order to solve the coming difficulties, he points, in particular, to the need to develop alternative forms of collaboration at the industrial level which are capable of mastering the commercial exploitation of advanced technology.5/ Although previous research has identified the need to understand the relevance of collaborative results in relation to specific funding objectives, limited efforts have been made to examine this issue in such a way as to facilitate a comparison between the different policy options; e.g. which option should be chosen in order to

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1/ Layton, European Advanced Technology - Programme for Integration, pp. 114-5.

2/ Ibid., p. 111.

3/ Williams, op.cit., p. 40.

4/ Schwarz, op.cit., 236.

5/ Ibid., 241.

realise a funding objective, such as supply security or economic growth, previously identified as being of major importance?

Finally, past research paid little attention to the relevance of national characteristics for the selection of the appropriate policy option. International collaboration could be more efficient than a national project from the perspective of a less advanced country, whereas this might not be the case from the perspective of an advanced country. Larger countries might be reluctant to accept the implications of sharing technology in international collaboration since national sovereignty is considered of prime importance, whereas smaller countries might show less hesitation. Quite clearly, this issue should be considered of major importance in the context of the research problem; e.g. which option should be chosen when national characteristics, such as small and large, advanced and less advanced countries, are considered?

In summary, it appears that there is an inadequate understanding of the research problem: research has focused on collaborative efficiency and neglected collaborative sharing; disagreement exists over whether international collaboration or a national project is more efficient; limited attention has been paid to the parallel option, the relevance of the specific funding objectives and national characteristics. This state of understanding is not surprising. Not only is there a lack of research on international collaboration, but the few studies that have been carried out are often rather prescriptive and based on inadequate empirical data. The shortcomings of previous research will be overcome in a new research effort outlined in the following section.

1.3 New research effort

The review of past studies has indicated an insufficient understanding of the research problem: to examine the three policy option from the perspective of international collaboration. This study is devoted to a new research effort aimed at resolving the debate and differences over the research problem while contributing a new perspective.

The new research effort is based on a major case study, namely the European Communication Satellite Programme, outlined in the next section. The case is examined according to the approach introduced in section 1.2.1 for the review of previous research. The approach consists of the three steps discussed below, which provide the basis for the subsequent description of the detailed research questions.

First, the funding objectives are identified. This identification is guided by the description of the funding objectives given in section 1.2.2, which highlights the objectives of supply security and economic growth.

Second, the concepts of collaborative sharing and collaborative efficiency, as described in section 1.2.3 and 1.2.4, are examined. Both focus exclusively on those results which distinguish participation in international collaboration from a national project. Collaborative sharing and efficiency are examined in terms of actual and expected results and perceived relevance for the achievement of the funding objectives from the perspective of small and large, advanced and less advanced countries. In addition, the study examines the disagreement in previous research over whether international collaboration is less or more efficient than a national project. To do so, the research questions on collaborative efficiency highlight the opposing positions of previous studies in order to contribute to their reconciliation. Furthermore, particular attention is paid to collaborative sharing and efficiency in the context of parallel national projects.

Third, the collaborative option is examined by summarising the findings outlined under collaborative sharing and efficiency. This identifies the specific contribution of the collaborative option to the achievement of the funding objectives from the perspective of small and large, advanced and less advanced countries. It should be noted that this assessment is not the outcome of a rigid calculation. Rather, it consists in summary conclusions based on a better understanding of the issues involved. Finally, describing the achievement of the funding objectives will shed light on the controversy over the justification for government funding.

According to this approach, the questions given below will be used to examine the case. The findings of the case study will be summarised in section 6.2 of the concluding chapter.

(1) Funding objectives

Did the funding objectives relate to the concept of supply security and/or economic growth? Was the collaborative programme considered of low priority within national technology policy?

(2) Collaborative sharing/Collaborative efficiency

What were the actual and expected results under collaborative sharing and efficiency for large and small, advanced and less advanced countries? Were the expectations justified? What was the impact of parallel national projects on the results of collaborative sharing and efficiency, and vice-versa?. Were the results perceived by the participating governments to contribute to or to hinder the achievement of the funding objectives?

The following detailed questions will be asked in order to identify the results under collaborative sharing:

Sharing of funding: What was the financial share of each participating country and on what basis was it decided? Was the financial burden of a national project too great for the participating country?
Sharing of technology: What was the technology share of each participating country in terms of 'quantity' and 'quality'? Was there a policy of 'fair return' and was it effective? Did the collaborative effort enhance industrial interdependence?

The following detailed questions will be asked in order to identify the results under collaborative efficiency:

Policy-making: Were decisions taken on time and at reasonable cost or were there long delays in decision-making, major conflicts and expensive committees?
Executive management: Was the executive management competent, entrusted with authority and cost-effective or did the executive management fail to exercise control and was it hindered by the supervision of the policy level?
Industrial rationalisation: Did collaboration result in the formation of transnational industrial entities, the enhancement of competition and the optimisation of complementary industries or was it characterised by struggling consortia, restricted competition and thwarted optimisation?
Production volume: Did governments procure the collaborative product, was production concentrated and did the collaborative product meet national requirements or did governments rely on other sources of supply, was there duplication of production lines and was the product overspecified?
Summary: Was international collaboration or a national project more efficient?

(3) Collaborative option

Did the results achieved under collaborative sharing and efficiency support or hinder the achievement of the funding objectives from the perspective of small and large, advanced and less advanced countries? Were the funding objectives achieved and was the funding justified?

Based on the findings of the case study, an attempt will be made in section 6.3 of the conclusions to elaborate a number of hypotheses on the appropriate policy option for government funding of advanced technology. With an understanding of collaborative sharing and efficiency, it is possible to conclude which policy option should be preferred in the European context: participating in international collaboration, a national project or the parallel option.1/

1/ If collaborative sharing and efficiency contribute to the achievement of the funding objectives, international collaboration would be the appropiate option; if they hinder the achievement, a national project should be preferred; finally, if the results which distinguish the parallel option contribute to the achievement of the funding objectives, this option would be appropriate rather than one of the single options.

1.4 Research concept

Since our present understanding of the research problem remains limited, this study is intended to discover cause-and-effect relationships for the purpose of developing new hypotheses in a problem area about which little is known. It is not intended to test or demonstrate hypotheses. Such a pioneering piece of research should be regarded as a first step, to be followed by more carefully controlled studies which would be necessary to test whether the established hypotheses have general applicability. Because of its exploratory nature, the research should be based on a thorough case study, utilising an exploratory analytical process and methodology, which are described below.

Case study

The selection of a case to be studied is a particularly crucial matter. Whereas one case might produce a wealth of new insights, others might yield only a few new ideas. In fact, it has been argued in section 1.3 that the shortcomings of past research can to some extent be attributed to the analysis of inadequate case material.

There is no simple rule for selecting a case. Experience has shown, however, that a case which exhibits the salient features of the phenomenon being studied may be more useful, since in exploratory work, minute differences is likely to be difficult to detect.1/ Hence, this study is based on the analysis of what is considered to be a major case in international collaboration, the European Communication Satellite Programme, also known as TELECOM. This case has the following characteristics. First, it is financed

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1/ C. Selltiz, et al., Research Methods in Social Relations (New York, Hold-Saunders, 1976), pp. 97-8.

by government agencies of Belgium, Denmark, France, Italy, the Netherlands, Spain, Sweden, the United Kingdom and West Germany; these agencies are, for example, ministries of economics, education, defence, research and foreign affairs. Second, it is managed by an international organisation, the European Space Research Organisation (ESRO), which was later transformed into the European Space Agency (ESA). Third, the programme is concerned with the development and production of highly advanced technology, namely communication satellite technology. Fourth, approximately 60 companies from the participating countries are associated with the industrial activity. Finally, the programme is carried out by a network of organisations participating in programme implementation, specifically the European technology user organisations known as CEPT and EBU, which are concerned with telecommunication and television distribution, the European Launcher Development Organisation (ELDO) and the European space organisations CETS and ESC.

The TELECOM programme, a major case of international collaboration, will be described in relation to parallel national efforts such as the Franco-German SYMPHONIE project, the Franco-German TV-SAT/Tdf project, the Italian SIRIO project, the British UKATS project and the Anglo-American SKYNET project.

The case study is based on information gathered from primary and secondary sources. Primary information was collected from ESA, ESRO, ELDO, CETS and ESC. This material consists of the minutes of meetings of the national delegations, papers prepared by the secretariat of the space organisations for the use of national delegations, status reports and internal documents on policy and procedure. Most of these documents have not previously been available to researchers. Access was granted by the European

Space Agency, and documents were collected at locations in France (ESA Headquarters), the Netherlands (ESTEC) and West Germany (ESOC). The availability of this primary material is considered to have been an invaluable part of this research. In addition to primary sources, secondary material in the form of books, articles and press clippings has been used. Again, access was granted to these sources by ESA at its library facilities located in the countries mentioned above. It should be noted that there is an excellent press-clipping service at ESA Headquarters, where all major newspapers and space journals from the member states of ESA and the USA are scanned.

Apart from the documentation described, interviews were an important source of information. These interviews, often carried out in multiple sessions, were conducted in a number of European countries with national delegations to the European Space Agency, executives of the Agency, national space organisations, aerospace and electronics companies, post and telecommunication organisations and the Commission of the European Communities.

In order to obtain candid views, it had to be agreed not to identify the interviewees in the study. In such cases, reference is not made to the individual but either to the organisation, e.g. ESA, or to the sector, e.g. the space industry. The documentation supporting each individual reference remains with the author.

Analytic process

The analytic process is the method by which the research variables will be identified and their relationship elaborated. As noted above, the aime of this research effort is to examine a problem area about which little is known. As a result of the exploratory character of the study, a 'stimulating insight' process is seen to be particularly appropriate for the purpose of this research.1/

The stimulating insight process takes account of the intention of the investigator to seek rather than to test. The investigation is guided by the research interest and not by preconceived hypotheses. The objective of this analytic process is to discover a pattern of consistency in the disparate pieces of data. This ordering process relies on the

> '...integrative power of the investigator, an ability to draw together many divers bits of information into a unified interpretation'.2/

Being concerned with a single case study, the investigator has to obtain a sufficient understanding to distinguish between the unique features of the case and those which appear to possess general applicability.

Two major analytic steps can be distinguished. First, the investigator searches for plausible reasons for the occurrence of the dependent variable, in an attempt to construct an explanation of why the dependent variable occurred. Second, the relationship between dependent and independent variables is subsequently explored by searching for similarities and differences in research variables which occur in the presence or in the absence of that which is to be explained. These analytic steps form part of a continuous, iterative process which is constantly reformulated and redirected as new data is considered. When the research results in hypotheses which require new information, new types of data have to be collected.

The stimulating insight process has been criticised as a projective technique which primarily reflects the investigator's bias. This, however, may not necessarily be considered an undesirable starting point since the

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1/ For a detailed description of the 'stimulating insight' process, see Selltiz, op.cit., pp. 92-8.

2/ Ibid., p. 98.

research does not attempt to test but to generate hypotheses.

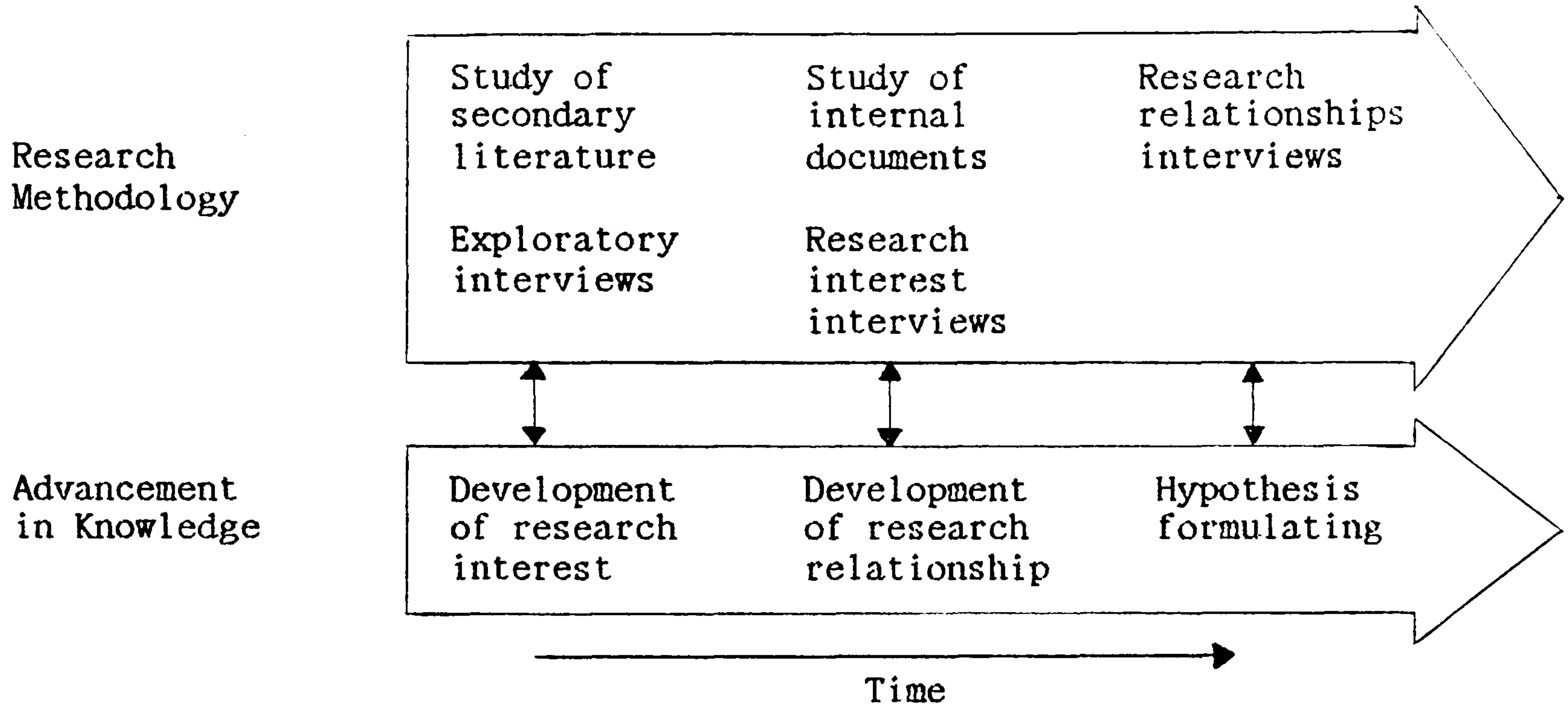
Methodology

Methodology refers to the procedure for gathering data. In order to avoid the risk of drawing incorrect conclusions during the analysis, the collected data on which the analysis is based should meet the following criteria. It should be an unbiased composition of information about the situation being described. It should have a direct and obvious relationship with the characteristics being examined. It should not reflect temporary and fluctuating behaviour on the part of the investigator or the individual being studied. Observing these criteria and combining relevance to the research purpose with economy in procedure, the researcher employs the following methodology.

As noted above, the analytic process is seen as a continuous, on-going activity through which the description of the research relationships evolves. In order to take account of the dynamic process, the research is based on the principle of varying the methodology in parallel to the acquisition of knowledge as illustrated on the following page.

Comparing successively more detailed descriptions of the case study during the three stages of the research - that is, starting with a broad perspective and subsequently narrowing the focus - ensures that no elements are overlooked.

Data provided by organisations has usually passed biased selection criteria which the analyst cannot control. During the second stage of the research, the analysis is based on unpublished primary sources in the form of internal documents, not accessible to outside observers, such as minutes of meetings, secretariat papers, reports of study groups from organisations such as ESA, ESRO, CETS and ESC. The use of such documents gives a less biased



view of the event; for example, the examination of internal documents might reveal conflicts which were not evident in published material.

The methodology provides for duplicate efforts. The extent of agreement between data collected by those duplicate efforts limits temporary and fluctuating behaviour. In the case study, different research methods are employed to gather data about the same event. For example, it is examined whether data gathered from documentary evidence is consistent with data gathered through interviews with key individuals. The effect of fluctuating behaviour on the part of the investigator or the interviewee is reduced by asking the same question in follow-up interviews with the same group of individuals after considerable time has elapsed, in some cases up to one and a half years.

The presentation of the research concept may create an impression which is more simplistic and neat than intended. The present simplification, however, is merely a guide; the complexity of the concept will become clearer as the description of the case study progresses.

CHAPTER 2

INITIATIVES FOR A EUROPEAN COMMUNICATION SATELLITE PROGRAMME

2.1 Origins and first activities in communication satellites

A communication satellite fulfils the function of a space-borne relay station for radio signals.1/ The concept of using communication satellites in space as repeaters for radio transmissions was suggested as long ago as 1945 in a classic article by Arthur Clarke.2/ It took, however, another thirteen years to develop the launching techniques and electronic devices to make Clarke's idea a reality.

The stimulus for this development was exclusively military: the desire to deliver nuclear warheads over long distances.3/ Whereas the United States had a fleet of intercontinental bombers, the Soviet Union, not possessing such a capability, emphasised the development of intercontinental missiles. As a result, the Soviet Union was ahead of the United States in missile development by the early 1950s, and demonstrated its technological lead to the world by putting the first satellite, named SPUTNIK 1, in space on 4 October 1957. The SPUTNIK shock triggered off an instant and massive effort on the part of the United States. In fact, there were two basic motivations for this reaction. First, the military relevance of missile technology - the ability to carry atomic warheads from continent to continent in a short length of time - had

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1/ Readers unfamiliar with satellite systems and satellite technology are advised to refer to appendix B for further explanations.

2/ A. Clarke, 'Extra-Terrestrial Relays', Wireless World, CI (1945), 305-8.

3/ The Aeronautical and Space Industries of the Community Compared with Those of the United Kingdom and the United States (Brussels, Commission of the European Communities, 1971), iii, pp. 420-80.

been demonstrated by the orbiting of a satellite in space. Second, the capability of launching satellites was suddenly perceived as a demonstration of technology, industrial and societal objectives.

On 31 January 1958, the United States launched its first satellite, EXPLORER 1, under the auspices of the Department of Defense (DoD). Along with increased military efforts in missile development, there was an even greater effort to build a civilian space programme. In 1958, the US government created the National Aeronautics and Space Administration (NASA), which was to take over the civil programmes initiated by the military and implement space projects in close cooperation with industry. Besides orbiting satellites, NASA was in charge of the manned space programme.

In fact, there are two kinds of satellites, scientific and application satellites. First, scientific satellites, like EXPLORER 1, were intended to serve the scientific community, carrying instruments to observe the outer atmosphere, the sun or the stars. Second, there are application satellites which have some kind of military or civilian utility. One kind of application is communication satellites, which provides communications between two distant points.1/

There was a significant military interest in communication satellites right from the beginning. The first communication satellite was launched by the US DoD with the orbiting of SCORE on 18 December 1958, soon after EXPLORER 1. SCORE was followed by COURIER in October 1960.2/ Like DoD, NASA

1/ Other application satellites are, for example, weather satellites for improving weather forecasting and remote-sensing satellites capable of detecting natural resources or military installations.

2/ V. Wall, 'Military Communication Satellites', Astronautics and Aeronautics, VI (1968), No. 4, 52-7. The precise number of military satellites is not known since the US and the Soviet Union do not publicize such launches.

has had an interest in communication satellites from the very beginning. In August 1960, ECHO 1, a balloon 30 m in diameter which acted as a passive reflector of radio signals, was launched. Not until the beginning of 1962, however, was NASA allowed to work on communication satellites using electronic receiving and transmitting equipment. Up to then, this was the exclusive concern of the military.

Funded by the Telephone and Telegraph Company (AT&T), NASA's first active communication satellite was TELSTAR, which was orbited in July 1962, linking the US with Europe. Further experiments followed under NASA contract: RELAY 1 and 2, built by RCA in 1962 and 1964, tested TV transmission between North and South America; SYNCOM I, II and III, built by Hughes in 1963 and 1964, linked the United States with Africa and Japan, televising among otherthings the Tokyo Olympics directly to the United States.1/

In fact, SYNCOM II was the first geostationary satellite which demonstrated the superiority of this orbital position for civilian use as opposed to the low-orbit position.2/

It should be noted that civilian and military application satellites both use essentially the same technology. In fact, the US industrial giants in the

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1/ I. Hargreaves, 'The US Space Invaders', Financial Times, 9 Nov. 1981. As in the case of military launches, the Soviet Union does not usually announce the purpose of its civilian launches. It appears that they revealed little activity in the area of communication satellites at that time. In fact, the first attempt failed with KOSMOS 41 in October 1964, followed by the successful launch of MOLNIYA 1 in April 1966. See C. Shelden, Review of the Soviet Space Program with Comparative United States Data (New York, McGraw Hill, 1968), p. 70.

2/ The geostationary orbit is at an altitude of 36,000 km, at which the satellite has exactly the same angular velocity as the earth, thus appearing to an observer on the earth to be stationary in the sky. The Soviet Union launched its first geostationary communication satellite in 1974. See 'Molniya 36', Raumfahrtforschung, XV (1974), No. 4, 251.

civilian communication satellite markets, such as Lockheed, TRW, Hughes, Ford Aerospace and RCA, have built and strengthened their technologies through military contracting.

2.2 INTELSAT: the global system

The first experimental communication satellites demonstrated their viability for long distance communication, particularly in comparison with submarine cables for intercontinental communication.

Being eager to establish an international communication satellite system before the Soviet Union, the United States Congress quickly passed the Communications Satellite Act in August 1962, authorising the creation of the Communications Satellite Corporation (COMSAT).

COMSAT was envisaged as the US share and the focal organisation of an international communication satellite network providing global coverage to serve the communication needs of the US and other countries. While NASA would retain responsibility for launcher vehicles and launching, COMSAT was authorised

> '...to plan, initiate, construct, own, manage, and operate, by itself or in conjunction with foreign governments or business entities, a commercial communications satellite system'.1/

In May 1963, COMSAT was established with a capital of $200 million; half of this stock was sold to the public and the other half subscribed by American communications carriers like ATT, ITT, RCA and WUI. Although set up as a private organisation aiming at achieving a profit, COMSAT was operating under the supervision and direction of the Department of State, particularly in its relations with foreign entities, and the Federal Communications Commission (FCC).

Maddox notes that the idea of the new global system was ridden with contradictions. First, the system was to be run by a private company in

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1/ International Cooperation and Organisation for Outer Space (Washington, United States Senate, Committee on Aeronautical and Space Sciences, Staff Report, 1965), p. 51.

conformity with the American tradition of keeping communication private, yet other nations were invited to participate. Second, while the system would provide for foreign ownership, it would be subject to regulations of the US government.1/

Following its creation, COMSAT, supported by the US Department of State, initiated discussions with the telecommunication organisations of Canada, Australia, Japan and several European nations on the establishment of a global satellite system. After some uncoordinated national planning, the Europeans found a joint approach.2/

The twenty-three European posts and telecommunication administrations were brought together in the European Conference of Postal and Telecommunication Administrations (CEPT).3/ Some of them had already been associated on a bilateral basis with the experimental communication satellite project of NASA by installing ground receiving facilities; e.g., the British Post Office had built the Goonhilly Down earth station. As for establishing a world system, however, a number of European officials in the telecommunication field considered regional cooperation in Europe to be desirable in order to protect their interests. In addition, telecommunication, especially on an international scale, was not considered to be subject to private responsibility. In fact, after the European governments showed a keen interest in the discussion between CEPT and COMSAT, activity shifted from the telecommunication to the political level.

1/ B. Maddox, 'Intelsat - Lament for a Lost Hope', New Scientist, XCII (1972), 482.

2/ International Cooperation and Organisation for Outer Space, p. 104.

3/ CEPT stands for Conférence Européenne des Administrations des Postes et des Télécommunications.

In July 1963, European governments established the Conference on Satellite Communications (CETS),1/ open to all member countries of CEPT and composed of foreign ministry officials, representatives of space-oriented ministries and the telecommunications administrations.2/ It was decided that CETS would deal with the organisational, financial and legal aspects of the satellite system, whereas CEPT would serve as an advisor on technical and operational questions.3/ CETS, a coordinative ministerial conference without any supranational authority, was set up to counter COMSAT, the private commercial corporation promoted and supported by the US government.

For all parties interested in participating in the global satellite system, it was unquestionable that the US was going to be dominant owing to its lead in satellite technology and launcher capability. The terms finally agreed upon, however, antagonised the Europeans.

In August 1964, the International Telecommunication Satellite Organisation (INTELSAT) was established by a consortium of, initially, twelve countries to own and operate an international space system, expected to achieve global coverage in 1967. The Europeans decided to join nationally, not collectively through CETS. Membership in INTELSAT was based on a traffic formula, whereby each country would contribute to the cost of the INTELSAT system in accordance with the amount of international communication traffic

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1/ CETS stands for Conférence Européenne des Télécommunications par Satellite.

2/ The head office was in London. The following countries participated: Austria, Belgium, United Kingdom, Denmark, France, Italy, Liechtenstein, Monaco, Norway, Netherlands, Portugal, Spain, Sweden, Switzerland, Vatican City, West Germany.

3/ F. Nicotera, 'The Position of CEPT on Telecommunications Satellite for Europe - Political and Economic Considerations', Spaceflight, XII (1968), No. 3, 91-3.

the country was expected to have in the global system. Membership, ownership and voting power were based upon the percentage contribution to the INTELSAT system. On the basis of the international traffic of the original twelve member countries, the United States, represented by COMSAT, had a sixty-one percent voting share in INTELSAT.1/

As other countries were expected to join INTELSAT, the contribution and voting power of the present members would be reduced. COMSAT, however, was guaranteed an absolute majority of at least 50.5 per cent and a veto power over its partners.2/ The influence of COMSAT, however, went beyond that of a dominant shareholder. The INTELSAT agreement made COMSAT the manager of the satellite system; in particular, COMSAT was put in charge of running the organisation, dealing with industry and preparing the decisions of the INTELSAT committee.

Under the arrangement, INTELSAT was responsible for the satellites (space segment) of the communication system, whereas the member states funded and owned the earth stations (ground segment). In April 1965, the first communication satellite of INTELSAT called Early Bird or INTELSAT I, was launched by NASA. Early Bird was developed by Hughes (USA) on the model of SYNCOM, a former NASA satellite, and provided up to 240 telephone channels or

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1/ Membership of INTELSAT was open to all member states of the International Telecommunication Union (ITU), 122 states at that time. The voting shares of the original 12 member countries were as follows: USA-61%, United Kingdom-8.4%, France-6.1%, West Germany-6.1%, Canada-3.7%, Australia-2.7%, Italy-2.2%, Japan-2.0%, Switzerland-2%, Spain-1.1%, Belgium-1.1%, and the Netherlands-1%.

2/ J. Johnson, <u>Organisation and Activities of the International Telecommunications Satellite Organisation</u> (New York, United Nations, 1969), ii, 1152-3.

one TV programme between North America and Europe.1/ In 1967, three INTELSAT II satellites, also developed by Hughes, followed, extending the coverage over the Pacific.2/

Industrial contracts were awarded by INTELSAT on a competitive basis. Owing to the lead which American industry already possessed in satellite technology, there was little chance that European industry could gain a share of the new technology sector.3/

Europe, Japan, Australia and Canada only accepted the current arrangement on condition that it would be temporary. After the global satellite system became operational, a new permanent arrangement would be defined in 1969. In addition, the current arrangement made it unlikely that the Soviet Union and its allies would join INTELSAT. Since the Soviet Union had little international communication traffic, its voting power in the American-controlled organisation would compare with that of Switzerland.4/

1/ For two satellites, a sum of $6 to $11 million was paid, depending on the performance of the satellite in orbit. Every additional satellite was expected to cost $1.4 million. INTELSAT I was in geostationary orbit, generated electrical power of 40 watts, operated in the 4/6 GHz region, weighed 38 kg and had an expected operating life of 1.5 years. See 'Nachrichten', Raumfahrtforschung, VI (1965), No. 2, 100.

2/ The geostationary satellite INTELSAT II had a weight of 86 kg, power of 25 watts, a design life of 3 years and a communication capacity of 240 circuits. The cost of a communication circuit per year dropped from $32,500 to $11,400 between INTELSAT I and II.

3/ 'The Case of a United Kingdom Space Programme', Spaceflight, X (1966), No. 11, 348-349. See also S. Metzger, 'The Commercial Communications Satellite System - 1963-68', Astronautics and Aeronautics, VI (1968), No. 4, 42-51.

4/ Member states contributed $128 million between 1964 and 1968, COMSAT $68 million and Europe $35 million. United States industry took some 95% of the industrial contracts awarded by INTELSAT. In 1968, INTELSAT revenues began to exceed expenditure.

2.3 Initiatives for a European communication satellite

Following the experimental projects carried out by NASA and the US Department of Defense, it became clear that satellites could open new possibilities in international communication. Not only of military interest, communication was considered by European governments to be of vital national concern. During the negotiations for the INTELSAT agreement, the European delegations realised that they would be merely customers in a US-dominated technology sector, unable to exercise discretion about development, production and management.

Worried about being left behind in the technology race, a committee of CETS began at the end of 1963 to examine how Europe could be put in a position to participate in the build-up of the INTELSAT system.1/ In October 1964, a five-year plan envisaging two phases was presented to the member states of CETS.2/

Starting in 1965, the member states, coordinated by CETS, would finance national research-and-development activities in satellite technology.3/ By the end of 1966, the national activities would be combined into a multinationally financed project, with the aim of demonstrating Europe's capability in the new technology sector by establishing a US-independent regional satellite system.

1/ Statement of Mr. A. Hartogh, Chairman of CETS, in CSE/CM(Dec.66)PV1, 13 Dec. 1966.

2/ P. Blassel, R. Collette, 'Les Efforts Européens dans le Domaine des Satellites de Télécommunications', ESRO Bulletin, IV (1968), No. 5, 12-8.

3/ It should be noted that the idea of a communication satellite to serve the needs of European countries had already been discussed before in industry and space technology circles; see 'A British Communication Satellite', Spaceflight, V (1961), No. 1, 2-4; 'European Co-operation in Space', Spaceflight, V (1961), No. 1, 8.

CETS recommended the implementation of phase one to the member states and requested a detailed study of the technical, economic and financial aspects of phase two. For this purpose, an expert group, named the Technical Planning Staff, was set up by industry and ministries under the guidance of Mr. Simmons, British Minister for Aviation.1/

The expert group undertook two major activities. First, it reviewed the current industrial and organisational capability on which the implementation of such a project could be based. Second, it discussed the viability of a satellite system with potential user organisations. In the following, the first point will be addressed in relation to the origins and basic policies of European space activities.

1/ Blassel, op.cit., 12.

2.4 Europe's activity in space by the early 1960s

As in the US and the Soviet Union, Europe's space activity up to the early 1960s was governed by military missile programmes intended for nuclear weapons.

Britain was the first European country in space, having developed the ballistic missile BLUE STREAK in the 1950s.1/ As a result of its long-standing relationship with the USA, Britain enjoyed privileged access to US technology. In fact, BLUE STREAK was developed on the basis of licence agreements with the US companies General Dynamics and North American Aviation. When Britain was allowed to procure the US missile POLARIS - and it was the only country allowed to do so - it abandoned its BLUE STREAK project in 1960 for cost-saving reasons. In addition, the United Kingdom decided to procure two American military communication satellites, called SKYNET, which formed part of a US/UK defence communication system. While military interest in developing a national industrial space capability faded, Britain was building up a small civilian space programme.

In the early 1960s, a series of scientific ARIEL satellites were developed in cooperation with US industry and launched by NASA. Orbited in April 1962, ARIEL 1 was in fact the first satellite developed with the participation of a European country; a US company, however, was still the prime contractor. In addition to the ARIEL programme, Britain embarked on the development of the satellite launcher BLACK ARROW and started a small programme for the development of satellite technology.

Besides reliance on US technology in the military sector and the building

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1/ See 'A Space Policy for Britain', Spaceflight, XII (1968), No. 2, 50-2; 'Britain in Space', Spaceflight, XII (1968), No. 3, 102-3.

of a small civilian space programme, Britain's space activity was characterised by a split of responsibility.1/ At government level, project responsibility was divided between the Ministry of Aviation, Department of Science and Education, Ministry of Defence, Department of Economic Affairs, Board of Trade, General Post Office, Foreign Office, Treasury and the Commonwealth Office.2/

France came second, also starting with military efforts in missile development. Unlike Britain, it did not consider the option of relying on US technology; its basic motive was to achieve military independence.3/ In fact, the French development efforts were adversely affected by an American embargo in 1960 on Boeing and Lockheed licences and know-how for the missile technologies used in POLARIS and MINUTEMAN; the embargo was imposed to prevent the proliferation of nuclear ballistic weapons.4/

In addition to building up its military projects, France started its civil space activity under the overall planning management of the National Space Research Centre (CNES) in 1961. Although the CNES was responsible to the Ministry of Scientific Research and Atomic Matters, it was closely affiliated with and dependent on the French military establishment.5/ CNES, as the French mini-NASA, embarked on a programme of space launchers and

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1/ N. Simmons, 'The British National Space Programme', Spaceflight, XV (1971), No. 1, 6-11.

2/ K. Gatland, 'Europe's Space Dilemma', New Scientist, LXXXVII (1967), 330.

3/ R. Gilpin, 'Technological Strategies and National Purpose', Nature, CCXXIII (1970), 441-8.

4/ The Aeronautical and Space Industries of the Community Compared with those of the United Kingdom and the United States, p. 415.

5/ Gilpin, France in the Age of the Scientific State, p. 278.

scientific satellites.1/ In November 1965, the first French satellite, named ASTERIX, was orbited by the French DIAMANT launcher; this was followed by FRI launched in cooperation with NASA. In summary, France's space activity was characterised by major efforts in military missile development and an integrated programme of space launchers and satellites in the civilian sector under the central management of CNES.

Unlike that of France and Britain, West Germany's space activity did not originate in military missile development.2/ In fact, since West Germany was not allowed to carry out missile development as a result of post-war restrictions, it embarked on a small civilian space programme under the responsibility of the Ministry for Scientific Research in the early 1960s. Early efforts were directed towards promoting an adequate industrial infrastructure, while relying on cooperation with France and in particular the USA.3/ At that time, the first German satellite, a scientific satellite named AZUR, was initiated.

Italy concentrated its early efforts on a small national programme, carried out in cooperation with NASA, to develop the SAN MARCO scientific satellites. In December 1964, SAN MARCO A was placed in orbit by NASA; this was in fact the first entirely European-built satellite.4/

The other CETS member states did not have national space programmes.

1/ Centre National d'Etudes Spatiales, 'The French National Space Programme', Spaceflight, XII (1968), No. 7, 262-4.

2/ B. Gaedke, 'Der gegenwärtige Stand der Weltraumforschung in der Bundesrepublik Deutschland', Astronautik, VII (1968), No. 2, 48-51.

3/ A. Spaeth, 'Status Report on Space Programmes and Policies of the Federal Republic of Germany', Spaceflight, XIV (1970), No. 2, 56-9.

4/ K. Gatland, 'Europe in Space', Spaceflight, X (1966), No. 6, 203-14.

Some of them, however, participated in two European space organisations which were formed in 1964, namely ELDO and ESRO.

When Britain cancelled its military BLUE STREAK missile programme, she offered it to Europe as the first stage of a civilian satellite launcher. There was much speculation about this move. Some viewed it as an attempt to support the British application to join the Common Market, whereas others saw it as a justification of past expenditures. In 1964, the European Launcher Development Organisation (ELDO) was established by Belgium, France, Italy, the United Kingdom, West Germany, the Netherlands and Australia. ELDO's aim was to develop the launcher EUROPA 1 within a seven-year budget of $400 million; this launcher having a larger orbiting capability than the ongoing national projects (BLACK ARROW in the UK and DIAMANT in France). ELDO launchers were intended to be used only for civilian purposes.

In parallel to ELDO, a sister organisation, known as the European Space Research Organisation (ESRO), was established to promote space research for peaceful purposes, mainly by developing scientific satellites which were beyond the means of national space programmes.1/ In addition to the members of ELDO (excluding Australia), Denmark, Spain, Sweden and Switzerland were member states of ESRO. The organisation was provided with an eight-year budget of $306 million.

Both organisations had different origins. ELDO was promoted by governments and ESRO was initiated within the scientific community, which explains why there has not been a unified organisation.2/ It took over three

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1/ J. Beattle, 'The European Space Research Organisation', Spaceflight, X (1966), No. 11, 345-6.

2/ Schwarz, op.cit.

years to establish ESRO and ELDO, during which time the European countries had already embarked on national civilian space programmes, thereby limiting somewhat the scope of activity of the new organisations.1/

Contribution rates of member states to both organisations were based on their respective gross national products (GNP), except that the UK agreed to pay a higher rate to ELDO during the early years.

ESRO and ELDO were governed through a Council on which member countries were represented. Each organisation had a permanent executive body, i.e., an international staff of administrators, engineers and scientists, headed by a Secretary General in ELDO's case and a Director General in ESRO's. The headquarters of both organisations were in Paris.

The development work was contracted to the aerospace and electronic industries of the member states. In contrast to ELDO, ESRO invested considerable amounts in the establishment of European research facilities to be used by its permanent body.2/ In fact, ESRO built facilities in France, the Netherlands, Italy, West Germany and Sweden; over 50% of the investment was concentrated in the Netherlands. ESRO's first scientific satellite, named IRIS, was launched free of charge by NASA in 1968, whereas ELDO unsuccessfully aimed for a first orbital launch during the same year.3/

American reaction to ESRO and ELDO varied.4/ As in the case of national

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1/ A. Cleaver, 'European Space Activities Since the War: A Personal View', Spaceflight, XVIII (1974), No. 7, 220-38.

2/ A. Lines, 'The First Two Years of ESTEC', Spaceflight, XI (1967), No. 3, 102-4.

3/ A table of European space expenditure in comparison to the USA, USSR and Japan is given in appendix A, table 3.

4/ T. Nesbitt, 'Future US-European Co-operation in Space: Possibilities and Problems', Spaceflight, IX (1965), No. 5, 150-2.

scientific satellites, there was an active co-operation between ESRO and the USA, notably in four areas: a considerable amount of equipment was purchased for ESRO projects in the USA; American companies, especially Lockheed and TRW, supported the construction of ESRO's first satellites, IRIS, AURORA and HEOS; European subsidiaries of American multinational companies participated actively in satellite development; and NASA provided launch services, putting up the first two satellites free of charge. American support for ELDO was less forthcoming. Like the French military missile programme, the European companies could not secure even old US licences or launcher technology except those already acquired by Britain for BLUE STREAK.

European industry, interested in space activity, also formed a European umbrella organisation.1/ In 1961, over 100 companies from the aeronautics, electronics, chemistry and metallurgy sectors of nine countries established the EUROSPACE consortium. EUROSPACE was a non-profit organisation concerned with promoting space research development in Europe. The organisation did not take part in commercial or contractual negotiations of a profit-making nature.

1/ H. Schneider, 'Die Raumfahrt im internationalen Rahmen', Astronautik, VI (1967), No. 3, 78-82.

2.5 CETS/A and CETS/B project initiatives

The industrial and organisational situation which the expert group of CETS was facing is outlined above. In order to study the economic and financial aspects of establishing a US-independent European satellite system, the potential user organisations of such a system were consulted by CETS.

Discussions with CEPT, the European organisation of telecommunication authorities, revealed considerable doubt about the desirability of a European communication satellite system. Satellite communication was most economical when it covered long distances; e.g., a satellite link between London and New York would cost the same as a link between London and Paris. Undoubtedly, a global system was economically viable, but the small distances in Europe made satellite communication less attractive. The European Broadcasting Union (EBU), on the other hand, showed interest in a European satellite system. The EBU was formed by national European broadcasting administrations to coordinate EUROVISION transmission. A communication satellite could fulfil certain requirements for television distribution in the EUROVISION network.

In December 1965, the Technical Planning Staff (TPS) of CETS issued its recommendation.1/ The proposal envisaged a two-phase programme. Phase I would be dedicated to the development of experimental communication satellites as test beds for space technology. These satellites would serve the needs of the European Broadcasting Union (EBU) for TV transmission, take five years to be developed and cost approximately $74 million.2/ The experimental satellites would utilise techniques, materials and components which met the

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1/ R. Shepard, 'A Space Programme for Europe', Spaceflight, X (1966), No. 1, 6.

2/ SCL/TPS/116E, Report on European Potential and Recommended Development Plan, 15 Dec. 1965.

general conditions required by INTELSAT. Phase II of the programme would see the build-up of an operational satellite system. ESRO would be charged with satellite development on behalf of CETS, and ELDO launchers would place the satellites in orbit.1/

At that time, ESRO's activity was limited by its convention to scientific research, which excluded the development of application satellites such as communication satellites. In fact, the CETS initiative received a mixed reaction from ESRO. First, the Council of ESRO hesitated over a positive reply to CETS. In particular, the British and Danish representatives pointed out that ESRO was a scientific organisation which should not be concerned with application work. The top echelon of ESRO's executive body, however, reacted very favourably to the invitation of CETS for further discussion.2/ Eager to enlarge ESRO's scope of activity, it argued that CETS had much to gain from the project experience of ESRO, while ESRO would gain from the need to develop reliable components, which would be beneficial for scientific satellite projects.3/

As for ELDO, the CETS initiative triggered a major crisis.4/ Although it

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1/ ESRO/C/276, Proposed Programme Study to be Carried out by ESRO and CETS, 4 Apr. 1967.

2/ ESRO/C/221, Report of the Secretariat to Council on the Prospects of a European Communication Satellite Project, 27 July 1966; ESRO/C/225, Report of the Secretariat to Council on the Prospects of a European Communication Satellite Project, 14 Sept. 1966.

3/ Although the technology of a communication satellite has to fulfil different requirements from that of a scientific satellite, there are a number of items which can be utilised in both. In general, the technology of a communication satellite is considered to be more demanding, particularly, with regard to reliability. See SCL/CD/8E, 23 Jan. 1968 (Technical CETS document on communication satellites).

4/ Global Communications by Satellite: Europe's Role (Paris, Assembly of Western European Union, 12th Ordinary Session, Document 372, June 1966).

was noted in the TPS report that no launcher was available in Europe to realise the satellite mission, it was assumed that the European communication satellite would be orbited by a European ELDO launcher so that it would be an all European approach. The present ELDO programme envisaged the development of a launcher with a capability to put 1000 kg into low orbit, i.e. 500 km above the earth's surface. The CETS study had stated that the satellites should, like the INTELSAT satellites, be placed in the geostationary orbit, at an altitude of 36,000 km.1/

France had strongly supported the CETS initiative for a communication satellite from the very beginning. The French delegation to ELDO was urging a redirection of the launcher programme with the aim of developing a capability of putting an application satellite into geostationary orbit.2/ Whereas France was prepared to rely on US technology for scientific missions, it was very sceptical about successful cooperation in the field of communication satellites, as it had been in the military field. Communication satellites were considered to be of strategic importance, possibly owing to their potential usefulness in nationally controlled or military communication networks. Hence, France strongly supported an integrated European programme of satellites and launchers.3/

The French policy, as articulated in ELDO, received a cool reception from

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1/ SCL/TPS/166, 14 Nov. 1968 (Technical CETS document on communication satellites).

2/ 'The Use of ELDO Vehicles for Communication Satellites in Synchronous Orbit', Spaceflight, X (1966), No. 11, 396-7.

3/ See also R. Shepard, A. Cleaver, 'A Future for ELDO', New Scientist, LXXXVI (1966), 470-1.

the British.1/ Just as it was in the military sector with the procurement of POLARIS missiles and SKYNET communication satellites, Britain was happy to rely on US technology, emphasising cost and not technological independence. In fact, at the beginning of 1966, the UK sent a memorandum to ELDO member states expressing its concern over cost increases, delays and the inability to produce a European launcher at a competitive cost.

By mid-1966, ELDO succeeded in redirecting its programme towards a launcher capable of putting a communication satellite of 150 kg into geostationary orbit.2/ As a result, the cost of ELDO's five-year programme increased from $400 to $626 million. The UK agreed on the condition that its contribution would be reduced by approximately 25%. As part of the programme redirection, Italy, which so far had not managed to secure a significant part of the ELDO programme, was put in charge of developing a small communication test satellite for the new launcher, called ELDO-PAS.

Finally, in accordance with the French call for an integrated European programme, ELDO recommended the establishment of a European Space Conference (ESC), open to all member states of ELDO, ESRO and CETS, with the purpose of coordinating and planning all space activities in Europe.3/

Decision-making on the CETS programme proposal was held up during 1966 as a result of the controversy which had to be resolved within ELDO. In November 1966, eleven months after the proposal of the Technical Planning Staff (TPS)

1/ Space Research and Development (London, Estimates Committee, Session 66-67, 13th Report, 1967).

2/ ELDO/Sec(66)76, Annex 3, Paper of ELDO Secretariat on ELDO-PAS, 6 Dec. 1966; 'ELDO-PAS-Trägerrakete', Raumfahrtforschung, VIII (1967), No.1, 50.

3/ ELDO/Sec(66)17, Resolution No. 2, Coordination of Space Policy in Europe, 8 July 1966.

had been published, the sixth CETS conference adopted the report as the basis of a joint European programme. As noted, the major potential user of communication satellites, the telecommunications authorities represented by CEPT, had not reacted very favourably towards the CETS programme initiative. This had led CETS to initiate a supplement to the TPS study, elaborating the communication satellite programme within the context of other application satellites such as meteorological and navigation satellites. In fact, based on this supplement, the sixth CETS conference agreed to enlarge its own terms of reference to cover the whole field of application satellites.

The study supplement again highlighted the need for a European launch facility:

> '...it should also be recognised that the satellite itself is only one part of a complex system including...launch techniques'.1/

Hence, provided that a European launcher was available, the communication satellite programme

> '...would demonstrate a European capability to provide space segment material both to the expanding basic global communication system and to television system in Europe paralleling domestic American developments...'.2/

Based on the TPS recommendations, the CETS conference decided to commission a feasibility study by ESRO at a cost of $0.3 million, aiming at the development of an experimental satellite, related space technology and further applications. Once this ESRO study was available, the final decision to implement the programme was expected to be taken by the European Space

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1/ SCL/TPS/116, Supplement to the Report on European Potential and Recommended Development Plan, 6 Sept. 1966, 17.

2/ Ibid.

Conference (ESC) in mid-1967.1/

Besides commissioning the feasibility study by ESRO, CETS requested CEPT to carry out a study of the economic viability of a European communication satellite system, covering telecommunication, television distribution and data transmission. At the same time, CETS was to make a broader study of the economic aspects of application satellites.2/

Unhappy with the slow progress during 1966, France announced that while it was still interested in the CETS project, it was embarking on a national communication satellite project for television transmission called SAROS, to be launched by ELDO-PAS. At about the same time, West Germany was also studying the OLYMPIA television satellite project, intended to broadcast the 1972 Olympic games from Munich.3/

The technical and economic studies requested by CETS were finalised in

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1/ SCL(66)4E, Technical Specifications for a Programme Study of a European Experimental Communication Satellite, 11 Nov. 1966; SCL(66)21E, Feasibility Study on Future Applications, 28 Nov. 1966; ESRO Communique, No. 37, 6 Dec. 1966. The programme called for up to three experimental satellites with a probable lifetime of five years and a first satellite launch by ELDO-PAS in 1970. The satellites were expected to have a total weight of 153 kg, to generate 100 to 400 watts through solar cells, to operate in the 4/6 GHz region and to provide two channels for European TV distribution or 1200-1500 communication circuits. The satellites would be either spin-stabilised (like INTELSAT) or 3-axis stabilised (more advanced). In fact, the experimental satellites would be basically comparable to the INTELSAT III satellites which were under development at that time. The programme was estimated to cost $104 million, of which 34% would be devoted to satellite development, 31% to the provision of launchers, 12% to the associated technology research and development programme and 23% to studies for other applications.

2/ SCL(66)18E, Economic Potential of a European Communication Satellite System, 28 Nov. 1966. The report excluded all costs that Europe had already incurred or authorised, such as the development cost of EUROPA II (ELDO-PAS) launcher, and merely balanced possible further expenditures.

3/ B. Gaedke, 'Förderungsmassnahmen des Bundesministeriums für wissenschaftliche Forschung auf dem Gebiet der Weltraumforschung', Astronautik, VI (1967), No. 3, 73-7.

May 1967. Based on the CETS specifications, ESRO had outlined two programme alternatives, including two different experimental satellites. CETS/A could be developed in four years without taking considerable technical risks, whereas CETS/B was more advanced, requiring a considerable longer development time.

The economic study had been requested to demonstrate the economic benefits of the proposed CETS programme by assessing the potential benefits of all foreseeable types of application satellites which could follow from a CETS programme, such as telephony, television relay, direct broadcasting, aircraft surveillance, navigation, meteorology and earth resources satellites.

The report concluded that the investment required would not be amortised by one type of application satellite considered in isolation. If, however, the development cost could be written off over the whole foreseeable field of satellite applications,

> '...the resulting benefits will be of direct monetary value many times the investments involved'.1/

However, since application satellites, except communication satellites, would not be realised in the near future, there would be no return during the early stage of the programme but

> '...there will be a benefit in 10 - 15 years'.2/

Nevertheless, when deciding on the CETS programme, it was argued that the

> '...decision is not whether to produce an experimental communication satellite; it is whether to start a programme of space application'.3/

1/ SCL/TPS/217E, Economic Potential for Europe of Application Satellite, 30 May 1967, 10.

2/ Ibid., 2.

3/ Ibid.

In other words, the report concluded that there was an economic justification for the CETS programme if it was viewed as an investment in the whole system of application satellites.

Concerning the possibility of relying on US technology to establish application satellite systems, the report came out strongly against 'outside procurement', arguing that

> '...expenditure by Europe in other countries on space tends to increase the "technology gap"...'1/

whereas procurement in Europe would result in

> '...a host of indirect benefits otherwise known as "spin-off" or "fall-out", in the form of capabilities transferred into other areas of technology...the effect is felt in all industries in the form of new materials, design principles, processes and techniques as well as specialised equipment and machinery'.2/

In addition,

> '...there is a balance of payment aspect'3/

and finally

> '...unquantifiable benefits of a political nature represent an additional bonus and a large one'.4/

The report concluded that buying

> '...technology from other lands...results in a degenerative effect on creative ability, a dependence on external resources, and increases emigration of trained men. The effects are cumulative'.5/

Consequently, the report identified

> '...an immediate need...to formulate a strategic plan for space

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1/ Ibid., 8.

2/ Ibid.

3/ Ibid.

4/ Ibid.

5/ Ibid., 9.

> applications, including launcher development and commercial aspects...', and for '...a decision to start work under the CETS plan',1/ arguing that '...if Europe delays entry, it will be more difficult to counter American-Russian hegemony'.2/

Despite the fact that the national delegates had approved the study of the working group, the representatives of the telecommunication administrations at CETS expressed doubts about its conclusions. It was argued that the technical problems, in particular the problem of communication reliability, had been underestimated.

The CEPT economic study requested by CETS had a different mandate. Assuming that CETS would cover the cost of developing the experimental satellite system, the CEPT study was concerned with the profitability of the operational satellite system for telephony and television immediately following the CETS programme. In other words, given the level of European technology by 1970, would the European telecommunication authorities be able to operate a profitable operational communication satellite system for which they would have to pay the development and production cost? CEPT, which had expressed reservations about a European satellite system as early as 1965 (see page 96), concluded that such an operational satellite system would cost $13.4 million per annum, compared with $11 million for conventional ground links, and would hence be unprofitable.

In addition, EUROSPACE, a group of European companies, had carried out a study similar to those of CEPT, commissioned out of its own resources. This study, however, concluded that such an operational system for telephony and

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1/ Ibid., 10.

2/ Ibid.

television transmission would be profitable vis-a-vis conventional systems.1/

One is inclined to argue that the different economic studies reflected the interests of the main groups involved.

First, the politicians of CETS supported the CETS programme in order to back their position for the renegotiation of the INTELSAT agreement scheduled for 1969. The establishment of a European experimental communication satellite system would obviously limit dependence on US technology. Since there could not be an economic justification for the CETS programme if communication satellites were considered in isolation, the CETS programme was viewed as the forerunner of a family of application satellites to be developed possibly in 10 to 15 years and beyond. The fact that such economic benefits could be derived possibly even more effectively from technology procured in the USA was not even considered in the analysis. The CETS programme was in fact a political programme supported by doubtful economic arguments.

Second, the potential users of a European communication system, the telecommunication administrations organised in CEPT, rejected the current programme concept. Even if the cost of the experimental satellite of the CETS programme were excluded, a follow-up operational CEPT system was not considered to be economically attractive. In other words, the amount of subsidies which CETS was possibly prepared to pay under its own project was not considered sufficient to interest CEPT in an operational system. In addition, there was no long-term experience with communication satellites, which still had to prove their reliability in comparison with terrestrial communication systems.

1/ G. Pardoe, 'Communications Satellite: The EUROSPACE Point of View', Spaceflight, XII (1968), No. 3, 94-8.

Third, the conclusions of the EUROSPACE report were not surprising. Space industry was obviously interested in developing an experimental satellite and receiving development and production contracts.

In early 1967, the discontent at the European level and slow progress on the CETS initiative prompted France and West Germany to join forces in a bilateral communication satellite project, known as SYMPHONIE. The two experimental SYMPHONIE satellites, each with a capacity of two TV channels or 260 telephone circuits, were intended to provide TV, sound broadcasting and telephone services, among others, between France and its overseas territories and between West Germany and a German radio station in Africa. The satellites were three-axis stabilised, a major innovation in satellite technology, operating in the 4 to 6 GHz region; they were to be launched by ELDO-PAS tentatively in 1972. The total project cost was $65 million.1/

The programme provided for equal participation in funding and industrial work by France and West Germany. Later, the inclusion of Belgium with a share of 4%, covering the participation of the Belgium company ECTA, was accepted. Belgium was also known as a strong supporter of the ELDO-PAS programme.

France, taking the view that it would not be allowed access to American know-how, had previously started a small national programme of research and development on the most critical technological equipment of communication satellites, such as travelling wave tubes and counter rotating antennas. It is interesting to note that in fact the American ITT subsidiaries in Europe,

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1/ 'Technical Dissent over Symphonie', New Scientist, LXXXVIII (1968), 561; H. Schendel, 'Das deutsch-französische Fernmeldesatelliten-Projekt Symphonie - Rückblick, Bedeutung, Ausblick', Raumfahrtforschung, XVII (1976), No. 3, 109-15.

such as LCT (F), Lorentz (D) and Bell (B), which participated in the ESRO scientific satellite programme, did not tender in the SYMPHONIE project.1/

After a competition between two industrial groups, including companies from France and West Germany, the industrial group CIFAS was awarded the SYMPHONIE satellite contract. The CIFAS group included the SNIAS (F), Thomson-CSF (F), SAT (F), MBB(D), Siemens (D), AEG-Telefunken (D) and ECTA (B) companies.2/

France, while reluctant to co-operate with American companies in the application field, had initiated the co-operation with West Germany, which was willing to provide the funds and eager to foster its limited industrial capability in the space sector. This policy was in fact in line with the attitude of De Gaulle, who argued that

> '...when it is opportune in a selected branch to join our inventions and money and skills with those of another country, we must choose the country nearest to us and whose weight could not crush us'.3/

The start-up of the French/German SYMPHONIE programme in parallel to the finalisation of the technical and economic studies on the CETS initiative coincided with a third event, the creation of the European Space Conference (ESC) as a permanent coordinating agency for ESRO, ELDO and CETS in 1967. As noted above, back in 1966 the ESC had been formed by ELDO to plan and co-ordinate an integrated European space programme, in particular for

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1/ The Aeronautical and Space Industries of the Community Compared with Those of the United Kingdom and the United States, p. 627.

2/ G. Mösl, 'Organisation und Durchführung des Projektes Symphonie', Raumfahrtforschung, XVII (1976), No. 3, 115-9.

3/ Charles de Gaulle, 27 April 1965, as cited in Gilpin, op.cit., p. 377.

launchers and communication satellites.1/ The ESC, meeting at the ministerial level, was to assemble annually to give approval to the various space projects carried out by ESRO, ELDO and CETS, where such decisions involved the corresponding member states of the three organisations.2/ Twenty countries were eligible for membership, but only the member states of ESRO and/or ELDO can be considered important: Belgium, Denmark, France, Italy, the Netherlands, the United Kingdom and West Germany.

At its second meeting, held in Rome in July 1967, the ESC was asked for authorisation for the CETS programme intended to serve the European Broadcasting Union (EBU) for live TV distribution in the EUROVISION network. The CETS proposal to the Conference envisaged two alternatives for project implementation. In the first, ESRO would manage the project in close co-operation with ELDO, under the supervision of a steering committee representing the participating governments of the CETS member countries. In the second, the CETS project would be integrated with the ESRO programme and carried out entirely as an ESRO operation.3/

Following a review of the various European space programmes, the

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1/ CSE/CM(July 1967), Resolution 4 (Final), 13 July 1967. Between the ESC meetings, a Committee of Alternates was responsible for discussing and negotiating space policy and preparing conference decisions.

2/ Decisions taken by the ESC were to be unanimous and binding on the member states. In case of abstention, the decision would be binding on those member states supporting the decision.

3/ SCL/Co. 25/7E, Report of the Chairman of the European Conference on Satellite Communication to the European Space Conference, 11 July 1967; 'Die ESRO Com-Sat Studie', Raumfahrtforschung, VIII (1967), No. 4, 198; ESRO/C/264, Communication Satellite, 27 July 1967. The use of a satellite for live TV distribution in the EUROVISION network would serve three purposes. First, it would expand the capacity of the current network. Second, it would improve the quality of TV distribution over that achieved by the current ground network. Third, it would expand service to a number of countries so far not included in the EUROVISION network.

Conference noted a lack of long-term planning and a considerable amount of duplication.1/ An Advisory Committee on Programmes was set up, under the chairmanship of Mr. J. Causse (France), to define a proposal for a European space policy, which

> '...should cover several years and be harmoniously divided between the scientific and technical research activities on the one hand, and practical application on the other, together with the construction of the launchers required for such projects'.2/

With the creation of the ESC and the Causse Committee, the organisation of European space efforts was as shown in the table on the following page.

With regard to the CETS project and various proposals for ESRO scientific satellites, the British Minister of Technology, Mr. J. Stonehouse, emphasising the economic aspect of a European space policy, informed the Conference that no new projects would be authorised by Britain before the conclusions of the Causse Committee became available. In addition, some delegates felt that rather less than the total estimated expenditures of $104 million could be made available for the CETS project, whereas others were anxious to ensure that there would be no duplication between the CETS and the SYMPHONIE projects. As a result of the British veto on new projects, it was expected that the final decision on the CETS project would be taken at the beginning of 1968 on the basis of the Causse report.3/ Although the report was available at that time, it took until November 1968 to reconvene the European Space Conference, for reasons which will be outlined below.

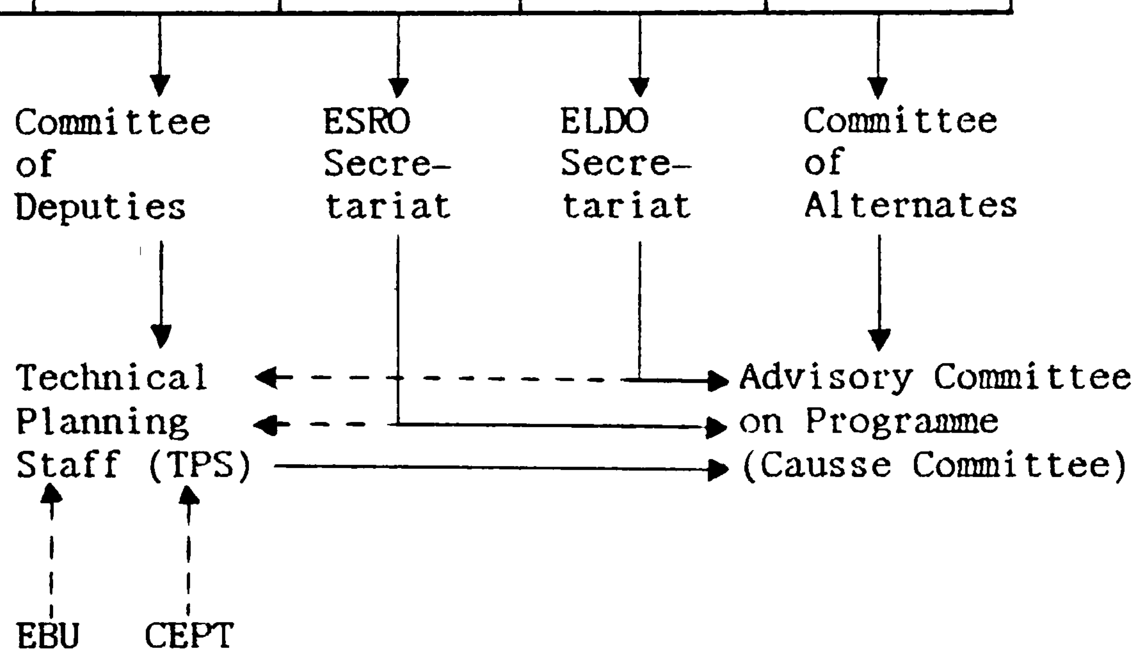
1/ CSE/CM(July 67), Resolution 11 (Final), 14 July 1967.

2/ CSE/CM(July 67), Resolution 4 (Final), 13 July 1967.

3/ CSE/CM(July 67), Resolution 15 (Final), 14 July 1967; 'Europe's Joint Effort in Space', New Scientist, LXXXVII (1967), 126.

Organisation of European space efforts 1/

Country	CETS	ESRO	ELDO	ESC
Australia	O	–	M	M
Austria	M	–	–	O
Belgium	M	M	M	M
Canada	O	–	–	O
Denmark	M	M	–	M
France	M	M	M	M
Greece	O	–	–	O
Ireland	O	–	–	O
Italy	M	M	M	M
Monaco	M	–	–	M
Netherlands	M	M	M	M
Norway	M	–	–	M
Portugal	M	–	–	O
Spain	M	M	–	M
Sweden	M	M	–	O
Switzerland	M	M	–	O
United Kingdom	M	M	M	M
Vatican	M	–	–	–
West Germany	M	M	M	M



M = Member
O = Observer

1/ N. Simmons, 'A Review of the Work of the Technical Planning Staff of CETS', Spaceflight, XII (1968), No. 2, 87-91.

2.6 The CETS-C/EURAFRICA project initiative

Following the non-approval of its project proposal and taking into account the consideration of the last ESC, CETS awarded a new study contract worth $0.2 million to ESRO for a revision of the technical satellite proposal.1/ At the same time, the European Broadcasting Union (EBU) conducted a market survey, concluding that on the basis of the CETS programme and funding concept, EBU would agree to use a TV communication satellite to replace existing earth-based EUROVISION networks.2/

The modified proposal, containing two alternative solutions, was submitted by ESRO to CETS in December 1967. The alternative preferred by CETS was the CETS-C or EURAFRICA project, which would relay two television programmes to Europe and Africa and meet the requirements of the EBU. The CETS-C proposal envisaged a total cost of $90 million and a satellite weight of 190 kg. The project, to be implemented by ESRO, was to be compatible with the use of an ELDO-PAS launcher; development work was to begin in early 1968.3/

Approved by CETS, the new proposal was submitted to the Causse Committee for further consideration in the context of an integrated European space policy. The Causse report, which came out in January 1968, suggested an ambitious programme based on the following premises:4/ first, a growth rate

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1/ ESRO/C/302, Note by the Secretariat, 26 July 1967.

2/ 'Satellites as Television Links', New Scientist, LXXXVII (1967), 208.

3/ CSE/CS(68)61, The Experimental Satellite CETS-C, 24 Oct. 1968.

4/ The report envisaged a total expenditure of $150 million in 1967, increasing to approximately $240 million in 1972. See CSE/CCP(67)5, Report of the Advisory Committee on Programme, 23 Jan. 1968; 'Europe Space Plans', New Scientist, LXXXVIII (1968), 6-7.

of ten per cent per annum in the funding of the European programme; second, a new launcher programme, called EUROPA III, capable of putting 500 kg into geostationary orbit; and third, the development of scientific satellites. The report gave top priority to the CETS-C project and emphasised the importance of other application satellites for weather forecasting and remote surveying.

In the Causse report, a European effort in application satellites was considered economically justified in line with the CETS report, and it was concluded that an operational communication satellite system following the CETS project would be profitable, in contrast to the CEPT study but in agreement with the EUROSPACE report. In addition, the Causse Committee pointed out the need to support a European launcher capability, arguing that the US would put restrictions on the use of American launchers for European communication satellites.

On the eve of the next planned European Space Conference, the British Minister of Technology, Mr. Wedgwood-Benn, sent a message to all members of the ESC expressing strong disagreement with the proposals in the Causse report and indicating that he was not willing to support the EUROPA III launcher programme and the CETS-C satellite project. The British believed that a European launcher was too costly and that there would be no difficulties in purchasing launch services from the United States.

Concerning the CETS-C project, Benn did not challenge the calculations in the Causse report but stated that the CETS project

> '...could not yield a commercially viable project unless all the research and development costs, both of the satellite and launcher, were completely and totally written off'.1/

1/ UK memorandum, April 1968, as cited in CSE/CM(November 68)9, Annex A, Appendix 2, Report by the Chairman of CETS, 1 Nov. 1968, 3.

This, however, was the very basis on which the CEPT and EUROSPACE economic reports had been carried out. In fact, Benn called into question the political motivation for the CETS-C project, which was outlined in the CETS's reply to Benn's memorandum:

> 'When judging the immediate profitability...it should not be forgotten what were the original aims of the activity of CETS, these were to bring into being a global, industrial and economic potential in Europe'.1/

Britain's attitude towards international collaboration had become more cost-conscious, now emphasising the economic return from such endeavours. This was possibly the result of the growing financial burden from another aerospace project the UK was carrying out, namely CONCORDE.2/ In fact, Mr. Wedgwood-Benn stated that

> '...joint intergovernmental projects, on many of which we are engaged, have a role provided that they are soundly based...but projects which are economically unsound do not become desirable merely because they are undertaken internationally'.3/

Since other countries were also reluctant to support a space programme which envisaged a growth rate of ten per cent per annum, it became clear that further discussions were needed on the Causse report before the European Space Conference could assemble to decide on a European space policy.4/ In fact, one issue became central in these negotiations: the US attitude towards launching a European communication satellite. Consequently, a mission was sent to Washington to discuss a possible European request with the State

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1/ Ibid.

2/ 'Retreat from Space', The Economist, CCLXXVII (1968), 20 Apr.; 'Britain's ELDO Withdrawal', Flight, LIX (1968), 25 Apr.

3/ 'Commons and ELDO', Flight, LIX (1968), 21 May, 687.

4/ CSE/CE(68)59, Report by the Chairman of the Committee of Alternates of the European Space Conference, 19 Oct. 1968; see also 'Europe's Impotent Optimism', Flight, LIX (1968), 4 July, 31-2.

Department and NASA.

The American response was ambiguous. It was assured that the US would launch European <u>experimental</u> telecommunication satellites. Launchers for <u>operational</u> satellites, however, would only be supplied on the condition that they were compatible with the INTELSAT system, even though the concept of compatibility could not be defined at that stage.1/

Meanwhile, the two European space organisations, ESRO and ELDO, were going through quite a different experience. In May 1968, ESRO's first scientific satellite, IRIS, was launched successfully by NASA. AURORA, the second satellite, followed in October 1968. This first visible success gave new confidence to ESRO and proved that it could successfully implement satellite projects. For ELDO, two attempts to launch EUROPA I in August 1967 and December 1967 were unsuccessful. In addition, in order to carry out the programme as originally envisaged, the total programme budget of $626 million would increase by $100 million.2/ The United Kingdom made it clear that it would not contribute any additional funds. In order to retain the collaboration of the United Kingdom in ELDO, an austerity programme was agreed on with a view to staying within the approved budget ceiling, which led to the cancellation of work. In particular, work on the test satellite ELDO-PAS, to be developed by Italy, was suspended. Displeased with this decision, Italy decided to continue the work already carried out for ELDO as a national communication satellite project, named SIRIO. The satellite was intended to provide experimental TV broadcast service between the USA and Europe and between European countries, costing, in addition to the funds already spent by

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1/ CSE/CE(68)46, <u>Report on the Mission to Washington</u>, 14 Sept. 1968.

2/ CSE/CM(November 68)8, <u>Report by the Secretary-General of ELDO</u>, 31 Oct. 1968.

ELDO, approximately $30 million.1/

Faced with this situation, the third European Space Conference finally met in November 1968 at Bonn to approve a European space programme.2/ The programme, based on the revised Causse report, envisaged the start of the CETS-C project, which was put forward with the backing of EBU, the EUROPA III launcher project, and the firm three-year budget for ESRO's scientific programme for 1969 to 1971.3/ In addition, the Conference had to decide on the amalgamation of the three European space organisations, ESRO, ELDO and CETS. In fact, the acceptance of the overall space programme was seen as a condition for membership in the new space organisation by those who were pushing this ambitious programme.

At the start of the Conference, Mr. Wedgwood-Benn made a statement which shaped the proceedings of the Conference. Referring to the integrated European space policy, he argued for the need

> '...to look at it as any commercial concern would have done to see how money can be made out of its investment which, although it is spent by governments, does come originally from industry and needs to get back into industry in order to strengthen the European economy'.4/ He

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1/ 'SIRIO', Raumfahrtforschung, X (1969), No. 3, 148. The satellite was developed under a contract from the National Research Organisation (CNA) by the Italian companies Selenia, Aeritalia, FIAR, Laben and Galileo. The satellite was spin-stabilised, with a lifetime of two years, a weight of 230 kg and electrical power of 120 watts to allow experimental communication tests; it was to be launched by the mid-1970s.

2/ 'The European Space Conference', ESRO Bulletin, IV (1968), No. 3, 9-10; 'The Bad Godesberg Conference, November 1968 - An ESRO Point of View', ESRO Bulletin, IV (1968), No. 4, 4-13. For a summary of national views, see A. Cleaver, 'The Crisis in European Space Affairs', Spaceflight, XII (1968), No. 11, 370-1.

3/ CSE/CS(68)59, Report by the Chairman of the Committee of Alternates of the European Space Conference, 19 Oct. 1968.

4/ CSE/CM(November 68)PV/1, Annex 3, Statement by the Rt. Hon. A. Wedgwood-Benn, Minister of Technology (UK), 12 Nov. 1968.

> continued '...The Causse report revealed what we in Britain had suspected, namely that a CETS satellite launched by a European launcher was completely uneconomic'.1/

This had been so far a repetition of the UK memorandum of April 1968. What followed was not a reversal of this position, but the consequent continuation of previous UK policy; Wedgwood-Benn argued that

> '...we should aim at an information transfer satellite based upon the CETS point-to-point proposal...', but '...we should launch by the most economical means available'.2/

At that time, ELDO launchers were expected to be twice as expensive as American launchers.3/ Relying on US technology would, of course, improve the economics of the CETS project. In fact, Wedgwood-Benn suggested the CETS project as the forerunner of a European effort in application satellites, and made the following offer:

> '...if we are released from our existing commitments to ELDO we would put that as a part, not in total...as our contribution to these programmes'.4/

Referring to the ELDO programme, he asked

> '...of course independence has a very attractive appeal at a conference in Europe, but the question is, independence at what cost?'.5/ He continued '...if others want to go ahead with the launcher, if that is their priority, and I must accept, of course, that others have a different view...it would be for them to finance it and to make it economically competitive'.6/

Wedgwood-Benn concluded that the British proposal

1/ *Ibid.*

2/ *Ibid.*

3/ CSE/CM(November 68)15, Add.1, *Cost Estimation of the Experimental Satellite CETS/C*, 11 Dec. 1968.

4/ CSE/CM(November 68)PV/1, *op.cit.*

5/ *Ibid.*

6/ *Ibid.*

'...represents a conscious switch of resources to the applications side in European space'.1/

In fact, this proposal went beyond a shift of resources; it implied a different type of European space organisation. At present, the member states of ESRO contributed to its costs in relation to their national income (GNP), whereas the ELDO scheme also assumed that the share of contribution for each member state was not subject to the preference of individual member states for certain projects.

'In the opinion of the United Kingdom...', Wedgwood-Benn stated, '...it was necessary that every country should pay for those parts of the programme in which it was interested'.2/

The British statement, including the so-called 'menu-a-la-carte' concept, whereby each member state would decide project by project what share of the costs it was willing to accept, was strongly opposed by Belgium, France, the Netherlands and West Germany, which were the ELDO member states.3/ The Belgian Minister of Scientific Policy and Planning, Mr. Lefèvre, argued that

'...nobody believed in the rentability of launcher development but...it was not prudent to undertake a large satellite development programme without guaranteeing that they could be launched'.4/

With the UK not participating in ELDO, the remaining countries would have to make up for the resulting shortfall of twenty-five percent of the total budget in order to provide such a guarantee. Lefèvre even suggested the possibility of a split in European space collaboration:

1/ Ibid.

2/ CSE/CM(November 68)PV/3, 13 Nov. 1968, 9.

3/ 'Europäische Raumfahrt à la carte', Frankfurter Allgemeine Zeitung, 15 Nov. 1968.

4/ CSE/CM(November 68)PV/4, 26 Nov. 68, 3.

> '...we would seek the possibility of co-operating in a more restricted framework with those who share our conviction'.1/

The menu-a-la-carte approach, which had emerged from the launcher discussion, called into question the proposed amalgamation of ESRO, ELDO and CETS into one organisation, since the concept envisaged the participation of at least the larger European countries in all space projects.2/ Hence, the Conference could not decide on a timetable for integration until agreement could be found.

This was the situation when the CETS-C project came up for approval by the Conference. In April 1968, the UK was the only ELDO member country which did not support the project. Now, she turned out to be the only country which did support the CETS-C project. The refusal to approve the project was justified by Lefèvre as follows:

> '...it was impossible to accept commitments now, even if they had to be taken very urgently, within the framework of an institution that was to be changed, and with partners whose long-term intentions were unknown'.3/

In fact, the UK's partners in ELDO were upset, whereas Wedgwood-Benn

> '...found the attitude of delegations towards the CETS-C proposal disappointing'.4/

The smaller countries participating in ESRO but not in ELDO expressed some support for the British statement, emphasising the application side of space. They could not, however, actively influence the course of events, as

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1/ CSE/CM(November 68)PV/2, Annex 1, Statement by the Belgium Delegation, 12 Nov. 1968.

2/ 'Merging ESRO and ELDO', New Scientist, LXXXIX (1969), 673.

3/ CSE/CM(November 68)PV/4, op.cit., 3.

4/ Ibid.; see also 'Britain Warned: No Space Breakaway', Daily Express, 14 Nov. 1968; 'Predictable Divisions at ESC', Flight, LIX (1968), 14 Nov., 823; 'Jitted', The Economist, CCLXXII (1968), 16 Nov.

the Swedish statement makes clear:

> 'I must emphasise the responsibility of the big nations, the final decision - at least the Swedish government's - depends on what you can agree on between yourselves'.1/

Strong support for the CETS-C project had also been given by the new Director General of ESRO, Mr. Bondi, a British scientist, who argued that

> '...if Europe intends to be any more than a consumer buying a product made without his advice and influence, then now is the time for decision...to accord to even the friendliest non-European nation a monopoly position in communications would be almost an unimaginable act of abdication'.2/

The political implications of the CETS-C poposal, however, had lost some relevance for France and West Germany, who were already involved in the SYMPHONIE programme.

Whereas no approval was given for the CETS-C project, the Conference decided to finance yet another economic study on application satellites.3/ At a cost of $1 million per annum, ESRO was requested to analyse the relative potential of communication, meterological and air and sea traffic satellite. In addition, the Conference approved the three-year budget for ESRO's scientific activity, $172 million for 1969 to 1971, and created a committee of senior officials to discuss and negotiate the questions left unresolved by the Conference.

1/ CSE/CM(November 68)PV/3, op.cit., 2.

2/ CSE/CM(November 68)7, Report by the Director General of ESRO, 5 Nov. 1968, 2.

3/ CSE/CM(November 68), Resolution 10 (Final), 14 Nov. 1968.

2.7 Renegotiation of the INTELSAT agreement

Whereas the European Space Conference had not managed to define a European space policy, a new important event was coming up: the renegotiation of the INTELSAT agreement. The existing interim arrangement was to run out at the end of 1969. In fact, the experience of the European member states in the US-dominated INTELSAT organisation had not been very happy. When the Board of Governors, on which the member states were represented, was to approve the contracts for the next generation of satellites, called INTELSAT III, it turned out that before it could do so, the Federal Communications Commission of the US had to give its permission. As Maddox notes,

> 'The international partners were furious: what kind of international organisation was it that owned the world's satellite system, yet could not act without the consent of a domestic agency of the US government?'.1/

The European countries were also displeased with the manager of the INTELSAT system, the US company COMSAT, which was at the same time the US representative in INTELSAT and its major shareholder. The European representatives felt so rushed into decisions that some member states

> '...became suspicious to the point of paranoia about what their manager was up to'.2/

Finally, it became clear that European industry would not be able to participate in the development and production of the INTELSAT satellites as had been hoped. In order to secure an INTELSAT contract, European companies had to underbid their American competitors, but this was impossible because of

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1/ Maddox, op.cit., 483.

2/ Ibid., 484.

the 'technology gap' between US and European industry.1/

The Conference to decide on permanent arrangements was opened in February 1969. Europe, represented by CETS, brought forward the following demands. First, the US had to surrender its position as majority shareholder. Second, an international directorate and not COMSAT should manage the INTELSAT system. Finally, the restrictions which INTELSAT could impose on the participaton of its member states in other communication satellite systems should be limited. In particular, the French hoped that their plan for a French-language satellite system would not be in conflict with the INTELSAT agreement.

The US was opposed to the European demands, believing

> '...that to be compelled to surrender its control over its own creation was unfair'.2/

In March 1969, after one month, the Conference broke up with no decision taken. This result certainly gave new impetus to the European effort in the communication satellite field.3/ Whereas the political trouble at INTELSAT had delayed the decision on a final arrangement scheduled to be taken by mid-1970, the operation of the satellite system had been a complete success. INTELSAT had established a global and reliable communication satellite system and was working at a profit.

1/ Not only was European industrial participation limited to 4.5%, compared with a financial contribution of 28%, but it also involved mainly repetitive work and little creative activity. See SCL/TPS/116 Supplement, op.cit.

2/ Maddox, op.cit., 486. By 1969, INTELSAT had 86 member states. The Soviet Union and its allies, however, did not participate in the US-dominated system, but decided to set up their own INTERSPUTNIK system, linking the socialist countries.

3/ 'US Volte-face over Space Cooperation', New Scientist and Science Journal, XCI (1971), 462.

2.8 The TELECOM programme initiative: approval of phase I

As noted above, the meeting of the European Space Conference (ESC) at its November 1968 meeting had not approved the CETS-C project but decided to finance another economic study on application satellites. Unhappy with this decision, the European Broadcasting Union (EBU) officially requested the ESC to state its intention with regard to the execution of the television satellite programme by November 1969. EBU was planning that its General Assembly should take a final decision on the use of this programme for the requirements of EUROVISION by the end of November 1969.1/ As a result of this move, the Committee of Senior Officials of the ESC initiated industrial consultations in order to obtain exact proposals.2/ On the basis of these proposals, a governmental conference or even a ministerial conference should decide on the start of the satellite project before the November deadline put forward by EBU.

Whereas the industrial consultations were essentially based on the previous EBU mission, i.e., the beaming of two television programmes to Europe and Africa, the technical concept of the CETS-C project was revised to take into account the technical progress achieved by the Franco-German SYMPHONIE programme.3/ In fact, the Committee of Senior Officials of the ESC asked ESRO

1/ General Report 1968 (Paris, ESRO, 1969), p. 124. See also ESRO/C/400, Orientation and Progress of Application Studies, 24 Mar. 1969; ESRO/C/425, Information Concerning Applications Studies in 1969 and 1970, 21 Mar. 1969.

2/ 'Industry Tenders Invited for European Comsat Work', The Times, 18 July 1969.

3/ Each television programme of the EBU mission comprised a vision channel (black and white, or PAL or SECAM colour), a sound channel accompanying the visuals, and twenty voice channels for commentaries.

to contract out the following studies between 28 July and 13 October 1969: 1/

> Four studies by industrial consortia on the development of a satellite with maximum use of the technology available in Europe.
>
> One study entrusted to the Board of Managment of SYMPHONIE for a SYMPHONIE satellite, modified in order to meet the EBU specification as closely as possible.

The report on the evaluation of the industrial proposals was distributed to the Committee of Senior Officals and EBU on 3 November 1969.2/ It indicated that a period of four and a half years from the beginning of definition work to the launch of the satellite would be required. Based on the estimates put forward by the companies and excluding the cost of launchers, the following costs at 1969 prices would result:

Detailed definition studies	6 MAU
Industrial contracts (satellite, associated equipment, control station, apogee motor)	50 MAU
ESRO internal direct costs	6 MAU
Reserve for technical contingencies	10 MAU
	72 MAU

At the meeting on 3 November, however, the EBU complained that the costs of the operational phase, which this organisation would be required to cover, were too high and hence the system was not economical.3/ In fact, a satellite solely devoted to the EUROVISION network would only be used at a maximum of a few hours per day. The limited use of the satellite capacity

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1/ ESRO/ST/328, Progress Report on Application Studies, 17 Oct. 1969.

2/ General Report 1968, p. 127; 'European Broadcasting Satellite Proposal', Financial Times, 15 Oct. 1969; P. Stubbs, 'Whither ESRO', New Scientist, LXXXIX (1969), 338.

3/ 'Vorarbeiten für ein europäisches Nutzsatelliten-Programm', Luft- und Raumfahrttechnik, XVI (1970), No.7/8, 205.

quite clearly affected the economics of the total system.

Faced with the disappointing reaction of the EBU, ESRO approached CEPT again.1/ By enlarging the mission of the communication satellite, and by adding to the television mission services such as telephone, telex and data communication, better use of satellite capacity was expected. In fact, CEPT had already indicated a renewed interest in a European communication satellite for such services during a meeting at Munich back in May 1969.2/ It was the successful demonstration during eight years of communication by INTELSAT satellites which led CEPT to rethink its previous negative attitude towards a European communication satellite system.

To take into account this new situation, the Committee of Senior Officials of the ESC decided during November 1969 to set up the Working Group on European Communication Satellites, comprising representatives of CEPT, EBU, ESRO and ELDO. The working group was requested

> '...to optimise a requirement for a European telecommunication satellite which would have the best prospect of economic viability and, at the same time, be of the greatest benefit to European space technology'.3/

The terms of reference for the satellite system assumed that two flight models would be developed to serve a joint CEPT/EBU mission, launched by a EUROPA II vehicle and handed over free of charge to the user organisations, CEPT and EBU, by 1975. The user organisations were expected to cover the operating costs of the satellite system after 1975. In particular, the users would cover the costs of the ground stations, the production of subsequent satellites and their launchings. The working group was requested to present

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1/ Ibid.

2/ Ibid.

3/ 'The European Space Conference', ESRO/ELDO Bulletin, I (1970), No. 8, 10.

its report on the satellite programme to the Committee of Senior Officials by March 1970.1/

As mentioned above, the system was to be optimised to achieve two major objectives. First, it should achieve what had been described as operational objectives in terms of the 'economic viability' of the satellite system. The costs of the operational satellite system from 1975 to 1985 were to be viewed solely in comparison with those of the terrestrial network of the user organisations and did not include previous investments in the development of the system.2/ 'Economic viability', therefore, can be seen as a synonym of system attractiveness to the potential user organisations. Second, the development programme should be of the 'greatest benefit to European space technology'. A satellite concept which utilised technology already developed under the SYMPHONIE or SIRIO project was not considered to provide this benefit. Instead, the new programme initiative was aimed at building on previous experience and presenting industry with a more demanding challenge for the advancement of satellite technology. In fact, this second objective coincided with the first. In order to achieve 'economic viability' as defined above, the communication satellite had to be of an advanced nature, which could only be achieved through previous extensive R&D subsidies.

The first outline of the European communication satellite system was presented by the working group to the Committee of Senior Officials in March 1970. ESRO had subsequently carried out a study on the economics of the

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1/ Ibid., 11.

2/ It may even be argued that the need to reduce the cost of the operational system tended to increase the cost of the technology development phase, thereby increasing the cost of the total investment (development and operational phase) in the satellite system.

system.1/ The new proposal which was finally submitted for approval to the European Space Conference in July 1970 went far beyond the already ambitious specifications defined back in September 1969 by the Committee of Senior Officials.

The satellite mission as defined by the potential user organisations had the following characteristics.2/ The CEPT mission included the provision of telephony, telegraphy, telex and data transmission. The service would complement, not replace the existing and planned terrestrial communication links. The first operational satellite, named European Communication Satellite (ECS), would provide approximately 6,500 space circuits in 1980. This capacity would be extended by the user organisations with additional satellites up to 22,000 circuits by 1990. This would represent between one third and two thirds of the intra-European communication over distances greater than 800 km.3/ The EBU mission for the television part of the space system provided for the total replacement of the terrestrial circuits currently in use for television transmission between countries in Europe and between Europe and North Africa. In addition, the system provided for the extension of the geographical coverage of EUROVISION to member countries of the EBU which were currently outside the zone of real-time television transmission, e.g., Iceland, Cyprus and Lebanon. From 1980 onwards, the ECS satellite would provide, similar to the previous CETS-C concept, two

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1/ Report of the Working Group 'ECS', March 1970; CSE/HF(70)19, European Communications Satellite, 12 June 1970.

2/ General Report 1969 (Paris, ESRO, 1970), p. 10-1.

3/ As outlined in appendix B, satellite communication is most economical over long distances. For reasons of flexibility and reliability, the PTTs did not want to route all their long distance communication through the satellite system but rather to diversify the existing system.

television programmes, one high-quality sound channel and 20 commentary channels. It was estimated that 80% of the capacity of the first ECS satellite would be devoted to the CEPT mission, with the satellite having a capacity four times as large as the previous CETS-C proposal.1/ In addition to the traffic requirements, the following major system characteristics had important implications for the satellite design.2/

First, CEPT requested that the new satellite system operate in the 12.75 to 13.25 GHz range for the up-link and 11.45 to 11.95 GHz for the down-link.3/ Unlike the INTELSAT and SYMPHONIE satellites and the CETS-C proposal, which used the 4-6 GHz range, CEPT chose a frequency range above 10 GHz for the ECS system. Higher frequencies are less economical to operate than lower ones. By selecting the higher frequency for the ECS system, CEPT wanted not only to reserve the lower frequencies for the microwave links of its ground system but also to avoid interference and jamming problems with the already overcrowded European terrestrial network.4/

1/ Additional satellites launched to extend the space system to 22,000 circuits would primarily be used by CEPT.

2/ J. Contzen, 'The European Telephone and Television Distribution Satellite System', Telecommunication Journal, XXXVIII (1971), 290-5; J. Davidson, 'The European Telecommunication Satellite Programme', ESRO/ELDO Bulletin, I (1970), No. 12, 8-13.

3/ The system is designed to operate in the 11 to 14 GHz frequency range, using a band width of 0.5 GHz for the down-link (11.45 to 11.95 GHz) and 0.5 GHz for the up-link (12.75 to 13.25 GHz). Frequency band is an extremely scarce resource in radio communication. In order to avoid interference, two transmissions (or two transmission systems) using the same line-of-sight path have to use different frequency ranges. For more detail, see appendix B.

4/ Attenuation suffered by radio signals which traverse the atmosphere can significantly limit the effectiveness of radio communication. At frequencies between 4 and 9 GHz, such attenuation is minimal; however, it increases exponentialy at frequencies above 10 GHz. For more detail, see appendix B.

There was little or no experience in satellite technology above 10 GHz, but it was expected that as soon as the lower frequencies became overcrowded in all parts of the world, this would be the frequency range for future communication satellites. Second, the communication capacity of the satellite largely depends on the frequency band earmarked for the system. In order not to limit the expansion of the other networks, CEPT only allocated a band width of 0.5 GHz each for the up- and down-link. This restriction posed a considerable problem in light of the traffic requirements. In order to use the limited band width to a maximum extent, the satellite system would require spot-beam antennas and communication techniques such as speech interpolation, frequency re-use and the channelling of communiction assignment on demand.

The system characteristics of traffic volume, frequency range and frequency band had important implications for the design of the spacecraft and the need for the development of new technology.1/ In particular, the choice of the 11 to 13 GHz frequency range implied the development of new on-board repeater equipment which included several microwave components, notably the travelling wave tube amplifier (TWTA). As a result of the large traffic volume, a TWTA with a high power volume was desirable. The objective of developing a 20 Watt TWTA to be used for a frequency range above 10 GHz was seen as one of the most challenging tasks of the programme. The use of spot-beam antennas would require a high satellite pointing accuracy, which could only be achieved by satellite sensors yet to be developed.2/ Satellite power of the order of 1000 Watts in sunlight and 550 Watts when the satellite

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1/ J. Davidson, op.cit., 8-13.

2/ Attitude sensors are used to detect the position of the satellite axis in relation to sun and/or earth. For more detail, see appendix B.

was eclipsed from the sun by the earth would be required. Such power requirements made a 3-axis stabilised satellite desirable instead of a less complicated spin-stabilised one. This in particular others necessitated the development of new momentum wheels,1/ unfolding solar arrays, solar cells and batteries which would operate the satellite when it was eclipsed from the sun.

Two additional characteristics of the satellite system were long life and reliability, with a 70% probability for a satellite lifetime of 7 years. This demanded, among other things, proper lubrication, and therefore development work had to be concentrated on space lubrication and the relevant problems of bearing designs. Although the precise definition of the form of the spacecraft would depend on the outcome of additional studies, preliminary investigations outlined an ECS satellite with a mass of 750 to 800 kg to be launched with a EUROPA IIIB vehicle or an equivalent American Atlas Centaur or Titan IIIB Centaur.

Starting out with the less ambitious specifications defined by the Committee of Senior Officials back in September 1969, the programme now envisaged a major technological push which could put Europe on an equal footing with the USA in satellite technology.2/ In fact, the proposed ECS satellite would be more advanced than the current INTELSAT satellites.

Different opinions existed on how to realise such a technology programme. On the basis of their previous experience gained in the SYMPHONIE programme, France and West Germany wanted to go straight ahead with the

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1/ Momentum wheels can be described as rotating tops which absorb pitch disturbances by varying their speed. For more detail, see appendix B.

2/ The system specifications as defined by the Committee of Senior Officals were for a 200 kg satellite, to be launched by EUROPA II, with a 7 Watt TWTA, operating in the 4 to 6 GHz range, spin-stabilised and with a lifetime of 5 years. See Doc T/CCTS(71)24E, July 1971, p. 12.

development of the operational ECS satellite.1/ In view of their limited experience in satellite technology, other countries, in particular the United Kingdom and the smaller ESRO member states, suggested developing and testing an experimental satellite during an intermediate programme phase before proceeding to the development of an operational satellite. Orbital testing of such an experimental satellite would help improve critical components and subsystems in space before they were used in the ECS satellite.

The potential user organisations, CEPT and EBU, decided the course of action. Supported by the United Kingdom and the smaller countries, they insisted on an intermediate phase in order to explore the technological and operational problems arising from the introduction of a satellite system into the European PTT network. Not only would such an intermediate phase improve the reliability of the subsequent operational system, but it would also enable the PTT organisations gradually to gain operational experience with the communication system during the test stage. In addition, countries which had not gained industrial experience in communication satellite technology through previous national efforts would be able to close the emerging European gap during an intermediate phase before advancing to the development of the operational system. Hence, the TELECOM programme was proposed with an intermediate phase which envisaged the development of a satellite specifically designed to fulfil the pre-operational and experimental objectives, followed by the development of the operational ECS.

The ambitious TELECOM programme outlined so far also had an ambitious price, approximately $450 million compared with $100 million for the CETS-C

1/ R. Ropelewski, 'Europe Reappraising Space Efforts', Aviation Week and Space Technology, LXIII (March 1978), 71-5.

proposal. The CETS-C proposal had envisaged basically the development of an experimental satellite, and it had always been assumed that the user organisations would cover the cost of setting up the operational system. Now, this latter step was part of the new TELECOM proposal.

Despite the dramatic increase in cost, the TELECOM concept found support among the funding organisations and interested parties, as will be elaborated below.

The renegotiation of the INTELSAT agreement had demonstrated the dependence on American technology and hence on American communication policy (see section 2.7). In addition, European industry would have to compete with American companies in order to participate in the development of INTELSAT satellites. This condition would considerably limit the opportunities for European companies to participate in INTELSAT contracts. The experience of the INTELSAT negotiations certainly strengthened the political will of European governments to create a competitive European industry in communication satellite technology. The support of an ambitious TELECOM programme by the funding organisations was primarily motivated by the objective of limiting dependence on American satellite technology and achieving equal status in the INTELSAT organisation. This motivation was described in chapter 1 as the objective of achieving supply security. Whereas this was the driving force during the last seven years of government support of communication satellite technology, all previous attempts at the European level had failed as a result of one major obstacle, the reluctance of the potential user organisations to commit themselves to using the European satellite system. Europe is too small to exploit the benefits of space communication, i.e., covering long distances economically. In addition, the European communication network was already well developed. Despite the subsidies previously offered by European governments for the development of the technology, a European system based on such proposals as CETS-A/B or C would not be competitive with the terrestrial network. Furthermore, not much experience with space-borne communication links or confidence in such systems existed at the time these proposals were presented.

In fact, however, the latter point had changed by 1969. The successful demonstration over eight years of communication by INTELSAT satellites had improved the confidence of CEPT in using such a system for its European needs. However, one condition became clear during the discussion of the Working Group on European Communication Satellites, comprising CEPT, EBU, ESRO and ELDO: European governments could only achieve supply security by first realising the operational objectives of the potential user organisations. In other words, a precondition for limiting dependence on American satellite technology was to subsidise the development of a satellite system until it could be operated economically by the user organisations in comparison with the terrestrial network. Economics was a synonym for system attractiveness to the potential user of the technology and was limited to the operational system, excluding all development efforts.1/ In fact, the TELECOM programme would not be an economic investment but a programme aimed at achieving supply security in a technology field considered to be of vital national importance.

The operational objectives of the user organisations and the supply security objectives of the national governments reinforced each other. First,

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1/ The strong negotiating position of the potential user organisations became obvious when the decision was taken on the phasing of the TELECOM programme. As outlined above, it was mainly on the insistence of the potential user organisations, supported by the United Kingdom and the smaller countries, that the TELECOM programme included an intermediate phase with the development of a test satellite and did not go straight to the development of the operational satellite.

this is highlighted by the relationship between development and operational costs. As a result of extensive R&D subsidies during the development phase, the cost of the operational system which does not necessarily mean the cost of the whole investment, could be limited. Second, this is highlighted by the relationship between space segment (satellite) and earth segment (earth stations). In general, a balance has to be found between the space and earth segments to optimise the cost of the overall system.1/ Under the TELECOM programme, the national PTT organisations represented by CEPT would have to cover the cost of the national earth stations. As a result of extensive R&D subsidies for the space segment, the cost of the ground segment could be limited, which does not necessarily mean the cost of the whole system. Obviously, the potential user organisations would benefit from the emphasis on the development of advanced satellite technology, since it would limit the cost of the operational phase and the cost of the ground segment, both of which the user organistions would have to cover. In addition, however, it also would contribute to the funding organisations' objectives of achieving supply security, since this approach emphasised the closing of the technology gap between Europe and the USA in advanced communication satellite technology. Finally, the development of an advanced satellite system at the European level would neatly fit into the current national activities of two major potential participants, France and West Germany. Whereas both these countries strongly supported a European programme when it was first considered, they were not the main sponsors of the CETS-C proposal since it was basically a copy of their bilateral programme SYMPHONIE. It was, in fact,

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1/ Increasing the power capacity of the satellite system and hence the cost of the satellite, for example, limits the need for large earth station antenna reflectors and thereby reduces the cost of the earth station segment.

the United Kingdom which had pushed for the CETS-C proposal during the third European Space Conference back in November 1968. Since the United Kingdom had no major efforts in communication satellite technology of its own, even a limited European programme would enable British industry to gain experience. For France and West Germany, the CETS-C proposal would result in the use of government money for off-the-shelf procurement of existing technology and not in a major technology break-through. The TELECOM programme, however, would allow both countries, and to some extent Italy, to progress from their limited efforts to a more advanced and demanding joint programme. In other words, building up industrial know-how at the national or bilateral level during the first phase would be followed by sharing the increasing costs of the second phase through international collaboration. This attempt was visible when France and West Germany intended to go straight ahead with the development of the operational ECS satellite. Only as a result of the opposition of the potential user organisations and in particular the United Kingdom, supported by the smaller countries, was an intermediate phase with the development of an experimental satellite included in the programme.1/ Those countries considered the TELECOM programme a means not only of catching up with American technological know-how, but also of closing the already emerging European technology gap.

It should be noted that CETS had not been involved in the definition of the TELECOM programme concept. Since the ECS satellite would mainly serve the

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1/ The drive towards international collaboration as a result of the austere funding programme is also described in 'Europe Shifts Goals in Funding Squeeze', Space Technology International, XII (1970), No. 2, 44-6; 'Satellites: Ruled by Politics', New Scientist and Science Journal, XCI (1971), 19-20. See also 'A Warning to Europe on Satellite Broadcasting', New Scientist, LXXXIX (1969), 274.

CEPT mission, it was decided that CETS should limit its activity to the European-US INTELSAT negotiations then in progress, for which it had been established originally. In fact, after the finalisation of the INTELSAT agreement, CETS was dissolved.1/ The TELECOM programme was subsequently integrated into ESC/ESRO activities. The shift of funding responsibility from CETS to ESC/ESRO can be seen as a formal act, since the funding responsibility remained essentially with the same national ministries concerned with industry, space and technology. This shift, however, would change ESRO, so far governed by a Council dominated by ministries mainly concerned with scientific research.

The new TELECOM programme concept was submitted for approval to the fourth European Space Conference held in Brussels.2/ The Conference had already been postponed for several weeks as a result of the general election in Britain. After the change of administration, the new Conservative government sought further postponement in order to review the whole field of public policy and expenditure.3/ In addition, Italy also requested a postponement of the meeting after the collapse of its coalition government.4/

1/ CSE/CM(July70)6, Report by the Chairman of the Committee of Alternates, 17 July 1970; CSE/CS(70)19, Letter from the Chairman of CETS, 30 Sept. 1970. The final INTELSAT agreement was signed on 20 April 1971, limiting the COMSAT/USA share to 38.3% but maintaining COMSAT as INTELSAT manager. See 'Das neue INTELSAT-Abkommen', Raumfahrtforschung, XII (1971), No. 3, 130.

2/ 'The European Space Conference', ESRO/ELDO Bulletin, I (1970), No. 8, 10-1; H. Bondi, 'Europe's Options in Space, New Scientist, XC (1970), 370-1; P. Stubbs, 'Possible Bargains for European Space', New Scientist, XC (1970), 82-3.

3/ CSE/CM(July 70)PV/1,Rev., Declaration of the British Minister of Technology, Annex 3, 30 July 1970.

4/ Ibid., Annex 5, Declaration of the Italian Minister of State for the Coordination of Scientific and Technical Research.

Belgium, France and West Germany, however, insisted on holding a conference in July 1970, since policy issues needed urgent decisions, which forced Italy to abstain from all decisions taken and Britain to take a cautious attitude towards new programmes.

The fourth ESC was basically confronted with the same problems as the last Conference back in 1968. The aim of the Conference was to approve a European space programme and the amalgamation of the existing space organisations. During the time which had passed, France and West Germany were not willing to accept the menu-a-la-carte approach suggested by the British delegation. In fact, both countries insisted that before creating a new joint organisation, at least the four large countries - France, Italy, the United Kingdom and West Germany - should approve the overall space programme, including the new communication satellite programme, the development of the EUROPA III launcher, the cost increase of the ELDO-PAS (EUROPA II) project and a scientific space programme. Firm financial commitments were expected for the years 1971 to 1973.1/

In addition, this Conference had to consider a new issue which had come up only a few months before: the invitation by NASA to participate in the financing and development of the American post-Apollo programme, known as the

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1/ Expenditures of ESRO and ELDO for 1970 amounted to $130 million, with one half allocated to launchers and one half to science. The total volume had fallen since 1968 as a result of the non-approval of EUROPA III and the CETS-C project by the third ESC.

Space Shuttle.1/ The Space Shuttle was described as a reusable transportation vehicle, to be used as an economic means of launching satellites, or as a 'work horse' for building up a permanent space station.

The proposal for a European space programme, the TELECOM programme, received general support from all delegations, although there existed different opinions on how to proceed. The programme, so far, had been outlined in terms of its major characteristics on the basis of requirements expressed by EBU and CEPT. The next step, described as the pre-development phase, would be to carry out studies leading to the specification of the operational satellite system, expected to be finalised by June 1971, which would be followed by the development programme. At this juncture between pre-development and development work, the potential users, CEPT and EBU, would be required to approve the programme and commit themselves to using the ECS system.

The British delegation, led by Mr. Rippon, Minister of Technology,

> '...wishes to limit his country's participation to the pre-development phase...before deciding to proceed to the development phase, the results of the pre-development studies should be examined to see whether the satellite envisaged indeed met the requirements of the P and T authorities'.2/

At this ill-defined stage, France and West Germany already wanted an agreement in principle to carry out the TELECOM programme and a funding commitment for the first three-year period. The French Minister of Industrial

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1/ The American offer had been viewed as an attempt to overcome the difficulties experienced in the USA of getting the project approved. Limiting the cost by internationalising the project was seen as enhancing the chance for final project approval. See 'Statement by NASA Administrator Plain on Space Cooperation', Spaceflight, XIV (1970), No. 6, 315-7; D. Fink, 'Europeans Seek Approval to Join Post-Apollo Work', Aviation Week and Space Technology, LV (July 1970), 2.

2/ CSE/CM(July 70)PV/2, Rev., 30 July 1970, 3.

Development and Scientific Research, Mr. Ortoli, argued that

> '...one could go on discussing...cost-effectiveness ad infinitum'.1/

Mr. Lefèvre,2/ Belgian Minister of Scientific Policy and Planning, emphasised the political character of the TELECOM programme by stating that

> '...it was for the space organisations to start on this project without waiting for the P and T administrations to commit themselves. In this connection, he quoted the example of NASA, who had developed and built a satellite communication system before the United States telecommunications administrations had decided to use it'.3/

Representing a new government, the United Kingdom delegation had difficulties in taking rapid long-term decisions, but finally approved the TELECOM programme in principle and made a three-year financial commitment.4/

Whereas there was agreement on the TELECOM programme, the division between pro-launcher and anti-launcher countries, as expressed in the last Conference, still persisted. Despite the new pro-European, Conservative government, the United Kingdom was happy to rely on US launch services. France, pressing for an independent European launcher capability, insisted on a UK contribution:

> '...we consider it as an essential precondition that all member countries...should subscribe to the whole of the programme'.5/

Because there was no agreement on the launcher issue, this question was

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1/ Ibid., 5.

2/ Since his country was hosting the Conference, Mr. Lefèvre was Chairman of the fourth European Space Conference.

3/ Ibid., 6.

4/ 'United Kingdom to Join European Space Efforts Balks', Space Technology International, XII (October 1970), 24-6.

5/ CSE/CM(July 70)PV/1, Rev., Annex 4, Declaration of M.B. Lafay, Secretary of State in the Ministry of Industrial Development and Scientific Research (France).

re-examined in light of the United States invitation to join the post-Apollo programme: Would the US guarantee to launch European communication satellites in return for European participation in the Space Shuttle project?

Since the position of the US was not clearly known, the Conference decided to send a mission to Washington to explore this question. The Conference would then meet again in November 1970 to consider the results of the mission in the context of approving the European space programme.

As a step towards final adoption by the Conference in November, and to enable ESRO and ELDO to fulfil their obligations during the next months, interim resolutions on European space programmes were put forward for approval. In fact, the following proposal concerning the TELECOM programme received support from Belgium, France, Italy, the Netherlands, Spain, Switzerland, the United Kingdom and West Germany.1/

> 'The conference decides to embark upon a programme of application satellite...with a view to the setting up of a European operational satellites communication system about the period 1978-1980 to meet the requirements expressed by CEPT...Decides to execute a communication satellite programme at an estimated cost of approximately 450 MAU 2/ to meet these requirements as well as those expressed by the European Broadcasting Union (EBU). This decision implies the firm intention of the Member Countries to channel through the European space system a certain percentage of their long-distance telephone and television traffic, to be determined in good time by their competent authorities, provided that the economic aspects are not disproportionate to those of terrestrial means...Decides in consequence to pursue actively the

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1/ Denmark did not support the proposal since it was considering plans to leave ESRO, being unhappy with the extent of Denmark's industrial participation in ESRO's projects. See 'Denmark to Quit ESRO', Financial Times, 31 Nov. 1970.

2/ MAU (million accounting units) is the accounting unit of ESRO; it is based on a calculation involving all national currencies of ESRO member states, with 1 AU approximately equivalent to $1 US. Hence, 1 MAU corresponds approximately to $1 million. For detailed exchange rate figures between AU and $, please refer to table 4 of appendix A. In the following, financial information on the TELECOM programme will mainly be presented in MAU.

parametric studies 1/ on all aspects of the operational system in cooperation with the telecommunication and television administrations and agencies concerned so as to be able to make the necessary decisions for the continuation of the programme. Decides to embark, at the same time, on the development of the first experimental ground and orbital elements of this satellite programme. Decisions to proceed to the next stage and to make the necessary funds available will be taken, in light of the results of the work undertaken, at a meeting of delegates from the participating countries by a double qualified majority 2/'.3/

For phase I of the TELECOM programme up to mid-1971, an amount of 5 MAU was made available, with the possibility of extending this phase up to the end of 1973.

The mission to Washington took place in September 1970. The Belgian Minister, Mr. Lefèvre, Chairman of the fourth ESC, headed the European delegation. As a strong supporter of a European launcher programme, he was accompanied by a French and a British colleague.4/ The American side made clear that for scientific projects, Europe could obtain launchings at a commercial price which even excluded amortisation of development costs. For satellites intended for international public telecommunications, launch service would be provided if these satellites were in conformity with the INTELSAT agreement. The INTELSAT Treaty, in the process of being negotiated at the same time, permitted its member countries only to establish regional satellite systems, which did not result in any major economic harm to the

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1/ Parametric studies are optimisation studies within the constraints of system characteristics (parameters).

2/ A double qualified majority is a majority of member states representing at least fifty percent of the total programme contribution.

3/ CSE/CM(July 70)7 Final, 24 July 1970. See also 'The Fourth Ministerial Meeting of the European Space Conference', ESRO/ELDO Bulletin, I (1970), No. 12, 8-12.

4/ CSE/CM(November 70)6, Statement and Report by the Chairman, 4 Nov. 1970; 'Way Out of the Space Dilemma', Nature, CCXXIII (1970), 427.

INTELSAT system, where the definition of 'region' was the subject of an ongoing controversy.1/

Making reference to the interrelationship between launcher access and a European share in the post-Apollo programme, Mr. Lefèvre concluded that

> '...the guarantees...are being offered on the assumption of substantial participation'.2/

Substantial European participation was expected to amount to ten per cent of the overall project costs, about twice the cost of the EUROPA III programme, namely $1,000 million spent over ten years.

On the basis of the result of the Washington mission, the fourth ESC, at its second session held in November 1970, set out to approve a European space programme. It ended in a fiasco. Before the Conference met, France made known its intention to leave ESRO if there were no general approval of a European launcher programme by

> '...those member states whose contribution represents a major part of the financial resources'.3/

At the start of the Conference, the French Minister Ortoli commented on the results of the Washington mission as follows:

> '...the conditions...are not those of "partners"...this is the word the Americans used in talking to us, referring not to international cooperation but to a genuine "partnership". Well, I do not detect in the

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1/ CSE/CS(70)23, Statement by Mr. Van Eesbeck Relating to the Washington Talks between the ESC Delegation and the American Authorities, 8 Oct. 1970; 'The European Space Conference', ESRO/ELDO Bulletin, I (1970), No. 12, 4-6.

2/ CSE/CM(November 70)PV/1, Annex 1, Declaration by Mr. Theo Lefèvre, President of the Conference, 4 Nov. 1970, 3; CSE/CM(November 70)6, op.cit.; K. Johnson, 'US/European Space Cooperation Spurred', Aviation Week and Space Technology, LV (Sept. 1970), 18-9.

3/ CSE/CS(70)22, Memorandum from the French Delegation to the Members of the Committee of Alternates of the European Space Conference, 7 Oct. 1970. See also A. Cleaver, 'The 4th European Space Conference', Spaceflight, XIV (1970), No. 11, 440-1.

> answer made to us...I do not detect this status of "partners"...I think one must have the courage to say this'.1/

Consequently, he argued:

> 'If Europe does really want to be present in the telecommunication market, then it should not make satellites which will be subject to outside control, which may or may not be launched, and should make a firm resolve to provide the means for launching its satellite itself'.2/

The United Kingdom, represented by Mr. Corfield, Minister of Aviation Supply, stated that

> '...we do not...see any need or scientific value in the light of the progress made by the Mission for the development of an independent launching capability'.3/

This opinion was supported for the first time by Italy, an ELDO member country.

When the European space programme, comprising application satellites, launchers and scientific programmes, was put forward for approval, only Belgium, France and West Germany voted in favour of the whole programme. The Conference, which had been scheduled for three days, collapsed after the first day.4/

The smaller countries represented at the ESC had not been able to

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1/ CSE/CS(70)22, Annex VII, Declaration by the Minister of Industrial Development and Scientific Research (France), 2-3. Similar views were expressed by B. Valentine, 'Obstacles to Space Cooperation: Europe and the Post-Apollo Experience', Research Policy, I (1971), 113.

2/ CSE/CS(70)22, op.cit., 3.

3/ CSE/CM(November 70)PV/1, Annex V, Declaration of the British Minister of Aviation Supply, 4 Nov. 1970. For further discussion see 'European Space Conference: The UK Position', Spaceflight, XC (1971), No. 3, 89.

4/ Some bad feelings remained after the collapse of the Conference. Britain, e.g., claimed that the press conference after the meeting was designed to discredit Britain in Europe. See also A. Cleaver, 'Resulting Confusion', Astronautics and Aeronautics, IX (1971), No. 1, 69-71; D. Verguese, 'European Space Research Totters', New Scientist, XC (1970), 324.

influence the course of events, which was determined by the different interests of the big four, namely France, Italy, the United Kingdom and West Germany. Whereas the representative of Switzerland had highlighted the importance of finding agreement between these countries earlier, arguing that

'...the solution of the problem lies in the hands of the major states',1/

he had to finally conclude

> '...the Conference was now in the process of destroying everything that had been built up'.2/

With the non-approval of the European space programme, there was no point in deciding on the amalgamation of the space organisations, according to the German Minister of Education and Science, Mr. Leussink:

> '...it was illusory to think it was possible to proceed to unification of the institutions...if there were not sufficient countries willing to participate in the complete programme';3/ he continued: '...there remains no other conclusion but to consider the years of effort towards a broadly-based European space policy as having failed. The delegation will therefore, in the future, pursue collaboration in space research and technology with those states willing to cooperate'.4/

In fact, what the British delegation was arguing for became reality, namely the menu-à-la-carte approach within a European space policy comprising application, science and launchers. After the United Kingdom and Italy had finally left ELDO, Belgium, France and West Germany decided to fund the EUROPA III launcher programme on their own. This new approach, however, characterised by project participation according to national priorities, had not come about within a European consensus but as the result of European

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1/ CSE/CM(November 70)PV/1, Annex IV, Declaration by the Head of the Swiss Delegation, 4 Nov. 1970, 2.

2/ CSE/CM(November 70)PV/2, 19 Nov.1970, 5.

3/ Ibid., 4.

4/ CSE/CM(November 70)8, Statement by the German Delegation, 4 Nov. 1970.

discord.1/

While ELDO felt apart, the result of the fourth ESC also had a considerable effect on developments at ESRO. So far, there had been no ministerial agreement for ESRO's space programme covering the years 1971–1973; nevertheless, ESRO was forced to approve its 1971 budget. When the ESRO budget was up for approval, the French ESRO delegation made a statement demanding a reduction of the ESRO budget and a renegotiation of the ESRO convention to provide for project-by-project participation. The statement was supported by the Belgian delegation, and both countries made it clear that they would leave ESRO if those demands were not met.2/

So far, member states had funded ESRO's activity according to their gross national product (GNP). Project-by-project participation would allow France and Belgium to shift their efforts within the ESRO programme and concentrate resources on application satellites instead of scientific projects.3/ Launchers and application satellites had first priority for France, whereas the United Kingdom was willing to support a strong scientific programme. The same flexibility which the United Kingdom had asked for with its menue-à-la-carte approach to overall space policy, France and Belgium were now demanding with their project-by-project approach to participation in ESRO's

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1/ The outcome of the fourth ESC supported the belief that ESRO was on the verge of collapse. See T. Dalyell, 'Staff Crisis at ESRO', New Scientist, XC (1970), 387–8; A. Cleaver, 'The 4th European Space Conference', Spaceflight, XC (1971) No. 3, 108–10.

2/ 'Pressure by France to Change ESRO Plans', The Times, 24 Dec. 1970; 'ESRO Discord', Flight, LXI (1970), 922; 'France Holds up Space Venture', The Guardian, 20 Nov. 1970; 'Questions Over ESRO's Future', Financial Times, 30 Nov. 1970.

3/ 'European Decision-Making on Space', New Scientist and Science Journal, XCI (July 1971), 176.

satellite programme.

Faced with the firm intention of France and Belgium to leave ESRO, other national delegations finally agreed to conduct negotiations with a view to submitting a proposal

> '...for a revision of the existing procedures and rules relating to the start and execution of projects, taking into account the proposals submitted by the French and Belgian delegations'.1/

After this concession, France and Belgium agreed to approve the TELECOM programme budget for 1971, as outlined in the resolution of the July 1970 Space Conference, amounting to 5 MAU until mid-1971. Not only was the interim resolution of the July Conference confirmed by the national delegations on ESRO, but the decision also authorised the first considerable expenditure covering study activities as well as the initiation of hardware development.2/

It is believed that the decision of the Council in December 1970 constitutes a turning point not only for the TELECOM programme but also for European space collaboration as a whole. In fact, it marked the beginning of a reorientation of European space activity from scientific research to application work, which allowed ESRO not only to continue to exist but also to grow during a decade of vanishing support for government space expenditure.3/

At this point, the start of the TELECOM programme, it is considered advantageous to summarise Europe's space capability. Table 3 of appendix A shows the space expenditure of the various ESRO member states by distinguishing national, ESRO, ELDO and total space expenditures up to 1970.

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1/ ESRO/C/MIN/35, 21 Dec. 1970.

2/ ESRO/C/482, Note by the Secretariat, 8 Dec. 1970.

3/ NASA, the American counterpart of ESRO, could not achieve such a reorientation to application work, which must be seen as one reason for its decline in activities.

The following major trends are evident: the winding down of ELDO's activity, a limited increase in ESRO's resources, and growing activity in national projects. It is also clear that smaller countries did not have substantial national projects but rather spent their limited financial resources in the European framework.

Whereas the expenditure figures give a general indication of national industrial capability in space technology, there also existed specific experience in communication satellite technology prior to the start of the TELECOM programme. Besides the bilateral French/German SYMPHONIE programme and the Italian SIRIO project, the United Kingdom had decided in 1969 to embark on its own national activity. Whereas the military communication satellite SKYNET I was essentially procured from the United States, SKYNET II was built with substantial participation by British industry.1/ In addition, European industry had managed to secure a share of the contract for the development of INTELSAT IV.2/

1/ SKYNET II was built for the Ministry of Defence by MSDS (UK). The satellite was spin-stabilised, with an expected lifetime of five years, a weight of 230 kg, electrical power of 186 Watts, and operated in the 4/6 GHz range. Development started in 1971, with a launch date of 1974. See W. Lovell, 'The SKYNET System, the Satellite Communications Network Built in Britain', Journal of the British Interplanetary Society, XXIX (1976), 19-39.

2/ INTELSAT IV was developed between 1968 and 1971 by Hughes (USA) and launched by NASA under a COMSAT contract. INTELSAT IV had a lifetime of seven years, a weight of 556 kg, electrical power of 500 Watts and a communication capacity of 4,000 circuits. The satellite was spin-stabilised and operated in the 4/6 GHz range. The following European companies participated in the $72 million contract: BAC (UK)-$2.5 million; Thomson-CSF (F)-$3.3 million; AEG-Telefunken (D)-$2.5 million; ETCA (B)-$0.8 million; Selenia (I)-$0.8 million; Contraves (CH)-$0.8 million; Ferranti (UK)-$0.6 million; SAT (F)-$0.5 million; Svenska Radio (S)-$0.4 million. See 'Participation Européenne aux Satellites Intelsat 4 et 5', Air et Cosmos, XIV (1977), No. 673, 42.

CHAPTER 3

THE MANAGEMENT SYSTEM OF THE TELECOM PROGRAMME AND IMPLEMENTATION OF PROGRAMME PHASE I

3.1 Introduction to the management system

In order to guide the subsequent description of the TELECOM programme implementation, more details are needed on the system of programme management, that is, the relatively self-contained and relevant system of programme implementation activity consisting of the organisations involved, their characteristics, policies, procedures and relationships.

The implementation of the TELECOM programme involved a number of organisations: the ESRO machinery with its committee structure and permanent body, industry and technology user organisations.1/

The committee structure of ESRO represented the government organisations of the member states which funded the TELECOM programme and decided on its implementation. The committee structure was headed by the Council as the governing body of the organisation. The permanent body of ESRO was responsible to the committee structure for carrying out the assigned tasks in the field of the TELECOM programme. It was a body of international civil servants, including administrators, engineers and scientists, and was headed by a Director General. One of its major tasks was to award and monitor industrial contracts for hardware development and production. The companies involved were mainly situated in the member states and were primarily in the aerospace or electronic sector. The user organisations, CEPT and EBU, formed the fourth part of the TELECOM programme system. Under the scientific programme, the scientists could be viewed as the user entities. They had been

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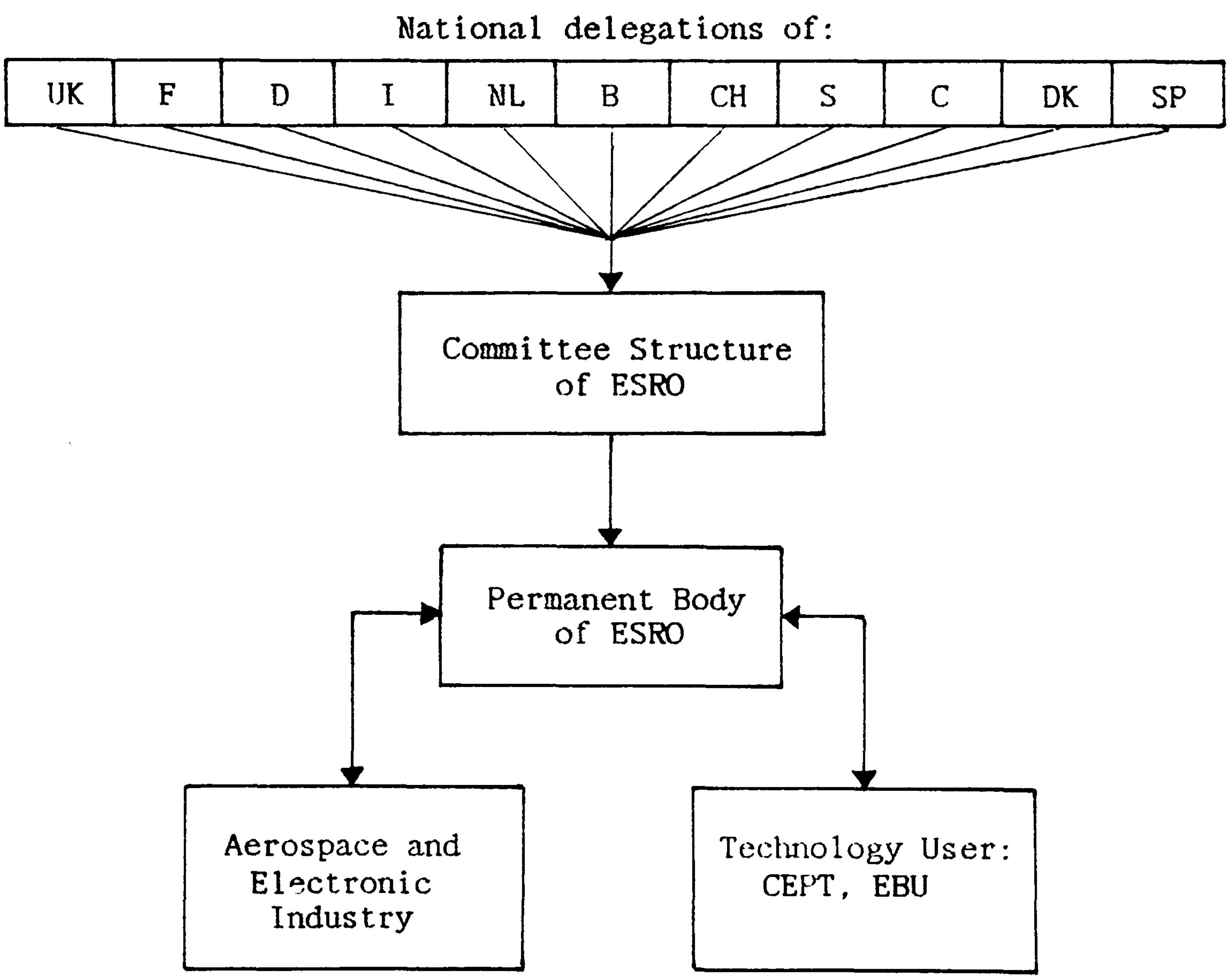
1/ See ESRO/C(73)65, Management of Operational Space Systems, 24 Oct. 1973.

closely involved in designing the experiments and utilising their results. In fact, the raison-d'être of ESRO had been to serve the interests of scientists. Under the TELECOM programme, it was CEPT and EBU which, although not funding the ESRO programme, were expected to use the technology and procure the follow-up systems. This called for a close alignment with the ESRO programme.

A graphical illustration of the management system is given below.



As can be seen, the role of ESRO's permanent body was that of a contracting agency; it essentially supervised and coordinated a large number of industrial companies, government authorities and technology users. Although the permanent body of ESRO produced little or no hardware itself, it could not be considered a simple post box between member states and industry. In fact, it held the final responsibility for the management of the projects, defining the technical specifications, preparing decisions for the committee structure and monitoring and controlling the development activities. Such 'in-house' activity, in contrast to outside activity carried out by industry, was supported by considerable resources in staff and facilities.1/

By the end of 1970, the permanent body of ESRO comprised 1300 employees, distributed over five main facilities. The head office, with 15% of the personnel, was in Paris; a European Space Technology Centre (ESTEC), with 60% of the personnel, was in the Netherlands; a European Space Operations Centre (ESOC), with 20% of the personnel was in West Germany; and further facilities were in Italy and Sweden. The basic infrastructure of ESRO in terms of buildings, personnel, and research laboratories was ESTEC. ESRO's importance as a contracting agency is shown by the fact that two thirds of ESRO's 1970 budget, amounting to 60 MAU, was spent in industry. So far, ESRO's major achievement had been the successful development of four scientific satellites, namely IRIS (ESRO I), AURORA (ESRO II), BOREAS and HEOS.2/ For the illustration of annual budget see appendix A, table 3. Following the overview of the management system, the ESRO machinery will be described in detail.

1/ ESA/AF(81)31, The Internal and External Costs of the Agency, 25 Oct. 1981.

2/ 'Die Satelliten Projekte der ESRO', Luft- und Raumfahrttechnik, XVI (1970), No.3, 71-3.

3.2 The legislative level: ESRO's committee structure

The committee structure originally consisted of the Council, the Scientific and Technical Committee (STC), and the Administration and Finance Committee (AFC).1/

The Council was the governing body of ESRO and had the power of decision to carry out the aims of the organisation. It met at least twice a year. Most decisions of the Council were taken by a simple majority of the member states; a two-thirds majority was required to approve annual budgets, appoint the Director-General and the top echelon of ESRO's permanent staff, determine the financial contribution of each member state, and decide on financial arrangements and staff complements. Every three years, the Council had to decide unanimously on the level of resources for the succeeding three-year period.

The Council delegated nearly all of its supervisory functions to the AFC and STC.2/ The STC took decisions on technical and scientific matters delegated to it by the Council, made recommendations to the Council on ESRO's programme and kept under review the progress made in carrying out the projects. Similar to the STC, the AFC took decisions and made recommendations to the Council. It was concerned with such matters as the audit of annual accounts, the recommendation of staff complements and regulations, and decisions on intellectual property rights, financial rules and contract procedures. One of its major tasks was the approval of contracts.

Decisions by AFC and STC were taken by a majority vote, where abstention

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1/ ESRO/C/APP(71)9, Reform of the Organisation, 3 May 1971. See also H. Kaltenecker, 'The Reform of ESRO -- its New Legal Concept and Committee Structure'. ESRO/ELDO Bulletin, IV (1973), No. 20, 8-10.

2/ ESRO/C(71)43, The Governing and Advisory Bodies of ESRO, 8 Sept. 1971.

did not count as a vote. In the case of recommendations, even on matters where the Council would take decisions by a two-thirds majority, both committees proceeded by a simple majority.

The original committee structure of the Council, the STC and the AFC was established for an organisation serving a scientific purpose. There was no committee of member states tasked with discussing the technical and financial implications of the application programme, since the STC was a body of delegates from scientific organisations. Hence, in March 1971, the Council established an Interim Application Programme Committee (IAPC).1/ The IAPC was concerned with the TELECOM programme and the studies undertaken for the aeronautical satellite and the meteorology satellite and studies on maritime and direct TV-satellites.2/ It was to remain an interim committee until a final TELECOM agreement was signed between the participating states and ESRO. Up to then, the IAPC had limited advisory power; it was to

> '...make recommendations to the Council on the preparation of application programmes and supervision of their implementation - including their technical and financial implications - bearing in mind existing or prospective programmes in the member states, receive the views of the user advisory committees and examine their proposals'.3/

The creation of IAPC demonstrated ESRO's shift from scientific research to application work. The table on the following page indicates the organisations of each member state represented on each body. It also indicates which national organisation in the ten countries was associated with the application programme of ESRO.

1/ Up to March 1971, the TELECOM programme was monitored by the STC.

2/ ESRO/IAPC/MIN/1, 8 Apr. 1971.

3/ ESRO/C(71)27, Report to the Council by the Chairman of the Interim Application Programme Committee, 24 May 1971.

Delegates to ESRO's legislative committees 1/	Committees 2/			
	C	AFC	STC	IAPC
Belgium				
Interministrial Commission for Sceintific Policy	X	X		
Ministry of Foreign Affairs	X	X		
Institute for Astrophyxics, University of Liege			X	
Defense Research Establishment				X
Denmark				
Danish Research Administration	X	X		
Institute for Space Research	X		X	
Danish Research Centre for Applied Electronics		X		X
France				
CNES (National Space Research Organisation)	X	X	X	X
Ministry of Industrial and Scientific Development	X			
Ministry of Foreign Affairs	X	X	X	
Italy				
Ministry of Foreign Affairs	X	X	X	X
National Research Council	X			
University of Bologne	X			
University of Milan			X	
Netherlands				
Ministry of Education and Science	X	X	X	X
University of Leiden	X		X	
Ministry of Transport				X
Spain				
Ministry of Foreign Affairs	X	X		
National Commission of Space Research	X			X
International Technical Cooperation	X			
Air Ministry			X	
Sweden				
Ministry of Education	X	X		
Royal Institute of Technology			X	
Kiruna Geophisical Observatory			X	
Board for Space Technology			X	
Ministry of Industry				X
Switzerland				
Genf Observatory	X		X	
Swiss Embassy, Paris		X		X
Department of Telecommunication				X
United Kingdom				
Science Research Council	X	X	X	
Imperial College of Science and Technology	X		X	
Department of Trade and Industry				X
West Germany				
Federal Ministry for Education and Science	X	X	X	X
Max Planck Institute	X		X	
Institute of Physics, University of Bonn			X	
DFVLR (National Space Research Organisation)				X

1/ General Report 1971 (Paris, ESRO, 1972), p. 184.

2/ C - Council; AFC - Administrative and Finance Committee; STC - Scientific and Technical Committee; IAPC - Interim Application Programme Committee.

The meetings of ESRO's committees were attended by the Director-General and staff members of ESRO's permanent body when appropriate. In fact, the permanent body provided the secretariat of the committees. The Director-General drew up the agendas after consultation with the committee chairmen and prepared the minutes of meetings. Decisions and recommendations of the committees were based on documents prepared by the permanent body, such as draft budgets, financial plans and project proposals.

In order to maintain close liaison between the committee structure and the permanent body, ESRO had established a 'Bureau' where the chairmen and the vice-chairmen of the committees met with the Director-General and the upper echelon of the permanent body to discuss and prepare decisions.

Committee members were mainly national civil servants delegated to the various committee meetings by their national authorities. It should be noted that the substantial costs of the committee structure, in terms of salaries and travel, were not paid by ESRO but by the delegating national authorities.

3.2 The executive level: ESRO's permanent body

The Director-General was the chief executive officer and the legal representative of ESRO. The responsibilities of the Director-General and his staff in regard to ESRO were international in character; they were not subject to instruction by any government. The working languages of ESRO were English and French. Staff appointments were expected to afford an adequate distribution of posts among nationals of the member states.

When ESRO was set up, the staff policy was based on two major objectives. First, member states should not be committed for too long in case the organisation were dismantled. Second, the interchange between national and international appointments was viewed as a healthy process. The interchange policy was based on the conviction that it was possible to ensure, on an international basis, flexibility of staff movements among European organisations, industrial firms and public institutions, so that, despite changes of employer and country of residence, each engineer could be assured a career in the space field. In the early years, ESRO's experience proved that this precondition was unrealistic.1/

When engineers or administrative staff were made available to ESRO by public institutions or industry, in most cases their careers in their respective countries came to a standstill during the appointment with ESRO. Even where resumption of their career in their home countries was guaranteed, their career prospects were adversely affected. The strength of this 'career trend' differed between countries, which again only aggravated the problem for ESRO, since it increased the difficulty of attaining an equilibrium in staff nationalities. Hence, by the end of the 1960s, ESRO adopted the principle of

1/ ESRO/C/149, Director General's Policy Statement, 29 Oct. 1969.

a career policy for professional staff. This meant that after a first limited contract, staff were usually offered indefinite contracts. A certain number of more flexible provisions concerning termination of contracts were laid down in order to ensure that work was performed satisfactorily. The recruitment of the most senior posts was different. Posts such as directors and heads of departments were considered to be political appointments, and incumbents were appointed directly by the Council under fixed-term contracts.

The organisational structure of ESRO's permanent body was based on the policy of separating policy elaboration and project execution.1/

Elaboration of policy was in the hands of the Director of Planning and Programmes and the Director of Administration; they, along with the Director-General, were located at the head office in Paris. Whereas the former was responsible for the preparation of short-, medium- and long-term programmes, the evaluation of the corresponding general financial implications and the elaboration of the industrial policy, the latter elaborated policy in the field of finance, personnel and contracts, ensured that homogeneous administrative practices were developed throughout ESRO and was involved particularly in external relations.

Execution of projects was entrusted to the Director of ESTEC and the Director of ESOC. ESTEC, situated in the Netherlands, was responsible for the implementation of satellite projects in industry and for satellite testing. Research on advanced space technology was conducted in ESTEC's Department of Development and Technology. Once the satellite was in orbit, the responsibility for its operation shifted to ESOC in West Germany.

Together with the Director-General, the four directors formed the

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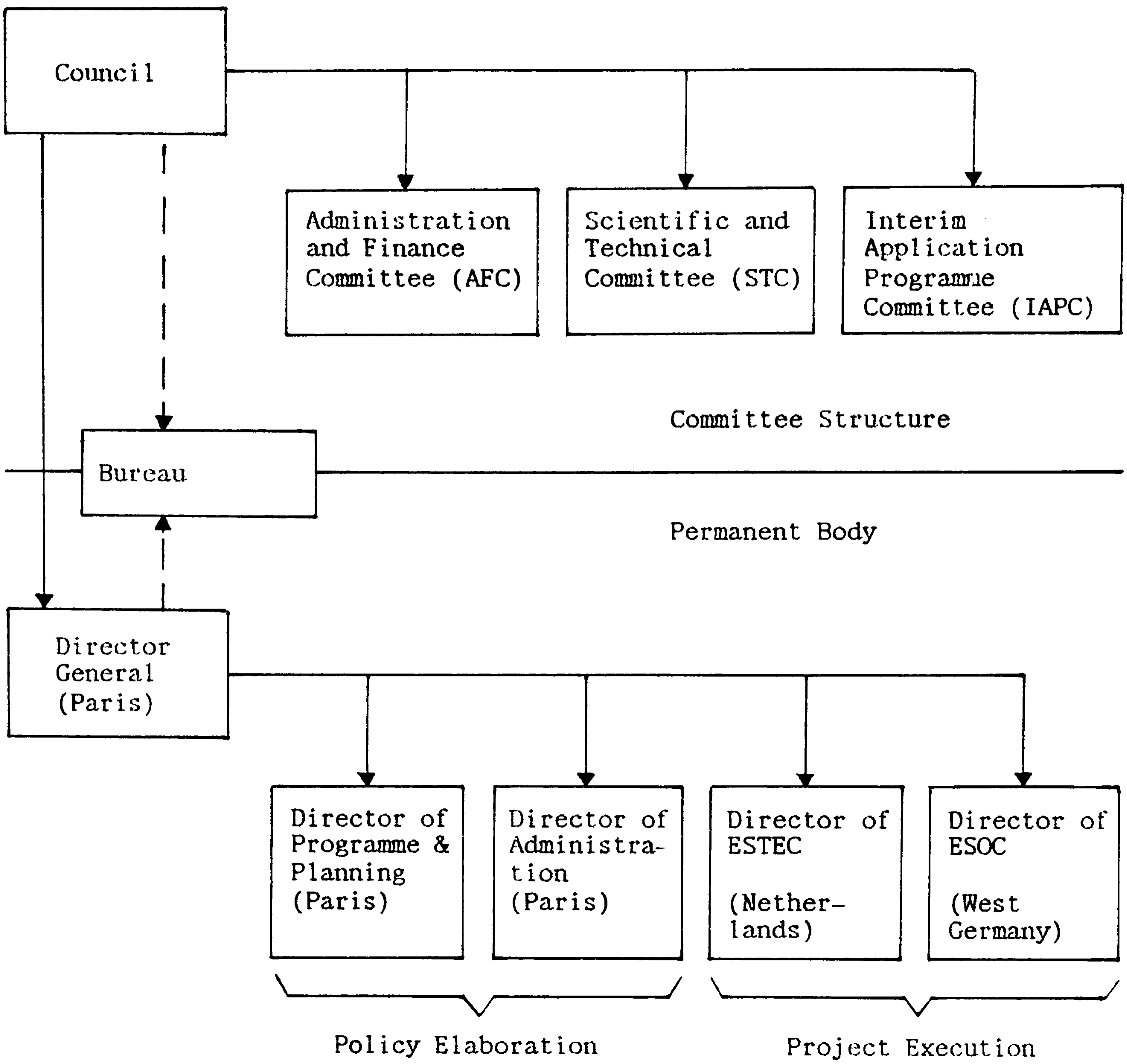
1/ ESRO/C/367/Rev.1, Director General's Statement to Council, 20 Oct. 1968.

Directorate of ESRO. The organisation chart of ESRO is illustrated below.



It should be noted that the ESRO system of 1970 was the result of a major organisational reshuffle back in 1968.1/ Recognising the need for smooth and timely execution of the scientific and technical work, the ESRO system was reorganised on the basis of two recommendation made in the Bannier report.2/ First, authority was delegated from the Council and its subordinate committees to the Director-General. Second, the permanent body of ESRO was decentralised by increasing the autonomy of the local establishments, in particular ESTEC for project management and technological research and ESOC for satellite operations management.

The committee structure confined itself to defining the policy and objectives, taking the decisions of major importance and ensuring that objectives had been realised. The authority of the Director-General was reinforced in the field of personnel and financial administration; his power to effect transfers within the financial plan was extended. In the field of contract approval, only contracts exceeding the value of 250,000 AU had to be submitted to the AFC for approval. In fact, the number and type of problems and decisions to be submitted to the committee structure were sharply reduced.

Decision-making within ESRO had been considerably hampered by the centralised structure during the early years, with tight control by the head office and the Director-General. While the allocation of problem-solving capability to the establishments eased the decision-making process, it resulted in a loss of control and coordination. The responsibility for budget implementation, including prior financial control, had been delegated to the local establishments, with the finance administration of the head office

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1/ ESRO/C/APP/48, Reform of the Organisation, 18 Aug. 1968.

2/ 'The Bannier Report', ESRO Bulletin, III (1967), No. 2, 12-6.

directing its efforts primarily towards the development of financial policy and post-factum control of financial management.

3.3.1 Project management at ESRO

So far, it has been noted that ESRO's activity was based on the concept of separating policy elaboration and project execution. The management of project execution for satellite development at ESRO was basically concerned with two major groups of activities.1/

The first group was the establishment of project requirements, the translation of these requirements into technical specifications, the evaluation of project proposals in the light of all known constraints and the monitoring of industrial contracts.2/ The second group was the implementation of project control, i.e. controlling progress and expenditure during the evolution of the project between conception and completion by seeking to keep the project within the technical, financial and time limits. Whereas the majority of the staff was needed for the first task during the early period of the project, requirements shifted to the second task in the subsequent period.

At ESRO, programme management was organised according to a matrix structure of project team and functional support. The system was based on single project responsibility in the hands of a project manager heading a project team, which received assistance in the form of functional support.

1/ For a discussion of the management of complex projects, see B. Baker, D. Wilemon, 'Managing Complex Programmes: A Review of Major Research Findings', R&D Management, VIII (1977), 23-9; J. Milliken, E. Morrison, 'Management Methods from Aerospace', Harvard Business Review, LI (Mar./Apr. 1973), 6-158.

2/ H. Gehriger, 'Making the Plan Work', ESA Bulletin, III (1977), No. 19, 56-63.

The project team was the coordinating point of project management, which conducted in-house studies and monitored the industrial activity. The support team provided assistance in the area of technology, contract negotiations, administration and project control.1/

ESRO's system for project management had evolved to serve the needs of a multi-project contracting organisation.2/ ESRO staff had to be assigned to projects according to the needs of project evolution. To ensure the efficient employment of personnel, ESRO activities were scheduled as a sequence of overlapping projects carried out within a matrix management system in order to find a viable compromise between fluctuation of personnel, project responsibility and utilisation of staff expertise.

ESRO's activity for the TELECOM programme first started with programme elaboration under the Director for Planning and Programme at the head office in Paris; a working group for the telecommunication mission comprising a staff of five had been established at the beginning of 1970. With the TELECOM programme approval by the ESC in July 1970, a project team headed by the project manager was established at ESTEC. Project and support teams had a staff of twelve by the end of 1970; this increased to 67 by the end of 1971. It was expected that total staff for the TELECOM programme would be peak in

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1/ In the area of project control, very incomplete instruments had been used by ESRO in the past. On the first scientific satellite project, the technical control was taken care of by the day-to-day contacts between ESRO and the contractor's project managers. Time and cost control aspects were not integrated. In particular, engineering change control was not used. Subsequently, a multitude of techniques and methods had been developed to integrate technical, time and cost control, like the Programme Evaluation and Review Technique (PERT), the Critical Path Method (CPM) and Work Package Cost Control (WPCC). See H. Gehriger, 'The ESTEC Project Control System', ESRO/ELDO Bulletin, II (1971), No. 16, 22-32.

2/ Project Management and Project Control (Paris, ESRO/SP-90, 1973).

1974 at approximately 120. The following table provides a breakdown of TELECOM personnel at the end of 1971.

TELECOM Project Management Staff (December 1971)1/

Activity	Project Team (ESTEC)	Functional Support			Total
		Department of Development and Technology (ESTEC)	Department of Administration and Facilities (ESTEC)	Head Office (Paris)	
Project Manager and Secretariat	4	–	–	–	4
Project Control	–	5	–	–	5
Product Assurance	4	3	–	–	7
Satellite System and Spacecraft Technology	15	5	–	–	20
Communication System	4	–	–	–	4
Communication Tech.	–	13	–	–	13
Technology Support	–	4	–	–	4
Contract Negotiators, Draughtsmen, Purchase and Store Officers, Clerks, Translators	–	–	8	–	8
Liaison with CEPT and EBU, Secretariat to Council, AFC and IAPC	–	–	–	2	2
Total	27	30	8	2	67

1/ ESRO/AF(72)18, Staff Complement, 26 Jan. 1972.

3.3.2 The multi-step planning and contracting procedure

During the early years of ESRO, the managment of satellite development was carried out in two steps: after a series of scientific and technical studies had been completed, a competitive tender process was initiated for the awarding of major satellite contracts to industry.1/ The first ESRO satellite project was implemented according to this procedure and ended in a recommendation to the AFC to enter into direct negotiations with the winning industrial bidder. Those negotiations continued for a considerable period. In the case of the scientific TD satellite, they took a whole year in parallel with the completion of the technical, managerial and contractual definition of the project before the final contract was signed. Accordingly, the cost estimate which formed one part of the basis for the go-ahead decision by the AFC when it selected an industrial group was in no way binding on the contractor.

The procedure resulted in large cost increases and slippages that not only burdened the relationship between the permanent body and the AFC, but also cast grave doubts on the choice of the contractors. In fact, it put the bidder in an impossible situation. The dramatic increases of costs and slippages of the scientific TD project pointed out the difficulties of estimating costs at the early stages of a project, which mostly tended to increase over time, and highlighted the need for a new planning and contracting procedure.2/

1/ For details, see P. Conchie, 'The Role of the Project Manager in the Management of Satellite Projects', Journal of the British Interplanetary Society, XXVI (1973), 242-5.

2/ ESRO/GEN/WP/98, Management of Satellite Projects, 26 Mar. 1968.

ESRO's contacts with NASA since the beginning of 1966 had yielded useful input in developing such a new procedure. In fact, the NASA experience had shown that for good cost estimates, it was essential that comparable cost figures be successively compiled as part of the information needed at important decision points.1/ Under previous procedures adopted by ESRO, sufficiently accurate estimates had not been obtained until 75% of contract value was committed, or at the earliest about one year after the start of the development work.

ESRO developed a multi-step planning and contracting procedure, whereby in order to maintain industrial competition, commitment of resources to a project increased with improvement of cost estimate reliability.2/ In fact, the procedure exhibits four distinct steps.

Step 0: Mission Definition or Assessment Stage

After the preliminary project analysis had been finalised, the mission definition evaluated the feasibility of the project approach, identified the advanced research and development efforts required to support the proposed project and made initial cost estimates. Although this was basically an ESRO in-house activity involving five to seven experts, limited definition studies could be awarded to industry. Step 0 normally required three months.

Step A: Project Definition Stage

On the basis of the proposal elaborated during Step 0, a detailed trade-off analysis and preliminary system designs were conducted to establish

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1/ R. Chapman, Project Management in NASA -- The System and the Men (Washington, NASA SP-321, 1973).

2/ ESRO/AF/918/Rev.1, Procédures pour l'Attribution des Grands Contracts Satellites, 14 Nov. 1969; ESRO/C/405, Phased Planning for Scientific Projects - Guidelines, 19 June 1969.

a single project approach. This was done under the direction of a technical study team, which contracted out some part of the study to industry. Up to three fixed-price contracts of equal amounts were awarded on a competitive basis; contractors were selected for their ability to carry out the study, not necessarily to develop the satellite. The studies involved detailed estimates of the development time and cost-to-completion and a thorough description of the satellite and ground support equipment. Step A required approximately six to twelve months and the industrial studies amounted to one to two per cent of final project costs.

Step B: Detailed Definition Stage

Subsequent to Step A, project implementation was carried out by a project team, which maintained responsibility until the satellite had been launched. Following the approval of the satellite project after Step A, two fixed-price contracts of equal amounts were awarded to industry on a competitive basis for a detailed definition study. In addition, those studies allowed the two contractors to elaborate their proposal for the subsequent detailed design and development stage, including the technical concept for meeting the technical specifications, the managment procedure to be employed, the geographical distribution of expenditures and, finally, the tender price. The industrial groups competing for Step B contracts were, in general, those companies which had performed Step A studies. The detailed definition contracts amounted to up to ten per cent of the total project cost and required nine to twelve months.

Step C/D: Detailed Design and Development Stage

Following the finalisation of the detailed definition studies along with the submission of tender proposals for Step C/D by the two Step B contractors, a single contractor was selected. A Step C/D contract covered hardware design and development, fabrication and testing. The contract price was based on the contractor's offer; in general, it was on a fixed-price basis but typically included some cost-plus elements and performance incentives. A Step C/D contract could take up to three years and amount to 50 to 70 MAU.

The new procedure entailed both advantages and disadvantages. On the one hand, the phasing of project work established the premises for the decision to go ahead with the development work after only ten per cent of the total project costs had been incurred. On the other hand, the procedure was more time-consuming. In addition, most of the study work carried out by the losing contractors would not be used. It had been argued, however, that the corresponding project expenditures of the rejected studies were not lost, since they played an important role in training and promoting industry - one of ESRO's overall objectives.1/ Industry favoured the new contracting procedure. The costs of the tender preparation were paid by ESRO, and the new procedure enabled industry to maintain a nucleus of well-trained staff even if unsuccessful in securing the final development contract.

3.3.3 ESRO's industrial policy

As noted above, although ESRO had built up a considerable infrastructure, it had little to do with technological hardware development; rather, it functioned as a contracting agency, monitoring the design, development and production of satellites in European aerospace and allied industry. ESRO's policy towards industry, known as industrial policy, had been of secondary importance when ESRO was set up as a scientific organisation. One industrial policy issue, however, had been considered to be of particular interest right

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1/ Interview with a senior ESA official.

at the beginning, namely the concept of 'fair return'.

Basically, the concept of 'fair return' was the idea that expenditure in a member state should correspond to the contribution of the member state to ESRO. Allocating a 'fair return' of contracts to national industry was not only seen as providing national industry with employment and profit opportunity, but also as enhancing national industrial competence in an advanced technology sector.1/ To this end, the following arrangement was approved concerning the intellectual property rights which resulted from ESRO's contracts:

> 'In contracts involving an element of research, development or experiment,...there should be obtained, as far as is reasonably practicable, sufficient rights of dissemination and use of technical results arising from the performance of the contract to enable those results to be made effectively available in the widest sense'.2/

The interest of the contractor, as against ESRO, was emphasised by the subsequent regulations:

> '...it will be proper, as standard practice, for ownership of intellectual property rights to be left with the contractor and for the rights obtained under the contract to be limited to secure that technical results generated in the performance of the contract shall be available for use free of charge to the organisation and member states only within the field of space research and space technology, with the right to grant sub-licenses only in the field of space research and technology'.3/

The right of member states to grant sub-licences, however, was limited to companies or organisations under their jurisdiction and resident in their territory. It was further agreed that

> '...in contracts requiring the application or generation of commercially

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1/ J. Beattie, J. DelaCruz, 'ESRO and the European Space Industry', ESRO Bulletin, III (1967), No. 3, 3-7.

2/ ESRO/C/305, Principles Governing the Policy and Practice of the Organisation in the Field of Intellectual Property Rights, 27 July 1967, 2.

3/ Ibid.

valuable industrial techniques or manufacturing designs, as opposed to information of general scientific interest, it will be proper for the organisation's right of dissemination of the results of work to be subject to limitations designed to safeguard the commercial interests of the organisation and to limit the use of the results to the persons and purposes agreed'.1/

Whereas the founders of ESRO had emphasised the need for a 'fair return', they failed to lay down an appropriate regulation for the allocation of contracts which would result in such a 'fair return'.2/ At that time, it was assumed that industrial contracts would be allocated on the basis of the most advantageous tenders. In fact, during the first years of ESRO's existence, from 1964 to 1968, contracts were awarded after a competitive contracting procedure to a prime contractor. The prime contractor was free to select subcontractors, which were solely responsible to him, in ESRO member states. In order to put together a competitive tender, the collaborating European companies had to be advanced aerospace firms, which obviously resulted in a concentration of expenditures for development contracts in a few countries. In particular, Italy and Denmark ended up with far less expenditure in their country than was required by the 'fair return' concept.

It was for this reason that the Council passed the following resolution on the 'fair return' issue:

'The Council...instructs the Director General to develop an industrial policy so that contracts are awarded by him and by the AFC in such a manner that...no member state's share is less than 0.7 times its share of contribution'.3/

In order to calculate the amount of contract value received by each

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1/ Ibid., 3. See also ESRO/AF(71)44, General Conditions for ESRO Contracts Royalty Clause, 2 Oct. 1971; ESRO/AFC(75), ESRO Royalty Clause, 14 July 1973.

2/ ESRO/ST/327, Rapport sur la Politique Industrielle, 20 Oct. 1969.

3/ ESRO/C/XX, Resolution 52, 14 Oct. 1968.

member state, a weighting system was used under which the most weight was given to contracts which required considerable research and development; thus, their benefit to national industry was taken into account. Such contracts were also described as 'noble' contracts.1/ In fact, a weighting factor of 0 was applied to staff expenditure and operating expenses, which therefore were not taken into account; a factor of 0.25 to the operation and maintenance of ground facilities; and a factor of 1 to expenditure on satellite research and development, computers, test facilities and telemetry equipment. The return coefficient of a country was then calculated by the following formula:2/

$$\frac{\text{Country's \% of contract value after weighting}}{\text{Country's \% of contribution}}$$

When ESRO began to move towards placing the emphasis of its work on applications rather than on scientific satellites, the concern for a 'fair return' became even more pronounced. In December 1971, the Council decided to increase the minimum return coefficient which a member state was guaranteed from 0.7 to 0.8. In addition, ESRO had set up an Adjudication Group, composed of the Directorate and ESRO staff, to assess the proposed contract awards according to their impact on ESRO's industrial policy, i.e. their impact on the overall distribution of contracts between member states.

At first, ESRO hoped to achieve a 'fair return' by awarding satellite contracts to different countries. When votes were taken in the AFC for the award of satellite contracts, however, it soon became apparent that member states placed a great deal more importance on their industry's share in

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1/ ESA/IPC(76)70, Weighting of Major Contracts, 5 Oct. 1970.

2/ ESA/IPC-IRWG(77)2, Geographical Distribution of Contracts, Rules and Methods of Calculation, 1 Mar. 1972. The procedure took account of the effect of different rates of inflation and variation in the exchange rates of member states' currencies in relation to the accounting unit.

developing the satellite than on the achievements of the scientific research programme or ESRO's industrial policy considerations.1/ In order to overcome this problem, ESRO encouraged the formation of multinational consortia, in which companies from the different member states were arranged in such a way as to spread work among the countries according to their contribution to ESRO.

When ESRO was requesting tenders from industry for large satellite contracts, it indicated the geographical distribution of expenditure which the proposals were to achieve. Since each country's expenditure share in each of the consortia proposals would be about the same, the national representatives of the member states were more likely to base their decision on the trade-off between technical evaluation and tender price when approving the contract, whereas in the former system, national delegations supported the tender which envisaged the largest expenditure share in their own country.

It was not surprising that the consortia system did not eliminate national attempts to influence the decision of ESRO in favour of their national industry. This was particularly true in cases where contracts, because of their limited size or special know-how requirements, were awarded to single companies and small groups of companies or where ESRO attempted to influence a consortia arrangement. In the opinion of the Director-General of ESRO, those national attempts were considered fair as long as they did not limit the freedom of ESRO to select competent contractors:

> '...signals from the member states regarding their hopes and aspirations, I regard this as fair for sometimes...the Secretariat cannot be fully aware of the domestic importance of an award of a particular contract. But there are evident limits: The Secretariat must refuse any attempt to impose a choice of contractor or sub-contractors when it considers the product to be below an acceptable level. Let me say quite clearly that,

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1/ 'Politique Spatiale Européenne', <u>ESRO Bulletin</u>, III (1967), No. 1, 30-1; ESRO/JPPC(73)6, <u>Politique Industrielle</u>, 8 Mar. 1973.

in order to achieve a fair geographical return to all member states, I do not at all rule out the acceptance of a product which is not considered to be the very best; I am merely saying that the Secretariat needs to trade off between quality, price and geographical distribution and that this latter factor is never the determining one'.1/

1/ R. Gibson, 'Space Development Europe', ESRO/ELDO Bulletin, V (1974), No. 26, 9.

3.4 The industrial level: European consortia system

By 1971, the European space industry employed between 7,000 and 8,000 people, 90% of whom were employed by 40 companies. ESRO was their main customer, representing approximately 50% of the market, with the remainder spread among national government contracting (40%) and commercial companies (10%) like INTELSAT.1/

At that time, three major industrial consortia whose composition remained more or less stable had evolved with a formal structure and internal rules; they were MESH, STAR and COSMOS, comprising the following permanent member companies:2/

COUNTRY	MESH	STAR	COSMOS
Belgium			ETCA
France	MATRA	Thomson-CSF SEP	SNIAS SAT
Italy	Aeritalia	FIAR	Selenia
Netherlands		Fokker	
Sweden	Saab	Ericsson	
Switzerland		Contraves	
United Kingdom	HSD	BAC	MSDS
West Germany	ERNO	Dornier	MBB Siemens

1/ ESA/IPC(76)3, EUROSPACE Study, 15 Jan. 1976

2/ G. Dondi, 'European Industrial Consortia for Space Projects - Their Origins, Development and Possible Evolution', ESA Bulletin, VII (1981), No. 24, 72-8.

The other main European companies that engaged in space activities joined one of these three groups for major satellite contract proposals, often from one project to the next: AEG-Telefunken (D) and the companies of the ITT group, such as BTM (B), LCT (F), STC (UK) and SEL (D), particularly for telecommunication matters; and CASA (E), INTA (E), SENER (E), Elektronik-centralen (DK), Terma (DK), CIR (CH) and Philips (NL).1/ The stability of the consortia meant that their speed of reaction to each new requirement of ESRO was considerably enhanced. In fact, this contributed to minimise management efforts, the need to amalgamate work procedures and hence extra overhead. A minimum of three independent industrial consortia were considered necessary by ESRO in order to provide for a sufficient level of competition.

When a consortium proposal was submitted to ESRO, the tender presented the industrial structure, gave a detailed description of the composition of the group, the paths of responsibility within it, the project management and control procedures and, of course, the resulting expenditure in each of ESRO's member states. Each consoritium was represented by a single firm, the prime contractor, which was responsible to ESRO both contractually and in all technical matters.

Besides the prime-contractorship, two other levels of responsibility could be distinguished in the consortia structure: co-contractors, which were responsible for individual satellite subsystems; and subcontractors, which were responsible for equipment. In general, a prime contractor was assisted by three or four co-contractors, in particular to meet geographical

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1/ ESRO/JPPC(73)6, op.cit.

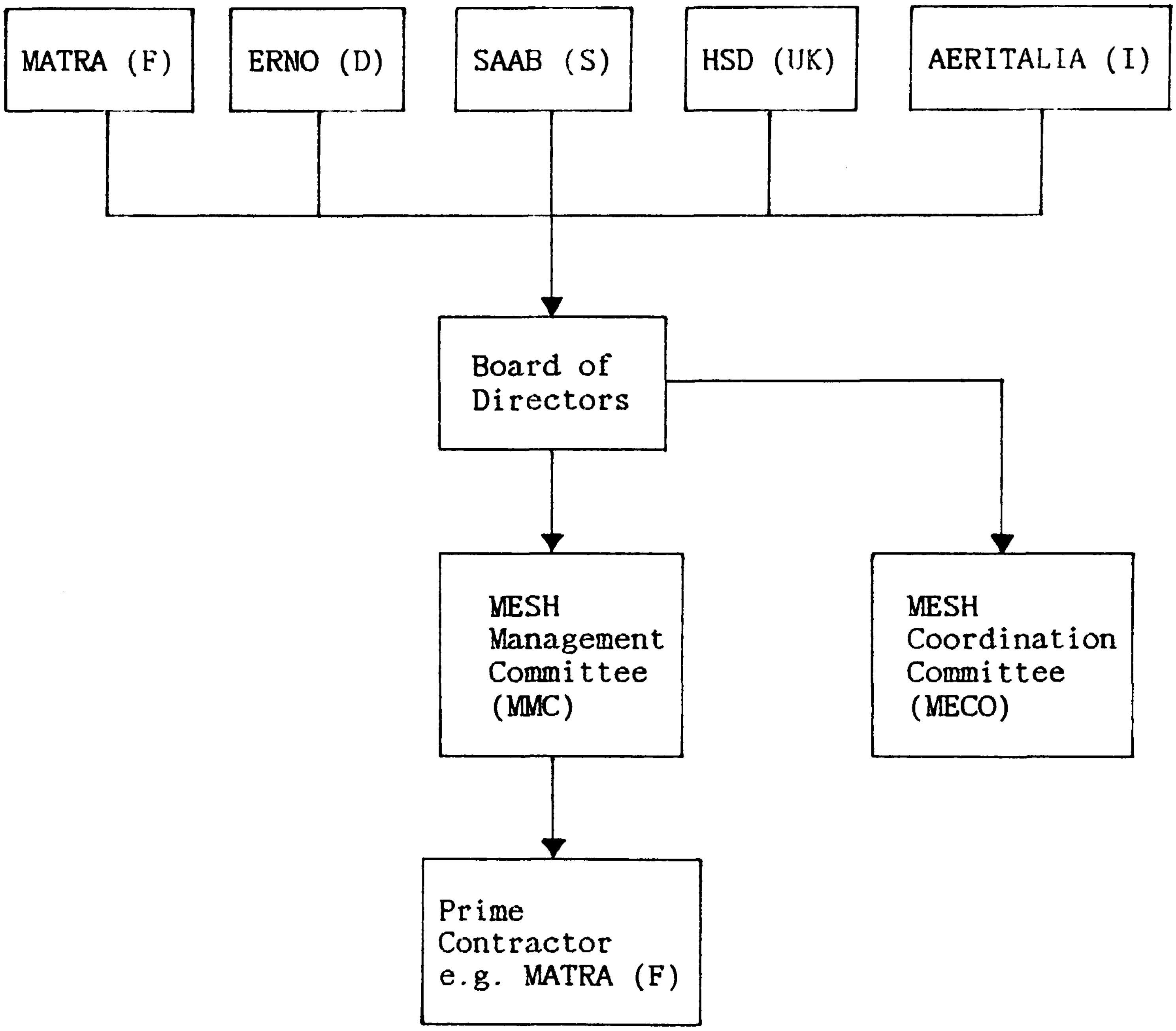
distribution requirements, and ten or more subcontractors.1/ From a technical point of view, the use of co-contractors was not essential. Without co-contractors, the responsibility of the prime contractor would have increased, as was the case in the development of satellites in the USA.2/

Although the arrangements of the three consortia differed, the principles will be described by using the MESH consortium as an example. The Board of Directors of the MESH consortium consisted of the member firms' presidents; it met every six months. Reporting to the Board was the MESH Management Committee (MMC), where the heads of the space departments of the member firms met approximately every four weeks to decide on technical and commercial matters. The project manager of the prime contractor reported to the MMC on issues of project implementation. For project implementation the industrial group, based on the consortium, worked with ESRO solely through the prime contractor. The MESH Coordination Committee (MECO) was responsible for the marketing activity of the consortium. Finally, the consortium had established profit-sharing schemes to reward the individual performance of companies. The arrangement of the MESH consortium is shown on the following page.

1/ There were approximately ten satellite prime contractors in Europe, fifteen co-contractors (the ten prime contractors all appeared as co-contractors) and forty more or less specialised subcontractors. The total number of prime and co-contractors was considered by ESRO to be too large for market needs. For prime contractor/sub-contractor relationships, see C. Claxton, 'Planning Major International Projects', Long Range Planning, XI (Apr. 1978), 25-33.

2/ ESA/C/BUR(79)7, Consideration on Industry Policy, 12 Dec. 1979.

Structure of the MESH consortium 1/



1/ Hochmuth, op.cit., pp. 91-2.

3.5 ESRO's liaison with the user organisations CEPT and EBU

Following the approval of the TELECOM programme by the European Space Conference (ESC) in July 1970, CEPT examined the terms under which it could cooperate with ESRO in its capacity as a potential user and customer of the satellite technology.1/ During its meeting in August 1970 at Montreux, CEPT set up an advisory committee to cooperate with ESRO in the preparation of the TELECOM programme implementation, known as the Working Group on European Communication Satellites. The advisory committee consisted of experts designated by the member countries of CEPT; it met at regular intervals to examine the essential aspects of the TELECOM programme. The advisory committee, in turn, set up a standing group of engineers and administrators, known as the Permanent Nucleus, whose only task was to proceed with the studies on the TELECOM programme. The EBU had established a Working Group on the Satellite Project for Eurovision to study the television aspects of the TELECOM programme; this group subsequently was invited to participate in the work of the Permanent Nucleus.

The contacts between the user organisations and ESRO were basically monitored by the relationship between, on the one hand, the Permanent Nucleus and, on the other, the project staff via the head office in Paris and ESRO's committee structure, in particular the Interim Application Policy Committee (IAPC). The chairman of the Permanent Nucleus, for example, not only attended the meetings of the IAPC as an observer but also those of the contract evaluation board of the ESRO secretariat, which assessed the industrial proposals. The contacts covered a more precise definition of the TELECOM

1/ ESRO/IAPC(71)8, Links with the User Committees, 5 May 1971; CSE/CS(70)13, Letter from the Chairman of CEPT to the Secretary-General of the European Space Conference, 2 Sept. 1970.

mission, such as geographical coverage, amount of traffic to be routed via space, quality of service, and all the technical and economic features of the system.

3.6 Phase I of the TELECOM programme: work plan

With the foregoing outline of the TELECOM management system, it is now possible to describe the implementation of programme phase I.

With the approval of the 1971 TELECOM budget of 5 MAU by the ESRO Council, the ESRO secretariat had been entrusted with programme implementation up to mid-1971, at which point CEPT and EBU would be requested to commit themselves to using and maintaining a European satellite system. On the basis of such a CEPT/EBU commitment, member states were expected to decide on the continuation of the 400/450 MAU TELECOM programme. For the first half of 1971, the ESRO secretariat was charged with preparing the information required for the go-ahead decision by CEPT/EBU and ESRO member states and with initiating preparatory activities in order to allow a smooth continuation of the programme once the approval was given.1/

Phase I of the TELECOM programme included three major activities.2/ First, further studies on the operational satellite, known as the European Communication Satellite (ECS), had to be carried out. The result of those studies, which corresponded to Step 0 of the planning and contracting procedure for satellite projects, would outline the satellite system expected to be ready for CEPT and EBU by 1978/1980. As noted above, the TELECOM programme envisaged the use of technology which European industry was not able to supply without considerable research, development and testing before it could be used in the ECS system. This activity was considered to be risky and time-consuming and was likely to cause a bottleneck in the development of the

1/ 'Key Year for European Satellite Communications', New Scientist and Science Journal, XCI (1971), 303.

2/ ESRO/ST/372, Progress Report on Telecommunication Satellite, 2 Oct. 1970.

ECS satellite if not initiated well before the final satellite configuration was chosen. As the second activity, therefore, ESRO identified equipment which was considered critical in terms of schedule or technology risk. It was proposed to monitor the development of these technologies outside the main ECS development contract under a Support Technology Programme (STP). As outlined above, it had been agreed to qualify the key satellite technologies and to test new communication techniques in a space environment by use of a test satellite before they could be included or used for the operational ECS. The definition of the functions and characteristics of such a test satellite was the third major activity of programme phase I.

The result of the three activities - ECS, Support Technology Programme, test satellite - had to be integrated in what is known as the programme strategy, outlining the time schedule and appropriate allocation of resources for the TELECOM programme. In fact, the programme strategy was expected to be the basis on which the go-ahead decision would be taken. It should be noted that the Support Technology Programme and the test statellite were a particular feature of the TELECOM programme not found in ESRO's scientific satellite projects. This highlights the programme as a major technology development effort. The individual activities will be outlined below.

3.7 The operational ECS

Following the ESRO in-house studies during early 1970, the ESRO secretariat intended to place two parallel Step 0 contracts with industry for a six-month ECS system study, each at a cost of 225 KAU.1/ To do so, the secretariat defined the mission objectives of the satellite in close cooperation with the Permanent Nucleus, which served as the baseline for the call to tender.2/

In October 1970, a letter was sent to 111 firms in Europe notifying them of ESRO's intention to call for tenders for a Phase 0 study of the operational European communication satellite system and requesting them to indicate whether they intended to bid.3/ Fifty-two firms expressed their interest and were sent the tender documents; the delegations of ESRO member states and representatives of the CEPT and EBU also received the documents.

The invitation to tender called for proposals for studies covering the overall aspects of the operational communications satellite system. Various system alternatives were to be examined, in particular those for the space segment (satellite) and the earth segment (ground station) within the framework of the preliminary mission and system boundary conditions. It was intended that those boundary conditions would be updated during the months of the industrial studies and consequently that ESRO, together with the Permanent Nucleus, would closely follow and guide the work of the industrial teams

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1/ For scientific satellites, no Step 0 contracts were awarded to industry in general. In the case of ECS, industry was consulted in order to improve the preparation of the go-ahead decision expected by July 1971.

2/ Since this is the first contracting action, a detailed description of the procedure will be given.

3/ Tender Evaluation Board Report, ESTEC/CO/SC/hb/30117, 18 Dec. 1970.

throughout the duration of the contracts.

On the closing date, 4 December 1970, proposals were received from the three industrial consortia -- COSMOS, MESH and STAR. The proposals were examined by the Tender Evaluation Board, consisting of personnel from the ESRO secretariat; the final assessment was also attended by the chairman of the Permanent Nucleus.1/

The Evaluation Board felt that none of the proposals were entirely satisfactory. The MESH proposal came first, closely followed by COSMOS. The STAR proposal was considered to lack competence in the overall system approach. All proposals, however, were judged above the level of acceptability. Hence, the Board decided to award three studies instead of two as originally planned in order to gain access to the whole of European space industry. Since the 1971 budget was exceeded by the amount of the third contract, the AFC had to approve the new approach.2/

1/ The Tender Evaluation Board (TEB) is nominated by the service initiating the contract action, in this case the project group, in cooperation with the contract department.

2/ ESRO/AF/MIN/77, 23 Dec. 1971.

3.8 The Support Technology Programme

For the various technologies to be developed under the Support Technology Programme, the ESRO secretariat intended to implement 20 to 30 separate competitive contracting actions. In general, study or definition contracts were to be awarded first, followed by development contracts with a total cost amounting to 45 MAU. Contracts under the Support Technology Programme were in general of a 'cost plus' type, where the tenderers' estimates constituted ESRO's limit of liability. For the main satellite development contract, the secretariat planned to negotiate a fixed price contract.1/

By late 1970, the secretariat called for tenders for the first items to be developed. They were considered to be the most critical elements in terms of schedule and risk for the ECS and required the largest share of resources under the Support Technology Programme.2/ They were the travelling wave tube amplifier (TWTA) and the repeater.3/ In fact, the TWTA was a sub-element of the repeater; 20 to 30 TWTAs and 5 to 8 repeaters were expected to be required for the ECS. Because of their crucial importance for the whole TELECOM

1/ A cost-plus contract was justified since accurate pre-estimates of the amount of work involved were difficult. First, there were the technical uncertainties of an advanced technology contract to meet the specifications. Second, as the TELECOM programme was in its early stages, the secretariat was likely to introduce modifications into the specifications. In addition, cost analysis and cost control, which are required by ESRO when awarding cost-plus contracts, would also facilitate ESRO's capability to judge more accurately the estimates of costs for the subsequent development of the technology. For these kinds of advanced technology work, ESRO considered cost-plus contracts to be more economical, since in a fixed price contract a contractor was likely to insist on too high a contingency to cover himself against the risk involved. See G. Hoss, 'The Role of Price-Revision Formula in ESA Contracts', ESA Bulletin, VI (1980), No. 20, 44-7.

2/ ESRO/C/452, Space Application Programme Budget 1970, 29 June 1970.

3/ For details on satellite technology, see appendix B.

programme, the secretariat decided to fund two definition contracts in parallel for both TWTA and repeater. Since there was a high technical risk involved, it was also intended to proceed with the development of the TWTA in parallel, whereas only one contractor would be selected for the development of the repeater. With this approach, the costs were expected to amount to 5 MAU for the TWTAs and 10 MAU for the repeaters.

Since both the TWTA and the repeater constituted the largest technology efforts under the Support Technology Programme, the secretariat instructed industry to submit proposals which envisaged a spread of expenditure in different countries, although a geographical distribution of expenditure according to the contribution of all member states was not required as it was for the main satellite development contract.1/

On the closing date, 4 October 1970, ESRO received three proposals for the TWTA. The tenderers had been asked to give their cost estimates for the definition phase, which would be the subject of the present contract approval, and to indicate their estimates for the subsequent development phase.

The Tender Evaluation Board of ESRO assessed the three proposals as shown on the following page. Since AEG-Telefunken and Thomson-CSF had submitted the most attractive offers in terms of cost and evaluation marks, the Board recommended that AFC approve the award of TWTA definition contracts to them amounting to 249,800 AU and 282,400 AU respectively.2/ Although the AFC unanimously approved the recommendation of the ESRO secretariat, the United Kingdom delegation criticised the offers for not having indicated realistic

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1/ ESRO/AF/1082, Request for Authority to Place a Contract, 6 Nov. 1970.

2/ Since the tender exceeded 250,000 AU, the contract had to be approved by the AFC.

Proposals Prime- Contractor	Sub- Contractor	Marks (out of 1000) 1/	Cost in accounting units (AU)		
			Definition	Development	Total
(1) Thomson-CSF (F)	FIAR (I)	567	282,400	2,150,000	2,432,400
(2) AEG-Telf. (D)	Selenia (I)	558	249,800	1,604,000	1,853,800
(3) STC (UK)	LCT (F)	485	465,000	2,660,000	3,125,000

cost estimates and argued that the figures quoted by STC (UK) were nearer to the truth.2/ In fact, it was possible to submit lower than realistic estimates and recover the shortfall by inflating the cost of the development phase, since the tenderer had only been requested to indicate those costs, and would not be held to them at a later stage. The ESRO secretariat explained the difference of high marks and low costs of the AEG-Telefunken proposal by previous experience which this company had acquired within the Franco-German SYMPHONIE programme for a 4/6 GHz TWTA. In addition, the Italian co-contractor Selenia had built up a relevant background in the national SIRIO programme.3/ It should be noted that one year later, AEG-Telefunken quoted a price of 2.6 MAU for development, whereas Thomson-CSF offered 2.3 MAU, with AEG-Telefunken being 62% and Thomson-CSF 7% above the original estimates.

1/ Highest mark was best. The following aspects of the tenders had been assessed: analysis and solution of the technical problems, reliability and quality product assurance, compliance with ESRO contract conditions, cost analysis, industrial organisation and management. These aspects had been analysed according to a weighting factor. This weighting factor was fixed by the Tender Evaluation Board two days preceding the closing date for the receipt of tenders.

2/ ESRO/AF/MIN/67, 4 Dec. 1970.

3/ See also J. Brettling, 'The Development of Satellite Traveling-Wave Tubes', Journal of the British Interplanetary Society, XXVI (1973), 521-32.

Support Technology Programme, the repeaters, were approved by the AFC in January 1971.1/ Only two industrial groups submitted proposals, outlined as follows:2/

Company				Share in tender	Price in AU
(1)	Prime:	AEG-Telefunken	(D)	50%	1,560,898
	Sub :	Thomson-CSF	(F)	28%	
		FIAR	(I)	16%	
		Ericsson	(S)	6%	
(2)	Prime:	Siemens	(D)	44%	996,926
	Sub :	SAT	(F)	21%	
		MSDS	(UK)	22%	
		Selenia	(I)	13%	

Both proposals were considered to be of excellent quality. The difference in price was the result of the somewhat arbitrary distinction between the definition and development phases. Siemens had obviously chosen to postpone some activities to the subsequent phase. Since the repeater was the key part of the ECS, the secretariat was enthusiastic about the tenders and emphasised

> '...that European industry was very well qualified to tackle the problems connected with telecommunications by satellite'.3/

In fact, this qualification had mainly been gained through national communication satellite projects.

For the same reasons as in the case of the TWTA, both repeater definition contracts were extended by riders with a total contract value of 1.8 MAU (AEG-Telefunken) and 1.6 MAU (Siemens).

1/ ESRO/AF/MIN/68, 29 Jan. 1971.

2/ ESRO/AF(71)5, Request for Authority to Place a Contract, 27 Jan. 1971.

3/ ESRO/AF/MIN/68, op.cit., 6.

Work started in January 1971. In the course of the contract, significant changes were made in the technical specifications by ESRO as regards the power of the TWTA (20 Watts instead of 9 Watts) and the operating frequency and band width (10.95 to 11.70 GHz instead of 11.45 to 11.95 GHz).1/ These changes were made necessary by decisions concerning earth/satellite interface as a result of the studies on the ECS system carried out by the three consortia in parallel, and new frequency allocations made at the World Radio Administration Conference in June 1971.

Owing to these changes, both definition study contracts were extended by a rider amounting to 59,900 AU for AEG-Telefunken and 101,400 AU for Thomson-CSF.2/ As regards the differences between the two riders, the explanation was as follows.3/ AEG-Telefunken had received a large contract in this field as part of the German national advanced research programme and consequently already had a lot of data available. Thomson-CSF was not similarly placed and had to request a much higher price for the specification modification. This price was accepted by ESRO because it wanted to maintain a competitive situation between the two firms. In fact, in addition to West Germany, France and the United Kingdom had launched independent national advanced research programmes for communication satellite technology in support of their own national or bilateral satellite projects. The total expenditure on those research programmes was estimated to be approximately equal to the ESRO effort, namely 45 MAU.

The two contracts for the definition of the second big item under the

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1/ ESRO/AF(72)39, Request for Authority to Place a Contract, 21 Mar. 1972.

2/ ESRO/AF(71)59, Request for Authority to Place a Contract, 25 July 1971.

3/ ESRO/AF/MIN/71, 28 July 1971.

Besides the two cases mentioned, there were a number of smaller contracts awarded for the definition of critical technology equipment or the investigation of advanced communication techniques under the Support Technology Programme up to mid-1971. A list of contracts awarded is given on the following page.

It was the policy of ESRO that the tenderers for the main satellite development contract would not be forced to envisage the use of equipment developed under the Support Technology Programme, but would be free to incorporate equipment from any supplier whatsoever. There was an important exception to this rule. The repeater, TWTA and antenna would be supplied to the satellite contractor under a separate ESRO contract. ESRO expected, however, that in practice, cost, time schedule and equipment quality considerations would lead the tenderers to select suppliers which had developed critical items under the Support Technology Programme. By leaving the choice to the tenderers, they would retain full responsibility for the part of the programme relating to the items of equipment in question. In addition, this approach gave the tenderers more flexibility to put together an offer which they considered to be the optimal proposal.

The distribution of contracts among the countries participating in the TELECOM programme showed rather an unbalanced spread, with expenditures concentrated in West Germany, France and Italy, as shown on page 186.

Although the current expenditure was rather small, made up of small-value study contracts, it was expected that the current distribution of contracts under the Support Technology Programme would not be too different from the final results, since the company or industrial group already concerned with the study stood a good chance in a competitive contracting procedure of being awarded the subsequent high-value development contract.

Contracts awarded under the Support Technology Programme (July 1970 to June 1971) 1/

Equipment	Company (Country)	Contract value in TAU
Payload		
Repeater subsystem		
(1) Repeater definition	a. AEG-Telefunken (D/F/I/S)	1,566
	b. Siemens (D/UK/F/I)	997
(2) TWTA definition	a. AEG-Telefunken (D/I)	250
	b. Thomson-CSF (F/I)	282
Antenna subsystem		
(3) Antenna despin study	Dornier (D)	10
(4) Antenna thermal study	SNIAS (F)	10
(5) Multiple beam antenna study	University of Birmingham	6
Service module		
Attitude and orbital control		
(6) Study of control and stabilisation of a flexible satellite	MBB/FIAR (D/I)	70
(7) Study of non-thermovoltaic infra-red sensors	Galileo (I)	50
(8) Study of thermovoltaic infra-red sensors	Sodern (F)	43
(9) Momentum flywheel study	HSD (UK)	42
Power subsystem		
(10) Study of lightweight rigid solar panels	MBB (D)	150
(11) Study of dynamic behaviour of flexible solar array	SNIAS (F)	56
(12) Battery development study	SAFT (F)	46
(13) Low speed mechanism design study for solar array	HSD/MSDS (UK)	44
(14) Study of optimisation of power regulation subsystem	ETCA (B)	10
Thermal control		
(15) Study of dissipation of high thermal load	MBB (D)	10
	Total	3,636

1/ Based on a compilation of contract documents. See also ESRO/IAPC(71)17, Supporting Technology, 31 Aug. 1971.

Geographical distribution of expenditure: the Support Technology Programme (July 1970 to June 1971) 1/				
Country	Contract value in TAU	Contract share in % (A)	Contribution to TELECOM programme (B)	Return coefficient (A)/(B)
West Germany	1,564	42.9	24.3	1.76
France	984	27.1	20.8	1.30
Italy	671	18.4	13.5	1.37
United Kingdom	311	8.6	22.7	0.38
Sweden	94	2.6	4.9	0.53
Belgium	10	0.3	3.9	0.08
Netherlands	0	0	4.6	0
Spain	0	0	2.0	0
Switzerland	0	0	3.3	0
Total	3,636	100.0	100.0	1.00

During the third IAPC meeting in June 1971, the United Kingdom delegation criticised the unbalanced distribution of contracts.2/ Unhappy with the British share of contracts, the delegation announced that this aspect was of critical importance for the final appraisal of the TELECOM programme by the United Kingdom authorities.

Why was there such an unbalanced distribution of contracts during the early stage of the programme?

Obviously, high technology contracts were awarded to companies with previous experience, built up under national communication satellite programmes. Whereas for large satellite contracts, the consortia system was established to implement a geographical distribution of expenditure according

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1/ Based on the compilation of contract documents. See also ESRO/IAPC(71)7, Geographical Distribution of Contracts under the Communication Satellite Programme, 10 May 1971.

2/ ESRO/IAPC/MIN/3, 30 June 1971.

to ESRO's 'fair return' principle, small-value contracts had to be awarded to a single company or a small industry group. Sharing a 10 TAU contract among nine countries would not make any economic sense. In addition, in order to make a quick start, the ESRO secretariat was obliged to have recourse to existing industrial capability.

Given the current concentration of industrial capability in communication satellite technology in France, Italy and West Germany, the achievement of a fair-return result would have implied a geographical proliferation of technology expertise and duplication of existing industrial capability. This, however, would not only result in higher programme costs but also increase the time required.

Despite the concentration of technology expertise in a few countries, the number of supplier companies for particular satellite components was already considered too high in comparison to the needs of the European market. This had come about mainly as a result of the implementation of a number of independent national and European activities. The solar cell technology used for the production of electric power for satellites was a case in point. Whereas total European expenditure on space, including national and international programmes, amounted to approximately 1/10 of the expenditure in the USA, the number of European solar cell manufacturers was even greater than the number of American manufacturers.1/

In addition to achieving a geographical distribution of contracts based on the 'fair return' concept, ESRO was charged with taking a rational approach in building a European space industry. In view of the European industrial

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1/ Bondi, op.cit., 18; ESRO/C/469, Director General's Policy Statement, 18 Nov. 1970.

reality, this would imply the need to enhance industrial specialisation by limiting the number of existing suppliers.1/ Hence, ESRO's industrial policy was characterised by the following compromise.

First, ESRO was obliged to reduce the number of existing centres of expertise mainly located in a few advanced countries in order to enhance European specialisation. Second, in order to achieve a balanced distribution of contracts, ESRO had to support the creation of new centres of expertise in the less advanced countries, thereby duplicating already existing capabilities in the advanced countries.

The question of European duplication and specialisation, however, was not only an economic problem, but also a sensitive political issue. Obviously, when implementing such a policy, some ESRO member states would have to abandon national technology supply and trade national independence against international interdependence. In fact, member states were often unwilling to do so.

Whereas the United Kingdom, as noted above, complained about the unbalanced distribution of contracts, France, supported by West Germany, demanded that particular care be taken to avoid duplication of development efforts between the TELECOM programme and their national activities and called for concerted action in the area of technology research.

On the initiative of France and West Germany, a round-table discussion group, composed of interested delegations of the IAPC and the Applied Research Development Committee (ARDC), was set up to discuss the possibility of concerted action among the TELECOM programme, other ESRO projects and national

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1/ For further elaboration, see ESA/IPC(77)28, The Agency's Technology Policy, 16 Mar. 1977; ESA/IPC(80)31, General Considerations on the Agency's Industrial Policy, 28 Feb. 1980.

space efforts.1/ Attempting to identify areas where concerted action seemed possible, the group aimed at reducing the cost of the TELECOM programme and not the cost of the national projects. The discussion was attended by the IAPC delegations of France, Italy, Sweden, the United Kingdom and West Germany. The smaller countries did not show any particular interest in participating. Since they had no major national efforts, they seemed happy with the anticipated cost reduction for the TELECOM programme.

Analysing the current and proposed activities, the study group could only identify minor areas of possible duplication between the Support Technology Programme on the one hand and the national activities and ESRO's scientific projects on the other, mainly due to the already advanced nature or the TELECOM programme. It was agreed, however, that this duplication should be eliminated by terminating ESRO's activity.

1/ ARDC was an advisory body composed of experts designated by the ESRO member states. The group was concerned with the examination of technical solutions of scientific research projects in terms of achieving an optimum coordination between joint action (ESRO) and the national action. ARDC attempted to prepare technical solutions compatible with the industrial situation in the member states. In this sense, ARDC was an expert and not an intergovernmental body, although the experts were designated by the member states. See ESRO/IAPC(71)19, Round-table Discussion on Concerted Action, 14 Sept. 1971.

3.9 Test satellite and programme strategy

As noted above, the TELECOM programme envisaged the testing of new technologies and communication techniques by means of a test satellite before they could be used for the operational ECS. The ESRO secretariat was instructed to define the characteristics of such a satellite within an appropriate programme strategy.

In May 1971, the secretariat submitted a paper to the delegation of the IAPC for discussion; a number of options for test satellites and programme strategies were summarized in it. The IAPC was expected during its meeting in June 1971 to make a clear recommendation on one of the options to the Council in order to allow a final go-ahead decision on the TELECOM programme by July 1971.

The ESRO paper distinguished between the three overlapping programme phases, the general pattern of which could vary depending on the programme strategy selected.1/

Programme Phase I: Preparatory Phase

This phase covered the period from the European Space Conference of July 1970 to the end of June 1971 and was nearly completed. During this time, the programme concentrated on defining the ECS system and initiating the development of critical equipment such as the TWTA and the repeater.

Programme Phase II: Test Phase

The test phase involved the development of a test satellite. Such a satellite could be either a derivative of existing national or bilateral communication satellites like the Italian SIRIO and the Franco-German

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1/ ESRO/IAPC(71)9, European Communication Satellite Programme - Proposal by the Director General, 24 May 1971.

SYMPHONIE, both weighing 200 kg (Option I), or a new test satellite with a weight of 500 kg (Option II). Two satellites were proposed, with one as back-up in case of a failure.

Programme Phase III: Operational Phase

The purpose of the final phase was the development of the ECS. Following the selection of a 200 kg modified test satellite during phase II, a prototype of the ECS satellite would be developed, to be closely followed by the operational ECS, both weighing 800 kg (Option I). If a 500 kg test satellite was selected under phase II, it would not be necessary to develop a prototype model owing to the close design features of the test and operational satellites. Hence, one could embark directly on the development of the operational ECS of 800 kg (Option II).

A summary of the options, including their financial and schedule repercussions is given on the following page.

The two principal options differed in terms of their emphasis, either on the test of communication techniques (Option I) or on the test of satellite technology (Option II). With a modified SIRIO or SYMPHONIE satellite, only a limited amount of technology specifically developed for the ECS could be tested in orbit, by comparison with the 500 kg test satellite. In addition, a heavy test satellite would offer an increased communication capacity for pre-operational use. As a result of the early launch date of SIRIO and SYMPHONIE, however, the time available for testing of communication techniques and propagation measurement would be longer.

When the options were discussed at the IAPC meeting in June 1971, it soon became clear that member states with national projects supported Option I, with the version corresponding to their national satellite (Italy - Option I,A; France and West Germany - Option I,B). Countries without a national

Summary of TELECOM strategy options

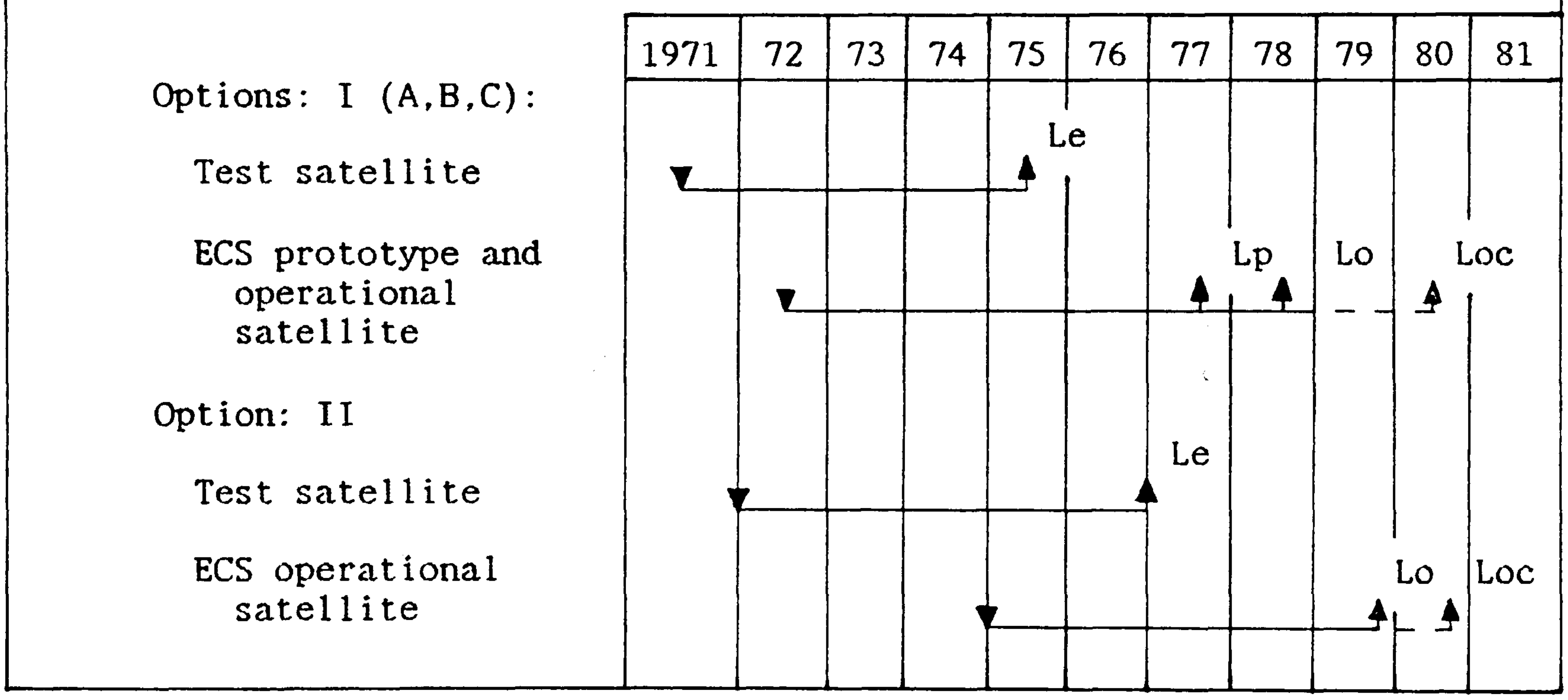
(1) Pattern of satellites

Option	Test satellite	ECS satellites
I, A	200 kg: 2 SIRIO	800 kg: 1 prototype 1 operational
I, B	200 kg: 2 SYMPHONIE	800 kg: 1 prototype 1 operational
I, C	200 kg: 1 SIRIO 1 SYMPHONIE	800 kg: 1 prototype 1 operational
II	500 kg: new satellite	800 kg: 1 operational

(2) Cost estimates in MAU

Option	Phase I	Phase II	Phase III	Total
I, A	5	144	211	360
I, B	5	161	211	377
I, C	5	179	211	395
II	5	255	176	436

(3) Timeframe for development and launch



Start of satellite development under ESRO's multi-step planning and contracting procedure

Satellite launch

Paid for under TELECOM programme:
Le = test satellite, Lo = operational satellite, Lp = prototype satellite

Paid for by user organisations CEPT and EBU:
Loc = operational satellite

effort, notably Belgium, the Netherlands, Spain and the United Kingdom, were strongly opposed to Option I and gave preference to Option II.1/

By supporting the inclusion of their national satellite into the TELECOM programme, the first group of delegations hoped to enhance their home industry's chances of securing a major share of the ESRO contracts. For exactly the same reasons, the other delegations were strongly opposed to Option I. The development of a new test satellite would avoid such a national bias in the joint programme. In fact, the ESRO secretariat had estimated the constraints in geographical distribution of extramural programme expenditure, excluding the launcher. The estimates indicated the percentage of expenditure which was likely to be allocated to companies of certain member states because of their unique competence as a result of the programme strategy; they are shown below:2/

Options: I,A = 40%; I,B = 47%; I,C = 51%; II = 17%

It should be noted that the fair-return principle of ESRO's industrial policy envisaged a balanced distribution of contracts only for the overall ESRO programme, including scientific projects. Whereas scientific projects were based on the desire to make scientific discoveries in space, the TELECOM programme was an attempt to establish an industrial capability in what was considered a strategic technology sector.

CEPT, which attended the IAPC meeting as an observer, criticised all options and emphasised that the programme strategy should provide for tests of communication techniques and propagation measurements (under Option I) <u>and</u> for tests of technology and availability of pre-operational capacity (under Option

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1/ ESRO/IAPC/MIN/3, 30 June 1971.

2/ ESRO/IAPC(71)9, add.1, <u>Presentation of a New Programme Option</u>, 18 June 1971

II). In addition, CEPT expected that the TELECOM programme would provide not only the first operational satellite in orbit but also a back-up satellite on the ground, free of charge to the user organisations.1/

The CEPT position had important financial implications, as it called for an even more ambitious programme than Option II. Obviously, by increasing the activities under the TELECOM programme, CEPT intended to limit the cost of the subsequent operational satellite system which the user organistions would have to pay (see also page 132 to 133).

Trying to find a way out of the deadlock, the French delegation suggested a third option which combined certain characteristics of Option I and II, and commissioned the secretariat to study its implications. Option III was to be discussed at the next IAPC meeting before the July session of the Council, which was expected to take a final decision.

It should be noted that during the IAPC meeting, the delegations of the member states complained about the lack of information which the secretariat provided to the IAPC. In particular, delegations requested more detailed analysis on the elements and cost structure of the various options. The secretariat, however, was not willing to reveal information about internal estimates which could then become known to industry via their national delegation. If industry knew the secretariat's estimates, such information could guide and hence limit competition in subsequent contracting procedures. One could in fact detect a general critical attitude between member state delegations and the secretariat towards each other. Delegations were mostly composed of national civil servants who had been trained as lawyers. ESRO's

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1/ ESRO/IAPC/MIN/3, Annex II, Presentation by Mr. Y. Fargette; Annex III, Statement by Mr. Y. Fargette, 30 June 1971.

staff were technically oriented people such as engineers, physicists and administrators. Their attitude was that member state delegations did not really understand the problems involved in advanced technology projects. The less they knew, the better.1/ They were seen as hindering 'proper' project implementation. On the other hand, member state delegations felt that they were deprived of information and that the ESRO secretariat assumed responsibility which was considered to belong to member state delegations.

Besides communication problems between different occupational groups, it should be noted that the ESRO secretariat had developed an identity of its own during the eight years of its existence. It had built up a strong technical and management capability, making use of extensive ESRO-owned facilities, and it could look back on a rather successful history. The secretariat did not consider itself merely an instrument for the execution of policies decided by member states, but had developed its own personality which influenced the course of events.

In early July 1971, ESRO presented Option III to the IAPC.2/ It envisaged the use of the national satellites SYMPHONIE and SIRIO and the development of the ECS with a second, back-up unit. The costs were estimated at 448 MAU, the highest so far, with 33% of expenditures being subject to constraints in geographical distribution, a figure somewhere between Options I and II. Obviously, a compromise was being offered at the expense of higher costs.

During the meeting of the IAPC, it became clear that the United

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1/ Interview with a senior ESA executive.

2/ ESRO/IAPC(71)9, Add.1, op.cit.

Kingdom,1/ supported by the Netherlands, Sweden and Spain, were still strongly opposed to any national bias in the joint programme, opting for Option II, whereas Belgium, France, Italy and West Germany now supported Option III.2/ CEPT made it clear that it could accept Option III and, subject to certain conditions, also Option II.3/

The IAPC was unable to reach a decision on the recommendation of one option. Consequently, the committee decided to pass the problem on to the Council, hoping that agreement could be reached at a higher level of decision-making. In fact, the July meeting of the Council was not only expected to adopt the programme option but also to decide on the go-ahead of the programme beyond the approved time frame ending by mid-1971. Before the national delegations could decide on the continuation of the programme, however, CEPT and EBU had to express their firm intention to use the operational ECS system.

A few days before the July meeting of the Council, CEPT made available its own report which contained views on the technical, financial and management aspects of the operational ECS system from the user perspective. Most important, the report outlined the conditions on which CEPT and EBU would be willing to commit themselves to using the system. The report arrived at a disastrous conclusion.4/

1/ ESRO/IAPC(71)14, United Kingdom Delegation Note on Choice of Options for the Communication Satellite Programme, 29 June 1971.

2/ ESRO/IAPC/MIN/4, 20 Aug. 1971.

3/ ESRO/IAPC(71)15, Statement by CEPT, 9 July 1971.

4/ Doc T/CCTS(71)24E, Study on the European Telecommunication Satellite System, July 1971; see also 'Will Domestic Satellites Get off the Ground', New Scientist, LXXXII (1972), 197-8.

Excluding the subsidy of the TELECOM programme, estimated at 436 to 448 MAU depending on the option selected, the total investment of the national post and telecommunication authorities using the ECS system would amount to 139 MAU to 230 MAU between 1980 and 1990 subject to the hypothesis chosen. This amount would include the procurement and launch of subsequent ECS satellites, the establishment of approximately 20 satellite ground stations in the participating countries and the operating cost of the system. As a result of the ECS system, the corresponding saving in the terrestrial network, however, would only be in the region of 84 MAU. Hence, the cost of the ECS system was in excess of the terrestrial savings by some 65% to 110%.1/

To overcome this large economic gap, CEPT proposed that ESRO should make up the difference in costs between the ECS system and the terrestrial system, on the assumption that the telecommunication administrations would normally only have to cover the costs of the latter. CEPT made it clear that the national PTTs could not commit themselves to using the ECS system until this economic aspect was settled.

During its July meeting, the Council was upset about the CEPT position as documented in the economic study.2/ In particular, the member states of ESRO were uneasy about having to give a guarantee regarding the commercial viability of the operational ECS system on the basis of the CEPT evaluation. The CEPT study, however, also revived some critical considerations among the national delegations concerning the viability of the system; the British

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1/ The ESRO secretariat had criticised some of the assumptions of the CEPT study; in particular, it complained that the failure rates of satellite launches were overly pessimistic and the calculation did not take into account the higher quality and flexibility of satellite communication links in comparison to a terrestrial network.

2/ ESRO/C/MIN/39, 3 Aug. 1971.

delegation remarked:

> '...had the project under discussion been a United Kingdom national project, it would certainly have been turned down in view of the CEPT report and in view of the fact that it would probably be necessary to subsidise the programme during the operational phase'.1/

Quite clearly, the Council could not approve the TELECOM programme or select a programme strategy option in this situation. Having received so much support during the European Space Conference back in July 1970, the TELECOM programme was in jeopardy once again.

The Council managed, however, to define a 'holding situation' characterised by referring the current conflicts to future meetings, a cautious attitude towards new financial commitments in the years to come and a desire to budget for a lower overall programme cost as a result of the disappointing reaction from the user organisations. In fact, the Council instructed ESRO to restructure the whole programme as follows.

First, on the basis of the argument that the CEPT authorities had opted for more pessimistic assumptions in their study than were justified, an intermediate programme phase was to be outlined, which would give CEPT the chance to postpone the final decision until the remaining uncertainties were resolved. Second, up to the time of final programme approval, the intermediate programme phase should only provide for a reduced yearly budget. Third, the TELECOM programme, including the ECS, should aim at a total programme cost substantially below those of the current options.

Following the Council meeting, the relationship between CEPT/EBU and ESRO, which had been characterised by close cooperation during the period from

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1/ ESRO/C/MIN/42, 3 Dec. 1971, 14.

July 1970 to July 1971, became worse as a result of the unfavourable impression which the CEPT report had made on ESRO. 'Political difficulties',1/ as this was called at a later stage, were evident in the fact that the ESRO secretariat did not even officially reply to the CEPT study. Disappointed by ESRO's reaction, and in the light of the vague future of the TELECOM programme, CEPT suspended its Permanent Nucleus consisting of six people working full-time.

In the month following the July meeting of the Council, the ESRO secretariat elaborated an intermediate programme. In order to achieve the requested cost reduction, particularly in the early years, it was considered that the intermediate programme would not be financed solely under the TELECOM programme but within a cooperative framework.

Two possible alternatives for cooperation were studied.2/ First, cooperation with the on-going SYMPHONIE programme. Second, cooperation with COMSAT in an experimental satellite project, which was envisaged as the preparatory phase for the development of the new INTELSAT V communication satellite series. In fact, an experimental satellite for the INTELSAT V programme could be seen as a parallel activity to the intermediate phase of the European TELECOM programme, with similar technology and mission objectives. The ESRO secretariat had established exploratory contracts with COMSAT, which declared its intention to report these talks to the governing body of INTELSAT. If reaction was favourable, more formal negotiations could

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1/ ESRO/IAPC/MIN/10, 2 Mar. 1972, 16.

2/ ESRO/IAPC(71)28, Study of a New Approach to the Programme Objectives, 9 Nov. 1971.

start.1/

The ESRO secretariat was more enthusiastic about possible cooperation with COMSAT/INTELSAT than about the SYMPHONIE programme. It was expected that such cooperation would give European industry access to the American state-of-the-art communication satellite technology. As a consequence of this cooperation, however, the launch of the ECS would be put back by 12 to 19 months, to 1980.

COMSAT motivation in such cooperation was different. As noted on page 120 to 121, there was permanent conflict between the American company COMSAT, manager of the INTELSAT system, and the European representatives on the governing body of INTELSAT. COMSAT wanted an experimental programme in order to generate income and utilise its extensive facilities. The member states of INTELSAT, with the exception of the American representative in the form of COMSAT, favoured direct development of INTELSAT V, owing to the lower cost involved and the advanced stage of American industry. Up to then, COMSAT had alone carried out some studies on an experimental satellite on its own initiative, with no decision having been taken by the governing body of INTELSAT. A reduction of costs via a cooperative arrangement and the participation of European industry could enhance the chance of a preparatory phase being approved by INTELSAT.

At the ninth meeting of the IAPC in November 1971, two new programme strategies (Option IV a and b), including an intermediate phase, were

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1/ Collaboration on an experimental satellite was envisaged to develop along the following lines:
- ESRO participation between 30% and 40%,
- satellite design by a mixed ESRO/COMSAT team,
- satellite development by European industry under ESRO contract and by American industry under COMSAT contract.

presented to the national delegations. The financial implications of the new option were as follows:

Option IV of TELECOM programme with cost in MAU at mid-1971 prices 1/					
Option	Test satellite	Phase I	Phase II intermediate	Phase III operational	Total
IV a	SYMPHONIE	5	43 - 67 2/	257 - 357 3/	305 - 429
IV b	COMSAT/ INTELSAT	5	100	167 - 295 3/	272 - 400

The IAPC was asked to select one option and recommend the implementation of the intermediate programme phase to the Council. At that stage, no decision was required on phase III of the TELECOM programme, including the selection of the ECS satellite size. Those decisions would have to be taken after the user organisations CEPT and EBU had committed themselves to using the ECS system, which was expected sometime in 1975.

The IAPC delegations were enthusiastic about possible collaboration with COMSAT/INTELSAT. Only France and West Germany still demanded that the SYMPHONIE version should be explored further and maintained as a programme alternative. Both delegations, however, accepted the COMSAT/INTELSAT alternative in principle.

The CEPT representative, who attended the IAPC meeting for the first time in July 1971, took a more critical approach. First, he expressed some resentment towards ESRO, which had not consulted CEPT/EBU in the evaluation of

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1/ ESRO/IAPC(71)28, op.cit.; ESRO/IAPC(72)7, Review of Discussion on a Possible ESRO/INTELSAT Collaboration, 15 Feb. 1972.

2/ Depending on the extent of ESRO's financing share.

3/ Lower limit applies to 400 kg and upper limit to 800 kg ECS baseline.

the new option. Confronted with the results for the first time, he could not judge the suitability of the new approach, but he underlined the uncertainties still involved due to the fact that until then INTELSAT had not decided to go ahead with the experimental satellite.

Despite CEPT's reservations, the IAPC recommended unanimously that the Council approve the intermediate phase of the TELECOM programme involving the INTELSAT/COMSAT cooperation.1/

1/ ESRO/IAPC/IX/Res. 5, 17 Nov. 1971.

3.10 Approval of TELECOM programme phase II and reform of the organisation: ESRO Council meeting, December 1971

The Council was not only requested to approve the intermediate phase of the TELECOM programme but also to decide on the reform of ESRO initiated by France and Belgium back in December 1970. It should be recalled that both countries had threatened to leave ESRO if the organisation failed to agree on a new participation concept whereby member states could decide on a project-by-project basis on the extent of their participation. In addition, both countries demanded a reduction of ESRO's scientific work in order to be able to fund new application activities. With the approval of the resolution on the 'Reform of the Organisation' at its 43rd meeting in December 1971, the Council managed to agree on a new foundation for ESRO.1/ The resolution included the definition of the financial commitments for the various ESRO activities for the next three-year planning cycle (1972-74) and defined both the baseline for the negotiations on the TELECOM agreement regarding the detailed terms and conditions of programme execution and the baseline for the negotiations on the revision of ESRO's convention primarily to allow for project-by-project participation.2/ Concerning the TELECOM programme, the following was agreed:

> 'Belgium, France, the Federal Republic of Germany, Italy, Sweden, Switzerland and the United Kingdom have decided to participatein a communication satellite programme that will comply with the requirements of the CEPT and EBU, to undertake Phase II of the programme lasting from 1972 to 1976 at a maximum cost of 100 MAU (at mid-1971 prices), and in the first half of 1975, by a two-thirds double qualified majority, to

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1/ ESRO/C/MIN/43, 14 Dec. 1971; ESRO News Release, 'ESRO Council Approves Resolution Governing 1972-1980 Programme', 9 Dec. 1971; 'ESRO Council Meeting Held on 20 December', ESRO/ELDO Bulletin, III (1972), No. 17, 7-18.

2/ ESRO/C(71)67, Level of Resources - Note by the Director General, 6 Dec. 1971.

define the content of, and decide whether to undertake, the succeeding phases of the programme'.1/

Until then, Spain, the Netherlands and Denmark had not decided to participate for different reasons. Although Spain was interested in participating, the delegation decided that Spain had to abstain from the TELECOM programme so as to maintain Spain's financial participation in European space activity not only within the limits of its financial possibilities, but also within the limits of Spain's industrial capacity to absorb 'return' contracts.2/

The Netherlands was unhappy with the decision on how to proceed to the next stage of the TELECOM programme, arguing that a double qualified majority would discriminate against member states with a smaller contribution to the programme. Whereas the major contributors had much greater power to obstruct the required two-thirds majority of contributions, the smaller contributors were less able to opt out of the programme after phase II and could be forced to continue to contribute to a new phase against their will. In fact, the Netherlands had proposed to proceed from one phase to another by unanimous decision. The participation procedure, however, was considered the right compromise between two requirements. First, no participating country should be forced to stay in the programme if the initial assumptions proved to be drastically wrong. Participating countries would be able to withdraw from the programme if the programme cost overrun exceeded 20%. Second, no participating country should be in a position to stop the programme

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1/ ESRO/C/XLIII/Res., 3 (Final), Resolution on the Reform of the Organisation, 22 Dec. 1971, 2. Although the resolution did not represent the final TELECOM agreement between participating member states and ESRO, it constituted a programme approval on the basis of general principles.

2/ ESRO/AF/MIN/74, Declaration of the Spanish Delegation, 21 Oct. 1971.

unilaterally by discontinuing its participation.

Finally, at that time Denmark was unable to decide on its participation in the ESRO programme. As noted above, Denmark, like Belgium and France, had announced its intention to withdraw from ESRO because it was unhappy with the share of Denmark's industry in ESRO contracts.1/

The resolution on the TELECOM programme only defined a commitment to finance phase II (100 MAU), leaving the decision on an indicative financial plan for phase III up to the participants at a later stage. The United Kingdom delegation feared that the deletion of an indicative programme cost might be taken to mean that there was no ceiling for the TELECOM programme. Only providing that it was clearly understood by all delegations that the ceiling for the TELECOM programme was 400 MAU could the United Kingdom approve the programme. In addition, the delegation made it clear that when the time came for a decision to embark on phase III of the programme, probably in 1975, the United Kingdom would vote against continuation of the programme if the user organisations did not commit themselves to using the system. If this was the case, the opinion of the United Kingdom would

> '...not be influenced by arguments of a political nature which might, in the view of some countries, militate in favour of continuing the programme'.2/

Concerning the reorientation of the programme concept to allow project-by-project participation, the resolution set out the following

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1/ At a later stage, Denmark reversed its intention to withdraw from ESRO and decided to participate in the TELECOM programme since measures had been implemented to increase Denmark's industrial share.

2/ ESRO/C/MIN/42, 3 Dec. 1971, 14.

principles.1/ ESRO's activities were broken down into a mandatory programme, including scientific and basic activities, and an optional programme, including application programmes. All ESRO member states would have to participate in the mandatory programme according to the GNP formula, whereas the member states were able to decide if they wanted to participate and what share of the programme expenditure they wanted to cover in an optional programme. Those countries taking part in an optional programme would be represented in a corresponding Programme Board, the supreme body, responsible for taking decisions specific to the implementation of that programme. In particular, the Board would observe the time schedule and fix the annual budgets.

Although the TELECOM programme was an optional programme, the participating countries agreed to share the programme cost according to the GNP formula, since the 'big four' - France, Italy, the United Kingdom and West Germany - were eager to take a substantial share in this programme. The contributions to the 1972 TELECOM programme budget are shown on the following page.

Two other major application satellite programmes were in preparation at that time. First, AEROSAT, a satellite intended to be used as a navigation aid and communication facility for air traffic across the Atlantic, proposed as a cooperative project between ESRO and NASA.2/ Second, METEOSAT, a weather recognition satellite, intended to improve weather forecasting.

Whereas the new programme concept provided for participation flexibility

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1/ See also ESRO/C/APP(71)9, Reform of the Organisation, 3 May 1971.

2/ The AEROSAT project was later abandoned since the US decided not to participate.

Contributions to the TELECOM programme in 1972 1/		
Member state	Contribution in %	Contribution in AU
Belgium	4.06	660,928
Denmark	2.42	392,324
France	23.70	3,858,123
Italy	15.07	2,453,245
Netherlands	-	-
Spain	-	-
Sweden	5.02	817,206
Switzerland	3.48	566,509
United Kingdom	20.60	3,353,474
West Germany	25.66	4,177,191
Total	100.00	16,279,000

in application projects, the approved level of resources for the next three-year planning cycle indicated a major shift of resources from scientific research towards applications, in addition to an increase in total resources. The application projects were expected to increase from 13% of total ESRO expenditure in 1971 to 65% in 1975. The estimated level of resources for ESRO's activity is given on the following page.

With the adoption of the resolution on the reform of ESRO, the demands made by France with the support of Belgium back in December 1970 had basically been accepted. As a result of this, both countries continued their membership in ESRO and even played a more dominant role by taking an above-GNP share in the growing application programme.2/

1/ ESRO/AF(71), Rev. 2, Scale of Contribution, 4 Dec. 1971.

2/ ESRO/C(72)1, Withdrawal of France's Denunciation of the Convention, 5 Jan. 1972.

Level of resources for the period 1972-1977 in MAU 1/

	Activity	Present	Next three years planning circle			Indicative		
		1971	1972	1973	1974	1975	1976	1977
Optional Programme	TELECOM 2/							
	Phase I	5.0						
	II		15.7	20.7	24.6	25.2	13.8	
	III						11.6	29.0
	AEROSAT 3/	5.0	4.0	17.9	20.5	18.0	18.8	6.2
	METEOSAT		2.1	7.9	16.3	26.8	25.8	25.0
	Other applications							9.8
	Contingency		1.0	2.0	2.0	2.0	2.0	2.0
	Total	10.0	22.8	48.5	63.4	72.0	72.0	72.0
Mandatory Programme	Science	49.0	41.7	36.0	31.7	27.0	27.0	27.0
	Basic activities	16.0	11.5	12.5	11.0	10.0	10.0	10.0
	Contingency		1.0	1.0	1.0	1.0	1.0	1.0
	Total	65.0	54.2	49.0	43.7	38.0	38.0	38.0
Grand Total		74.0	77.0	97.5	107.1	110.0	110.0	110.0

1/ ESRO/AFC(71)60, Rev.1, Level of Resources, 1 Dec. 1971. Resources are shown at mid-1971 prices.

2/ Maximum cost of the TELECOM programme is 400 MAU, with Phase II amounting to 100 MAU.

3/ Reflects 50% of European cost share for the proposed joint ESRO/NASA programme.

CHAPTER 4

TELECOM PROGRAMME PHASE II

4.1 Phase II of the TELECOM programme: work plan

Subsequent to the Council decision in December 1971, the intermediate phase (phase II) of the TELECOM programme started early in 1972.1/ Programme implementation continued in parallel to the drafting of the final TELECOM agreement between the participating states and ESRO. This agreement would not only describe the general characteristics and principles already approved by the Council but also details still to be decided such as the technical features of the test and ECS satellites, annual budgets, etc.

The table on the following page gives a summary of the TELECOM work plan, particularly for phase II, which had a budget of 100 MAU; one third of this was earmarked for ESRO's internal costs, including direct, common and support costs.2/

It should be recalled that the awarding of new industrial contracts had virtually come to a standstill during the second half of 1971 as a result of the non-approval of the TELECOM programme.3/ The approval was originally envisaged for July 1971. ESRO was now able to continue programme

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1/ ESRO/C(72)8, Note by the Director General on Action to be Taken Following the Council's Decisions on Reform of the Organisation, 15 Feb. 1972.

2/ With the introduction of optional programmes, ESRO replaced its traditional input budget, which had been in operation since 1962, by project budgeting. The budget distinguished between external direct costs (industrial contracts) and internal ESRO costs. Internal direct costs could be directly attributed to the programme; internal support costs were charged on the basis of the use the programme made of support facilities; and internal common costs were apportioned pro rata to the internal staff costs.

3/ ESRO/IAPC(71)10, Telecommunications Programme Budget, 3 June 1971.

TELECOM programme Phase I and II with cost figures in MAU at mid-1971 prices 1/

Activities	Phase I		Phase II					Cost of Phase II	
	1970	1971	1972	1973	1974	1975	1976		
(1) ECS									
- System		Step 0	Overall system studies/transmission studies/propagation experiments/earth station					7.87	Industrial contracts 68.40
- Satellite			Step A	Studies		Step B		5.50	
(2) Support technology programme - Communication technology			TWTA/repeater/antenna					17.38	ESRO cost: personnel, investment, facilities 31.60
- Spacecraft technology			Structure/attitude control/thermal control/power system/etc					17.65	
(3) ESRO/INTELSAT test satellite		ESRO/INTELSAT negotiations/studies		Test satellite development & manufacture			Launch	20.00	Total 100.00

Annual budgets (MAU)		1970	1971	1972	1973	1974	1975	1976	
	Phase I	0.5	4.5						5 (1970/71)
	Phase II			15.7	20.7	24.7	25.2	13.8	100 (1972/76)
	Phase III							11.6→	167-295 (1976/80)

ESRO/IAPC(72)6, <u>Proposal for the Execution of Phase II</u>, 25 Feb. 1972.

implementation within the approved 1972 TELECOM budget of 16.3 MAU in payment appropriation and 18 MAU in contract authority.1/

As in the previous chapter, programme implementation will be described by distinguishing between three major activities: ECS, Support Technology Programme and test satellite.2/

1/ Contract authority refers to the value of contracts placed during the financial year. Payment appropriation refers to the value of payment due in the financial year. The payment appropriation corresponds to the income side of the budget.

2/ A detailed description of the proposed programme is given in the ESRO document European Communications Satellite Programme, Programme for the Execution of Phase II, ESTEC, Feb. 1972.

4.2 The operational ECS

The first milestone was reached in July 1971 with the completion of the ECS system studies (Step 0) carried out in parallel by the three consortia COSMOS, MESH and STAR.1/ These studies were used by the ESRO secretariat as the basis for detailed studies on ECS system parameters, such as satellite configuration, communication techniques, propagation experiments, earth station, etc.2/ In January 1972, the ESRO secretariat awarded satellite configuration definition studies (Step A) of six months' duration to the three consortia COSMOS, MESH and STAR at a cost of 200,000 AU each.3/

For the award of Step A studies, the work distribution between the companies of the participating member states was not considered to be important for achieving a balanced distribution of contracts for the programme as a whole owing to the small amount of money involved. The consortia were free to organise the work according to their own experience and the requirements of clear technical interface. The study contents relating to subsystems, however, had in general already been allocated according to the probable geographical distribution for the subsequent development and production phases, since it did not make sense to shift responsibility at a later stage. As a result, some companies in the consortium study had very little work to do. Hence it was evident that a higher percentage of the

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1/ 'ESRO TELECOM', Raumfahrtforschung, XII (1971), No. 6, 298.

2/ For a description of the satellite system, see appendix B.

3/ On completion of Step A studies by mid-1972, a two-year lapse would be ensured before Step B commenced, during which time both the Support Technology Programme and the test satellite activities would progress. The subsequent Step B studies would still be covered by TELECOM programme phase II, whereas the development and production of the ECS (Step C/D) would be covered by phase III.

available money was not going directly into engineering work but was spent on travel to attend necessary clarification, review and presentation meetings. On average, this activity accounted for approximately 30% of a Step A contract. The corresponding figure for a similar study in the USA, where the only communication is between the customer and the company carrying out the study, was less than 5%.1/

While each of the consortia investigated a distinct case under Step A contracts, namely a single 400 kg satellite, a twin 400 kg satellite and an 800 kg satellite configuration, the results of the studies showed a remarkable convergence of proposed technical solutions at the subsystem level.2/ This was probably the result of the stringent specifications within which the satellite mission had to be realised, necessitating the use of techniques and components of an advanced nature in many areas.

Concerning communication techniques, preliminary examinations of new techniques such as speech-interpolation, frequency re-use, pulse code modulation and time division multiple access (TDMA) were carried out. Transmission test equipment was procured to verify the validity of the theoretical approach.3/

1/ H. Tolle, 'Management Problems in European Projects with Regard to the Geographical Distribution of Tasks', Journal of the British Interplanetary Society, XXVII (1974), 321-7.

2/ Technical similarities in all three consortia studies were:
- identical modular repeater elements;
- same power conditioning;
- sun tracking, north-south oriented, deployable arrays;
- similar TT&C subsystems;
- precision two axis horizon sensor;
- double-gimballed momentum wheel on orbit stabilisation.

3/ ESRO/PB-TEL(72)1, Study of a New Approach to the Programme Objectives, 25 Aug. 1972.

A programme of propagation experiments aimed at obtaining a statistical picture of the propagation effects at 11/14 GHz in the whole European area. Those measurements were carried out by the German, Italian, Swedish and Swiss telecommunication administrations under ESRO contracts.

Activities in the area of earth stations, however, did not develop significantly. ESRO planned to seek the cooperation of CEPT and EBU to establish an inventory of relevant activities in the member states, and contracts with industrial companies were placed to study the effect of equipment design on the overall system configuration.

4.3 The Support Technology Programme

With ESRO/INTELSAT cooperation now being envisaged for the test satellite, the Support Technology Programme was revised to allow for the production of equipment on a time-scale consistent with the launching of the test satellite by the end of 1975. The final definition of the content of the whole programme was updated in the second half of 1972, after the results of the ECS Step A studies became available.

It should be recalled that the two items, TWTA and repeater, had been contracted to industry under the Support Technology Programme in 1971. Meanwhile, as a result of the overall system studies (Step 0) and frequency changes imposed by the World Radio Administration Conference, important technical modifications were introduced by mid-1971. Owing to the considerable cost increase resulting from those technical modifications, it was no longer possible to continue both activities in parallel to the extent originally planned and stay within the financial programme budget. In particular, the two contracts for the definition of the repeater awarded to the consortia AEG-Telefunken and Siemens, had increased from a total of 2.6 to 4.4 MAU.1/

In March 1972, the ESRO secretariat informed the IAPC about their new approach for the repeater and TWTA development. Concerning the repeater, ESRO wanted to make the choice of the final contractor for the development prior to

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1/ When approving the contract riders to cover the cost increase, the AFC expressed some fear that in the past the acceptance of a low offer had been followed by substantial rider which rendered the final price higher than that of the rejected competitors. At the time of contractor selection for the repeater definition, this is in fact what the British delegation claimed. The ESRO secretariat was asked to investigate the existing contracting procedure; it found that the procedure provided sufficient safeguard against the problem described. See ESRO/AF(72)49, Request for Authority to Place a Contract, 8 June 1972.

the end of the definition phase and to incorporate in the winning proposal certain elements which had been more successfully defined in the rival offer. Concerning the TWTA, ESRO intended to stop one of the industrial efforts at the end of the definition studies and to award only one contract for the final development and qualification of the TWTA.1/ The IAPC approved the new approach, although the French delegation felt that it was extremely unwise, in view of the importance of the TWTAs, to select the final contractor after the definition phase.

Following the IAPC approval, the ESRO secretariat requested early completion of the repeater definition work by the two contractors and asked both consortia to submit proposals for the execution of the repeater development and qualification work.2/ The two contractors, the AEG-Telefunken and the Siemens consortium, proposed very similar designs for the repeater, as derived from the parallel definition phase. AEG-Telefunken, however, had a better administrative management proposal and had gone much deeper in the planning and costing area, which was reflected in the cost estimates. Whereas the AEG-Telefunken proposal amounted to 5.8 MAU, the Siemens proposal amounted to 10.5 MAU. Hence, the contract was awarded to AEG-Telefunken, subject to the condition that the power supply unit, the IF filters and the up-converters, all parts of the repeater, would be subcontracted to ETCA (B), MSDS (UK) and Selenia (I), which had made very good technical proposals within the Siemens group. As a result of this condition, the contract was increased

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1/ ESRO/IAPC/MIN/10, 14 Mar. 1972.

2/ ESRO/AF(72)38, Request for Authority to Place a Contract, 21 Mar. 1972.

by 0.2 MAU, from 5.8 to 6 MAU.1/

Concerning the TWTA, the financial proposal for the development and qualification phase from the two industrial groups, AEG-Telefunken/Selenia (D/I) and Thomson-CSF/FIAR (F/I), was as follows:2/

TWTA 3/	Group I		Group II	
TWT proper	AEG-Telefunken	- 1.5 MAU	Thomson-CSF	- 1.5 MAU
EPC	Selenia	- 1.1 MAU	FIAR	- 0.8 MAU
		2.6 MAU		2.3 MAU

The overall marking of both proposals was practically identical. The Thomson-CSF/FIAR proposal received marginally higher marks in the 'technical' panel evaluation whereas AEG-Telefunken/Selenia proposal was better from the administrative point of view. As regards the individual technical parts of the offer, there was a marked preference for FIAR's (I) EPC, whereas for the TWT proper, AEG-Telefunken (D) had received somewhat higher marks than Thomson-CSF (F) essentially because of its background and experience related to the 4 GHz TWT developed under the SYMPHONIE project. In other words, the Thomson/FIAR offer was considered to be more balanced whereas the AEG-Telefunken/Selenia offer exhibited deficiencies in the Selenia part of the offer. Since, in addition, the former offer was slightly less expensive, the ESRO secretariat requested the AFC to approve the award of a 2.3 MAU contract to Thomson-CSF/FIAR (F/I) for the development and qualification of the TWTA

1/ ESRO/AF/80, Request for Authority to Place a Contract, 12 Apr. 1972. The geographical distribution for the development and qualification contract was as follows: AEG-Telefunken (D) - 41%, Thomson-CSF (F) - 26%, Selenia and FIAR (I) - 21%, ETCA (B) - 7%, MSDS (UK) - 3.5%, Ericsson (S) - 1.5%.

2/ ESRO/AF(72)39, Request for Authority to Place a Contract, 21 Mar. 1972.

3/ The TWTA consists of two major building blocks, the TWT proper and the electronic power conditioner (EPC).

(TWT proper and EPC) and to award a contract of 0.25 MAU to AEG-Telefunken for the continuation of the work on the TWT proper up to the end of 1972 as back-up.

At the AFC meeting in April 1972, the German delegation strongly opposed the ESRO proposal, stating that it could not agree to the rejection of the better offer (meaning the German AEG-Telefunken proposal) and recommended that the development of the two TWTs should be pursued in parallel as far as the qualification test. This approach would require an additional amount of 0.3 MAU.1/

Just three weeks before, as noted above, the IAPC had decided to limit the development efforts to one TWTA owing to financial constraints. At that time, before the recommendation of the ESRO secretariat for the French Thomson-CSF TWT was known, the German delegation had agreed to this approach, whereas the French delegation had been the only one to express any reservations. Now, with the French offer having been accepted, the positions of the two delegations were reversed. Finally, however, the AFC approved the placing of the contracts in accordance with the ESRO proposal, despite a negative vote by the Germans.

As noted above, the TWTA is a key element of the satellite repeater and its sophistication is essential to the competitive nature of the satellite as a whole. After German industry lost this key technology contract under the ESRO programme, the German Ministry of Science and Education approached ESRO during June 1972 and offered to fund the development and qualification of the AEG-Telefunken TWT outside the ESRO programme as part of the German national technology programme. In exchange for this funding, ESRO would have to

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1/ ESRO/AF/MIN/80, 12 Apr. 1972.

guarantee that the AEG-Telefunken TWT would be incorporated in and tested on board the ESRO test satellite along with the ESRO-financed Thomson-CSF TWTA. This was possible, since a number of TWTAs were required for the test satellite.1/

In general, the ESRO secretariat was always interested in achieving redundancy of critical functions by duplicating equipment within budgetary and satellite weight limitations. While the parallel use of the same item offered assurance against random failure, parallel use of items based on different technological approaches offered assurance against systematic failures which could be inherent in one of the approaches used. Furthermore, comparative experiments with two different items would allow a choice to be made when the technology was selected for the ECS.

After the ESRO secretariat had supported the incorporation of the nationally-financed AEG-Telefunken TWT in the ESRO programme, the newly created Telecommunication Satellite Programme Board (PB-TEL) 2/ accepted the German offer at its first meeting.3/

While there were a number of good technical reasons for accepting the

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1/ ESRO/PB-TEL(72)3, Possibility of In-Orbit Testing of the AEG/Telefunken 12 GHz 20 W Travelling Wave Tube, 28 Aug. 1972.

2/ In line with the resolution on the reform of the organisation approved by the Council in December 1971, ESRO's committee structure was reorganised. The IAPC was disbanded and its function was taken over by the various Programme Boards created for the optional programmes. Pending the approval of the TELECOM arrangement, the PB-TEL was established as an advisory body to the Council with the task of preparing the Council's decisions. Each ESRO member state participating in the communication satellite programme was represented on the PB-TEL by at least two delegates; unofficially one of them was to be a representative of the national user organisation (national telecommunication authority) for which the satellite system was developed. This was to ensure that the users would be directly involved in the decision process.

3/ ESRO/PB-TEL/MIN/1, 2 Nov. 1972.

German offer, the decision also had industrial policy implications. As noted above (see page 164), ESRO's industrial policy was guided by the objective of building a rational European space industry and achieving a balanced distribution of contracts among ESRO's member states. Implementing such a policy implied the abandonment of national technology supply in the advanced countries in order to eliminate over-capacity (specialisation) at the European level and the creation of new centres of expertise in the less advanced countries (proliferation). The German offer to finance the AEG-Telefunken TWT development on a national basis was in fact aimed at avoiding such European specialisation by establishing and maintaining national supply in key technology areas.

The contracting history of the TWT reveals some interesting aspects of the relationship between national and international projects. In the TWT case, the international programme was used to increase the effectiveness of the national technology programmes. The German ministry would not have been in a position to support the development of a national TWT at such a low cost within a national programme, since the test statellite was paid for by the member states participating in the ESRO programme.

In addition to the Support Technology Programme, a new opportunity became available for space testing of key technology items as part of cooperation between the TELECOM programme of ESRO and the experimental Canadian Communications Technology Satellite Project (CTS), a joint project of the Canadian Department of Communications (DOC) and NASA (USA). Although the CTS project was already at an advanced stage, with an expected launch in March 1975, it was still possible to incorporate some key hardware developed under the ESRO Support Technology Programme into the CTS satellite. The prime interest for ESRO in participating in the CTS project was to test equipment in orbit some 9 to 13 months prior to the launching of the TELECOM experimental satellite. ESRO's participation was associated with the Canadian portion of the DOC/NASA project and reduced the Canadian project expenditures.1/

ESRO's commitment was to provide two models of the TWTA as well as the parametric amplifier to DOC at no cost. The DOC agreed to incorporate the equipment in the CTS satellite and to procure the solar blankets, developed under the ESRO Support Technology Programme, from the European source. After the cooperation was approved by the IAPC in March 1972, a Memorandum of Understanding was signed by DOC and ESRO. The extra cost for ESRO was 1.6 MAU.2/

The ESRO/DOC agreement was seen as a first step to extend ESRO's sphere of direct cooperation to other major aerospace countries and thus expand market opportunities for European industry. Any close ties between European and Canadian industry that might result from this cooperation would improve the position of European industry in competing for future international projects such as the INTELSAT V series of satellites.3/

ESRO procured the two TWTAs from Thomson-CSF/FIAR (F/I) and the two parametric amplifiers from GTE (I), and initiated during February 1972 the call for tender to European industry for a solar array to be used for the CTS,

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1/ ESRO/AF(72)19, Possible ESRO Involvement in the Canadian Communications Technology Satellite, 24 Jan 1972; ESRO/IAPC(72)8, Proposals for ESRO's Participation in the Canadian Communications Technology Satellite, 21 Feb. 1972.

2/ ESRO News Release, 'ESRO to participate in Joint Canada/US Communication Satellite Programme', 18 May 1972.

3/ K. Reinhartz, P. Paulsen, R. Buhs, 'European Flexible Solar-Cell Blanket on the Canadian/US Communications Technology Satellite', ESA Bulletin, II (1976), No. 6, 6-9.

based on Canadian/ESRO specifications.1/ In fact, the solar array was also part of the Support Technology Programme.

The tender evaluation was carried out by ESRO. Canadian DOC representatives and their NASA advisors participated as members of the evaluating teams, which came up with the following results (listed by evaluation score, excluding price):

Proposal	Country	Price in KAU		
		Phase I	Phase II	Total
(1) AEG-Telefunken	West Germany	1,004	561	1,565
(2) BAC/Ferranti	United Kingdom	850	734	1,584
(3) MBB/AEG-Telefunken	West Germany	1,022	639	1,661
(4) MBB/Ferranti	West Germany/ United Kingdom	1,280	569	1,849
(5) MBB/Selenia	West Germany/ Italy	1,613	791	2,408
(6) SNIAS/SAT	France	1,693	857	2,550

Phase I : Development, prototype array, qualification (ESRO share)
Phase II: Supply of two flight units of solar arrays (DOC share)

The technology proposed by AEG-Telefunken (D), which had based their offer on experience gained in the SYMPHONIE programme, appeared less risky than the BAC (UK) approach. This prompted the Canadian project team to express strong preference for the AEG-Telefunken solution. Consequently, the ESRO secretariat recommended that the AFC award the contract to the German company; this was approved by six votes to one in April 1972 despite strong

1/ ESRO/AF(72)28, Request for Authority to Place a Contract, 21 Mar. 1972.

opposition by the British delegation.1/

Besides the repeater, the TWTA and the solar array, most of the critical equipment under the Support Technology Programme was contracted to industry during 1972. The main activities in 1973 were the monitoring of the industrial development contracts by the ESRO secretariat, which had increased the TELECOM staff complement to 140 by the end of 1972, compared with 67 at the end of 1971.2/

The following four tables show the results of the tender actions for the most costly developments (listed by evaluation score, excluding price).

Item: Gimballed momentum wheel 3/ Design, development and qualification contract		
Winning Proposal	Country	Price in KAU
(1) Teldix	West Germany	772
Refused Proposals		
(2) BAC	United Kingdom	685
(3) SAGEM	France	1,291
(4) HSD	United Kingdom	911

1/ ESRO/AF/MIN/80, 12 Apr. 1972.

2/ General Report 1971 (Paris, ESRO, 1972), p. 178.

3/ ESRO/AF(72)112, Request for Authority to Place a Contract, 5 Oct. 1972. The wheel is part of the attitude and orbital control subsystem. Its function is to keep the satellite in its orbital position.

Item: Infrared horizon sensor 1/ Design and development contract		
Winning Proposal	Country	Price in KAU
(1) Galileo	Italy	702
Refused Proposals		
(2) HSD	United Kingdom	1,116
(3) MSDS	United Kingdom	1,418
(4) SODERN	France	1,844

Item: Antenna-pointing mechanism 2/ Design and development contract		
Winning Proposal	Country	Price in KAU
(1) HSD	United Kingdom	435
Refused Proposals		
(2) MSDS	United Kingdom	228
(3) MATRA	France	328
(4) Dornier	West Germany	249
(5) Crouzet	France	410
(6) SNIAS	France	659

1/ ESRO/AF(72)111, Request for Authority to Place a Contract, 6 Oct. 1972. The sensor is part of the attitude and orbital control subsystem. Its function is to detect the satellite's orbital position.

2/ ESRO/AF(72)166, Request for Authority to Place a Contract, 27 Dec. 1972. The antenna-pointing mechanism is part of the antenna subsystem. Its function is to redirect the satellite antenna to allow a change of coverage zone while the satellite is in fixed orbital position.

Item: Antenna in the 11 and 14 GHz bands 1/
Phase I : Two definition contracts
Phase II: After phase I, selection of one contractor for the development and qualification contract

Winning Proposals	Country	Price Phase I in KAU	Estimated Phase II in KAU
(1) Selenia	Italy	150	465
(2) MSDS	United Kingdom	120	900
Refused Proposals			
(3) Thomson-CSF	France	144	2,520
(4) LCT	France	69	250
(5) TERMA	Denmark	105	442
(6) STAREC	France	106	559
(7) Ferranti	United Kingdom	77	469
(8) HSA	Netherlands	108	Not Quoted
(9) Ericsson	Sweden	119	561

The table on the following page gives a list of the main contracts awarded under the Support Technology Programme and the ESRO/DOC cooperation up to the end of 1972. The table is arranged according to the subsystems of the communication satellite as described in appendix B.

The results of contract awards under the Support Technology Programme in 1972 highlight the conclusions which have been drawn on the basis of the early activities in 1971. The competitive award of 'noble' technology contracts

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1/ ESRO/AF(72)37, Request for Authority to Place a Contract, 22 Mar. 1972; ESRO/AF(72)126, Request for Authority to Place a Contract, 16 Nov. 1972.

Contracts awarded under the Support Technology Programme (compiled from contract documents)

Module	Subsystem	Equipment	Company/Country	Value in KAU
1. Payload module	1.1 Repeater-subsystem	a. Development and qualification of modular repeater (excluding TWTA)	AEG/Telefunken group (D/F/UK/I/B/S)	6,000
		b. Development and qualification of TWTA	Thomson/CSF-FIAR (F/I)	2,300
		c. Development of TWT up to 1972 only	AEG/Telefunken (D)	250
		d. Development and qualification of low-noise parametric amplifier	GTE (I)	87
	1.2 Antenna-subsystem	a. Development of antenna pointing mechanism	HSD (UK)	435
		b. Definition of 11/14 GHz antenna (duplicate effort)	Selenia (I) MSDS (UK)	150 120
2. Service module	2.1 AOCS-subsystem	a. Development and qualification of a gimballed momentum wheel	Teldix (D)	772
		b. Development of an infrared horizon sensor	Galileo (I)	702
		c. Investigation of different attitude control systems (duplicate effort)	MATRA (F) MBB (D)	80 80
		d. Study of advanced hydrazine propulsion system	ERNO (D)	45
	2.2 Power-subsystem	a. Development or solar generator for the Canadian Communication Technology Satellite (CTS)	AEG/Telefunken (D)	1,004
		b. Development of solar array drive mechanism	HSD/MSDS (UK)	189
		c. Development of lightweight panels for solar array	MBB (D)	83
		d. Development of storage and deployment mechanism for rigid solar array	MBB (D)	40
		e. Study of batteries	SAFT (F)	36
	2.3 Structure-subsystem	a. Study programme of mass optimisation	Contraves/Fokker (CH/NL)	242
			Total	12,615

resulted in the virtual exclusion of companies from smaller countries which had not previously built up technological know-how within national space programmes. Those countries were only able to secure small study contracts.

The following table highlights the close link between success in contract awards under the TELECOM programme and previous experience in national communication satellite or national/ESRO scientific satellite projects.

Equipment	Company(Country)	Experience
Payload module technology - communication-satellite-specific		
(1) Repeater	AEG-Telefunken (D)	SYMPHONIE
(2) TWT	Thomson-CSF (F)	SYMPHONIE
(3) Antenna	Selenia (I) MSDS (UK)	SIRIO SKYNET
(4) Antenna pointing	HSD (UK)	New area of development
Service module technology - not communication-satellite-specific		
(5) Wheel	Teldix (D)	SYMPHONIE, ESRO
(6) Sensor	Galilieo (I)	SIRIO
(7) Solar array	AEG-Telefunken (D)	SYMPHONIE, ESRO

It can be concluded that the industrial activity under the Support Technology Programme did not lead to the proliferation of know-how envisaged in ESRO's industrial policy, but to a concentration of industrial competence in the already advanced countries such as France, Italy, the United Kingdom and West Germany.

4.4 The test satellite

Whereas the Support Technology Programme had advanced considerably during 1972, the terms of collaboration between ESRO and INTELSAT/COMSAT on the proposed joint test satellite had still to be agreed upon.

It should be noted that the renegotiation of the INTELSAT agreement (see page 120) had been finalised by mid-1971; a compromise had been reached between the Americans and the Europeans which limited the influence of the American COMSAT organisation in the INTELSAT system.1/ As outlined above (see page 201), it was COMSAT which pushed the implementation of a test satellite project in preparation for the future INTELSAT V satellite series, whereas INTELSAT, representing the member states and owners of the global satellite system, was reluctant to approve the execution of such a project. Many national representatives believed that a preparatory experimental project was not required, but constituted a waste of resources resulting in a reduction of INTELSAT's profits. In fact, European delegations to ESRO and INTELSAT pursued quite different policies. Whereas the United Kingdom delegation to INTELSAT was opposed to a test satellite project, including the option of ESRO/INTELSAT cooperation, the British delegation to ESRO was strongly in favour of supporting such cooperation. Unhappy with the current proposal, INTELSAT requested additional information from COMSAT on the need for an experimental system. In addition, INTELSAT suspended discussions with ESRO on a joint programme in March 1972 until the requested information was made

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1/ In accordance with US demands, COMSAT remained as manager of the INTELSAT system and as US representative on the INTELSAT Board of Governors. However, it would only be manager for the next six years and would be supervised by a Secretary General appointed by INTELSAT. In compliance with European demands, the US/COMSAT voting share on the INTELSAT Board of Governors was reduced to 40% in line with the declining American communication volume in the INTELSAT system.

available.1/ In fact, the prospects for collaboration between INTELSAT and ESRO looked dim, in particular since it would have required a two-thirds majority of the INTELSAT members, which seemed very unlikely at this stage.

In the light of these developments, the Director-General of ESRO decided not to pursue discussions with INTELSAT for the time being, thereby ruling out the implementation of the TELECOM programme as approved by the Council meeting back in December 1971.2/

The decision to suspend negotiations with INTELSAT/COMSAT had some interesting side-effects. With the current programme uncertainties, it was of great importance for the ESRO secretariat to resume the dialogue with the potential users, CEPT and EBU, with a view to renewing the close consultations unprejudiced by the events of the past.3/ CEPT, too, seemed to be interested in closer cooperation, expressing its interest in the development and setting up of ground stations, not only during the operational phase but also during the test phase, and asking ESRO to reinforce the technical link between ESRO and CEPT.

Thus, after one year of discussion, the key decision to be made was the choice of the spacecraft for tests in orbit. Since ESRO/INTELSAT collaboration did not seem to be possible any more, the discussion reverted to the original proposals. Italy insisted on re-using the SIRIO satellite; France and West Germany proposed a SYMPHONIE derivative paid for by ESRO; and the United Kingdom, the small countries and the ESRO secretariat wanted a new dedicated technological satellite. However, there was a new element in the

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1/ ESRO/C/MIN/43, 11 Apr. 1972.

2/ Ibid.

3/ ESRO/PB-TEL(72)4, Relations with CEPT, 21 Aug. 1972.

picture. The United Kingdom would not go along with one of the nationally-based projects. In order to create a complete deadlock, the United Kingdom announced its intention to develop a national communication satellite, named UKATS (United Kingdom Application Technology Satellite).1/ With the project still on paper and not approved, the United Kingdom demanded that UKATS, intended to be more technologically advanced than SIRIO and SYMPHONIE, should be considered the test bed for the European satellite.2/ Now, each of the 'big four' was pressing for its own national project.

In order to find a way out of this deadlock over the choice of the experimental spacecraft, the ESRO secretariat decided to re-examine the needs of a test satellite in conjunction with the Step A studies of the operational ECS being carried out by industry (see page 213). Without authorisation from the IAPC, the secretariat placed three two-month studies (July/August 1972) with the three consortia, COSMOS, MESH and STAR.3/ Industry was given the opportunity to express its views freely on all aspects of phase II, analysing a range of satellites from the 40 kg Franco-Russian SRET vehicle to a new dedicated 400 kg spacecraft, including such intermediate options as SIRIO, SYMPHONIE and UKATS.

On the basis of the Step A studies of the ECS, the consortia selected those orbital tests of satellites, subsystems and units which were considered to be critical elements in the operational programme. It was regarded as

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1/ Interview with a senior ESA official.

2/ Initiatives for a UK communication satellite date back to early 1971. See 'UK Satellite Communications - Pie in the Sky', New Scientist and Science Journal, XCI (1971), 528.

3/ ESRO/PB-TEL(72)1, Report by the Secretariat on the Progress of the Telecommunication Satellite Programme, 25 Aug. 1972.

necessary that those orbital tests be carried out before the development of the ECS.

The common view of the three consortia was that there was no substitute for a dedicated orbital test satellite, named OTS, with a weight of 350 to 400kg, a modular design and a configuration as close as possible to that of the proposed ECS.1/ In fact, as the aerospace journal Flight put it,

> 'OTS is not a reinvention of the INTELSAT wheel but a programme based on much more advanced technology'.2/

Owing to such characteristics, the pre-operational flight unit previously foreseen in phase III of the TELECOM programme would not be required, resulting in a lower overall TELECOM programme cost, although the cost of phase II would increase and the time-frame of phase II would go beyond the envisaged period (1972-1976), extending to 1978. The financial implications of the OTS proposal are shown on the following page.

The ESRO secretariat was very much in favour of a programme strategy including OTS and proposed to the national delegations that this option be approved during the first meeting of the Telecommunication Satellite programme

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1/ The modular design was characterised by the use of essentially the same building elements for both the OTS and the ECS satellite, the difference between the two being only of a quantitative nature. In addition, two major satellite building blocks would be physically separated, namely the service module and the payload module (see appendix B). This modular concept allowed the service module to be adapted easily and economically to different missions. Such a modular design, characterised by a high degree of standardisation and long production runs, had already been employed for satellite production in the Soviet Union. See K. Müller, 'Europas Kunststerne steigen auf', Die Welt, 16 Feb. 1979; R. McQueen, 'The Impacts of the Communications Mission on the System Design of the Orbital Test Satellite', Journal of the British Interplanetary Society, XXX (1977), 135-42.

2/ 'Europe's OTS Satellite', Flight, LXVIII (1977), 1664. The OTS was even considered to be technologically more advanced than the civilian spin-stabilised US satellites. See N. Valéry, 'Space Business Bridges the Atlantic', New Scientist, XCV (1975), 23 Oct.

Financial implications of OTS proposal				
TELECOM programme cost in MAU at mid-71 prices	Phase I	Phase II	Phase III 1/	Total 1/
Including OTS	5	144	138-233	287-382
Present financial plan	5	100	167-295	272-400

Board (PB-TEL), in October 1972.2/

No decision could be reached at the first PB-TEL meeting.3/ The German delegation criticised the secretariat for having placed the study contracts with the three consortia without the consent of the national delegations. In its view, it seemed evident that consortia would prefer a new project to a nationally-based one in which they would not participate. Whereas the countries with national projects still insisted on their satellite being used in the TELECOM programme, the remaining member states supported OTS. Unable to take a decision on the test satellite, the Programme Board agreed to approach CEPT to ask which option would give them the most confidence in the ECS system.4/

Although not opting for one option, CEPT pointed out the need for a significant pre-operational capacity during the test phase in order to permit the progressive installation of a network of earth stations before the ECS system came into operation. Such a pre-operational communication capacity,

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1/ Depending on the size of the ECS.

2/ ESRO/PB-TEL(72)2, Experimental and Technological Phase (Phase II), Proposals for Experimentation in Orbit, 11 Aug. 1972.

3/ ESRO/PB-TEL/MIN/1, op.cit.

4/ ESRO/PB-TEL(72)8, Exchange of Letters between the Director General of ESRO and the Chairman of the CCTS, 14 Nov. 1972.

which the European PTTs could use free of charge for routing their telecommunication traffic, was a prior condition to the construction of an earth station for some national telecommunication authorities. As noted above, these telecommunication authorities had offered to establish a ground network system during the test stage of the TELECOM programme, which, however, did not constitute an agreement to use the final ECS system. This emphasis on the need for pre-operational capacity in fact supported the OTS option, which could be designed to provide such a capability within the remaining mission objectives of the test satellite.

At the second Programme Board meeting in November 1972, ESRO presented a further comparative analysis of the alternative approaches envisaged and proposed the OTS options to be selected on the basis of the following characteristics:1/

(1) Minimum overall programme cost;

(2) Proposed start of CEPT/EBU operational system in 1980 in line with the programme objectives;

(3) Geographical distribution of contracts would not be a problem;

(4) Because of its modular approach, OTS could be re-used later as a basic geostationary platform in support of other missions;

(5) OTS provided significant pre-operational capability before 1980, which CEPT considered to be of major importance;

(6) The option preserved the principle of a flexible definition of the contents of phase III of the programme in 1979;

(7) OTS did not include too much technical risk.

1/ ESRO/PB-TEL(72)6, The Impact of Various Options for the Experimentation in Orbit of Phase II of the Telecommunication Satellite Programme, 7 Nov. 1972.

The Belgian delegation made a statement strongly supporting the OTS option, since this solution would meet all the objectives. It noted that the other options had failed to reach an agreement since the participating nations would not accept the inclusion of a national project in the European programme. The delegation pointed out that those countries engaged in national projects were already

> '...placed in a sufficiently privileged position and that there is no need to strengthen their position further through the medium of a European budget...'1/

by including the national satellites in the European programme.

The smaller countries such as Sweden, Denmark and Switzerland supported the Belgian statement and pressed for a decision very soon. Despite the fact that France, the United Kingdom and West Germany expressed their doubts about OTS, criticising its pre-operational communication capacity and the effect of the modular design and pointing out the need for a real prototype flight model, the Programme Board recommended and the Council subsequently approved the secretariat's proposal of an OTS, subject to clarification of the financing aspects.2/

It is argued that only France and West Germany intended to include their bilateral SYMPHONIE project in the ESRO programme. Italy and the United Kingdom had advanced their national projects only to thwart the French and German attempt; both options were unacceptable since the Italian SIRIO was technically outdated and the British UKATS project was still on the drawing

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1/ ESRO/PB-TEL/MIN/2, Annex II, Statement of the Belgium Delegation, 12 Nov. 1972.

2/ ESRO/C(72)73, Recommendation to the Council by the Provisional Telecommunication Satellite Programme Board, 4 Dec. 1972; ESRO/C/MIN/52, 10 Jan. 1973.

board.1/ In this situation, France and West Germany had to realise that the United Kingdom would never participate in an ESRO programme based on the Franco-German SYMPHONIE project. Realising the unacceptability of their own proposal for the remaining countries, which represented 55% of the programme's contribution, and sensing the resulting risk for the programme's continuation were certainly major reasons for both countries to go along with the OTS proposal. Elaborating and offering an acceptable solution, however, made this agreement possible in the first place. With the decision to approach the industrial consortia and to award the OTS study contracts without approval from the IAPC/PB-TEL, the ESRO secretariat pushed ahead and introduced new arguments into the discussion against the opposition of France and West Germany. The secretariat guided the discussion at the delegate level and offered a compromise solution which not only received the whole-hearted support of the smaller countries but was also a good proposal in terms of its technical and financial characteristics, against which a nationally-based ESRO programme could no longer be justified. With the agreement on the selection of the OTS, the Programme Board was able to recommend and the Council to approve the 1973 TELECOM budget of 24 MAU payment appropriation, which mainly covered the cost of the Support Technology Programme under way in industry.

1/ The UKATS project was later renamed Geostationary Technology Satellite (GTS). See 'Geo-Stationary Technology Satellite', Spaceflight, XVI (1972), No. 12, 45.

4.5 A launcher for the TELECOM programme

As noted above, the European communication satellites were intended to be orbited by the European launcher EUROPA, built by the European organisation ELDO. The unhappy history of ELDO continued with a series of launch failures, with the result that the government backing of the remaining ELDO member countries, Belgium, France and West Germany, vanished.1/ Accepting the failure of ELDO, France, which had always been a strong supporter of an independent European launcher capability, initiated studies in 1972 related to a French national launcher programme called L III S. The launcher was designed to put 750 kg into geostationary orbit by the end of 1980, tailor-made to launch the operational ECS satellites.

Initially, during the bilateral discussions, the French government presented the French launcher project to the governments of ESRO member states and invited them to participate. Following the interest shown especially by West Germany, the European Space Conference (ESC) gave general approval to the implementation of the French launcher proposal, named ARIANE, in a common European framework in December 1972.2/ In fact, this decision coincided with the agreement by the European Space Conference to amalgamate ESRO and ELDO into a new organisation named the European Space Agency (ESA).3/ This decision was the result of three years of discussion and marked essentially

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1/ The Netherlands, Italy and the United Kingdom had already left ELDO by 1970. See 'Is a European Space Policy Possible?', New Scientist, XCIII (1973), 217-28.

2/ CSE/CM(July 73)5, Report of the Secretary General of the European Space Conference on the Implementation of the Decision on the Ministerial Conference, 2 July 1973; 'European Space Tantalizer', New Scientist, XCIII (1973), 4.

3/ CSE/CM(July 73)5, op.cit.

the termination of the activities under the ELDO programme and the Europeanisation of the French launcher programme within the new organisation ESA, which was based on the structure and convention of ESRO.1/ The ARIANE programme, however, was not expected to be just a new ESA programme; it would have the characteristics of a French national programme with substantial participation by interested European countries. It would be managed by CNES, the French national space organisation, and would only be administered and supported by ESRO and later ESA.2/

Whereas ARIANE was to be ready in time for the operational ECS satellites, with the termination of ELDO there was no European launcher to orbit the test satellite. Hence, the Space Conference decided to approach the USA again, requesting clarification of the American position on the supply of launch vehicles for the TELECOM programme. After a detailed description of the TELECOM programme was submitted in December 1971, Mr. Johnson, US Under-Secretary of State, replied in June 1972, outlining the conditions on which launcher access would be provided.

First, it was required that the orbital position of the TELECOM satellite

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1/ In addition, the Space Conference gave general approval to carry out the SPACELAB project as the European contribution to the SPACE-SHUTTLE programme. See 'European Space Conference, Brussels 1972', ESRO/ELDO Bulletin, IV (1973), No. 20, 4-7.

2/ The ARIANE programme was estimated to cost 445 MAU at 1973 prices during the period 1974-1980. France was to cover 60% of the programme budget. A Programme Board composed of the participating countries would govern the programme implementation. ESRO and later ESA would prepare, in consultation with CNES, all the technical, financial and administrative documentation for submission to the Programme Board. The technical and financial management was entrusted to the French CNES. CNES would define the industrial arrangements and place contracts with industry on behalf of the programme participants. Total ESRO/ESA in-house costs were expected to amount to only 2 MAU. See CSE/CM(July 73)5, op.cit.; CSE/CM(July 73)PV/2, Appendix, 14 July 1973.

be located differently in order to avoid economic harm to the INTELSAT system and technical incompatibility with future INTELSAT requirements. Second, the satellite service and coverage had to be limited to the countries whose telecommunication administrations were members of CEPT at that time. The USA would not support the European system if it provided television relay services to countries of the European Broadcasting Union (EBU) which were not members of CEPT 1/ or if this appeared possible from the fact that the capability and capacity of the proposed system exceeded the need to satisfy its communication mission to the CEPT countries.2/

It was the conclusion of ESRO that the American conditions did not hinder the fulfilment of the TELECOM programme mission although the system would now be under tighter constraints and was limited in its possible geographical expansion of coverage and service. In October 1972, the Programme Board noted the American conditions on the supply of launchers and their repercussions for the TELECOM system.3/

Quite clearly, the USA used its monopoly supply position to protect its interest in the INTELSAT system. This policy had an even more serious impact on the Franco-German SYMPHONIE programme, which was also forced to request American launch service as a result of the termination of the ELDO programme. SYMPHONIE was designed to have a much wider coverage than the TELECOM

1/ CEPT member states included the European countries from the Scandinavian countries to Spain and Turkey. The EBU area included, in addition to the CEPT countries, the western part of the USSR, North Africa and the Middle East. Those countries were excluded from the TELECOM television coverage as a result of the American conditions.

2/ ESRO/PB-TEL(72)5, Availability of Launchers for the European Communication Satellite Programme, 22 Sept. 1972. See also 'Getting a Half-Nelson on NASA', New Scientist, XC (1972), 13 July.

3/ ESRO/PB-TEL/MIN/1, op.cit.

programme, including France, West Germany, the French overseas territories, Canada, Saudi Arabia and the German broadcasting station in Rwanda. The USA only agreed to launch SYMPHONIE on the condition that its use would be solely experimental and not operational as intended. This restrictive policy certainly gave new impetus to the Franco-European ARIANE launcher programme.

4.6 Definition of the Orbital Test Satellite (OTS) and approval of the TELECOM arrangement

Having unanimously approved the general OTS concept during the November 1972 meeting, the Programme Board agreed to call together a group of experts consisting of CEPT and representatives appointed by the delegations, for the purpose of examining the detailed definition of the programme and defining the essential aims of the OTS project. In addition, the ESRO secretariat worked out a first draft of the TELECOM arrangement, defining the financial commitment, the technical programme content and the programme schedule, expected to be signed by the participating member states by March 1973.

In early January 1973, the conclusions of the group of experts and the draft of the TELECOM arrangement were submitted to the Programme Board for discussion and approval. The objectives of the OTS mission were described as follows:1/

(1) Demonstrate the performance and, above all, the reliability of all equipment on board OTS, the general configuration of which should prefigure an operational vehicle.

(2) Fulfil, from the communication system point of view, the experimental objectives required by the CEPT mission, e.g. propagation, frequency re-use and transmission tests.

(3) Provide, for pre-operational purposes, a reasonable traffic capability, i.e., of the order of two television and 5000 telephone channels.

Although the list of objectives was approved by the Programme Board, various delegations expressed reservations regarding the financial implications, as outlined in the following table, since the upper limit of expenditure had been fixed at 100 MAU for phase II by the Council in December

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1/ ESRO/PB-TEL(73)1, Conclusions of the Group of Experts, 17 Jan. 1973.

TELECOM programme phase II 1/ at mid-1972 prices 2/

Purpose: Technology development and subsequent in-orbit evaluation by means of OTS during 1972-1978

Activities	Cost in MAU		Cost in %
1. ESRO			
1.1 Direct cost	13.5		
1.2 Common and support costs	28.8	42.3	27.3
2. Industrial contracts (direct costs)			
2.1 Communication system and ground facilities	13.5		
2.2 Support Technology Programme	31.9		
2.3 OTS proper	53.7		
2.4 OTS launcher	9.2		
2.5 ESRO/DOC cooperation	1.5		
2.6 Step A and B of ECS	3.7	108.2	69.9
3. Contingency margin		4.4	2.8
Total		154.9	100.0

1971. Hence, the Programme Board agreed to hold a second meeting after the financial implications had been discussed with the national authorities.3/

During the next Board meeting in February 1973, Belgium, France and the United Kingdom in particular declared that the costs of phase II were too high and demanded a re-examination of the work plan with a view to deleting those elements which seemed redundant and to concentrating efforts on indispensable

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1/ The indicative financial budget for phase II, covering the operational satellite development during 1975-1980, amounted to 160 to 283 MAU, which would result in a total TELECOM programme cost of 314.9 to 439.9 MAU at mid-1972 prices.

2/ ESRO/PB-TEL(73)4, Current Estimates of Direct Costs of the Communication Satellite Programme (Phase II), 28 Mar. 1973.

3/ ESRO/PB-TEL/MIN/3, 22 Feb. 1973.

technological tasks.1/ Although recognising that it was somewhat late to review the technology programme, the Board agreed to set up a small ad hoc group for the purpose of reviewing the direct cost elements relating to phase II.

The report of the ad hoc group acknowledged that it was difficult to reduce the programme costs drastically without modifying the whole programme. However, the group identified work on technical support and system studies which would either be started during phase III (2.8 MAU) or was not strictly indispensable (3.8 MAU).2/

During the Board meeting in March 1973, ESRO insisted that cutting out certain studies could seriously jeopardise the whole programme, arguing that a programme of this kind comprised a certain number of risks, whereas some delegations, in particular France, were strongly in favour of reducing the direct cost of phase II by 6.6 MAU from 121.7 to 115.1 MAU.3/

A compromise solution was found, whereby the Board approved the reduced figure of 115.1 MAU and blocked the 6.6 MAU in question until otherwise decided by the Board with a double qualified majority.4/ With this final amendment, the Board agreed on the TELECOM arrangement and decided to submit the text to the Council for examination and final approval.

At the following 56th Council meeting in April 1973, the Belgian, British, Danish, French, German, Swedish and Swiss delegations declared the

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1/ ESRO/PB-TEL/MIN/4, 15 Mar. 1973.

2/ ESRO/PB-TEL(73)9, Report by the Group of Experts, 28 Mar. 1973.

3/ ESRO/PB-TEL/MIN/5, 17 Apr. 1973. The reduction would result in a new total cost of 147.5 MAU for phase II.

4/ ESRO/C(73)23, Report of the Chairman of the Provisional Telecommunication Satellite Programme Board, 6 Apr. 1973; ESRO/C/MIN/56, 3 May 1973.

commitments of their governments to participate in the TELECOM programme.1/ The Italian delegation, however, was not in a position to announce its agreement since the relevant government authorities had not taken a decision. The delegation hoped to make known its decision to participate by 1 June. Hence, the Council decided to delay the last date on which the TELECOM arrangement was open for signature or ratification by the respective governments to 1 June 1973.2/

That date passed, however, without the Italian government having taken a decision. A subsequent deferment of the deadline by two weeks also failed to produce a decision.3/ At the end of June, the Italian government informed ESRO that it demanded a renegotiation of the TELECOM programme with the aim of staying within the financial limits of 100 MAU as originally envisaged and in contrast to the 147.5 MAU currently proposed.4/ At an extraordinary meeting on 29 June 1973, the Council expressed regret at the Italian decision but decided not to renegotiate the TELECOM programme. Instead, it sought further negotiations with the Italian government with the aim of changing the Italian attitude.5/

Meanwhile, the difficulties concerning the approval of the TELECOM arrangement had repercussions on ESRO's activity at the level of programme

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1/ After the Council had approved a programme, a detailed programme arrangement had to be signed by all participating governments on the one hand and ESRO as a legal entitiy on the other. The April meeting of the Council authorised the Director General to sign the arrangement on behalf of ESRO. See ESRO/C/LVI/Dec 1, 12 Apr. 1973.

2/ ESRO/C/LVI/Res. 2(Final), 12 Apr. 1973.

3/ ESRO/C/MIN/57, 20 June 1973.

4/ ESRO/C(73)62, Letter from the Italian Delegation, 18 Sept. 1973.

5/ ESRO/C/MIN/58, 6 July 1973.

implementation. The selection of the consortia for the development of OTS was in full swing, as described in the following section, and in order to structure the competing consortia according to the geographical distribution figures required, it was necessary to know which countries would participate and what their shares would be.

It took another three months of intensive negotiations between the ESRO secretariat, the Council chairman, the Italian delegation to ESRO and the Italian government authorities to finally convince the Italian government to approve the programme as proposed.1/ The TELECOM arrangement formally entered into force on 21 September 1973 after having been signed by the governments of Belgium, Denmark, France, Italy, Sweden, Switzerland, the United Kingdom and West Germany.2/

The scale of contribution for the subsequent three-year period

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1/ ESRO/C/MIN/60, 3 Oct. 1973.

2/ ESRO/C(73)63, Arrangement between Certain Member States of ESRO and ESRO Concerning the Execution of a Communication Satellite Programme, 8 Oct. 1973. The major provisions of the TELECOM arrangement were as follows. The governments agreed to finance phase II, at a cost of 147.5 MAU at mid-1972 prices, from 1972 to 1978, with the launch of OTS by the end of 1976. The start of subphase 'II bis', covering further work on advanced techniques and specialised studies at a cost of 6.6 MAU and phase III at an indicative cost of 160 to 283 MAU, would be decided by a double-qualified majority. Phase III would last from 1975 to 1980 with the launch of ECS. Within each programme phase, annual budgets would be approved by a two-thirds majority. If the cumulative overruns of estimated costs to completion exceeded 20% of the cost of the programme phase for reasons other than changes in price levels, participants could withdraw from the programme. ESRO would be the owner of the satellites and equipment up to the end of Phase III. The transfer of ownership to the potential users would be subject to terms to be agreed upon between the TELECOM participants and the users. The participants could terminate execution of the TELECOM programme by a double-qualified two-thirds majority. In addition, the arrangement gave a detailed description of the technical content of phase II, covering overall system studies, support technology programme, ECS studies, the ESRO/DOC cooperation and the OTS.

(1972-1974) was determined in accordance with ESRO's GNP procedure as follows.1/

Country	Contribution share in %
Belgium	3.96
Denmark	2.35
France	23.01
Italy	14.69
Netherlands	2.50
Sweden	4.90
Switzerland	3.39
United Kingdom	20.09
West Germany	25.01
Total	100.00

With the TELECOM arrangement coming into force, the Programme Board, which had worked on a provisional basis until then, became the governing body of the programme, holding responsibility for decisions concerning programme implementation.

1/ Ibid. The Netherlands, which had not supported the TELECOM programme during the Council meeting in December 1971, subsequently decided to join the programme with a fixed contribution share of 2.5%. On a GNP scale, the Netherlands' contribution would have amounted to 4.8%.

4.7 Selection of the OTS contractor

The TELECOM arrangement of November 1973 defined the OTS as a 3-axis-stabilised, three-year-lifetime vehicle of modular design, carrying sun-oriented solar panels, with 40 and 120 MHz bandwidth, 20 Watt repeaters.1/ OTS was expected to be orbited by a NASA launcher of the Delta 2914 class, capable of lifting 350 kg into geostationary orbit.

With the equipment under the Support Technology Programme and the studies on the overall system and the ECS configuration having already been contracted out to industry, the major industrial contract still to be awarded during phase II of the TELECOM programme was the development and production of the OTS and the ground station for telemetry and command control.

The selection process for the OTS contractor had already been prepared by ESRO during August 1972.2/ On the basis of ESRO's technical specifications derived from previous in-house and industry activities,3/ three Step A studies, amounting to 200 KAU each, were carried out by the COSMOS, MESH and STAR consortia during October 1972 and January 1973. They resulted in a detailed definition of the OTS at the subsystem level, in some areas at the equipment level, and an understanding of the mass implications of the technical specifications.

In parallel to the finalisation of Step A studies, ESRO requested proposals for the Detailed Design Study (Step B) of an Orbital Test Satellite

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1/ For a technical description, see appendix B.

2/ ESRO/PB-TEL(72)10, OTS Project - Summary of the Phased Planning Procedure, 22 Dec. 1972.

3/ Previous industrial activities were the Communication System Studies (January-July 1972), the ECS Step A studies (January-July 1972) and the studies on re-examination of the experimental satellite (May-June 1972).

on the basis of revised technical specifications during January 1972.1/

Owing to the small amounts involved, the geographical distribution of work under Step A contracts was not considered to be important for achieving a fair return within the TELECOM programme. The distribution of work under Step°B, however, would pre-define the final allocation of work among the participating countries during the development and production stage (Step C/D). The industrial structure of the three industrial consortia which submitted their Step B proposals to ESRO in February 1973 is shown on the following page.

It should be recalled that the proposals put together under Step B covered the whole of the OTS. The consortia, however, were obliged to incorporate in their proposals the repeater from AEG-Telefunken (D), the TWTA from Thomson-FIAR (F/I) and the antenna from Selenia (I) developed under the Support Technology Programme.2/ Those companies would therefore be subcontractors in the final consortium selected. Concerning the remaining equipment of the Support Technology Programme, the consortia were, as noted above, free to select different equipment.

In general, each consortium decided for each main satellite contracting procedure which member company should take the prime contractorship. Prime contractorship was an attractive responsibility, since it enabled the company

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1/ For details on Step B contract conditions, see ESRO's tender document Invitation to Tender AO/521, Detailed Design Study of an Orbital Test Satellite, ESTEC, Jan. 1973.

2/ ESRO/PB-TEL(73)3, OTS Phase B Specification, 20 Feb. 1973.

Structure of consortia for OTS Step B proposal 1/

Country	COSMOS		MESH		STAR	
	Firm	Work share in %	Firm	Work share in %	Firm	Work share in %
PRIME CONTRACTOR						
United Kindom	MSDS	26.5	HSD	26.6	BAC	30.5
CO- AND SUBCONTRACTOR						
Belgium	ETCA	6.7	BTM	5.0	-	-
Denmark	Terma	1.0	Rovsing	3.6	Electronic-centralen	2.8
France	SNIAS SAT	20.7	MATRA LCT	23.9	Thomson-CSF SEP	17.5
Italy	Selenia	13.4	Aeritalia	6.3	FIAR Montedel	14.0
Netherlands 2/	-	-	Van der Heem	0.3	Fokker	5.0
Spain 2/	-	-	-	-	Sener	1.5
Sweden	Svenska	1.0	Saab	7.6	Ericsson	4.8
Switzerland	CIR	1.0	3/	1.4	Contraves	5.0
West Germany	MBB	19.7	ERNO AEG-Telef.	15.1	Dornier	15.0
USA	Philco Ford Honeywell	5.0	TRW	10.2	Lockheed Radiation	3.9
Unallocated		5.0				

1/ ESRO/AF973)35, Request for Authority to Place a Contract, 28 Mar. 1973. Permanent consortia members are underlined.

2/ Negotiations were under way to include firms from these countries. Although the Netherlands and Spain had not participated in the programme so far, it was considered possible that both countries would sign the final programme arrangement.

3/ MESH had named Contraves as the participating firm in the event that STAR did not receive a Step B contract. In the case of a MESH and a STAR award, MESH would subcontract an equivalent work share to an as yet unspecified Swiss firm.

to gain management experience in implementing complex satellite projects.1/ Whereas subcontracting is a common feature in aerospace development to keep costs down, there exists what is seen as an 'optimum' distribution of work between subcontractor and prime contractor. Not constrained by geographical distribution requirements, US space projects exhibit a prime contractor share of 50% to 60% as against 30% or less for ESRO projects. The limitation of 30% left nearly no hardware development for the European prime contractor; a US prime contractor would do some development work to reduce interface and communication costs. Since subcontracting is traditionally an even more common feature in US industry than in European industry, those figures may even understate the cost impact of limiting prime contractorship to 30%.2/

To reduce costs, the prime contractor would have to take a work share as large as possible within the limits of the geographical distribution requirements. Hence, the prime contractor had to come from a country with a large distribution share, which excluded some competent companies from smaller countries, such as Sweden's Saab.

From the preceding table, it can be seen that all consortia were led by British prime contractors, namely MSDS (COSMOS), HSD (MESH) and BAC (STAR). If this structure was kept, it was already certain that the prime

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1/ It is interesting to note that the consortia changed prime contractors for nearly every new satellite project. This prime contractorship 'by rotation' was not considered very satisfactory by ESRO secretariat, since it enhanced proliferation of expertise among the larger countries and hindered specialisation within each consortium. Through the rotation of responsibility within the consortium, each company was able to learn with ESRO money and to build up an overall competence, which in turn would put it in a better position for national satellite projects. See also G. Dondi, Space Activities in the Eighties (Paris, ESA/SP-1012, 1981), i, p. 278.

2/ For a comparison of approaches to subcontracting in Europe and the USA, see Maddock, op.cit., 595.

contractorship for the OTS project would go to a British firm. So far, British companies had not been very successful, compared with French and German firms, in obtaining contracts under the Support Technology Programme. Consequently, in order to achieve a balanced distribution of contracts within the overall TELECOM programme, a British company was an obvious candidate for prime contractorship. In other words, since the 'noble' hardware contracts (Support Technology Programme) were awarded <u>before</u> the 'noble' software contracts (prime contractorship), the former were given to the most competent companies whereas the latter had to be allocated to one of the companies from a country which contributed a large share of the funding of the programme but had not been successful in securing contracts.

In a letter to ESRO, the German delegation criticised the dominance of British companies in the prime contractorship, arguing that this was inconsistent with the equitable geographical distribution of contracts.1/ During the fourth Board meeting, the German delegation called upon ESRO to take the necessary steps to revise the structure of the consortia in order to guarantee that there would be genuine international competition. The national lobbying for 'noble' contracts was countered by the ESRO secretariat, which explained that it was difficult to intervene in this area, since industry was entirely free to decide on how it wanted to group together and to select the lead firm.

The three consortia proposals were evaluated by six panels, with the following results:

1/ ESRO/AF(73)27, <u>Letter from the German Delegation</u>, 16 Mar. 1973.

Panel evaluation criteria 1/	Weight factor	Consortium COSMOS	MESH	STAR
TECHNICAL PANELS		Evaluation marks		
1. System aspect, assembly, integration and testing	20%	11.74	12.55	13.42
2. Electrical systems	10%	5.80	6.63	5.72
3. Mechanical systems	15%	8.86	10.70	10.35
4. Product assurance	20%	9.79	12.25	7.93
MANAGEMENT PANELS				
5. Organisational, managerial and contractual aspects	20%	12.20	11.30	13.19
6. Planning and costing	15%	7.43	8.96	10.01
TOTAL	100%	55.80	62.40	60.70

The marks obtained during the evaluation of the tenders resulted in a preference for the MESH and STAR proposals. MESH was particularly well-experienced in the area of mechanical systems owing to its experience on the three-axis-stabilised ESRO scientific satellite called TD 1A. The MESH consortium featured a new joint approach by HSD (UK) and MATRA (F) to the management of the project: HSD, the prime contractor, was responsible for management and system design, and MATRA for integration and testing, which was generally considered to be the task of the prime contractor as well. Whereas this new scheme was not judged ideal by ESRO secretariat, since administrative and technical problems were anticipated, it was needed to share work among the permanent consortia members. The permanent members, as participants in the formal consortium arrangement, expected to receive a substantial share of work

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1/ The evaluation criteria were as follows: interpretation of requirements and constraints, quality and accuracy of analysis, demonstration of compliance with work statement, technical experience of bidder, suitability and availability of key personnel, distribution of responsibility and authority, management methods and coordination, project control procedure, realism of proposed schedules for Step B, Step C/D, correlation between structure, costs and planning. See ESRO/AF(73)35, op.cit.

in each consortium proposal, whereas the non-permanent consortium members were included in the consortium proposal on a more flexible basis.

The STAR consortium was organised along classical lines, as management responsibility was vested in the prime contractor. The central project team had a fairly large support team. The offer was marginally unacceptable in the areas of quality assurance, and improvement was necessary before the start of the contract.

In April 1973, on the basis of recommendations by the ESRO secretariat, the AFC decided to award Step B contracts to STAR and MESH, each amounting to 1.5 MAU and covering the period from May 1973 to September 1973.1/

In view of the long lead-time for breadboarding 2/ and high-reliability components required for Step C/D, ESRO intended to contract such critical activities outside the current Step B contract but prior to the commencement of Step C/D in order not to delay the project schedule. At that time, however, it was not known whether STAR or MESH would be the successful Step C/D tenderer. Consequently, ESRO contracted such critical activities to each of the competing consortia, knowing that most of the money paid to the unsuccessful tenderer would be lost.3/

After consultation with the industrial groups concerned, ESRO awarded advance procurement and breadboarding contracts to MESH and STAR, each amounting to 1.1 MAU, and a long-lead procurement contract to the repeater

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1/ ESRO/AF/MIN/89, 12 Apr. 1973.

2/ A breadboard is a preliminary grouping of components, sub-units and other parts which can easily be shifted about in order to test different wiring arrangements, to prove the feasibility of a device or system.

3/ ESRO/AF(73)62, Request for Authority to Place a Contract, 11 July 1973.

contractor, AEG-Telefunken, for 1.2 MAU during July 1973.1/ It was estimated that approximately 1 MAU of the total 2.2 MAU allocated to the consortia would be lost.

It is interesting to note that 57% of the consortia contract funds and 75% of the repeater contract funds for long-lead high-reliability components were spent in the USA. This indicated that despite ESRO's 'buy European' policy and ten years of European space research, industry still had to rely on the USA for the procurement of high-technology components.2/

On the basis of the Step B final report submitted to ESRO at the end of September 1973, the STAR and MESH consortia defined their proposals for Step C/D, which were received by ESRO in October 1973.3/ As required by ESRO, each consortium integrated the repeater subsystem group, led by AEG-Telefunken (D), into the proposal and included the costs incurred under advance procurement and breadboarding. The selection of the final contractor was of vital importance for the TELECOM programme. The OTS contract was not only the largest single contract to be awarded, but since OTS was basically a scaled-down model of the operational ECS, the industrial consortium which was awarded the OTS contract would also be selected to develop and produce the subsequent ECS satellites, depending on the results of direct negotiations between ESRO and the industrial group. Because of its advanced nature and the

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1/ ESRO/AF/MIN/92, 2 July 1973.

2/ On the topic of European dependence on US electronic components, see also U. Ernsberger, 'Promotion of European Components for ESA Projects', ESA Bulletin, VII (1981), No. 24, 68-71.

3/ For details on contract conditions, conditions of tender, geographical distribution and evaluation criteria of Step C/D, see ESRO's tender document Invitation to Tender AO/575, Orbital Test Satellite, ESTEC, Sept. 1973.

financial resources involved, the OTS contract was expected to hold importance beyond the TELECOM programme, shaping the future technological competence of European industry in the area of communication satellites.1/ The evaluation of the two tenders was based on price, quality and geographical distribution of contracts. The prices quoted by MESH and STAR for Step C/D were as follows at mid-1973 prices:2/

	MESH	STAR
Total price	55.177 MAU	53.691 MAU
Fixed-price share	63%	81%
Cost-reimbursement share	36%	19%

The results of the of the tender evaluation panels and the geographical distribution of contract value is shown on page 256. The structure of the consortia for OTS Step C/D is shown on page 257.

Until then, the STAR and MESH consortia had only been concerned with the development of scientific satellites. STAR had won the last two ESRO satellite contracts, GEOS and COS-B, whereas MESH had been more successful previously with ESRO II, ESRO IV and TD 1. In order to compete for OTS, both consortia had to expand and include a number of firms with suitable experience, mainly in electronics. MESH had only limited experience with regard to communication payloads, whereas STAR was well-suited for a communication satellite programme, since the BAC/Thomson-CSF (UK/F)

1/ H. Hartbaum, 'The Application Satellite Programme - A Challenge to the European Communications Industry', Journal of the British Interplanetary Society, XXVII (1974), No. 3, 177-80; 'MESH Wins OTS...and MAROTS Too?', New Scientist, XC (1973), 771.

2/ It was considered feasible to negotiate an increase in the fixed-price content of the MESH offer up to about 78%. ESRO/AF(73)127, Request for Authority to Place a Contract, 14 Nov. 1973.

Marks awarded by tender evaluation panels:1/			
Panel evaluation criteria	Maximum points	Points awarded MESH	STAR
1. Overall system	160	85	101
2. Assembly, integration, test and operation	130	81	85
3. Electrical systems	120	67	62
4. Mechanical systems	140	86	86
5. Product assurance	150	79	91
6. Organisational, managerial and contractual aspects	150	85	96
7. Planning and costing	150	74	88
Total	1000	557	609

Geographical distribution of contract value:2/		
Country	Contract value in %	
	MESH	STAR
Belgium	4.2	3.7
Denmark	1.5	1.7
France	25.6	17.8
Italy	14.1	17.7
Netherlands	2.8	3.2
Spain	0.8	1.8
Sweden	6.8	0.7
Switzerland	2.4	3.1
United Kingdom	17.3	21.2
West Germany	18.8	23.8
USA	6.1	5.3
Total	100.0	100.0

1/ Ibid. The evaluation criteria correspond to those applied for the selection of Step B contracts (see page 252).

2/ Ibid.

Structure of consortia for OTS Step C/D 1/

Country	MESH	STAR
PRIME CONTRACTOR		
United Kingdom	HSD	BAC
CO-CONTRACTORS		
Belgium	-	ETCA
Denmark	-	Elektronikcentralen
France	MATRA	Thomson-CSF
		SEP
Italy	Aeritalia	FIAR
		Selenia
		Montedel-Laben
Netherlands	-	Fokker-VFW
Spain	-	Sener
Sweden	Saab	-
Switzerland	-	Contraves
West Germany	ERNO	Dornier
		AEG/Telefunken
		MBB
SUBCONTRACTORS		
Belgium	BTM	-
Denmark	Christian Rovsing	-
France	Air Equipment	SAFT
	Crouzet	SAT
	LCT	Starec
	Sodern	SODERN
Italy	Galileo	Galileo
	Selenia	
Netherlands	Philips	
	TNO	
	Van der Heem	
Spain	INTA	
Sweden		Ericsson
Switzerland	CIR	-
United Kingdom	MSDS	MSDS
West Germany	AEG/Telefunken	Teldix
USA	Aerojet	Thiokol
	TRW (Consultant)	Lockheed (Consultant)

1/ *Ibid*. Permanent consortium members are underlined.

combination possessed valuable experience - BAC in the area of service module development and Thomson-CSF in the area of communication payload as a result of its participation in the SYMPHONIE programme.

As noted above, the prime contractor was free to procure the equipment and components he wished to incorporate from any supplier whatsoever with the important exception of the repeater and the subsystem. ESRO expected that in practice, considerations of cost, time schedule and equipment quality would lead the prime contractor to select suppliers which had developed critical items under the Support Technology Programme.

The MESH proposal, however, envisaged the procurement of items which were somewhat outdated or insufficiently tested and qualified, instead of using the corresponding equipment designed under the Support Technology Programme. For example, MESH had chosen to use the solar array developed by MATRA and not the array developed under the ESRO programme by MBB. As the Tender Evaluation Board noted, the cost advantages claimed for this approach had been exaggerated and its mass penalty compared to the ESRO developments ignored. The MATRA solar array was even considered to be unacceptable owing to unanalysed failure modes.

MATRA was a permanent member of MESH, and consequently the prime candidate for taking most of the French work share in the MESH proposal. This, however, could only be achieved by entrusting MATRA with the production of the solar array and the array release mechanism. Originally, MESH had planned to use the MBB array; it only introduced the MATRA equipment at a late stage in the Step B studies, which was reflected by the lack of detailed design work. As noted in the evaluation of Step B proposals, the satellite management was split between MATRA and the prime contractor HSD: MATRA was responsible for the integration and testing of the satellite and HSD for the system management and design. Both responsibilities were considered to be the task of the prime contractor by the ESRO secretariat. This approach, however, was introduced in order to achieve an adequate work load for MATRA.

There had been some other instances of consortium solidarity. MESH did not select the French company SAFT as subcontractor for the satellite batteries, but assigned this task to the less experienced Spanish company INTA, which was a permanent member of MESH. The Spanish company Sener was selected as a co-contractor by STAR even though it had become clear at that time that Spain would not participate in the satellite project. Sener was a permanent member of the STAR consortium.

This consortium solidarity resulted in a paradoxical situation. In the case of the satellite contract, there was competition at the overall project level, but not at the level of some of the elements of the subsystem because the tasks were distributed, a priori, on the basis of the firms' consortium membership. It should be noted, however, that whereas interchangeability at the equipment level would have enhanced competition, it also would have limited consortium stability, with possible drawbacks in the area of company interface and coordination.

The STAR proposal was significantly better than the MESH proposal, technically as well as administratively, as can be seen from the results of the evaluation panel (see page 256). In addition, the STAR proposal was cheaper and had a higher proportion of fixed-price parts.

Consequently, the Tender Evaluation Board clearly recommended the awarding of the OTS Step C/D contract to STAR. The award, however, was to be conditional on the consortium making the necessary improvements in the areas where its proposal had been judged unsatisfactory and rearranging subcontracts so as to achieve satisfactory participation by Swedish industry with no impact on the price or the time scale.

During November 1973, the AFC was asked by the ESRO secretariat to award the OTS Step C/D contract to STAR.1/ Only the British, Dutch and Swiss delegations, however, supported the STAR proposal, whereas Belgium, Denmark, France, Sweden and West Germany favoured MESH.

Belgium, Denmark and France argued that the award of the OTS contract to STAR would jeopardise the future of the MESH consortium since this industrial group had not managed recently to secure any major satellite contracts, as noted above. This in turn was seen as putting in danger the conditions for free industrial competition if the European industrial groupings were reduced to two instead of the current three consortia. Sweden, in particular, was dissatisfied with the geographical distribution of the STAR proposal since only 0.7% of contract value was allocated to Swedish industry, compared with 6.8% in the MESH proposal. West Germany, on the other hand, favoured the MESH proposal despite having a larger work share in the STAR proposal. By that time, the German company ERNO, a permanent member of MESH, was running into serious difficulties because of its failure to secure a sufficient work load. ERNO is situated in the northern part of West Germany (Bremen), which had a particular high unemployment rate and a lack of advanced industry.2/ In addition, for national space projects a strong ERNO company was needed to maintain competition between the German space companies ERNO, MBB and Dornier. The Danish delegation expressed more clearly national employment considerations when justifying its position:

1/ ESRO/AF/MIN/95, 4 Dec. 1973.

2/ 'ERNO erhielt Entwicklungsauftrag für den Satelliten OTS', HOG-Nachrichten, X (1974), No. 1, 25; 'ESRO-Auftrag für ERNO', HOG-Nachrichten, X (1974), No. 3, 90.

> '...it would base its choice on industrial considerations, with a view to providing the firms involved with a sufficiently full order book, and avoiding unemployment'.1/

The Netherlands, Switzerland and the United Kingdom strongly supported the proposal of ESRO's secretariat to award the OTS Step C/D contract to STAR. All three countries had a larger work share in the STAR proposal than in the MESH offer.

Defending its proposal, the secretariat drew the delegations' attention to the real shortcomings of the MESH tender in project management, systems engineering and several of the components. In reference to the industrial difficulties of the MESH consortium, ESRO argued that it did not wish to deal with groupings whose constitution was 'frozen', but supported the possibility of a regrouping of the firms in order to enhance competitiveness. In addition, ESRO claimed that if the AFC was to base its judgement merely on considerations of industrial policy, independently of ESRO's technical and financial evaluation, the latter would become meaningless.

Against ESRO's recommendation, however, the AFC awarded the OTS Step C/D contract to MESH by six votes (Belgium, Denmark, France, Italy, Sweden, West Germany) to two (Netherlands, Switzerland), with one abstention (United Kingdom). The contract was awarded on the condition that an acceptable solution would be found in respect of those aspects of the tender which ESRO had considered poor, with no increase in the ceiling price of 55.177 MAU and no major change in the timetable for the programme.

Analysis of the OTS Step C/D contract award clearly shows that government representatives were primarily concerned with the well-being of their own national industry by protecting their unsuccessful national companies from

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1/ ESRO/AF/MIN/95, op.cit., 5.

having to face the consequences of being defeated in a European competition. The need to avoid unemployment and to maintain a competitive national industrial structure in the larger countries seemed to be the basic motivations in the contract approval. Obviously, such protective habits hampered necessary industrial specialisation within a European framework, which was characterised by excess industrial capacity for European market needs, as outlined above.

Consortium solidarity at the equipment level also enhanced existing overcapacity since it supported the creation of new sources of supply. It should be noted, however, that the optimum balance between building up a competitive system through duplication and promoting industrial specialisation is difficult to determine. In fact, specialisation could lead to a situation in which one company would hold a European monopoly, with the resulting drawbacks for subsequent tender actions.

Following the AFC approval, the revision of the MESH offer as requested by the ESRO secretariat covered various deficient areas of the original tender. In particular, MESH had agreed to select the MBB solar array substrate and mechanism instead of the MATRA equipment. In addition, further improvements were achieved in aspects of the overall system, telemetry and telecommand requirements, antenna arrangement, product assurance, planning and costing. The central project team of MESH was drastically revised and considerably reinforced.

The make-or-buy plan for the various equipment items used for the OTS incorporated duplicate technology as protection against possible systematic design deficiencies, that is to say, to provide functional redundancy in addition to protection against random failure by the parallel use of the same technology. Such a 'mixed' solution had been chosen for the TWT by using equipment developed by AEG-Telefunken (D) and Thomson-CSF (F). When the MESH offer was being revised, 'mixed' solutions were also considered for the sensors and momentum wheels.

As for sensors, MESH proposed to retain the equipment developed by Galileo (I) under the Support Technology Programme, but had serious doubts in terms of development schedule and product assurance, in particular lifetime. The possibility of using a sensor from SODERN (F) in addition to Galileo was reviewed from the technical and financial point of view. The SODERN design, derived from the SYMPHONIE satellite, was inherently simple and hence potentially more reliable, its probable drawback for the OTS/ECS mission being its limited accuracy.1/ ESRO approved the mixed solution and covered the additional cost by increasing the contract price by 532 KAU.2/

As for momentum wheels, MESH had proposed to use the wheel developed by Philips (NL) instead of the wheel developed by Teldix (D) with experience gained through SYMPHONIE.3/ Both momentum wheels were the subject of technological support contracts under the TELECOM programme from 1972 onward.4/ Since two redundant wheel units were planned for OTS, the possibility of a 'mixed' solution was investigated. Finally, for reasons of economy, MESH and ESRO agreed on the Philips design only, as originally proposed by the consortium.

1/ ESRO/AF(74)26, Request for Authority to Place a Contract, 20 Feb. 1974.

2/ ESRO/AF/MIN/92, 22 Mar. 1974.

3/ ESRO/AF(72)137, Request for Authority to Place a Contract, 16 Nov. 1972.

4/ The Philips wheel employed a new type of bearing, known as a grease bearing, instead of a roller bearing, of particular interest from the durability angle. The Teldix wheel used a more complex wheel mechanism, known as a double gimbal, instead of a fixed type of wheel. The Teldix wheel was considered more advanced.

The revision of the MESH tender in the areas originally judged to be weak had resulted in acceptable solutions and an acceptable programme slippage of four weeks.1/ Excluding the 'mixed' sensor solution, MESH had agreed to absorb the price increase resulting from the revision. Hence, an overall ceiling price of 55.709 MAU was set, with a fixed-price content of 78%. ESRO released the main OTS development contract to MESH on 28 February 1974.2/

During the Programme Board meeting in September 1974, the question of introducing the Teldix wheel was again raised by the German delegation.3/ It informed the Board that the German Ministry of Research and Technology had decided to finance a study of a mixed Teldix/Philips solution and was prepared to cover part of the adaptation cost if the 'hybrid' system were approved by the Board. The total amount of funding provided by the German government was

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1/ ESRO/AF(74)16, OTS Development Contract - Review of Negotiation with Hawker Siddeley Dynamics, 31 Jan. 1974.

2/ The objectives of the contract provisions were to obtain a satisfactory product within schedule and cost. The technical baseline established in the contract was controlled down to the equipment level in accordance with standard product-assurance procedure, and monitored at monthly project progress meetings at various levels. The incentive scheme, in which all contractors and a number of subcontractors participated, was a major feature of the contract and the key to contractual performance. The scheme was heavily oriented towards performance, with three quarters of the fee being allocated to the in-orbit performance of OTS over five years, the remaining quarter being allocated for schedule performance. Besides incentive fees associated with the timely delivery of the satellite, the contractor was encouraged to achieve schedule goals by the attachment of fixed-price payment (four fifths of the contract was fixed-price) to the achievement of milestones at predetermined times during the course of the contract. In order to achieve cost control for the 22% of the contract price that was on a cost-reimbursement basis, the incentive scheme provided for a cost-sharing arrangement by which the contractor would receive a bonus of 20% to 40% of any cost savings (depending on the performance fee earned) or pay a penalty of 5% to 10% of any cost overruns to ESRO. It should be noted that similar US satellite contracts included a much larger incentive share than the OTS contract.

3/ ESRO/PB-TEL/MIN/11, 14 Nov. 1974.

of the order of DM 500,000.1/

A mixed solution would increase the redundancies of the satellite, thereby improving the chances of a successful operation, and hence was welcomed by the ESRO secretariat and CEPT. Since financing was provided outside the ESRO programme as part of a national effort, the cost consideration which led to the rejection of a mixed solution was no longer valid. The inclusion of the Teldix wheel, however, would not only limit the Philips contract share but also create a competitive situation for Philips regarding the ECS satellites and subsequent missions.

The Dutch delegation was strongly opposed to the German intention and drew attention to the fact that such a step was in clear violation of the industrial policy principles laid down for ESRO to avoid duplication of work. In addition, the French delegation raised a question of principle:

> '...was it admissible for a proposal of this nature to be made, not by the firms concerned with the contract (HSD as OTS prime contractor) but by a delegation?'.2/

The French delegation concluded:

> '...if this attitude was considered admissible, there would be no objection to the French delegation proposing that the satellite be equipped with SAT solar cells (a French company) provided that it financed the corresponding studies'.3/

Although the Board noted that this was a question of principle, it considered that it had no authority to judge the desirability for the German authorities of financing work in their national industry since at the current stage, the Board had only been invited to take note of the German activity.

1/ ESRO/PB-TEL(74)28, Implication of the Introduction of a Teldix Inertial Wheel on OTS, 23 Sept. 1974.

2/ ESRO/PB-TEL/MIN/11, op.cit., 4.

3/ Ibid.

By November 1974, the study of a mixed Teldix/Philips solution, which was carried out by MATRA (F) as the contractor for the OTS attitude control subsystem, was completed and the results were analysed by HSD (UK) as the OTS prime contractor, which recommended that the OTS programme should go ahead on the basis of the mixed Teldix/Philips solution. In light of the increased redundancy of the wheels (double assurance against random and systematic failure) and the increased timetable and cost guarantee due to the existence of two supply sources, HSD put forward a recommendation and submitted a financial proposal to ESRO for the adoption of the 'hybrid' system. The modification would result in an additional cost of 100 KAU and the ESRO secretariat recommended that the Board should approve the prime contractor's proposal and authorise the additional funding.1/

Before the issue was discussed at the Board meeting in November 1974, the Dutch delegation submitted a statement to ESRO strongly opposing the inclusion of a Teldix wheel in OTS on technical, financial and industrial policy grounds.2/ It noted that the double assurance of the mixed solution was very doubtful since diversification would also result in less reliability caused by complication. The industrial policy consideration, however, dominated the Netherlands statement. Not only would the change from the Philips wheel to any other adversely affect the already unfavourable work share of the Netherlands in OTS, but heavy German support for Teldix would also lead to unfair competition inconsistent with the industrial policy principles advocated by ESRO. The delegation stated that such a precedent would lead to a chaotic

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1/ ESRO/PB-TEL(74)31, Inclusion of a Teldix Momentum Wheel on the OTS Service Module, 18 Nov. 1974.

2/ ESRO/PB-TEL/MIN/12, Statement of the Netherlands Delegation with Regard to Item 6, 30 Dec. 1974.

situation in all European programmes, as it contained an invitation to all countries to bring forward back-up proposals for the benefit of national industries after the award of any contract to a consortium. The German delegation challenged the arguments of the Netherlands, pointing out that, since the test programme's purpose was to pave the way for operational satellites, it was highly desirable that OTS should provide an opportunity to flight-test equipment of varying technical design.1/

By five votes (Denmark, Italy, Sweden, United Kingdom, West Germany) to one (Netherlands), with two abstentions (Belgium, France), the Board approved the prime contractor's proposal to introduce a Teldix wheel into the OTS satellite. The Dutch delegation, however, was not prepared to accept the Board's decision and announced its intention to refer the matter to the Council. This was supported by the French delegation, which also considered that the Board's decision raised a problem of industrial policy.

Subsequently, the Netherlands delegation approached the Council, demanding a discussion of the Teldix wheel issue. In a statement at the Council meeting, the delegation concluded that the

> '...reversal of an earlier decision to use only Philips wheels has been made possible by German governmental financial support towards the Teldix solution, i.e., by subsidising a study once a decision had been made. It is felt that such a procedure distorts normal competition'.2/

In reply, the German delegation argued that the Council had no authority to overturn the Progamme Board's decision.3/

As noted above, there had been a similar case which the development of a

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1/ ESRO/PB-TEL/MIN/12, op.cit., 30 Dec. 1974.

2/ ESRO/C(74)74, Statement by the Netherlands Delegation on Industrial Policy, 2 Dec. 1974, 2.

3/ ESRO/PB-TEL(74)31, Add.1, Statement by the German Delegation, 6 Dec. 1974.

technology was financed outside the ESRO programme in order to support its inclusion in the OTS, namely the case of the travelling wave tube (TWT). In this case, the German Ministry had covered the development cost of the AEG-Telefunken (D) TWT on the condition that it would be incorporated in the OTS along with the Thomson-CSF (F) TWT, which was selected under the ESRO programme.1/ In view of the Netherlands intention to initiate a discussion of the industrial policy implications of the Teldix/Philips wheel solution, the French delegation asked the ESRO Council to consider the practice of the TWT development as well. The delegation believed that the procedure followed by ESRO was

> '...an open invitation to dumping, it may serve certain short-term interests of a particular programme, but it is clearly contrary to European interest as a whole'.2/

The ESRO secretariat defended its technology policy with respect to the critical elements of the TELECOM programme. The general line of thought was based on the following principles. As regards the programme elements that were new and critical from the technology viewpoint, two qualified sources of supply had to be available in Europe. This was to be achieved either through ESRO funding of research and development or through national or private funding. Second, it was considered highly desirable to provide, aboard the OTS, redundancy of those critical elements by using different technologies. This policy had been advocated by the ESRO secretariat in three new technological areas, namely wheels, TWTs and sensors. However, such a technology policy was restricted to OTS in the view of importance of this

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1/ ESRO/C(74)75, Technological Policy with Respect to the Critical Elements of the Communication Satellite Programme, 6 Dec. 1974.

2/ ESRO/C(74)70, Letter from Mr. M. Bignier, French Delegate to the Council of ESRO, 18 Nov. 1974.

project as a 'test bed' for the new technologies and hence its importance for subsequent satellite missions.

During the Council meeting in December 1974, the positions of the ESRO secretariat and the German delegation came under heavy criticism. The Netherlands delegation stated that

> '...it was wholly unacceptable that a member state should be able to induce the organisation to go back on the choice of a contractor by offering a certain price reduction which the member state itself had brought about by subsidising its industry'.1/

The United Kingdom delegation likewise found it

> '...unacceptable that the choice of a contractor should be called into question simply because the "losing" tenderer offered to reduce its original quotation after the evaluation procedure had been completed'.2/

Supporting national industry independently of European coordination was seen as a threat to European cooperation. The Belgian delegation pointed out the relevance of this particularly for the smaller countries:

> '...anything that might suggest "dumping"...run counter to the principles of European coordination and is particularly prejudicial to the "small" countries'.3/

Noting the criticism, the Council nevertheless agreed with the technology policy defined by the ESRO secretariat, owing to the special nature of the OTS project and in view of the advanced stage of the project. By emphasising the exceptional nature of the measures taken by the German authorities to promote the development of a TWT and a wheel, the Council made clear that these cases should therefore not constitute a precedent.

The wheel case reinforces the conclusions drawn from the case of the TWT

1/ ESRO/C/MIN/71, 6 Dec. 1974, 7.

2/ Ibid.

3/ Ibid., 8.

development (see page 218), namely that national funding organisations avoided European specialisation if this implied the abandonment of national technology supply. Obviously, the intention was to maintain national supply security for key equipment.1/ These cases also support the observation made by J.P. Causse, a senior official of ELDO, in looking back on his experience with this organisation:

> '...each country tends to develop its own technology and then tries to impose it on the community'.2/

In fact, as a result of national support, the Teldix company established what can be considered a world foothold in advanced satellite wheel technology. Teldix wheels were not only used for the European satellites but also for INTELSAT and Japanese satellites.3/

1/ R. Mayer, 'Zur Technologie-Förderung zukünftiger Kommunikations-Satelliten (ZKS-Programm des BMFT)', Raumfahrtforschung, XIV (1973), No. 3, 153-60.

2/ J.-P. Causse, 'Europe's Space Cooperation, Astronautics & Aeronautics, IX (1971), No. 4, 63.

3/ 'Germany Improves the Wheel', Flight, LXIX (1978), 1514.

4.8 <u>The Satellite Control and Test Station (SCTS) for OTS</u>

Besides development of the OTS, the TELECOM arrangement for phase II included the provision of telemetry tracking and command control (TTC) 1/ during the entire lifetime of the OTS and of facilities required to carry out the basic transmission measurements on the communication payload, both by means of a satellite ground station.

ESRO envisaged the development and setting up of a Satellite Control and Test Station (SCTS) with a 15 m antenna to fulfil these obligations under the TELECOM arrangement and called for tenders from European industries for production of such a station in the beginning of 1974. It was assumed that the SCTS station would receive and transmit the satellite data and that all monitoring and processing of the data would be carried out at ESRO's Operational Control Centre (ESOC) situated at Darmstadt (West Germany), in order to avoid the duplication of computer facilities. The ESRO secretariat proposed to establish the SCTS station at the Odenwald site near Darmstadt, already used by ESRO's ground stations for the control of its scientific satellites.2/ Since ESOC and the proposed SCTS site were not far apart, the establishment of a required highly reliable, good-quality data link between the two locations would be facilitated. Hence, the Council 3/ selected the

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1/ Each satellite is controlled by a ground station which observes and directs the station-keeping of the satellite and is in charge of switching satellite functions on or off. See C. Hughes, H. Uhrig, S. Tirro, 'The Satellite Control and Test Earth Station at Fucino', <u>ESA Bulletin</u>, II (1976), No. 5, 44-9.

2/ ESRO/C(74)15, <u>Ground Station for the Control of OTS</u>, 28 Apr. 1974.

3/ ESRO/C/MIN/64, 29 Apr. 1974. The decision on the SCTS needed approval from the Council since the establishment of ESRO ground stations was planned within the framework of a general policy on control stations in order to ensure their optimal use in the overall ESRO programme.

Odenwald site in April 1974, subject to the availability of the necessary OTS frequencies at this location.

In July 1974, the German authorities confirmed that the necessary frequencies were available at the Odenwald site, but they were not able to guarantee their availability after 1980. The ESRO secretariat considered it unreasonable to lay out a considerable amount of capital for the construction of SCTS, estimated at 5.5 MAU, for such a short period of time, i.e. 3.5 years (OTS was to be launched in mid-1977). Quite apart from the fact that the OTS might have a real lifetime greater than its nominal three years, such a solution would not allow the station to be reused for the operational ECS, which would operate on the same frequency bands as OTS. The ESRO executive therefore examined alternative sites in Redu (Belgium), Madrid (Spain) and Usingen (West Germany).

In June 1974, the Italian delegation put forward an alternative proposal for the SCTS.1/ It essentially consisted of having OTS operated and controlled under ESRO contract from an Italian PTT station at the Fucino site (Italy), financed and operated by the Telespazio company which was acting on behalf of the Italian PTT authorities. This station could be used, after it had fulfilled the ESRO contract, by the Italian PTT authorities as their ground station in the operational ECS system.2/

The Italian proposal differed considerably from the option currently envisaged: an earth station operated and owned by ESRO. The adoption of the

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1/ ESRO/C(74)33, Italian proposal, 3 June 1974.

2/ As noted above, the TELECOM programme envisaged that the national PTT administrations would set up, at their own expense, the ground stations required for the operational use of the ECS system. In addition, some administrations had already agreed to set up these stations for use in the pre-operational phase of the OTS project.

Italian proposal would therefore call for a fresh decision by the Council, after consultation with the Programme Board.

The following procedure was approved by the Council.1/ At the end of July, the executive was to submit to AFC the outcome of the technical assessment of replies received from industry in response to the call for tenders for the ground station, and would ask for authority to place the relevant contract, with a study phase of 10 weeks. During these 10 weeks, detailed negotiations would continue with the Italian PTT administration and Telespazio on the financing and operation of the station, so that a decision on the final solution could be made at the beginning of October. In addition, other delegations were asked to let ESRO know whether any other national bodies would be likely to tender for the setting up and operation of the SCTS station.

This new approach was not supported by all delegations. In particular, Belgium favoured a ground station owned by ESRO, arguing that this would mean

> '...participants would be co-owners of the facilities; any other solution could be to the disadvantage of the "small" countries, who were not in a position to make proposals'.2/

Meanwhile, during June 1974, ESRO had received two offers by industry in response to the tender action for the design, development and manufacture of the SCTS station, one by a consortium led by AEG-Telefunken (D) at a cost of 5.505 MAU, and one by a consortium led by Siemens (D) at a cost of 5.907 MAU.

The industrial structure of the consortia and the proposed geographical distribution of contract was as follows:3/

1/ ESRO/C/MIN/65, 6 June 1974.

2/ ESRO/PB-TEL/MIN/10, 3 July 1974, 8.

3/ ESRO/AF(74)82, <u>Request for Authority to Place a Contract</u>, 18 July 1974.

Country	AEG-Telefunken consortium		Siemens consortium	
	Company	Contract share	Company	Contract share
PRIME CONTRACTOR				
West Germany	AEG-Telefunken	50.4%	Siemens	38.8%
SUBCONTRACTORS				
Belgium	BTM	6.3%	BTM	1.1%
France	LCT	8.5%	Schlumberger	9.2%
Italy	STS	19.0%	STS	0.6%
Sweden	-	-	Silvers	0.5%
Switzerland	Oscilloquartz	2.4%	Oscilloquartz	2.3%
United Kingdom	-	-	MSDS	32.9%
West Germany	Krupp	13.4%	Krupp	14.6%
Total		100.0%		100.0%

The ESRO executive recommended and AFC approved the award of the contract to AEG-Telefunken in July 1974.1/ The total price of the contract was limited to 5.325 MAU, of which only 750 KAU were committed for a 10-week design phase and for critical long-lead items. The remaining amount would be approved as soon as possible after 1 October 1974 in light of the final financing and location option chosen and subject to satisfactory allocation of contract shares to Denmark and the United Kingdom.

In addition to selecting the industrial contractor for the building of the SCTS station, the ESRO executive studied the two options concerning the station's financing and operation. In addition to Telespazio (I), two other national telecommunication companies informed ESRO of their intention to offer their services for the control and testing of OTS, namely CTNE (E) and Deutsche Bundespost (D). In order to meet the technical and timetable

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1/ ESRO/AF/MIN/101, 25 July 1974.

constraints of the TELECOM programme, the ESRO secretariat asked the three organisations which intended to offer their services to accept the AEG-Telefunken consortium as the choice of contractor for the construction of the SCTS station.

In August 1974, the Deutsche Bundespost (D) stated that it was not in a position to accept either ESRO's choice of contractor or the current technical design of the station. CTNE (E) also informed ESRO that it was not prepared to accept the choice of the AEG-Telefunken consortium or any restriction on its freedom to use the ground station. Consequently, no detailed offer was made by either organisation. Only Telespazio (I) accepted ESRO's requirements and proposed to build the AEG-Telefunken station at the Fucino location in Italy under an ESRO/Telespazio financial arrangment.1/

The analysis of the ESRO secretariat of the other options, namely a station owned by ESRO, had resulted in the selection of the Redu site in Belgium, which offered the best conditions from the technical and economic standpoints.2/

The two basic alternatives were as follows:

> Would the SCTS be mainly financed and owned by Telespazio (I), built by the AEG-Telefunken (D) consortium, located at Fucino (I) and operated by Telespazio under ESRO contract?
>
> or
>
> Would the SCTS station be financed, owned and operated by ESRO, built by the AEG-Telefunken (D) consortium and located at Redu (B)?

1/ ESRO/PB-TEL(74)23, Ground Station for the Control of OTS, 17 Sept. 1974.

2/ Ibid.

The two solutions were both acceptable and virtually equivalent from the technical angle. The Telespazio/Fucino solution, however, presented an appreciable advantage with regard to the total cost, as shown below:1/

	Telespazio/Fucino	ESRO/Redu
Over 3.5 years	5.340 MAU	6.860 MAU
Over 7.0 years	8.095 MAU	8.295 MAU

The ESRO executive favoured the Telespazio/Fucino solution and invited the Programme Board to recommend its approval to the Council. In addition to the financial considerations, the executive argued that the Telespazio/Fucino solution would promote close cooperation between ESRO and the Italian telecommunication organisation and hence provide a strong incentive for this organisation to participate in the subsequent operational phase of the programme.

In September 1974, three days before the two options were to be discussed by the Programme Board, ESRO received a telex from the German delegation. Since the executive's new proposal on the SCTS site was seen to run counter to the Council's previous decision on the selection of the Odenwald site, the German delegation felt that the choice of the site should be fully open to discussion and proposed Weilheim (D), which was close to ESOC, as a new site. The ESRO executive was requested to assess the merits of this proposal. During the Board meeting, the executive replied that the stage which the work had already reached would not allow the assessment of the Weilheim site since this involved a delay of one or two months. The Belgian delegation expressed

1/ Including capital expenditure, annual rental, operation and maintenance.

its deep regret that the ESRO/Redu solution was not favoured by the executive, and pointed out the desirability of ESRO owning the facility.1/

Following the discussion, the Board was not able to make a clear recommendation to the Council on the preferred option. Consequently, the Council was requested to find a solution on its own and to make a final decision at its next meeting in October 1974.

During the following Council meeting, the positions were unchanged: Italy supported the Telespazio/Fucino option, Belgium pressed for the ESRO/Redu solution, West Germany demanded analysis of the Weilheim site and even Spain asked for reconsideration of the Madrid site, which had been rejected six months before. France, Sweden and Switzerland expressed a slight preference for Telespazio/Fucino in view of the fact that it would lead to the active participation of the future users of the system. Belgium insisted on the selection of ESRO/Redu and underlined the importance that its authorities attached to the maintenance of an ESRO establishment in Belgium. In this respect, it was argued, the selection was a political issue and should not be solely based on technical and economic considerations.

Since no decision could be reached at that meeting, the issue was deferred to the continuation of the meeting the following morning. The Swiss delegation noted that

> '...nothwithstanding the political commitments to rationalisation and pooling of infrastructure equipment, concern for national interests continued too often to predominate'.2/

The Belgian delegation protested the way in which the Swiss delegation had sought to interpret its position.

1/ ESRO/PB-TEL/MIN/11, 30 Sept. 1974.

2/ ESRO/C/MIN/66, 18 Oct. 1974, 14.

Despite the differences between the delegations, the Council managed to come to a decision the next morning, when it approved the executive's proposal (Telespazio/Fucino) with one vote against (Belgium) and two abstentions (Netherlands, Sweden).

Following the Council's decision, AEG-Telefunken was instructed to redirect the design study in close consultation with Telespazio in order to take into consideration the location of the station at Fucino. AEG-Telefunken revised its original proposal accordingly and included, as demanded by AFC back in July, a British company in the consortium - namely MSDS, as recommended by the ESRO secretariat. As a result of the changes, AEG-Telefunken submitted a revised price of 8.3 MAU for the station, compared with the original 5.3 MAU. The main reason for the increase was the change of subcontractors recommended by ESRO.

The ESRO secretariat did not consider this increase justified and felt obliged to reopen the competition. It awarded a study contract of 150 KAU to Siemens (D) in order to make its former offer technically acceptable by incorporating the specifications resulting from the new design study. A final choice of the contractor for the SCTS station was scheduled for January 1975. Siemens, however, was unable to submit a revised proposal in time for ESRO's overall programme. As a consequence, the idea of continuing the competition with Siemens was abandoned, and AEG-Telefunken was instructed to review its detailed design again, using the cheapest subcontractors.

The newly revised offer of AEG-Telefunken now amounted to 6.545 MAU. It excluded MSDS (UK) and was based on the participation of the industrial group originally proposed in the initial offer, except for a few minor changes.

In February 1975, the AFC approved the final contracts covering the arrangment for the OTS ground station SCTS, as follows:1/

(1) AEG-Telefunken contract (ESRO's share of the ground station cost)	2.345 MAU
(2) Telespazio contract 2/	
Rent of the SCTS station over 3.5 years	1.665 MAU
Maintenance and operation for 3.5 years	2.295 MAU
Total	6.305 MAU

The United Kingdom did not approve the AEG-Telefunken contract, as it was unhappy with the participation of British companies. The disappoval of Belgium was based on the rejection of the ESRO/Redu option.

The contracting history of the SCTS ground stations highlights a number of interesting points. First, it shows the interest of member states in having facilities of the joint undertaking established in their own country. Obviously, this is motivated by fair-return, employment and prestige considerations. Second, the SCTS case demonstrates the link between tender cost and fair-return policy. Third, it elaborates the relationship between the ESRO secretariat and industry. There was a give-and-take between the two interest groups. Whereas ESRO pushed for the rearrangement of the industrial grouping in order to achieve a balanced distribution of contracts, industry resisted this pressure by quoting an inflated price for the change in the

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1/ Negotiations between ESRO and Telespazio had resulted in the following arrangement. Basically, ownership of the station would be split between Telespazio and ESRO on a two-thirds/one-third basis. ESRO would own all the equipment required to perform the satellite control functions, whereas Telespazio would own all the communication equipment, of which the major items were the main antenna, two transmitting chains and the base-band equipment. ESRO would rent from Telespazio the equipment it had purchased from AEG-Telefunken.

2/ The Telespazio contract included the possibility of extending the 3.5 year period if necessary.

tender. The company might have been aware of the limited industrial competition of the contracting procedure at that stage. Finally, the SCTS case also demonstrates the flexibility of ESRO. Having to choose between tender cost and fair-return considerations, the cost criterion was considered more important, despite the criticism of those member states whose industries would not achieve a 'fair return'.

4.9 A launcher for the OTS

Originally, it had been planned to launch OTS on NASA's Thor Delta 2914, which was capable of putting 350 kg into geostationary orbit. During the summer of 1973, it became likely that the 2914 launcher would be upgraded to a Thor Delta 3914 capable of launching 450 kg.

During the Board meeting in May 1974, the French delegation proposed the adaptation of OTS from the 2914 to the 3914 launcher in order to raise the weight constraints for the satellite.1/ This would allow more redundancy for the most critical items and an increase in the hydrazine mass to prolonge the spacecraft's life in orbit.

Following an exchange of views among the delegations, the ESRO secretariat was instructed to request a formal proposal from the prime contractor of the MESH consortium for the conversion of the OTS vehicle by June 1984.

The conversion of the OTS to a Delta 3914 was estimated to cost an additional 6.25 MAU.2/ As a result, the satellite mission would be more reliable since various redundancies would be possible, the OTS lifetime would increase from three to five years and an up-graded OTS would require less modification to adhere to the ECS configuration, decreasing the development cost of ECS.

The ESRO secretariat strongly supported the conversion, which appeared to

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1/ ESRO/PB-TEL(74)16, Proposals by the French Delegation on the Conditions for Carrying out the OTS Project, 23 June 1974.

2/ The additional cost of 6.25 MAU was distributed as follows: service module 2.68 MAU, payload module 1.57 MAU, launcher 2 MAU. The additional expenditure was beyond the estimated cost-to-completion of phase II of the programme as defined in the TELECOM arrangement, but within the 20% overrun which could be approved by a two-thirds majority. ESRO/PB-TEL(74)17, Proposal for Adapting the OTS to the Delta 3914 Launcher, 25 June 1974.

be most justified from the technical and economical point of view. It also cited commercial considerations, pointing out that European industry could develop a competitive stand vis-a-vis American industry in the world satellite market, since some of the American companies would be flying 3914 satellite versions as of 1975/1976.

The Programme Board approved the conversion in July 1974. The German delegation, however, underlined the technical risk inherent in the 3914 solution since the development programme of the launcher was still incomplete and the OTS launch would be one of the first firings.1/ In fact, as will be shown in section 5.7, the first attempt at launching OTS ended with the explosion of the Delta 3914.

1/ ESRO/PB-TEL/MIN/10, 22 Aug. 1974.

4.10 OTS derivatives

As noted above, the United Kingdom had initiated a national telecommunication satellite project called UKATS/GTS, which was offered as an option for the test satellite in the TELECOM programme back in 1972. With the selection of OTS, the British UKATS/GTS project was reoriented to meet the requirements for maritime communications and navigation.1/ Because of a funding shortage, however, the United Kingdom submitted to the ESRO Council a proposal to 'Europeanise' its national effort in May 1973, taking into account the stage reached at the national level.

By the end of 1973, the national delegations to ESRO agreed to carry out a maritime satellite programme, with the United Kingdom being responsible for the development of the payload module; the OTS service module would be used as the platform.2/ Since the development costs of the service module were already covered by the TELECOM programme, the total cost of the new maritime progamme, called MAROTS, only amounted to 50 MAU, of which the United Kingdom agreed to cover 55%. Subsequently, the payload module was contracted to MSDS (UK) and the MESH consortium was responsible for producing the service module, at an estimated cost of 5.1 MAU each.3/

The decision to develop MAROTS within the ESRO framework was taken in the

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1/ Maritime satellites provide communication links between ships at sea and land-based stations. See R. Brown, 'Profiting from a Satellite for Shipping', New Scientist, XCIII (1973), 319-20.

2/ ESRO/C(73)12, Add.1, Maritime Communications Satellite, 23 May 1973; ESRO/C(73)39, Management of GTS Project - Note by the United Kingdom Delegation, 30 May 1973; ESRO/C(73)63, Draft Agreement between Certain Member States of ESRO and the ESRO Concerning the Execution of a Maritime Satellite Programme, 18 Sept. 1973.

3/ ESRO News Release, 'ESRO Awards Three Design and Development Contracts', 3 Dec. 1974.

context of the '1973 package deal', which marked the start of three important new programmes and ESRO's victory over the problems and uncertainties it faced during the transition from a scientific to an application-oriented organisation.1/ Besides the start of the MAROTS project, it was decided to carry out the ARIANE launcher programme at an estimated cost of 400 MAU, with France taking 63%, and the SPACELAB programme at an estimated cost of 290 MAU, with West Germany taking 53%.

1/ CSE/CM(July 73)PV/1, 29 July 1973; CSE/CM(July 73)PV/2, 22 Aug. 1973.

4.11 CEPT's participation in the OTS utilisation programme

Despite the advanced stage of the TELECOM programme implementation in 1974, no commitment on the part of the CEPT in general or any national PTT administration in particular had been made to participate in the OTS project.

As noted above, the OTS project mission was to investigate the soundness of the general design, as forerunner of the ECS system, by means of a number of tests and experiments. Such tests, including communication and propagation experiments, were expected to be carried out in the context of an 'Orbital Test Programme' after OTS had been launched.1/ In addition, OTS was expected to be used for pre-operational traffic in order to enable national PTTs to become familiar with intra-European satellite communication.

For the Orbital Test Programme, a number of earth stations were required. The TELECOM programme envisaged the setting up of one large ground station with a 15 m antenna for telemetry tracking and command control. As part of the Orbital Test Programme, this ground station would also perform tests on satellite performance. As described in section 4.9, this ground station was set up in Fucino (I) under a cooperative arrangement with the Italian PTT organisation Telespazio.

Other large stations with 15 m antennas were expected to be set up and operated by the national PTT organisations for communication tests and pre-operational communication traffic, as well as small stations with 3 m antenna for propagation measurements. The larger stations would be of similar technical performance to those stations ultimately required for the ECS system.

By July 1974, CEPT had defined the conditions on which the national PTT

1/ ESRO/PB-TEL(73)16, Proposed Orbital Test Programme and Associated Ground Equipment, 22 Oct. 1973; P. Barthman, 'The CEPT Programme of Experiments for OTS', ESA Bulletin, IV (1978), No. 14, 25-32.

organisations would participate in the Orbital Test Programme and hence invest substantial funds in their ground stations.1/ The primary demand was that of a back-up OTS in case of launch failure.2/

The ESRO secretariat felt that CEPT's condition could be accepted 3/ and with ESRO giving a positive response, the telecommunications entities of France, Italy,4/ the United Kingdom and West Germany committed themselves to set up large-antenna earth stations so as to be in a position to use the OTS satellite as soon as it was launched. In addition, twelve PTT organisations had agreed to participate in the propagation experiments.

Since the current TELECOM programme did not include the back-up satellite demanded by CEPT, the ESRO secretariat was charged with analysing different back-up solutions. As there was no material difference between the OTS and MAROTS platform, the secretariat outlined a joint back-up policy on the basis of the partial use of test hardware and spare equipment of both satellite projects together with additional hardware procurement. The cost of the back-up solution for the OTS project amounted to 4.5 MAU, with 50% of the

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1/ ESRO/PB-TEL(74)22, Exchange of Letters Between the Chairman of the CEPT and the Director General of ESRO, 15 Sept. 1974.

2/ ESRO/PB-TEL(74)26, Commentary by the Secretariat on the Conditions of the CEPT for Participating in the Programme of use of OTS, 16 Sept. 1974. The probability of successfully achieving the OTS mission with one satellite was assumed by ESRO to be 0.7, covering launcher reliability, the reliability of injection into orbital position and the operational reliability of the satellite during the first 24 months. With a back-up satellite, this figure would increase to 0.91.

3/ ESRO/PB-TEL/MIN/11, 19 Nov. 1974.

4/ The Italian PTT organisation was setting up a large station in cooperation with the TELECOM programme, as noted above.

third platform shared with MAROTS and additional payload equipment.1/ The proposal was approved by the Board in March 1975. Thus, a second OTS launch could take place less than six months after a satellite failure.2/ Without any back-up, the minimum time needed would have been about two years.

1/ ESRO/PB-TEL(74)29, Add.2, Philosophy for the Sharing of Space Equipment between MAROTS and OTS Project, 3 Mar. 1975.

2/ ESRO/PB-TEL/XV/Res.1, 12 May 1975.

4.12 Financial situation of the TELECOM programme under phase II

In order to implement the decision on the back-up policy, the financial situation of the programme had to be analysed in detail. The ESRO secretariat was instructed to review the cost-to-completion (CTC) for phase II of the TELECOM programme and to report to the Board if additional funds were required.1/

In the TELECOM arrangement, phase II was estimated to cost 147.5 MAU at mid-1972 prices. After the initial approval of the arrangement, additional tasks had been introduced which had a direct impact on the estimated CTC. The major programme changes were the conversion of OTS from the Delta 2914 launcher to Delta 3914, the Teldix wheel solution, the OTS back-up policy and various other minor changes amounting to a total of 13.36 MAU at mid-1974 prices.2/ The current CTC was estimated to amount to 169.8 MAU at mid-1974 prices, compared with commitment in the initial arrangement of 160.7 MAU at mid-1974 prices (equivalent to 147.5 MAU at mid-1972 prices).

At this stage of the programme, significant savings could not be achieved even if major simplifications were introduced, since only 4.2 MAU of the 169.8 MAU were still uncommitted.3/ The 4.2 MAU were planned to be spent mainly within the Support Technology Programme and in preparation of the ECS. When the ESRO secretariat invited the Board to approve the 9.2 MAU overrun at mid-1974 prices, the French delegation disagreed strongly and proposed to

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1/ ESRO/PB-TEL(75)5, Financial Situation of the Programme (Phase II), 29 Apr. 1975.

2/ The additional cost of 13.36 MAU already reflects the savings achieved by the ESRO/Telespazio ground station solution.

3/ ESRO/PB-TEL(75)9, Analysis and Justification of Uncommitted External Costs in Phase II of the Programme, 29 May 1975.

block all currently uncommitted expenditures related to the ECS satellite.1/ Supported by the German delegation, the French delegation particularly criticised the high ESRO support charges. Finally, France expressed suspicion about the work carried out by the ESRO secretariat and accused the secretariat of being reluctant to cut programme costs and of defending the high costs for support and common costs.2/ The French delegation felt that a more favourable result could be obtained by entrusting the cost review to an expert body composed of experts nominated by the participating countries.

The ESRO secretariat reacted strongly, insisting that the question came within its competence. It was from this point of view that the French proposal was unacceptable to the secretariat, which confirmed that it was fully prepared to provide delegations with all information they required. Following these comments, the French delegation withdrew its proposal and invited the secretariat to provide a new paper.

The issue of cost overruns in the TELECOM programme coincided with the definition of a new updating procedure proposed by the ESRO secretariat to the Council, aimed at taking more realistic account of the effect of inflation on the cost of the programme and maintaining the purchasing power of the financial envelopes set down in the programme arrangements.

Since the approval of the new procedure by Council was in sight, the secretariat produced a comparison, including the calculation of CTC according

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1/ ESRO/PB-TEL(75)8, Identification and Review of Non-Fixed Common Cost and Support Charges of the Programme (Phase II), 30 May 1975.

2/ The support and common costs amounted to 32.6 MAU, 19.2% of the total programme cost for phase II of the TELECOM programme.

to the new procedure.1/ Unlike the previous procedure, which consisted in updating the current year's budget to the price level as at the middle of the preceding year, the new procedure allocated to the current year's budget a reserve for inflation which was unblocked during the year within the limits of the inflation actually observed. This procedure permitted the sums made available to the project to be adjusted for inflation, without providing the secretariat with funds in anticipation of inflation.

With the new updating procedure, the initial commitments of the TELECOM arrangement amounted to 173.3 MAU at mid-1974 prices, compared with a current CTC of 169.8 MAU at mid-1974 prices.2/ In other words, since the current CTC was 2% below the initial commitment, no cost overrun of the TELECOM programme had to be approved. Concerning national contributions to the TELECOM programme, the triennial adjustment of the initial scale, as provided for in the arrangement, had resulted in a new scale for 1975-1977, shown on the following page.3/

1/ ESA/C(76)113, Comparison of Cost-to-Completion Estimates with the Financial Envelopes of Programmes, 16 Nov. 1975.

2/ ESA/JCB-C(75)1, New Updating Procedure and Cost-to-Completion of Phase 2 of the Communication Satellite Programme, 24 July 1975.

3/ ESRO/PB-TEL(74)21, Add.6, New Scale of Contribution for TELECOM Programme, 1975-1977, 16 Jan. 1975.

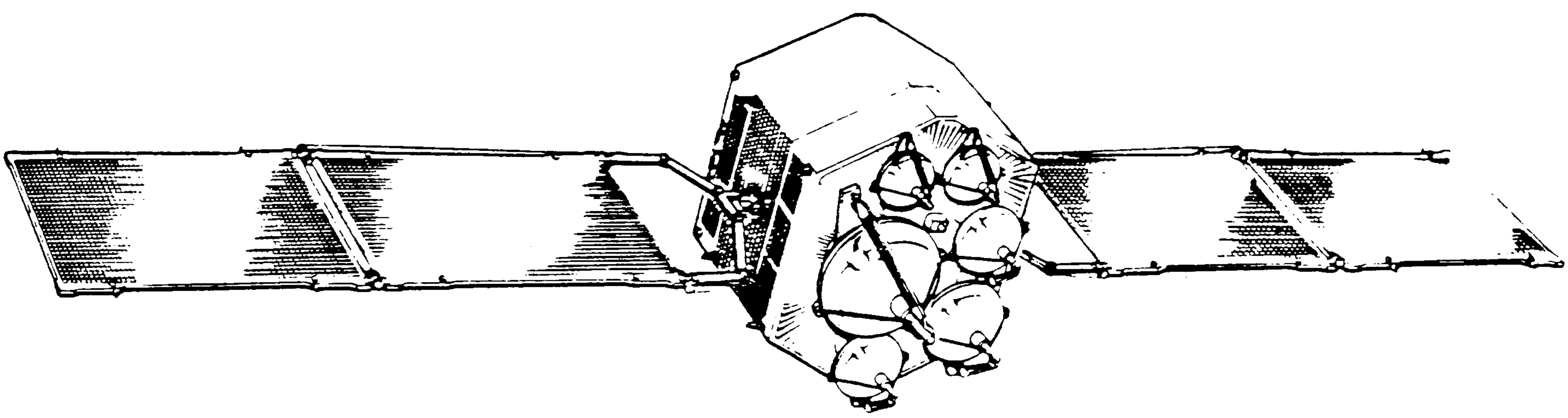
Country	Scale of contribution in % 1972-1974	1975-1977
Belgium	3.96	4.04
Denmark	2.35	2.42
France	23.11	22.58
Italy	14.69	15.01
Netherlands	2.50	2.50
Sweden	4.90	5.10
Switzerland	3.39	3.65
United Kingdom	20.09	19.04
West Germany	25.01	25.66
Total	100.00	100.00

The new scale was defined according to the GNP formula for all countries except the Netherlands, which kept a constant contribution of 2.5%.

4.13 The status of the OTS project and industrial results: May 1975

Some 17 months had now passed for the OTS project. Design and development were practically complete, and production and testing were the two major types of activities remaining. In fact, 50% of planned industrial manpower under the OTS project had been expended by May 1975.1/ The final satellite design had been established, including 21 change requests, such as the 3914 conversion, the back-up satellite, the inclusion of the Teldix wheel, etc.

An illustration of the final OTS in orbital configuration is given below.2/

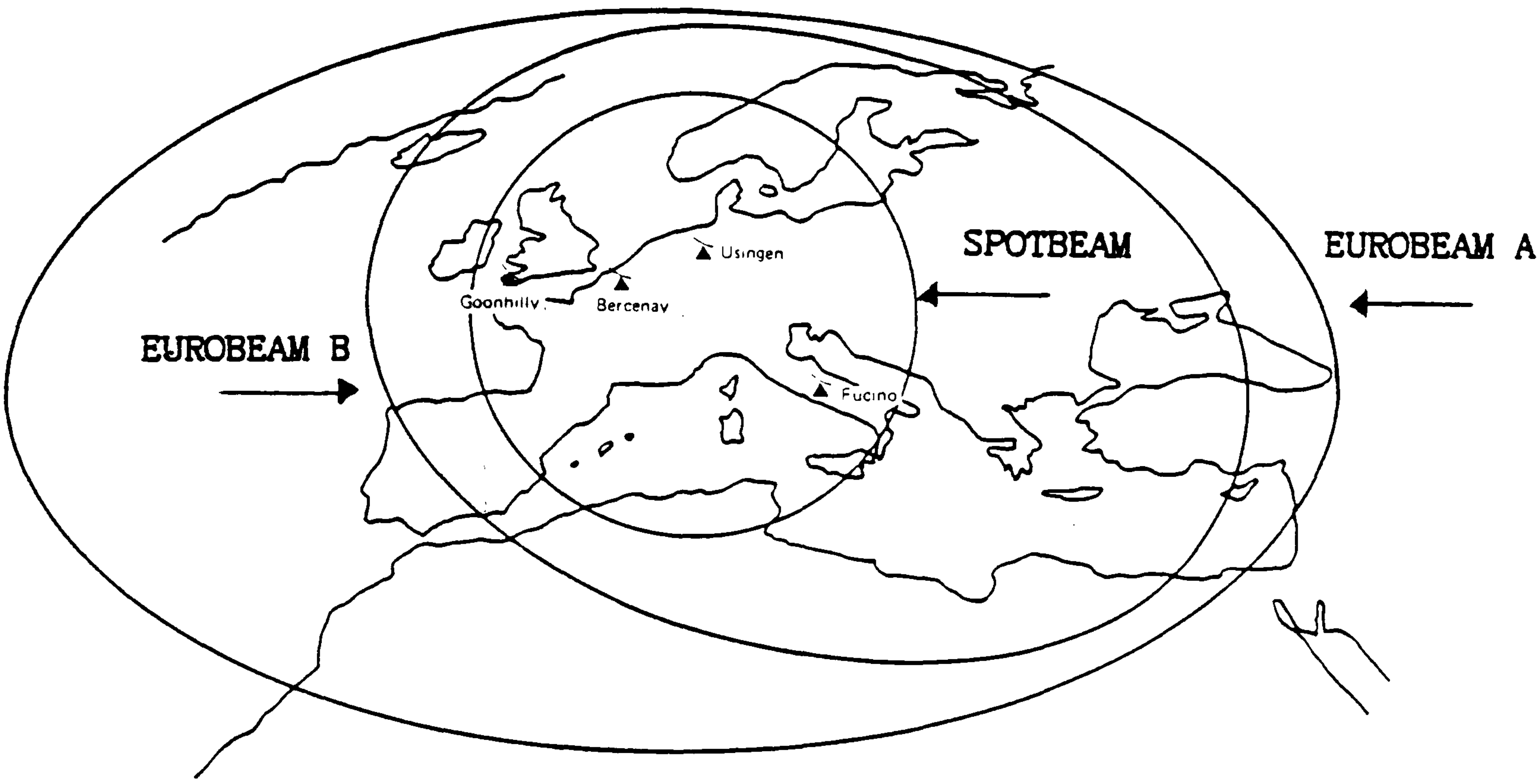


1/ Report on the Status of the Programme, ESRO, Communication Satellite Programme Board, 12 May 1975.

2/ R. Collette, B. Stockwell, P. Bartholomé, 'The Orbital Test Satellite', ESA Bulletin, IV (1978), No. 14, 7.

As a result of the OTS programme, European industry had gained a foothold in several important satellite technology areas, in particular in transmitting and receiving equipment for super-high frequencies.1/ In fact, all submissions by American-led consortia for the development of the new INTELSAT V satellites proposed the use of European TWTs.

The OTS was to be launched in May/June 1977. It would provide 5,000 telephone channels and one television channel, and have a lifetime of three to five years and an orbital mass of 470 kg.2/ The coverage area of the OTS is given below.3/



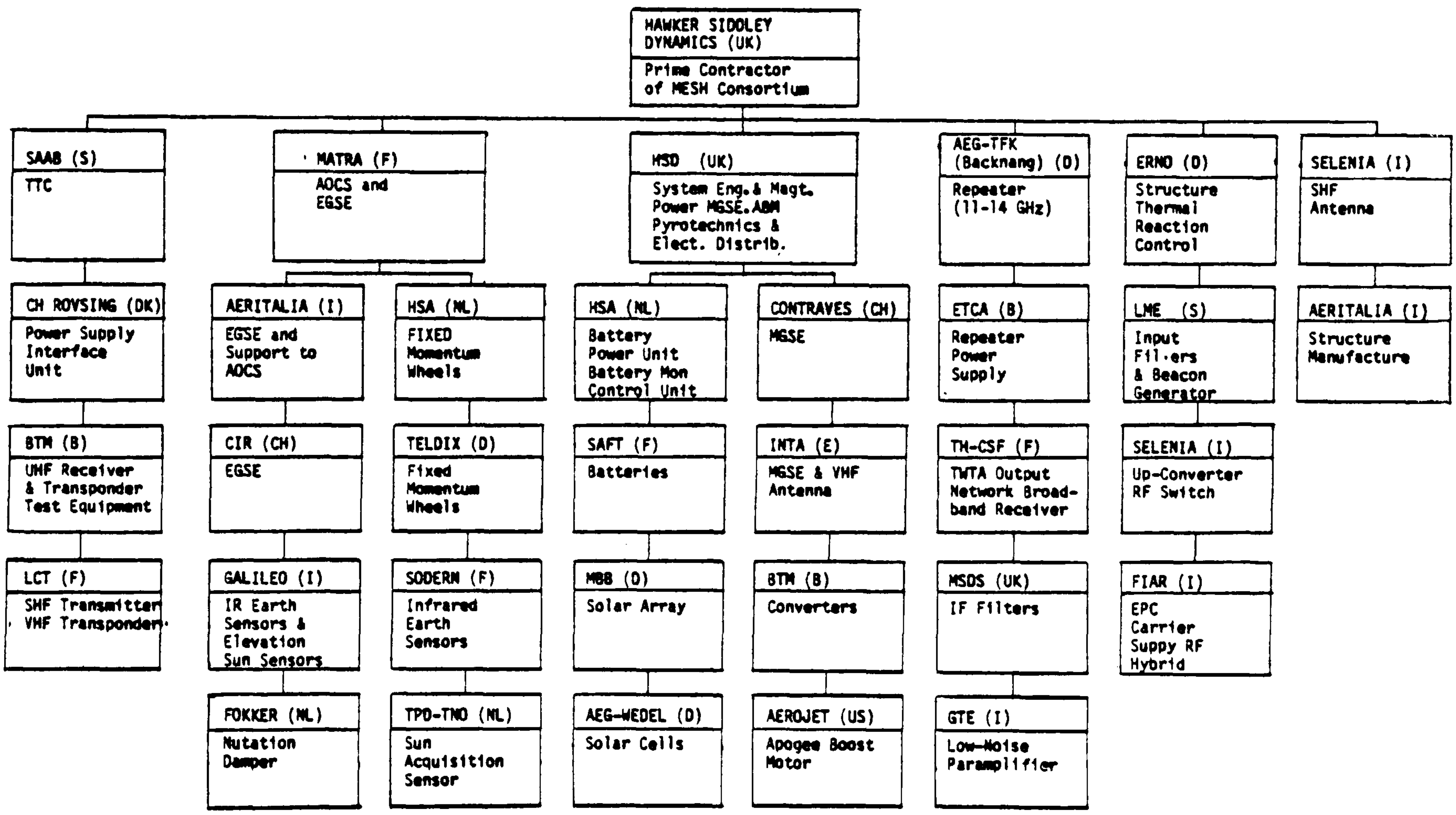
1/ 'Europe's OTS Satellite', Flight, LXVIII (1977), 1664.

2/ Meanwhile, the first SYMPHONIE satellite had been launched successfully on 19 December 1974 by a NASA Thor Delta 2914. The satellite provided 750 telephone channels and had an orbital mass of 235 kg.

3/ A. Preukschat, 'The Orbital Test Satellite OTS for the European Communication Satellite Programme', Raumfahrtforschung, XIV (1973), No. 6, 298-302.

The satellite repeater capacity was divided into several parts to carry transmissions to the various regions. Within the SPOTBEAM area, in which the large earth stations were placed, telephone traffic was possible. EUROBEAM A covered TV transmission of the EUROVISION type and EUROBEAM B included narrow-band transmission for propagation experiments with small earth stations.

The final industrial team in charge of OTS development, led by the prime contractor HSD (UK), is shown below.1/



1/ B. Stockwell, 'Procurement of the Orbital Satellite', ESA Bulletin, IV (1978), No. 16, 62.

What were the industrial results of TELECOM programme phase II for the participating countries?

Concerning the distribution of contracts, the results are shown in the following table:

Ratio between share of contracts received and share of contribution 1/			
Country	Share of contracts (A)	Share of contributions (B)	Return coefficient (A)/(B)
West Germany	27.27%	25.33%	1.08
France	23.18	22.89	1.01
United Kingdom	19.00	19.46	0.98
Italy	15.78	14.93	1.06
Sweden	5.12	4.99	1.03
Belgium	4.34	4.00	1.09
Netherlands	2.42	2.50	0.97
Switzerland	1.66	3.51	0.47
Denmark	1.23	2.39	0.51
Total	100.00	100.00	1.00

As for the quantity of contracts, only the figures for Switzerland and Denmark indicate a considerable shortfall in the industrial share. However, it can be concluded that the ESRO secretariat managed to achieve a balanced result in the distribution of contracts in accordance with the requirements of the 'fair return' principle.

Concerning the quality of contracts, it has already been shown that most of the 'noble' contracts under the Support Technology Programme went to the companies which had already established an industrial competence in communication satellite technology. Those companies had established their industrial expertise through national space programmes or national and

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1/ ESA/JCB(76)22(C), Report on the Progress of the Communication Satellite Programme, 20 Aug. 1976.

bilateral communication satellite projects and were mainly located in France, West Germany and to some extent in the United Kingdom and Italy.

Apart from the Support Technology Programme contracts, the OTS project represented the major part of industrial activities under the TELECOM phase II programme. In order to evaluate the industrial results for the participating countries under the OTS contract, some data were collected in the context of this study by means of a small questionnaire and processed according to the following procedure.

First, the OTS was divided into 49 technology work packages. A work package is a distinct and separate contract share, and it is possible to identify the company and hence the country which carried out the industrial activity associated with each work package. Second, each work package was evaluated by an OTS project manager at ESA 1/ in response to four questions on the results of carrying out the industrial activities under the work package. The OTS project manager described his assessment according to a rating system. Finally, the industrial results were evaluated by combining the ratings of the work packages for each participating country.

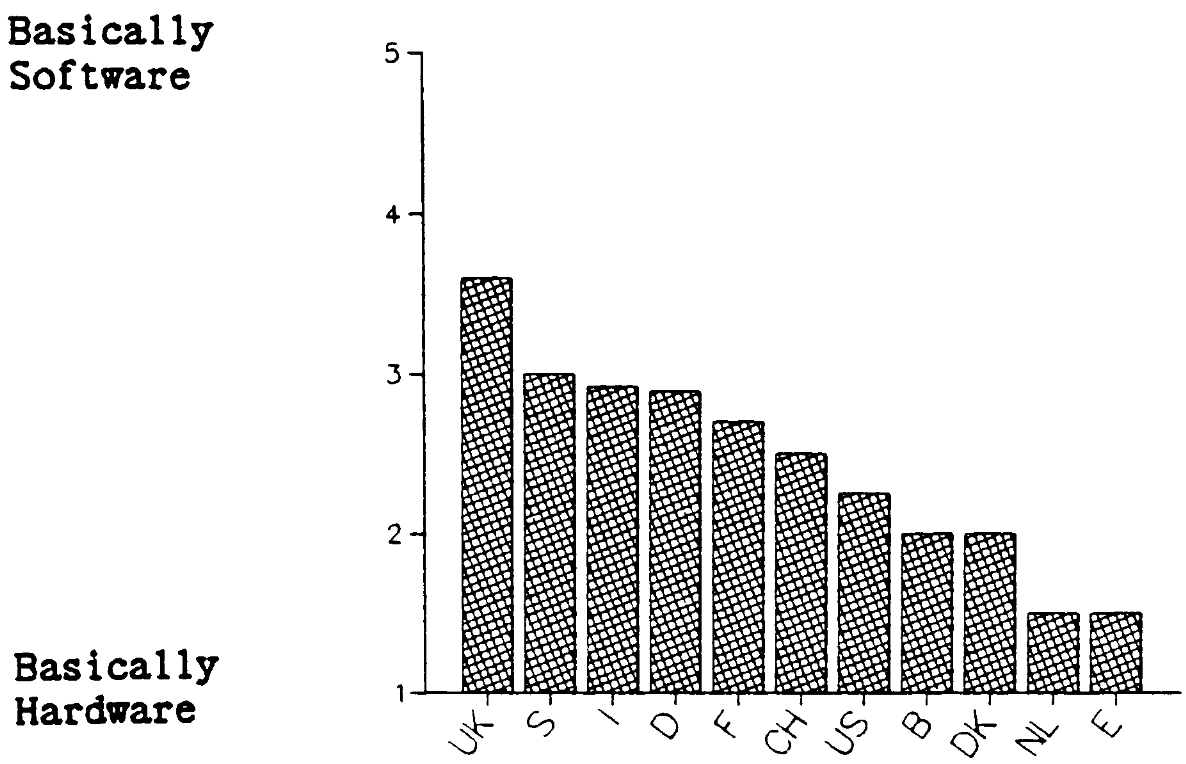
It is not claimed that the illustrations shown below reflect reliable statistical data. There are too few data points and their identification is too subjective. It is argued, however, that those figures represent an educated understanding of the subject under discussion, since they are based on the judgement of a person considered to be most competent to evaluate the industrial results of the OTS contract. Owing to the limitations of the survey already mentioned, the relative results (comparison between countries)

1/ The European Space Agency (ESA) was set up in 1975 by amalgamating the space organisations ESRO and ELDO, as described in section 5.1.

and not the absolute result for each country are considered to be of particular interest.1/

The questions asked and the result of the data processing are shown below.

QUESTION 1: Is the work package hardware- or software-related?



As shown in the illustration above, software-related work packages, e.g. management responsibity for satellite system and subsystems, were mainly carried out by companies from the larger countries. In particular, the result for the United Kingdom reflects the award of the OTS prime contractorship to HSD. The major exception to this rule is Sweden. As noted above, Saab was

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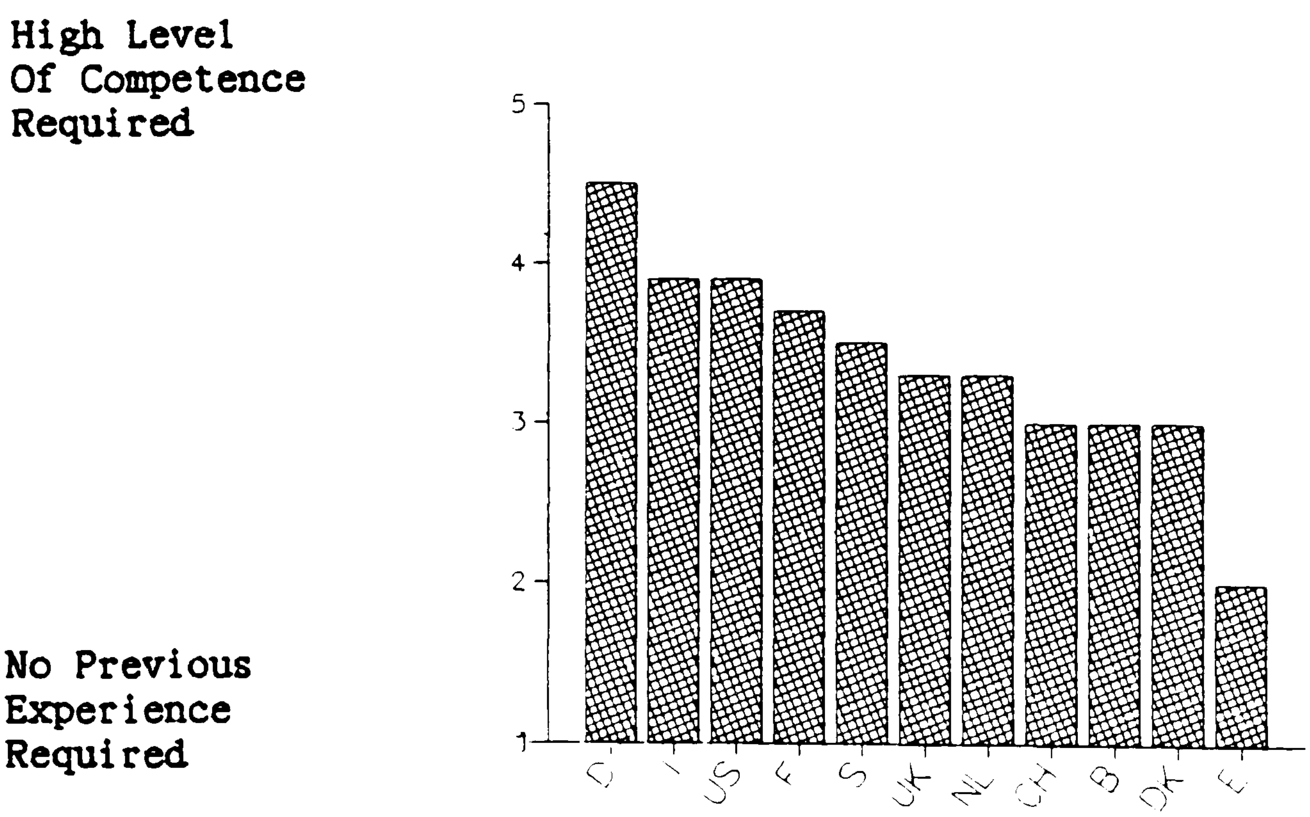
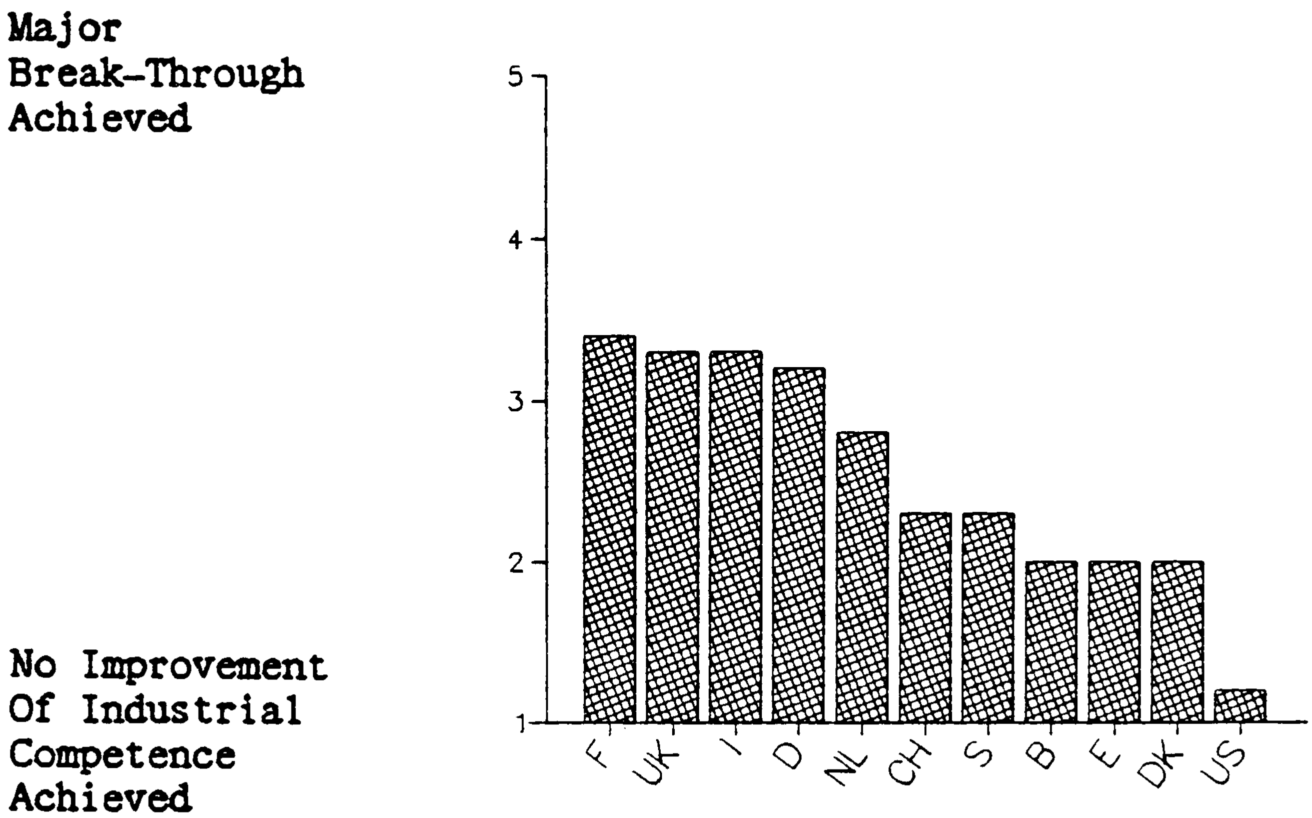
1/ The person assessing the work packages was not aware of the purpose, namely to elaborate the industrial results for the participating countries. This issue, as noted above, was an extremely controversial matter within the ESRO secretariat and between the national delegations to ESRO. In order to obtain a view independent of the ongoing controversy, it was considered necessary to avoid any information disclosure on data processing.

responsible for the telemetry, tracking and command subsystem. In general, however, smaller countries participated through hardware-related industrial activity, i.e. the supply of equipment. There are two major explanations for this result. First, management responsibility was given to firms that had already gained management experience through previous national and international satellite projects. Those companies were located in the larger countries. Second, management responsibility required a comparatively large share of the OTS contract value. Hence, it was obviously difficult for competent companies like Philips (NL) to gain management responsibility, since the small contribution of the Netherlands to the TELECOM programme excluded this company on the basis of fair-return considerations.

<u>QUESTION 2</u>: Which level of industrial competence was required to carry out the work package (industrial know-how, previous R&D investment and management experience)?



<u>QUESTION 3</u>: What progress in improving industrial competence was achieved through industrial activity associated with the work package (advancement of industrial know-how, extensive R&D activity, new management methods)?



The results for questions 2 and 3 should be discussed together. Work packages whose implementation required a high level of industrial competence (question 2) and, in addition, enabled industry to improve this competence (question 3) were awarded to companies located in France, Italy, United Kingdom and West Germany. The results for these questions also give some information on the participation of American companies. The implementation of the work packages allocated to American companies required advanced industrial capability, but those work packages did not contain any major R&D effort. In fact, this can be explained by ESRO's 'buy European' policy, which approved off-the-shelf procurement from Amercian companies only in cases where European sources could not supply the equipment within 'reasonable' time and cost.

As in the case of the Support Technology Programme, the 'noble' share of the OTS contract, the share which required state-of-the-art industrial capability and had a high R&D content, was taken by companies which had already established an industrial capability in communication satellite technology through national or bilateral projects. Despite ESRO's requirement for a balanced distribution of work under the OTS contract, the smaller countries were awarded what may be called the 'second rate' contract share, which did not enable the companies from those countries to build up a competitive competence in advanced technology. This may be explained as the result of the constraints of optimising cost, quality and geographical distribution which each consortium faced when putting together the tender for the OTS contract. In general, the competent companies were located in the larger countries. The need to share out work to the less advanced companies located in the smaller countries limited the competitiveness of the tender. In fact, it was a challenging problem for the consortia not merely to select but to find an acceptable industrial participant in the smaller countries without inflating the tender price considerably.1/ Obviously, the cost penalty resulting from ESRO's geographical distribution requirements could be minimised by allocating a 'second rate' work share to the less advanced companies located in the smaller countries. The implementation of the work share not only required limited industrial experience in the development of satellite technology, but also had only a small R&D content. In addition, the companies implementing these 'second rate' work packages were not motivated by international competition to improve their industrial competence. There was little or no competition between companies of the same small country to participate in one of the three tender proposals. In some cases, the same company had to be included in competing tenders: for example, Contraves (CH)

1/ Interview with a senior executive of a European aerospace industry.

capability and had a high R&D content, was taken by companies which had already established an industrial capability in communication satellite technology through national or bilateral projects. Despite ESRO's requirement for a balanced distribution of work under the OTS contract, the smaller countries were awarded what may be called the 'second rate' contract share, which did not enable the companies from those countries to build up a competitive competence in advanced technology. This may be explained as the result of the constraints of optimising cost, quality and geographical distribution which each consortium faced when putting together the tender for the OTS contract. In general, the competent companies were located in the larger countries. The need to share out work to the less advanced companies located in the smaller countries limited the competitiveness of the tender. In fact, it was a challenging problem for the consortia not merely to select but to find an acceptable industrial participant in the smaller countries without inflating the tender price considerably.1/ Obviously, the cost penalty resulting from ESRO's geographical distribution requirements could be minimised by allocating a 'second rate' work share to the less advanced companies located in the smaller countries. The implementation of the work share not only required limited industrial experience in the development of satellite technology, but also had only a small R&D content. In addition, the companies implementing these 'second rate' work packages were not motivated by international competition to improve their industrial competence. There was little or no competition between companies of the same small country to participate in one of the three tender proposals. In some cases, the same company had to be included in competing tenders: for example, Contraves (CH)

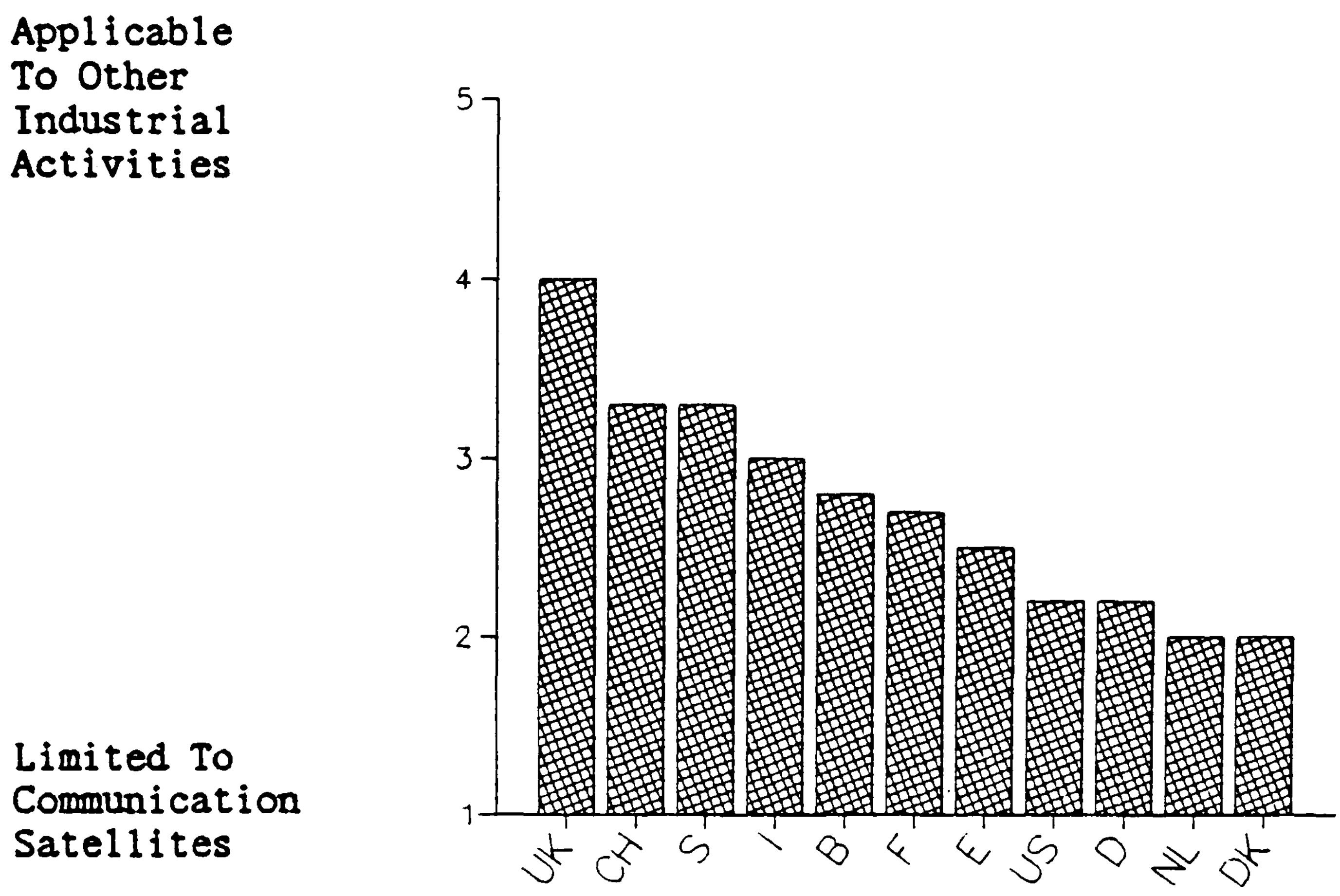
1/ Interview with a senior executive of a European aerospace industry.

was in both the MESH and STAR consortia (see section 4.7), since there was no reasonably competent company as an alternative. The situation in the larger countries was quite different. Within a large country, there was intense competition between companies to participate in the work share of this country in one of the three consortia. In fact, for reasons outlined above (the need to allocate prime and subcontractorships to large countries), the small companies in the larger countries which specialised in equipment manufacturing stood a limited chance of being included in a tender proposal. This is also illustrated in table 1 of appendix A, which gives details on all companies participating in the TELECOM programme.

The results of question 4 on the applicability of industrial competence acquired through OTS work packages to industrial activities outside the communication satellite field are shown on the following page. It can be concluded that experience gained through software work packages, predominantly carried out in the United Kingdom, Sweden and Italy, is highly applicable to industrial activity outside the communication satellite field. 'Noble' hardware-related work packages carried out in France and West Germany built up highly specialised industrial competence whose application is essentially limited to the communication satellite field. The results for the remaining countries are not of particular interest, since their industries were unable to establish industrial capability through the OTS contract in the first place.

The evaluation of the industrial results for the countries participating in phase II of the TELECOM programme has led to some general conclusions. The programme did not enhance European specialisation in communication satellite technology but supported proliferation of competence and European industrial overcapacity. In addition, the companies from the larger countries built up industrial competence as a result of the TELECOM programme based on their

QUESTION 4: Is the industrial competence acquired through the work package applicable to industrial activities outside the communication satellite field?



experience derived from previous national and bilateral projects. In view of both conclusions and the way in which the collaborative programme was used to support and supplement national technology efforts, it can be argued that phase II of the TELECOM programme contributed to build up overall competence in satellite technology for a few large countries and did not establish European technological interdependence. In fact, in a review of the German space effort, a major space journal concluded that

> '...technological independence is in sight, with hopes that Germany will be competitive in the production and sale of the telecommunication satellites by 1980'.1/

By the end of 1975, the German Ministry for Research and Development had established a new national programme to support such a competitive edge; it was named 'Future Communication Satellites' and envisaged participation in development funding by the companies involved.2/

1/ 'West Germany Emphasises Space Effort', Aviation Week and Space Technology, LX (June 1975), 223.

2/ 'BMFT zieht eine Bestandsaufnahme', Astronautik, XV (1976), No. 1, 18.

CHAPTER 5

TELECOM PROGRAMME PHASE III

5.1 The unification of the European space organisations: the European Space Agency (ESA) is established

The various attempts to form a joint European space organisation comprising ESRO and ELDO, as outlined in chapter 2, finally resulted in the setting up of the European Space Agency (ESA) in 1975.1/

In comparison to ESRO and ELDO, ESA had something new to offer.2/ First, it included an institutionalisation of the political level, which until then had been the task of the European Space Conference. The Conference was abandoned, and the ESA Council was provided with a real political status by enabling it to meet at the ministerial level if required. Second, the new ESA convention included the provision for the gradual Europeanisation of the various national programmes within the ESA framework in order to pave the way for the creation of a real European space community, avoid duplication and enhance specialisation. Finally, particular emphasis was laid, in the ESA convention, on the shift from scientific research to technological development for application purposes. This emphasis was reflected in the definition of ESA's industrial policy, which was to

> '...improve the world-wide competitiveness of European industry by maintaining and developing space technology and by encouraging the rationalisation and development of an industrial structure appropriate to market requirements, making use in the first place of the existing industrial potential of all member states...', and, '...exploit

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1/ CSE/CM(April 75)5, Rev.1, Confirmation of the Text of the ESA Convention, 18 Apr. 1975; see also B. Battrick, 'ESRO + ELDO = ESA', ESA Bulletin, X (1984), No. 38, 20-30.

2/ CSE/CM(April 75)PV/1, Annex I, Opening Address by Mr. Gaston Green, Belgian Secretary of State for Scientific Policy, 12 May 1975.

> the advantage of free competitive bidding in all cases, except where this would be incompatible with other defined objectives of industrial policy'.1/

Such other objectives were of course that of 'fair-return', to

> '...ensure that all member states participate in an equitable manner having regard to their financial contribution, in implementing the European space programmes and in the associated development of space technology'.2/

More specifically, the ESA convention stated that

> '...ideally the distribution of contracts placed by the Agency should result in all countries having an overall return coefficient of 1',3/

whereas,

> '...for the purpose of calculating return coefficients, weighting factors shall be applied to the value of contracts on the basis of their technological interest'.4/

As an extension of the fair-return policy of ESRO, the Convention also envisaged that

> '...separate assessments shall be made...of the return coefficients for various categories of contracts and contracts for project-related technology'.5/

Following the formation of the Agency, steps were taken to set up the necessary machinery, both within the Agency committee structure and within ESA, to implement in particular the industrial policy principles incorporated in the new convention.

1/ Convention for the Establishment of a European Space Agency, Article VII, paragraphs (b) and (d) (Paris, ESA, 30 May 1975). The shift from scientific research to application work is described in 'ESRO is Dead, Long Live ESA', New Scientist, XCV (1975), 560.

2/ Convention for the Establishment of a European Space Agency, Article VII, paragraph (c).

3/ Ibid., Annex V, Article IV, paragraphs (3) and (6).

4/ Ibid., Annex V, Article IV, paragraph (2).

5/ Ibid., Annex V, Article IV, paragraph (7).

In June 1975, an Industrial Policy Committee (IPC) was set up at the intergovernmental level. Its responsibility was threefold. First, it monitored the harmonisation of European programmes and industrial specialisation. Second, it assessed the geographical distribution of contracts and considered weighting factors to be applied for the determination of the return coefficient. Finally, it approved procurement proposals and maintained a dialogue between ESA and industry.

In the past, contract adjudication had been a task within the province of the AFC. This AFC responsibility was transferred to the IPC. The AFC was retained as a committee, but its task was limited to the definition and the monitoring of ESA's financial plan and annual budgets and, on request, to the analysis of the legal and financial aspects of specific contracts.1/

At the executive 2/ level, a new Industrial Policy Department was set up, which was responsible for keeping industry up-to-date with the Agency's procurement programme, providing the secretariat to the executive-internal adjudication committee which carried out the preliminary analysis of directorates' contract award proposals, monitoring the geographical distribution of contracts, executing studies on industrial policy matters, etc. In addition, an Industrial Policy Internal Group was created which included representatives of all the departments to advise the Director General on matters which he intended to put to the IPC.3/

1/ ESA/IPC(75)1, Terms of Reference of the IPC, 25 Nov. 1975.

2/ The description of the permanent body was changed from 'secretariat' in the case of ESRO to 'executive' for ESA in order to indicate a recognition of the growing competence of the permanent body.

3/ Minutes of the Preparatory Meeting for the Setting-up of the Internal Group for Industrial Policy (GIPI), ESTEC, 12 Sept. 1975.

As part of the revision of the committee structure, it was decided to join the Telecommunication Satellite Programme Board (PB-TEL) and the Maritime Satellite Programme Board (PB-MAR) in a single body which was called 'Joint Board on Communication Satellite Programmes' (JCB).1/

With the establishment of ESA, the pendulum swung back to a centralised management concept. The organisation had established working routines which allowed to achieve greater control and coordination without loss of speed of decision-making. In the ESA concept, the main programmes were managed in 'directorates' housed at the ESA headquarters in Paris, with working-level units at ESTEC, CNES, etc. These establishments maintained their technical expertise but evolved towards a more 'executive' role. Planning and administrative functions were centralised, leaving the local units to handle current activities. The concept of a Directorate, composed of the Director General and the various programmes and establishment directors as the management units of the organisation, was maintained and reinforced.

1/ ESA/JCB-C(75)6, Special Rules of Procedures, 4 Aug. 1975.

5.2 Planning for phase III of the TELECOM programme: the package deal concept and the H-SAT proposal

As mentioned above, phase II of the TELECOM programme covered the OTS project and the system design of ECS, whereas phase III was devoted to the development and production of the ECS satellite. The cost of phase III was estimated in the TELECOM arrangement of November 1973 to fall between 203 and 353 MAU at mid-1975 prices, depending on the satellite configuration chosen for ECS. It was understood that in order to fulfil the CEPT request, two ECS flight units would be delivered to CEPT free of charge, one in orbit by 1980 and one as back-up on the ground.

As a result of the OTS conversion from the NASA launcher 2914 to 3914, the OTS turned out to be much closer to the operational ECS vehicle than originally expected at the time the TELECOM arrangement was approved. As a consequence of the commonality between OTS and ECS and the fact that the original estimates for phase III were rather conservative, it seemed possible that only 80 to 90 MAU would be required for the CEPT satellites, compared with the minimum figure of 203 MAU originally envisaged.1/ If at least the minimum amount of 203 MAU was forthcoming, then there would be a sufficient margin to carry out technological developments for future satellites and even to permit the development of another satellite.

In May 1976, the ESA executive presented a first proposal to the Joint Board on Communication Satellites (JCB) for phase III of the TELECOM

1/ ESA/JCB(76)7(C), Proposal for Phase III of the Communication Satellite Programme, 20 Apr. 1976. See also T. Howell, S. Hanell, 'A Possible Evolution of European Communications Satellite Systems', ESA Bulletin, II (1976), No. 5, 10-5.

programme; it included three lines of activities:1/ first, the production of the ECS and the launch of one, called the CEPT mission; second, the development of a heavy spacecraft platform in support of a wide spectrum of communication missions to be compatible with the ARIANE launch capacity of 1,000 kg in orbit mass; and third, the continuation of an advanced technology development programme in the area of communication system, microwave and spacecraft technologies. The total cost of the programme was estimated as follows:

(1)	CEPT mission (ECS project)	87 MAU
(2)	Heavy platform for multipurpose use 2/	79 MAU
(3)	Advanced System and Technology Programme (ASTP)	37 MAU
Total		203 MAU

Concerning the heavy platform, the ESA executive proposed a new concept of satellite development. A common satellite platform, developed as part of one project, should be used to support a multitude of future satellite missions. A number of specific mission payloads could be attached to the standard heavy platform, respresenting the future 'work horse' for the various satellite missions. Considerable savings were expected since the development cost of the platform would be incurred only once. The satellite using a heavy platform would be compatible with the ARIANE launcher, which could launch

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1/ See also 'Europe Seeks Self-Sufficiency in Communications Satellites', Aviation Week & Space Technology, CXII (Sept. 1976), 62.

2/ The satellite payload using the first heavy platform was expected to be financed outside the current TELECOM programme. The heavy platform could be launched free of charge on the last experimental test launch of ARIANE (L04).

satellites twice as heavy as could to the American launcher Thor Delta 3914.1/

Concerning the Advanced System and Technology Programme (ASTP), the progress of European technology should be supported further so that it would not be outdistanced by American products. At that time, according to ESA, European technology was, at least in a certain number of areas, equivalent to American hardware.

During its May 1976 meeting, the JCB was asked to approve in principle the basic elements of the TELECOM programme 'package deal' for phase III.2/

The current situation was unique in European space history. For the first time, the European space organisation had concrete plans to proceed from the development programme to a programme of commercial application in the form of activities which went beyond phase II of the TELECOM programme. In fact, the Heavy Platform project was intended to be a competitive European entry in world markets.3/

While the Board expressed satisfaction with the low cost of the CEPT mission (ECS project) and was willing to approve in principle the package deal elements, the German and French delegations were not too enthusiastic about the large technology research programme. In addition, the smaller countries

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1/ Indeed, the driving force for the heavy platform programme was the ARIANE launch programme. With unrestricted access to the ARIANE launcher, it was desirable to plan future satellite programmes around this European launcher capability.

2/ ESA/JCB/MIN/5, 4 Apr. 1976.

3/ As a result of European, bilateral and national programmes, European industrial competence in satellite technology was considered to have passed the development stage, ready to compete with US technology in the growing international commercial market for satellite communication. In addition to the INTELSAT market, countries like Brazil, Indonesia, India, Canada and the Arab countries had embarked on plans to establish national satellite systems for telecommunication and TV broadcasting. Other major markets were NATO, US domestic, intra-European and national European systems.

requested that particular attention should be paid to the industrial policy of the coming programme phase. In particular, Switzerland, whose return figures during phase II of the TELECOM programme had remained extremely low, argued that the commercial benefits of the Agency's programme should not be enjoyed by only some of the participants in the programme. While the Netherlands emphasised the merits of the Swiss intervention and the importance for the small countries of obtaining a significant share of the work in the field of technological research, the Belgian delegation went one step further. It indicated that it would express reservations on the

> '...whole Phase III if the distribution of "noble" technological contracts turned out to be unsatisfactory for the "small countries"'.1/

Finally, the ESA executive was instructed to draft a detailed proposal on the ECS project and to give further consideration to the remaining elements of the proposed package deal.

In July 1976, the Director-General of ESA received a letter signed jointly by the companies SNIAS (F), MBB (D) and ETCA (B), proposing to develop a heavy platform for ESA, called PHEBUS X. The industrial group, named EUROSATELLITE, quoted a ceiling price of 30 MAU, which included neither the cost of adapting the platform to a specific payload, nor the cost of developing such a payload.2/ To avoid restricting the platform supply to the European market and to achieve a fully competitive position within the international market, EUROSATELLITE proposed that the development philosophy and management scheme should be geared to minimising costs and obtaining a commercial product. Industry would be fully responsible for platform

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1/ ESA/JCB/MIN/5, op.cit., 7.

2/ ESA/JCB(76)23, Director-General's Proposal for an Overall Programme in the Field of Communication Satellites, 31 Aug. 1976.

performance. A major part of the ESA's responsibility for the development of the satellite would be transferred to industry, resulting in a marked reduction of the non-fixed common costs relating to the project. A very important factor was that ESA would not be able to impose geographical distribution on industrial contracts for PHEBUS X.

It should be noted that the EUROSATELLITE group included the core industrial companies of the Franco-German SYMPHONIE programme. Since the industrial work on SYMPHONIE was running out, PHEBUS X was seen as the commercial follow-up project, taking advantage of the ARIANE launcher and the industrial competence established so far. In fact, MBB (D) and SNIAS (F) had already achieved the first major European success in the international satellite market when they secured a substantial share of the $235 million INTELSAT V development contract. MBB was the first European company involved in the INTELSAT programme as a co-contractor instead of a subcontractor, taking full responsibility for a satellite subsystem.1/

The EUROSATELLITE group employed a new consortium concept similar to that of another major European collaborative effort, the AIRBUS programme. Like the AIRBUS group, EUROSATELLITE was organised as a 'Groupement Industriel Economique' (GIE), registered under French law as a type of international association.2/ Whereas the consortia system was characterised by the prime contractor/subcontractor relationship, the GIE arrangement provided for joint sharing of management responsibility, risks and profits.

Not surprisingly, the new project initiative, put forward by industry,

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1/ 'Participation Européenne aux Satellites INTELSAT 4 et 5', op.cit.; 'Der INTELSAT-Auftrag', Raumfahrtforschung, XVII (1976), No. 5, 258.

2/ J. Pellandini, 'EUROSATELLITE: Une Société pour Vendre des Productions Spatiales', Les Echos, 29 Nov. 1978.

received strong support from the French and German delegations.1/ The ESA executive considered the concept of the PHEBUS X platform to be interesting. Owing to its low cost, financial resources would even be available for the development of a dedicated payload under phase III of the TELECOM programme.

When the ESA executive submitted a revised package deal to the Board, a new satellite project, known as H-SAT, was proposed.2/ H-SAT included a PHEBUS X platform and a paylaod for experimental direct-to-home broadcasting 3/ and high-power telecommunication.4/ Since ESA would not impose any geographical distribution scale on the PHEBUS platform, participating countries should contribute to its cost in proportion to the amounts of the contracts received by their industry. In addition, the role of the ESA executive vis-a-vis PHEBUS X would be limited to drawing up and

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1/ ESA/JCB(76)14(C), Phase III of the TELECOM Programme, Telex Sent by the German Delegation to the Director General of ESA on 14 July 1976, 16 July 1976.

2/ ESA/JCB(76)25, Legal Framework for the Overall Programme in the Field of Communication Satellites, 9 Sept. 1976.

3/ Direct-to-home TV is used to transmit television programmes directly to the end user via satellite. For reception, the user needs to have installed a small satellite receiver station (dish) at his home. The principal advantages of the TV satellite are to open up new frequency bands, thus overcoming the limitations of the overcrowded terrestrial systems, and to achieve rapid, 100% coverage of the user population. TV satellites use similar technology to telephone communication satellites. Whereas the latter are primarily used to provide international telecommunication, the former are applied in a national context, with TV broadcasting basically limited to one country. The market for TV satellites therefore consists of independent national procurement. While no country had decided to implement a TV satellite system until then, studies had been carried out on such a system by ESA (1970), West Germany (1971) and the Nordic countries (1975). See 'Die zweite Studienphase des Fernsehrundfunksatelliten', Raumfahrtforschung, XIV (1973), No. 4, 206.

4/ High-power telecommunications in the region of 20 to 30 GHz explore new frequencies for communication satellites and demand advanced technological developments.

negotiating a minimum satellite performance specification and a work plan at the start of the programme whereas ESA proposed to retain full control for the paylaod. As a preliminary estimate, such a payload would amount to 15 MAU, resulting in a total cost of 50 MAU for the H-SAT project.

While the H-SAT project was approved in principle by the Board, the smaller countries expressed concern about the 'revolutionary' nature of the proposed management method. In particular, Denmark, Italy, the Netherlands, Sweden and Switzerland supported the H-SAT project on the condition that a satisfactory solution would be found in respect to geographical distribution and return. West Germany, on the other hand, stressed the need to adopt more commercially oriented schemes:

> '...it would no doubt be desirable to work out a new arrangement regarding industrial participation'.1/

As a result, the ESA executive was invited to prepare detailed proposals for each element of the TELECOM package, including information about geographical distribution. In addition, delegations were asked to indicate the extent to which their countries were prepared to participate in the H-SAT project.

On the basis of preliminary definition results, the Council, meeting in February 1977 for the first time at the ministerial level, was expected to reach a decision in principle on the implementation of the TELECOM package deal, including the H-SAT satellite project. Such a satellite project would be the first not primarily intended for the 'ESA-market' but aimed at direct

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1/ ESA/JCB/MIN/8, 5 Oct. 1976, 6. The German Ministry for Research and Development (BMFT) had already emphasised the need for commercial competitiveness in space projects in 1975. See 'European Space Ties Showing Stress', Aviation Week and Space Technology, CXII (Oct. 1975); 'Deutsches Weltraumprogramm 1976-1979', Astronautik, XV (1976), No. 2, 36.

confrontation with US competitors in the future markets of the developing countries. It was considered that an efficiently produced H-SAT, dedicated to direct TV broadcasting and launched by the European-controlled ARIANE vehicle, would hold considerable marketing potential, in particular for developing countries. This was especially the case since neither NASA nor US industry had a comparable programme for a TV satellite, which was unnecessary in their home market. Hence, TV satellites were considered a market niche capable of being seized by European industry.1/

In fact, a EUROSPACE study carried out under contract from ESA had highlighted an emerging commercial market for satellite communication technology in the medium term.2/ For the 10-year period between 1976 and 1985, it was expected that about 30 to 50 regional communication space systems would be operating globally. About half of that number would be bought by developing countries. The largest increase would be in television broadcasting systems, which were expected to comprise about a tenth of the total sales volume in the period 1976-1980 and a quarter in the period 1981-1985. For the ten-year period 1976-1985, the civil market available for industrial competition was estimated at about 4,000 MAU, including space segment, ground segment and launchers but excluding sales of domestic receivers for direct television systems. A breakdown of the estimates is shown in the table on the following page.

The possible sales volume for European space industry was expected to amount to 600 to 800 MAU, or 14% to 20%, if Europe continued its development

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1/ See New Scientist, XCIX (1979), 653.

2/ J. Henrici, Study on the Competitiveness of European Space Industry (Paris, EUROSPACE, Industrial Policy Committee, 30 Oct. 1975).

Distribution of world-wide sales in terms of systems, periods and regions in MAU 1/

(A) Telecommunication and television distribution systems	1976/80	1981/85	Total
- INTELSAT	250	400	650
- USA domestic	250	350	600
- European PTT	50	100	150
- Middle East	150	250	400
- Africa	70	130	200
- South America	50	100	150
- India, Indonesia, Australia	100	150	250
Total	920	1,480	2,400
(B) Direct television broadcast systems			
- Europe	100	200	300
- USA	200	400	600
- Africa	0	100	100
- India	0	100	100
- South America	0	100	100
Total	300	900	1,200
(C) Aeronautical systems	80	120	200
(D) Maritime systems	100	150	250
Total	1,400	2,650	4,050

effort in communication satellite technology. In fact, the potential market outside Europe was considered a major justification for supporting a direct television satellite project.

The report also noted that in most cases, the sales related to the space segment would be significantly smaller than those related to the ground segment. It was considered doubtful, however, that a major share of the ground segment market could be secured without a corresponding share of the space segment. This assumption was proven incorrect in subsequent years by

1/ Ibid., 9.

the success of Japanese industry in the ground segment market. Japanese industry did not possess a competitive capability in communication satellite technology.

The H-SAT proposal

As proposed during the September meeting of the Board, the ESA executive had placed feasibility studies with interested industrial groups with a view to giving the project an adequate European basis reflected in the geographical distribution of work.1/

Besides the EUROSATELLITE group, the MESH consortium expressed its interest in the H-SAT project. Both groups were awarded preparatory definition work contracts (Step A) 2/ for the satellite platform, and AEG-Telefunken (D) 3/ was put in charge of defining the first experimental payload. In addition, both groups were invited to submit their Step B tenders by May 1977. The ESA executive intended to place two competitive Step B contracts, which would be followed by the selection of the final contractor for Step C/D.4/

On the basis of the study activities, the cost of the H-SAT project was expected to be about 69 MAU at mid-1976 prices, of which 8.5% related to ESA

1/ M. Payne, 'ESA Starts Design of Big Comms Satellite', Electronics Weekly, 8 Dec. 1976.

2/ The contracts amounted to 350 KAU each and run from November 1976 to March 1977. Originally, Dornier (D) was interested in commencing its own Step A study, but finally decided to join EUROSATELLITE. See ESA/IPC(76)94, Request for Authority to Place a Contract, 9 Nov. 1976.

3/ AEG-Telefunken (D) acted as prime contractor for the Step A study, amounting to 350 KAU, with Thomson-CSF (F), Ericsson (S), MSDS (UK), Siemens (D) and Selenia (I) as subcontractors. See ESA/IPC(76)96, Request for Authority to Place a Contract, 9 Nov. 1976.

4/ ESA/JCB(76)38, Progress Report on the Preparation of a Heavy Platform, 13 Dec. 1976.

costs, compared with 30% in the OTS project. As noted above, contributions to the project were expected to be proportional to the amount of work performed by the companies of the countries participating in the project. As far as possible, the delegations' wishes regarding their financial participation in the project would be taken into account when the proposal was adjusted after evaluation. In an attempt to comply with the delegations' wishes, the ESA executive made the following estimates of the geographical distribution of contract shares:1/

Country	Contract share in %
France	32.0
West Germany	30.0
United Kingdom	10.3
Italy	9.8
Sweden	5.9
Belgium	5.1
Switzerland	3.4
Netherlands	1.5
Denmark	1.3
Spain	0.7
Total	100.0

1/ ESA/JCB(77)1, Heavy Platform and Associated Payload, 12 Jan. 1977.

5.3 ESA-CEPT negotiations on the operational use of the ECS

In preparation for the final decision on the start of phase III of the TELECOM programme, the ESA executive was conducting negotiations with CEPT with the aim of defining the conditions on which CEPT would agree to use the ECS satellites.

In March 1976, a large majority of PTT administrations of CEPT, representing 75% of the traffic forecast for the ECS system, had declared their intention to take part in the setting up and utilisation of the ECS system from 1980-1981 on.1/ These administrations, however, made their participation conditional

> '...upon the costs chargeable to them for such participation remaining within acceptable limits'.2/

Following this preliminary position of the PTT administrations, the following initial conclusions were reached in the ESA/CEPT negotiations at the end of 1976:3/

(1) Concerning the earth segment, national PTT administrations would be responsible for maintaining their own earth stations participating in the ECS system.

(2) Concerning the space segment, the PTT administrations were expected to delegate their authority to a new legal entity of the space segment management organisation, named EUTELSAT, which they intended to set up shortly.

1/ Ireland had decided not to participate because of the high cost of the ground station. The United Kingdom and West Germany did not support the current plan, expecting that the ECS system would not be economical. It was clear that the possible non-participation of these countries had major repercussions for the economy of the overall system. See also 'SATCOM Leadership Gravitates to UK', Aviation Week & Space Technology, CXIII (Sept. 1976), 96-105.

2/ Letter of the Chairman of the CCTS, Mr. F. Locher, to the Director General of ESA, dated 2 Apr. 1976.

3/ ESA/JCB(76)15(C), Report on the Discussions between the ESA Executive and the Representatives of the CEPT Administration, 26 July 1976.

(3) EUTELSAT would be the owner of the satellites and solely responsible for the operation of the space segment. The use of the space system for television broadcasting by the EBU would be negotiated between EBU and EUTELSAT.

(4) ESA would play the role of a body providing services against renumeration from EUTELSAT. This service would consist of supplying and operating two satellites permanently in working order during the period 1980-1991.1/

(5) The national PTTs were prepared to pay an amount for the space system equivalent to the cost of the terrestrial facilities.

On the basis of this concept, the PTTs were prepared to pay 55 MAU at mid-1976 prices for the ESA services during the ten-year operational period, in addition to the cost of the ground stations, approximately 100 MAU.2/ Since the total cost for ESA of providing the service (construction, launch and maintenance operation of the ECS satellites) was estimated at approximately 90 to 95 MAU at mid-1976 prices, ESA member states were expected to cover the shortfall of 35 to 40 MAU in excess of the service charge. Although these figures were a rough estimate, it was expected that in addition to phase III of the TELECOM programme, ESA member states would have to enter into new financial commitments to cover part of the cost for the space segment during operational use, to be defined in a new programme phase known as 'Phase III bis'.3/

1/ ESA/JCB(77)2, Latest Developments Concerning the Legal Framework for an Overall Communication Satellite Programme, 14 Jan. 1972. The provision of the ten-year space segment was expected to require three additional satellites (ECS 3,4,5) and three launches besides the two satellites (ECS 1,2), and one launch under phase III of the TELECOM programme.

2/ The ground segment was expected to consist of a network of 20 to 25 ground stations.

3/ ESA/JCB(76)34, Next Steps in an Overall Communication Satellite Programme, 3 Dec. 1970; ESA/JCB(77)4, Extension of the Communication Satellite Programme, 8 Feb. 1977.

5.4 Decision on the package deal proposal: ESA Council meeting at the ministerial level, February 1977

The Council of ESA, meeting for the first time at the ministerial level, was asked to take decisions in principle on the continuation of current programmes, new projects and the level of resources for the subsequent years. A major item on the agenda was phase III of the TELECOM programme, for which the ESA executive had submitted the following new package deal proposal in the hope that its principal features would have the support of the member states.1/

(1)	CEPT mission (ECS project)	102.8 MAU
(2)	H-SAT project	79.4 MAU
(3)	Advanced System and Technology Programme (ASTP)	28.4 MAU
(4)	Extension of the MAROTS project 2/	29.4 MAU
Total		235.0 MAU 3/

For the H-SAT project, the ESA executive proposed to adjust the national contributions to the industrial return which each country achieved under unrestricted European competition. In fact, discussion at the Council meeting centred on this new contribution scheme. As the preliminary figure indicated (see page 318), the new contribution scheme resulted in a considerable

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1/ The package deal did not include any commitments by the ESA member states for the operational use of ECS as requested by CEPT. No decision was required at that time since the ESA-CEPT negotiations were still in progress. See ESA/C-M(77)11, Add. 2, Extension of the Communications Programme, 27 Nov. 1977.

2/ ESA proposed an extension of the present MAROTS project, a derivative of the OTS: namely the procurement of two additional MAROTS satellites (B and C) for the setting up of an operational maritime system to provide satellite communication between offices of shipping companies and their ships.

3/ 235 MAU at mid-1976 prices corresponds to the 203 MAU at mid-1975 prices defined as the minimum commitment in the TELECOM arrangement for phase III.

reduction of industrial participation by the smaller countries. The representatives of the smaller countries were not willing to accept this; as the Dutch Minister of Science, Mr. F. Trip, put it:

> '...the industrial return [must] be based on a formula in which the industrial distribution of work was adapted to the financial contribution of the member states, and not other way around...',1/

on the condition, of course, that

> '...a fair industrial return was guaranteed'.2/

The larger countries, in particular West Germany, were not willing to continue with the old industrial policy:

> '...the programme must be executed with greater speed and less cost'.3/

Linked to the need to enhance the cost-effective and economical use of resources, the question of 'fair return' was considered to be

> '...a too timid approach...with the emphasis on short-term goals...fraught with risks: risks of fragmenting projects and making them more costly which should not be underestimated in view of the keen competition for the limited world market'.4/

In addition, the German delegation threatened that his country might go its own way:

> '...Germany had calculated that...it would be more advantageous for it to carry out certain parts of the programme as a national undertaking ...in particular a national heavy platform programme'.5/

In fact, the discussion marked a major turning point in European space cooperation. The new contribution scheme was oriented towards utilising

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1/ ESA/C-M(77)19, 3 Mar. 1977, 9.

2/ Ibid.

3/ Ibid.

4/ Ibid., Annex VII, 1-2.

5/ Ibid., 10.

existing industrial capability in a European context, combining, making use of and optimising the various national capabilities in the most effective way. Merging the complementary industrial strengths within an efficient subcontracting scheme and a low-cost monitoring set-up could result in a product which the individual national industries on their own could not produce at the same low price. From the perspective of countries whose space industries were already well advanced, such a commercially oriented policy was a pre-condition for success in the world market of communication satellites. For those countries which had not managed to establish a competitive industrial competence during the previous years of European space collaboration, such a policy would result in reduced or even non-existent participation by national industry. While the need to re-direct ESA's industrial policy to commercial exploitation was apparent, the less advanced countries tried to stop the required adjustments in order not to be left out of the technology sector in which they had already invested considerable national funds. Although limiting international competitiveness, their policy would at least guarantee them a national share in the European market.

Regarding the question of contribution and industrial return, a compromise formula for the TELECOM programme was found by the Council. First, it was agreed in principle to adjust contribution to industrial return by taking into account as far as possible the wishes of the delegations regarding the extent of their country's participation. Second, it was agreed to apply a new procedure to achieve an optimum 'fair return', i.e., a return coefficient of one: the return coefficients of past industrial activity would be taken into account in the calculation of future project contributions. This new procedure was intended to make up for past 'hardship', namely low industrial return, for Denmark, Italy, the Netherlands, Sweden and Switzerland.1/

France and West Germany had argued for commercially oriented participation in the H-SAT project, and continued to do so when the technical characteristics of the project were discussed. In fact, both countries demanded a more operational orientation of the H-SAT project so that it would be solely devoted to direct television broadcasting and its experimental characteristics would be dropped. In other words, they considered their industry capable of skipping the experimental stage (such as the OTS in the ECS programme) and going directly to a 'marketable' operational satellite in order to save investment and time.

Concerning the CEPT mission (ECS project), the national delegations were not prepared to approve the start-up unless CEPT agreed to use the system opertionally on acceptable terms. It was agreed to continue the negotiations with CEPT and defer the project approval until the definite financial arrangement for the subsequent operational system was known.

While the extension of the MAROTS project received general approval from the delegations, France announced that it did not want to take part in the technology research programme (ASTP), and West Germany took a critical stance, demanding further drastic reductions in this package-deal element. For the smaller countries, the ASTP was of key interest, since unlike France and West Germany they did not carry out national technology programmes but depended on ESA for the advancement their industries outside particular project

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1/ Further negotiations on this new procedure resulted in the definition of the '92% rule' in September 1977. After the industrial return of future activities in the TELECOM programme was determined, Belgium, France, the United Kingdom and West Germany agreed to contribute 8% in excess of their future industrial return, which was subsequently redistributed to the remaining countries to improve their return coefficients.

activities. This was also the case for the United Kingdom, which, in accordance with the ESA convention, had completely dismantled its national technology programme over the preceding years.1/ France and West Germany were reluctant to abandon their national activities, retaining their national independence in monitoring the development of key technologies.

In view of the reservations expressed by the various delegations on particular aspects of the TELECOM package deal prepared by the ESA executive, the Council was not able to approve the deal but only agreed on a declaration outlining the intention to spend between 200 and 235 MAU on all package-deal elements, with the lower limit being suggested by the German delegation.2/ The final decision on the TELECOM package deal was deferred to mid-1977 pending the result of further negotiations.

Events following the ministerial meeting

The Council had not given authority to start the ECS or the H-SAT project under the TELECOM arrangement. The current stage of both projects, however, demanded urgent decisions and the approval of further funds to continue work in industry. In order to keep the programme moving until a final decision could be reached in March 1977, the ESA executive proposed to the JCB the approval of interim measures, mainly to fund work until 31 July 1977.3/ Whereas France and West Germany were not willing to approve any funds before

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1/ This may not have been the result of observing the ESA convention but of cutting national space expenditures.

2/ P. Langereux, 'Décision Attendu fin Juin sur l'Extension du Programme Européen de Télécommunications', Air et Cosmos, XIV (1977), No. 675, 69-70.

3/ The interim measures amounted to 10 MAU, later revised to 6 MAU during the meeting. See ESA/JCB(77)5, Overall Programme in the Field of Communications - Director-General's Proposal for Further Programme Definition, 28 Feb. 1977.

further results were known from the ESA-CEPT negotiations concerning the operational use of ECS, both countries made it clear that they would not provide any funds for the H-SAT project until the prime contractor which would develop the satellite was selected.1/

Obviously, France and West Germany made their participation in the H-SAT project dependent on the selection of the EUROSATELLITE group which was based around the industrial core structure responsible for the Franco-German SYMPHONIE project. Founded on the advanced satellite space industries of France and West Germany, EUROSATELLITE was considered to provide the best commercially oriented structure from the perspective of both countries.

The other delegations, which were willing to approve the interim measures and go along with a competitive Step B for the H-SAT project, were utterly perplexed by the attitudes of the French and German representatives. Indeed, the procedure to approve the programme after the industrial group was selected was new. The ESA executive pointed out that the demands of France and West Germany would cause the discontinuation of work in industry and the disbanding of industrial teams, leading to a substantial increase in costs. The Italian delegation even considered that

> '...this attitude was a dangerous form of sabotage and that it was up to France and Germany to bear the full responsibility for the consequences of discontinuing the work'2/.

1/ ESA/JCB/MIN/12, 6 Apr. 1977; ESA/JCB(77)10, Memorandum from the French Delegation on the Communications Programme, 11 Mar. 1977. Following the preparatory definition work carried out by the MESH and EUROSATELLITE groups, the ESA executive had planned to run two definition phase contracts (Step B) in competition and to select the better proposal for Step C/D. The French wanted a final selection of the industrial group to cover Step B/C/D, with no competition during Step B.

2/ ESA/JCB/MIN/13, 22 Apr. 1977, 2.

Because of the demands of France and West Germany, the industrial work on ECS and H-SAT had to be discontinued and the ESA executive was asked to prepare a new proposal after the H-SAT contractor had been selected and further results of the ESA-CEPT negotiations were known. The ESA executive therefore extended the ongoing Step A studies for the H-SAT project carried out in industry and requested the submission of a final bid for the detailed design, development and manufacture of H-SAT (Step B/C/D) from the two interested groups, EUROSATELLITE and MESH.1/

1/ The payload study was extended by 500 KAU and the two platform studies by 600 KAU; they ran from May to June 1977. See ESA/IPC(77)35, Request for Authority to Place a Contract, 15 Mar. 1977.

5.5 ESA-EUTELSAT negotiations on the operational use of the ECS and their impact on the implementation of the ECS project

During the spring of 1977, the national PTT administrations of CEPT finally set up EUTELSAT, which would be responsible for the management of the European operational satellite communication system.1/ EUTELSAT subsequently became ESA's negotiating partner responsible for defining the arrangements for the operational use of ECS.

So far, the total cost of the space segment for the first ten-year period was expected to amount to approximately 90 to 95 MAU at mid-1975 prices. EUTELSAT expected that ESA would cover 35 to 40 MAU of this amount.

No final agreement on the ESA-EUTELSAT arrangement could be reached by mid-1977 as originally planned. In fact, negotiations continued throughout 1977; additional changes were introduced, resulting in a considerable increase in programme cost. First, owing to the difficulties that the national PTTs had in putting ECS ground stations into operation before 1983, the start of the operational period was put back by about one year. Since the launch date for the first ECS remained unchanged for 1981, additional costs resulted from the separation of the manufacturing of the ECS 1, 2 satellites (phase III of TELECOM programme) and the ECS 3, 4, 5 satellites (proposed phase III bis).

1/ Contributions of the PTT members to EUTELSAT were regarded as utilisation charges for the space segment capacity within the limits of capacity allocated to each EUTELSAT member administration, which was similar to the INTELSAT set-up. The initial scale of contribution and hence the initial distribution of space segment capacity to the national PTT administrations was as follows: France 17%, United Kingdom 17%, Italy 12%, West Germany 11%, Sweden 6%, the Netherlands 6%, Spain 5%, Switzerland 5%, Belgium 5%, Denmark 3%, Portugal 3%, Finland 3%, Norway 3%, Austria 2%, Turkey 1%, Yugoslavia 1%, Luxembourg 1%. See ESA/JCB(77)18, Final Act of the Conference for the Establishment of Interim EUTELSAT, 31 Mar. 1977; 'L'Europe à l'Ere des Télécommunications par Satellite', Air et Cosmos, XVI (1979), No. 883, 49.

Second, the new calculations included the insurance cost against launch failure, which resulted in additional cost.

The new cost-splitting scheme looked as follows:1/

Cost of space segment	167 MAU
EUTELSAT contribution	80 MAU
ESA contribution	87 MAU

In addition to the increased ESA contribution of 87 MAU, there was still one important unresolved question. Owing to customary practice in aeronautical insurance matters, it was not possible to insure the total ECS lifetime of five years in advance.2/ EUTELSAT demanded that this residual risk should be covered by ESA, whereas ESA insisted on a risk-sharing formula. The national delegations on the JCB regarded the results of the negotiations as unsatisfactory and demanded that the contribution of EUTELSAT to the space segment should be increased and a definite financing limit should be established for the ESA member states, without any additional risk involved. Against this background, the ESA executive was instructed to negotiate a lower and definite contribution ceiling.3/

ECS project implementation

In phase II of the TELECOM programme, the ESA executive had awarded the ECS study contract (Step B) to MESH in September 1976.4/ During Step B, the

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1/ ESA/JCB(78)5, Continuation of Support of the ECS Mission - Costs Associated with the Complementary Phase of the ECS Programme, 3 Jan. 1978.

2/ Insurance was only available for a three-year block; thus it was not possible to insure the expected ECS lifetime of five years in advance.

3/ A. Johansen, 'Europäische Raumfahrt wieder in der Krise', Frankfurter Allgemeine Zeitung, 14 Dec. 1977.

4/ ESA/IPC(76)57, Request for Authority to Place a Contract, 9 July 1976. The original contract amounted to 1.5 MAU and was later extended by 2.7 MAU.

final ECS configuration was established and redirected to conform with the ARIANE launcher instead of the US Delta 3914. The switch of launcher was made possible by the successful outcome of the ARIANE development programme.

The industrial activities of the ECS project, however, came to a standstill by March 1977 since no additional funds were approved beyond phase II of the TELECOM programme. In the meantime, negotiations between MESH and ESA continued on the contractor's formal offer for the development and production (Step C/D) of two ECS satellites.1/

In June 1977, the prime contractor of MESH, HSD (UK), submitted the final offer for the two ECS satellites at a fixed price of 59.9 MAU at mid-1976 prices; the first ECS would be ready for launch if the contract were awarded in July 1977. The ESA executive had managed in its negotiations to improve the industrial return figures of the smaller countries, compared with the preliminary figures submitted by MESH. The final result, however, still failed to meet the expectations of those countries. The estimated geographical distribution of contracts is shown on the following page.

Despite criticism of the geographical distribution by the smaller countries, the IPC authorised the award of the Step C/D contract to the MESH consortium, subject to the approval of phase III of the TELECOM programme, which was still outstanding. Since such approval was not expected in the near future because of the difficulties with the TELECOM package deal, the Board was asked to approve intermediate measures, namely the placing of a preliminary contract amounting to 6.5 MAU in order to cover procurement of long-lead parts and the initiation of critical development.2/ Since the

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1/ ESA/JCB(76)16(C), Procurement Procedure for ECS 1, 13 July 1976.

2/ ESA/JCB(77)37(C), Actions Necessary for the ECS Project, 4 Nov. 1977.

Country	Contract share in % 1/
West Germany	26.62
France	19.80
United Kingdom	16.78
Italy	11.02
Sweden	3.63
Belgium	2.09
Switzerland	1.99
Netherlands	1.75
Denmark	0.40
Spain	0.40
United States	10.88
Unallocated	4.64
Total	100.00

negotiations between ESA and EUTELSAT had resulted in a more accurate definition of the commitments expected to be covered by ESA member states, the Board approved the interim measures pending the final approval of the CEPT mission (ECS project).2/

1/ ESA/IPC(77)70, Request for Authority to Place a Contract, 21 June 1970.

2/ ESA/JCB/MIN/17, 5 Dec. 1977.

5.6 The H-SAT project: pre-selection of the contractor

In conformity with its position at the ministerial Council meeting during February 1977, West Germany continued its critical attitude towards the technical specification of the H-SAT mission. In essence, the German delegation demanded a change of the satellite payload specification from the proposed experimental direct-to-home TV mission and 20/30 GHz communication experiments to a pre-operational mission solely devoted to direct-to-home TV.1/ During the Council meeting in June 1977, the German delegation informed the Council that its Ministry had requested the German national space organisation DFVLR to study the design of such a satellite and the technical and economic considerations, including an analysis of the potential markets.2/ It should be noted that this study was awarded to the German companies represented mainly in the EUROSATELLITE group.

The majority of the Council delegations expressed concern about the new situation and the prospect that West Germany might not participate in the H-SAT project, whereas France considered it worthwhile to review the H-SAT mission in order to ensure that it would meet the requirements expressed by the German delegation.

Following the German criticism, the H-SAT mission specifications were reviewed by an expert group appointed by the ESA member countries and the

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1/ The outcome of the 1977 World Administration Radio Conference (WARC), which had fixed the main parameters for the setting up of direct TV satellite systems and the national allocation of geostationary orbit slots and frequency bands, caused an acceleration in the interest of the potential users of such systems. West Germany, the Nordic countries, France, Italy, Yugoslavia and Switzerland were now actively studying the possibility of introducing operational direct-to-home TV satellite services.

2/ ESA/C/MIN/18, 18 July 1977. See also A. Johansen, 'Das Satelliten-Fernsehen gewinnt Konturen', Die Welt, 6 Sept. 1977.

EBU. With the vote of the German expert, the group managed to adopt unanimously the technical parameters of the H-SAT project, considered to be fully compatible with the standards of future operational systems.1/

In the meantime, EUROSATELLITE and MESH had submitted their final bids for the design, development and production of the H-SAT (Step B/C/D) after a heated competition.2/ The two groups, taken together, represented the balk of European capability in communication satellite technology, which MESH had acquired through OTS/ECS and EUROSATELLITE through SYMPHONIE and INTELSAT. Since there were no other programmes of comparable dimensions in the future, it was expected that the winning consortium would also be best prepared to exploit the future market potential in the space telecommunication field outside Europe.3/ In fact, many commentators said that the two consortia had cut their prices to such an extent that they would probably make no profit on the contract, but were hoping to make a profit in the future.

Two offers were received by ESA on 8 April 1977. They were evaluated as

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1/ The main mission of H-SAT was defined as the transmission of TV programmes to two areas. By shifting the coverage area, the whole of Western Europe and part of North Africa and the Middle East could be covered. At that time, 25 broadcasting entities of the EBU had stated their intention to participate in the satellite utilisation. See ESA/JCB(77)24, Principle for the Elaboration of an H-SAT Utilisation Programme, 13 July 1977.

2/ The heated competition was extensively covered in the press. See M. Arronny, 'Qui Construira les Satellites Européens des Télécommunications?', Le Monde, 3 June 1977; J.-P. Croizé, 'La Guerre de l'Espace se Joue Entre Matra et la SNIAS', Le Figaro, 24 June 1977; G. Patri, 'Matra-Aérospatiale: Un Satellite de Discorde', D'Aurore, 27 June 1977; P. Langereux, 'Décision sur "H-SAT" le 25 Juillet', Air et Cosmos, XIV (1977), No. 679, 45.

3/ 'Satcom Leadership Gravitates to UK', op.cit.

follows:1/

Consortium	Evaluation marks out of 100	Contract price in MAU
EUROSATELLITE	53.84	83.46
MESH	52.74	70.81

During the tender period, some changes had to be introduced in the specifications, primarily in the area of payload, to comply with the outcome of the 1977 WARC. These changes occurred too late to be included in the two offers received by ESA. The two tenderers were therefore requested to submit revised final bids on 13 June 1977. On the basis of the initial evaluation, the ESA executive had undertaken negotiations to obtain improvement of both offers in weak areas and to obtain a price reduction before the final bids were submitted.

The evaluation results for the revised tenders is shown on the next page. The evaluation had not revealed any significant difference, if price and geographical distribution were disregarded. Both proposals were judged acceptable and compatible with the mission and project requirements. In the revised final offers, EUROSATELLITE cut its price by 28.4%, while MESH cut its price by only 7.2%. In contrast to the initial offers, EUROSATELLITE's bit was substantially cheaper, with a price advantage of 6 MAU. The difference in the proposed geographical distribution was judged by the ESA executive not to constitute a determining factor in the choice of the contractor since it considered that the contribution to the H-SAT project would be linked to the percentage of industrial return. The IPC was therefore requested to select

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1/ ESA/IPC(77)68, <u>Request for Authority to Place a Contract</u>, 16 June 1977.

Final H-SAT tenders 1/	EUROSATELLITE	MESH
(1) Overall mark out of 100	54.75	54.81
(2) Price in MAU	59.73	65.74
(3) Contract share in %		
Belgium	4.87	0.45
Denmark	0.86	1.36
France	26.00	28.81
Italy	17.92	18.60
Netherlands	0.15	1.39
Spain	0.38	0.30
Sweden	6.21	8.16
Switzerland	1.70	-
United Kingdom 2/	3.77	5.82
West Germany	35.17	29.02
United States	2.82	3.96
Canada	0.15	0.13
Unallocated	-	2.00
Total	100.00	100.00
(4) Industrial structure 3/		
Prime contractor		
France	SNIAS	MATRA
Co-contractor		
Belgium	ETCA	BTM
France	SNIAS	MATRA
Italy	Selenia	Selenia Aeritalia
Netherlands	-	Fokker
Sweden	Ericsson	Ericsson Saab
United Kingdom	-	HSD
West Germany	AEG-Telefunken MBB Dornier	AEG-Telefunken ERNO

1/ ESA/IPC(77)68, op.cit.

2/ The United Kingdom had limited its participation to somewhere around 5% since it was heavily engaged in the extension of the MAROTS project.

3/ In addition, EUROSATELLITE included 18 subcontractors and MESH included 24 subcontractors. The subcontractors of both tenders were in many cases identical.

the EUROSATELLITE group for the H-SAT project. The selection of EUROSATELLITE had also been justified by industrial policy considerations. The ESA executive claimed that the award of the H-SAT contract to MESH, in addition to the ECS contract, would have put this group in too much of a monopolistic position in Europe.1/

'The MESH offer was very good for smaller member states ...',2/ as the Danish delegation to the IPC put it, since it envisaged a larger industrial participation for these countries than the EUROSATELLITE offer. With regard to the industrial policy considerations of the ESA executive, the Swedish delegation came to a different conclusion. Believing that the market potential was not great enough to maintain two European consortia in the space telecommunication field, the delegation argued that a monopoly should be created in this field by awarding the contract to MESH. Other smaller countries supported this view and announced that they would not approve ESA's choice. The German delegation, on the other hand, made it clear that it would only support the programme if the German company MBB, a core member of the EUROSATELLITE group, participated.3/ In order to overcome this deadlock, the ESA executive proposed the following solution.

The IPC was asked to approve the choice of EUROSATELLITE as prime contractor for the H-SAT project. The awarding of the contract, however, would have to be delayed as much as possible while the negotiations on the

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1/ P. Langereux, 'La Compétitivité de l'Industrie Européenne au Coeur du Débat sur le Choix du Constructeur de "H-SAT"', Air et Cosmos, XIV (1977), No. 675, 36-7.

2/ ESA/IPC/MIN/16, 27 June 1977, 7.

3/ MBB was desperately seeking work to occupy its team and its new spacecraft assembly building at Ottobrunn; see 'ESA Postpones Heavy Platform Decision', Flight, LXVIII (1977), 267-8.

industrial return proceeded during August in order to improve the distribution of work to the smaller countries by revising the contractual baseline. The revised contractual baseline would be submitted to the IPC in September 1977, with the distribution of work corresponding as closely as possible to the wishes of the delegations. Should the majority decide that no satisfactory solution had been found, the choice of the prime contractor would then be reconsidered.

Under these conditions, the IPC approved the choice of EUROSATELLITE as prime contractor for the H-SAT project by a vote of six in favour (Belgium, Denmark, France, Spain, Switzerland, West Germany, with Denmark voting ad referendum) and four against (Italy, the Netherlands, Sweden, the United Kingdom).1/ The Belgian delegation told the ESA executive that

> '...the return to some small countries must not be improved at the expense of that of other small countries'.2/

Belgium had gained a comparatively large industrial share in the EUROSATELLITE offer since the Belgian company ECTA formed part of the core industrial structure of this group.

The selection of EUROSATELLITE as prime contractor was heavily criticised by MESH, which argued that the evaluation of the tenders had not followed the usual rules since EUROSATELLITE was allowed to modify drastically its financial proposal after the formal submission. MESH asked for a re-examination of the proposals based on the original tenders. The request

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1/ ESA/IPC/MIN/16, op.cit.

2/ Ibid., 9.

was dismissed by ESA.1/

Following the selection of EUROSATELLITE by the IPC, the mechanism to link contribution to the percentage of industrial return was called into question by the Dutch delegation at the JCB meeting:

> '...some countries, for example Denmark, Switzerland and the Netherlands, were "bought out" of the telecommunication programme because the overall contribution came down to less than half of what they intended to contribute...this was an important point which went far beyond the programme itself since the H-SAT was the programme which had the greatest chance of having a commercial follow-up. The proposed participation from some countries had been accepted, whereas that from other coutries had not. All member states should be treated in the same way'.2/

The ESA executive was strongly pressed to consider the interests of the smaller countries during the revision of the EUROSATELLITE offer, the result of which is shown on the following page.

The revision had been initiated on the understanding that there should be no price increase in the offer. However, the allocation of a larger contract share to the smaller countries resulted in a price increase of 1.77 MAU.

During October 1977, the IPC was asked to approve the revised offer, thereby confirming the selection of EUROSATELLITE as contractor. The ESA executive emphasised the extremely delicate nature of any negotiations to change the geographical distribution of work under a major development contract. This was so because some firms that had carried out extensive preparatory work subsequently found that they would not be getting any work under the contract. In order to ease the difficulties of this redistribution, the ESA executive had changed the technical specifications of the satellite.

1/ ESA/C(77)59, Letter from Mr. Lagardere, Chairman of MATRA to the Chairman of the ESA Council, dated 20 June 1977, 23 June 1977; and ESA's response, ESA/IPC(77)68, Add.1, Selection of Contractor for Step B/C/D of the Heavy Satellite Project, 13 July 1977.

2/ ESA/JCB/MIN/14, 5 July 1977, 4.

Adjusted EUROSATELLITE offer 1/	Adjusted offer	Change in initial offer
(1) Overall Price in MAU	61.50	+ 1.77
(2) Contract share in %		
Belgium	5.00	+ 0.10
Denmark	1.30	+ 0.40
France	24.70	- 1.30
Italy	15.90	- 2.00
Netherlands	1.60	+ 1.40
Spain	1.30	+ 0.90
Sweden	8.00	+ 1.80
Switzerland	2.20	+ 0.50
United Kingdom	3.70	-
West Germany	28.00	- 7.20
United States	3.50	+ 0.70
Canada	0.20	-
Unallocated	4.40	+ 4.40
Total	100.00	-

In fact, more demanding specifications were defined to enable the introduction of an antenna-pointing system and a more acceptable workload for HSD (UK), which was responsible for this equipment.

Another aspect of the tender adjustment was the friction between the prime contractor and those companies which became subcontractors of the consortium as a result of pressure by ESA. The Italian delegation, for example,

> '...protested against EUROSATELLITE's attempts to impose a price reduction in the Selenia offer in what the delegation considered to be an arbitrary manner'.2/

Despite the major changes which had been achieved, Denmark, Italy, the Netherlands, Spain, Switzerland and the United Kingdom expressed their

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1/ ESA/IPC(77)88, Report on the Heavy Satellite Development Contract, 19 Sept. 1977.

2/ ESA/IPC/MIN/18, 24 Oct. 1977, 9.

disappointment with the proposed geographical distribution and demanded a higher share of work for their industry. On the one hand, the United Kingdom delegation blamed the ESA executive for this unsatisfactory situation, maintaining that EUROSATELLITE had imposed its viewpoint while the executive had failed to win acceptance for that of the delegations, and regretted that the executive

> '...did not, as in other cases, accept a certain cost increase where such cost increases made it possible to achieve more satisfactory geographical distribution of work...in the case of the British industry'.1/

On the other hand, the Spanish delegation was aware of the constraints:

> '...bearing in mind the cost increase that usually resulted from the splitting up of work beyond a certain limit, it was concerned at finding that the "small" countries could logically only expect to be awarded relatively marginal work batches and that they were too often compelled to compete with one another'.2/

Quite clearly, the revision of the initial offer was not in the interest of the German delegation, as the participation of German industry was reduced by 20% and the overall offer price increased. In fact, the delegation made known that

> '...certain requirements had to be met before Germany was to participate in the programme'.3/

One of the technical requirements was a change of the apogee booster motor, a key piece of technology.4/ Both H-SAT offers had envisaged the use

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1/ Ibid., 12. Contrary to the original figure of 5%, the British delegation had informed ESA before the revision of the tender took place that the United Kingdom wished a 10% share.

2/ Ibid., 6.

3/ Ibid., 5. See also ESA/C(77)93, Text of a Letter from the German Ministry of Science and Technology to the Director General of ESA, dated 24 Aug. 1977, 4 Oct. 1977.

4/ Originally, a MAGE motor was to be used for the OTS. Since the motor was not ready in time, US equipment had to be purchased.

of the MAGE III apogee booster motor developed under an ESA project, and in accordance with previous Council decisions, it was expected that this equipment would be used for satellites launched by ARIANE. The MAGE III motor was developed by the industrial consortium of SEP (F), SNIAS (F), VISCOSA (I) and MAN (D). Now, the German delegation demanded the inclusion of an apogee booster motor developed by MBB (D), an upgraded version of the motor used in the SYMPHONIE project. As in the case of the TWT and wheel for the OTS, West Germany was prepared to bear any additional costs involved by providing this equipment under its national programme.

One of the financial requirements was to reduce the total programme cost by removing some of the experimental technology work from the programme.

The German attitude found harsh criticism from other delegations. Sweden, supported by the Netherlands, expressed its disapproval as follows:

> 'While it readily accepted that a country like Germany should exercise a profound influence in the orientation of the European space programme, it would regret it if that country was to forego assuming its responsibilities; the delegation was indeed extremely surprised that the German delegation, after urging the committee to vote in favour of EUROSATELLITE, was not prepared to confirm its attitude'.1/

However, with the majority of the IPC delegations approving the revised EUROSATELLITE offer - only Italy, the United Kingdom and West Germany had not voted in favour - the selection of EUROSATELLITE as prime contractor was confirmed and definite. In addition, the H-SAT contract of 61.5 MAU was approved subject to a decision by the JCB and the Council to carry out the H-SAT project.

Following the confirmation of EUROSATELLITE's selection as prime

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1/ ESA/IPC/MIN/18, op.cit., 5. See also P. Langereux, 'ESA: Incertitudes sur la Production "ARIANE" et les Satellites des Télécommunications', *Air et Cosmos*, XIV (1977), No. 698, 23-4.

contractor for H-SAT, the ESA executive requested the JCB to approve interim funding of 1 MAU, the minimum resources needed for the most urgent work before the final project decision could be taken at the next Council meeting in December 1977.1/ Owing to the negative stance of the German delegation, the Board could not approve the interim measure, and had to wait for new directives from the Council.2/ As a result, industrial work came to a standstill, and project teams which had been in existence since May 1977 and were ready to proceed were disbanded.3/

1/ ESA/JCB(77)35, Actions Necessary for the H-SAT Project, 4 Nov. 1977.

2/ ESA/JCB/MIN/17, 5 Dec. 1977.

3/ Report on the Status of the Heavy Satellite Programme (H-SAT) as of 15 November 1977, ESTEC (no date given, approximately end of November 1977).

5.7 The OTS launch failure

The final construction of the OTS flight model had been completed in early 1977, and the launch was planned for mid-June on a Thor Delta 3914 from the NASA launch station in Florida. Because of an accidental release of the solid boost motors attached to the launch vehicle, the launch had to be rescheduled. On 13 September 1977, OTS lift-off took place, but only 56 seconds later, the Thor Delta 3914 vehicle exploded.

The satellite's on-board telemetry system had indicated that the satellite functioned normally up to the time of the explosion. A NASA failure review board, including an ESA representative, announced in early 1978 that the failure had been due to a wall burn-through in one of the solid strap-on motors attached to the launcher, and it recommended a number of modifications to launcher hardware and launching procedure.1/

Because of the insurance that ESA had for the launch, the direct financial effect on the TELECOM programme was minimal.2/ The insurance of 26.5 MAU was used to finance the construction and launch of a second flight model, OTS 2. As noted above, the OTS project included a back-up policy whereby a second flight model could be ready approximately six months after an OTS failure. Immediately after the OTS launch failure, the OTS 2 integration programme was brought up to full speed. The second launch was scheduled for 20 April 1978.

No lasting damage was caused by the OTS launch failure, but the delay in the OTS project increased the overlap with the ECS project and was a blow to

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1/ ESA/JCB(77)36, Report on the Inquiry into the OTS Launch Failure, 4 Nov. 1977.

2/ ESA/JCB(77)31(C), Consequence of the OTS Launcher Failure, 20 Sept. 1977.

staff morale.1/ In addition, an OTS operating in orbit might have helped to find a solution for the difficult discussions on the continuation of the communication satellite programme.

1/ Since this was the second consecutive failure of a launch carried out by NASA for ESA, some European newspapers speculated that this was an American attempt to sabotage the European space programme. Other papers used the launch failure to highlight the difficulties associated with European multinational projects, although the failure was entirely caused by the American launcher. See 'Einfach Pech', Der Spiegel, 19 Sept. 1977; 'Wrong Number', Time, 26 Sept. 1977; 'Second Chance', Nature, CCLIV (1977), 22 Sept.; 'Rocket Failure Shakes US Space Industry', New Scientist, XCVIII (1977), 715.

5.8 Decision on the new package deal proposal: ESA Council meeting, December 1977

During the last Council meeting in 1977, another attempt was made to get approval of the TELECOM package deal.1/ Since there were still many uncertainties in the H-SAT project, the ECS project and the ASTP, the ESA executive only requested the approval of a 'guideline resolution' which would enable the JCB to conclude the corresponding agreements for the package deal elements, estimated to cost as follows at mid-1976 prices:

(1)	CEPT mission (ECS project)	109.5 MAU
(2)	H-SAT including operational ARIANE launch	107.7 MAU
(3)	MAROTS extension	19.2 MAU
(4)	Advanced System and Technology Programme (ASTP)	7.1 MAU
Total		243.5 MAU

The total cost of 243.5 MAU had to be compared to the total cost of 200 to 235 MAU estimated at the ministerial Council meeting in February 1977. Despite drastic reductions in the ASTP programme and the MAROTS project, a considerable increase over the initial cost estimate had to be expected for the CEPT mission because of the switch of launchers (now ARIANE instead of Delta 3914). As a result of the delay in approving the H-SAT project, the new proposal assumed launch by an operational ARIANE vehicle instead of the previously envisaged experimental ARIANE launch (L04), which would have been free of charge.

At its December meeting, the Council almost managed to finalize the package deal by adopting the resolution necessary to allow the projects to be

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1/ For a detailed description of the package deal, see ESA/C(77)127, Telecommunication Package Deal 1977, 12 Dec. 1977.

undertaken.1/ It was only West Germany which declared that it could not go along with the proposal since it did not conform to the funding limitations of 200 MAU set by the German delegation during the ministerial Council meeting. The German position, however, resulted from a more basic difference in opinion.2/

West Germany demanded a new industrial policy for those ESA projects which turned commercial. With no provisions on geographical distribution and a limited role for ESA, industry should be able to develop competitive space technology for the growing world market. Following the Council meeting, a senior German official from the aerospace department in the Ministry of Economics was quoted as follows:

> 'The immediate problem is to make ESA more efficient...Industry sources confirmed what appears to be a growing German doubt about the capability of ESA to manage commercial programmes'.3/

In fact, the German position expressed at the Council meeting was at least partly based on a push by the largest German aerospace company MBB to establish new commercially oriented schemes for government funding of advanced technology.4/

Since the majority of ESA member states, namely the smaller countries, were strictly opposed to this change of industrial policy for reasons outlined above, West Germany realised that it had little chance of getting its way within ESA. At that time, a senior German official in the Ministry of

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1/ ESA/C(78)14, Telecommunication Package Deal 1977, 7 Feb. 1978.

2/ Interview with a senior official from the Ministry of Research and Technology.

3/ R. Ropelewski, 'European Reappraising Space Efforts', 71.

4/ Ibid., 72.

Research and Technology was quoted as follows:

> 'All our practical space applications which worked were national, bi-national or tri-national. In a wider framework, with many nations, only scientific programmes work'.1/

Did West Germany explore the possibility of a national or limited international programme outside the ESA framework, in violation of the ESA convention?

In the end, no decision was taken at the Council meeting, but all delegations except that of West Germany subscribed to a declaration indicating that they were prepared to contribute to the package deal. The JCB was asked to pursue matters further, so that a definitive decision could be taken at the February meeting of the Council.

Events following the Council meeting

Following the Council meeting, the German delegation informed the Bureau at its meeting on 2 February 1978 that it did not in principle intend to take part in the H-SAT project.2/ Furthermore, the delegate informed his colleagues that the German ministry was financing its own studies in German industry with a view to carrying out a pre-operational direct-to-home television satellite programme. No further ESA expenditure for H-SAT would therefore be approved by the German delegation until the results of these

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1/ 'Europäische Raumfahrt wieder in der Krise', op.cit.

2/ ESA/C(78)14, op.cit. See also J.-P. Croizé, 'L'Europe Spatiale bat de l'Aile', Le Figaro, 2 Mar. 1978; A. Johansen, 'Bonn setzt wieder auf eigene Nachrichtensatelliten', Frankfurter Allgemeine Zeitung, 29 Mar. 1978; 'German Government is Funding Industry Studies of an Operational Direct Television Broadcasting Satellite', Aviation Week & Space Technology, LXIII (Feb. 1978); 'L'Allemagne Décide de Soutenir le Programme Télécommunications', Les Echos, 24 Mar. 1978.

studies were known by the end of 1978.1/

This decision did not come as a surprise, but it necessitated new discussions to achieve a redirection of the project. The French delegation proposed to the remaining states that the commitment to the H-SAT programme should be reaffirmed and the selection of EUROSATELLITE with SNIAS (F) as prime contractor, should be maintained.2/ While it wanted to leave the door open to subsequent German participation, project financing should be limited to an initial period of six months during which a new distribution of the industrial work would be arranged in the light of West Germany's withdrawal, the basic technical and contractual documents would be updated and the definition and development of critical components would be initiated. Following this six-month period, participating countries would have to confirm the approval of the project by October 1978.

In accordance with the suggestions of the French delegation, the ESA executive submitted a proposal for a six-month study phase for the H-SAT project at a cost of 6.1 MAU to begin on 1 April 1978 during the subsequent Council meeting in March 1978.3/

The study phase was approved and financed by the member states as shown in the table on the following page.

West Germany was invited to participate in the study phase and to declare its final intention as soon as possible. In order to keep the door open for

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1/ The German definition studies for a national TV satellite were performed between March and December 1978 by an industrial team including MBB, AEG-Telefunken, ERNO and Dornier. Up to 70 experts in total worked on this study under a contract from the Ministry for Research and Development (BMFT) in cooperation with the German national space organisation DFVLR.

2/ ESA/JCB(78)10, Note by the French Delegation, 7 Feb. 1978.

3/ ESA/C/MIN/23(I), 7 Mar. 1978.

Participation in 6-month H-SAT study 1/	
Countries	Share of contribution in %
France	43.0
Italy	20.0
Sweden	13.0
United Kingdom	10.0
Belgium	5.5
Switzerland	3.0
Denmark	2.0
Spain	1.0
Total	100.0

subsequent participation by German industry in the development of H-SAT, EUROSATELLITE was requested to prepare two project offers, one with German participation and one without.

Germany's intention not to participate in the H-SAT project, with the resulting threat to the project due to the increase of costs for the remaining countries, had initiated a reflection on the past industrial results of the TELECOM programme. In particular, the sole fact that West Germany considered it possible to proceed alone, despite having advanced its technology in a European framework, made smaller countries wonder who benefited from past development efforts. During a Board meeting, the Swiss delegation, supported by the Danish and Swedish delegations, stated that it:

> '...really regretted that the Agency's previous policy had in fact led the "small countries" to contribute towards the development of certain specialisations in the industry of the major contributors without themselves being in a position to gain a capability in interesting areas'.2/

1/ ESA/C/XXIII/Dec.2, Declaration by the Participants in the Studies Devoted to a Programme for the Development of a Heavy Platform and Payload, 1 Mar. 1978.

2/ ESA/JCB/MIN/19, 10 Mar. 1978, 5.

Applying this past experience, the Belgian delegation commented on the proposed project as follows:

> 'It must be borne in mind that unlike the case of the major contributors, participation in programmes such as the H-SAT programme did not afford the "small" countries the opportunity of developing a new national potential in the field of facilities or technical know-how'.1/

While pursuing their own studies at national level, the German authorities decided in April 1978 on a limited resumption of their H-SAT activity. In fact, they decided to provide up to 1 MAU for the updating of the alternative H-SAT proposal that included German participation.2/ Hence, by autumn 1978, two project alternatives would be available to the German authorities, namely the collaborative (ESA) and national (German) approaches.3/

1/ ESA/JCB/MIN/21, 7 Apr. 1978, 3.

2/ ESA/C/MIN/23(II), 20 Apr. 1978; ESA/C(70)39, Telex from the German Delegation to the Director General, 5 Apr. 1978. The task entrusted to German firms was only related to satellite software and excluded experimental or practical technological hardware work.

3/ 'H-Satellit überträgt direkt Radio- und TV-Programme', *Astronautik*, XVII (1978), No. 3, 86.

5.9 ECS development, ECS derivatives and successful launch of OTS 2

Since no final decision on the H-SAT project was expected in the near future in the context of the package deal, the Director General proposed to the JCB to vote on the package deal elements separately and to decide on the ECS project then. It was argued that any further delay would increase the cost considerably and put back the launch date. Until then, a condition for the approval of the ECS programme had been a binding utilisation commitment on the part of EUTELSAT for the operational system. Although this was not yet in hand, a successful outcome of the current negotiations seemed likely.

After a redistribution of work primarily to take account of the wishes expressed by the Italian delegation for an increase in the workload, the ECS project was approved unanimously by the JCB in February 1978; its total cost was 128.9 MAU at mid-1977 prices.1/ The Board also decided to agree to Spain's request to become a party to the TELECOM arrangement and to participate in the ECS project with a contribution of 0.17%. Although the Spanish request found unanimous approval, the question was raised as to whether a minimum figure should be laid down with respect to the contribution to be paid by participants in a programme of the Agency.

The contribution of the participating member states to the ECS project is shown on the following page. With regard to the final satellite characteristics, each ECS would provide 5,000 telephone circuits and two television channels, with an operational lifetime of seven years and an in-orbit satellite mass of 590 kg. The first ECS was to be launched from the

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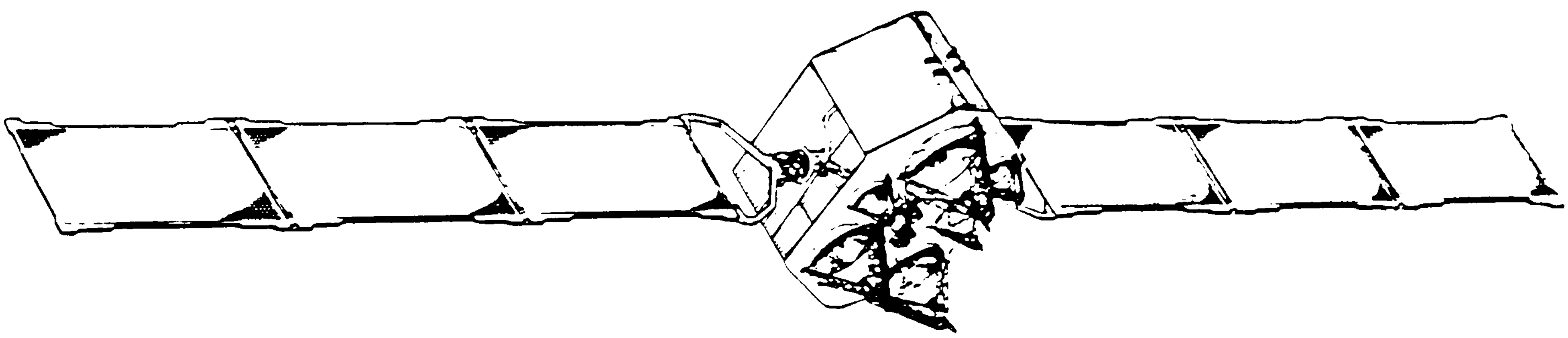
1/ ESA/JCB/MIN/20, 13 Mar. 1978; ESA/JCB/XX/Res.1, Rev.1, Final, 13 Mar. 1978. The CEPT mission comprised the procurement of two ECS satellites, one ARIANE launching, ground support equipment and six months in-orbit control of one ECS satellite.

Contribution to the ECS project 1/	
Country	Contribution in %
West Germany	30.68
France	25.93
United Kingdom	20.15
Italy	14.78
Belgium	3.27
Switzerland	2.13
Sweden	1.62
Netherlands	0.94
Denmark	0.33
Spain	0.17
Total	100.00

ESA base in Kourou, French Guiana, at the beginning of 1982.

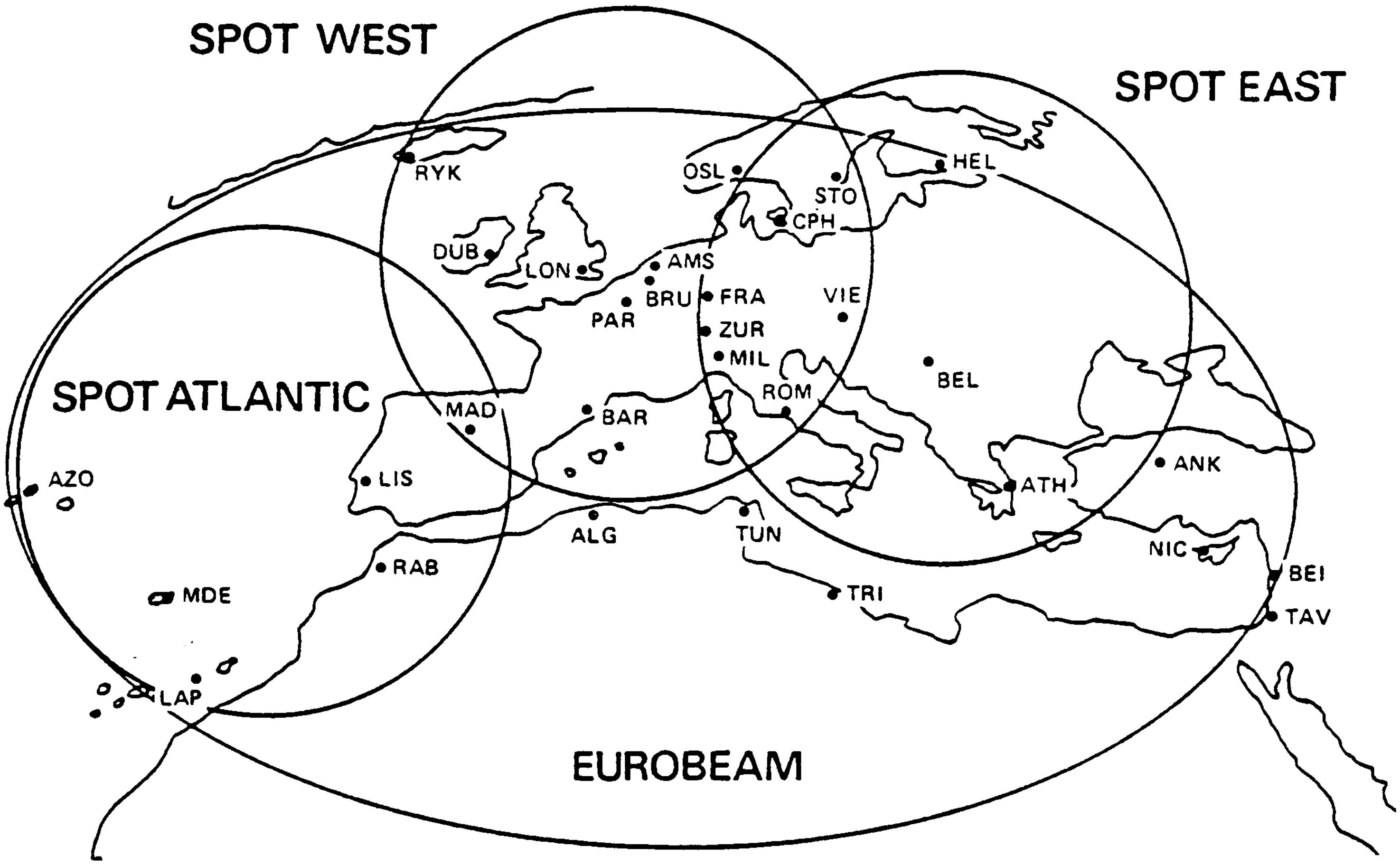
The orbital configuration of the ECS is given below.2/



1/ ESA/JCB/XX/Res.1, Rev.1, op.cit. The participating member states contributed according to their industrial return and the '92% rule'. Under this rule, the industrial return of Belgium, France, the United Kingdom and West Germany only corresponded to 92% of the contribution and hence these countries had to pay 8% in excess to the industrial project share.

2/ P. Bartholomé, 'The European Communications Satellite Programme', ESA Bulletin, IV (1978), No. 14, 46.

The antenna coverage (or service zones) is indicated on the following map:1/



Transmission of television service would be possible for ground stations located in the Eurobeam area, whereas telephone traffic exchange would be possible for ground stations located in the spot beam areas (spot Atlantic, spot west, spot east).

ECS derivatives 2/

As outlined above, ESA carried out a maritime communication satellite programme called MAROTS, which used an OTS derivative platform. During mid-1978, it was decided that the maritime programme should be switched from

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1/ Ibid., 41.

2/ C. Raith-Brown, A. Haigh, 'The European Communication Satellite and Derivatives', Journal of the British Interplanetary Society, XXXII (1979), 191-7.

experimental to operational and hence should be based on the ECS platform rather than the OTS one. The maritime derivative of ECS, called MARECS, was designed to participate along with the American-built maritime satellites in a global system providing communication service between the offices of the world's shipping companies and their ships. To this end, an international maritime satellite organisation called INMARSAT, with headquarters in London, was set up to cover all technical, operational and financial issues. INMARSAT can be seen as the international maritime counterpart of INTELSAT, which is in charge of transcontinental telephone traffic.

Before the European-built MARECS satellites would be accepted for use in the INMARSAT system, they had to compete successfully with American industry for the INMARSAT maritime satellite market. In fact, this would be the first test of the direct competition between the technology developed in the European framework of ESA and American technology, and it would indicate to what extent the European model had managed to catch up with American technology.

When INMARSAT called for tenders, it received proposals from INTELSAT, MARISAT (a US consortium of COMSAT and Western Union International) and ESA. The ESA offer was based on a marginal costing approach, i.e., it included only those additional costs which were incurred directly as a result of running the MARECS project for INMARSAT. In addition, ESA covered much of the service risk itself so that it was not reflected in the tender price, thus 'saving' insurance costs. The ESA offer for the seven-year operational maritime service, including two MARECS satellites, amounted to only 46.7 MAU with marginal costing and minimum insurance, as against 121.99 MAU with full costing and full insurance.1/

Only by heavily subsidising the tender, ESA managed to become internationally competitive and get its offer accepted. Along with two MARECS satellites, INMARSAT decided to procure one INTELSAT V satellite carrying a maritime payload and three American MARISAT satellites.

Although this marked ESA's entry into the international commercial satellite market as well as the end of long periods of spacecraft development and testing, it did not prove that the ESA approach had resulted in competitive products. On the contrary, the ECS tender illustrated that though technologically competitive, the satellites at full cost were twice as expensive as their American rivals.

Successful launch of OTS 2

After the launch failure of OTS 1 in September 1977, the back-up flight model, OTS 2, was launched successfully on 11 May 1978 from Cape Canaveral on the NASA Delta 3914 vehicle.

The satellite test programme covered the verification of satellite performance in orbit, transmission tests, measurements of propagation effects and experiments related to new applications of satellite communication. The test programme was carried out jointly by ESA, PTT administrations, broadcasting agencies and other experimenters, using more than 30 stations which represented an investment of 40 MAU.

All subsystems of OTS 2 functioned well throughout 1978 except for one of the six on-board repeater channels, which had to be declared non-operational owing to failure of an output power amplifier.

1/ ESA/JCB(80)9, MARECS and a Lease Offer to INMARSAT, 12 Mar. 1980; ESA/JCB(80)32, Costing Aspects of the ESA Offer to INMARSAT, 15 July 1980.

After the initial measurement programme had been completed by ESA, OTS 2 was used extensively by the PTT administrations for real-time pre-operational traffic.1/ A number of satellite performance demonstrations were carried out, in particular TV transmission demonstrations at the Farnborough Air Show, at the International Broadcasting Convention in the United Kingdom and at the Conference of Space Technology in Cairo, Egypt. In all cases, excellent results were achieved.

1/ ESA/JCB(78)34, The Orbital Test Programme, Use of OTS for Special Communications and Demonstration Tests, 26 June 1978; ESA/JCB(78)42, Agreement between ESA and Interim EUTELSAT on the use of OTS, 8 Sept. 1978.

5.10 ESA-EUTELSAT agreement on the operational use of the ECS and the corresponding 'phase III bis' of the TELECOM programme

Concerning the last round of ESA-EUTELSAT negotiations, the JCB regarded the results as unsatisfactory (see page 329). Further negotiations, in particular on a risk-sharing formula, finally resulted in a compromise by November 1978. ESA was expected to try to obtain insurance for the satellite within the limits of the funding provided for this purpose as soon as it was possible to do so. If ESA could not insure the fourth and fifth years of satellite operation on 'reasonable terms', ESA and EUTELSAT would consult on the matter.1/

New estimates of the cost of the operational phase, however, had resulted in a considerable increase in the amount which ESA was required to pay. The ESA share increased from 87 MAU to 122 MAU, as EUTELSAT would not accept any increase in its 80 MAU share negotiated back in December 1977.2/

Quite clearly, EUTELSAT was in a very strong negotiating position since it was not the user which requested the satellite system but the ministries concerned with space technology. Thus the latter had to convince a monopolistic user to accept the ECS satellites after their development under the TELECOM programme was well advanced. It took until May 1979 to conclude the ESA-EUTELSAT agreement, based on the cost-sharing formula outlined on the following page.

Whereas ESA delegations considered the agreement to be unduly 'generous',

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1/ ESA/JCB(79)5, Letter of the Secretary General of Interim EUTELSAT to the Director General of ESA, 8 Jan. 1979.

2/ Launcher costs were based on single satellite ARIANE launches. If it proved possible, as expected, to launch two satellites of the ECS type on a single ARIANE, the ESA share would be reduced accordingly.

Total ECS programme cost		202 MAU 1/
ESA cost for management and control of satellite in orbit	27 MAU	
Satellite procurement (ECS 3,4,5)	69 MAU	
Launches (ECS 2,3,4)	74 MAU	
Insurance	32 MAU	
EUTELSAT share		80 MAU 2/
ESA share		122 MAU

the German delegation pointed out that while this negotiation result was to some extent inevitable, the utmost should be done to prevent any recurrence of such a situation.3/

The corresponding arrangement among ESA's participating member states to cover the ESA share of 122 MAU, known as 'phase III bis' of the TELECOM programme, was concluded in April 1979.4/

The ESA member states agreed to finance the ESA commitment according to the geographical distribution of work associated with the procurement of the operational satellites ECS 3,4 and 5. The distribution of the work is shown on the following page. These figures indicate that the smaller countries had smaller shares than in OTS 1 and 2 or even ECS 1 and 2. Basic hardware, such as ground support equipment, which was developed mainly by the smaller

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1/ ESA/JCB(78)57, Add.1, Continued Support for the ECS Programme Proposal for the Financing of Phase III bis, 20 Nov. 1978.

2/ In addition to the 80 MAU for the ECS service, the user organisations would have to fund the ground segment, composed of 20 to 25 ground stations and estimated to cost 250 MAU. Hence, the total cost of the ten-year operational space system was estimated at approximately 450 MAU, of which the users would cover 330 MAU and ESA 120 MAU.

3/ ESA/C/MIN/26, 14 Sept. 1978.

4/ ESA/C(79)25, Add.3, Declaration Relating to Phase III bis of the Communication Satellite Programme, 5 Apr. 1979.

Distribution of work under phase III bis 1/		
Countries	Overall in %	Europe in %
West Germany	26.35	31.95
France	22.10	26.84
Italy	12.86	15.56
United Kingdom	11.75	14.22
Sweden	3.30	3.99
Belgium	2.75	3.33
Netherlands	1.60	1.93
Denmark	0.75	0.95
Switzerland	0.56	0.68
Spain	0.45	0.55
USA and others	13.13	
Unallocated	4.40	
Total	100.00	100.00

countries for the OTS and ECS projects, could be reused for the subsequent ECS satellites. This limited the opportunities for the smaller countries to participate in the series production of the operational satellite units.

1/ ESA/JCB(79)2, Phase III bis, Work Distribution within European Industry, 16 Jan. 1979. The total industrial work for the three satellites was expected to amount to 65 MAU. See ESA/JCB(78)7, Phase III bis of the Communication Satellite Programme, 20 Nov. 1978.

5.11 H-SAT project: the final split

Following the German decision to participate in the six-month study, full industrial teams were working again on the H-SAT project by mid-July 1978.1/

On the basis of the demands of West Germany, the H-SAT mission was revised to provide a TV channel in maximum conformity with the coverage requirements of a prospective German operational system, particularly in respect to spill-over towards East Germany. All requests had been met, and at the October meeting of ESA's expert body, the Satellite Broadcasting Advisory Group (SBAG), no expert raised any objections to the position adopted by the broadcasting authorities of his country, namely that the H-SAT project would meet their national requirements in terms of satellite coverage and utilisation time.2/

By the beginning of September 1978, the work of the H-SAT study phase had almost been completed by industry. The detailed definition work, together with supporting analysis and some limited breadboarding of key equipment, had not revealed any unforeseen problems. The satellite design had proved to be fully compatible with the H-SAT mission objectives, and the H-SAT platform was very close to the operational platform which West Germany would require shortly. The launch of the first H-SAT could be in mid-1982 providing the main development contract started at the beginning of 1979.3/

The ESA executive had requested detailed price estimates from

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1/ ESA/IPC(78)62, Interim Report on the H-SAT Preliminary Step B Contract Background, 19 July 1978.

2/ ESA/SBAG(78)10, Proposal for a European Programme Devoted to Direct Television Satellite Broadcasting, 12 Oct. 1978; ESA/JCB(78)63, Report on H-SAT by the Chairman of SBAG, 23 Oct. 1978.

3/ ESA/JCB(78)55, Technical Results of the H-SAT Preliminary Step B Contract, 9 Oct. 1978.

EUROSATELLITE for the main development contract during October 1978. The offer submitted by EUROSATELLITE, however, had little meaning, since the prices submitted by a number of contractors were without any supporting detail or any reference to the previous financial baseline of October 1977. The executive identified the reason for this lack of interest as

> '...the general political environment surrounding the programme and the fact that some industries have allowed themselves to be influenced by parallel national activities'.1/

The matter was discussed with the prime contractor SNIAS (F), and subsequently the ESA executive prepared its own estimates for the development of H-SAT: 86 MAU at mid-1978 prices.

The general political environment to which the executive referred to above was characterised by bilateral consultations between France and West Germany on the possibility of developing a Franco-German broadcasting satellite.2/ West Germany, which carried out national studies in parallel to the current ESA activity, had managed to interest France in such a project using the commercial and operational arguments outlined above. France was particularly attracted by the possibility of early operational use, which was related to the fact that the payload of such a Franco-German satellite would be virtually identical to the operational satellite.

The two countries not only had similar interests in the TV satellite mission, but there also existed obvious industrial reasons for a joint Franco-German programme with a commercial orientation. First, the satellite

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1/ ESA/JCB(79)14, Report on the Progress of the H-SAT Project, 8 Jan. 1979.

2/ West Germany also held discussions on a collaborative effort with the Italian authorities. Those discussions, however, were not pursued any further since Franco-German collaboration was favoured. See A. Lloyd, 'Europe Looks to Space for TV', Interavia, 25 May 1978, 99-100; 'Bonn plant Weltraum-Fernsehen', Frankfurter Allgemeine Zeitung, 21 Feb. 1979.

industries of both countries could be considered the most advanced in Europe. Having carried out the SYMPHONIE programme jointly, France and West Germany also managed to take the 'noble' industrial share under the TELECOM programme (see pages 295 to 303).1/ Second, although West Germany had aimed to establish an independent national communication satellite industry as a result of its national, bilateral and European efforts, its industy was complementary to France's in selected technological areas. France, for example, was leading in battery and sensor technology, whereas West Germany was leading in payload (TWTA) and solar cell technology. Hence, merging their industrial capabilities would result in an even more competitive position for securing a share of the world market. Finally, West Germany was seeking a joint venture for political reasons as well.2/ Leaving a European programme would be easier to justify with the support of another country.

Although it had been expected that authorisation for the start of H-SAT's main development phase would be given before the end of 1978, the ESA executive had judged it advisable to take into account the past evolution of the situation, namely the Franco-German initiative. In order to adjust the current H-SAT concept, in particular to France's desire for early operational service, the executive proposed not to start the development phase as originally planned, but to carry out a supplementary programme while bearing in mind the need to keep funding to a minimum until France and West Germany decided on the bilateral or the European option. Following the supplementary

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1/ The major space companies of the two countries, MBB (D) and SNIAS (F), not only worked together on the SYMPHONIE programme, but together they also secured the lion share of Europe's industrial contribution to the INTELSAT V satellites.

2/ A. Johansen, 'West Germany Plans Direct Broadcasting TV Satellite', New Scientist, XCIX (1979), 653.

programme, EUROSATELLITE would be required to elaborate the detailed design of H-SAT with necessary changes and to make a revised fixed-price offer for the H-SAT development phase.1/

Meanwhile, German criticism of ESA continued. At a space conference in Darmstadt, West Germany, senior German ministry officials and leading representatives of the aerospace industry argued that ESA was unable to compete effectively in international space markets. In fact, a ministry representative asked

> '...whether it would not be better for Germany to cooperate with one or two nations in different projects instead of becoming embroiled with the cumbersome ESA'.2/

In an address to the Committee on Science and Technology of the German House of Representatives, a senior official of the Ministry for Science and Technology commented in an ironic way when referring to ESA that the cost of an international project

> '...is more or less equal to the product of the "true" costs of the project done nationally and the square root of the number of participating countries'.3/

On another occasion, an official of the space ministry stated that

> '...applications should only go on in ESA for a short time, then they must be marketed and taken out of ESA's control'.4/

Later, in 1980, a German space official stated that the

> '...unwieldly committee structure of ESA...causes delays, raises costs

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1/ ESA/JCB(78)67, An Integrated European Approach to the Development of Operational Broadcast Satellites, 20 Nov. 1978.

2/ 'Germans give a Rocket to European Space Projects', New Scientist, XCVIII (1978), 917.

3/ 'What the Critics Say', Nature, CCLXXI (1978), 356.

4/ Ibid., 358.

and hinders commercial development of products'.1/

Even according to a British member of an ESA committee,

> '...attaining decisions is an absolute nightmare'.2/

Whereas the remaining countries supported France and West Germany in their pressure to reduce bureaucratic procedures at ESA, the smaller countries in particular were opposed to France's and West Germany's view of

> '...ESA primarily as a research and development agency rather than a profit-making space multinational'.3/

During the JCB meeting on 5 December 1978, the ESA executive requested the approval of the new approach and the provision of 4.5 MAU for the supplementary programme to cover work from January 1979 for a period of four to nine months, depending on how rapidly decisions were taken.4/ The French and German delegations, however, announced that they were not in a position to decide on participation in the supplementary programme since such a decision would depend on the conclusions of national studies being carried out at that time. Other delegations expressed strong support for ESA's proposal and reminded the French and German delegation that the obligations imposed by the ESA convention for the harmonisation of national programmes with those of the Agency and for the Europeanisation of national activities also covered application satellites (see page 304).5/

1/ P. Marsh, 'Europe Falters on the Brink of Space', New Scientist, C (1980), 321.

2/ P. Marsh, 'Space Agency Cuts out Bureaucracy', New Scientist, C (1980), 95.

3/ 'Supposing Stability', Nature, CCLXXXIII (1980), 30 Oct.

4/ ESA/JCB(78)68, Immediate Actions for Continuation of the H-SAT Programme, 20 Nov. 1978.

5/ ESA/JCB/MIN/28, 17 Jan. 1979.

In view of the remarks made by the French and German delegations, the ESA executive revised the proposal for a supplementary programme in order to secure approval at least of a minimal budget of 1 MAU. This was to enable work during the first three months of 1979 by the ESA team and a rump team in industry, until a final decision had been taken.1/ Since France and West Germany were not able to approve even the limited funding of 1 MAU, there was no point in continuing the discussion and it was decided to report to the Council on the deadlock in the H-SAT project.

During the subsequent Council meeting on 13 December 1978, the delegations were asked to support in principle a supplementary programme during 1979. The Swiss delegation appealed to the French and German delegations

> '...to reverse the stance they had taken and thus keep open the option of a European programme'.2/

Both delegations, however, reaffirmed the statements they had made at the last JCB meeting, maintaining that they could not approve any commitments concerning the H-SAT project until the national investigations had been finalised. In view of this situation, the Director-General of ESA proposed to defer the principal decision on the H-SAT programme to February 1979 in order to allow the French and German delegations to arrive at a decision. To keep ESA's H-SAT team together until then, the remaining delegations immediately approved an amount of 0.3 MAU.3/

The German initiative for a TV satellite project outside ESA had received

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1/ ESA/JCB(78)78, Immediate Actions for Continuation of the H-SAT Programme, 5 Dec. 1978.

2/ ESA/C/MIN/28, 26 Jan. 1979, 19.

3/ Ibid.

a decisive push from the industrial interest group. On 15 February, MBB (D) signed an agreement in Peking to supply up to seven communication satellites of the German TV-SAT type to China. The agreement, signed after a keen competition with American industry, was expected to lead to the delivery of up to 20 TV satellites.1/

With the German-Chinese deal on the cards, it was considered very likely that the German government would give the go-ahead for a TV satellite programme either together with France or on a national basis. In addition, EUROSATELLITE had won a study contract for a TV satellite serving the Nordic countries of Europe (NORDSAT project). A second study contract was awarded to an American group.2/

In February 1979, the ESA executive submitted a new H-SAT project proposal as part of an overall programme strategy to the Board for discussion.3/ The executive went a long way to adjust the technical and

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1/ The MBB deal was widely publicised in the press. See 'Deutsche Fernsehsatelliten ersetzen Lehrer in China', Die Welt, 16 Feb. 1979; 'MBB-Delegation verhandelt in Peking', Süddeutsche Zeitung, 15 Feb. 1979; 'Deutsche Satelliten für das Chinesische Fernsehen', Süddeutsche Zeitung, 22 Feb. 1979; 'Bonn plant Weltraum-Fernsehen', Frankfurter Allgemeine Zeitung, 21 Feb. 1979; 'West Germany Gains Firm Foothold with Technology', Financial Times, 23 Feb. 1979; 'China-MBB Sign Exchange Agreements', Aviation Week & Space Technology, LXIV (Feb. 1979); 'The European Space Agency May Fall Apart', The Economist, CCXXVIII (1979), 14. Apr.; 'Bientôt l'Ere des Satellites', Les Echos, 26 Feb. 1979; 'Satellites de Télévision Directe pour la Chine', Les Echos, 19 Feb. 1979. Although the agreement was mainly described as a contract, The Economist pointed out that an agreement was not quite a final contract, which proved to be important, since at a later stage, the contract approval was postponed indefinitely.

2/ 'TV-NORDSAT für die skandinavischen Länder', Astronautik, XVIII (1979), No. 1, 14.

3/ In addition to describing the new H-SAT project, the proposal outlined a comparison between what was called a 'European' and a 'bilateral' approach, emphasising the advantages of the former. See ESA/JCB(79)6, The Development of Operational European Broadcast Satellite Systems, 12 Jan. 1979; ESA/JCB(79)4, H-SAT Preliminary Step B Studies, 11 Jan. 1979.

managerial characteristics of the H-SAT project to the wishes expressed by the French and German delegations.

Concerning the technical project characteristics, the executive now envisaged an H-SAT based on an operational platform together with a payload which could provide limited operational service for France and West Germany, in view of their apparent interest in the early development of an operational system.

Concerning the management scheme, the executive would only be responsible for the initial development of a common platform suited to the needs of a range of foreseen operational payloads, whereas the H-SAT payload could be provided by France and West Germany. The procurement of subsequent operational stellites, the adaptation of the common platform design and the development of other payloads would be delegated to appropriate national authorities such as the French space organisation CNES or the German space organisation DFVLR or to ESA if required by member states. Beyond this industrially oriented work, it was proposed that ESA should remain responsible for certain coordination tasks.

The position of France and West Germany, however, had not changed from the last JCB meeting in December 1978: neither delegation was in a position to take a decision owing to the on-going studies at the national level.1/ In fact, the ESA proposal came too late. Since France and West Germany were on the verge of taking decisions on the implementation of a joint TV satellite project, they were not able to discuss any new ESA project proposal. It might be speculated that the proposal would have had a greater chance of being supported if it had been submitted at an earlier stage of the project

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1/ ESA/JCB/MIN/30, 12 Mar. 1979.

discussion.

In view of the uncooperative stance of France and West Germany, the chairman of the Board asked the ESA executive to study to what extent a European TV satellite programme could be carried out without the participation of these two countries. The majority of delegations, in particular Italy and Sweden, felt it would be unrealistic to carry out such a programme without two of the main contributors.

Nevertheless, during the subsequent Council meeting, eight countries, namely Austria,1/ Denmark, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom, approved a new study programme at a cost of 550 KAU to cover work during the period March-July 1979.2/ The aim of the study was to investigate a wider range of future communication missions compared with the limited H-SAT broadcasting satellite and to evaluate their compatibility with a large platform development. A market survey was to proceed in parallel.3/ It was planned to select a limited range of typical missions for further study and for translation into the corresponding satellite designs.

With the H-SAT project terminated, a new initiative for a European programme was launched by the United Kingdom. In fact, this country had a particular interest in the commercialisation of communication satellite technology based on its considerable investment in the OTS/ECS project and in the MARECS project. When it became clear that France and West Germany would not participate in the H-SAT programme, the United Kingdom conducted national

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1/ The participation of Austria, which was a non-member state of ESA but an observer to this organisation, was approved by the Council.

2/ ESA/C/MIN/29, 4 Apr. 1979.

3/ ESA/JCB(79)14, Continued Studies of the Future European Telecommunication Satellite Programme, Study Plan, 27 Mar. 1979.

studies in parallel to those of ESA. It concluded, however, that a purely national project would cost too much.1/

In May 1979, the British delegation sent a letter to the Director-General of ESA proposing that a new programme proposal should be made for future action at the next Board meeting, since the delegation considered that there was still considerable interest in a multi-purpose platform.2/

During the following Board meeting in July 1979, the ESA executive presented a new project proposal for the development of a multi-purpose large platform and the associated communication payload, known as the L-SAT proposal.3/ Concerning the payload to be supported in the first demonstration flight of the platform, the obvious option was a direct broadcast payload. In addition, the multi-purpose nature of the platform should be demonstrated by payload elements dedicated to the provision of special services primarily to business users and of future inter-city communications in the high frequency band. Concerning the industrial configuration for the L-SAT development, technical trade-offs had to be made to avoid the selection of technology available only in France and West Germany.4/ Despite the extensive

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1/ Like the British, the Italian authorities gave serious consideration to the option of continuing satellite work within a national programme after France and West Germany had left the ESA framework. See 'Industry Funds Initial Studies for Italian Space Programme', Aviation Week & Space Technology, LIX (Mar. 1979); 'Italy Reaches for a Bigger Share of Eurospace', New Scientist, XCIX (1979), 11 May.

2/ Letter from the United Kingdom Delegation addressed to the Director General of ESA, dated 24 May 1979.

3/ ESA/JCB(79)28, Future European Telecommunications Satellites: Study Results and Programme Proposals, 19 June 1979.

4/ The impact of the withdrawal of France and West Germany on the technology configuration of a future European satellite is discussed in Marsh, 'Europe Falters on the Brink of Space', op.cit.

development expected for an L-SAT project without the participation of France and West Germany, the cost of the platform was optimistically estimated at 40 to 50 MAU, whereas the payload would cost between 10 and 15 MAU. The launch of L-SAT was scheduled for the end of 1983.

At the Board meeting, France and West Germany stated that they did not intend to participate in the L-SAT project of ESA.1/ Their national authorities had already agreed to carry out a bi-national development programme for broadcasting satellites, of which the first flight model, serving West Germany, was called TV-SAT and the second, broadcasting to France, was called Tdf-1.

The positions of the other delegations on the L-SAT proposal were divided. While some delegations supported the programme, others queried the cost estimates and wondered whether the necessary funds would be forthcoming if France and West Germany did not participate. The proposal, however, was judged suitable to go forward to the Council, which would decide on the first step of its implementation.

During the subsequent 33rd Council meeting in July 1979, Denmark, Italy, the Netherlands, Switzerland and the United Kingdom decided to finance the preliminary project definition phase of L-SAT between August and December 1979 at a cost of 1.5 MAU. Austria, Belgium and Spain expressed their interest but required further time to think the matter over. France and West Germany confirmed their authorities' lack of interest in the proposed programme.2/

The outcome of the Council meeting marked the end of the collaboration in a communication satellite programme involving all European countries, as there

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1/ ESA/JCB/MIN/32, 28 July 1978.

2/ ESA/C/MIN/33, 20 Sept. 1979.

were now two parallel ventures: the ESA project (L-SAT) and the Franco-German project (TV-SAT/Tdf-1).1/ This split also markes the end of the case study.

The failure to achieve a European approach was noted by European political organisations, which pointed out the danger of this development; for example, the Committee on Science and Technology of the Council of Europe commented with regret on the past events as follows:

> 'The Committee heard with some concern...that a coherent multi-lateral approach within the framework of the European Space Agency might be endangered by a bi-lateral initiative on the part of France and Germany. This initiative...risks leading to other bi-lateral or tri-lateral initiatives by other countries - and thus to a general fragmentation of the European effort'.2/

Indeed, the collapse of the collaborative approach in communication satellites was seen as a major threat to ESA's existence.3/ Reflecting on the causes of those developments, a senior ESA official noted that

> 'At the present stage there is a severe strain on the cooperation structures that were conceived at a time when market forces did not play the predominant part they do today'.4/

In fact, ESA had come a long way, from a scientific organisation in the 1960s

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1/ In parallel to their decision on the L-SAT project, France and West Germany decided not to participate in ESA's technology programme ASTP, which was later redirected by the remaining countries to serve as a support technology programme to the L-SAT project. See ESA/JCB(79)62, ASTP Status Report on 1979 Programme and Additional Programme Proposals, 12 Oct. 1979.

2/ Press Release by the Chairman of the Committee on Science and Technology, Parliamentary Assembly of the Council of Europe, Stockholm, 26 June 1979.

3/ G. Schulze, 'Countdown für Europas Raumfahrt-Organisation?', Darmstädter Echo, 12 May 1979; 'The European Space Agency may be Falling Apart', op.cit.; 'Gefahr für Europas Raumfahrt', Frankfurter Allgemeine Zeitung, 30 Apr. 1980; 'TV Satellites Split Europe's Solidarity on Space', New Scientist, C (1980), 12 June.

4/ March, op.cit. See also M. Trella, 'Cooperation in Space: 20 Years After', ESA Bulletin, X (1984), No. 37, 32-7; A. Dattner, 'International Cooperation and High Technology - Some Reflections from the Standpoint of European Collaboration in Space', ESA Bulletin, IX (1983), No. 36, 56-60.

to one which challenged the American technological monopoly in the early 1970s and finally to an organisation which attempted to enter the commercial markets in the late 1970s.

5.12 Summary of subsequent events

OTS/ECS and MARECS

The OTS-2 satellite was a technical success; it completed over five years in orbit, whereas its specified three years minimum lifetime was three years.1/ In addition to carrying out many satellite experiments, tests and demonstrations, the telecommunication authorities utilised OTS-2 for pre-operational telephone transmission in preparation for the introduction of the ECS system.2/ The use of OTS-2 averaged 80% of capacity overall and full capacity during working hours.3/ OTS-2 was finally switched off near the end of its expected lifetime in 1984.

The development of the ECS satellites continued as planned and according to schedule. While the test of ECS-1 was carried out in spring 1982, work was proceeding on the subsequent flight unit under the CEPT mission (ECS-2) and under phase III bis (ECS 3,4,5). As a result of difficulties in the launcher programme, the launch of ECS-1 by ARIANE had to be put back to June 1983, and the launch of ECS-2 followed in February 1985. Since both satellites fulfilled the performance requirements, they were handed over to EUTELSAT and took their place in the European communication satellite system. In addition, the OTS/ECS satellites were a financial success as far as the accuracy of the cost-to-completion figures was concerned, as the final costs of the OTS and

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1/ E. Ashford, 'OTS Enters Sixth Year of Service', ESA Bulletin, X (1984), No. 37, 72-6.

2/ ESA/JCB(79)24, OTS Data Transmission Experiments Involving ESA Establishments, 18 May 1978; ESA/JCB(78)41, Comparison of the Proposed ESA Internal Experiment with OTS, with the CERN High Energy Physics Laboratories Experiment, 26 June 1978; C. Wearmouth, 'The OTS Development/Test Programme - Contractor Summary', ESA Bulletin, IV (1978), No. 14, 13-7.

3/ Annual Report 1983 (ESA, Paris, 1984), p. 42.

ECS projects were only 13.2% and 6.8% respectively above the estimates included in the project arrangements.1/ It should be noted that the increase for the OTS encompassed all project modifications such as back-up satellite, launcher conversion, etc.

In parallel to the ECS, the maritime derivative MARECS was developed. In fact, MARECS A was launched before ECS-1, in January 1982.

The L-SAT project (later renamed OLYMPUS) 2/

Following the approval of the project, the prime contractorship was awarded to British Aerospace (UK) in competition with MSDS (UK) in January 1980. HSD (UK), which by then was part of British Aerospace, had been the prime contractor for OTS and ECS, whereas MSDS had been the prime contractor for the British-American military system SKYNET and responsible for the development of the MARECS payload module.3/

The participating countries contributed to the project according to their industrial return, which in turn corresponded as far as possible to the wishes expressed by the delegations. The scale on the following page shows the distribution of industarial shares under the OLYMPUS/L-SAT project.

Although the participation of Canada 4/ had been secured in addition to the European partners, 18.7% of the work had to be contracted to companies

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1/ See appendix A, table 1.

2/ OLYMPUS is basically a multi-purpose platform, able to provide basic service functions to communication payloads. The first demonstration flight will carry a multi-element payload consisting of television broadcasting, specialised services and 20/30 GHz communication experiments. See ESA/JCB(81)35, L-SAT Satellite Description, 7 Oct. 1981.

3/ ESA/IPC(80)6, Proposal to Place a Contract, 22 Jan 1980.

4/ ESA/C(80), Arrangement Concerning the Participation of the Government of Canada in the L-SAT Programme, 17 Mar. 1980.

OLYMPUS/L-SAT project 1/		
Countries	Industrial shares in %	
	Between participants	Overall
United Kingdom	34.30	27.68
Italy	32.80	26.53
Netherlands	11.80	9.58
Canada	9.00	7.26
Belgium	4.80	3.89
Spain	2.90	2.34
Switzerland	2.60	2.11
Denmark	1.30	1.06
Austria	0.50	0.86
USA		13.30
France		2.92
West Germany		2.57
Total	100.00	100.00

outside the participating countries in order to stay within 'reasonable' project costs and time schedule. Those contracts were basically of an advanced technology nature, indicating that the participating countries still depended on outside technology supply despite their industrial efforts under the TELECOM programme.2/

In December 1981, the development, production and launch of OLYMPUS were approved at a cost of 388.5 MAU at mid-1980 prices, with the satellite costing

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1/ ESA/IPC(82)54, L-SAT Step C/D - Updated Information on Distribution of Work, 28 June 1982.

2/ USA: propulsion system (Marquardt, Fairchild Vacco), 20/30 GHz TWTA (Watkings Johnson); France: 12 GHz TWT (Thomson-CSF), battery (SAFT), sun sensor (MATRA); West Germany: 10 GHz TWT (AEG-Telefunken), solar cells (AEG-Telefunken), pipes (Dornier), valves (MBB). See ESA/IPC(82)54, op.cit

256 MAU and the support, including launch, amounting to 119 MAU.1/ The launch of OLYMPUS is scheduled for the first half of 1988 by means of ARIANE. Whereas the first flight unit will be used as a test and demonstration satellite, subsequent satellites are intended to be used operationally by those countries which have financed their development. In addition, OLYMPUS derivatives are expected to compete for a share of the commercial satellite market.2/ So far, however, no potential customer outside the framework of participating countries has indicated interest.

The Franco-German TV-SAT/Tdf project

In April 1980, the French and German authorities signed a treaty for industrial and commercial cooperation in the area of broadcasting satellites.3/ The approval of cooperation had been delayed because of the opposition of the German Social Democratic Party (SPD), which was part of a coalition government with the Liberal Democratic Party (FDP), on the grounds that it would lead to 'too much' TV and the possibility of private satellite TV in competition with the existing government-controlled broadcasting system.4/ The treaty provided for the development of two television satellites, one to serve West Germany (TV-SAT) and one to broadcast into France (Tdf). In addition, the aim of the development efforts was to seize a

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1/ Up to then the cost of the OLYMPUS project had amounted to: Phase B1 - 2 MAU at mid-1978 prices; Phase B2 preliminary - 1.4 MAU at mid-1979 prices; Phase B2 - 16 MAU at mid-1979 prices; Phase B bridging - 11.6 MAU at mid-1980 prices. See ESA/IPC(81)64, Proposal to Place a Contract, 2 Dec. 1981.

2/ E. Bassett, 'European Space Agency Planning', Aviation Week & Space Technology, LXIV (Dec. 1979).

3/ R. Boyes, 'Bonn and Paris Sign Space Deal', Financial Times, 2 May 1980.

4/ 'Geld für Fernsehsatelliten von Haushaltausschuss gesperrt', Süddeutsche Zeitung, 27 Sept. 1979.

major share of the commercial TV-satellite market.1/

The satellites are being developed under a fixed-price contract by the EUROSATELLITE group under the prime-contractorship of MBB (D) and the major group members SNIAS (F), Thomson-CSF (F) and AEG-Telefunken (D). The total cost of the programme is estimated to amount to $180 million, with France paying 46% and West Germany 54%.2/ The first satellite is expected to be launched by ARIANE by mid-1987.

The TV-SAT/Tdf satellites were judged to be the most advanced operational television satellites, even holding a two-year industrial lead over American industry. Though still at the development stage, the Franco-German programme had already secured export orders.3/

First, in Europe, the Nordic countries of Sweden, Norway and Finland, which had already conducted studies for a Nordic satellite television service (NORDSAT programme), had decided to use a TV-SAT/Tdf derivative, called TELE-X, for their cooperative effort. TELE-X is expected to be launched by ARIANE at the end of 1987; it will be devoted to experimental/pre-operational direct TV broadcasting, high speed data transmission and two-way mobile telex for long-distance truck and train communications.

Second, a major break-through was achieved when a TV-SAT/Tdf derivative was exported outside Europe for use in the ARABSAT programme, which serves 21 Arab countries with semi-direct television transmission. The tender was

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1/ R. Metzler, 'Bonn will Weltraumtechnik vermarkten', Süddeutsche Zeitung, 27 Nov. 1979.

2/ 'Europeans Building TV Satellite Systems', Aviation Week & Space Technology, LXV (Apr. 1980); '1.3 Milliard F Aux Satellites Franco-Allemands de TV Directe', Air et Cosmos, XVI (Oct. 1979), 52-5.

3/ K. Müller, 'TV-Satelliten: Europa hängt die USA ab', Die Welt, 18 Aug. 1979; Johansen, op.cit.

accepted in competition with a MESH offer, based on an OLYMPUS/ECS derivative, and offers from Hughes (USA), RCS (USA) and SPAR Aerospace (Canada).1/

However, the prospects for large export sales to China, once a strong argument for leaving the ESA programme, have not materialised so far. As in the case of other proposed industrial undertakings involving foreign participation, China has been reluctant to fulfil its intention with a final contract.2/

1/ M. Donne, 'Satellite Bids Being Studied to Choose Contractors', Financial Times, 6 Jan. 1981.

2/ P. Schulz, 'Das Abenteuer All ist den Chinesen zu teuer', Die Welt, 23 Dec. 1980.

5.13 Market potential of European industry in communication satellite technology

As indicated above, government funding for such projects as H-SAT, L-SAT (OLYMPUS) and TV-SAT/Tdf was justified in the late 1970s on two major accounts. First, it was expected that there would be considerable growth in the commercial communication satellite market; second, based on the projects mentioned above, European industry would be capable of securing a sizable share of this market.

It is interesting to recall a study on the commercial space market accessible to European industry carried out by EUTELSAT in the early 1980s under contract from ESA.1/ Table (A) on the following page shows the turnover of the European space industry.2/ The table indicates a considerable increase in total turnover relating to space, particularly commercial space activity from 1977 to 1988. Table (B) on the following page shows the commercial

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1/ Study of the Workload of the European Space Industry, Summary Report (Paris, EUROSPACE, February 1984). Commercial markets are considered to be formed by those customers who operate space technology (user organisations) in contrast to government space organisations which develop space technology. Even if the user organisation is practising a 'buy national' or 'fair return' policy in awarding the contract, in contrast to free competitive bidding, the organisation is still considered to be a commercial customer. According to this definition, projects like SYMPHONIE, SIRIO, OTS, ECS 1/2, MARECS A/B, TV-SAT/Tdf and OLYMPUS are considered pre-commercial; DFS (D), UNISAT (UK), STARIT (I), future ECS and future MARECS are considered commercial subject to 'buy national' or 'fair return' procurement; and ARABSAT and sales of TWTs in the USA are considered commercial subject to free competitive bidding. The figures exclude defence communication programmes which are implemented by European countries, such as UK IV (UK), or potentially accessible to European industry, such as NATO communication satellites, since those markets are seen to be relatively modest.

2/ Employment in the space industry and in institutions for 1983 is estimated as follows: industrial companies - 22,000; institutions and administrations - 5,000; universities and laboratories - 3,800; total - 30,800. See ibid.

Table (A): Turnover of European space industry 1/

	1977	1983	1988
Total in MAU	400	1,000	1,700
Share in %			
National	20	29	22
ESA	70	43	33
Commercial	10	28	45
Total	100	100	100

Table (B): Commercial markets accessible to European space industry 2/

Technology sector	Total market in MAU	Share in % for European industry	Share in MAU for European industry
Television and communication satellites (1984-1993)	14,000 3/	19.3	2,700
Launchers (1987-1991)	6,300	30.0	2,100
Ground equipment for television and communication satellites (1984-1993)	14,000	15.0	2,000
Total	34,300	19.8	6,800

market accessible to European industry by major technology sectors.4/ The table indicates that the world market for ground equipment will be of the same order of magnitude as the satellite market. The European share of the ground

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1/ Ibid.

2/ Ibid.

3/ Between 1964 and 1983, about 100 civilian communication satellites were launched. For the period 1984-1994, it is expected that 240 satellites will be put in orbit. This EUROSPACE figure is in line with estimates by the French national space organisation CNES and a study by David Baker, published in the journal Communication International in November 1982. Based on a unit price of 35 to 55 MAU, the global value of the satellite market for 1983 to 1994 should comprise 14,000 MAU at 1983 prices.

4/ Excluding home receivers for television satellites.

equipment market is expected to be smaller than its share of the launcher or satellite market, which reflects previous emphasis of development efforts. Finally, table (C) below gives a further breakdown of the commercial market for direct television and communication satellites.

Table (C): Commercial world market in direct television and communication satellites for 1984 to 1993 1/

Customer groups	Total world	Share accessible to European industry in %	Share accessible to European industry in MAU
EUTELSAT	700	100	700
European national direct broadcasting	700	100	700
European national telecommunication	300	100	300
INMARSAT	300	30	100
INTELSAT	3,000	20	600
USA and Canada	6,000	0	0
Developing countries and others	3,000	10	300
Total	14,000	19	2,700

Some interesting observations can be made. First, the commercial market accessible to European industry is basically a market protected by a 'buy national', 'buy European' or 'fair return' policy. Government-controlled PTT organisations are guided by a 'buy national' policy and are the customers in the European national market. Those organisations form EUTELSAT and represent the European share in the global organisation INMARSAT and INTELSAT. Although the latter organisations are guided by competitive procurement procedures,

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1/ Ibid.

they have practised an implicit 'fair return' policy on the basis of regional contribution to the global network. A tender to INTELSAT, for example, is more likely to be accepted if it includes a substantial share for European industry. A truly competitive market of private customer organisations - and at the same time the largest market - is that of the USA. No sales, however, are expected for European industry in this country. In summary, commercial opportunities were basically expected in markets in which European industry interests are protected. Opportunities in developing countries, which were estimated in a study back in 1975 to account for 50% of the commercial market, are now considered to be not only limited in size but also to have only a limited share available to European industry.1/ In addition, the 1975 study was based on the invalid assumption that a substantial share of the ground equipment market could only be secured by taking a corresponding share of the space segment market. Whereas the European share in ground equipment is expected to fall short of that in the space segment, Japanese industry has already successfully penetrated this market despite its lack of competitive competence in satellite technology.2/

The EUTELSAT study of 1983 carried out under ESA contract did not bear out the hopes of the mid-1970s. The expectation of limited commercial success for European industry was nevertheless based on the assumption that there would be a substantial expansion in the total market for communication satellites. In a recent OECD study,3/ this assumption was critically

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1/ For a summary of the report, see pages 315 to 316.

2/ Trade in High-Technology Products. The Space Products Industry: Markets, Industrial Structure and Government Policies (Paris, OECD DSTI-1447 B, Restricted, November 1984).

3/ Ibid.

reviewed. The study emphasises that overcapacity in orbit is growing. In the American domestic market, 45% of communication satellite capacity was not used in 1983, compared with 33% in 1982. The original estimate of 20 to 30 million American subscribers for direct broadcasting satellites at the end of the century is considered too optimistic. In fact, the report concluded that the growth of space telecommunication would remain favourable in the medium term but that there is considerable uncertainty in the long-term prospects. In addition, with regard to the economic growth potential of the communication satellite industry, it should be noted that most profits in the US market have not been made by the companies which develop and produce the satellites but by the carriers which lease transponders to users.

The assumption that European industry will be successful in entering the commercial market in communication satellites does not imply that governments will not be required to continue the funding of space technology in order to keep national industries competitive. It should be remembered that whereas the American civil space organisation NASA has only provided limited funds for communication satellite development since the initial systems were established, the American Department of Defense continued a large programme of R&D funding in private industry. In 1982, $460 million was spent by the Department of Defense on communication satellites. The approximately 40 military communication satellites to be developed in the 1980s constitute a safety net for US industry to advance technology, extend production runs and reduce manufacturing costs. Since Europe does not possess a comparative military programme, continuous funding of civilian satellite programmes might be required in order to maintain the advanced technology competence of European industry.

CHAPTER 6

CONCLUSIONS

6.1 Presentation

The following presentation summarises the findings of the case study according to the research questions outlined in section 1.3. The research questions are examined separately for two overlapping periods characterised by different government objectives for funding satellite technology: the period of supply security (1963-1978), which includes the initiation and implementation of the OTS/ECS programme, and the period of economic growth (1975-1983), which covers the initiation and abandonment of the H-SAT project followed by the start of the collaborative OLYMPUS (L-SAT) project in 1982 and the bilateral TV-SAT/Tdf project in 1983. Based on the results of the case study, a number of hypotheses will be established in section 6.3.

6.2 Conclusions of case study

Funding objective of supply security: the OTS/ECS programme

The idea of a European communication satellite programme can be traced back to the 1963 negotiations initiated by American authorities on the setting up of a world satellite communication system, known as INTELSAT. The European position in these negotiations was coordinated by CETS, an organisation of post and telecommunication authorities and ministries of foreign affairs and space research. The American partner was a government-backed, private entity known as COMSAT. It soon became apparent that the United States, based on its technological lead, could define the arrangement for the new world system.

The interim arrangement agreed on in 1964 antagonised the European partners: COMSAT, as the American representative, at INTELSAT would not only hold the majority vote but also act as manager of the INTELSAT system. In addition, based on the agreed terms, American industry was put in charge of developing and producing the INTELSAT satellites and launchers.

The unfavourable results of the INTELSAT negotiations were perceived by CETS as the result of a technology gap between the USA and Europe. It was considered that closing this technology gap would not only limit European dependence on US technlogy but also strengthen the European position for the renegotiation of the INTELSAT agreement. Until then, European industry had had little or no experience in the development and production of satellite technology. Based on a CETS review of European industrial capabilities, a government-funded R&D programme was defined with the aim of setting up a European regional satellite system.

In 1964, preliminary discussions remained inconclusive between CETS and CEPT, the European telecommunication organisation reponsible for monitoring the terrestrial network for intra-Eurpean telephone and telex traffic. Although it was subsidizing the development of the European satellite system, CEPT, as the potential user of the satellite system, considered its operation uneconomical compared with terrestrial means. Despite a much smaller volume of telecommunication traffic, EBU, which was responsible for the monitoring of intra-European television transmission in the EUROVISION network expressed interest in the system. Hence, the CETS A/B/C satellite projects were designed to serve the needs of EBU with European technology.

Before development of the European satellite could begin, the problem of launching the satellite had to be resolved. Since the national and collaborative efforts to build a satellite launcher had proven unsuccessful until then, the possibility of relying on US launch service for a European communication satellite was considered. Based on their experience in military projects, the French, unlike the British, were strongly opposed to this option and pressed for continuous and increased European efforts in launcher development. The restrictive conditions attached to the launcher supply for the Franco/German communication satellite, SYMPHONIE, in addition to the ambiguous response to the request for clarification from the US on launch service for a European satellite, increased the misgivings about European dependence on US space technology. In fact, the communication satellite project was the decisive point in the launcher discussion and the principal justification for the launcher development. As soon as a solution was found for the launcher problem, with the United Kingdom being released from its commitment to the launcher development and France together with Belgium and West Germany assuming the additional financial requirements, decision-making on the joint satellite project continued in the late 1960s. Further support for a communication satellite programme stemmed from the unhappy European experience in the INTELSAT organisation. During the renegotiation of the INTELSAT arrangement in 1969, major policy changes were demanded by the Europeans. The attempt failed as the US partners insisted on controlling what they considered their own technological creation.

In reaction to the restrictive US attitude, in 1970 the European countries decided to embark on the TELECOM programme in order to break the American monopoly in communication satellite technology and to establish European supply security. The programme was estimated to cost $400 to 450 million, approximately four times as much as the previous CETS proposals. Based on such government funding, a European satellite system became economically attractive for the principal user, CEPT. The interim agreement by CEPT to use the system was in turn a major justification for a government-funded R&D programme. In addition to closing the technology gap between Europe and the USA, the TELECOM programme was conceived as an opportunity by the smaller countries, and to some extent by the United Kingdom, to close the emerging technology gap between the European countries.

The economic growth objective was not considered to be of major importance in the CETS A/B/S or TELECOM proposals. Of course, in order to secure project approval, it was hinted that there would be considerable economic benefits. These benefits could not be demonstrated for the immediate future, but were expected to be realised in the long term.

Supply security in communication satellite technology was a high priority objective in the context of the national technology policy of European countries. The funding of this technology was conceived from the very beginning within the collaborative framework rather than a national project. Two major issues favoured the collaborative option. First, the perception of being dependent on US technology was expressed by the European organisation CETS, which enhanced the likelihood of responding within a similar framework. Second, since satellite communication is most economical over long distances, it made more sense to establish a system for intra-European communication traffic than to cover the short distances within national boundaries. Only after CEPT, as the potential European user organisation, had declined to employ the system based on the initial CETS proposals were national or bilateral projects such as SIRIO and SYMPHONIE initiated. After the difficulties with the European user had been resolved, the emphasis shifted back to international collaboration. Hence, the argument that European governments offloaded those projects to a European budget which had low national priority is not supported by the case study.

Supply security has been identified as the major funding objective which led to the decision in 1970 to embark on the collaborative OTS/ECS programme and its implementation between 1970 and 1978. In the pages that follow, the programme will be described in detail under the concepts of collaborative sharing and collaborative efficiency.

Collaborative sharing: the OTS/ECS programme

Sharing of funding: Each funding authority which participated in the TELECOM programme was requested to contribute a financial share in proportion to the gross national product (GNP) of its country. Since breaking the technology monopoly of the US was considered to be beneficial to all European countries, there was justification for sharing the cost and thereby limiting the burden for each national budget. National economic strength was seen as a measure that could be used to distribute the financial burden of breaking the US monopoly position. The largest financial share was approximately 25%. While the sharing of funding resulted in a substantial reduction of the financial burden for each participating country compared with the alternative of a national project, this incentive of sharing the funding was even more important in view of the magnitude of resources required for the envisaged development effort. Basically, the first phase in the development of satellite technology - the experimental testing of key equipment - had already been implemented in bilateral and national projects such as SYMPHONIE (F/D), SIRIO (I) and to some extent SKYNET (UK). Now, there was a need to advance industrial capability further in order to close the technology gap between Europe and the USA with a more demanding and expensive follow-on programme. International collaboration enabled, in particular, France, Italy, West Germany and the United Kingdom to share the additional resource requirements of a more advanced programme which would follow from the limited activities they had undertaken previously. In fact, the financial share of the countries in the TELECOM programme was approximately equal to their previous share in bilateral or national projects.

While the sharing of funding was a prime incentive for the larger countries to join in international collaboration and support the TELECOM programme, it might have been possible for them to carry out a similar programme in a national or bilateral project if the collaborative option had not been available. This was unlikely to apply to the smaller countries such as Belgium, Denmark, the Netherlands, Sweden and Switzerland. For them, the collaborative TELECOM programme provided the only opportunity to get a foothold in the new technology sector at a low cost, since a national project was considered to be too expensive.

Sharing of technology: The sharing of technology was guided by two major principles, namely to avoid a national bias in the collaborative programme and to achieve a 'fair return' of industrial contracts. The first principle was in evidence in the negotiations for the selection of an experimental satellite during phase II of the TELECOM programme. Italy lobbied for its national SIRIO satellite, and France and West Germany for their bilateral SYMPHONIE satellite as test vehicle for the joint programme. The United Kingdom, supported by the smaller countries, thwarted all attempts to do so in order to avoid any national bias in the collaborative programme. After difficult negotiations, a solution was found with the approval of a new, dedicated experimental OTS satellite.

In the second principle, the concept of 'fair return' was measured by the ratio between a country's financial contribution and the industrial contracts it was awarded. This principle was further nuanced by the weighting of ratios according to the R&D content of the contract.

Why was the sharing of technology so important to the participating countries? First, there were economic considerations involved: national funds were invested internationally with the hope of providing national industry with employment and profit opportunities. In fact, preferences were sometimes based on a desire to increase the work load of a certain company or national region to limit the hardship of unemployment. The German and Danish delegations, for example, put forward such arguments during the award of the OTS contract. Second, the sharing of technology was seen to be the principal vehicle for participation in the establishment and control of supply security.

Although the contracts were awarded according to the 'fair return' concept, participating countries had a number of ways of influencing the contracting procedure in order to realise national interests. First, under the 'fair return' concept, the minimum level of industrial participation was a 0.8 ratio of share in contracts to share in contributions. Industrial participation could be well above this target, but only at the expense of other participating countries. Consequently, national delegations attempted to maximise their national share when deciding on contract approvals in the AFC or IPC. Second, national delegations attempted to secure 'noble' contracts, as shown, in particular, by the voting patterns in the AFC on the award of support technology contracts and the main OTS satellite contract. Such 'noble' contracts, for components such as the TWTA, sensors, repeater, solar panels or the mementum wheel, had a large R&D content. In addition to the R&D contracts, the prime contractorship was considered of particular interest. Not only was the experience gained in system management applicable to and beneficial for subsequent industrial activity, but the prime contractorship was often seen as the most prestigious portion of the overall satellite contract.

In contrast to the national interests expressed by participating countries, the ESRO secretariat voiced the interests of the project. In fact, the secretariat was requested by the participating countries to accommodate the 'fair return' policy with acceptable results in price and quality of the industrial tenders. Quite often, the latter issue prevailed against the wishes of some of the participating countries. This emphasis on price and quality favoured the selection of contractors from the larger countries, which could base their tender proposals on the experience gained in previous national efforts.

Finally, the contracting activity under the OTS programme highlighted an interesting aspect of the policy of maintaining national efforts in parallel to participation in international collaboration. The German delegation managed to get approval for the inclusion in the OTS satellite of equipment developed under national programmes, namely the TWTA (AEG-Telefunken) and the momentum wheel (Teldix). The German delegation ensured national control over these key technology items and achieved this objective rather cheaply: space testing of the technology would be carried out on the OTS satellite. Although the inclusion of nationally developed equipment improved the reliability of the OTS satellite and was therefore supported by the ESRO secretariat, it was not welcomed by all delegations. The case of the momentum wheel demonstrates this point. The Dutch industry had managed to secure the ESRO contract to develop this technology as one of the few major items which were entrusted to a small country. The German subsidy, offered in the form of funding for the development of the technology nationally, eliminated the key industrial share of the Netherlands, much to the disappointment of the Dutch delegation.

The case of the TWTA and the momentum wheel highlights the different perception of international collaboration between countries which continued national efforts in parallel to participation in the collaborative venture (France and West Germany) and countries which limited government funding to international collaboration and had not maintained (smaller countries) or discontinued national efforts (Italy and the United Kingdom). In particular West Germany viewed international collaboration as a complement to its national activity. This was emphasised during the award of the OTS contract by the AFC. The German delegation supported the MESH proposal, since it could contribute to maintaining an intra-country competitive balance between the ERNO and MBB companies. At that time, such a balance was seen to be desirable for the implementation of national projects. In fact, West Germany could have abandoned its participation in international collaboration in favour of a national project if this had appeared advantageous. In contrast, the smaller countries had no option but to rely on international collaboration or abandon their support of satellite technology.

What were the results of ESRO's contract actions? The 'fair return' concept as defined by ESRO was successfully implemented. The share of contract value was approximately equal to the share of contribution for each country. Hence, it is argued that there was equitable sharing among the participating countries of the benefits - profits and employment opportunity for national industry. On the other hand, no 'fair return' was realised in terms of contract 'quality'. This conclusion has been substantiated in particular on pages 295 to 303, and some major findings should be recalled. The 'noble' contracts of the Support Technology Programme and the 'noble' share of the OTS and ECS satellite contracts went to those countries which had already established an industrial capability in communication satellite technology prior to the TELECOM programme: France and West Germany with their SYMPHONIE programme, and to some extent Italy with its SIRIO project and the United Kingdom with its SKYNET project. Despite ESRO's requirement of a balanced distribution of work under the OTS contract, the smaller countries were awarded what may be called the 'second rate' contract share which did not enable the companies from those countries to build up a competitive capability. This may be explained as the result of the optimisation constraints between the cost, quality and geographical distribution requirements with which each consortium was faced when putting together the tender for the OTS contract. In general, the competent companies with previous experience were located in the larger countries. The need to share out work to the less advanced companies located in the smaller countries limited the competitiveness of the tender. Obviously, this cost penalty resulting from ESRO's geographical distribution requirements could be minimised by allocating a 'second rate' work share to the less advanced companies located in the smaller countries. The implementation of this work share required only limited industrial experience.1/

Allocating 'second rate' work to smaller countries was a general pattern. Nevertheless, there were a few cases in which companies from smaller countries were able to secure major contracts, such as Philips (NL), for the development of the wheel, and Saab (S), for the telemetry, tracking and command (TTC) subsystem. Whenever this occurred, the larger countries, in particular France and West Germany, were likely to duplicate the collaborative contracts in their national programmes. One example is the duplication of the wheel development within the German national programme mentioned above. Hence, smaller countries were not able to take a share in an interdependent system. Even where they established a small technology base, they remained

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1/ It is interesting to note that the smaller countries not only failed to receive 'noble' contracts, but also received less technology (not contract value) for their financial contribution, despite having achieved a 'fair return'. This is based on the assumption that the development of a particular technology requires more financial resources if the contract is awarded to a less advanced company (located in the smaller countries) than if it is given to a more advanced one (located in the larger countries).

dependent on their collaborative partners but not vice-versa. Hence, it is argued that the technology gap between the smaller and larger countries, which already existed prior to the collaborative programme, widened as a result of the OTS/ECS programme and the continuing national activities. The gap was also the result of the limited participation of the smaller countries, which was based on a financial contribution of only approximately 2.5% for Denmark and the Netherlands and 3 to 4% for Switzerland and Belgium. In fact, this effort could hardly be considered adequate to close the technology gap. As a result, the smaller countries remained dependent. Their dependence on US technology prior to the TELECOM programme was now extended to dependence on their collaborative partners.

It has been argued that the industrial capability derived from the collaborative programme of nine countries had been concentrated in the three or four major contributors. If this issue is viewed in isolation, it appears that the smaller, less advanced countries subsidised 'noble' industrial activity in the larger, more advanced countries through their contributions to the collaborative project. One might argue, however, that the larger countries would have carried out a national project if the collaborative option had not been available. For the smaller countries, international collaboration was the only option. The allocation of 'noble' contracts to the larger countries could be seen as the 'entrance ticket' of the smaller countries which had to be agreed on in order to draw the larger countries into collaboration.

Even the larger advanced countries had not succeeded in establishing an interdependent system of industrial capabilities. Through their participation in the OTS/ECS programme and previous and continuing national efforts, France and West Germany had managed to establish adequate industrial capabilities in nearly all aspects of the technology system. Interdependence existed only, for example, in the areas of battery and sensor technology, where French industry was leading, and payload (TWTA) and solar cell technology, where German industry was ahead. With their continuing national activities, however, both countries possessed the overall capability to carry through a national OTS/ECS follow-up project without major difficulties. Hence, the industrial capability of France and West Germany can be described as limited interdependence with the emphasis on independence. In fact, the collaborative effort helped to establish independence not only from American supply but also from the collaborative partners in the case of France and West Germany.

The larger countries which had previously maintained national efforts but discontinued them, Italy and the United Kingdom, had managed to establish technological capabilities thanks to the advanced state of their industry and their substantial contract share under the OTS/ECS programme. While some of this capability formed part of an interdependent system, the rest was duplicated by France and West Germany in the context of their continuing national efforts. Hence, Italy and the United Kingdom had to depend on the industrial capability created in France and West Germany, but the reverse was true only to a limited extent. Therefore, the industrial capability of Italy and the United Kingdom could be described as limited interdependence with the emphasis on dependence.

It is argued, however, that this result, attributed to previous and continuing national efforts, was not the outcome of a deliberate policy, but rather the outcome of failed attempts to establish a collaborative effort in the early 1960s. As demonstrated earlier, European countries first attempted to establish a European programme. Only after this had failed, mainly because of the related launcher issue, did European countries initiate national efforts. In fact, it is argued that, at least initially, European countries were willing to surrender their national sovereignty in communication satellite technology to a European effort, although the larger countries were reluctant to relinquish their national ambitions entirely. Nevertheless, European countries considered themselves allies against American industry, and the major objective was to break the monopoly of American technology. In fact, there was a large increase in resources for European space efforts during the late 1960s and early 1970s and a corresponding decline in national expenditures. Finally, there existed a spirit of European unity in the late 1960s and early 1070s - when the OTS/ECS programme was approved - which contributed to the perception of compatible national interests.

Collaborative efficiency: the OTS/ECS programme

Policy-making: The start of the TELECOM programme with the OTS/ECS satellites, which every European funding organisation essentially supported, was delayed because of the inability of the four major countries, France, Italy, United Kingdom and West Germany, to agree on an overall European space policy, including scientific projects, application satellites and launcher development. In addition, the negotiations on project approval between approximately 15 countries were constantly being held up by national political developments in one of the potential partner countries. There were major political upheavals in the United Kingdom and Italy just before the fourth European Space Conference in 1970, which was called to decide on major issues. The indecision of both delegations due to national developments was not only the reason for the delay of the conference but also one of the causes for its limited success. Quite clearly, the lack of coordination between the political cycles in Europe upset the decision-making on the TELECOM programme. Another case in point was the inability of the Italian delegation to approve the TELECOM Arrangement in 1973, which defined programme details of the OTS/ECS satellites, financial commitment and the decision-making procedures by which programme implementation would be guided. Before the Italian delegation could support the TELECOM Arrangement, the financial allocation had to be approved within the budget cycle of the national government. Obviously, the national budget cycles of the European countries were not scheduled to provide for joint financial commitment. Indeed, the mismatch between the Italian budget cycle and the collaborative effort was a major cause of delay in project approval.

After the principal decision to carry out the TELECOM programme was taken in mid-1970, further negotiations continued on the TELECOM Arrangement. This was guided within the ESRO policy level and by the ESRO-user liaison. In fact, the policy level of ESRO constituted what might be regarded as a complex system of committees and expert groups, such as the Council, AFC, IPC, JCB etc. It took about 3 1/2 years, from mid-1970 to late 1973, to conclude the TELECOM Arrangement. It was not the structure, however, which held up decision-making but the fact that the participation concept was not flexible enough to resolve major conflicts. Although the TELECOM programme was considered an optional programme in the context of ESRO's new participation concept, optionality applied only to the smaller countries. The four larger countries had already committed themselves to participation in the TELECOM Arrangement. Even without the mandatory participation of the four big countries, the TELECOM programme was considered of prime importance within ESRO's overall programme. Receiving unanimous support, it was impossible to refuse the participation of a member state in an ongoing concern like ESRO, despite major conflicts of interest between the parties involved. Realizing that there would be no exclusion of interested parties, national delegations had no incentive for compromise: each pressed for its own interests, possibly with the hope that other delegations would agree in order not to hold up the joint undertaking. Since all major interested funding organisations were pursuing this course, decision-making on the TELECOM Arrangement was slowed considerably.

After the TELECOM Arrangement was approved, decisions on guiding and monitoring the programme implementation were taken at the policy level according to the procedure described in the Arrangement. Although it was not necessary to do so, the TELECOM Arrangement had adopted the procedure by which ESRO had run the scientific projects. In fact, in creating ESRO, the member states had endowed the policy level of ESRO with considerable authority. Once a project was approved, decisions were taken by majority or double qualified majority. This freedom of decision-making was possibly the result of the scientific orientation, which lessened the need to protect national interests during project implementation. The adoption of this decision-making procedure for the TELECOM programme, which made it possible to act without unanimous agreement, made the decision-making process considerably easier. In addition, such decision-making at the policy level supported programme implementation, as will be described below under executive management.

Although they did not appear in any record of project costs, the policy level incurred considerable expenses which were covered under the national budgets of the participating countries. These expenditures comprise primarily the salaries of national employees from the funding organisations who were directly concerned with the project (e.g., those who attended Programme Board meetings) or partly concerned with the project (e.g., those who attended Council, AFC, IPC meetings), their travel costs, their secretarial support staff, and the cost of national expert meetings. If it is assumed that three to six professionals were seconded to the project by each country, that twenty meetings of the legislative level were held each year, and that at least the equivalent of one full-time expert was required, the individual national costs amounted to at least \$300,000 to \$500,000 per year or \$2 to \$4 million per country and OTS/ECS programme. If the fact that smaller countries employ a smaller national set-up is disregarded, it is believed that with each additional country participating in the collaborative project, the overall project costs increase by approximately the same amount. If those costs are compared with the amount of national financial contribution to the collaborative project or the amount of industrial contracts awarded to national industry under the TELECOM programme, it can be seen that, for the smaller countries, the national costs of participating in the policy-making level might be even greater than the contracts awarded to their industry. Such considerations call for the striking of some kind of balance between minimum involvement in collaborative projects and the costs estimated above. In view of the size of the TELECOM programme, it is argued that such a minimum involvement is certainly not achieved by a contribution of 2.5% (Denmark and the Netherlands) or 3 to 4% (Belgium and Switzerland).

The costs of the policy level indicated so far were not shared among the participating countries but covered within national budgets. This, however, does not apply to the expenditures incurred by ESRO as a result of serving the policy level. In fact, the TELECOM programme was characterised by what is considered an excessive amount of documentation, reporting, monitoring and checking. Every committee meeting required rather detailed and extensive reports, issued in English and French. The detailed documentation on all possible policy options, proposed changes in approved policies and contracting actions had to be prepared by ESRO's technical specialists. A number of people were needed to keep track of and monitor the 'fair return' principle by taking into account different inflation and exchange rates.

Despite this extensive documentation, national delegations felt they were being deprived of information by ESRO management. There was a general mistrust, possibly not to be found in national projects, between the policy and executive levels, which could only be overcome by providing project transparence through the reporting of information. In general, however, it may be argued that the policy level failed to apply the same scrutiny to its own operation as it did to ESRO's expenditures. Based on the legitimate objective of controlling the spending of taxpayers' money, committees were set up, meetings extended and reports requested, sometimes without due regard for the costs of such decisions in relation to their contribution to the programme.

Executive management: When the European communication satellite project was first initiated, the interested funding organisations had different opinions about the management role that ESRO should be given vis-a-vis private industry: Should ESRO assume prime contractor responsibility? Should ESRO have its own engineering capability? Should ESRO manufacture some parts itself? Should ESRO allow industry to organize itself or should it award subcontracts? The smaller countries supported a strong ESRO organisation which had some authority over the industries of the larger countries, whereas the larger countries wanted to delegate as much work as possible to their own national industries. Since ESRO had already developed considerable in-house management competence and technological expertise, it made little sense not to use this capability for the implementation of the TELECOM programme.

The need for such in-house competence could be justified on two major accounts. First, the companies which would be involved in the European project were located in different countries, had different industrial capabilities and employed different management methods. The difficulties associated with the diversity of the industrial structure were aggravated by the complexity of the advanced technology project. It was felt that tight central control by an executive management body such as ESRO was required. Second, besides implementing the TELECOM programme, ESRO was involved in a number of other space projects, all with the general objective of guiding, rationalising and improving European space capability as a whole. Because the project had to be carried out within the framework of such an industrial policy, additional monitoring and management attention were required.

When ESRO was entrusted with the task of implementing the TELECOM programme, it already had seven years of experience behind it. In fact, ESRO was originally established as an ongoing concern and a multi-project organisation. Although more successful than its sister organisation ELDO, ESRO had struggled during its early years to establish an efficient management approach to the implementation of collaborative projects. The first satellite projects were marked by hugh cost overruns and high overheads. Over time, however, ESRO gained experience and learned by it. By the late 1960s, before it was entrusted with the TELECOM programme, ESRO had improved its structure and procedures. Its relationship with NASA helped it to introduce new management methods, including the multi-step planning procedure. Based on its own experience, it developed a new relationship with industry that was aimed at improving competition within the 'fair return' concept through a system of competing consortia.

The centre of ESRO's management capability was ESTEC, its establishment in the Netherlands. In fact, all parts of the OTS satellite were designed by ESRO engineers and detailed specifications were sent to the companies with a request for precise tenders. The necessary development work on those specifications was done in ESRO laboratories by ESRO staff. Industry was used as a workshop and ESRO was, in principle, able to take the lowest bid since specifications were already established.

Since ESRO was a multi-project establishment, its basic facilities could be used more effectively and the proportion of funds allocated to external development contracts in industry was large. In addition, this set-up limited work peaks and troughs due to the inception and completion of projects. By the end of the 1960s, the multi-project establishment had evolved towards a matrix organisation. Although human resources could be employed more effectively in such a matrix organisation, there were drawbacks: the authority of the project manager was diluted, and the speed and accuracy of communication between project manager and project participants were impaired.

Because it was a permanent organisation, ESRO was able to attract competent staff and provide career opportunities. Staff members were usually offered indefinite contracts after their first fixed-term contracts, and a number of flexible provisions concerning contract termination were instituted in order to ensure that work was performed satisfactorily. Political appointments were limited to the most senior posts, such as directors and department heads, which were the province of the Council.

Basically, the ESRO system and its successor, the ESA system, worked. For example, there was cost discipline - realism in the cost-to-completion figures - as the final costs of the OTS project were only 13.2% above the estimate made when the ESA member states signed the project arrangement.1/ Within this increase, all subsequent project modifications were accommodated. As in the case of OTS, the ECS development was characterised by the realism of

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1/ See appendix A, table 2.

the cost-to-completion estimates.

The project modifications mentioned above are a common feature of aerospace projects which are spread over a period of several years and go through streams of design changes before the final design is frozen. The fact that ESRO's executive management could successfully adjust project specifications to changes in project requirements and environment demonstrated its competence. This was aided by the decision-making procedure at the policy level, which required only a majority vote to approve major project changes. The OTS project went through a number of substantial changes, such as the switch of launchers, with a corresponding increase in mission redundancy and capacity, implementation of alternative technical solutions, the back-up arrangement with MAROTS, etc. Finally, the ESRO secretariat was not just an instrument for executing policies decided by the national delegations, but an organisation which had built up a considerable reputation, expertise and authority vis-a-vis the policy-making level. The secretariat influenced and guided policy decisions from the perspective of programme needs. For example, the deadlock in decision-making on programme strategy was overcome by an unauthorised initiative on the part of the ESRO executive body, which requested industry to study the OTS satellite option. It was due to the authority and independence of the executive level that the OTS programme option was established, providing a compromise solution for the decision-making on programme strategy. The authority and independence of the executive management level were also highlighted by its perception of the policy level as lacking the technical competence to discuss and negotiate technical issues.

This executive management body also had a price. Between 20% and 30% of total project costs (excluding the cost of policy-making) can be attributed to

ESRO's expenditures, which comprised the cost of providing information to and servicing the policy level, the technical and management aspects of the research and development programme and extra costs related to the collaborative character of the whole programme. The latter point includes a number of issues. First, ESRO's staff had to be recruited from all European member states, which entailed extra costs in the form of settlement allowances and salary premiums to entice competent staff to relocate. Second, additional management activities were required to implement the project within European industry: it was necessary to coordinate, travel and get industry to work together. As a result of experience, the extra costs incurred by the latter issue tended to decline over time in this multi-project organisation. In fact, ESRO's overhead charges decreased, from 30% for the OTS project to 20% for the ECS project, for example.

Industrial rationalisation: Industrial rationalisation has been understood as the combined result of optimising industrial capabilities and interface costs to create new industrial structures of increased efficiencies characterised by large industrial entities, enhanced specialisation and increased competition.

In chapter 1, it was argued that optimisation of industrial capabilities would result in an efficiency gain for all participating countries if two conditions were realised: first, there had to be an interdependent system of complementary capabilities; second, the sharing of technology had to be in accordance with the industrial capability of the participating countries, i.e. industrial capabilities had to be optimised. The first condition describes the potential for efficiency gains; the second describes the realisation of that potential. Neither condition materialised in the OTS/ECS programme. In fact, prior to the start of the OTS/ECS programme, there existed a technology gap between the countries that had previous experience in communication satellite technology and those which did not.1/ The former were mainly the larger countries such as France and West Germany, with their SYMPHONIE programme, and to some extent Italy, with its SIRIO project, and the United Kingdom, with its SKYNET project. The latter were mainly smaller countries. Whereas the existence of the technology gap violated the first condition for efficiency gains, the TELECOM programme did not provide for the realisation of the second condition. As outlined above, the sharing of contracts was determined according to the 'fair return' policy and the GNP formula. Each country contributed to the cost of the programme according to its GNP and received in return an equivalent share of industrial contracts. Despite contributing most and therefore receiving a major contract share, the larger countries - based on their advanced industrial capability - would have secured even more contracts if the collaborative agreement provided for industrial optimisation, i.e. if there was unrestricted competitive bidding. By the same token, the smaller, less advanced countries would have received fewer contracts, even though they were already receiving a small contract share based on their GNP contribution. Hence, the TELECOM programme thwarted optimisation and industrial work had to be given to 'second-best' companies from the smaller, less advanced countries, whereas competent companies of the larger, advanced countries were excluded from industrial participation. This was a general pattern. There were, however, exceptions to the rule. A small country like Sweden, for example, might have secured a larger contract share if industry had been free to align itself. In particular, the Swedish company

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1/ As shown under sharing of technology, this technology gap was not closed as a result of the subsequent collaborative and national efforts but appeared to have widened.

Saab was well advanced in aerospace technology.1/

Limiting optimisation of industrial capabilities limited collaborative efficiency. In order to examine the relevance of this result, two groups of countries must be distinguished. From the perspective of the larger, advanced participating countries, the collaborative project became less efficient than a national project. Such a national project could have relied entirely on the advanced companies of its national industry and excluded the 'second-best' companies from the smaller countries. The collaborative inefficiencies associated with the failure to optimise industrial capability, however, were not a burden to the larger, advanced countries. As a result of the collaborative policy of 'fair return', nationally performed work was essentially paid for by national contribution during the government-funded stage of industrial activity. Hence, the collaborative inefficiencies introduced by 'second-best' companies were covered by those countries which were responsible for their occurrence, namely the smaller, less advanced countries.

From the perspective of the smaller, less advanced countries, the costs associated with the collaborative inefficiencies would also have occurred in a national project, since the companies considered 'second-best' in the collaborative project were 'best' from the national perspective. In fact, the collaborative effort was still likely to be more efficient than a national project: in a national project, the smaller, less countries would not be able

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1/ It is interesting to note that the 'fair return' policy based on the GNP formula thwarted optimisation at the collaborative level, but not at the national level. Essentially, the most competent companies of each country participated in the collaborative venture. More detail on the selection process within the national context will be given in the description of industrial competition.

to rely on the advanced capabilility of the larger countries.

A number of alternatives could have been pursued to realise industrial optimisation. One could have abandoned the 'fair return' policy and accepted an imbalance between financial contribution and industrial participation. As shown under sharing of technology, this was not supported by those countries which would receive a smaller share of the contracts, a fact that highlights the inflexibility of the 'fair return' concept. Alternatively, optimisation could have been achieved by adjusting financial contribution to industrial capability and not determining the contribution according to the GNP formula. The GNP funding formula, however, was considered an acceptable compromise to distribute the financial burden of breaking the US monopoly, as shown under sharing of funding. In addition, adjusting financial contribution to industrial capability would have excluded the financial participation of the smaller countries from the joint effort, which was supposed to be beneficial to Europe as a whole. Furthermore, the GNP formula and the resulting industrial participation were regarded by the less advanced countries as an opportunity to close the emerging European technology gap, a hope which did not materialise, as shown above.

The 'fair return' concept based on the GNP formula limited not only the optimisation of industrial capabilities but also the optimisation of interface costs. In order to reduce interface costs, it was preferable to allocate subsystem responsibility to a single company. Subsystem responsibility involves management responsibility and is mainly carried out by large companies rather than small, specialised equipment manufacturers. Subsystem responsibility also entails a major share of the total satellite contract and therefore, it had to be awarded to a contractor from a large country which provided a major share of the funding. Subsystem responsibility also absorbed most of the contract value allocated to the larger countries and thereby excluded the participation of its smaller specialised equipment manufacturers. Similarly, subsystem responsibility could not be accommodated in the small contract share of the smaller countries. In general, these countries participated through their smaller equipment manufacturers, which assumed limited management responsibility. This was basically not a problem, since the competent companies were, in general, in the larger countries, as noted above. In the case of Sweden, however, the participation formula limited the contribution of SAAB at the subsystem level.

Other interface costs resulted from the geographical distance between companies and the failure to share contracts according to the requirements of advanced technology work. In particular, the work share of the prime contractor was obviously too small to achieve the most efficient prime-contractor/subcontractor relationship. The allocation of subcontracting responsibility was based on the dictates of the work share formula, not on the requirements of advanced technology work.

Interface costs also include the issue of industrial competition. First, the competition between companies at the national level for partnership in an international consortium varied considerably in the different countries participating in the joint project. While it was difficult for companies from France and West Germany to get into one of the three consortia, it was sometimes impossible to locate enough competent companies in Denmark or Switzerland for all three consortia. In fact, the participation of companies from those smaller countries was characterised by multiple consortia membership.

Second, ESRO's contracting policy for tenders resulted in what is known as 'consortium solidarity'. This refers to a situation where the flexibility to change consortium members from one tender action to another is limited despite its efficiency benefits. All of ESRO's satellite tenders had similar workshare distribution requirements. Because of the need to outline a full scale consortium composition in each tender action, there was a tendency to freeze the industrial composition despite the different technical requirements. It is understood that a degree of permanence in the composition of the consortium is desirable in order to limit the time needed by the members to learn how to work together, to respond quickly to ESRO's requests for tenders and to limit the run-in period required when work begins under the contract. Such permanence of composition, however, is generally only required for the major firms involved, that is, the companies with subsystem responsibility. For advanced technology work, a higher degree of flexibility is beneficial at the equipment level, where interchangeability of contractors is, in princple, easier to arrange than at the subsystem level. Owing to ESRO's requirements, however, all tasks were distributed a priori on the basis of the firm's membership in the consortium before the contract was awarded. The protection of consortium members from external competition by the solidarity of the consortium structure had a paradoxical aspect. Whereas there was competition at the overall system level, there was only limited competition at the equipment level. In recent years, ESA has moved to a different competitive policy. Before awarding a main satellite contract, ESA now requests that only the main companies be identified in the fixed-price offer, leaving the consortia more room for competition after the contract has been awarded to them. However, the winning consortium is still required to achieve an industrial distribution defined by ESA for the overall contract.

Competition between the consortia was mainly influenced by ESRO's aim of maintaining a competitive system of three independent consortia. Since the workload resulting from Eurpean projects was too small to maintain such a system, ESRO was forced to award contracts in rotation in order to keep the consortia system alive. In fact, a consortium which had not won a satellite contract in the past stood a better chance in the future solely because of its former uncompetitive offer. Despite the drawbacks of the policy of contract rotation, the consortia system provided a European framework for industrial competition.

After the consortia system was established, a certain degree of stability between industrial groups developed. However, the consortium system did not lead to closer cooperation such as commercial agreements and risk sharing. For most of the companies involved, satellite development activities only formed a small fraction of their overall activity. Only small units of those companies were concerned with tendering for ESRO contracts, while the company itself was mainly geared to non-government-funded activities. In addition, the company departments devoted to space activity had to be arranged to serve a double purpose. On the one hand, they participated in international projects (ESRO/ESA) and, on the other, they carried out national projects. In particular, France and West Germany maintained large national programmes, thereby hindering European industrial integration. In addition, despite being an ongoing concern, the European space commitment was faced with major crises which at some stage threatened the existence of the collaborative effort as a whole. An unswerving commitment on the part of the funding organisations would certainly have increased the incentives for integration between the potential contractors.

The limited integration between consortium members stemming from the need to sub-optimise in order to meet conflicting needs was a cause of inefficiency. Companies were more interested in learning and perfecting their overall skill in the space field than in contributing to intra-consortium specialisation, resulting in a rotation of responsibility within the consortium. In fact, the MESH consortium had an arrangement under which functions and responsibilities rotated among the main consortium members on a contract-to-contract basis. The latter issue, namely the accumulation of overall technological competence within an individual member of the consortium, was supported by the national policy of complementing the participation in the collaborative venture with parallel national activities in order to build up system competence in communication satellite technology.

Production volume: The TELECOM programme started out in 1970 to develop one ECS satellite. As the programme evolved, two OTS satellites were added which bore a close resemblance to the subsequent operational ECS satellite. When the TELECOM 'III bis' programme is included, the total production volume was five ECS satellites. In parallel to the ECS satellites, a derivative called MARECS was developed for maritime communications and navigation, as Europe's bid for the business of INMARSAT, an international organisation concerned with maritime satellite communication. Substantial subsidies were required, however, to win the INMARSAT contract for the production of two MARECS satellites, which were procured along with American-built systems.

Besides MARECS, a second ECS derivative was developed in the framework of a French national programme. In 1980, it was decided to implement the French 'TELECOM' programme under the scrutiny of the French national space organisation CNES, with three ECS derivatives. The first TELECOM 1 satellite, launched by ARIANE in July 1984, is used by businesses for internal communications, by the French government for telephone and television links with the overseas territories and by the French armed forces.

In tendering for the Brasilian communication satellite BRASILSAT, European industry attempted to succeed commercially, without additional government subsidies, using the experience gained through the TELECOM programme. Although the BRASILSAT offer had been made outside the ESA framework by European industry using a more commercial approach - e.g., the offer was put together without much attention to geographical distribution - the European bid was heavily outpriced by the Canadian competitor and hence refused. Since the BRASILSAT offer was based on the ECS satellite, the flexibility to rearrange the industrial structure was somewhat limited, and hence competitive disadvantages had to be accepted.

With the two OTS, five ECS, two MARECS and three French 'TELECOM' satellites, European industry had attained what may be termed a major production run of twelve essentially identical spacecrafts. As a result, recurring costs for each spacecraft had been markedly reduced. The joint approach led to savings, particularly in the MARECS and French 'TELECOM' programme. The benefits of long production runs, however, were not fully realised, since the satellite specifications had to be tailored to the different operational requirements. Additional costs resulted from the attempt to increase, in the production of the derivatives, the national industrial participation of the funding countries. For example, the industrial contribution of non-French companies to the French 'TELECOM' satellite was considerably smaller than their contribution to the ECS satellites. The savings derived from longer production runs were, of course, limited to those countries which required follow-up systems and were able to provide the corresponding funding. Both conditions excluded the smaller European countries.

It should be noted that at the time the TELECOM programme was conceived, limited attention had been paid to the potential for derivatives and no detailed plans had been established to extend production beyond the ECS model. In fact, the benefits of achieving a longer production run in a collaborative framework were of little importance in the decision on the TELECOM programme, whose main objective was to break the US monopoly in communication satellite technology by establishing supply security.

Collaborative efficiency: Collaborative efficiency of the OTS/ECS programme has been described under the categories of policy-making, executive management, industrial rationalisation and production volume. What summary conclusions can be drawn? In particular, is international collaboration more efficient than a national project?

The policy-making which led to the principal agreement in 1970 and the TELECOM Arrangement in 1973 was cumbersome and marked by long delays. These delays were considered important by the national delegations and prompted France, West Germany and Italy to initiate the bilateral project SYMPHONIE and the national project SIRIO, since no programme go-ahead was decided on at the collaborative level. In contrast, policy-making on programme implementation continued smoothly since decisions only required a majority or a double qualified majority. The cost of the policy level was considerable. No indication has been found, however, that the expenditures covered under national budgets were of major concern to the funding organisations. Those covered under the project costs were reflected in ESRO's overhead and will be discussed in more detail below.

The ESRO system of executive management maintained close supervision of industry, which was considered necessary in order to implement an advanced technology project in an industry characterised by diversity. Essentially, industry had to learn how to work together and was guided by ESRO in this effort. The ESRO system worked but resulted in considerable expenditures.

Although these expenditures were frequently criticised by ESRO's member states, they also recognised and appreciated the results of the ESRO system.

The results achieved under industrial rationalisation were confined to the existence of a technology gap between the participating countries, the 'fair return' policy, the GNP funding formula and the policy of maintaining national activities. The optimisation of industrial capabilities did not realise its full potential and resulted in collaborative inefficiencies. Furthermore, it has been pointed out that additional interface costs occurred, such as the costs associated with the geographical distance between contractors. Finally, it was noted that although the full potential was not realised, industrial competition was enhanced in particular in the advanced countries.

Quite clearly, the advanced, larger European countries, such as France, the United Kingdom and West Germany, could base national projects on less complex decision-making at the policy level and less cumbersome executive management, optimise the interface costs at the industrial level and, most important, optimise the industrial capabilities by relying on the advanced capability of their own national industry rather than including 'second-best' companies from the smaller, less advanced countries. Those countries, however, did not cover the collaborative inefficiencies related to the failure to optimise industrial capabilities. This was done - as a result of the 'fair return' policy and at the government-funded stage of industrial activity - by the smaller, less advanced countries, in which the 'second-best' companies were located. In conclusion, one has to recognise that the collaborative programme was less efficient than a national project carried out in France, the United Kingdom or West Germany. The inefficiencies related to the failure to optimise industrial capabilities, however, were not considered relevant by those countries.

The less advanced European countries such as Belgium, Denmark, the Netherlands, Sweden and Switzerland would also be able to avoid the collaborative inefficiencies associated with policy-making, executive management and interface costs in a national project. In addition, however, the national project would exclude an efficiency gain which was realised in the collaborative programme: although the optimisation of industrial capabilities was thwarted, the efficiency realised under this issue in the collaborative programme was still higher than what could be achieved in a national project. In fact, in a national project those countries would have to rely on their less advanced companies and exclude the advanced companies of France, the United Kingdom and West Germany. It was likely, therefore, that the collaborative project would be more efficient than a national project carried out in the less advanced countries.

When these conclusions on collaborative efficiency are compared with the findings of previous research, in particular with regard to the controversy over whether international collaboration or a national project is more efficient, a number of interesting observations can be made. First, the case study has not verified the importance of production volume for collaborative efficiency, since there was no substantial government or government-controlled procurement.1/ Previous research focused mainly on government funding of military technology, of which governments are almost the only customers and

1/ If such procurement of the collaborative product did exist despite the availability of more competitive alternative products, it would be necessary to compare the resulting gain in collaborative efficiency with the cost of the subsidy which such procurement implies. Alternatively, it appears possible that government funds collaborative supply security only as a fall-back capability in case technology access is denied, but procures the more competitive product from outside sources.

production runs tend to be long. This does not apply to advanced technology such as communication satellites, of which production runs tend to be short and governments exercise less influence on procurement. Second, a number of issues have been identified which emphasise the inefficiency of international collaboration, such as policy-making, executive management and industrial rationalisation. These findings are seen to support the 'negative' position of previous research, as outlined in section 1.2.5. Third, it has been pointed out that collaboration can be more efficient where collaborative capability complements national capability, as was the case for the less advanced countries in the OTS/ECS programme. In addition, it has been argued that inefficiencies attributed to the policy-making, executive management and industrial levels tend to be greatest at the initial stage of the collaborative venture and to decline as the partners learn how to work together. This would support the 'positive' position of previous research. Fourth, the findings emphasise the need to examine the issue of efficiency from the perspective of each participating country and show that the conclusion for each individual country might differ depending on national charactistics.

<u>Achieving supply security: the collaborative option</u>

The OTS/ECS programme, along with the national activities, succeeded in breaking the monopoly of the United States in communication satellite technology by the late 1970s. It did not, however, close the technology gap. With its large military communication satellite programme, the US is still ahead, although most of the advanced technology is classified and not available for civilian use. Europe managed, however, to create supply security, which was considered to be of vital importance during the late 1960s. Such independence had its price. In all national, bilateral and collaborative efforts combined, approximately $1,000 million were spent to achieve this goal. To this must be added part of the cost for the development of the launcher facilities necessary to place the satellite in orbit.1/

Was this effort worthwhile? The answer depends on political opinions and national ambitions. A Gaullist in France would probably approve of the achievement, whereas the smaller countries might be less reluctant to rely on American assurance of supply.

Regardless of differences, it must be noted that even without a European effort, the monopoly position of the USA in communication satellite technology was eroding during the 1970s. Japanese industry has established a competence in communication satellite technology, and the Soviet Union has offered to supply satellite communication services to Europe. Arguments of supply security seem to have lost importance when national space policy is discussed. It is difficult to determine to what extent this is the result of having established supply security and to what extent the original objective was unjustified. From the perspective of the 1980s, however, it appears that the fears of the 1960s were exaggerated.

While opinions may differ as to whether the effort was worthwhile, it should be possible to identify the appropriate policy option: participation in international collaboration, a national project or the parallel option. This can be done by summarising the findings outlined under collaborative sharing and efficiency and thereby distinguishing three groups of countries.

France and West Germany pursued a parallel option. For both, participating in international collaboration while maintaining national

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1/ The launcher development programme, in particular in France and the United Kingdom, was mainly geared to the development of ballistic missiles for nuclear warheads.

activities resulted in limited interdependence, with the emphasis on independence in the area of technology which established supply security.1/ This result still falls short of that of a national project, namely total national independence. The joint perception of an American threat in communication satellite technology and the perception of common interests, however, reduced the relevance of this shortcoming: it reduced the shortcoming of surrendering a share of national sovereignty to the collaborative entity. In fact, it is argued that the shortcoming was acceptable in view of the substantial benefits realised through the sharing of funding and that there was a gain associated with collaborative sharing for France and West Germany. This has to be compared with the results achieved under collaborative efficiency. As noted above, France and West Germany were able to implement national projects which were more efficient than the collaborative OTS/ECS programme. During the government-funded stage of industrial activities, however, neither country covered the collaborative inefficiencies related to the failure to optimise industrial capabilities. The funding objectives of supply security can be considered realised as a result of this industrial stage with the establishment of the technology capability. It follows that only the inefficiencies associated with policy-making, executive management and interface costs were considered a detriment to the achievement of the funding objectives in the case of France and West Germany, whereas the inefficiencies related to the failure to optimise industrial capabilities were not. In fact, it is argued that for

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1/ It should be recalled that the 'fair return' concept, as defined by ESRO, was successfully implemented. Hence, the sharing of benefits - profits and employment opportunities - associated with technology contracts was in general acceptable to all participating countries. Similar results were likely to be achieved in national projects.

both countries the gain associated with collaborative sharing outweighed the loss associated with collaborative inefficiencies. In other words, participation in international collaboration was successful in achieving the objectives of supply security for France and West Germany.

Similar results with regard to collaborative efficiency were achieved by Italy and the United Kingdom, but not with regard to collaborative sharing. Both countries had restricted their government funding to participation in international collaboration and had discontinued national efforts. As a result, their industrial capability was characterised by limited interdependence, with the emphasis on dependence. If France and West Germany decided to leave the collaborative framework and rely on their independent capabilities, no short-term alternative would be available to Italy and the United Kingdom.1/ As a result of this volatility, one might argue that an industrial capability characterised by limited interdependence, with the emphasis on dependence, is a shortcoming which is not offset by the benefits realised under the sharing of funding. Even if there were a small gain associated with collaborative sharing, it would be outweighed by the loss associated with the inefficiencies described under policy-making, executive management and interface costs. This rendered participation in the collaborative programme unsuccessful in achieving supply security for Italy and the United Kingdom.

The smaller, less advanced countries, such as Belgium, Denmark, the Netherlands, Sweden and Switzerland, had implemented government funding only through the collaborative option without prior or parallel national activities. It has been argued that the collaborative option was more

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1/ In fact, this was the case in the subsequent H-SAT project, as will be described below.

efficient for them than a national project. While this was a strong incentive for participating in international collaboration, the benefit of increased efficiency was outweighed by the shortcoming associated with the results achieved under collaborative sharing. The smaller countries only managed to secure partial system capability. In addition, this capability was duplicated in the partner countries. As a result, the smaller countries were dependent on their collaborative partners but not vice-versa, which prevented participation in an interdependent system. Others, particularly the small, less advanced countries, even failed to achieve those results and secured only 'second rate' work. The latter countries essentially contributed financially to the establishment of a technology capability in the larger, advanced countries; they contributed to a widening of the technology gap. This was mainly attributed to the limited financial participation of the smaller countries and the lack of supplementary parallel activities due to their already limited industrial capability. Hence, participation in the collaborative programme appeared even less successful in achieving supply security for the smaller countries such as Belgium, Denmark, Sweden, Switzerland and the Netherlands than for Italy and the United Kingdom.

In summary, one has to acknowledge that the success of France and West Germany was mainly achieved at the expense of their partner countries in the collaborative effort. This result stemmed not only from the collaborative effort but also from the continuing national activities, which wre not subject to the control of the partner countries.

The conclusions outlined above apply only to the OTS/ECS programme, which was initiated and implemented between 1963 and 1978 with the aim of achieving supply security. In the following section, the initiation and abandonment of the H-SAT project, followed by the start of the collaborative OLYMPUS (L-SAT) project and the bilateral TV-SAT/Tdf, will be described in detail. This activity covers the period between 1975 and 1983.

Funding objectives: the H-SAT project

As noted above, the OTS/ECS programme was initiated in the 1960s, approved in 1970 and implemented between 1970 and 1978 in order to establish supply security. In 1975, in the midst of the industrial activity of the OTS project, planning for the final operational ECS project indicated considerable savings compared with the original estimate of 400 MAU provided under the TELECOM Arrangement. Based on these savings, a new project initiative was established, known as H-SAT. The satellite was basically an adaptable platform capable of carrying out a multitude of communication satellite missions. The first mission was expected to be for direct TV satellite distribution. In addition, the satellite would be tailor-made for the ARIANE launcher, which had been funded primarily by France and to a lesser extent by West Germany. Although it was proposed that H-SAT be funded from the savings achieved in the TELECOM programme, this project had little in common with the original funding objectives of this programme. Whereas the OTS/ECS satellites were supported to break a technology monopoly and to achieve supply security, the H-SAT/ARIANE combination was aimed at capturing a sizeable share of a huge market that was expected to develop by the mid-1980s: government funding was requested fro the H-SAT project to support economic growth. A number of facts point to the shift in funding objectives from supply security to economic growth. First, there was no dependence on outside TV satellite technology since European know-how in this area was considered to be at the forefront of development. US industry had built up little expertise in the area of TV satellite owing to the lack of US military and domestic civilian needs. Second, whereas the effort to create supply security was initiated by the government level, interest in the initiation of the H-SAT project was expressed by industry: a group of companies approached ESA, lobbying for support for their PHEBEUS project. This initiative by industry was subsequently taken up by government on the understanding that there was a potential market for TV satellites, which European industry could seize with government funding. Third, the intense industrial competition for the H-SAT satellite development contract indicated the industry's keen interest in this project. It was argued that industry underestimated the development costs in the tender offer for the H-SAT satellite in view of subsequent commercial prospects which the initial effort would open up. Fourth, there were a number of indications that a large potential market for TV satellites existed. A EUROSPACE study published in 1975 had identified a potential market of 4,000 MAU by the mid-1980s. Based on the H-SAT project, it was argued, European industry could capture up to 20% of this market. Finally, the Nordic countries showed interest in a TV satellite called NORDSAT; a consortium of publishing companies developed plans to establish a commercial TV satellite in Luxembourg; there were initiatives in France, Italy, the United Kingdom and West Germany; and one additional outstanding market opportunity presented itself when China announced plans to establish an ambitious direct TV satellite system requiring more than twenty satellites.

As described in the case study, it was finally decided to abandon the H-SAT project. Instead, the joint European effort split up into the bilateral Franco-German TV-SAT/Tdf project and the OLYMPUS project supported by all ESA member states except France and West Germany. The following description of collaborative sharing and efficiency will centre on the H-SAT proposal, which provides the information to examine the preference of the ESA member states for a particular policy option.

Collaborative sharing/collaborative efficiency in the H-SAT project: achieving economic growth and the collaborative option

H-SAT was considered to be the European entry in the world market for TV satellites. In order to be competitive, the price and quality of the final product was of utmost importance. Hence, there was general agreement among the funding organisations to outline a programme arrangement which would enhance collaborative efficiency essentially in two ways. First, the programme arrangement should provide for industrial rationalisation. Second, the inefficiencies associated with policy-making and executive management should be limited by increasing the involvement of industry in the management of the satellite project.1/ In addition, in accordance with the OTS/ECS programme, it was expected that a similar arrangement for collaborative sharing would be approved for the H-SAT project.

From the earliest stages of the H-SAT project, France and West Germany pressed for a programme arrangement which would impose no requirements regarding the geographical distribution of contracts. The two countries wanted to ensure the optimisation of both interface costs and industrial capabilities and thereby prevent the selection of 'second-best' companies located in the smaller, less advanced countries. Eliminating interface costs would limit inefficiencies and increase the competitiveness and commercial success of the final product. As described above, inefficiencies introduced

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1/ As in the case of the OTS/ECS programme, the issue of production volume appears to be of limited relevance for the H-SAT project. There was no substantial government or government-controlled procurement. While it was expected that the direct TV satellite H-SAT would lead to long production runs, this would be achieved only if it was successful in commercial markets with customers such as Radio Luxembourg or developing countries. Governments which funded the project were expected to play only a minor role and, at the time the project was initiated, only the government of West Germany appeared to have plans to establish a direct TV satellite system.

by the failure to ensure optimisation of industrial capabilities had been of little concern to the larger, advanced countries in the OTS/ECS programme. This, however, applied only to the government-funded technology stage, whose aim was to establish supply security. It did not apply to the non-government-funded production stage, which was intended to capture commercial market opportunities. Since the competitiveness of the final product is of major importance for success in commercial markets, limiting competitiveness with inefficiencies introduced through the use of 'second-best' companies would limit the commercial success.

In order to limit the inefficiencies associated with policy-making and executive management, France and West Germany demanded a greater role for industry in the implementation of the H-SAT project. ESA's involvement was to be limited by giving greater decision-making power to the industrial level, since industry would subsequently market and produce the final product, thereby enhancing a smooth transition from the R&D stage, where governments were involved through ESA, to the production stage, where industry was to be solely responsible, and expediting the decision-making process.

The increasing involvement of industry was also needed in order to limit ESA's overhead. Since industry had already established considerable know-how and competence in the area of communication satellite technology, less guidance and monitoring were required by the central management agency.

ESA responded to the demands of the funding organisations and proposed a new role for itself, in which its function would be to provide co-ordination and minimum supervision and the role of industry would be enhanced, particularly in matters of technology development. As a result, ESA's overhead was expected to be reduced from 20-30% to under 10%.

When the proposal of France and West Germany with regard to industrial rationalisation was tested in industry, it became clear that the industries of the two countries would take the lion's share of the industrial work for the H-SAT satellite. The share of industrial contracts for the smaller countries was well below their expectation, resulting in some cases in almost no participation at all. This was basically the result of optimising industry, which was characterised by a technology gap between the smaller and the larger countries, an industrial structure created by the previous efforts, including the OTS/ECS programme. The outcome was not acceptable to the smaller countries, which demanded a revision of the existing arrangement with the aim of increasing the contract share allocated to their industries.

Why was the sharing of contracts so important for the achievement of economic growth? Basically, the contract share was considered to determine the share of the economic growth derived from the H-SAT project. It was seen as an approximate measure, not only of the employment opportunities created in national industry, but also of how the forthcoming profits would be distributed between the participating countries. Limiting the contract share, even if it implied reducing the financial share, could be viewed as an opportunity loss associated with international collaboration, since a national project would maintain the economic growth potential of the entire product within national industry.1/

Hence, the loss associated with collaborative sharing could be reduced if the collaborative share, including technology and funding, were increased. In order for international collaboration to become the appropriate policy option,

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1/ This, of course, assumes that the project is a viable economic proposition for investing government funds, an assumption which will be critically reviewed for the communication satellite programme at a later stage. It is argued, however, that at the time the H-SAT project was discussed, the funding organisations considered it an attractive economic investment.

however, the remaining loss associated with collaborative sharing had to be offset by gains in collaborative efficiency. It is argued that this was the case for the initial H-SAT proposal from the perspective of the larger, advanced countries. First, the loss associated with collaborative sharing was limited since the major share of the industrial activities would be given to the larger countries. Second, there was an efficiency gain associated with the optimisation of interface costs and the industrial capabilities characterised by limited interdependence between the larger countries. Finally, inefficiencies associated with policy-making and executive management were kept to a minimum by allocating project responsibility to industry and limiting ESA overhead costs. The larger countries appeared to be satisfied with the initial proposal and supported the collaborative option. The smaller, less advanced countries did not: they could only benefit from the increase in collaborative efficiency if they secured a technology share, a condition not yet fulfilled.

As a result of the criticism from the funding organisations of the smaller countries, an attempt was made to restructure the initial sharing of technology in order to provide for a larger share for the smaller countries. The consequences of this adjustment, however, were not appreciated by West Germany in particular. First, its national industrial share was reduced and hence the loss associated with collaborative sharing increased. Second, the adjustment reduced the efficiency gain by limiting industrial optimisation, e.g. by increasing interface costs and selecting 'second-best' companies from the less advanced countries. In fact, it became likely that a national or a bilateral effort of advanced countries would be more efficient than the collaborative effort.

The smaller, less advanced countries strongly supported the new proposal. Although the efficiency gain of the collaborative venture would be limited, the collaborative option was still more efficient than a national project. In addition, the penalty of reduced efficiency was the price that had to be paid in order to secure a share of collaborative contracts. The alternative would be exclusion from follow-up programmes, which would make their previous investment appear to have been wasted.

Limiting collaborative efficiency and increasing the loss associated with collaborative sharing in order to accommodate the participation wishes of the smaller countries made a national effort more attractive for West Germany. The decision to leave the collaborative framework, however, was only taken after information became available that the initial assumption of considerable economic growth potential in TV satellite markets appeared to be correct. The German company MBB concluded a pre-agreement with the Chinese authorities on the joint production of up to 20 TV satellites.

West Germany violated the ESA constitution when it broke away from the collaborative effort. This, however, seemed less important than the possibility that national industry could capture the commercial benefits of the Chinese market for direct TV satellites. Although the German industry was capable of maintaining a national project, the German authorities opted for a bilateral arrangement with France for political reasons - to have a partner in leaving the joint framework. In addition, the French and German satellite industries were the most advanced and partly interdependent, and the two countries also held the major industrial interest in the commercial TV satellite launch vehicle ARIANE.

The decision of France and West Germany to leave the ESA framework resulted in some bitter feelings among their former partners. Having supported the creation of an advanced industrial capability in those two countries, the other countries could no longer rely on this capability for the continuation of the collaborative effort to achieve economic growth. In fact, for these countries, the remaining options appeared to be limited. Discontinuing government funding was considered to be a waste of previous government investment in communication satellite technology. The choice of a national approach could not be justified by most of the countries owing to their limited industrial base in the technology sector. Finally, the ESA countries, supported by Canada, managed to put together a new project initiative known as L-SAT (later renamed OLYMPUS), considered to be in direct competition with the Franco-German TV-SAT/Tdf project for a share of the world market for communication satellite technology.

A divided Europe had chosen to embark on two major efforts in TV satellite technology in order to promote economic growth. At this stage, it is not considered possible to determine whether those efforts have been worthwhile. However, a preliminary assessment can be made by comparing the cost with possible economic benefits. Excluding the initial development efforts in Europe, which were basically motivated by the objective of supply security, approximately 1,000 to 1,500 MAU at 1982 rates was probably spent in Europe to achieve economic growth objectives. This conservative figure includes the current market which is basically confined to government-sponsored procurment such as the larger projects TV-SAT/Tdf and OLYMPUS and the smaller national efforts, such as ITALSAT, and UK V. When the subsidy inherent in protected procurement for DFS, follow-up ECS, MARECS etc are added to the above figure, the total cost probably equalled the possible turnover figure of European industry, estimated at 2,700 MAU in the medium term, as outlined in section 5.13. On the basis of this preliminary calculation, it might be argued that the communication satellite market, as it is currently understood, provides limited justification for the scale of government funding approved back in the 1970s. In fact, the case under study provides limited support for government funding to achieve economic growth.

6.3 Some hypotheses on the appropriate policy option

The hypotheses will be outlined first regarding the achievement of economic growth, then regarding the achievement of supply security.

For the achievement of economic growth, the study has demonstrated that participation in international collaboration may hold an advantage over a national project if it provides a gain in collaborative efficiency for all participating countries which outweighs the opportunity loss associated with collaborative sharing. International collaboration, therefore, might be an appropriate option if the opportunity loss is limited and the efficiency enhanced. The first requirement can be fulfilled by restricting the number of collaborating countries. This enables each country to secure a larger share of the collaborative effort, thus limiting the loss associated with collaborative sharing. Collaborative efficiency has been discussed under the issues of policy-making, executive management and industrial rationalisation.1/ The history of the TELECOM programme has challenged previous conclusions that the inefficiency described under policy-making and executive management thwarts successful collaboration. Such ineffciencies can also be found in national projects. Although they might be emphasised in the collaborative framework, the OTS/ECS programme and in particular the H-SAT proposal have demonstrated that those inefficiencies can be minimised. To

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1/ The issue of production volume has been considered of limited relevance in the case under study. Hence, the hypotheses will not cover the possible existence of government procurement.

this end, a number of guidelines can be followed. First, restricting the number of collaborating countries, as already suggested in order to limit the opportunity loss associated with collaborative sharing, would also reduce the inefficiencies associated with policy-making and executive management. Second, international collaboration should not be established on an ad hoc basis but given permanence. A central executive management body is probably required during the initial stage of a collaborative venture as a 'start-up cost' in order to control and guide companies from different countries in working together. After this initial period of learning, industry will be in a position to take over responsibility from the central management body. In addition, the costs associated with industrial coordination are likely to decline as a result of learning. Third, and most important, collaborative efficiency can be realised by industrial rationalisation, including the optimisation of interface costs and industrial capabilities. Whereas the former is a burden to the programme already from the initial stage of industrial activity - which is government-funded unlike the subsequent stage - this does not apply to the latter if nationally performed work is paid for by national contribution. Here, inefficiencies resulting from failure to optimise industrial capabilities during the initial stage will be covered by the respective funding organisation in which the inefficiencies occure, i.e. in which the 'second-best' companies are located.1/ This does not apply, however, for the subsequent non-government-funded production stage, which serves commercial markets. Since securing a major share of the commercial

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1/ This applies if optimisation is thwarted only at the collaborative level, not at the national level; i.e. although 'second-best' companies are selected from the perspective of the collaborative level, the best companies are selected nationally.

market is a precondition for realising the economic growth objectives, any inefficiencies which are carried over to and/or occur during the production stage - the failure to optimise interface costs and/or the failure to optimise industrial capabilities - will limit the achievement of the funding objective.

Avoiding inefficiencies is not sufficient. As outlined above, successful collaboration to achieve economic growth has to realise an efficiency gain. This cannot be done if there exists a technology gap between the participating countries, but only if the industrial structure is characterised by interdependence. To realise the efficiency potential associated with an interdependent industry, industrial participation should be determined by optimising this structure through a competitive arrangement and by adjusting the financial participation according to the resulting industrial participation, not vice-versa. This would not only provide an efficiency gain through the joining of complementary capabilities, limit interface costs and provide for substantial participation by all participating countries, but also observe a fundamental principle of international collaboration, namely that of 'fair return'.

However, the European industrial structure in advanced technology such as aerospace, nuclear energy and computers cannot be considered interdependent. First, there is a technology gap between the smaller, less advanced countries, such as Belgium, Denmark, Spain and Switzerland, and the larger, advanced countries such as France, Italy, the United Kingdom and West Germany. Second, there exists limited interdependence between the larger countries only in a few technology areas, such as the commercial civilian aircraft industry. Here, the United Kingdom specialised in engine technology, France in airframes and West Germany in electronics. This specialisation, however, did not come about as a result of free international competition and industrial alignment, but was guided by government funding and intervention.

Consequently, based on the understanding of the European industrial structure, it may be argued that there are few cases in which international collaboration would provide an efficiency gain vis-a-vis a national effort for all participating countries. National efforts by advanced European countries appear, therefore, to be the appropriate choice for funding advanced technology to achieve economic growth, and international collaboration is restricted to a few cases involving the advanced European countries. In addition, there appears limited justification for a parallel option. This option could lead to duplications of capabilities and expenditures. While this might enhance competition, it might also limit the economic benefits since each of the parallel products would probably secure a smaller market share than would the product resulting from the single effort. Clearly, however, the smaller, less advanced countries have no major role to play in European collaboration to achieve economic growth. These countries are unlikely to be willing or able to provide the necessary resources which would enable them to share in an interdependent system with the larger, advanced countries, a precondition for successful participation in international collaboration for the achievement of economic growth. Furthermore, the need for efforts in addition to the financial contribution to the collaborative venture might render government support an unattractive economic proposition. The latter issue shows that the final success of such undertakings, whether national or collaborative, depends on the justification for government funding. The case study does not demonstrate that European governments have been successful in identifying opportunities for government support.

The conclusions outlined above relate to the achievement of supply security. Those identified with regard to collaborative inefficiencies and described under policy-making, executive management and interface costs also apply to the achievement of supply security: the inefficiencies can be controlled although it seems likely that they limit the attractiveness of the collaborative option. In addition, as in the case of economic growth, inefficiencies associated with the failure to optimise industrial capability are not of major relevance during the government-funded industrial activity; they would be relevant, however, during the non-government-funded production stage. As already outlined above, the achievement of supply security does not necessarily require success in commercial markets; it does not require a non-government-funded production stage. Supply security is achieved with the establishment of the technological capability as a result of the government-funded industrial activity. It may be argued, therefore, that the inefficiencies associated with the failure to optimise industrial capability at the collaborative level does not affect the success of the collaborative option, contrary to the conclusion regarding economic growth.

With regard to collaborative sharing, the study has indicated that in order to contribute to the achievement of the funding objectives, the sharing of technology has to establish national control over the collaborative product. Such national control can be exercised by all collaborating countries if there exists an interdependent system of industrial capabilities. This would make the duplication of national system capability by other partner countries undesirable, since it would prevent interdependence - the sharing of control - and enhance national independence. Hence, national activities which duplicate existing capabilities and enhance national independence should not exist. National activities should be undertaken only where they strengthen the less advanced countries to enable them to contribute to the interdependent system. The case study has shown, however, that it was mainly the larger, advanced countries which continued national activities in parallel to participation in international collaboration. Assurance must be given prior to the start of a collaborative effort that this practice will not continue. Hence, successful collaboration must be based on concerted action; participating countries must be willing to align their national activities to achieve the overall objective of establishing an interdependent system.1/

Although an interdependent system should be the result of a collaborative effort, this outcome would fall short of the independence in supply security established through a national effort. This shortcoming, however, would be limited if the collaborating countries have compatible interests since the surrender of national sovereignty, which the establishment of an interdependent system implies, would be considered acceptable. In this situation, the benefit of sharing the funding would outweigh the shortcoming of sharing technology: there would be a gain in collaborative sharing. As a result, international collaboration could be the appropriate option even though less efficient than a national project, on two accounts. First, the gain associated with collaborative sharing could offset the inefficiencies identified under policy-making, executive management and interface costs. Second, inefficiencies resulting from the failure to optimise industrial capabilites at the collaborative level are not relevant to the achievement of supply security. An interesting consequence follows. It has been noted above that a technology gap between participating countries leads to collaborative

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1/ In addition, a collaborative effort solely devoted to enhancing the independence of all participating countries by supplementing national activities appears possible. This, however, does not seem to be a valid option, since the collaborating countries could achieve the objectives of independence through a national project, possibly involving less duplication and expenditure.

inefficiencies. International collaboration could still be successful, however, since such inefficiencies might not be relevant, as in the case of the failure to optimise industrial capabilities, or might be outweighed by the gain associated with collaborative sharing, as in the case of the failure to optimise interface costs.

At this point, it may be hypothesised that Europe has moved towards political integration during the last decades not only as a result of efforts at the political level but also as a result of economic integration, in particular within the European Community. In fact, this process has led to and reinforced political collaboration, e.g., in the area of defence, where the perception of compatible interests and interdependence is widespread. Hence, it might be argued that European countries are willing to accept the political implication of successful collaboration, namely collaborative interdependence. In order to realise such collaboration, each participating country would have to make a substantial contribution to the interdependent system. To do so, less advanced countries would have to make additional efforts, preferably through parallel national activities, to supplement their participation in international collaboration. Hence, for the achievement of supply security, collaboration appears to be the appropriate option for the large, advanced European countries, whereas the parallel option is appropriate for the large, less advanced countries. The smaller countries, less advanced or advanced, however, have only a limited role to play in establishing supply security. They might not be able to provide the substantial resources required to participate in an interdependent European system, nor might they be willing to do so since the issue of supply security appears to be a major concern only for larger countries.

As in the case of economic growth, government funding of advanced technology to achieve supply security, whether in a collaborative or a national framework, has to be justified by the validity of the objectives. The case study indicates, however, that European governments tend to exaggerate the importance to establishing supply security.

The appropriate option for government funding of advanced technology to achieve economic growth and/or supply security has been outlined above for European countries. Different options have been highlighted not only for the achievement of different funding objectives, but also for different countries depending on their size and state of industrial capability. The latter issue not only affects the selection of the appropriate policy option but also the extent to which the funding objectives can be realised. This highlights the interrelationship between the main research problem of this study - the identification of the appropriate policy option - and a related area of interest, namely the controversy over the justification for government funding.

In the following paragraphs, some of the findings on which the conclusion on the appropriate policy option is based will be recalled and contradictions with previous research as well as differences between the achievement of the two funding objectives will be noted.

The research has highlighted the need to distinguish government funding aimed at economic growth from government funding aimed at supply security. Collaborative sharing, for example, has been associated with a gain when achieving supply security, in case the collaborative partners have compatible interests, but it has been associated with an opportunity loss with respect to economic growth. On this basis, the importance of collaborative efficiency can be determined. In fact, it has been argued that international collaboration can be the appropriate option for achieving economic growth only if it is more efficient than a national option. Increased efficiency is required to overcome the opportunity loss associated with collaborative sharing. For the achievement of supply security, however, collaboration might be appropriate even if it is less efficient. This is in clear contradiction to the efficiency perspective of previous research, outlined in section 1.2.5.

The research differs with previous findings on the inefficiencies attributed to policy-making and executive management; it is argued that such inefficiencies can be controlled, although national projects are likely to achieve better results. The industrial structure is considered of major importance for successful collaboration. Collaboration to achieve supply security should lead to or enhance industrial interdependence in order to establish collaborative control. As outlined above, such collaboration could be based initially on a structure characterised by a technology gap, since resulting inefficiencies might not be relevant or outweighed by the gain associated with collaborative sharing. This is in contrast to the achievement of economic growth. Here, collaboration has to be based on an interdependent industry in order to be successful. Only by optimising such complementary capabilities is collaboration likely to achieve the efficiency gain required not only to offset the inefficiencies associated with policy-making and executive management but also to overcome the opportunity loss associated with collaborative sharing. This difference in emphasis is particularly important when funding objectives change, as was the case in the TELECOM programme. The industrial realities created during the supply security phase prevented the continuation of the programme during the subsequent phase, which was aimed at achieving economic growth. This resulted in bitter feelings between the partner countries which went beyond the TELECOM programme and reflected on the wider efforts of European integration.

Appendix A

Tables and graphs on European space industry, expenditure and programmes

Table 1: Companies participating in the TELECOM programme 1/

No.	Company	Natio-nality	Owned by	Contracts from ESA in MAU 2/	ESA supplier rank	Staff/ total	Staff/ space
1	AEG-Telefunken	D		60.0	8	155,000	500
2	Aeritalia 3/	I	Finmeccanica (I) which is part of IRI Group (I) 4/	54.8	9	10,000	NA
3	Bell Telephone Manufacturing Company (BTM)	B	ITT (USA)	23.0	16	11,500	100
4	British Aerospace Corporation (BAC)	UK	see number 5, BADG/BAC				
5	British Aerospace Dynamics Group BADG/BAC (Bristol) 5/	UK	British Aerospace 6/	40.2	11	4,000	1,000
6	British Aerospace Dynamics Group BADG/HSD (Stevenage) 7/	UK	British Aerospace 6/	134.7	4	8,000	1,000
7	Campania Nazionale Satelliti (CNS)	I	various Italian aerospace companies	5.4	39	100	100
8	CH. Rovsing	DK		9.9	26	200	70
9	Compagnie de Signaux et d'Entreprises Electriques (CSEE)	F		4.7	40	5,000	NA
10	Compagnie Industrielle Radio Electrique (CIR)	CH		8.6	29	120	70
11	Computer Technology Limited (CTL)	UK		6.0	37	360	NA
12	Consorzio per Sistemidi (STS)	I	STET Group (I) 8/ which is part of IRI Group (I) 4/	0.3	55	70	NA
13	Construcciones Aeronauticas (CASA)	E	Eram (USA)	16.3	21	8,000	180
14	Contraves	CH	Oerliko-Bührle Holding (CH)	15.6	23	7,500	80
15	Crouzet	F		3.4	47	6,000	30
16	Dornier	D		100.9	6	8,200	800
17	Elektronikcentralen 9/	DK		6.8	35	100	30
18	ERNO Raumfahrttechnik	D		207.2	2	1,000	1,000
19	Etudes Techniques et Construcations Aerospatiales (ETCA)	B	ACEC (B) with General Dynamics (USA) as major shareholder	40.2	10	730	150
20	EUROSAT	CH	European electronic and aerospace companies	4.3	42	100	75
21	Fabbrica Italiana Apparecchiature Radioelettriche SpA (FIAR)	I	L.M. Ericsson (S) and GE (USA)	18.0	19	1,500	100
22	Ferranti	UK		6.6	36	17,000	NA
23	Fokker	NL		29.2	13	7,300	160
24	Galileo	I	Bastogi Sisteme (I)	6.9	34	1,500	50
25	GTE Telecommunicazioni	I	GTE (USA)	4.4	40	6,500	300

No.	Company	Nationality	Owned by	Contracts from ESA in MAU 2/	ESA supplier rank	Staff/ total	Staff/ space
26	Hawker Siddeley Dynamics (HSD)	UK	see number 6, BADG/HSD				
27	Hollandse Signaal Apparaten (HSA)	NL	Philips (NL)	3.0	48	NA	NA
28	Instituto Nacional de Technica Aerospacial (INTA)	E		8.7	28	1,700	600
29	International Computer Ltd (ICL)	UK		21.8	17	33,000	NA
30	Laboratoire Centre de Télécommunications (LCT)	F	ITT (USA)	4.4	41	800	NA
31	L.M. Ericsson	S		8.9	27	70,000	NA
32	MAN	D		29.0	14	62,500	200
33	Marconi Communication System (CS)	UK	GEC Marconi Electronics (UK) which part of General Electric Company (UK) 10/	2.4	50	5,000	NA
34	Marconi Space and Defence Systems (MSDS)	UK	GEC Marconi Electronics (UK) which part of General Electric Company (UK) 10/	44.7	10	11,000	NA
35	MATRA	F		105.4	5	5,000	500
36	Messerschmitt-Bölkow-Blohm (MBB)	D		75.5	7	22,300	1,100
37	Montedel/Laben	I	Bastogi Sisteme (I)	19.6	18	250	110
38	National Lucht und Ruimtevaart (NLR)	NL		1.6	52	760	NA
39	Office National d'Etudes et de Recherches Aérospatiales (ONERA) 11/	F		3.9	44	1,900	NA
40	Oscilloquartz	CH	Watch Group ASUAG (CH)	0.5	54	100	NA
40	Philips	NL		0.5	54	380,000	NA
41	Plessey	UK		4.2	43	53,000	NA
42	RCA	UK	RCA Corporation (USA)	8.0	30	5,000	NA
43	Saab-Scania	S		15.9	22	40,000	NA
44	Selenia	I	STET Group (I) 8/ which is part of IRI Group (I) 4/	28,6	15	6,000	250
45	Sener	E		17.8	20	1,100	200
46	Siemens	D		14.9	24	320,000	NA
47	Société Anonyme de Télécommunications (SAT)	F		3.6	46	6,700	NA
48	Société Anonyme d'Etudes et de Realisations Nucleaives (SODERN)	F	Philips (NL)	7.3	32	330	NA

No.	Company	Nationality	Owned by	Contracts from ESA in MAU 2/	ESA supplier rank	Staff/ total	Staff/ space
49	Société Européenne de Propulsion (SEP)	F	controlled by French aerospace companies	247.3	1	2,500	2,500
50	Société Européenne d'Etudes et d'Essais d'Environment (SEEEE)	F	Thomson-Brandt (F) 12/	7.9	31	60	60
51	Société des Accumulateurs Fixes et de Traction (SAFT)	F	CGE Group (F) 13/	2.4	50	4,000	NA
52	Société d'Etudes Techniques et d'Entreprises Générales (SODETEG)	F	Thomson-Brandt (F) 12/	16.3	20	1,400	280
53	Société Nationale Industrielle Aerospatiale (SNIAS)	F		165.7	3	35,000	5,800
54	Standard Elektrik Lorenz (SEL)	D	ITT (USA)	12.6	25	33,000	100
55	Svenska Radio AR	S	L.M. Ericsson (S) and Marconi (UK)	1.2	53	2,100	NA
56	Technisch Physische Dienst (TPD-TNO)	NL	TPD is part of TNO (NL) which controls 35 laboratories	2.6	49	250	NA
57	Telespazio	I	IRI Group (I) 4/	7.2	33	350	NA
58	Teldix	D	AEG-Telefunken (D) and Bosch (D)	2.1	51	800	80
59	Terma Elektronik	DK		3.8	45	260	20
60	Thomson-CSF	F		39.9	11	60,000	NA
61	Vereinigte Flugtechnische Werke (VFW)	D		5.7	38	NA	NA

1/ The list includes all companies participating in contracts or tenders of the TELECOM Programme. The informations are as of end 1979 and were compiled from the publication: G. Dondi, Space Activities in the Eighties (Paris, ESA/SP-1012, 1981), ii, pp. 23-511.
2/ Includes all ESA projects, not only the TELECOM Programme, for the period 1972 to 1979.
3/ Aeritalia was formed through a merger in 1969 from the aerospace activities of the companies FIAT, Aearfer and Sacmoiraghi.
4/ 50,000 employees.
5/ Former British Aerospace Corporation (BAC).
6/ 70,000 employees.
7/ Former Hawker Siddeley Dynamics (HSD).
8/ 130,000 employees.
9/ Private non-profit organisation under auspices of the Danish Academy of Technical Science.
10/ 160,000 employees.
11/ Non-profit organisation.
12/ 3,000 employees.
13/ 180,000 employees.

No.	Company	Natio- nality	Owned by	Contracts from ESA in MAU 2/	ESA supplier rank	Staff/ total	Staff/ space
26	Hawker Siddeley Dynamics (HSD)	UK	see number 6, BADG/HSD				
27	Hollandse Signaal Apparaten (HSA)	NL	Philips (NL)	3.0	48	NA	NA
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29	International Computer Ltd (ICL)	UK		21.8	17	33,000	NA
30	Laboratoire Centre de Télécommunications (LCT)	F	ITT (USA)	4.4	41	800	NA
31	L.M. Ericsson	S		8.9	27	70,000	NA
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33	Marconi Communication System (CS)	UK	GEC Marconi Electronics (UK) which part of General Electric Company (UK) 10/	2.4	50	5,000	NA
34	Marconi Space and Defence Systems (MSDS)	UK	GEC Marconi Electronics (UK) which part of General Electric Company (UK) 10/	44.7	10	11,000	NA
35	MATRA	F		105.4	5	5,000	500
36	Messerschmitt-Bölkow-Blohm (MBB)	D		75.5	7	22,300	1,100
37	Montedel/Laben	I	Bastogi Sisteme (I)	19.6	18	250	110
38	National Lucht und Ruimtevaart (NLR)	NL		1.6	52	760	NA
39	Office National d'Etudes et de Recherches Aérospatiales (ONERA) 11/	F		3.9	44	1,900	NA
40	Oscilloquartz	CH	Watch Group ASUAG (CH)	0.5	54	100	NA
40	Philips	NL		0.5	54	380,000	NA
41	Plessey	UK		4.2	43	53,000	NA
42	RCA	UK	RCA Corporation (USA)	8.0	30	5,000	NA
43	Saab-Scania	S		15.9	22	40,000	NA
44	Selenia	I	STET Group (I) 8/ which is part of IRI Group (I) 4/	28,6	15	6,000	250
45	Sener	E		17.8	20	1,100	200
46	Siemens	D		14.9	24	320,000	NA
47	Société Anonyme de Télécommunications (SAT)	F		3.6	46	6,700	NA
48	Société Anonyme d'Etudes et de Realisations Nucleaives (SODERN)	F	Philips (NL)	7.3	32	330	NA

No.	Company	Nationality	Owned by	Contracts from ESA in MAU 2/	ESA supplier rank	Staff/ total	Staff/ space
49	Société Européenne de Propulsion (SEP)	F	controlled by French aerospace companies	247.3	1	2,500	2,500
50	Société Européenne d'Etudes et d'Essais d'Environment (SEEEE)	F	Thomson-Brandt (F) 12/	7.9	31	60	60
51	Société des Accumulateurs Fixes et de Traction (SAFT)	F	CGE Group (F) 13/	2.4	50	4,000	NA
52	Société d'Etudes Techniques et d'Entreprises Générales (SODETEG)	F	Thomson-Brandt (F) 12/	16.3	20	1,400	280
53	Société Nationale Industrielle Aerospatiale (SNIAS)	F		165.7	3	35,000	5,800
54	Standard Elektrik Lorenz (SEL)	D	ITT (USA)	12.6	25	33,000	100
55	Svenska Radio AR	S	L.M. Ericsson (S) and Marconi (UK)	1.2	53	2,100	NA
56	Technisch Physische Dienst (TPD-TNO)	NL	TPD is part of TNO (NL) which controls 35 laboratories	2.6	49	250	NA
57	Telespazio	I	IRI Group (I) 4/	7.2	33	350	NA
58	Teldix	D	AEG-Telefunken (D) and Bosch (D)	2.1	51	800	80
59	Terma Elektronik	DK		3.8	45	260	20
60	Thomson-CSF	F		39.9	11	60,000	NA
61	Vereinigte Flugtechnische Werke (VFW)	D		5.7	38	NA	NA

1/ The list includes all companies participating in contracts or tenders of the TELECOM Programme. The informations are as of end 1979 and were compiled from the publication: G. Dondi, Space Activities in the Eighties (Paris, ESA/SP-1012, 1981), ii, pp. 23-511.

2/ Includes all ESA projects, not only the TELECOM Programme, for the period 1972 to 1979.

3/ Aeritalia was formed through a merger in 1969 from the aerospace activities of the companies FIAT, Aearfer and Sacmoiraghi.

4/ 50,000 employees.

5/ Former British Aerospace Corporation (BAC).

6/ 70,000 employees.

7/ Former Hawker Siddeley Dynamics (HSD).

8/ 130,000 employees.

9/ Private non-profit organisation under auspices of the Danish Academy of Technical Science.

10/ 160,000 employees.

11/ Non-profit organisation.

12/ 3,000 employees.

13/ 180,000 employees.

Table 2: Cost to completion of the TELECOM programme in MAU at mid-1977 prices 1/

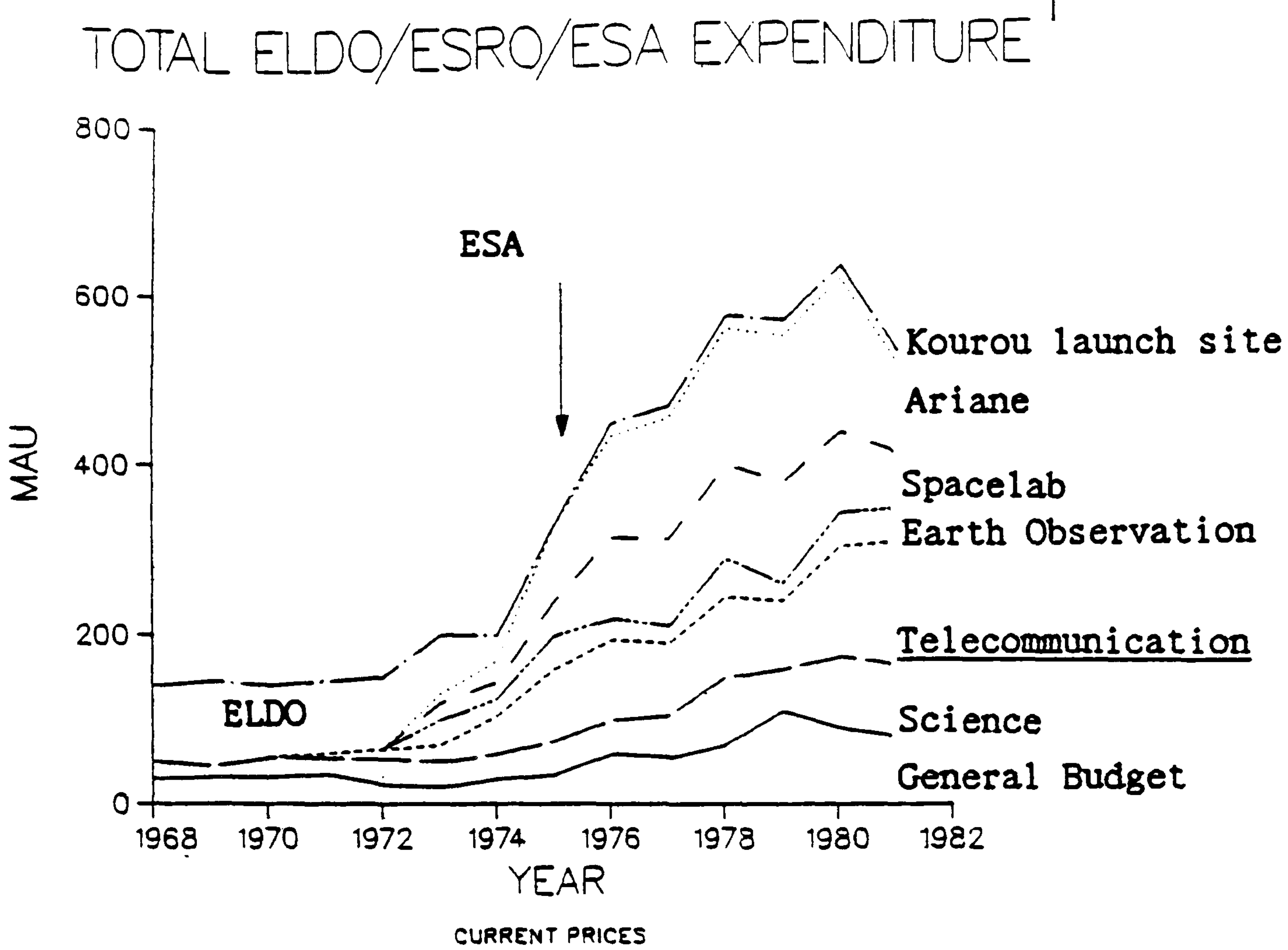
EXPENDITURE	Phase II 1972	1973	1974	1975	1976	1977	1978	1979	1980	Total	Phase III (ECS satellite) 1977	1978	1979	1980	1981	1982	Total
Direct External Costs																	
Communication System	0.54	0.79	0.47	0.20	0.09	0.03	0.06	–	–	2.18	–	–	–	–	–	–	–
Microwave technology	5.54	4.33	2.30	4.70	1.75	0.17	0.29	–	–	19.08	–	–	–	–	–	–	–
Spacecraft technology	0.07	2.20	1.69	1.05	0.87	0.45	0.25	–	–	6.58	–	–	–	–	–	–	–
ECS satellite	1.13	0.24	0.29	0.18	0.21	3.13	2.30	–	–	7.48	–	–	–	–	–	–	–
CTS and OTS 1	0.77	4.16	14.57	32.84	19.57	0.41	9.16	5.08	–	86.56	3.49	14.90	16.04	17.29	12.91	6.01	70.64
OTS 2/back-up	–	–	–	0.07	3.92	–	2.81	–	–	6.80	–	–	–	–	–	–	–
Launcher OTS 1	–	0.04	–	0.76	5.08	8.50	0.62	0.67	–	15.67	–	–	–	–	–	–	–
Launcher OTS 2 & ECS 1	–	–	–	0.05	0.87	1.81	13.61	0.72	–	17.06	–	–	6.50	9.00	8.94	–	24.44
Reimbursement to MAROTS	–	–	–	–	–	–	1.34	3.56	–	4.90	–	–	–	–	–	–	–
Preparation studies	–	–	–	–	0.57	1.44	0.50	0.02	–	2.53	–	–	–	–	–	–	–
Insurance OTS 1,2, ECS 1	–	–	–	–	–	1.26	3.54	–	–	4.80	–	–	–	–	3.50	–	3.50
Total	8.50	11.76	19.32	39.85	32.93	17.20	34.48	10.05	–	173.64	3.49	14.90	22.54	26.29	25.35	6.01	98.58
Direct Internal Costs																	
Personnel	0.96	1.66	1.20	1.47	1.70	2.08	0.57	0.23	0.22	10.09	–	1.18	1.29	0.84	0.77	0.38	4.46
Running	0.19	0.32	0.27	0.29	0.48	0.62	0.28	0.05	0.05	2.55	–	0.26	0.32	0.31	0.26	0.15	1.30
Facilities	0.01	–	–	0.10	0.21	0.39	0.74	0.21	–	1.66	–	0.03	0.09	0.13	0.04	0.02	0.31
Investment	0.71	0.65	0.08	0.26	0.42	0.83	0.48	0.05	–	3.48	–	0.90	0.50	2.30	1.98	0.02	5.70
Total	1.87	2.63	1.55	2.12	2.81	3.92	2.07	0.54	0.27	17.78	–	2.37	2.20	3.58	3.05	0.57	11.77
Indirect Costs																	
Administrative support	1.46	1.55	0.76	0.89	0.83	0.53	0.13	0.06	0.05	6.26	–	0.27	0.36	0.18	0.18	0.09	1.08
Special-to-project	4.45	4.67	1.10	2.33	3.87	3.95	3.01	0.94	2.28	26.60	–	0.10	0.35	2.52	1.78	0.30	5.05
Support accord. to usage	–	–	2.60	2.80	5.71	8.32	4.42	2.34	3.27	29.46	–	2.27	4.15	3.90	7.91	2.89	21.12
Total	5.91	6.22	4.46	6.02	10.41	12.80	7.56	3.34	5.60	62.32	–	2.64	4.86	6.60	9.87	3.28	27.25
Exchange rate losses	–	–	0.06	0.02	–	–	1.61	1.36	0.26	3.31	–	–	–	–	–	–	–
Insurance compensation 2/	–	–	–	–	–	–	(17.57)	–	–	–	–	–	–	–	–	–	–
TOTAL EXPENDITURE	15.83	20.61	25.39	48.01	46.15	33.92	28.15	15.29	6.13	239.48	3.49	19.91	29.60	36.47	38.27	9.86	137.60
ARRANGEMENT COST ESTIMATE 3/										211.53							128.94

1/ The table was compiled from following document: ESA/JCB(78)51, Reexamen des Couts a l'Achevement des Programmes TELECOM Phase II, ECS et MARECS et des Contributions a Programme, 8 Sept. 1978.

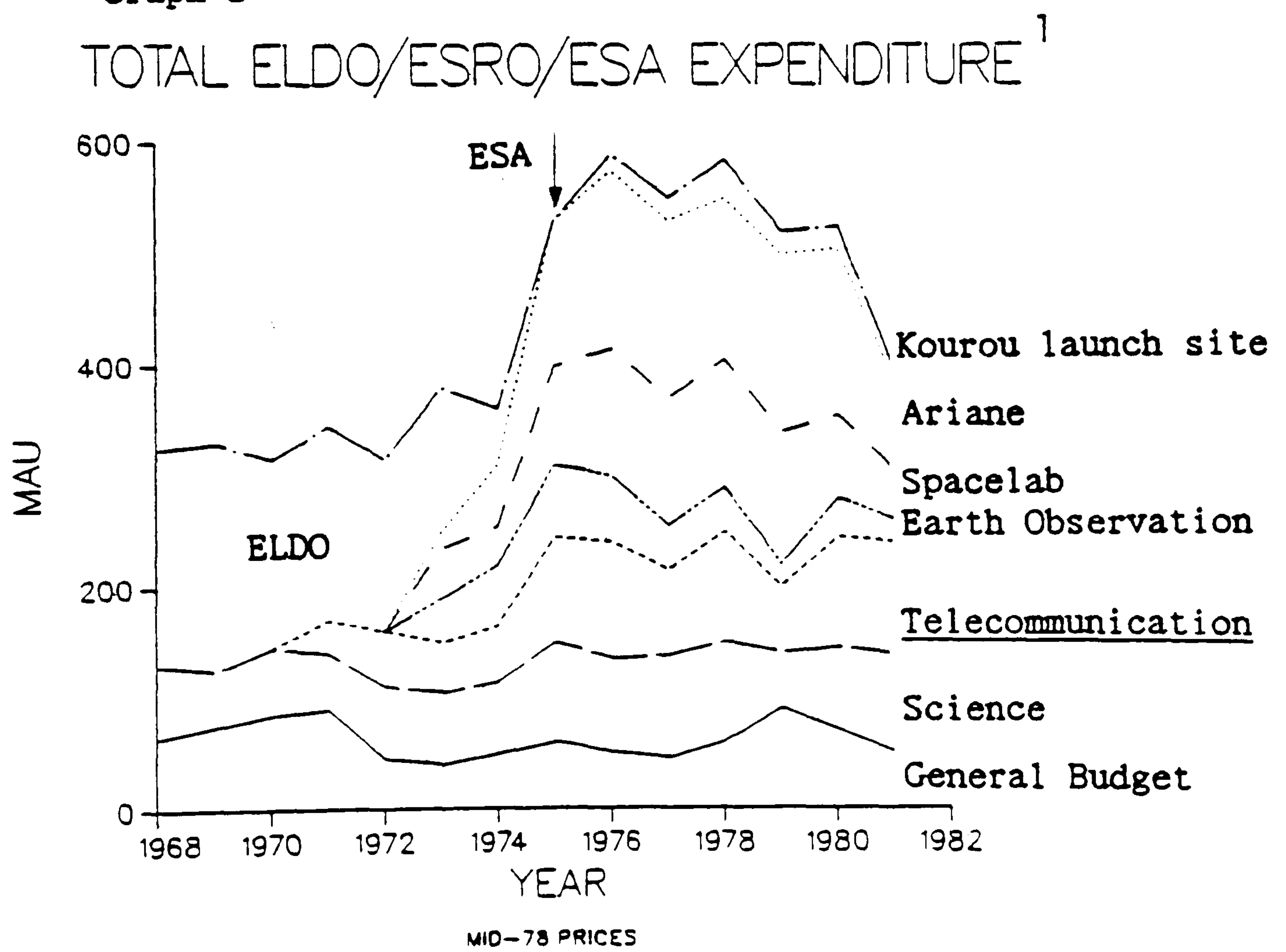
2/ Insurance compensation was paid after the launch failure of OTS 1.

3/ The TELECOM arrangement Phase II included total cost estimates of 147.5 MAU at mid-1972 prices. Adjusted for inflation to mid-1977 prices, this amount increases to 211.53 MAU. The TELECOM arrangement Phase III included total cost estimate of 128.94 MAU at mid-1977 prices.

Graph 1

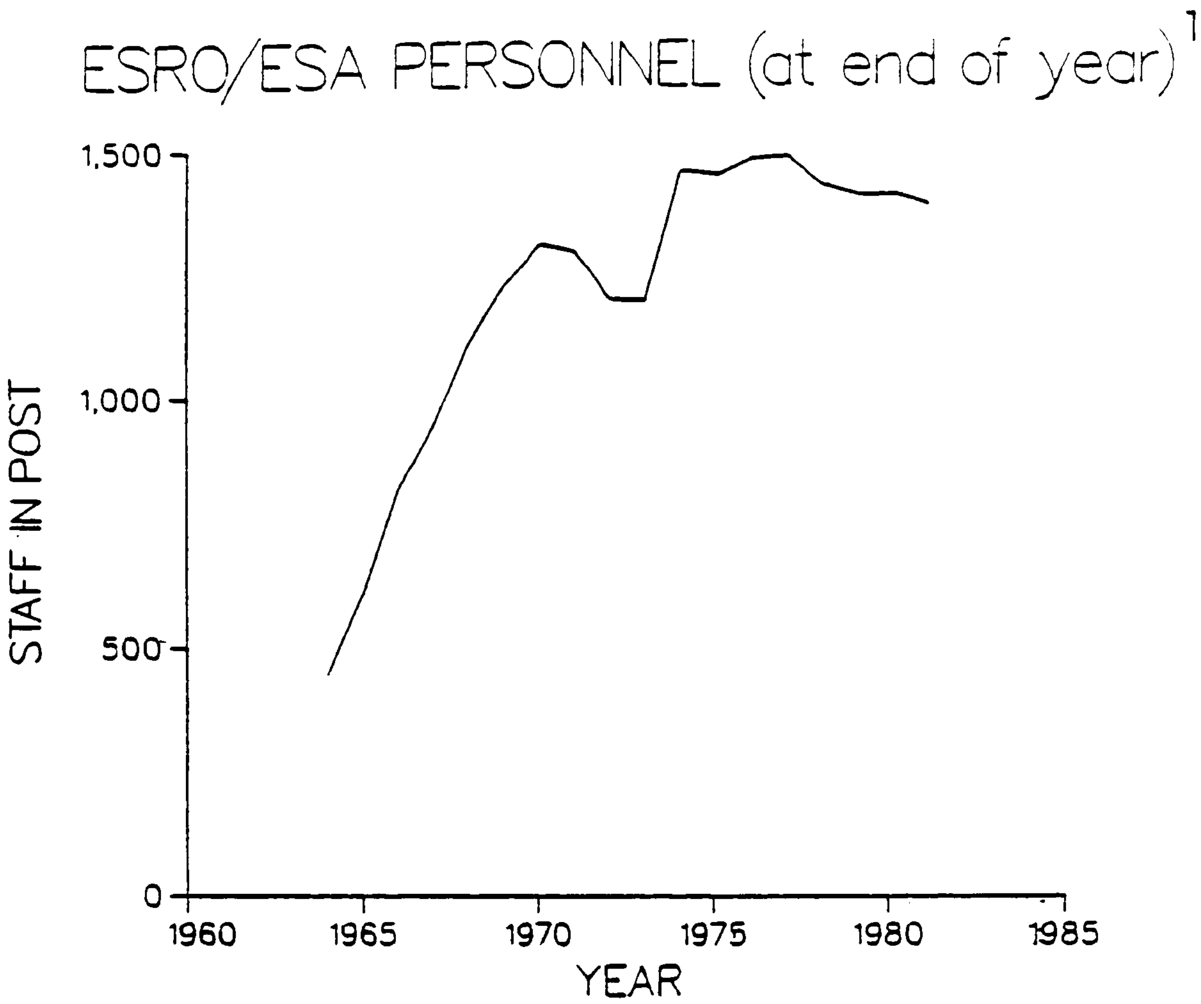


Graph 2

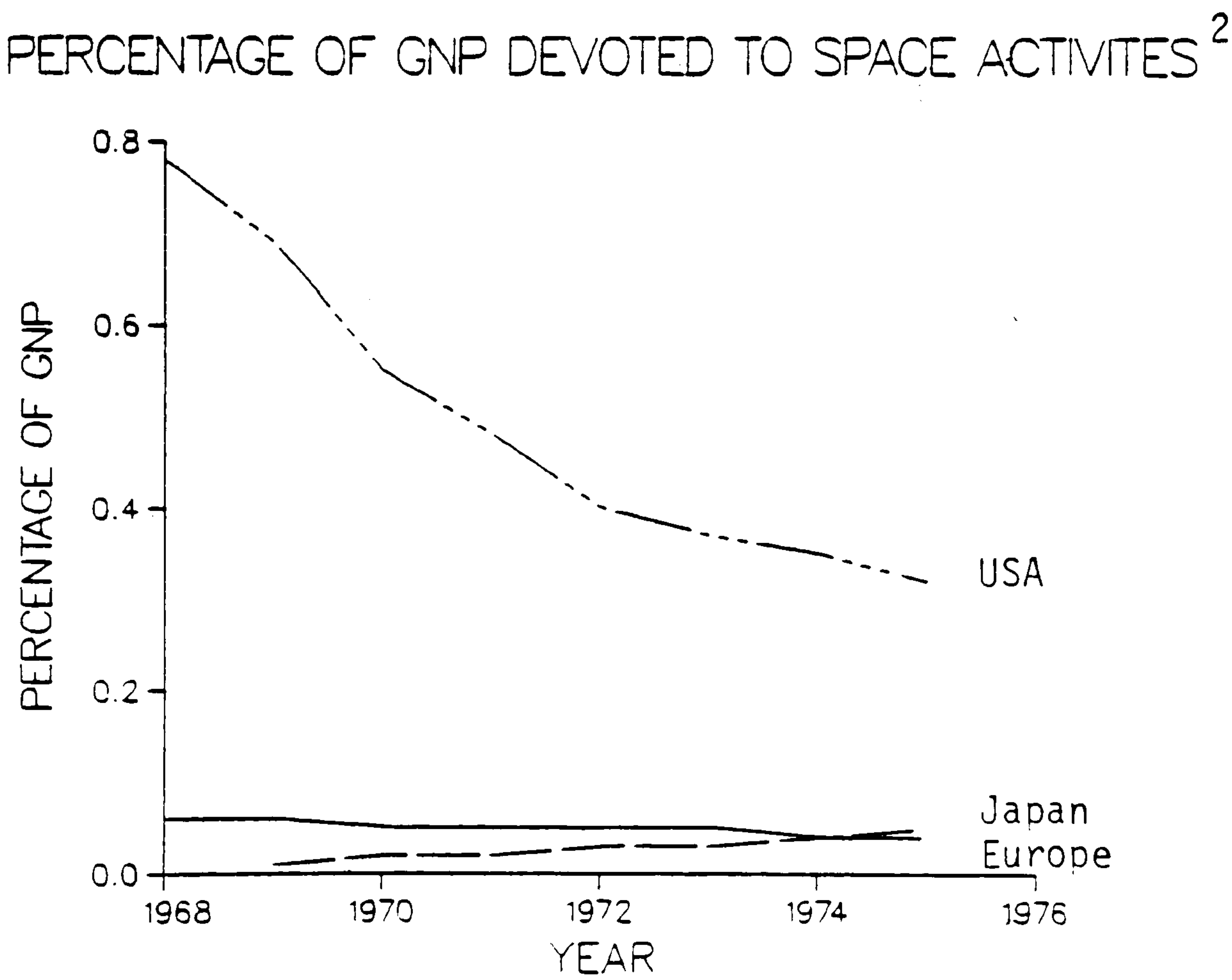


1/ L. Reuter, 'Forward-Looking Financial Planning', ESA Bulletin, V (1979), No. 18, 12; Annual Report 1979 to 1981 (Paris, ESA, 1980 to 1982); graph is own production.

Graph 3



Graph 4



1/ General Report 1964 to 1974 (Paris, ESRO, 1965 to 1975); Annual Report 1975 to 1981 (Paris, ESA, 1976 to 1982); graph is own production.

2/ Reuter, op.cit., 13.

Appendix B

Communication satellite systems and technology

1. Communication systems

Telecommunication networks which cover long distances can be classified in two categories: those using physical lines such as wires or cables and those using radio waves.1/ Radio waves are electromagnetic waves, waves of energy, which travel through space at approximately the speed of light and are produced by reversing the current in a conductor at frequencies from about 10 KHz to 3000 GHz.2/ A number of radio systems utilise skywave reflection from the ionosphere or atmospheric scattering from the upper layers of the troposphere. Those systems provide limited communication capability and are unreliable. In line-of-sight radio systems, such problems are overcome. They provide the same high communication capacity as cable systems but can be operated at lower cost, particularly in sparsely populated areas. Here, the radio waves follow a direct path of transmission between transmitter antenna and receiver antenna. In a terrestrial line-of-sight radio system, both antennas are mounted high above the ground (e.g., on towers). For economic reasons, radio towers are usually not higher than 30 meters; as a result the towers for a communication line are at 50 km intervals. Communication satellite systems are space-borne line-of-sight radio systems.

2. Communication satellite systems

In a communication satellite system, a transmitting earth station sends radio signals to the satellite, which returns the signals to a receiving earth station. If the earth station transmits and receives radio signals, a

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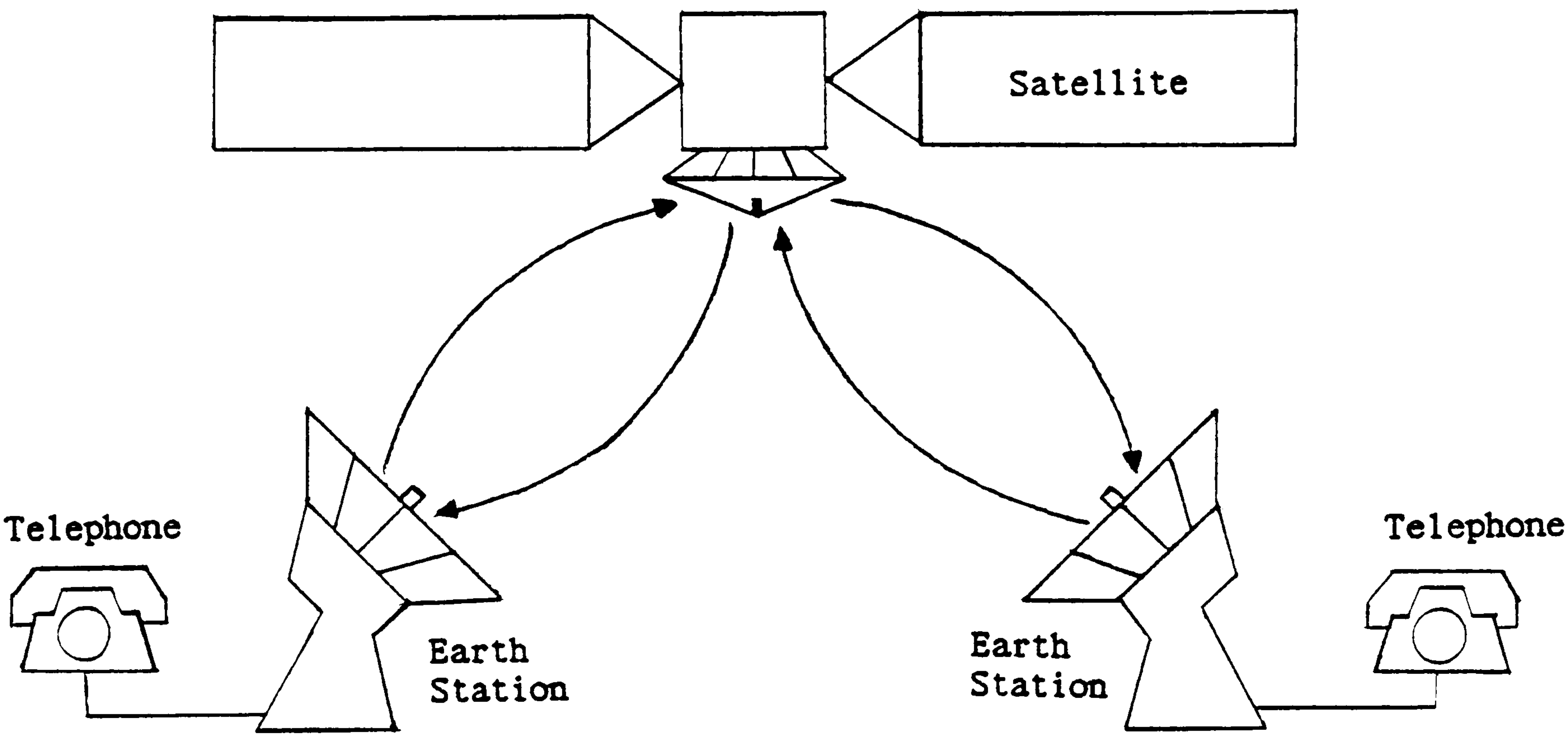
1/ L. Yeh, 'Satellite Communications and Terrestrial Networks', Telecommunications, XIX (1977), 23-30.

2/ Hz (Hertz) is the unit of frequency equal to one cycle per second. K stands for kilo and G for giga.

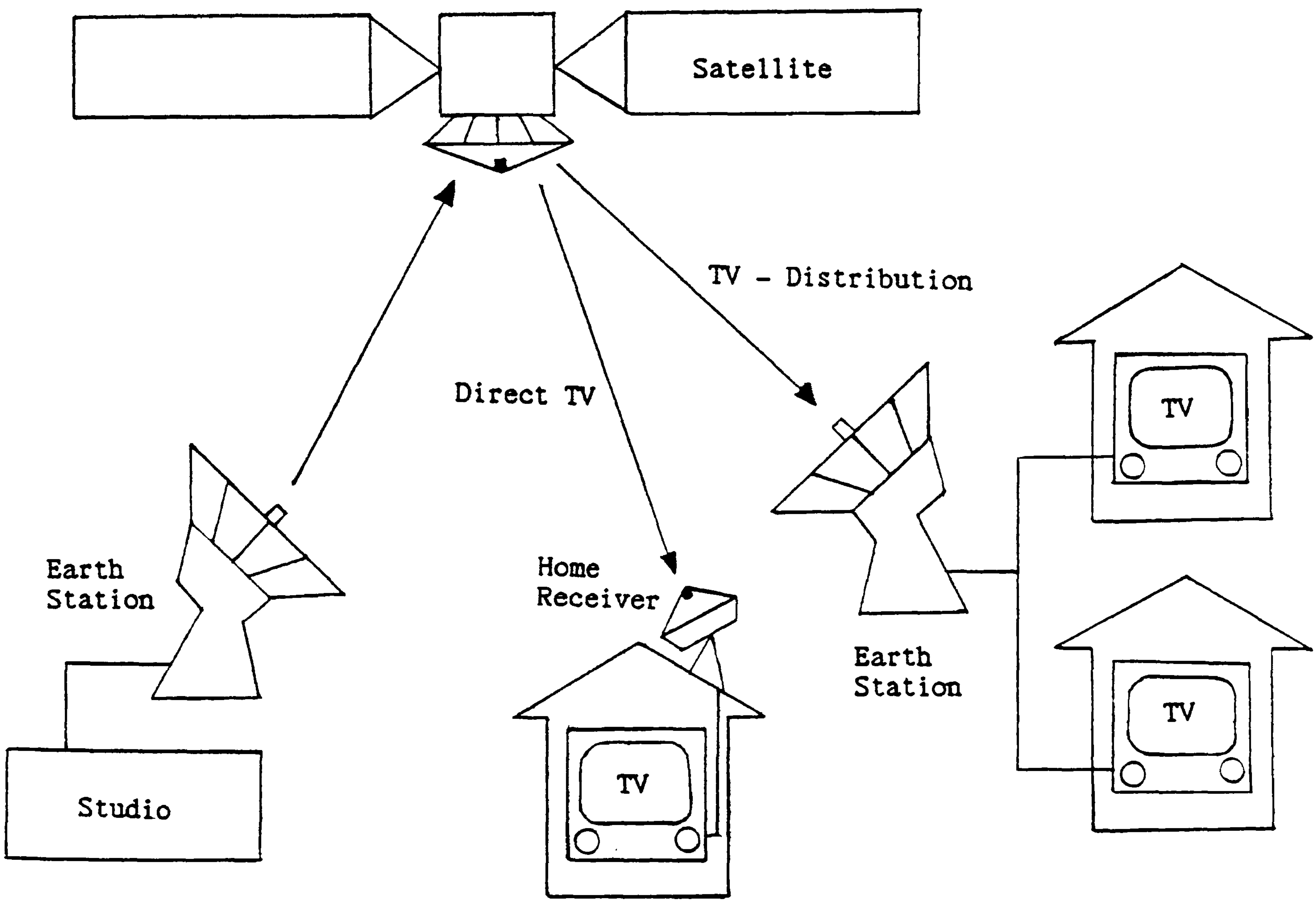
communication circle is established, e.g., for telephone communication. The following graph illustrates the system.



Communication satellites act as repeaters: they receive the weak radio signals and transmit corresponding stronger signals back to earth. Satellites can have a communication capacity similar to that of terrestrial line-of-sight systems.

Satellites rotate around the earth. At a height of 36,000 km above the earth, the angular velocity of the satellite is equal to that of the earth. Hence, for an observer from the earth, the satellite appears to remain stationary in space. Geostationary satellites are the preferred type for communication systems. They not only make possible a fixed earth station orientation, but also provide wide communication coverage: three geostationary satellites cover the whole earth. In fact, the ability to bridge intercontinental distances will one satellite is the prime advantage of the system.

Besides establishing communication circles, communication satellites can serve as transmitting antennas for radio, TV or direct TV services. The satellite receives the signals from the earth station and sends them back to earth without establishing a returning connection. Whereas a semi-direct TV satellite transmits to an earth station which subsequently feeds the signals into a terrestrial distribution network, a direct TV satellite transmits directly to the end user antennas, as shown in the following illustration.



3. Communication satellite system parameters

A communication satellite system is defined within the following major parameters: the satellite (space segment), the earth station (earth segment), and the frequency on which the system operates.1/

Space segment: The mass and size of the satellite must be compatible with the capacity of the launcher used to place it in orbit. System characteristics like communication capacity, satellite lifetime and reliability have to be reconciled with this constraint.

Earth segment: In general, a satellite system includes a number of earth stations scattered within the area of service. Since they represent a major fraction of the total system costs, an optimum balance has to be found between space and earth segments. The cost of an antenna, for example, increases steeply if it is more than 15 to 20 m in diameter. Increasing the power capacity of the satellite also increases its cost, but limits the need for large earth station antenna reflectors.

Frequency spectrum: In order to avoid interference, a particular frequency spectrum can be used in the same location by only one radio system. Since the spectrum is limited, it is difficult to allocate sufficient frequency bandwidth in the preferred frequency range. Whereas the bandwidth constrains the volume of communication traffic, the frequency range has an impact on the effectiveness of the communication link. Since communication satellites were late-comers in radio transmission, they were forced to operate within the constraints defined by the terrestrial system. The European Communication Satellite (ECS) operates in the frequency range of 14 to

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1/ P. Bartholomé, 'The European Communications Satellite Programme', ESA Bulletin, IV (1978), No. 14, 40-2; B. Edelson, L. Pollack, 'Satellite Communications', Science, CLXXVI (1977), 1125-33.

14.5 GHz for transmissions from the earth stations to the satellite (uplink) and 10 to 10.5 GHz for transmissions from the satellite to the earth stations. Hence, the satellite operates in the 11/14 GHz range, utilising a bandwidth of 0.5 GHz.

Frequency range: Radio signals from communication satellites, which traverse the atmosphere, can suffer attenuation, limiting the effectiveness of the satellite system. At frequencies in the 4 to 9 GHz range, which are occupied by European terrestrial systems, such attenuation is minimal. It increases exponentially, however, at frequencies above 10 GHz. Atmospheric attenuation depends on the weather conditions prevailing at the location of the earth station; it is highest when rain is falling. Costly technical provisions are required to offset the effect of attenuation in the higher frequency range.

Bandwidth: The bandwidth allocated to the ECS satellites was limited to 0.5 GHz or 500 MHz. In order to increase the communication capacity of this bandwidth, a number of sophisticated communication techniques had to be used, such as frequency re-use, digital transmission, time division multiple accessing (TDMA) and speech interpolation.

4. Satellite technology development work

Advanced technology is essentially a complex collection of hardware, which does not, in fact, contain any very advanced parts.1/ If one can avoid it, one does not innovate by using new devices but rather relies on equipment which has undergone a long series of tests. The advances lie in the ways many different pieces of equipment are put together. This is extremely complex and

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1/ Bondi, op.cit., 16.

costly. For a single satellite, development and quality control represent approximately 80% of the total cost, while manufacturing accounts for only 20%. If a whole series of satellites can be produced, manufacturing becomes the predominant cost.

When developing satellite technology, one attempts to minimise weight and cost, to maximise reliability and performance and to ensure the compatibility of satellite technology parts.1/ Since those objectives are often in conflict, different trade-off options have to be compared in order to select the optimum solution. The definition of the overall satellite parameters within such an optimisation process is called system engineering. The development of a satellite goes through a series of models and tests to ensure that potential problems can be solved while the satellite is still on the ground. For example, a satellite model is tested in a vacuum chamber, using temperatures higher than those expected in space, to check material sublimation or thermal behaviour. Vibration tests are conducted to simulate stress conditions during satellite launch.

5. Satellite technology

Satellite technology is usually described in terms of standard sets of modules and sub-systems which perform specific tasks. A number of different classifications and technical solutions are possible, but only those used in the TELECOM programme are described here. An illustration of a communication

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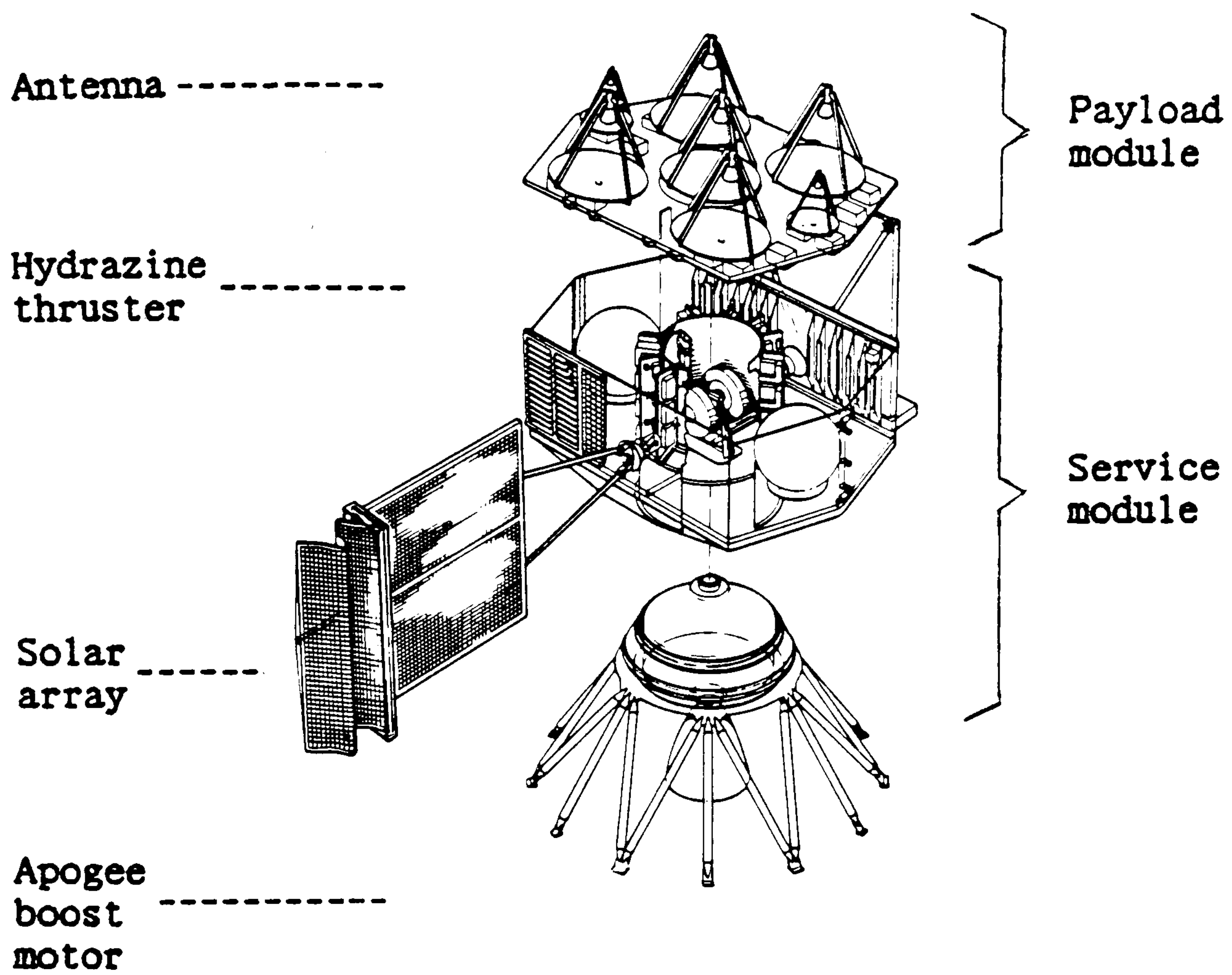
1/ M. Davidoff, 'Satellite Systems', Journal of the British Interplanetary Society, XXXII (1979), 339-46.

satellite configuration is given below.1/



A brief description of communication satellite modules, subsystems and functions is given on the following page.

1/ General Report 1971 (Paris, ESRO, 1972), p. 119.

Module	Subsystem	Function
Payload module	Communication payload	Provides for reception and transmission of radio signals
Service module	Attitude and orbit control system (AOCS)	Keeps satellite in required orbital position
	Telemetry, tracking and command (TTC)	Measures the operating status of on-board subsystems, determines satellite's orbital position, transmits those data to earth, receives spacecraft commands
	Power	Provides power for all on-board subsystems
	Thermal control	Regulates temperature level
	Apogee boost motor	Provides thrust for orbital changes, in particular from the transfer orbit where the satellite is released by launcher to near-synchronous orbit
	Structure	Provides the support, protection and packaging function

The key technologies of communication satellite subsystems can be identified as follows.1/

Communication payload: This subsystem includes the antennas and the repeater. The repeater receives, translates and retransmits the signals after amplification and incorporates a number of independent repeater chains which may be used according to communication traffic requirements. A key element of the repeater is the travelling wave tube amplifier (TWTA), which amplifies the communication signals. TWTAs use a lot of electric power and are

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1/ Collette, et al., 'The Orbital Test Satellite', op.cit., 6-14; B. Stockwell, et al., 'Technological Developments Needed for Communications Satellite Systems', ESA Bulletin, II (1976), No. 5, 21-2.

regarded as critical in terms of reliability. A repeater chain can include a number of TWTAs, some of which are provided as redundant equipment in case of single TWTA failures.

Attitude and Orbital Control: This subsystem incorporates sensors, momentum wheels, the propulsion reaction system and hydrazine thrusters. Sun or earth sensors are used to detect the position of the satellite axis in reference to sun or earth. Momentum wheels can be seen as rotating tops which absorb pitch disturbances by varying their speed. If the angular momentum of the wheel changes, then the angular momentum of the rest of the satellite changes in the opposite direction. Propulsion reaction systems are essentially small rockets which may be switched on and off in order to perform station manoeuvres; they are under the control of the attitude control system.

Telemetry, tracking and command: This subsystem consists of an antenna, receiver, transponder and transmitter, like the communication payload. The subsystem, however, is only concerned with communications required to operate the satellite in orbit.

Power: This subsystem includes solar arrays carrying solar cells, the batteries and the bearing and power transfer assemblies (BAPTA). The solar cells produce the electric power to operate the service and payload modules. The BAPTA rotates the solar arrays in order to position them towards the sun. Electrical energy is stored in batteries which operate the satellite when it is eclipsed from the sun by the earth.

Thermal control: This subsystem includes aluminium radiator plates to disperse heat, insulation for thermal regulation and a heater to maintain necessary thermal conditions during eclipse.

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1.1 Unpublished documents

The author was able to make extensive use of unpublished material from organisations such as CEPT, CETS, ESA, ESC, ELDO and ESRO. Access to those documents was granted at ESA's archives in Paris (headquarters), Noordwijk (ESTEC) and Darmstadt (ESOC).

For illustrative purposes, the unpublished documents are listed according to the organisation by which they were produced. The bibliography does not list every document used, but rather describes the categories of documents in cases where the author has relied to a large extent on those materials. In other cases, single unpublished documents are listed.

(A) Conférence Européenne des Administrations des Postes et des Télécommunications (CEPT)

Single document

Doc T/CCTS(71)24E, Study on the European Telecommunication Satellite System, July 1971.

(B) Conférence Européenne des Télécommunications par Satellite (CETS)

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SCL/CD/8E, 23 Jan. 1968 (Technical CETS document on communication satellites).

SCL/Co.25/7E, Report of the Chairman of the European Conference on Satellite Communication to the European Space Conference, 11 July 1967.

SCL/TPS/116, Supplement to the Report on European Potential and Recommended Development Plan, 6 Sept. 1966.

SCL/TPS/166, 14 Nov. 1968 (Technical CETS document on communication satellites).

SCL/TPS/217E, Economic Potential for Europe in Application Satellite, 30 May 1967.

SCL(66)4E, Technical Specifications for a Programme Study of a European Experimental Communication Satellite, 11 Nov. 1966.

SCL(66)18E, Economic Potential of a European Communication Satellite System, 28 Nov. 1966.

SCL(66)21E, Feasibility Study on Future Applications, 28 Nov. 1966.

(C) European Launcher Development Organisation (ELDO)

Document categories

ELDO/C(year)PV number: Minutes of the Council meetings between 1965 and 1968.

ELDO/C(year)number: Documents submitted to the Council meetings between 1965 and 1968.

ELDO/CM(month year)PV number: Minutes of the Ministerial Conferences between 1965 and 1968.

ELDO/CM(month year)number: Documents submitted to the Ministerial Conferences between 1965 and 1968.

ELDO/Sec(year)number: Papers from the secretariat between 1965 and 1968.

(D) European Space Agency (ESA)

Document categories

ESA/AF/MIN/1-46: Minutes of the Administration and Finance Committee meetings between 1975 and 1983.

ESA/AF(year)number: Documents submitted to the Administration and Finance Committee between 1975 and 1983.

ESA/C/BUR(year)number: Papers from the ESA Bureau between 1977 and 1983.

ESA/C/MIN/1-51: Minutes of the Council meetings between 1975 and 1983.

ESA/C(year)number: Documents submitted to the Council meetings between 1975 to 1983.

ESA/C-M(77)1-23: Minutes of and documents submitted to the Ministerial Conference in 1977.

ESA/IPC/MIN/1-49: Minutes of the Industrial Policy Committee meetings between 1975 and 1983.

ESA/IPC(year)number: Documents submitted to the Industrial Policy Committee meetings between 1975 and 1983.

ESA/IPC-AF/WG/MIN/1-2: Minutes of the Joint IPC-AFC Working Group on Contract Rules meetings between 1977 and 1978.

ESA/IPC-AF/WG(year)number: Documents submitted to the Joint IPC-AFC Working Group on Contract Rules meetings between 1977 and 1978.

ESA/IPC-IRWG/MIN/1-2: Minutes of the IPC-Industrial Return Working Group meetings in 1977.

ESA/IPC-IRWG(77)1-4: Documents submitted to the IPC-Industrial Return Working Group meetings in 1977.

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ESA/JCB(year)number: Documents submitted to the Joint Communication Satellite Board meetings between 1975 and 1983.

ESA/committee abbreviation/roman number/Res. number: Resolutions approved by the corresponding committees.

Single documents

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Letter of the Chairman of the CCTS, Mr. F. Locher, to the Director General of ESA, dated 2 Apr. 1976

Minutes of the Preparatory Meeting for the Setting-up of the Internal Group for Industrial Policy (GIPI), ESTEC, 12 Sept. 1975

Report on the Status of the Heavy Satellite Programme (H-SAT) as of 15 November 1977, ESTEC (no date given, approximately end of November 1977).

(E) European Space Conference (ESC)

Document categories

CSE/CM(month year)PV number: Minutes of the Conference meetings between 1966 and 1975.

CSE/CM(month year)number(Final): Resolutions approved by the Conference between 1966 and 1975.

CSE/CS(year)PV number: Minutes of the meetings of the Committee of Alternates between 1967 and 1972.

CSE/CS(year)number: Papers from the Committee of Alternates between 1967 and 1972.

CSE/HF(year)number: Papers from the Senior Officials between 1969 and 1970.

Single document

CSE/CCP(67)5, Report of the Advisory Committee on Programme, 23 Jan. 1980.

(F) European Space Research Organisation (ESRO)

Document categories

ESRO/AF/MIN/1-108: Minutes of the Administration and Finance Committee meetings between 1964 and 1975.

ESRO/AF/1-1073: Documents submitted to the Administration and Finance Committee meetings between 1964 and 1970.

ESRO/AF(year)number: Documents submitted to the Administration and Finance Committee between 1971 and 1975.

ESRO/C/APP/1-117: Papers from special committees established to study the organisation between 1967 and 1970.

ESRO/C/APP(year)number: Papers from special committees established to study the organisation between 1971 to 1972.

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