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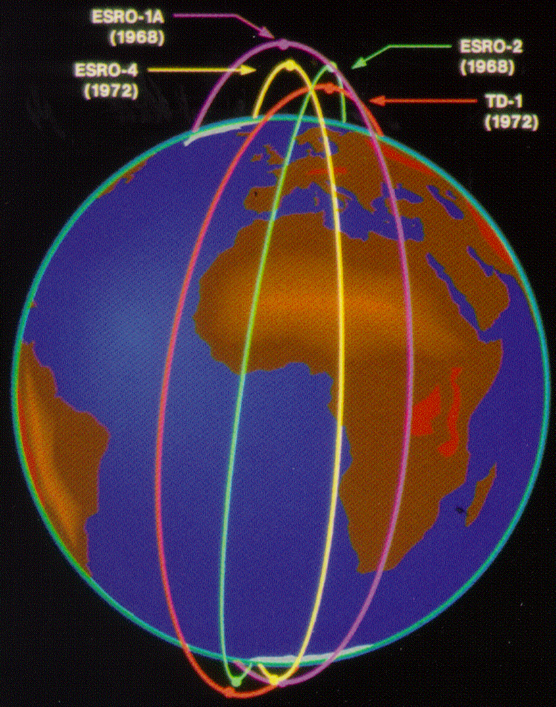
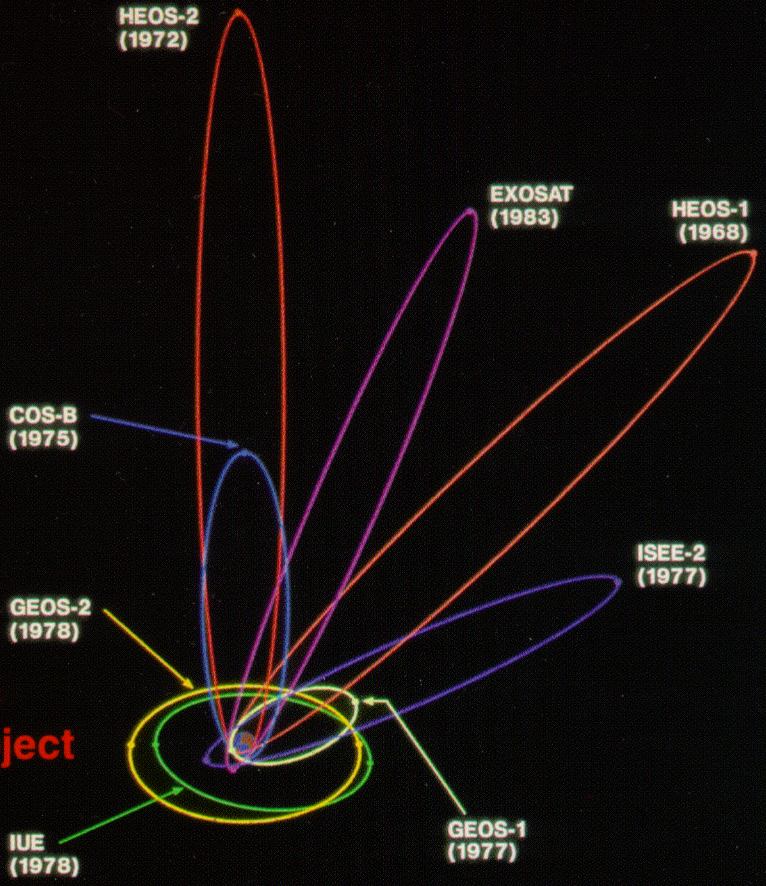
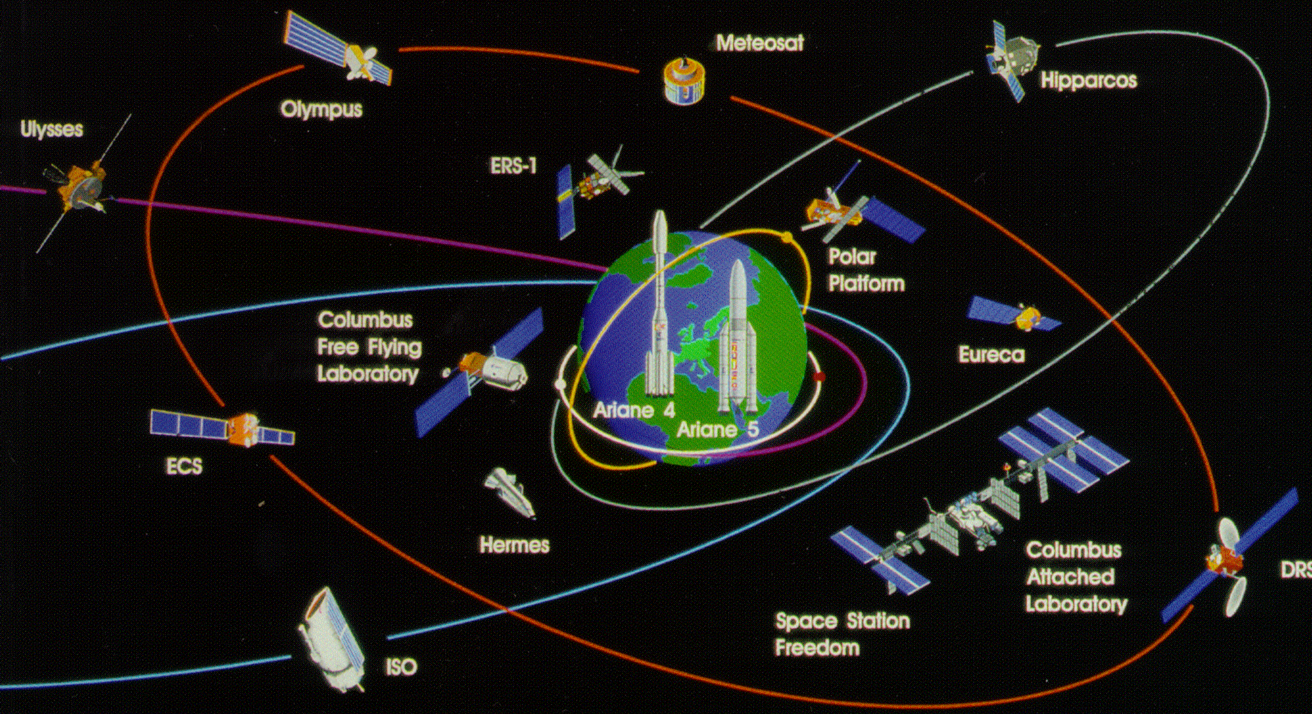




ESRO's Telecommunications Programme and the OTS Project (1970-1974)

by Arturo Russo



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ESRO'S TELECOMMUNICATIONS PROGRAMME AND THE OTS PROJECT (1970–1974)

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Arturo Russo

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INTRODUCTION

In a previous report in this series we discussed the start of ESRO's telecommunications satellite programme in the late 1960s.[1] It was at the end of 1966 that the ESRO Council agreed to undertake a preliminary study on the technical feasibility and economic viability of a joint European communications satellite system, on behalf of the European Conference on Satellite Communications (CETS). Five years later, after further studies and laborious negotiations, the Council itself finally approved the start of a research and development (R&D) programme aiming at establishing such a system in the 1980s, in collaboration with the Conference of European Postal and Telecommunications Administrations (CEPT).

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1 Russo (1993a).

This difficult beginning was analysed against a background whose main aspects can be summarized in the following elements. Firstly, the European start in space telecommunications occurred much later than the developments in this field realized in the United States. The first commercial service of satellite communications was inaugurated in the summer of 1965 by the American satellite *Early Bird*, after several years of experimentation with satellites like *Echo*, *Telstar*, and *Syncom*. *Early Bird*, eventually renamed *Intelsat I*, was followed in 1967 by three *Intelsat II* satellites. Two years later, the third generation of Intelsat satellites established a world-wide service, with one satellite over each of the earth's oceans and many ground stations spread all over the world. At the beginning of the 1970s, the U.S. still controlled the technology of communications satellites and dominated the international consortium Intelsat, created in 1964 with the task of establishing and operating a global commercial system. Any European undertaking in this rapidly expanding field meant leapfrogging the technological gap and finding a viable niche within the Intelsat system.

The second element regarded the institutional framework in which the European initiative took place. ESRO, the European Space Research Organization, had been formally established by ten European countries in 1964 as an organization solely devoted to space research. Its programme included the launching of sounding rockets and spacecraft to investigate physical phenomena in the upper atmosphere and the earth's magnetosphere, and to observe celestial bodies from outside the atmosphere. The Organization's charter did not consider the building of application satellites, and even though its executive and technical staff looked with interest upon the involvement in this field, this required the definition of a new Convention and new financial arrangements from member states. This was not the only problem, however. More important by far was the question of launching the spacecraft that ESRO was to build. A second multinational organization did exist in Europe to develop launchers, the European Launcher Development Organization (ELDO), which included six of ESRO's member states, plus Australia. ELDO, however, was hampered by severe managerial problems and the cost of its programmes escalated dramatically. A strong disagreement then arose between countries sceptical about the prospects of a European launcher development programme and those firmly committed to achieving European autonomy in launching capability. Britain and France led the opposite camps, the former stressing the high cost of the envisaged European launchers in comparison with the American vehicles, and the latter insisting that Europe could not sustain a credible space policy without the availability of its own launchers.

This brings us to the third element of the background, namely the discussions and negotiations about a coherent space policy to be pursued by Europe. Ten years after the first Sputnik's historic launch, space no longer appeared as merely a new frontier for esoteric scientific investigation or a spectacular stage for the ongoing political and military confrontation between the two superpowers. Social and economic objectives were more and more among the principal aims of space programmes, and space appeared as an important ground for technological innovation in all industrialized countries. Whence a challenge for the Old Continent: which space policy for Europe? How to set European aerospace and electronic industry to compete successfully with their American and Japanese counterparts? How to cope with the economic and cultural challenges that communications satellites posed on a planetary scale? How to take advantage of Western Europe's position in the "free market area" without suffering from the economic and military supremacy of the United States? To these and other questions the European countries gave different and even conflicting answers, according to their respective interests and policies. Finding a compromise, or a "package deal" as it was eventually called, was not easy but it was a necessary condition before agreeing on the start of ESRO's telecommunications programme.

Finally, the fourth element we must recall here is the question of users. Developing a communications satellite system for Europe implied in fact some commitment from the post, telephone and telegraph (PTT) administrations and from television companies to use such a system to provide services to their customers. But such a commitment could only be granted if satellites proved more economical than the ground network, and this was by no means obvious. On the contrary, the potential users' economic studies showed that the satellite system would hardly be viable and its operating cost could not be charged on telephone bills.

When, in December 1971, the ESRO Council approved the start of the telecommunications programme, the problems referred to above had found a first solution. The new Intelsat agreements provided for the possibility of establishing regional communications satellite systems and ESRO engineers, in collaboration with industry, had designed a programme foreseeing the development of advanced spacecraft and communications technologies. With regards to the institutional aspects, ESRO member states had agreed on a package deal that definitely transformed the Organization into one mainly devoted to the implementation of application satellite programmes. And if the problem of launchers was still under discussion, a compromise was agreed on by which ESRO would give priority to European rockets, if available, on the condition that the cost of launching did not exceed 125 % of the cost of using a non European vehicle. Finally, the question of users had also been settled, at least partially. While not committing themselves yet to using the envisaged satellite system, both the CEPT and the European Broadcasting Union (EBU) had agreed to be involved in the design of ESRO's telecommunications programme, on the basis of their forecasts about tele–communications traffic and Eurovision distribution in the 1980s.

In this paper we will discuss the first phase of implementation of ESRO's tele–communications programme and the definition of the OTS (Orbital Test Satellite) project. We shall see how two main questions were debated in this period which posed a serious challenge to the ESRO executive's negotiating capability. The first is again the question of users, i.e. the economic viability of the system. While expressing their interest in being involved in the experimental phase of the programme, the PTT administrations reserved their position about the use of the eventual operational system until the real economic advantage of such a system was demonstrated. The second question regarded the essential tension between the national interests of ESRO member states and their cooperative undertaking in the Organization. The telecommunication programme, in fact, involved a large scale technological effort in key industrial sectors, with important financial investments and promising returns on the commercial level. ESRO's scientific programme as well as the various national space programmes in the 1960s had made possible the formation of a significant industrial capability in Europe; the consolidation and success of national industries and individual companies now strongly depended on the much more important communications satellite programmes of the 1970s and 1980s. ESRO's member states entrusted to the Organization not only the task of building and launching application satellites but also that of achieving this objective in the framework of an industrial policy whose main element was the so–called "just return" principle, namely that each member state should receive a share of the Organization's high–technology industrial contracts equal to the share of its financial contribution to it. And it was not easy, of course, to implement such a principle against strong conflicting interests in a rapidly expanding new field.[2]

The narrative is divided into three main parts. The first deals with the definition of the programme in the months preceding the actual approval of it by the ESRO Council. This process involved negotiations with the CEPT and intertwined with the discussions that eventually led to the ESRO's package deal. The programme, as it was approved in December 1971, consisted of two phases: the first aiming at developing and launching an experimental satellite; the second at developing and launching the final operational unit. The start of the experimental phase until the approval of the OTS project and the associated technological research programme will be the object of the second part of this paper. The main issue in this analysis will be the conflict between national interests, in particular between the countries with ongoing national communications satellite programmes and other ESRO member states. In the framework of this conflict, the OTS solution represented the result of a successful initiative of the ESRO executive, supported by the expertise of the Organization's technical staff. The third part will present the early implementation of the OTS project, with special emphasis on the industrial policy aspects involved in the choice of the contractors for building the satellite and its earth control station.

THE DEFINITION OF ESRO'S TELECOM PROGRAMME (1970–1971)

The fourth session of the European Space Conference (ESC) held in Brussels in July 1970 agreed that ESRO should undertake a programme with the aim of establishing by 1978–1980 an operational European communications satellite system (hereafter Telecom programme). The objective of the programme was to provide in the 1980s a satellite system capable of handling a certain percentage of the total telecommunication traffic between CEPT member countries, and capable of distributing real-time television programmes in the EBU Eurovision area. The programme was also intended to fulfil a technological objective, i.e. the qualification of the European industry in the satellite telecommunication field, in order to make it capable of participating competitively in the development of future communications systems such as the Intelsat V system. The total cost of the

[2] For a thorough analysis of the industrial policy aspects of ESRO's telecommunications programme see Müller (1990).

programme was estimated at 450 MAU.[3] The ESC decision came after several years of technical and economic studies.[4] The Conference, however, authorized and funded only the very first phase of the programme, i.e. "parametric studies on all aspects of the operational system in cooperation with the telecommunication and television administrations and agencies concerned [and] the development of the first experimental ground and orbital elements of this satellite programme."[5] The sum of 5 MAU was made available to ESRO to pursue this preliminary work up to mid–1971, when a decision to proceed to the next stage of the programme would be taken by the participating countries by a double qualified majority, i.e. a positive vote of two–thirds of states covering at least two–thirds of contributions.

The caution expressed by the participants in the Brussels meeting towards full commitment in the telecommunications programme derived from three main reasons. Firstly, the still uncertain situation regarding the overall European space policy, in particular about the controversial question whether Europe should build its own launching vehicle or rely on American rockets. Secondly, the uncertainty about the economic aspects of the programme, in particular whether a European communications satellite system would be more economical compared with the expanding ground network. Finally, the telecommunications programme represented an important technological challenge for ESRO and for the European industry, which suffered from a ten–year delay with respect to their American counterpart. In order to reach a competitive position in this rapidly expanding industrial and commercial field Europe had to develop second generation communications satellites , and for all the optimism of ESRO engineers success could not be assured.

The preparatory programme for a European communications satellite system agreed at the July 1970 session of the ESC survived the dramatic crisis of the following November session of the same conference, again in Brussels. Here, the deep disunity between countries favouring a "coherent space policy" that would include the development of a European heavy satellite launcher, on the one hand, and those that considered that this was a wasteful use of limited resources, on the other, reached such a magnitude that a compromise could not be agreed on and the

[3] *ESRO/ELDO Bulletin*, n. 11 (September 1970), p. 12 (Resolution n. 1 of the Conference). MAU stands for *Million Accounting Units*, ESRO's conventional monetary unit based on a gold standard. One AU was roughly equivalent to one US dollar.

[4] Russo (1993a).

[5] *ESRO/ELDO Bulletin*, n. 11, cit., p. 12.

conference collapsed after the first day. A door was left open for further negotiation, however, as the Conference did agree on a resolution which invited ESRO to take the appropriate budget decisions for 1971. And in fact the ESRO Council succeeded in keeping alive the telecommunication and other application programmes, as well as the very idea of a European joint effort in space.[6] The Telecom programme budget for 1971 was approved as outlined in the resolution of the July ESC meeting (i.e. 5 MAU until mid-1971), and the Council authorized to undertake hardware development. Moreover, a new Interim Application Programme Committee (IAPC) was established, with the task of supervising the implementation of these programmes and of making recommendations to the Council.[7]

The positive vote on the Telecom budget was not important from the political point of view, as it concerned only the completion of the preliminary phase decided on in July by the ministers while the passage to the actual development of the programme was to be decided later on. But in the delicate political situation following the ESC crisis it was by no means obvious that the ESRO member states would be willing to make a further commitment to a programme alien to the Organization's charter and whose future was so uncertain. In fact, this vote was made possible by one important element, namely the decision to start negotiations for a revision of the ESRO Convention in order to include application programmes and to provide for optional participation of member states to the various programmes instead of mandatory participation to all. This condition had been put forward by France and Belgium, which wanted to shift their contribution to the ESRO programme and to concentrate on applications rather than on scientific projects. The Council agreed to entrust to its new chairman, the Italian physicist G. Puppi, the task of negotiating a suitable compromise in order to guide the Organization to the new institutional framework. In the event, the compromise was reached after one year of intense negotiations, becoming known as the "first package deal". In this same period, the preliminary phase (or phase 1) of the

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6 ESRO Council, 35th meeting (25-26/11/70), ESRO/C/MIN/35, 21/12/70. See also: the letter of the Council chairman to delegations (5/11/70) reported in ESRO/C/473, 10/11/70; the statement by the Director General in ESRO/C/483, 18/11/70; and the note by the Secretariat in ESRO/C/482, 8/12/70.

7 ESRO Council, 36th meeting (22/12/70), ESRO/C/MIN/36, 5/3/71. See also ESRO/C(71)6, 4/2/71, and add. 1, 9/2/71.

Telecom programme was brought to an end and negotiations started for the definition of the second phase.

Designing a European communications satellite system

Soon after the ESC July session, ESRO started studying a satellite system meeting the instructions of the Conference, in collaboration with a special working group on telecommunication satellites (SET Working Group, from the French *Satellite Européen de Télécommunications*) established by the CEPT Coordinating Committee on Satellite Communications (CCTS).[8] The operational objective of the system was to handle a significant fraction of intra-European traffic in the 1980s at a cost comparable with that of land-based systems. The system was to provide two types of services: (a) public telecommunication services (telephony, telegraphy and telex, with the possible addition of wideband data transmission), and (b) television distribution of Eurovision programmes.

A key element in the design of the system was the estimate of the number of telecommunication circuits to be routed through the space system in the decade 1980–1990. This depended on three main parameters, i.e., the growth rate of traffic, the minimum distance between centres to be linked by satellite, and the distribution of total traffic between the ground and the space networks. On the basis of the growth rate calculated by the PTT administrations, and assuming that satellite circuits would be convenient over distances of 800 km or more, the ESRO study adopted the figures reported in the table below for the number of circuits to be routed by satellite.

Fraction of traffic routed by satellite	1980	1985	1990
one third	4600	8400	16000
one half	6900	12600	24000
two thirds	9200	16800	32000

The requirements for the television broadcast service had been defined by the EBU. In this case, the purpose of the system would be to replace all the terrestrial circuits used for transmitting television programmes between European countries

[8] ESRO/ST/372, 2/10/1970. A description of these studies is in Contzen (1971). See also Davidson (1970).

and between Europe and North Africa. Moreover, it had to extend the Eurovision geographical coverage to those EBU member countries (Iceland, Cyprus, Lebanon, etc.) where it was not possible to distribute programmes in real time. It was estimated that, after 1975, Eurovision needs would be met by the provision of two permanent television channels capable of transmitting colour TV programmes and high quality sound. An operational satellite with a mass in geostationary orbit of 700 to 800 kg was assumed as the basic element of the space segment of the system. It was eventually named ECS (European Communications Satellite). One or two such satellites would be operated simultaneously by some 30 to 35 earth stations in Europe, North Africa and the Near East, twenty of which for both telephony and television, a few for telephony alone and fewer than ten (essentially the North African and Near Eastern ones) reserved to television.

As regards the technical characteristics of the communication system, the most important aspect was the adoption of carrier frequencies above 10 GHz, i.e. in the so-called K_u band. In particular, the 14.0–14.5 GHz band was adopted for uplink (ground-to-satellite) transmissions and three 250-MHz bands between 10.95 and 12.75 GHz were adopted for downlink (satellite-to-ground) transmissions.[9] This was a novelty in satellite telecommunications, for which the use of frequencies in the C-band (around 6 GHz for uplink transmissions and 4 GHz for downlink transmissions) was a standard because of the minimum combination of natural and man-made noise sources. But the use of such a frequency band suffered from being shared with terrestrial radio services, and this limited the choice of earth station sites and imposed limitations in the power flux from the satellite in order to eliminate possible interference. The choice of frequencies in the K_u band significantly reduced the overlapping and, as the lower frequencies were becoming overcrowded, it was expected that future communications satellites would mostly operate in this frequency band. At that time, however, there was little or no experience in satellite communication technology above 10 GHz, and

[9] The problem of which frequency to adopt in the European communications satellite system was much debated in that period within the CEPT's political and technical bodies. In the event it was agreed to adopt the K_u band and the CEPT applied to the International Telecommunication Union's World Administrative Radio Conference for Space Telecommunications held in Geneva in 1971 for use of the 12.75–13.25 GHz band for uplink transmissions and 11.45–11.95 GHz band for downlink transmissions. This request was not accepted, however, and the plan eventually adopted provided for the bands specified in the text. ESRO, *General Report*, 1970, p. 12, and 1971, p. 46.

the use of such frequencies presented several difficulties for the design of space communication systems.[10]

The first difficulty was that radio signals at frequencies around 12 GHz may be subject to heavy attenuation in the atmosphere, mainly due to rain. Measurements of this phenomenon were rare, particularly in Europe, and this implied a large margin of uncertainty in planning for satellite–earth links. An experimental programme was therefore required in order to get statistically reliable data from measurements at different geographical locations, and extending over a sufficiently long period of time and in different climatic conditions. Such a measurement programme could be carried out using either the sky as a natural source of radiation or a satellite specially designed for this purpose.

The second difficulty derived from the limitation of the frequency bandwidth available for transmissions (500 MHz for uplink and 250 MHz for downlink). This limited the capacity of the satellite and therefore, in order to meet the expected demand for telephone circuits in the 1980s, it was necessary to study and implement sophisticated transmission techniques. These included:

a) the use of spot–beam antennae to concentrate the radiated power around areas of highest traffic density;
b) the re–utilization of frequencies within the allowed bandwidth, i.e., transmitting two different signals on the same frequencies but with different polarizations;
c) the use of the speech interpolation technique, which enables the most efficient utilization of the telephone channels by assigning them to users only when they are actually talking;
d) the assignment of communication channels on demand rather than permanently.

Other difficulties derived from three technical requirements imposed by the use of such a technology. The first was the need to develop new on–board repeater equipment including several microwave components, notably a travelling wave tube amplifier (TWTA). The second was the need to achieve high pointing accuracy, of the order of 0.1 degrees, and then to design a sophisticated three–axis stabilized spacecraft instead of using the standard spin–stabilization technique.

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[10] The following presentation is derived from Contzen (1971), pp. 292–295. The practicability of the K_u band (at 14/12 GHz) was under study at that time in the joint NASA–Canada CTS (Communications Technology Satellite) programme and in the Italian Sirio programme. The CTS was launched in January 1976, *Sirio* was launched in August 1977. The first commercial use of the K_u band was on Canada's ANIK–B satellite, launched in December 1978: Fordyce (1986), p. 206.

Finally, a power as large as 1000 Watt was required, which implied the development of a complex sun–tracking solar array.

In conclusion, the telecommunication programme designed by ESRO's engineers envisaged a major technological push, which they hoped would put Europe on an equal footing with the US in communications satellite technology. Thanks to the important financial effort by governments in the R&D phase, channelled to industry through ESRO's managerial and technical expertise, the technological leapfrogging that European industry needed in order to compete successfully on the world market would be made possible. And the user organizations in the telecommunication field, on their part, would be granted a reliable satellite system, technologically up to date and economically competitive.[11]

The search for a programme strategy

With the approval of the 1971 budget ESRO could keep implementing the preparatory activities of the Telecom programme, as defined by the ESC in July 1970. The aim was twofold: (a) to define the overall programme development strategy, including phasing and costing, and (b) to initiate the industrial development of important technical equipment, notably the TWTA and the repeater. At the end of this preparatory phase, and on the basis of its results, it was expected that CEPT and EBU would commit themselves to using the system and therefore ESRO member states would decide on the continuation of the programme and the start of the development phase.

In the first half of 1971 the three European industrial consortia COSMOS, MESH and STAR were contracted to carry out studies on the complete system (satellites and launching, ground stations, communication techniques) and study contracts were awarded for the TWTA and the modular repeater.[12] An overall programme concept was then worked out by the ESRO Secretariat, to be submitted to the IAPC.[13] The most important aspect of the proposed strategy was

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11 Collette (1993).

12 ESRO, *General report*, 1971, pp. 45–48; Müller (1990), pp. 138–143. The three consortia had been established in the late 1960s in order to associate European industries with the twofold aim of sharing know–how and management effort, and meeting just return requirements. On the formation and evolution of consortia, see Beattie & De la Cruz (1967) and Dondi (1980b). See also Krige (1993), pp. 42–47.

13 ESRO/IAPC(71)9, 24/5/71.

the definition of an intermediate phase between the preparatory activities (phase 1) now near to completion, and the development and launching of the operational ECS satellite meeting the users' requirements (now called phase 3). The intermediate phase (phase 2) was essentially devoted to technological development and to the qualification of critical equipment on board an experimental satellite to be launched before the ECS satellite. Two motivations justified this experimental phase: firstly, the need to test and qualify in the space environment the subsystems to be used in the final system; and secondly, the need to provide the users (PTT administrations and TV companies) with some pre-operational capability, in order to enable them to gradually gain experience with satellite telecommunications and to progressively integrate the space system in the existing terrestrial network.

The R&D work not involving tests in orbit was well defined for the experimental phase, as well as ESRO participation in the 12-GHz propagation experiments using the Sirio-A satellite developed under the Italian national programme.[14] Two options were then presented regarding the experimental satellite for the orbital tests (Table 1). The first foresaw the use of a 200 kg satellite, mainly devoted to the testing of communication techniques: this satellite could be either specially designed or derived from satellites under development in national or multilateral programmes, namely the Italian Sirio and the Franco-German Symphonie.[15] The second option involved the development of a satellite of the 500 kg class, able to test most of the spacecraft technology intended for use aboard the future ECS and to offer users some kind of pre-operational communication capability. The total cost of the programme varied between 360 MAU and 436 MAU depending on the option, the least costly being option Ib (Sirio-B) and the most expensive option II (Table 2). The latter, in particular, involved greater spending in the experimental phase than in the operational one, because most of the development work for the test satellite would be directly transferable to the operational unit.

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[14] Sirio (Satellite Italiano per la Ricerca Industriale Operativa) was a 200 kg spin stabilized satellite designed for propagation experiments at frequencies above 10 GHz. It had originated from the PAS vehicle foreseen on top of ELDO's *Europa 2* rocket. On the Sirio programme see: Sirio (1978) and Ragno & Amatucci (1978), pp. 63-122.

[15] The Symphonie programme had been established by France and Germany in 1967 and it aimed at launching a 250 kg three-axis-stabilized satellite for telecommunications experiments in the 4-6 GHz band. The primary objective of the programme was to gain technical knowledge and experience in the development of communications satellites.

The overall timetable of the programme depended on the option selected for the intermediate phase (Figure 1). If the first option was approved, the test satellite could be developed in a relatively short time and launched in the second half of 1975 or in mid–1976. In this case, however, in order to make up for the large technical difference between the 200 kg test satellite and the large operational satellite to be launched in 1980, it was necessary to develop two prototype flight models of the latter, to be launched in 1977 and 1978. A different pattern presented itself for the programme development in the second option. In this case, the development work for the 500 kg experimental satellite and the 800 kg operational satellite would largely overlap, the former being considered a technological prototype of the latter and the same industrial group being entrusted with the task of building both. The experimental satellite would be launched by end–1976 or early–1977, with a second one available for launching at the end of 1977 if necessary. No prototype for the operational satellite was foreseen: it was assumed that two 800 kg satellites would be launched in 1979 and 1980 which could be shifted to operational use after some testing in orbit.

The programme elaborated by the Secretariat was submitted in June 1971 to the IAPC, called to issue a recommendation to the July session of the Council where a final decision had to be taken.[16] Here, not surprisingly, France and Germany strongly supported option Ic, also preferred by Belgium, and Italy option Ib. The ESRO programme, these delegations argued, should take advantage of the technology and expertise already available as a consequence of national efforts, and the development of an experimental satellite could be accomplished at a minimum cost by starting from an existing programme. In actual fact, by supporting the integration of their national satellites into ESRO's Telecom programme, these countries wanted to guarantee their home industry the most favourable conditions in the future competitive tenders for the most important ESRO contracts, and then to structure the whole European industrial capability in the field of communications satellites around the core already established by the national programmes. But for exactly the same reasons the United Kingdom, the Netherlands and Spain gave preference to option II. As the UK delegation put it:

> Option I was almost exclusively based on national satellite proposals and inherently led to a bad geographical distribution [of ESRO's contracts], something which probably could not be corrected by any

[16] IAPC, 3rd meeting (8/6/71), ESRO/IAPC/MIN/3, 30/6/71.

reasonable industrial measure and which was likely to be perpetuated throughout the programme.

And the Dutch delegate argued that "the Netherlands participation in the programme would depend on a fair return to its industry, which seemed very difficult to achieve in the case of option I".[17]

While ESRO's member states tried to shape the joint programme as far as possible according to their national interests, the CEPT, which attended the IAPC meeting as an observer, wanted to include as much as possible of the R&D work in the ESRO programme, in order to limit the cost of the operational system which the users would have to pay for. The CEPT representatives, in fact, emphasized that both carrying out the communications experiments at an early stage, as foreseen in option I, and testing the components and subsystems intended for the operational unit on board a technological satellite, as foreseen in option II, were necessary. They stressed how important it was, on the one hand, to obtain as soon as possible reliable information about the possibility of frequency re–use, because this had important implications for the design of earth stations, and, on the other hand, to have maximum assurance on the good performance of the final system, thanks to orbital tests of the most critical communications and spacecraft technologies. The CEPT also made it clear that they were not particularly interested in pre–operational capability on board prototypes before 1980. They rather expected two flight units of the ECS to be supplied to them by that time – one in orbit and one kept in reserve on the ground. These were to be completely free of any prototype aspect and built in conformity with the final configuration of the satellites that the PTT administrations would subsequently procure in order to maintain the system in operation.

Unable to reach an agreement among the national delegations and facing the CEPT requirements, the IAPC found itself in a deadlock and a new meeting had to be called before the Council meeting. ESRO then worked out a third option which combined the two basic elements expressed in the previous ones, namely the early launch of a 200 kg satellite for telecommunications experiments and the development of a pre–operational satellite (Figure 2).[18] Option III foresaw a two–stage experimental phase: in the first, two satellites in the 200 kg class (i.e., Sirio–

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[17] ESRO/IAPC/MIN/3, cit., pp. 5 and 8. The British position was spelled out in detail after the meeting in ESRO/IAPC(71)14, 29/6/71.

[18] ESRO/IAPC(71)9, add. 1, 18/6/71.

B or Symphonie–B) would be placed in orbit in the second half of 1975, to be used primarily for radio propagation experiments at 11 and 13 MHz, for frequency re–use experiments, and for space qualification of critical communications equipment. Subsequently, by the end of 1977, a 700 to 800 kg prototype of the operational satellite would be launched, to be used as a technological test bed for the final product and, possibly, for some pre–operational activity of experimental character. Two flight units of the operational satellite would finally be supplied to the users, as required by the CEPT, one of them to be launched by the end of 1979 at ESRO's expense. The estimated cost of such a programme was 448 MAU, i.e. higher than in the case of option I but of the same order of magnitude as in the case of option II (table 3). Most of the money would be spent in the experimental phase, owing to the fact that the development and launching of both the 200 kg satellites and the pre–operational satellite were included in this phase.

In spite of this effort from ESRO to find an acceptable compromise, the national delegations in the IAPC again could not find an agreement. The countries without a national programme in satellite telecommunications (Netherlands, Spain, Sweden and the U.K.) continued to oppose any national bias in the joint programme and maintained their support for option II. France, Germany, Italy and Belgium, on the contrary, now supported option III. Switzerland also expressed some inclination towards the latter, while Denmark abstained as it had not yet decided to participate in application programmes. For the British delegation, option II represented a single line of development, whereas the new option "appeared to consist of two quite distinct and separable parts." The first of these lines, they argued, satisfied the industrial interests of some member states but "would be carried out at the expense of development of the large satellite, certain aspects of which would be deleted for want of money." The French, on the contrary, stressed that option II was not acceptable "because it involved the successive and costly development of two different large satellites, of 500 and 700 kg." Moreover, under this option, it would require six years before the first technological tests in orbit could be conducted while the use of a 200 kg satellite would permit them very quickly.[19]

Good technical reasons existed for both arguments, of course, but the issue was clearly not only technical and involved important industrial policy considerations. Two main aspects were discussed by the advocates of the two

[19] IAPC, 4th meeting (9/7/71), ESRO/IAPC/MIN/4, 20/8/71, p. 7.

options under discussion. The first concerned the need to perform experiments on frequency re-use at an early stage in order to test the possibility of implementing such a technology. The CEPT stressed that, from the point of view of the construction of earth stations, this verification should be effected at least two years before the start of the operational phase. It added however that "for the purposes of designing and developing these stations it will be necessary to have the results of the verification much sooner." But how much sooner remained unspecified and the conclusion was that "as regards the potential user requirements, there is not sufficient difference between options II and III for CEPT to be able to recommend one in preference of the other."[20] This position of CEPT's left the field open to confrontation between divergent opinions. For the British delegation, frequency re-use experiments could be done at considerably less expense by means of point-to-point ground links or using an aircraft equipped with a stabilized platform. They also pointed out that a Canadian satellite scheduled for launch in 1975 would conduct this type of experiment and it would be possible to use the results provided by this satellite. France and Germany, on their part, insisted that the need to conduct the technological tests in orbit very quickly could only be satisfied by using the 200 kg satellites and underlined that option III would permit advantage to be taken of development work already done in Europe.[21]

The second aspect regarded the ever-present issue of just return. For the U.K., option III had the "unacceptable disadvantage [...] of a geographical distribution of contracts that distinctly favoured certain member states from the outset".[22] In fact, an ESRO study had shown that the choice of this option implied that 31 per cent of the extra-mural programme expenditure, excluding launchers, involved constraints in the geographical distribution, i.e. it was likely to be allocated to companies of certain member states because of their unique competence in the programme. This percentage was of course significantly lower in option II, namely 17 per cent.[23] For ESRO, a fair geographical distribution of

[20] ESRO/IAPC(71)15, 9/7/71, pp. 1-2. See also ESRO/IAPC/MIN/4, cit., pp. 3-4.

[21] ESRO's engineers did not like the British suggestions. They argued in fact that the use of an aircraft would provide only data on local phenomena and of little statistical value while, as regards the Canadian satellite, it was doubtful whether its position in orbit would be compatible with the measurements that needed to be made in Europe. They also stressed that both Sirio-B and Symphonie-B had been designed to enable the requisite verification to be made under truly representative conditions.

[22] ESRO/IAPC/MIN/4, cit., p. 7.

[23] ESRO/IAPC(71)9, add.1, cit., p. 8 (table III).

about 70 per cent of extra-mural expenditure was still equitable, as it corresponded to what had been achieved in the scientific programme. It was not so for the British delegation, who thought that in the new application programmes, which involved much more important economic and technological aspects than in the scientific programme, an unfavourable situation should not develop from the beginning.

The long discussion again came to nothing and the meeting ended with a resolution which registered the disagreement among the delegations and left the Council the task of choosing between options II and III. As the IAPC chairman, M. Bignier, explained to the Council: "There was no certainty that the IAPC would be able to take a final decision, because political considerations might prevail over the technical aspects."[24] The Council, however, was not in a better position to take a decision.

Working out a "package deal"

In July 1971, the ESRO Council was actively engaged in the negotiations on the reform of the Organization that were to lead to the so-called "first package deal".[25] While agreeing in principle that ESRO should devote its main effort to application satellite programmes, member states were still a long way from the definition of a suitable framework for such undertakings. Divergences existed about the financing and management of programmes which not all member states were to be involved in; about the relationship between the scientific programme, from which ESRO had derived its *raison d'être*, and the application programmes; about the future of ESRO's establishments ESRIN, the research institute near Rome whose activity was to be stopped, and ESRANGE, the shooting-range near Kiruna no longer necessary after the winding up of the sounding rocket programme. And finally, by far the most important issue, disagreement and uncertainty existed on the critical question of the European launcher. No application satellite programme could be undertaken, in fact, without a guarantee that it would actually be possible to launch such satellites, and on this question the Council was in a deadlock. The U.K. argued that American launchers would certainly be made available for European communications satellites, as they

[24] Council, 39th meeting (13-14/7/71), ESRO/C/MIN/39, 3/8/71, p. 23.

[25] A detailed analysis of these negotiations will be presented in a forthcoming report. See however Russo (1993a), pp. 57-67, and Krige (1992).

always had been for scientific satellites, while ELDO's experience had shown that it made no sense to embark on uncertain and expensive programmes to achieve European independence. France, on the contrary, did not believe that the U.S. would launch European satellites that were potentially harmful for their commercial interests, and insisted that Europe should build its own launchers as a part of a coherent space policy. The position of the American authorities, in fact, was ambiguous, and it seemed that it would depend on the outcome of the negotiations about the possible European participation in NASA's post–Apollo programme. Informal negotiations were being pursued at the U.S. embassy in Brussels by the ESC President T. Lefèvre in order to have a clarification of this mostly important issue.

In the event, the Council adopted the proposal worked out by its chairman G. Puppi as a generally accepted basis for further negotiations.[26] It recognized the need for Europe to undertake a substantial telecommunications programme, and stated that the countries willing to participate in such a programme should eventually choose one of the proposed options. The four largest contributors to the ESRO budget (France, Germany, Italy and the U.K.) committed themselves to participating in this as well as other approved application programmes and to contributing to a minimum total level of resources of 70 MAU per year from 1974 to 1980 for their execution. (An aeronautical and a meteorological satellite programme were also under study, and the expenditure for all application programmes in 1972 and 1973 was established at 27 and 53 MAU, respectively). The decision about which strategy should be adopted for the Telecom programme – indeed about the actual start of the programme – was postponed to when the final package deal would be agreed on. The programme in fact was an element of a general agreement in which all aspects of the European space policy were to find their own place. At the July meeting of the Council an important step was actually achieved, namely the definite adoption of the principle of optional programmes and the commitment of ESRO's "big four" to participate in all application programmes with an assured minimum level of resources. It still depended on the negotiating ability of chairman Puppi to bring the process to a successful outcome.

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[26] ESRO/C/MIN/39, cit., pp. 17–19. The approved resolution is reported in ESRO/C/XXXIX/Res. 4, with attached ESRO/C/XXXIX/Res. 3, rev. 2 (draft), 14/7/71. See also *ESRO/ELDO Bulletin*, n. 15 (August 1971), pp. 24–26.

The CEPT report on the viability of the system

There was a second important reason for the Council to suspend the decision, namely that several PTT administrations were not ready yet to commit themselves to using a satellite system for their telecommunications needs. A few days before the Council meeting, in fact, the CEPT had made available a report on the technical, financial and operational aspects of such a system from the user's perspective: a document whose conclusions were discouraging.[27]

The report had been prepared by the CEPT Coordinating Committee on Satellite Communications (CCTS) and its SET Working Group with the aim of assisting the PTT adminstrations and the ministers "in deciding under what terms [they] might take part in the [ECS] project". Starting from the already defined mission requirements and from the available information on the technical and financial aspects of the programme, several scenarios were discussed. These involved: two hypotheses on the fraction of circuits to be routed via satellite, one third and one half; two values for the launch success probability, 0.75 and 0.9; two confidence levels (i. e. the probability of not needing more than the stated number of satellites), 50 % and 90 %; and two different system configurations, with and without frequency re-use. Having excluded the cost of the first operational satellite in orbit and a second spacecraft in reserve on the ground, both to be provided by ESRO, the total investments by the users for the decade 1980–1990 were estimated at 139.1 to 271.2 MAU depending on the hypotheses chosen. This amount included the procurement and launch of subsequent satellites, the establishment of about 30 earth stations, and the operating cost of the system. Most of the investments regarded the ground segment (i.e. the earth stations and associated facilities), whose cost was estimated at 102.6 to 120.1, with an additional 5.7 to 5.9 MAU if the Atlantic islands Madeira, Azores and Canaries were to be covered.[28]

The above figures had to be compared with the savings in the terrestrial network achievable as a consequence of the transfer to the satellite system of part

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27 CEPT, *Study on a European telecommunication satellite system*, Doc T/CCTS(71)24E, July 1971. Also attached to ESRO/IAPC(71)18, 26/7/71.

28 In order to give an idea of how the cost was shared between the different elements of the system, we can note that the study estimated the cost of the satellite at 9 to 11 MAU depending on the configuration, and the launching cost at 18 MAU if the *Atlas Centaur* rocket was used and at 22.5 if *Europa 3* was used. These figures were taken as a basis for calculation in the different scenarios.

of the total telecommunication traffic. And the comparison could not be more depressing, as the total savings were estimated at 84 MAU if one third of the traffic was shifted to the satellite system, and 113 if the fraction was one half. The possible inclusion of the Atlantic islands added 6 and 10 MAU, respectively. In conclusion, the cost of operating the ECS satellite system resulted in excess of the corresponding savings by some 65 to 175 % if the former was to carry one third of the traffic, and 39 to 140 % if the fraction was one half. The lower figures, of course, implied the most optimistic assumptions about the launch success probability and the performance of the satellites in orbit.

The report acknowledged that this economic comparison did not take into account certain factors which could not be evaluated in financial terms, such as the fact that the satellite system would provide the EBU with a significantly more extensive coverage than that of their existing networks (and with two channels instead of a single one), or the diversification and flexibility that satellites provided to the global telecommunication system. It was also noted that the method employed for the economic evaluation meant comparing the costs of establishing a new system with the costs of extending a system already in existence. All the same, from the point of view of the CEPT no doubt could exist that, in one way or another, the governments had to make themselves responsible for the difference between the actual costs of the satellite system and those which the users would normally have to bear. The development of the European aerospace and communications industry could not be financed by telephone subscribers, and the financing of a European satellite telecommunication system required a political decision involving PTT ministers and the ministers responsible for space activities.

The commitment of the potential users to the Telecom programme was of course a *sine qua non* condition for the implementation of the programme itself, and therefore the CEPT report raised great concern. It appeared once again that space was not a matter of crude economics but of political strategy on a continental level. As the British delegation at the Council put it (with the Italians concurring):

> 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 its operational phase. However, the

case under discussion was not a national project but an international undertaking which formed part of the package deal and with which [the UK delegation] could go along.[29]

And in fact it was only when such a political agreement was eventually reached, in December 1971, that the start of the Telecom programme could finally be approved.

A new option is worked out

As we have seen, the ESRO Council had decided in July 1971 that the three application programmes (telecommunications, meteorological and aeronautical) should be executed simultaneously, and had fixed an overall financial envelope for them, i.e 27 MAU for 1972, 53 MAU for 1973, and 70 MAU per year as of 1974. The Telecom programme, under either option II or III, could not be accommodated within these limits and therefore the ESRO secretariat was instructed to study a new programme strategy, compatible with the stated budgetary constraints, as well as with the new situation emerging from the CEPT report. One month later the new option had been worked out, which differed from the previous ones in two main aspects (Figure 3).[30] The first was that phase 2 was now essentially characterized by a technological programme, while the orbital tests would be based on the utilization of one experimental satellite to be realized within a cooperative effort and therefore with financial contributions from outside ESRO. The second difference was that the decision to proceed with phase 3 was now required only by mid-1975, on the basis of the results of the experimental phase as well as of the financial, technical and operational conditions prevailing in the mid-1970s. The programme was thus broken into two clearly different ones, each requiring a specific decision to start: the first aiming at launching an experimental satellite by the end of 1975, the second aiming at developing the operational satellite as defined by the users' requirements.

Two possible alternatives for the realization of the experimental satellite were discussed. The first was cooperation with the on-going Symphonie programme, aiming at launching one Symphonie-B spacecraft by the end of 1975. This had been preferred to Sirio-B because the latter did not allow the testing of either

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[29] Council, 42nd meeting (23-24/11/71), ESRO/C/MIN/42, 3/12/71, p. 14.

[30] ESRO/IAPC(71)28, 9/11/71.

three-axis stabilization techniques (because Sirio was spin stabilized) or frequency re-use (because of on-board antenna problems). The second alternative involved a collaboration with the American company COMSAT within the framework of the Intelsat programme. As Intelsat's operating manager COMSAT was in fact studying an experimental satellite as a technological step in the development of the new Intelsat-V spacecraft, and its project corresponded closely to that of the ESRO programme: it aimed at launching in 1975 a 350 to 400 kg, three-axis stabilized satellite, with orienting solar panels, high gain antennas, K_u band frequencies, and active thermal control. Exploratory contacts had already been established between ESRO and COMSAT and collaboration appeared possible along four main lines: (i) the satellite would be designed by a mixed ESRO/COMSAT team; (ii) ESRO participation would be of the order of 30–40 % of expenditure; (iii) the satellite and its subsystems would be developed by both European and American industry under ESRO and COMSAT contracts, respectively; and (iv) integration and testing would be conducted by the COMSAT laboratories at Clarksburg with the participation of an ESTEC team and representatives of European industry.[31]

As regards the content of the operational phase no specific proposal was presented at this stage. It was suggested that a prototype satellite might be developed and launched by 1979–1980, followed by the production of two flight models of the final operational unit and the launch of one of them in early 1982. The latter could be either a 700 to 800 kg spacecraft, as previously envisaged, or a spacecraft of the order of 400 kg, in the event that a review of the mission, the communications system and the technologies used showed such a mass to be adequate. In this latter case, an optimistic possibility was that this spacecraft might be a direct follow-up of the experimental satellite, if the ESRO/COMSAT option was chosen, thus making the prototype and the operational unit one and the same. In any case, no decision about the operational phase was required before 1975, thus leaving enough time for clarifying the political and economic aspects and obtaining the commitment of the potential users. This was much appreciated by national delegations less enthusiastic about the European communications satellite programme. The British, as usual, gave voice to them:

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[31] ESRO/IAPC(71)28, cit., p. 9. The possible ESRO/COMSAT collaboration is reviewed in ESRO/IAPC(72)7, 21/2/72.

> The United Kingdom delegation, recalling that it had laid down two conditions to be met before it could vote in favour of proceeding to the second phase [i.e. the viability of the programme and the commitment of the potential users], pointed out that this meant that when the time came it 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.[32]

The new programme strategy was presented to the IAPC in November 1971 together with the financial implications of the different possibilities (table 4). The CEPT, represented at the meeting by the chairman of the SET Working Group, Fargette, took a critical approach towards the new version of the programme and expressed some resentment at not having being consulted by ESRO when the new option was being elaborated. Two aspects in particular were criticized. The first regarded the envisaged collaboration with COMSAT. Intelsat, in fact, had not as yet taken any decision on the execution of an experimental programme in preparation of the Intelsat-V series, and no guarantee existed that COMSAT's plans would actually be approved by the governing body of the international consortium. The second aspect was that under the new approach a decision on the operational system was not to come before 1975. This might discourage certain users, for instance EBU, and might lead them to route their traffic differently.[33] Regarding the foreseen launch of the first operational satellite in 1982, the CEPT representative recognized that it was difficult to assess the exact date at which a European system was actually required to be operational and that CEPT had adopted 1980 as a working hypothesis. He added however:

> If this was now to be postponed, the effects resulting from such a slippage would have to be studied in detail. In this context, it could not be denied that a European system might run certain risks if it became operational only after Intelsat-V, because the history of international telecommunications showed that the carrier who enters the market first is usually the best placed competitor.[34]

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32 ESRO/C/MIN/42, cit., p. 14.

33 As early as mid-1969 the EBU had in fact received an offer to use the Intelsat system for the needs of Eurovision: CSE/HF(69)22, 16/7/69.

34 IAPC, 9th meeting (9-10/11/71), ESRO/IAPC/MIN/9, 22/12/71, p. 23.

Despite CEPT's reservations the IAPC considered with great interest the envisaged ESRO/COMSAT collaboration for an experimental communications satellite. Pending the Intelsat decision, however, France and Germany insisted that the possibility of using Symphonie, at conditions still to be defined, be maintained "as a veritable programme alternative".[35] In the event, "after a lengthy discussion", no choice between the various programme alternatives was clearly recommended; the IAPC simply recognised that collaboration with COMSAT "might offer certain advantages" and recommended the Council to base its examination of the Telecom programme on the main principles set out by the new option, namely the implementation of a cooperative experimental satellite programme and the procedure of staggered decisions for the funding of successive phases.[36]

The 1971 package deal and the approval of the Telecom programme

In the one-month period between 20 November and 20 December 1971 the ESRO Council held three busy meetings, thus bringing to a conclusion the long negotiating process started one year before and destined to radically change the Organization's role and aims. With the final approval of the resolution on the "Reform of the Organization", ESRO member states agreed on a package deal which definitely transformed the former *space research* organization into an organization mainly devoted to *space applications*. While in the old framework all member states were called to finance the Organization's programme according to the GNP (gross national product) formula, now this condition applied only to the basic activities and the scientific programme. The application satellite programmes, on the contrary, were considered optional, and each of them was financed only by the participating countries. As a consequence of this agreement, the three programmes whose definition studies had been under development for a few years were finally approved: the Telecom programme we have been dealing with in this and the previous paper; an aeronautical satellite programme in collaboration with the U.S. Federal Aviation Administration and Canada; and a meteorological satellite programme deriving from a project already studied by the French space agency. These programmes were to be executed simultaneously, with the "big four" confirming the decision taken in July to participate in all three

[35] ESRO/IAPC/MIN/9, cit., p.24.

[36] ESRO/IAPC/IX/Res. 5, 12/11/71.

with a minimum total level of resources of 70 MAU per year. At the same time, ESRO would also carry out exploratory studies in other application fields such as satellites for earth resource survey, maritime navigation, and semi-direct and direct television broadcasting.[37]

After five years of technical studies and political negotiations, a decisive step was thus taken regarding the Telecom programme, approved under the sponsorship of eight of ESRO's ten member states, Belgium, Denmark, France, Germany, Italy, Sweden, Switzerland, and the U.K.[38] According to the plan elaborated by the ESRO Secretariat and recommended by the IAPC, these participating countries decided to undertake phase 2 (experimental) of the programme, from 1972 to 1976, at a maximum cost of 100 MAU, and agreed that a decision about the succeeding phase would be taken in 1975 by a double qualified majority.

THE START OF THE EXPERIMENTAL PHASE AND THE APPROVAL OF THE OTS PROJECT (1972–1973)

The content of the experimental phase programme

With the approval of phase 2 of the Telecom programme, real development work could finally start. The programme for this phase was divided into four main parts (table 5).[39] The first regarded the communication system and included studies on the satellite, the earth stations, the communication techniques, and the propagation problems at 14/11 GHz. The latter, in particular, required an extensive experimental programme which involved the building and installation of radiometers at five different locations in Europe, the execution of propagation experiments on terrestrial links, and ESRO participation in the Italian Sirio project.

The second part of the programme was the so-called Supporting Technology Programme (STP), consisting in the development of the new technologies

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[37] The final Council resolution, adopted at its 44th meeting (20/12/71), is reported in *ESRO/ELDO Bulletin*, n. 17 (February 1971), pp. 6–11. See also Russo (1993a).

[38] Denmark's participation was actually decided at a later stage because Denmark had first to officially withdraw its denunciation of the ESRO Convention pronounced by the Danish government at the end of 1970.

[39] ESRO/IAPC(72)6, 23/2/76.

required by the advanced design of the envisaged system. The most important elements in the STP programme were the travelling wave tube amplifier (TWTA) and the modular repeater at 14/11 GHz, i.e. the basic components of the communication payload. Preliminary industrial studies of these components had already started in 1971; in 1972 contracts were awarded to the French firm Thomson–CSE for the development and qualification of the TWTA, and to the German AEG–Telefunken for the development and qualification of the modular repeater. Most of the critical equipment under the STP programme was contracted to industry during 1972.[40]

The third and by far the most important part of the programme consisted in the development and launching of an experimental satellite at the end of 1975. This satellite would enable orbital tests of the communications techniques foreseen, of the 14/11 GHz communications equipment, and of the three–axis–stabilized platform. As said above, the financial limitations on the programme imposed either the use of a spacecraft modified from that employed in another programme (the Symphonie–B option) or alternatively the development of a new spacecraft in collaboration with another organization (the ESRO/COMSAT option). The ESRO Secretariat, however, recommended the latter for two main reasons. Firstly, the Symphonie option was not compatible with the budgetary constraints unless France and Germany undertook to cover part of the satellite cost and, secondly, the three–axis stabilization techniques required to be tested were in many cases different from the Symphonie configuration. This part of the programme also included ESRO participation in the Canadian Communication Technology Satellite (CTS), by which some key hardware developed under the STP programme could be tested on board the CTS, whose launch was expected in March 1975, i.e. some eight months before the launching of the ESRO satellite.[41]

The fourth part of the programme consisted of preliminary studies of the operational ECS satellite, in preparation of the subsequent phase 3. These studies were to be performed in two steps (Figure 3). The first, in 1972, regarded the definition of the operational satellite configuration (phase A study), in order to detail the necessary supporting technology and flight experimentation. The second, whose aim was to prepare a more definite design of the satellite (phase B

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40 ESRO/PB-TEL(72)1, 25/8/72; Müller (1990), pp. 139–148 and 170–181.

41 ESRO/IAPC(72)8, 21/2/72; IAPC, 10th meeting (2–3/3/72), ESRO/IAPC/MIN/10, 14/3/72, p. 18. The hardware to be tested on board the CTS included the TWTA, the parametric amplifier and the solar array blanket.

study), would start after a two-year lapse, in order to take advantage of the results of the other parts of the programme. In January 1972, six-month contracts for phase A studies were placed with the three industrial consortia COSMOS, MESH and STAR, which independently studied three possible configurations, namely: (a) a dual satellite system consisting of two 400 kg satellites separated by about 3 degrees and not implementing frequency re-use technology (COSMOS); (b) a system using a single 680 kg satellite with frequency re-use (MESH); and (c) the so-called "baseline system", involving the use of a single 800 kg satellite with frequency re-use (STAR).[42]

Before closing this section we have to note that, with the start of the phase 2 of the Telecom programme, contacts between ESRO and CEPT were resumed on a formal basis, after a period of cooling off in their relations subsequent to the presentation of the CEPT report. Technical collaboration was thus re-established with the SET Working Group while some PTT administrations expressed their interest in the developing and setting up of some earth stations already during the experimental phase of the programme.[43]

The failure of ESRO/COMSAT cooperation and the OTS proposal

The prospects of ESRO/COMSAT collaboration in the framework of the Intelsat programme were short-lived. COMSAT's experimental satellite project in preparation of the new Intelsat-V satellite generation was in fact strongly opposed within Intelsat. The American company had a strong societary interest in developing this programme in its laboratories in order to gain the expertise needed to compete in the U.S. domestic satellite communications market. Most Intelsat signatories, however, felt that the international consortium should not pay for COMSAT's apprenticeship in satellite design and construction. The issue, which coupled with the fierce competition for the choice of the satellite destined to bridge the gap between Intelsat-IV and Intelsat-V, was hotly debated between late 1971 and early 1972 by the Interim Communications Satellite Committee

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42 ESRO/PB-TEL(72)2, 11/8/72.

43 Exchange of correspondence between the chairman of the CEPT Coordinating Committee for Telecommunications by Satellite (CCTS) and ESRO's director general, in ESRO/PB-TEL(72)4, 21/8/72; also IAPC, 10th meeting (2-3/3/71), ESRO/IAPC/MIN/10, 14/3/72.

(ICSC), Intelsat's governing body.[44] On 3 March, the CEPT representative informed the IAPC that the ICSC had decided to suspend discussions with ESRO until its June meeting, by which time its technical sub-committee would have produced a report on whether or not Intelsat needed an experimental satellite. But it was clear that COMSAT's plans could hardly win approval of two-thirds of Intelsat members, as required under the new Intelsat agreements.[45]

The new situation re-opened the key question of the choice of the spacecraft for the orbital tests. This in fact had never been completely settled, as France and Germany had always insisted that the Symphonie option should be considered in parallel with the ESRO/COMSAT satellite. Now, however, the issue presented itself in a much more controversial way. Against Symphonie-B, Italy re-proposed its Sirio-B and, more important, the U.K. announced its intention to develop a national communications satellite, named UKATS (United Kingdom Application Technology Satellite), and demanded that this satellite should be used within the European programme. All three national options were unsatisfactory, however: Sirio-B was technically outdated, UKATS was still on the drawing board and the programme had not even been approved yet, and finally France and Germany had not made any firm offer of financing the use of Symphonie-B within the ESRO experimental programme. It was evident, however, that no major country would have agreed to go along with another nationally-based project, and a deadlock seemed inevitable.

In these circumstances, the ESRO Secretariat decided to by-pass the IAPC and to re-examine the needs of a test satellite in the framework of the ongoing configuration definition studies of the ECS system. Three new independent study contracts were thus placed with COSMOS, MESH and STAR, "to give to industry an opportunity to express their view freely on all aspects of the problem." These studies, conducted in the summer 1972 in close relation with the ECS phase A studies, analysed separately, "on an open basis", a range of satellite options from the 40 kg Franco-Russian SRET vehicle to a dedicated 400 kg ESRO spacecraft,

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44 The competition was mainly between Hughes Aircraft, supported by COMSAT, which proposed a modified version of Intelsat-IV (Intelsat-IVA), and Lockheed Aircraft, supported by most other Intelsat signatories, which proposed a completely new design (early Intelsat-V programme). Both Hughes' and Lockheed's satellite projects were also intended for U.S. domestic services. Eventually, Hughes won the contract, thanks to COMSAT's dominant position as the U.S. representative in Intelsat. See Kinsley (1976), p. 125-126; Müller (1990), p. 182; Podraczky & Pelton (1984), p. 111.

45 IAPC, 10th meeting (2-3/3/72), ESRO/IAPC/MIN/10, 14/3/72, p. 17.

including of course Sirio–B, Symphonie–B and UKATS. The conclusions of these studies paved the way for coming out of the impasse:

> The common view is held by the consortia that there is no substitute for a dedicated orbital test satellite with a configuration approaching as nearly as reasonable that of the preposed operational vehicle. All three consortia, while using sometimes very different criteria, placed such an experimental satellite well ahead of any other option.[46]

In order to understand this conclusion and its implications we have to analyse the results of the ECS configuration definition studies and their relevance for the experimental satellite programme. As discussed above, the three consortia had independently studied three different system configurations. These studies, however, had resulted in a remarkable degree of similarity in the definition of the sub–systems: identical modular repeater elements; same power conditioning; similar telemetry, tracking and command (TT&C) subsystems; etc. All three approaches foresaw the use of advanced technologies and recommended a comprehensive development, qualification, and flight test programme, in order to meet the planned schedule for the ECS deployment and to increase confidence in its ultimate successful operation. It is in this framework that the three consortia assessed the different options for the experimental satellite, i.e. each of them independently considered which option would allow the most profitable orbital test programme from the point of view of the operational system defined by its own phase A study. The result was unequivocally the same for all three: a dedicated 350 to 400 kg satellite whose configuration and critical technological content would be as close as possible to that of the ECS. This satellite was eventually named OTS (Orbital Test Satellite).

Important technical and financial implications derived from the OTS proposal. The use of such a dedicated satellite, in fact, required an integrated phase 2/phase 3 approach and a new programme development. The launch of the experimental satellite was postponed to the end of 1976, the prototype unit was no longer necessary, and the launch of the operational satellite was definitely planned in 1980 for any ECS configuration (fig. 4). The deletion of the prototype and the close technical similarities of the OTS and ECS spacecraft resulted in significant savings of the programme costs. In comparison with the current programme

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46 ESRO/PB–TEL(72)2, 11/8/72, pp. 2–3.

(ESRO/COMSAT test satellite plus 800 kg ECS with prototype) the total saving was 19 MAU in the case of an 800 kg ECS, and 112 MAU in the case of a 400 kg ECS.[47] These savings, however, could only be achieved at the expense of exceeding the overall ceiling of 100 MAU for the experimental phase approved by the ESRO Council in December 1971, as a consequence of the effort for the development and building of the OTS (table 6).

The OTS proposal was presented at the first meeting of the newly created Telecommunication Satellite Programme Board (PB-TEL), the Council's delegated body in charge of supervising ESRO's telecommunication programme.[48] Here, as to be expected, the initiative of the ESRO Secretariat was strongly criticized by the German, French and British delegations. The Germans stressed that:

> The procedure of the Secretariat was incorrect in approaching the consortia before all the possibilities of [...] external collaboration had been definitely eliminated. It was evident that the consortia would naturally prefer a new project to one in which they did not participate.

The French, on their part, proposed that "the possibility of passing from Symphonie-B to an operational satellite should also be studied." And finally, the British pointed out that the UKATS project (now renamed GTS, Geostationary Technological Satellite) had been approved recently and that "the possibility of in-orbit testing of equipment on this satellite should now be studied in detail by the Secretariat."

After a lengthy discussion of the technical and financial aspects of the OTS proposal, it was clear that no decision could be reached at the meeting. It was finally agreed that ESRO should further study the alternative approaches to experimentation in orbit, and that the CEPT CCTS should be asked to express their opinion, as potential users of the system, on which approach would give the greatest confidence in the programme.

Although refraining from expressing any preference for the different options, the CEPT Committee pointed out that the availability of a significant pre-operational communication capacity during the experimental phase would be very

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47 The comparison is with option IV (iv) in table 4.

48 PB-TEL, 1st meeting (6/10/72), ESRO/PB-TEL/MIN/1, 2/11/72; following quotations from pp. 4-5. It must be noted that until the formal approval of the Telecom programme, the PB-TEL acted on a provisional basis and its decisions had to be endorsed by the Council.

useful. Such a capacity, the CCTS argued, could be used free of charge for routing some telecommunication traffic via satellite, and it was "very desirable to permit the progressive installation of a network of earth stations before the commencement of the operational phase." For some national PTT administrations, they concluded, this was a prior condition to the construction of an earth station.[49] This emphasis on the need for pre-operational capability in fact supported the OTS option, as this satellite could be designed to provide such a capability within the remaining mission objectives of the test satellite.

The case for OTS was presented by the ESRO Secretariat at the second meeting of the PB-TEL, on the basis of a thorough comparative analysis of the various options under discussion.[50] Their reasons for selecting the OTS programme against others based on Symphonie or GTS can be summarized as follows:[51]

1) Greater technical merit, i.e. relative fulfilment of the orbital test programme objectives;
2) Minimum overall programme cost;
3) Best solution from the point of view of industrial policy (i.e. geographical distribution of contracts and return of investments in ESRO's Supporting Technology Programme);
4) Possibility of re-using the modular-designed OTS platform in support of other geostationary missions;
5) Significant pre-operational activity in the experimental phase and start of operational activity by 1980;
6) Greater flexibility in the definition of the content of the operational phase.

Flexibility and industrial policy considerations were the two decisive factors that the ESRO Secretariat particularly pointed out at the meeting. They also stressed that the OTS "had been designed very much more as a prototype than as a test bench" and that the communication capability offered by this satellite in 1977 would be 5000 telephone channels and 2 television channels, namely of the same order as that of an Intelsat-IV satellite.[52] The discussion at the meeting, in fact,

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49 ESRO/PB-TEL(72)8, 14/11/72, annex II.

50 ESRO/PB-TEL(72)6, 7/11/72; PB-TEL, 2nd meeting (17/11/72), ESRO/PB-TEL/MIN/2, 11/12/72.

51 Müller (1990), p. 186.

52 ESRO/PB-TEL/MIN/2, cit., pp. 5-6.

made the strength of the Secretariat's proposal quite evident against the national–biased alternatives. Despite the doubts and criticisms expressed by the French, German and British delegations, the OTS option was strongly supported by the smaller member states, which also pressed for a decision to be taken very soon. The Belgian delegation, in its statement, fully interpreted their opinions:

> [All other options] involve one or several national industries having a preponderant position and pose the issue of Europeanisation of the project [...] This issue of Europeanisation was the stumbling block in all previous attempt to reach agreement on a telecommunications programme. The Delegation considers that those industries in the Member States that are engaged on national studies are thereby 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.[53]

In the event, despite the reservations expressed by the British delegation, the Programme Board recommended the Council to approve the Secretariat's proposal and to adopt the OTS project.[54]

The approval of the Telecom programme arrangement

After the PB–TEL approval of the OTS concept for the Telecom programme's phase 2, it still remained to define the financial plan of the programme and the legal framework within which ESRO would implement it. These elements were to be included in the formal arrangement between ESRO and the governments of the participating member states.[55]

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53 ESRO/PB–TEL/MIN/2, cit., annex II.

54 ESRO/C(72)73, 4/12/72. The precise objectives of the OTS programme were eventually discussed by a group of experts consisting of ESRO staff, CEPT's Permanent Nucleus, and representatives appointed by the delegations. The group held two meetings (on 8/12/72 and 11/1/73, respectively), reported on in ESRO/PB–TEL/EXP/MIN/1, 18/12/72, and ESRO/PB–TEL/EXP/MIN/2, 25/1/73. Their final report, ESRO/PB–TEL(73)1, was discussed and amended at the 3rd meeting of the PB–TEL (30/1/73), ESRO/PB–TEL/MIN/3, 22/2/73, and the conclusions are in ESRO/PB–TEL(73)6, 13/2/73.

55 The first draft of this Arrangement is ESRO/PB–TEL(72)7, 14/11/72, and the laborious elaboration of the final text is recorded in its various revisions and addenda. The final text is ESRO/PB–TEL(72)7, rev. 4, 7/5/73, but the scale of contribution of participating countries reported there was subsequently changed as in ESRO/C(73)64, 8/10/73.

The main controversial issue regarded the financial aspects, as the estimated cost of the experimental phase now exceeded the upper limit of 100 MAU fixed by the ESRO Council in December 1971. The ESRO Secretariat estimated in fact the direct cost of this phase at 121.7 MAU, at mid-1972 prices, plus 28.8 MAU for the programme share of ESRO's common and support costs (distributed pro rata among all programmes). The payment schedule had also been changed, extending beyond the originally envisaged period of this phase (1972-1976) up to 1978.[56] Apart from inflation, the reasons for the increase were to be found, according to the ESRO Director of Programmes and Planning, "in the decision [...] to develop an experimental satellite on a purely European basis [as well as] in the objectives which the delegations had fixed in respect of this satellite, with particular reference to the wish to have a certain pre-operational capacity."[57] The argument did not convince all PB-TEL delegations, however. Belgium, France and the U.K. said that if such cost estimates should be confirmed their participation in the programme would be called into question, and argued that the budget presented by ESRO included some elements in the Supporting Technology Programme which seemed no longer necessary. The Board then decided to set up a small group of experts with the task of reviewing the programme and suggesting possible cuts.

After a two-day meeting, the expert group could do no better than identify a few programme elements that either could be started during the following operational phase or were not strictly indispensable for the OTS or ECS, and this allowed a possible reduction by 6.6 MAU.[58] This gave rise to a hard confrontation at the following PB-TEL meeting between the French delegation and the ESRO Secretariat. The former made it clear that they would not subscribe to the programme if the budget for the experimental phase were not reduced of 6.6 MAU, according to the findings of the expert group. Against this position, the Director of ESTEC, O. Hammarström, "insisted on the speed with which the experts had had to carry out their work and on the numerous doubts that still persisted regarding the possibility of actually cutting out certain studies without

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56 ESRO/PB-TEL(73)4, 20/2/73; PB-TEL(72)7, rev. 2, 13/2/73.

57 PB-TEL, 4th meeting (27/2/73), ESRO/PB-TEL/MIN/4, 15/3/73, p. 5.

58 ESRO/PB-TEL(73)9, 28/3/73. The precise figures were 2.8 MAU for expenditures that could be deferred to the following phase and 3.8 MAU for not indispensable expenditures.

seriously jeopardizing the programme as a whole." And the chief of the Telecom programme, R. Collette, spoke out recalling that:

> One of the basic aspects of the programme was the development of technologies that would enable Europe to catch up with the United States in a number of fields. This was why ESRO had preferred a three-axis-stabilized spacecraft to the conventional type of spin-stabilized satellite and had also defined "advanced" tele-communications systems. A programme of this kind therefore necessarily comprised a certain number of unknowns and risks, and if funds were drastically curtailed it was to be feared that it would not be possible to overcome the difficulties that were to arise. [...] It would not be realistic to maintain the technical specifications and timetable of the programme, and at the same time to cut down the expenditure considered indispensable to meet the specifications in question.[59]

Both Hammarström and Collette stressed that "very important decisions would soon need to be taken in collaboration with industry" and that any further delay would endanger the normal progress of the work which had been under way for two years. Just in those days, in fact, ESRO was evaluating the tenders for the important phase B OTS contract, as we shall soon be considering.

A tentative compromise was suggested by ESRO and supported by the British delegation, namely that the original amount of 121.7 MAU should be retained but that the sum of 6.6 MAU would remain blocked subject to subsequent decisions by the Board. But the French delegation "stated categorically" that it was opposed to this proposal and the Board had to yield. It was agreed to remove that sum from the budget and to fix the financial envelope for phase 2 at 115.1 MAU, plus 28 MAU for common and support costs. The work corresponding to the 6.6 MAU was placed in a so-called sub-phase 2 bis whose execution would be decided, as in the case of operational phase 3, by a double-qualified majority (table 7). In this form the Telecom Arrangement was finally approved by the Board, with the French delegation expressing its reservation, and then submitted to the Council for final approval.[60]

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[59] PB-TEL, 5th meeting (21/3/73), ESRO/PB-TEL/MIN/5, 17/4/73, pp. 3, 4 and 5-6.

[60] ESRO/PB-TEL/MIN/5, cit. p. 8. See also the report of the chairman of the PB-TEL to the Council: ESRO/C(73)23, 6/4/73. The text submitted to the Council (with the cover ESRO/C(73)11, add. 1, 26/3/73) is ESRO/PB-TEL(72)7, rev. 3, Annex I, rev. 1 [21/3/73]. The

Why was the French delegation to the PB–TEL so critical of the technological work proposed by the ESRO Secretariat as to risk jeopardizing the whole experimental programme to defend savings of the order of 5 % of the estimated cost? And so unhappy about the solution eventually agreed on that it was unable to approve even the text of the Arrangement that the Committee was to submit to the Council? Three reasons were given by the delegation for its negative vote: (a) the uncertainty in the exact content of the programme after the revision of the group of experts; (b) the fact that a substantial amount of the basic technology in the programme was of general interest and yet was funded solely by the tele-communications programme; and (c) the lack of coherence between the industrial policy pursued for the technology programme and that followed for the development of the satellite.[61] All this can hardly be taken at face value. As to the first point, in fact, the group of experts had considered "satisfactory" the technical content of the Supporting Technology Programme (STP) and had accepted the ESTEC analysis of the OTS. Moreover, most of the industrial contracts under the STP had already been placed and it was not desirable to interrupt work in progress. Finally, their revision had produced possible savings for 6.6 MAU over 121.7 MAU, certainly not a conclusion that could make the content of the programme uncertain.

The second reason had some justification. The director of ESTEC, in fact, had recognized that "it was very often extremely difficult to fix the dividing line" between studies of general interests and those connected to a specific programme, a statement strongly criticized by the French delegation.[62] Nevertheless, here again the amount of money involved was negligible: the group of experts had concluded that studies worth only 3.8 MAU were not strictly indispensable for the OTS or ECS and therefore had to be considered of general interest. Certainly not enough to justify a negative vote even after these studies had been moved to phase 2 bis and subject to approval by double–qualified majority.

The last point regarded the lack of coherence in the industrial policy. This term, in the ESRO framework, meant essentially geographic distribution of industrial contracts or, more explicitly, the pressure from member states to get a share of technologically important contracts for their national industry that was

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work to be performed in phase 2 and that shifted to phase 2 bis were eventually detailed by the ESRO Secretariat in ESRO/PB–TEL(73)12, 6/7/73.

61 ESRO/PB–TEL/MIN/5, cit., p. 8.

62 ESRO/PB–TEL/MIN/5, cit., p. 3.

not less than their financial contribution to the Organization (the "just return" concept). In this respect a difference did exist between the policy followed for the STP and that followed for the development of OTS. In the latter case, owing to the importance of the contract, a procedure now standard for ESRO procurement contracts was being used, i.e. tenders for detailed design studies of the satellite configuration (step B studies) had been requested from the industrial consortia COSMOS, MESH and STAR.[63] In the case of the high-technology, small-value contracts under the STP, on the contrary, ESRO tended to award these contracts more freely, on the basis of the technical experience and capability of bidding companies. This of course resulted in a rather unbalanced distribution of contracts among the countries participating in the telecommunications programme, with expenditures concentrated in those countries which supported national communications satellite programmes: France, Germany and Italy.[64] This situation had been criticized at the PB-TEL by the Belgian delegation, which complained that "such scattering of contracts might [...] distort the geographical distribution of work within the consortia."[65] But if the French delegation could rightly claim that a certain "lack of coherence" in industrial policy did exist bewteen these two parts of the programme, it is less clear why they felt unhappy about a situation in which France was certainly not penalized, and which could in any case be justified and did not involve a large fraction of the programme budget.

A more general answer should therefore be given to the question posed above. French space policymakers, as we have seen, did not like OTS. They had to come to terms with it when it became clear that Symphonie had no chance of being incorporated in the ESRO programme; now they wanted to prevent ESRO from implementing a fully-fledged R&D technological programme in space tele-communications which might lead to duplicating national activities. Such a concern about the relationship between the technological research activity within ESRO's Telecom programme and national efforts in similar fields had already been expressed by France (and Germany as well) two years earlier, and a whole IAPC meeting had been devoted to discussing this issue. The respective positions were clearly expressed here: the French delegation argued that the ESRO programme should be used "in complement of national efforts"; the German

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63 The selection process for the OTS contractor will be discussed in the following section.

64 Müller (1990), 145–146.

65 ESRO/PB-TEL/MIN/5, cit., p. 6.

stressed "the importance of coordination with national programmes"; and ESRO's Director of Programmes and Planning J.A. Dinkespiler advocated the need of a certain degree of duplication appealing to the interest of all member states of the Organization:

> When an action is carried out within the ESRO programme, the hardware or the software which results from it becomes the property of the Organization and the use of the know-how which has been acquired is made available both to the Organization and to each one of its Member States. When a similar action is undertaken in one of the national programmes, the know-how which results from it is made available to the Member State in question, not to the Organization as such or to the other Member States. It is therefore not a matter of indifference to each one of the Member States to see an action undertaken in one of the national programmes, rather than in the international programme. This means that all Member States [i.e. not only those having national space programmes] must participate in the decisions regarding coordination. It also means that this coordination would be greatly facilitated and encouraged if some measure of symmetry was restored between national programmes and the ESRO programme as regards access to technical know-how.[66]

The quotation is long but it makes it clear that what ESRO meant by coordination was just the opposite of what France and Germany did. For these countries European space activities had to be considered as a whole and therefore the international programme had to be used to increase the effectiveness of national programmes and not to compete with them: coordination meant complementarity, integration and rationalization. For the ESRO Secretariat the Organization had to develop its own programmes on behalf of its whole membership and the relationship with the stronger member states had to be on equal footing. "Coordination does not necessarily mean that all duplication should be avoided," argued Dinkespiler, "some competition may be desirable; coordination efforts should aim at avoiding haphazard duplications and at filling

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66 IAPC, 6th meeting (3/9/71), ESRO/IAPC/MIN/6, 17/9/71, p. 10 and 11–12. The issue had been raised at the 4th meeting of the IAPC (9/7/71), ESRO/IAPC/MIN/4, 20/8/71. ESRO's technology programme was presented in ESRO/IAPC(71)17, 31/8/71.

gaps."[67] After further discussion in a round table organized by the ESRO Applied Research Advisory Committee (ARAC) and in other IAPC meetings, the issue did not resulted in major modifications in the STP plan for 1971–72.[68] We have seen how the same issue was still outstanding in spring 1973.

After this digression about the French aversion towards ESRO's technology programme, we can resume our narrative. After the PB-TEL's approval of the Telecom Arrangement, the final decisions on the programme had to take the practical form of: (a) a declaration by the member states which had supported the programme in December 1971 regarding their intention to participate in the programme as now proposed; (b) the approval of the Telecom Arrangement by the Council; and (c) a Council resolution authorizing the Director General to sign the Arrangement in the name of ESRO. The Arrangement would then enter into force after being signed by the governments of the participating states and by ESRO. At the Council meeting in April 1973, the delegations from Belgium, Denmark, France, Germany, Sweden, Switzerland and the U.K. confirmed the commitments of their governments to participate in the Telecom programme. The Italian delegation, however, pointed out that it could not take any position because its government had not yet approved the new plans and budget for phase 2 of the programme. Hence all decisions were taken subject to the condition that by 1 June Italy confirmed its participation in the programme.[69]

That date passed, however, without Italy having taken a decision because of a government crisis (an often recurring event in this country, actually). Nor did a subsequent deferment of the deadline by two weeks produce a decision. On the contrary, the Italian delegation declared that, pending government endorsement of the modified programme, it was not even in a position to repeat its commitment within the limits of the December 1971 agreement (i.e. within a total budget of 100 MAU for phase 2).[70] This position created "a very serious situation", as for the other delegations the 1971 package deal had been "the legal basis for all undertakings of the Organization since its adoption, [it] was equivalent to a

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67 ESRO/IAPC/MIN/6, cit., p. 12. Müller (1990), pp. 171–175 and 208–214, presents the cases of the development contracts for the TWTA and for the momentum wheels as interesting examples of the relationship between ESRO's technology policy and national industrial interests.

68 The ARAC discussion is reported in ESRO/IAPC(71)26, 29/10/71.

69 Council, 56th meeting (11–12/4/73), ESRO/C/MIN/56, 3/5/73.

70 Council, 57th meeting (1/6/73), ESRO/C/MIN/57, 20/6/73; 58th (extraordinary) meeting (29/6/73), ESRO/C/MIN/58, 13/7/73.

promise to participate in the programme and permitted the programmes to be modified on the basis of consultations among member states concerned." The Council then adopted a firm resolution expressing its "acute disappointment" regarding the Italian government's attitude, "which threatens the very existence of this important programme", and stating that the package deal could not be called into question.[71] In the event, after three months of negotiations, the Italian government did approve the programme as now defined and the Telecom Arrangement could finally be signed.[72]

THE TELECOM ARRANGEMENT AND THE START OF THE OTS PROJECT DEVELOPMENT

The Telecom Arrangement formally entered into force on 21 September 1973, after having being signed by the governments of the eight member states which had originally supported the programme in December 1971 (Belgium, Denmark, France, Germany, Italy, Sweden, Switzerland and the U.K.) and by the Director General of ESRO. Subsequently, the Netherlands decided to join the programme too, with a fixed contribution share of 2.5 % instead of 4.8 % as resulted from the GNP formula. The balance was covered by the other participating countries on the basis of a GNP scale of contribution (table 8).[73]

The content of the Telecom Arrangement

The Telecom Arrangement consisted in a formal agreement between ESRO and the governments of the states participating in ESRO's telecommunications programme. The Telecommunications Programme Board, composed of representatives of the participating states, was made fully responsible for the programme and delegated to take decisions related to it. The objectives of the programme were defined as follows:

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71 ESRO/C/MIN/58, cit., p. 3. The quotations are from the French and the German delegations, respectively, and from the Council resolution reported in ESRO/C/LVIII/Res. 1 (Final), 29/6/73.

72 Council, 60th meeting (21/9/73), ESRO/C/MIN/60, 3/10/73. The final text of the Arrangement is ESRO/PB-TEL(72)7, rev. 4, 7/5/73.

73 ESRO/C(73)64, 8/10/73. Spain was the only ESRO member state not supporting the Telecom programme.

> To design, develop, construct and set up the experimental and pre-operational space segment of a space communications system matching the objectives of the users, and to make reliable operational satellites available to the users on completion of the programme.[74]

The programme, as discussed in this paper, was broken down into two phases. The first phase was a technological and experimental phase which the governments agreed to finance on the basis of a firm financial envelope of 115.1 MAU (at mid-1972 prices), with the addition of 28 MAU as the programme's share of ESRO's common and support costs. This phase would run from 1972 to 1978, with the launch of the OTS at the end of 1976. As we have discussed above, a possible sub-phase 2-bis was foreseen, covering further work on advanced technologies at a cost of 6.6 MAU, plus a contingency allowance of 4.4 MAU. The decision to start such a sub-phase was to be decided by a double-qualified majority.

The second phase of the programme would be devoted to the development of two operational flight units (ECS) to be made available to the users, one in orbit and the other on the ground, on terms still to be defined. The launch of the first ECS was foreseen in 1980, but the possible launching of a prototype model was also foreseen, if necessary. The indicative financial envelope of this phase, including common and support costs and contingencies, was estimated at 160 to 283 MAU, depending on the configuration of the satellite (i.e. 400 or 800 kg) and on the possible additional launching of a prototype. Decisions on the start and precise content of this phase would be taken in 1975 by a double-qualified majority, and its completion was foreseen for 1980, with the launch of the first ECS.

The Arrangement gave the participating states firm financial control over the programme but, at the same time, it bound them to its execution up to completion. On the one hand, any change of the firm financial envelope established in the Arrangement was subject to the approval by a two-thirds majority and the same majority was required for approving the annual budgets relating to the programme. On the other hand, no participant could withdraw from the programme unless the cumulative overruns of estimated cost to completion exceeded 20 % of the amount of the firm financial envelope for reasons other than changes in the price levels. Should this be the case, those participants wishing to

[74] ESRO/PB-TEL(72)7, rev. 4, 7/5/73, p. 3.

continue the programme would determine the arrangement for such continuation and report to the Council for any necessary decision. The participating countries authorized ESRO to conclude the necessary contracts for the execution of the programme in conformity with the Organization's rules and procedures. The Arrangement, however, stated explicitly that:

> In placing contracts and sub-contracts for the execution of this programme, preference shall be given, wherever possible, to execution of the work in the territories of the participants, taking into consideration the Council's decisions in the matter of industrial policy and distribution of work.[75]

We shall see in the following two sections how this statement, which touched the ever present question of just return, became a hot issue when ESRO had to award the most important contracts in this phase, namely for the construction of the OTS and for the satellite control and test station.

Selection of the OTS contractor

Two months after the approval of the Telecom Arrangement, ESRO brought to an end the selection process for awarding the contract for the development and bulding of the OTS.[76] This process had started in October 1972, on the basis of the standard phase procedure adopted by ESRO for the development of its satellite projects.[77] This foresaw four main phases as defined in the following table:

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[75] ESRO/PB-TEL(72)7, rev. 4, cit. p. 7.

[76] This process has been described in detail by Müller (1990), pp. 195–214, and we shall recapitulate the story here, after independent checking with the relevant documents.

[77] ESRO/PB-TEL(72)10, 22/12/72.

Phase A	Definition of the mission, preliminary analysis of the satellite, identification of the various possible design concepts.
Phase B	Detailed definition of the satellite and start of critical activities, especially as regards the schedule.
Phase C	Final development of the subsystems, with production of mockups, test models and engineering model of the satellite.
Phase D	Fabrication, integration and testing of the qualification and flight units of the satellite followed by the launch.

Phase A studies had been performed by the COSMOS, MESH and STAR consortia between October 1972 and January 1973. The same consortia were then invited to tender for the more important phase B studies, for which only two parallel contracts were to be awarded. According to the technical specification defined by ESRO, the final OTS had to incorporate three critical elements developed under the STP programme, namely the repeater from AEG–Telefunken, the TWTA from Thomson–FIAR and the antenna from Selenia. As France, Germany and Italy had obtained such important contracts for their national industries, a British company was the obvious choice for prime contractorship, in order to achieve a balanced distribution of contracts within the overall programme. In fact, in their tenders all consortia were led by British companies: COSMOS by Marconi, MESH by Hawker Siddeley Dynamics (HSD) and STAR by British Aircraft Company (BAC).[78] After proper evaluation, the ESRO Secretariat recommended and the Administrative and Finance Committee (AFC) approved the awarding of phase B contracts to MESH and STAR.[79] The exclusion of the COSMOS consortium definitely left out of the OTS development (and eventually of ESRO's Telecom programme) the industries involved in the Symphonie project, namely *Aerospatiale* (SNIAS) and *Messerschmitt–Bölkow–Blohm* (MBB), thus predetermining the emergence of two major European industrial groupings for communications satellites, one from the COSMOS

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[78] The other most important members of the consortia were: in COSMOS: SNIAS (F), SAT (F), MBB (D), Selenia (I), ETCA (B); in MESH: MATRA (F), ERNO (D), SAAB (S), Aeritalia (I); in STAR: Thomson–CSF (F), Dornier (D), FIAR (I), Fokker (NL), Contraves (CH), Ericsson (S).

[79] ESRO/AF(73)35, 28/3/73; AFC, 89th meeting (11/4/73), ESRO/AF/MIN/89, 18/4/73. The value of the contract was 1.5 MAU for a 24–week period.

consortium and the Symphonie experience and the other from the OTS/ECS experience.[80]

At the end of September 1973, the same time the Telecom Arrangement came into force, the MESH and STAR consortia had completed their competitive phase B studies and submitted proposals for phase C/D, i.e. for the actual development of the OTS flight model. The selection of the final contractor was of vital importance:

> 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 [...]. Because of its advanced nature and the 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.[81]

The two tenders were evaluated from the point of view of price and quality and the result of the evaluation was definitely in favour of the STAR proposal.[82] The ESRO Secretariat then recommended the AFC to award the contract to this consortium. When, however, the Committee discussed the question, only the British, Dutch and Swiss delegations supported this recommendation. The other delegations, while recognizing the superior quality of the STAR tender, argued in favour of the MESH proposal on the basis of industrial policy considerations.[83] In fact, awarding the OTS contract to STAR could jeopardize the future of the MESH consortium, since the two last major ESRO satellite contracts, for COS-B and GEOS, had been awarded to COSMOS and STAR, respectively, and the Meteosat contract was also being awarded to COSMOS.[84] This, they argued,

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[80] From the COSMOS consortium and the Symphonie experience emerged the *Eurosatellite* group. The other is *Satcom International*, essentially deriving from the MESH consortium, the winner in the competition for the OTS main contract. See Müller (1990), 302-337, and also Collette (1993).

[81] Müller (1990), p. 201.

[82] ESRO/AF(73)127, 14/11/73.

[83] AFC, 95th meeting (29-30/11/73), ESRO/AF/MIN/95, 13/12/73.

[84] MBB was the prime contractor for COS-B and BAC for GEOS; the Meteosat contract was awarded to SNIAS as prime contractor for the COSMOS consortium. Müller (1990), p. 204,

would endanger the conditions for real industrial competition in Europe and would also raise serious problems of unemployment in some countries.

Against these arguments, the ESRO Secretariat defended the validity of its technical and financial evaluation. They drew the delegations' attention to the real shortcomings of the MESH tender, "which were to be found at the levels of project management and system engineering". And the director general went as far as to emphasize that:

> If the AFC was to base its judgement merely on considerations of industrial policy, independently of the Secretariat's technical and financial evaluation, the latter would become meaningless.[85]

In the event, the Secretariat's proposal was put to the vote and rejected by six votes (Belgium, Denmark, France, Germany, Italy and Sweden) to three (Netherlands, Switzerland and the U.K.). The AFC then approved the awarding of the OTS contract to MESH with the negative vote of Switzerland and the abstension of the U.K.[86] As we have intimated, this decision had important consequences on the shape of the European aerospace industry, contributing to giving MATRA and ERNO the leading role they would eventually have in France and Germany, alongside SNIAS and MBB respectively. This aspect, however, is beyond the scope of this paper.

The OTS control and test station

The exploitation of OTS as an experimental satellite required the establishment of a dedicated earth station to provide for the functions of telemetry, tracking and telecommand (TTC), and to carry out the required experiments of the communications payload. It was envisaged that such a station should be linked by high-quality data transmission link to ESRO's Operational Center (ESOC) in Darmstadt, Germany. Two questions were involved in the discussions about the OTS control station: the first regarded the choice of the site where the station had

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wrongly ascribed the COS-B contract to STAR; this satellite was in fact being developed by the CESAR consortium, the forerunner of COSMOS.

85 ESRO/AF/MIN/95, cit., p. 5.

86 The Spanish delegation did not take part in either vote because Spain did not participate in the Telecom programme. The contract was awarded on the condition that acceptable solutions would be found in respect of those aspects of the tender which ESRO had considered poor, with no increase of the tender price and no major change in the timetable for the programme.

to be built, the second regarded the choice of the contractor for its design and manufacture.[87]

With regard to the choice of the site, the starting point was the Council decision, taken in November 1972, that all ESRO's geostationary satellites should be operated by one control station located in Odenwald, near Darmstadt. Should it prove impossible to operate any particular satellite from this station, a second possibility was offered by installing the necessary facilities at the station ESRO had established in Villafranca del Castillo, near Madrid, to operate the IUE satellite (International Ultraviolet Explorer).[88] On this basis, and having received assurance from the German authorities that the 11 and 14 GHz frequency bands could be used at the Odenwald site, the Council decided in April 1974 that the OTS control station should be located there.[89] At the same time, a tender action was started for the choice of the contractor, and in June 1974 ESRO received two offers, one from a consortium led by AEG-Telefunken and another from a consortium led by Siemens. Neither of them was entirely satisfactory from the technical point of view, but the Secretariat recommended the former, subject to the condition that the deficiencies found in the offer were overcome. It was also expected that the British company Marconi would be included among the sub-contractors, in order to achieve a more balanced geographical distribution of work. Pending this revision of the tender proposal, and because the question of the location had been re-opened, only 0.750 MAU out of the 5.325 MAU contract value was committed for a 10-week design phase and for critical long-lead items.[90]

The question of the location was again on the table because in July the German authorities had informed ESRO that the availability of the OTS frequencies could

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[87] As noted above, the national PTT administrations would set up, at their own expenses, the earth stations required for the operational use of the ECS system. In addition, some administrations were willing to set up facilities for the experimental programme and pre-operational use of the OTS. For ESRO/CEPT negotiations on the future OTS operation see ESRO/PB-TEL(74)22, 21/8/74, and ESRO/PB-TEL(74)26, 16/9/74.

[88] Council, 51st meeting (23-24/11/72), ESRO/C/MIN/51, 5/12/72. The Odenwald station was already destined to operate the ESRO satellites GEOS and METEOSAT. The Villafranca station was ESRO's main contribution to the joint NASA/UK/ESRO IUE space telescope in geostationary orbit: Russo (1993b).

[89] ESRO, 64th meeting (29/4/74), ESRO/C/MIN/64th, 10/5/74. The Council decision was based on ESRO/C(74)15, 25/3/74, with add. 1 and 2, 29/4/74. See also ESRO/PB-TEL(74)3, 1/2/74.

[90] ESRO/AF(74)82, 12/7/74; AFC, 101st meeting (25/7/74), ESRO/AF/MIN/101, 8/8/74.

only be guaranteed in Odenwald until 1980. Given this situation, the ESRO Secretariat considered it unreasonable to build the station there, both because the OTS was likely to have a lifetime extending beyond 1980 and because the same station was also to be used for the ECS, which would operate on the same frequency bands as OTS. On the other hand, the Villafranca site also had to be excluded because the eccentric location of the station in relation to the coverage area of the satellite antenna beams prevented the possibility of properly conducting the required experiments on the OTS communications system.[91]

After the elimination of Odenwald and Villafranca, three other alternatives were analysed by ESRO, only two of which, however, deserved consideration.[92] The first was the offer by the German authorities to build the OTS control station at the Usingen site, 30 km north-west of Frankfurt, where the Deutsche Bundespost had its overseas transmitting station and where they planned to build the German station for pre-operational use of OTS. The main problem with Usingen was the existence there of high-power HF transmitters, with a high risk of interference with the ESRO station. This problem was discussed with representatives of the German PTT administration but could not be solved satisfactorily. The second alternative foresaw the building of the OTS control station at the Redu site, in Belgium, where one of the stations of ESRO's satellite control network (ESTRACK) had been established since the beginning of the Organization's life. The choice of Redu did not present any major technical problems: all services and facilities existed on the site, reliable data link to ESOC was quite feasible, and no objections existed to the use of the required frequencies on the part of the Belgian authorities. In fact, the latter had already advocated the choice of Redu for the OTS station even against Odenwald, in order to give more prominence to "the Organization's only facility located in Belgium."[93] The third alternative was offered by the Italian authorities. It consisted of having OTS controlled under ESRO contract by the Italian company Telespazio, which operated the Italian PTT station at Fucino, near Rome. The OTS control station at Fucino would be partly financed by Telespazio and used both for the ESRO experimental programme and for OTS pre-operational use by the Italian

91 PB-TEL, 10th meeting (3/7/74), ESRO/PB-TEL/MIN/10, 22/8/74. About the problems at the Villafranca site, see ESRO/C(74)15 and ESRO/PB-TEL(74)3, cit.

92 ESRO/C(74)50, 17/9/74.

93 ESRO/C/MIN/64, cit., p. 7.

company. Eventually, the station would become the Italian earth station in the operational ECS system.[94]

The real choice, for the ESRO Secretariat, was between Redu and Fucino, both solutions being acceptable and virtually equivalent from the technical point of view. A significant difference did exist, however, from the political point of view: while the earth station at Redu would be owned and operated by ESRO, the one at Fucino would be owned by Telespazio and operated under ESRO contract. The Secretariat definitely recommended the latter for two main reasons. Firstly, the Fucino/Telespazio option presented an appreciable economic advantage over Redu, with regard to both the total cost and the timetable of payments. Secondly, it involved a direct commitment by a telecommunication organization and hence closer cooperation between ESRO and users; this would facilitate the transition to the subsequent operational phase of the programme.

The final choice of the site for the OTS control station pertained to the Council, as it involved a decision running counter to its own decision of 1972, but the PB-TEL was invited to discuss the issue and express its position.[95] The discussion, however, came to nothing. On the one hand, the Belgian delegation expressed "its deep regret" at the fact that the Redu solution had not been adopted outright and stressed that, in choosing the Fucino site, ESRO was delegating one of its responsibilities to a member state. On the other hand, the German delegation proposed a new site in Germany, Weilheim, near ESOC. They argued that, since the Council's previous decision had been called into question, the choice of the site should be fully open to discussion and the Secretariat should now assess the merits of their proposal. Italy, of course, advocated the Fucino option. After a long

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[94] ESRO/C(74)33, 6/6/74. It must be noted that, after receiving the Italian offer, all member states were invited to let ESRO know whether any other national bodies were interested in tendering for the setting up and operation of the OTS control station. In addition to Telespazio, the German Bundespost and the Spanish national telephone company (CTNE) offered their services. Both bodies, however, stated that they were not willing to accept the contractor ESRO had selected for the construction of the station nor the fact that the station itself might be used by ESRO after the end of the OTS nominal life of three years. Consequently, these offers were not taken into consideration. For these negotiations see ESRO/AF(74)89, 12/7/74, with add. 1, 22/7/74, and add. 2, 25/7/74; together with ESRO/C(74)50, cit.

[95] PB-TEL, 11th meeting (30/9/74), ESRO/PB-TEL/MIN/11, 19/11/74. At the PB-TEL meeting, the document ESRO/C(74)50, cit., was presented under the cover ESRO/PB-TEL (74)23, 17/9/74, with add. 1, 30/9/74.

discussion, the Board was unable to agree on a clear recommendation and the question was finally deferred to the Council.[96]

At the Council meeting, one week later, the question had definitely become a highly political issue, with four member states advocating the establishment of the new facility in their own territory: Italy supported the Fucino/Telespazio option recommended by the Secretariat; Belgium pressed for the Redu/ESRO solution and stressed "the capital importance of the Organization being the owner of the ground station"; Germany argued that the choice of the Weilheim site was the most consistent with the Council's established policy about earth stations; and even Spain asked for reconsideration of the Villafranca site, which had been rejected months before.[97] The Belgian delegation was the most sanguine. According to the minutes of the meeting:

> The Belgian Delegation voiced the grave concern of its authorities about the situation that had developed in the Organization during recent months, in particular the repeated postponement of the appointment of a Director General, the absence of a final decision on the Aerosat [aeronautical satellite] programme, and now budget difficulties. Faced with the Council's attitude towards a decision on the choice of the ground station, the Belgian authorities wanted to see the whole of these problems dealt with at political level and they reserved the right to initiate action to that end.[98]

The ESRO Council found itself in a very delicate situation. More than one year had elapsed since the European Space Conference had finally agreed on the so-called "second package deal", which paved the way to the transformation of ESRO into a European Space Agency (ESA) devoted to all space activities (science, application and launchers). The birth of the new agency, however, had been repeatedly postponed because of persisting political and financial problems, and the Council could not add to its already hot agenda a critical consideration of the location of all the Organization's facilities, as requested by the Belgian delegation. They still had in mind the difficult situation in which ESRO had found

96 ESRO/C(74)50, add. 1, 1/10/74, and add. 2, 7/10/74.

97 Council, 68th meeting (8/10/74), ESRO/C/MIN/68, 22/10/74, p. 10.

98ESRO/C/MIN/68, cit., p. 11. The lack of agreement on the choice of A. Hocker's successor as ESRO's director general had led the Council to appoint the director of administration R. Gibson as acting director general: Council, 66th (restricted) meeting (26/6/74), ESRO/C/APP(74)17, 8/7/74.

itself after the decision to stop the research activity at ESRIN and to wind up the sounding rocket programme based in ESRANGE. In that circumstance, it had required laborious negotiations with the Italian and Swedish authorities before a compromise about the future of these establishments could finally be reached.[99] After a harsh discussion in which the Dutch delegation supported the Redu solution and France, Sweden, Switzerland and the U.K. supported Fucino, the Council decided, by the narrow margin of four votes (Belgium, Germany, Netherlands and Switzerland) to one (Italy), with five abstensions (Denmark, France, Spain, Sweden and the U.K.), to defer any decision on the location of the OTS control station to its next meeting. The French chairman, M. Lévy, one of the main authors of the second package deal, expressed his "grave disappointment" at this outcome of the Council's discussion. And the Swiss delegation noted disconsolately that "concern for national interests continued too often to predominate."[100]

The problem found a solution at the following Council meeting, at the end of October 1974, but the persisting disagreement was recorded in the outcome of two votes. By the first, the Belgian proposal to locate the OTS control station at Redu was rejected by four votes in favour (Belgium, Netherlands, Sweden and Spain) and five against (Denmark, Germany, Italy, Switzerland and the U.K.), with one abstension (France). By the second, the Council adopted a resolution, by seven votes to one (Belgium) with two abstensions (Netherlands and Sweden), which provided for the OTS control station to be located in the Telespazio facilities at Fucino.[101]

The issue of the site having being settled, the question of the contractor came to the forefront. In October, AEG-Telefunken returned with a revised offer in which the price had escalated to 8.25 MAU, the reasons for the increase being mainly ascribed to the introduction of new sub-contractors. Under these circumstances, in which the just-return policy so considerably contrasted with the tender cost, the ESRO Secretariat felt obliged to re-open competition by awarding

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[99] ESRIN became the seat of the new Agency's Space Documentation Center; ESRANGE was transferred to the Swedish government but it continued to be used by ESRO for its sounding rocket "special project". The similarity between the Redu situation and that of ESRIN and ESRANGE was explicitly underlined by the Belgian delegation.

[100] ESRO/C/MIN/68, cit., p. 12.

[101] Council, 69th meeting (30/10/74), ESRO/C/MIN/69, 8/11/74, with attached ESRO/C/LXIX/Res. 1, 30/10/74.

an eight-week study contract of 150 KAU to Siemens in order to make this company's former offer technically acceptable.[102] Siemens, however, could not submit a revised bid before the end of Febraury 1975, which made it impossible to meet the schedule of the OTS programme. Consequently, negotiations with AEG-Telefunken were undertaken with a view to reducing their price. The company, in particular, was now instructed to review its design using the cheapest sub-contractors.[103] The newly revised offer of AEG-Telefunken, which excluded Marconi, now amounted to 6.545 MAU, the increase compared to the original offer being mainly due to the technical requirements imposed by the move from Odenwald to Fucino. In the event, two different contracts were approved by the AFC, one directly with AEG-Telefunken, at a cost of 2.345 MAU, for the ESRO share of the station's equipment, and another with Telespazio, at a cost of 3.854 MAU, for the renting, maintenance and operation of the station over 3.5 years.[104]

CONCLUDING REMARKS

The launch of the OTS, originally planned at the end of 1976, was eventually scheduled for September 1977. On Friday 13th of that month, an unfortunate date indeed, the Delta rocket carrying the satellite exploded shortly after lift-off from Cape Canaveral and the 900 kg spacecraft was lost in the ocean.[105] Fortunately enough, a back-up policy for the OTS project had been agreed in 1975, and a second flight unit could thus be integrated in six months. This was successfully launched on 11 May 1978, opening a "new era in European communications", as

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[102] ESRO/AF(74)82, add. 1, 28/10/74; AFC, 103rd meeting (29/10/74), ESRO/AF/MIN/103, 8/11/74.

[103] 104th meeting (28-29/11/74), ESRO/AF/MIN/104, 12/12/74; ESRO/AF(74)154, 19/12/74.

[104] ESRO/AF(75)8, 23/1/75; ESRO/AF(75)9, 24/1/75; ESRO/AF(75)10, 24/1/75. AFC, 108th meeting (10-11/2/75), ESRO/AF/MIN/108, 20/2/75.

[105] The satellite was heavier than originally designed because in 1974 it had been decided to use the new and more powerful Delta 3914 launcher instead of the standard 2914 model. The upgrading of the OTS made it possible to design it much closer to the operational ECS than originally planned. On the other hand, the use of such a new vehicle involved some technical risk. See the discussion at the PB-TEL, 10th meeting (3/7/74), ESRO/PB-TEL/MIN/10, 22/8/74, as well as the documents ESRO/PB-TEL(74)17, 25/6/74, and ESRO/PB-TEL(74)19, 26/6/74.

heralded in *ESA Bulletin.*[106] Earlier that year the ESA Council had finally approved the undertaking of the next phase of the Telecom programme, after two years of laborious negotiations both among member states and between ESA and EUTELSAT, the new organization to which the PTT administrations had delegated authority for owning and managing the space segment of the communications satellite system.[107] The ECS development could then go into full swing and the first ECS satellite, now re-named EUTELSAT I, was eventually launched on 16 June 1983 from the ESA range in Kourou by an Ariane rocket. A second satellite was launched in August 1984 while the third was lost in September 1985 because of a launch failure. Two other satellites were then launched in September 1987 and July 1988, respectively, thus bringing to completion the full ECS system with four satellites in orbit. We should also recall that the Telecom programme also produced the MARECS satellite, a satellite for maritime communications based on the ECS design, two of which were successfully launched in 1981 and 1984 (a launch failure occurred in 1982).[108]

A thorough presentation of these developments is beyond the scope of this paper. At the conclusion of this second part of our story of ESRO's tele-communications programme, a few considerations are called for. The first, and the most obvious, concerns the long time required to get a definite programme under way and to harvest the expected achievements. We have seen that the first ideas on a joint European communications satellite programme had been discussed as early as in 1963 and that definite plans had been elaborated by the end of 1965.[109] It then required six years to get ESRO's Telecom programme approved (but only the first phase of it) and two more years before the programme arrangement was agreed on and the construction of the OTS was contracted with industry. The approval of the next phase then required another four and a half years. When, in the summer of 1983, the first ECS finally began its operational life, six Intelsat V satellites were orbiting over the earth's oceans and another was about to move onto the launching pad; domestic satellite telecommunications in the United States were being implemented by several private companies (Western Union, AT&T,

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[106] *ESA Bulletin*, n. 14 (May 1978): *OTS opens new era in European communications*. This issue of the bulletin is completely devoted to a description of the OTS and its orbital test programme.

[107] Müller (1990), 244–301.

[108] On MARECS see *ESA Bulletin*, n. 28 (November 1981).

[109] Russo (1993a), pp. 16–26.

RCA, SBS, Hughes), the first launchings occurring in 1974; Canada had already launched seven satellites of the ANIK series; Japan, India and Indonesia had also acquired independent space communications capability; and two Symphonie satellites were approaching the end of orbital life after several years of good performance. Not all these spacecraft were as complex and up-to-date as the ECS, but the European system was certainly too late to play a major role in the competitive market of space telecommunications.[110]

The patient reader of this paper, and of that preceding it, will agree that it was not technical difficulties that caused such a prolongation in the development of ESRO's (eventually ESA's) telecommunications programme. Notwithstanding the sophistication of the OTS and ECS design, engineers in ESTEC and in industry seemed perfectly capable of meeting the technical challenge; at least, no evidence can be found in the IAPC and PB-TEL documents of any major delay caused by technical difficulties. What we find, on the contrary, is the evidence of the many political and institutional problems arising from the complex framework of the history of space in Europe. Let us recall three of them that deserve some further comment.

Firstly, the laborious search for a coherent space policy for Europe. ESRO's Telecom programme was hardly considered or evaluated just for itself, it was always an element of a process which involved many other elements, such as the question of the European launcher and the relationship between Europe and the United States, or the problems of industrial policy and European economic integration. In order to start a viable space telecommunications programme, package deals had to be agreed on in which both common undertakings and national interests could be guaranteed, and this took time.

The second problem regarded the question of users. As the Swiss delegation put it at a PB-TEL meeting:

> The initiative to develop a telecommunications system rested entirely with the ministers of ESRO's member states, and [...] the decision had not been taken solely with a view to meeting the users' requirements, but within a much wider political context. Indeed, it had to be

[110] For technical information on all communication satellites up to 1992 see Martin (1991).

recognized that the users had never formally requested the introduction of such a system.[111]

The development of space telecommunications in Europe was not spurred on by a strong demand, with generous funding provided by interest groups. On the contrary, it was political push which furthered the development. This however lacked clear objectives, firm determination and adequate funding, because of the uncertainty regarding the economic benefits and the multinational structure of the institutions called to implement the programme. Another kind of deal, in fact, had to be negotiated between ESA, the ministers and the users organizations in order to cope with the financial aspects of the ECS system.

A third reason for delay was the rather cumbersome procedures for taking decisions. This was due to the complex institutional framework in which the decision-making process developed, with several bodies involved at different levels and different times. Not only did all major decisions of the Telecommunications Programme Board have to be endorsed by the Council, but the latter was invested with all issues of political relevance (i.e., each time the PB-TEL delegations could not find an agreement). Questions affecting the budget had to be discussed by the Administrative and Finance Committee, while those involving more than one programme had to be discussed by the appropriate Programme Board or the Joint Programmes and Policy Committee. Groups of experts were often set up to discuss technical questions (which often had political importance, as we have seen in the case of the STP programme), and the smoothness of the whole process depended of course on the general political conditions. The decision process was also affected by the performance of other actors, like the CEPT and its committees, the national PTT administrations, the EBU, the governments of ESRO's member states, the individual ministers in those governments, and so on. And the multinational structure of so many decision-making bodies added a new dimension to the usual slowness of any complex bureaucratic process.

The second consideration regards the political role of the ESRO/ESA executive *vis-à-vis* the legislative arms of the Organization. We have seen how important this role was when, after the failure of the envisaged ESRO/COMSAT cooperation, theESRO Secretariat succeeded in proposing the OTS project and getting it through against the no-issue situation of competing national interests.

[111] PB-TEL, 4th meeting (27/2/73), ESRO/PB-TEL/MIN/4, 15/3/73, p. 7.

On the other hand, they were not able to get the technical arguments recognized against "industrial policy" arguments when the choice of the OTS contractor was discussed. ESRO was capable of defending the viability of the Telecom programme against the CEPT's pessimistic analysis on the financial aspects of the envisaged ECS system; but they failed when they claimed support for a fully fledged technological research programme. A fair conclusion might be that the Telecom programme certainly gave ESRO a more important political role than the Organization had when its programme was limited to scientific projects. The Secretariat always acted now as an authoritative protagonist in the negotiating process, taking advantage of its established technical and managerial capability, as well as the political credibility which ESRO had *vis-à-vis* the shortcomings of the European Space Conference. On the one hand, the Telecom programme had provided the Organization's technical staff with invaluable know-how on advanced space technology and on the management of important industrial contracts. On the other hand, it became clear that projects like Symphonie or Sirio could not serve a European ideal in space, and if such an ideal was to survive ESRO was the only instrument to achieve it and the Telecom programme its main implement.

Our last consideration regards ESRO's industrial policy. We have seen how the concern about this aspect was particularly exasperated among the Organization's member states. The enforcement of the just return concept was always at the core of any political negotiation or technical discussion, and the difficulty of finding a compromise on this issue was often the main reason for delays and setbacks. The stakes in fact were high. Telecommunications appeared as the most promising sector in space activities, both from the point of view of economic investments and from that of commercial returns. Governments and industries could not afford to miss the opportunity that ESRO's Telecom programme was offering. The just return concept was at the very core of ESRO's foundation: in fact, at the conference at which the ESRO Convention was opened to signature, the plenipotentiaries had adopted a resolution which stated that the Organization should "place orders for equipment and industrial contracts among Member States as equitably as possible, taking into account scientific, technological, economic and *geographic* considerations."[112] The geographic constraint, however, had not been particularly emphasized in the first years of the Organization's existence,

112 Quoted in Krige (1993), p. 43; my italics.

from 1964 to 1968, and it became an important issue only when ESRO started to develop more sophisticated scientific satellites like the TD–1. With the undertaking of application programmes, the budget escalation, and the evolution of ESRO towards a comprehensive space agency, the just return principle became the main element of the Organization's industrial policy. Just return, however, could not be a substitute for a real industrial policy. This should also imply the planned use and development of Europe's industrial resources, with the aim of improving its competitiveness and rationalizing its structure and services, and this often contrasted with the requirements of fair geographical distribution.[113] We cannot discuss this topic here, but we should recall that the pressure for fairly distributing industrial contracts among participating countries, on the one hand, and the development of both national and joint European programmes, on the other, led in fact to duplication and to productive over–capacity. In the event, this essential tension between industrial rationalization and just return, as well as between national policies and ESA's joint ventures, led to the emergence of two parallel and competing programmes on second–generation communications satellites, the Franco–German TDF/TV–SAT and ESA's *Olympus*. That, however, is a story to be told in a subsequent paper.

113 On the discussion about ESRO's and ESA's industrial policy see Beattie & De la Cruz (1967), Palacios (1978) and Dondi (1980a). See also Müller (1990), pp. 353–357.

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Table 1

Alternative options for the orbital tests

Option I		Use of satellites of the 200–kg class. Four possible sub–options:
	Ia	Sirio–B and Symphonie–B
	Ib	Sirio–B only
	Ic	Symphonie–B only
	Id	A specially developed satellite
Option II		Development of a satellite of the 500–kg class

From: ESRO/IAPC(71)9, 24/5/71

TABLE 2

FINANCIAL PLAN FOR THE TWO OPTIONS OF TABLE 1 (MAU AT 1971 PRICES)

Options	Phase 1 (preparatory)	Phase 2 (experimental)	Phase 3 (operational)	Total
Ia	5	179	211	395
Ib	5	144	211	360
Ic	5	161	211	377
Id	5	176	211	392
II	5	255	176	436

From: ESRO/IAPC(71)9, 24/5/71

TABLE 3

FINANCIAL PLAN FOR THREE OPTIONS (MAU AT 1971 PRICES)

Options	Phase 1	Phase 2	Phase 3	Total
Ia	5	179	211	395
Ib	5	144	211	360
Ic	5	161	211	377
Id	5	176	211	392
II	5	255	176	436
III	5	331	112	448

From: ESRO/IAPC(71)9, add. 1, 18/6/71

TABLE 4

COST-TO-COMPLETION OF OPTIONS II, III AND IV (MAU AT 1971 PRICES) *

Option II	500-kg experimental satellite; 700-800 kg prototype/operational satellite	473
Option III	200-kg experimental satellite; 700-800 kg pre-operational satellite; 700-800 kg operational satellite	497
Option IV	Several alternatives, e.g.:	
(i)	ESRO/COMSAT satellite and 400-kg operational satellite without prototype	271.5
(ii)	Symphonie-B financed outside ESRO and 400-kg operational satellite with prototype	305
(iii)	Symphonie-B financed outside ESRO and 800-kg operational satellite with prototype	381
(iv)	ESRO/COMSAT satellite and 800-kg operational satellite with prototype	400
(v)	Symphonie-B financed by ESRO and 800-kg operational satellite with prototype	424

From: ESRO/IAPC(71)28, 9/11/71, and ESRO/IAPC/MIN/9, 22/12/71, annex V.

* Figures in this table include ESRO direct costs, industrial development contracts, and common and support costs calculated according to the new programme budgeting and accounting which took into account the eventual optionality of programmes (see ESRO/C(71)46, 21/9/71, and add. 1, 18/10/71). Common and support costs were estimated at 91 MAU for option III and at 56.5 to 85 MAU for the various sub-options in option IV.

TABLE 5

PROGRAMME OF THE EXPERIMENTAL PHASE (1972–1976) WITH ESTIMATED COSTS (MAU AT 1971 PRICES)

1. Communication system a) Overall system studies b) Studies of transmission problems c) Propagation experiments d) Earth segment studies	7.5
2. Supporting Technology Programme (STP) a) Communication technology a1) Travelling wave tube amplifier a2) 14/11 GHz modular repeater a3) Qualification of parts and technologies a4) Advanced developments a5) Antenna developments b) Spacecraft technology b1) Structures and mechanisms b2) Thermal control b3) Attitude and orbit control b4) Energy conversion	33.0
3. Experimental satellite (including CTS) * a) Definition and development b) Manufacture c) Launch	20.0
4. Pre-operational and operational satellites a) Satellite configuration definition studies (phase A study) b) Further work on the operational system (phase B study)	5.5
Total cost	76.0
ESRO direct costs	10.0
Common and support costs	25.0
Grand total	101.0

From: ESRO/IAPC(71)28, 9/11/71, and ESRO/IAPC(72)6, 23/2/72

* The cost of the experimental satellite is for the ESRO/COMSAT option . The cost of the Symphonie option was estimated at 40 MAU in the event of 100 % financing of Symphonie-B under the ESRO programme.

Table 6

Cost estimates of the telecommunications programme according to the OTS option (MAU at 1971 prices)

	Phase 1	Phase 2	Phase 3	
			400 kg	800 kg
ESRO direct costs	1	11.5	11	11
Communicat. System	1	7.5	3	3
Technology	3	33	4	14
Experimental satellites (OTS + CTS)	–	55.5	–	–
Operational satellites	–	3.5	94	160
Sub totals	5	111	112	188
Total cost			228	304
Common and support costs			60	77
Grand total			288	381

From: ESRO/PB–TEL(72)2, 11/8/72, and ESRO/PB–TEL(72)6, 7/11/72.

TABLE 7

FINANCIAL ENVELOPE OF THE EXPERIMENTAL PHASE (PHASE 2) OF THE TELECOM PROGRAMME (MAU AT 1972 PRICES)

	Phase 2	Phase 2 bis
ESRO's internal costs	12.9	0.6
Communication system	7.1	1.1
Supporting technology		
a) microwave	17.8	0.9
b) spacecraft	9.6	3.6
Experimental satell. (OTS and CTS)	64.4	–
Operational satell.	3.3	0.4
TOTAL	115.1	6.6

From: ESRO/PB–TEL(73)12, 6/7/73.

TABLE 8

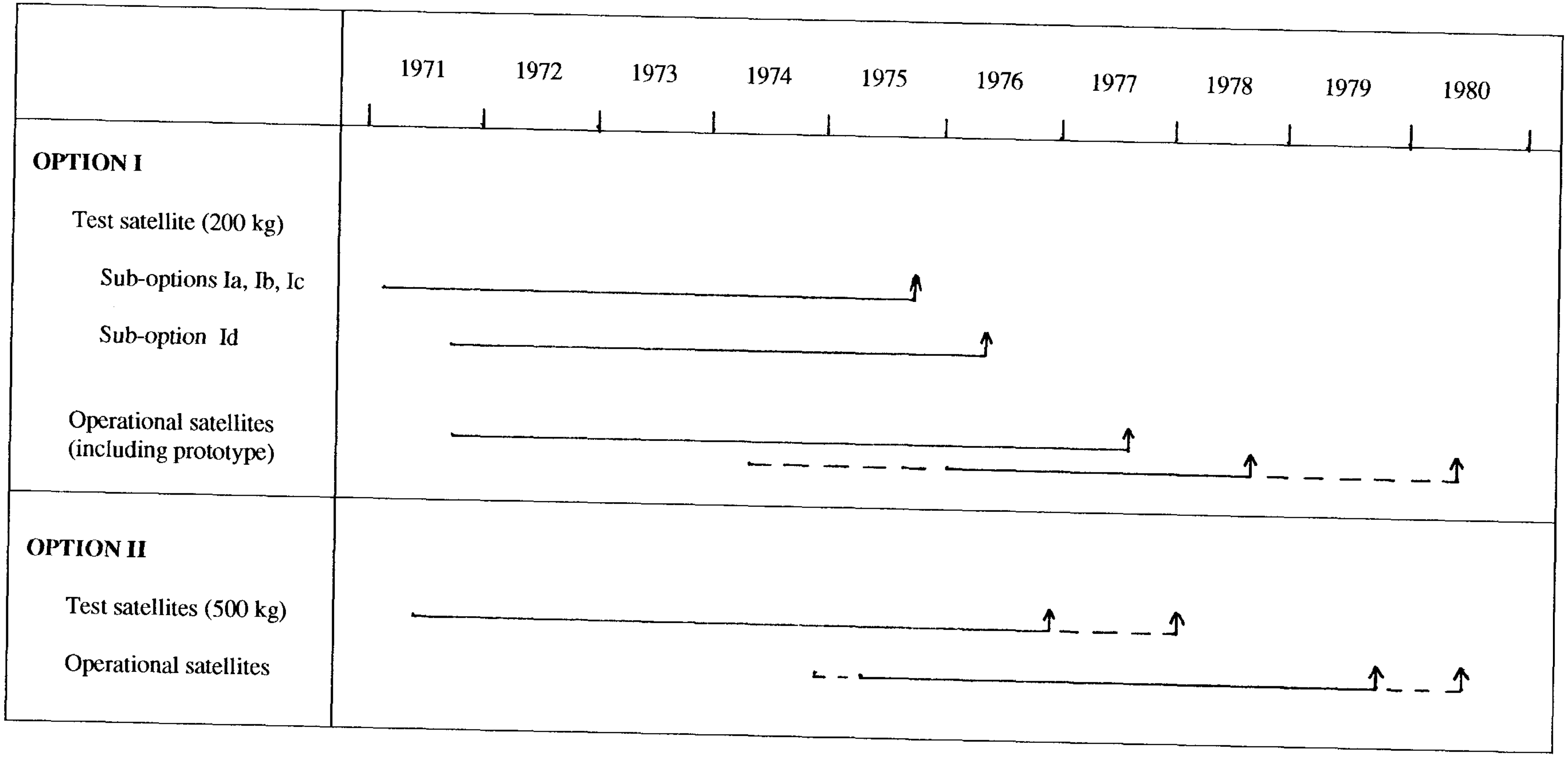
SCALE OF CONTRIBUTION TO THE TELECOM PROGRAMME

Country	Contribution share in %
Belgium	3.96
Denmark	2.35
France	23.11
Germany	25.01
Italy	14.69
Netherlands	2.50
Sweden	4.90
Switzerland	3.39
United Kingdom	20.09
Total	100.00

From ESRO/C(73)64, 8/10/73.

FIGURE 1

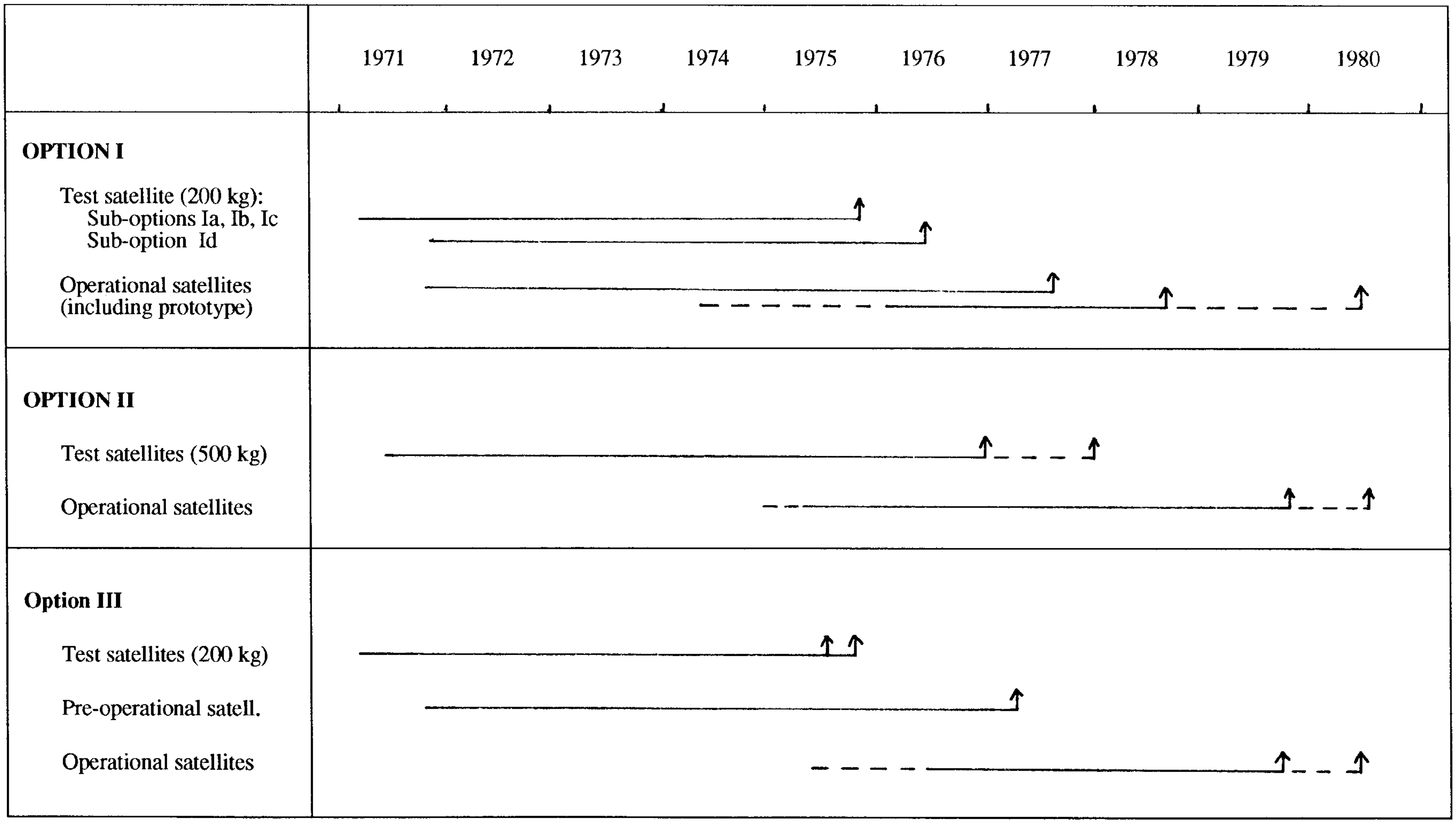
PROGRAMME DEVELOPMENT IN TWO DIFFERENT OPTIONS



From: ESRO/IAPC(71)9, 24/5/71

Figure 2

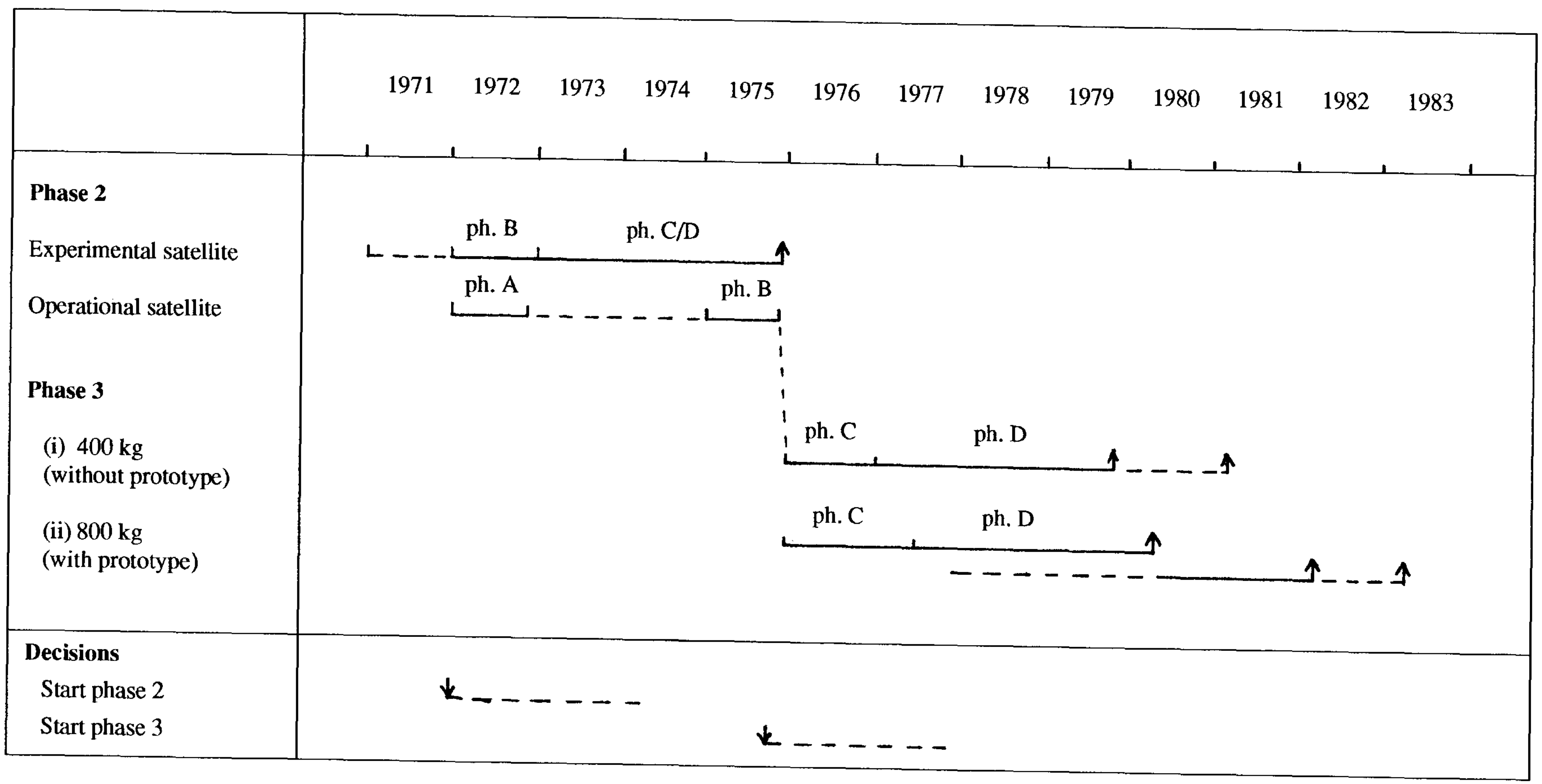
Programme development in three different options



From: ESRO/IAPC(71)9, add. 1, 18/6/71

FIGURE 3

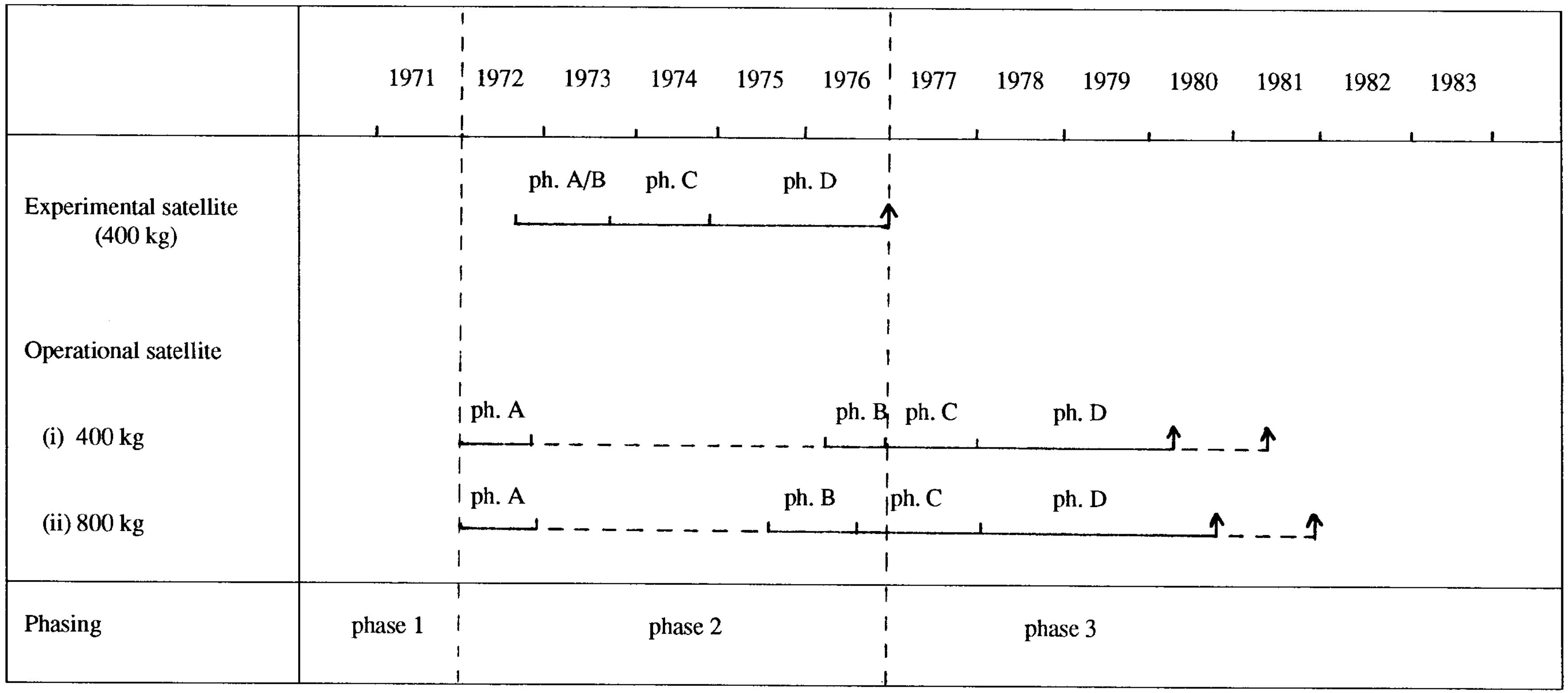
PROGRAMME DEVELOPMENT IN OPTION IV



From: ESRO/IAPC(71)28, 9/11/71.

Figure 4

Programme development in the OTS option



From: ESRO/PB-TEL(72)2, 11/8/72

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