Chapter 7

INTERNATIONAL EFFORTS IN SPACE

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INTERNATIONAL EFFORTS IN SPACE

INTRODUCTION

The shape, direction, and very existence of the U.S. civilian space program owe much to international competition. The basic events are well known: the launch of Sputnik in 1957 and the sudden public discovery of the "space age;" the continuing series of Soviet space "firsts" in unmanned and then manned satellites; and the sometimes desperate attempts by the United States to catch up, culminating in President Kennedy's 1961 commitment to a manned lunar landing by 1970, ahead of the Russians. (For a more detailed description of the early phases of Soviet-American rivalry in space, see app. G.)

During these years of competition the United States and the Soviet Union had a virtual monopoly on space systems and technologies: boosters; tracking systems; communications, remote sensing, and weather satellites; and manned spacecraft. Other countries, lacking the military and political motivation, did not at first choose to expend the resources needed to develop independent space capabilities.

We will not attempt hereto describe the course of these developments during the 1960's; the main elements of the current Soviet space program will be presented later (see pp. 204-209). Suffice it to say that the U.S. program had, by the end of the decade, succeeded in demonstrating its superiority in virtually every area—without, however, forcing the Soviets to abandon their own efforts or to concede permanent U.S. preeminence.

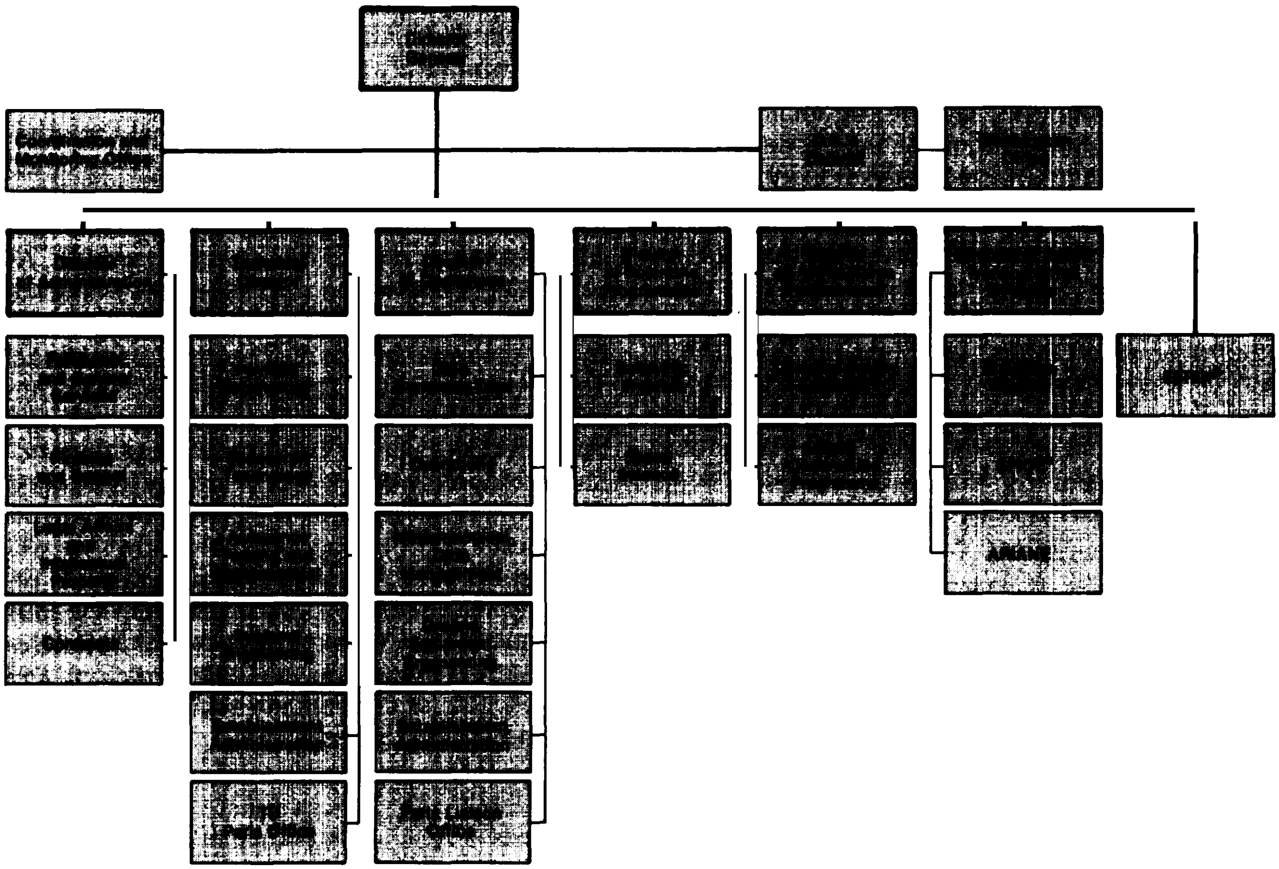
The important point is that, beginning in the 1960's but accelerating rapidly in the 1970's, other countries began to enter the field. Political motivations, as will be seen, played and continue to play a crucial role; to a large extent these were identified with maintaining economic competitiveness vis-a-vis commercial rivals, particularly the United States. As the U.S. post-Apollo space activities, both public and private, have come to concentrate more on potential economic payoffs rather than on large prestige projects, and the Soviet program has turned toward the long-term goal of permanent manned orbital platforms, the commercial competition in space applications technologies and systems from Europe and Japan has become increasingly important. The significance of competition between nations has also altered, due to the expanded global use of space technology rising largely out of the successes of the U.S. space program. International organizations for global communications, such as INTELSAT and INMARSAT, have continued to grow and now include most of the world's users of telecommunications. Through the National Aeronautics and Space Administration (NASA) and the U.S. Agency for International Development, many developing countries have gained first-hand experience in the ways satellite communications and remote-sensing systems can supply services crucial for economic growth. As one result, the laws and regulations governing the use of outer space have been widely discussed by international bodies such as the International Telecommunication Union and the U.N.'S Committee on the Peaceful Uses of Outer Space. Space technology has become an important political resource whose effective use by the United States will be affected by the development of international competition. In what follows we will outline, for each major foreign program, its organization and goals, its main efforts in the four applications areas (communications, remote sensing, materials processing, and transportation), and the prospects for cooperation and/or competition with the United States.

EUROPEAN SPACE AGENCY AND JOINT EUROPEAN EFFORTS

Since the early 1960's Europe has attempted to mount a coordinated space program to compete with the United States and Soviet programs in key areas and to ensure European participation in the economic, scientific, and political benefits of space activities. The latest and most successful organization to attempt this task is the European Space Agency (ESA), made up **of 11 full members—Belgiu m, Denmark, France, Germany, Ireland, Italy, the Netherlands, Spain, Sweden, Switzerland, and the united Kingdom–and two associate members—Austria and** Norway. ESA **is involved in space science, applications, and launch vehicle development, as well as the formulation of policy** for European cooperative ventures (see fig. 1 1).

At the **beginning of the space age, individual European states recognized that they could not mount space programs on the scale of those in the United States or** U.S.S.R, unless there was extensive cooperation among interested parties. Even so, there was no attempt to match the manned capabilities being competitively developed by the superpowers. European interest has been focused on basic science, on applications satellites for regional use, and on supporting an industrial/technical infrastructure that could contribute to high-technology enterprises. Despite these shared interests, however, there have been continuing difficulties caused by: 1) differences between members about what programs to support and general policies to follow, 2) problems

Figure II.—Organizational Structure of the European Space Agency



[a]SPICE - Spacelab Payload Integration and Coordination in Europe
[b]ESRIN - European Space Research Institute (includes Earthnet), Frascati, Italy

SOURCE: *Europe's Place in Space* p. 6.

in allocating contracts between industries in various countries, 3) disagreement about the appropriate degree of cooperation with, and dependence on, the United States, and 4) competition between ESA and national programs.

Policy and Budget

ESA was founded in May 1975 following several years of negotiations and compromises among the major participants. ESA inherited the programs and facilities of its predecessor organizations, the European Space Research Organization (ESRO), the European Launcher Development Organization (ELDO), and the European Space Conference (ESC). (For a description of Europe's pre-ESA activities, see app. G.) An important point is that, unlike NASA, ESA is specifically allowed to operate applications systems, once developed, with the costs being borne by the users of the system.1 A second difference, one which partially offsets the first, is that ESA is responsible for carrying out an "industrial policy" designed to "improve the worldwide competitiveness of European industry," while ensuring that member states participate equitably and, in particular, that the return to any member state—i.e., the value of the contracts let by ESA—is approximately proportionate to the members' contributions (the principle of "juste retour" or fair return). The ESA convention explicitly states that it shall "exploit the advantages of free competitive bidding in all cases, except when this would be incompatible with other defined objectives of industrial policy. "z Hence considerations of cost or efficiency may have to take a back seat to the principle of fair return, with predictable results for timeliness and cost effectiveness. This is one of the inevitable shortcomings of a mu Itinational agency, and a prime reason why operational systems have generally been handled outside of ESA.

The ESA members contribute to the organization in two ways: mandatory activities, which include the scientific programs and basic organizational expenditures; and optional **activities,** which are specific programs for satellite design and operations, launch facilities, and space transportation.[3] The major programs, such as Ariane and Spacelab, are optional, which means that members can request to be specifically excluded. Mandatory contributions are based on each state's national income; however, no one state can contribute more than 25 percent of the total budget. For optional projects, interested participants pay a variable percentage which is negotiated between the participants. The degree of national support for various programs in **1981** is given in table 17.

ESA'S budget for its first full year of operation (1976) was approximately $600 million, of which one-third went for mandatory and two-thirds for optional programs. This compares with NASA's fiscal 1976 appropriation (for space) of $3.22 billion. In 1980, ESA'S budget had risen to $846 million, while NASA's was $4.68 billion. In both years, the ESA budget was between one-fifth and one-sixth NASA'S. (These figures do not constitute a complete comparison of United States and European civilian space expenditures, since they fail to include non-NASA programs in the United States, both Government and private sector, as well as the space budgets of individual European countries). Since ESA'S two most expensive projects, Ariane and Spacelab, are largely complete and are not likely to be soon replaced by comparable programs, ESA'S budget is not expected to increase over the coming years.[4]

Current and Projected Applications Programs[5]

Communications

European communications needs and programs have been defined largely by the national PTTs (postal, telephone, and telegraph agencies) acting through CEPT (Conference Europeene de Postes et Telecommunications and the European

I "Convention for the Establishment of a European Space Agency," done at Paris May 30, 1975, art. V.

"'Convention," art. VI], par. 1 sec. d.

3"Convention," art. V.

[4]As a multinational organization, ESA has had to develop an accounting system to provide for changes in exchange rates between member states. ESA accounts are kept in ESA Accounting Units (AU) rather than any single national currency. The value of the AU vis-a-vis other currencies is reevaluated annually; in 1981, one AU = $1.4.

'Unless otherwise indicated, figures and information in this section are taken from *Europe's P/ace in Space,* ESA, Paris, January 1981.

Table 17.–Contributions of Member States to the Principal ESA Programs in 1981

	General budget	Science	Meteosat expioita-tion	Sirio-2	OTS	ECS	ECS phase 3 bis	Marecs A	Marecs B	Spacelab	Ariane develop-ment
Member states:											
Belgium	4.71	4.49	4.06	3.30	5.17	3.27	3.19	0.95	0.14	5.07	1.92
Denmark.	2.63	2.51	2.41	—	2.90	0.33	0.74	—	—	1.81	0.40
France	22.45	21.40	23.70	7.50	24.69	25.93	26.52	11.92	5.74	12.07	79.34
Germany.	26.82	25.57	25.66	9.00	25.00	30.68	30.42	19.08	13.29	64.78	5.31
Ireland	0.54	0.54	—	—	—	—	—	—	—	—	—
Italy.	5.51	12.46	15.07	72.39	14.38	14.78	13.85	2.20	1,28	1.00	5.31
Netherlands.	6.29	6.00	—		2.50	0.94	1.77	4.63	1.49	2.53	0.34
Spain	5.29	5.04	—	0:50	—	0.17	0.53	0.95	0.34	3.38	4.18
Sweden. , ., ... , . .	4.16	4.25		1.50	4.91	1,62	3.97	2.96	6.61	—	0.63
Switzerland	4.19	3.99	3.48	3.50	4.59	2.13	0.55	—	—	1.00	0.08
United Kingdom . .	14.42	13.75	20.60	1.83	15.86	20.15	18.46	55.81	69.89	7.60	2.49
Other participants:											
Austria	0.68	—	—	0.48	—	—	—	—	—	0.76	.
Canada.	2.23	—	—	—	—	—	—	—	—	—	—
Norway.	0.08	—	—	—	—	—	—	1.50	1.22	—	—
Other income.	—	—	5.02	—	—	—	—	—	—	—	—

SOURCE: From *Europe's Place in Space*,p,9.

Broadcasting Union (EBU). More recently, forecasting and coordination have been done within the Interim Eutelsat Organization, set up within CEPT in 1977 to establish a European satellite communications system.

OTS ***(Orbital Test*** Sate//ite).–The OTS project was approved by ESRO in 1971 and launched into geosynchronous orbit in 1978 (aboard a U.S. Delta 3914) after development by British Aerospace Dynamics Group. With a capacity of 3,000 telephone circuits, it has been used for various experimental purposes including high-speed scientific data transmission and television broadcasting. Current projections are that it may be able to provide useful services for up to 5 more years. Program cost has been $365.4 million.

ECS (European Communications Satellites).– The OTS was designed to prove the usefulness of an operational European telecommunications system. In 1978, ESA approved a five-satellite system, based on the OTS design, to provide regional communications needs for 10 years. interim Eutelsat will pay user fees for international trunk telephone services and for television transmission between members of the European Broadcasting Union. High-speed data transmission and communication with off-shore oil and gas platforms may also be provided. British Aerospace Dynamics Group is the prime contractor for the estimated $632.8 million program (not including ground terminals); the first satellite is scheduled for an Ariane launch in 1982.

Marecs.–Marecs is a direct descendant of Great Britain's Marots program for ocean communications, but its design is based, like ECS, on the experimental OTS. Two satellites will be placed in geostationary orbit over the Atlantic (the Atlantic satellite may eventually be relocated over the Indian Ocean) and Pacific to provide ship-to-ship communications. The international maritime satellite organization, inmarsat, is leasing the satellites for its mission. The British Aerospace Dynamics Group is prime contractor, and Britain has put up most of the development funding, some 55 percent of Marecs A and almost 70 percent of Marecs B. (In the OTS and ECS programs, by contrast, Great Britain contributed a more usual 15 to 20 percent.) Marecs A was launched on the fourth Ariane test flight December 20, 1981, and Marecs B is scheduled for the first operational flight in September 1982. Program cost is $359.8 million.

L-Sat (large-satellite). –The L-Sat is a descendant of an earlier program, H-Sat, which was abandoned by France and Germany in favor of going ahead with more rapid deployment of their own joint (non-ESA) operational communications and television direct broadcast system (see description, p. **188).** As presently envisioned, L-Sat would be a very large, advanced experimental communications satellite to test the feasibility of direct TV broadcasting and specialized/business communications using small roof-top size terminals. In addition, it would include equipment for experiments with the as-yet unexploited 30/20 GHz band. The British have been most enthusiastic about L-Sat development, which is seen as competitive with U.S. technology for future INTELSAT satellites, and British Aerospace has been awarded the prime contract. Still in the design definition stage, its estimated launch (either on the space shuttle or an advanced Ariane), is set for 1986. The estimated development cost is $520 million (1 980 price levels).[b]

One of the striking facts in looking at ESA'S communications program is the leading role played by Great Britain and British industry. Since there are national and bilateral European projects being conducted outside ESA, Britain is not the only European country fostering satellite telecommunications expertise, but it has one of the broadest and most forward-looking programs (see pp. **40-41** for further discussion).

Remote Sensing

ESA has been active in both meteorological and remote-sensing development, though with primary emphasis on the former,

Meteosat 7 ***and*** 2.—The Meteosat program was approved by ESRO in 1972; Meteosat 1 was launched (by Thor-Delta) in 1977, and placed in a geostationary orbit allowing it to survey Europe, Africa, and the Mediterranean. It provides raw imagery to central European ground-processing stations for short-term weather forecasting, as well as relaying the processed data to users and transmitting imagery from U.S. weather satellites stationed over the Western Hemisphere. Meteosat 1 has also contributed to global programs set up by the World Meteorological Organization. in 1979, Meteosat 1 suffered a partial failure of its power system; Meteosat 2 was launched in June 1981 on the third Ariane test flight. The prime contractor for the $301 million program was Aerospatiale of France.

Sirio 2.—Sirio 1 was an experimental Italian communications satellite; the spare, Sirio 2, will be launched by ESA in 1982 to provide meteorological data transmission to African ground centers, as well as to conduct scientific experiments. Cost for the Italian-built satellite will be $40.6 million.

Earthnet. -A mandatory ESA program, Earth net consists of four receiving stations and two processing centers which receive remote-sensing and meteorological data from U.S. satellites: Landsat, Nimbus-7, the Heat Capacity Mapping Mission, and (formerly) Seasat. The data are available to all ESA members as well as to outside requesters.

Spacelab Remote-Sensing Programs. –The first Spacelab flight, scheduled for 1983, will carry two European remote-sensing experiments. One will use a very high resolution camera for 1:100,000-scale mapping. The second involves the development of a microwave remote sensor to collect data through cloud cover.

ERS 1 (European Remote-Sensing Satellite).– The Earthnet and Spacelab projects, along with other activities, are designed to prepare for an advanced remote-sensing satellite, ERS 1. ERS 1 will be used to monitor icepacks and to sense coastal and ocean regions; its instruments include a synthetic aperture radar, a radar altimeter, and wind and wave scatterometers. Tentative launch date is mid-1987. (It should be noted that a major civilian operational/commercial remote sensing system, SPOT, is being undertaken by France, Sweden, and Belgium as a national project; the proposed ERS will use the SPOT bus but contain different instruments. For a description of SPOT, see pp. 25-29.) ERS-1 is considered to be one element i n a continuing program of Earth observation satellites. Studies are underway for further satellites, including one for land remote sensing.

Materials Processing

ESA does not yet consider materials processing to be an applications area per se, but rather an area in which to do basic research that may someday lead to useful products or processes.

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[6]ESA **News** Release, "New European Telecommunication Satellite, Program is Approved," Dec. 22, 1981. ESA **News Release, "ESA** Microgravity **Programme Gets Underway, "** Jan. **18, 1982.**

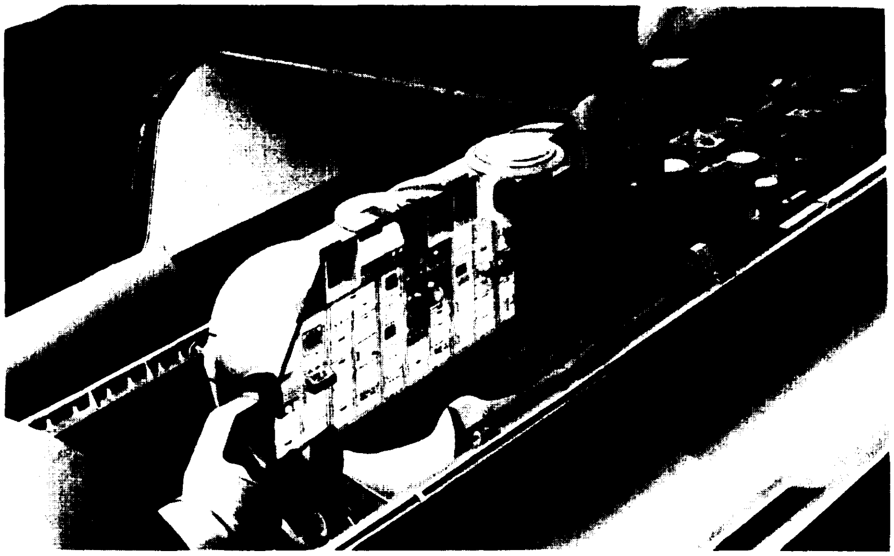


Illustration: Courtesy of European Space Agency

Spacelab (artist's conception)

The term "materials science" is used instead of materials processing; experiments in both biology and materials science will be carried out as part of an approved 4-year "microgravity programme" budgeted at $52.4 million.[7]

ESA'S main contribution to materials science will be through Spacelab, although sounding rockets are also being used. Spacelab will be the major facility for space-based experimentation in the physical and biological sciences during the next decade. Spacelab consists of a pressurized module capable of being carried in the payload bay of the space shuttle and allowing experimenters to work at a variety of projects in a shirt-sleeve environment. There are also pallets that allow equipment to be exposed directly to vacuum and radiation (see artist's rendition). Equipment for conducting processing experiments will include furnaces and remote manipulators.

Spacelab is ESA'S largest cooperative project with NASA. ESA is responsible for designing and delivering, free of charge, an engineering model and a first flight unit (delivered in December 1981), which NASA is scheduled to launch in mid-I983. The first flight program will involve a joint European-American crew conducting a variety of test projects. In 1980, NASA contracted to purchase a second spacelab, including a pressurized module and five instrumentation pallets, for $183.9 million from the prime contractor, the German firm ERN0.[8]

Spacelab is Europe's first attempt at constructing a manned system; partly for this reason, and also because of internal management problems compounded by continuing changes in the requirements for integration with the shuttle orbiter, the project has cost considerably more than initially estimated, and has also been subject to delay. The 1973 agreement between NASA and ESA called for delivery of the first unit by 1979; however, since the shuttle program has also been behind schedule, these delays have had little effect. The increase in costs, however, has caused problems among the ESA supporters. According to the ESA agreement, if costs rose above 120 percent of original estimates, the supporters could withdraw or renegotiate the terms. In 1979, estimated costs to completion (approximately $860 million; dollar amounts are inexact because of built-in inflation escalators and exchange-rate fluctuations)[9] were 140 percent of the original

[7] ESA News Release, "ESA Microgravity Programme Gets Underway," Jan. 18, 1982.

[8] "Europe Competes With U.S. Programs, " *A W&ST,* Mar. 3, 1980, p. 89.

[9] "Sweeping Changes Spur Spacelab Pace, " *AW&ST,* Feb. 11, 1980).

estimates. Italy in particular felt it could not continue to fund Spacelab at its original level of 18 percent and threatened to block the project (largely because its share of Spacelab's industrial participation had fallen to 11 to 12 percent) unless its contribution was reduced. As a result, Italy's contribution dropped from 18 percent in 1979 to 1 percent in 1981, with the shortfall being taken up by other contributors in proportion to their level of participation.

There have also been various tensions between NASA and ESA over secondary issues. One problem has been the flight schedule for Spacelab missions, especially since the number of shuttle flights for the first several years has recently been cut back. ESA is also concerned that changing specifications for shuttle payloads will lead to expensive redesign of Spacelab components. " Some European scientists think that NASA requirements for documentation and prior consultation on Spacelab experiments are overly stringent and reflect a desire to restrict European participation .12 NASA counters that preparations for manned missions are of necessity more rigorous than for other types of flights. Some Americans think that, despite the money saved by cooperative development, an American SpaceJab program would have been faster and would have produced a design better suited to U.S. needs and to the shuttle's capabilities, and that the (politically motivated) inclusion of the Europeans has resulted in a less-than-optimal technology.

It is difficult to evaluate these charges and countercharges objectively; in large part, they stem from the inevitable problems of conducting any major cooperative program in advanced technology, especially one with significant potential economic effects. Since, for budgetary reasons, the alternative to a European Spacelab was not a U.S. Spacelab, but no Spacelab at all, many U.S. criticisms are strictly hypothetical. The question of who will exploit Spacelab's capabilities most effectively-the United States, the Europeans, or perhaps the Japanese—remains open.

[10] Chris Bulloch, "Spacelab Status: Some Action at Last, " *Interavia*, November 1981, p. 1,168.

[11] Eric Quistgaard, Director General of ESA, statement before Senate Commerce Committee, Mar. 25, 1981, p. 7.

[12] "U.S.-Europe Collaboration Variable, " A W&ST, Sept. 1, 1980, p. 275.

Launch Vehicles

The Ariane I launcher, ESA'S most expensive single program, has recently completed a four-flight test program; the first operational flight will take place in September 1982.

Ariane I is a three-stage expendable vehicle, including an advanced liquid oxygen/liquid hydrogen third stage. For a comparison with U.S. launch vehicles, see table 18.

The current design of Ariane is only the first in a series of as many as five models; successive designs are planned to improve payload capacity and performance through the 1980's. The ESA member states have already approved a program to develop Ariane 2, 3, and 4. Ariane 2 will be able to place 4,4oo lb in a transfer orbit, and Ariane 3,5,280 lb.[13] Ariane 4, under study by ESA and CNES, will more than double the performance of Ariane 1; its further development was approved in January 1982, and first launch is scheduled for 1985. An even more ambitious improvement, a fifth Ariane version having a liquid oxygen/liquid hydrogen second stage and able to launch 12,100 lb into transfer orbit, is also under consideration for potential development by the end of the decade.

[13] Jeffrey Lenorovitz, "Arianespace Completing Payload Plans, " *AW&ST*, July 6, 1981, pp. 19-20.

Table 18.—Capacity of Ariane and U.S. (Commercial) Launch Vehicles (in lb)

	LEO	Transfer orbit
Ariane 1	10,500	3,700a
Space shuttle	65,000	—
Space shuttle with Delta upper stage	—	2,750
Space shuttle with internal upper stage (under development)	—	5,000
Thor-Delta	6,490	2,420
Atlas-Centaur	11,200	4,510

aThese figures assume the Ariane is launched from the Kourou launch site near the Equater, while U.S. launches are from Kennedy Space Center in Florida. The equatorial site gives any geostationary payload an approximately 15 percent performance improvement over KSC

SOURCE: Off Ice of Technology Assessment

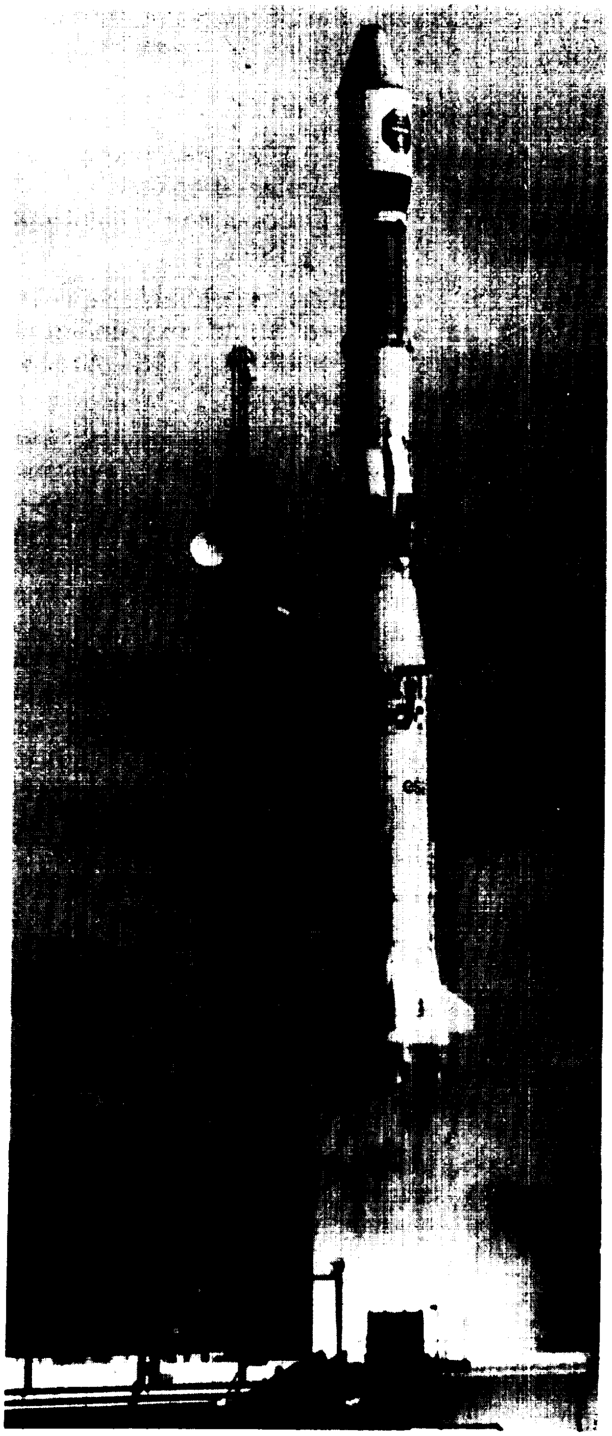


Photo credit European Space Agency

First launch of *Ariane /*

Utilizing a dual launch system (SYLDA), each Ariane is capable of carrying two separate payloads on each flight. Launches will be made from the French-owned, ESA-funded Kourou spaceport in French Guiana, South America. Located close to the Equator, Kourou is well placed for launching stationary satellites (which orbit over the Equator). With only one pad, it is currently capable of launching five to six flights per year, but construction of a second pad has been approved for operation in 1984 or 1985, allowing for 10 annual launches and providing redundancy.

When the Ariane was first proposed, there was considerable skepticism as to whether it could be competitive with the space shuttle and the various U.S. expendable vehicles. There were strong political reasons why several European countries, especially France, desired an independent launch capability (see app. G); in addition, it appears that, as a result of several considerations, the Ariane will be able to compete with the shuttle for many kinds of payloads through the 1980's. First of all, the shuttle itself is 2 years behind schedule, and has not yet been flown sufficiently to convince users of its reliability. Second, U.S. production of expendable was slowed down and in some cases virtually halted, in expectation that the shuttle would replace all of them during the early 1980's. As a result, the cost of the Thor-Deltas and Atlas-Centaurs has risen sharply over the last several years. Third, the commercial demand by a number of likely users, especially for communications satellites, is projected to be much larger in the coming decade than was previously thought. Even with the shuttle operating at its initially projected pace, there would be demand for additional launch services.ld However, because of recent and projected budget cutbacks there will be fewer shuttle flights than previously scheduled, another circumstance forcing users to turn to alternate launch vehicles. Fourth, Arianespace is offering customers highly attractive terms, including below-market financing through European banks, and an extended period in whic:h to make repayment. For these reasons, the Ariane is likely to

[14]Jerry Grey, "Case for a 5th Shuttle and More Expendable Launch Vehicles," *Astronautics and Aeronautics,* March 1981.

have a full manifest for the foreseeable future, despite the superior capabilities of the shuttle. Frederic D' Al lest, chairman of Arianespace, projects continued use of Ariane for at least 20 years despite competition from reusable spacecraft.[15]

The Ariane is now scheduled for a series of ESA and INTELSAT launchings (under ESA auspices) in 1982. As of january 1982, there were approximately $350 million worth of firm orders for Arianespace, which will take over Ariane operations in 1983.16 There were also a large number of reservations, which may be turned into firm orders in the future. These include non-European customers such as Colombia, Australia, and the Arabian Satellite Corporation .17 Recently, Arianespace received its first firm order from an American company, General Telephone & Electronics, to launch two domestic communications satellites **in 1984.**[18] Other orders have followed from Western Union and Southern Pacific Communications. Ariane is being marketed in the United States through an arrangement with Grumman Aerospace Inc. Arianespace policy is to sell its services to "any customer whose payload is designed for peaceful use;" this includes payloads from the French military, NATO, and a British Defence Communications Satellite.[19] Control over the political aspects of launch policy is retained, according to ESA'S agreement with Arianespace, by the ESA Council.

The development and subsequent operation of Ariane have been marked by a number of peculiarities. We have seen the dominant role that France played in proposing and developing the project. The prime contractor has been not a private firm or industrial consortium, as for other ESA programs, but CNES (Centre National d'Etudes Spatiales or National Center for Space Research), the French Government equivalent of NASA. CNES in turn has let contracts primarily to French firms, in particular Aerospatiale, the prime contractor, and SEP (Societe Europeenne de Propulsion), which is building the propulsion system. Overall, France has funded over 60 percent of the project, rising to 79 percent in 1981.

Perhaps the most interesting aspect of the Ariane program is the arrangement for commercial operation. Instead of leaving it to ESA or CNES, a quasi-private corporation called Arianespace has been established to produce, finance, market, and launch Ariane vehicles. ESA and CNES remain responsible for further development of Ariane 2-5, and for operation of the Guiana spaceport.

Arianespace is incorporated in France and owned by firms from the states that funded Ariane's development, by CNES, and by European banks. French investors (including CNES itself, which is the largest single shareholder with 34 percent), will own 60 percent; German ones 20 percent; and the remainder is split up into smaller portions. Its initial capitalization was approximately $20 million. The first chairman of Arianespace, Frederic D'Allest, is the former CNES project director for Ariane, and the production and launching teams will be transferred directly from CNES in 1982.20 Clearly, the new firm will be dominated by the French, and it is not surprising that France was the prime mover behind Arianespace's emergence. The idea of a private firm was first suggested in 1979, with the original proposal by CNES calling for 70 percent French ownership. The basic rationale was that only a commercially oriented operation could manage Ariane so as to compete effectively with the shuttle; trying to operate in a framework requiring the unanimous consent of 11 sovereign nations would be far too inefficient. [21] In subsequent negotiations with ESA and the potential partners, the French percentage was reduced to approximately 60 percent. The most difficult part was getting the agreement of other ESA members to turn over the technology and facilities, including future developments, to Arianespace; Germany was particularly opposed. In 1980, France withheld support for Spacelab funding for 2 months until Germany signed a political dec-

[15] Jeffrey Lenorovitz, "Arianespace **Completing Payload Plans,"** *AW&ST,* July **6, 1981, p. 19.**

[16] "Why **NASA's Shuttle May be Left** in the Dust," **Business** *Week,* **Jan.** 18, 1982, p. 38.

[17] "Arianespace Press Kit," at 34th International Airshow, Paris, June 1981, pp. **10-13.**

[18] **"Europeans Win Orders to Launch 2 GTE Satellites,"** *Wall Street Journal,* **Nov. 25, 1981.**

[19] Arianespace **Press Kit, p.** 13.

[20] Arianespace **Press** Kit.

[21] "Europeans Organize Commercial Ariane Satellite Launch Company," *AW&ST,* **July 9 1979,** p. **18.**

Advertisement from AW&ST, May 1982

laration agreeing to the transfer to Arianespace.[22] Arianespace is currently scheduled to assume responsibility in 1983 following a series of seven ESA flights in 1982 and early 1983.

Future Plans

with the imminent completion of ESA'S two **largest** applications programs, Spacelab and **Ariane,** the level of ESA activities in the 1980's **is likely** to diminish, For the immediate future the **valuable industrial and technical teams organized** for these projects will remain occupied building the second Spacelab and designing Ariane 2-5. No comparable applications projects have yet been approved to take their place (though there has been consideration of a plan to develop Spacelab into a free-flying platform as part of a cooperative program with the United States). A reduction in ESA activity may reflect the preference of several member nations for national or bilateral programs, especially for commercial applications systems, where the cumbersome ESA apparatus can impede timely decisions. **It also** reflects a general worsening of the major European economies over the past several years, especially those of West Germany and Great Britain. Under its recently elected Director General, Eric Quistgaard, ESA has been preparing a 10-year plan for the future which is likely to emphasize basic science within an overall reduced budget. The proposed plan estimates a reduction to an annual budget of $532 million to $598 million, compared with a 1980 level of $845.8 million .23 in establishing future programs, it will be necessary for the major partners to compromise as they did in the past. The British interest in L-Sat development remains high, while the Germans are **more interested** in exploiting Spacelab by conducting scientific and materials processing missions, and expanding Spacelab's capabilities. France would like to see aggressive development of the Ariane, including a possible automated processing station (Solaris) or a manned reusable vehicle. [24] If a successful compromise is not reached, many of these programs may become exclusively national efforts.

According to an address given by Dr. Massimo Trella, Technical Director of ESA, at the Paris Air Show in June of 1981, overall European space activities will continue to grow in the 1980's at least as rapidly as in the 1970's, but the division of responsibility between ESA and national efforts can be expected to change. ESA and the various national programs will cooperate in defining and coordinating a European program, while ESA itself "will build up, more than before, its identity as an R&D organization devoted mainly to large projects. More clearly we **believe that commercially exploitable systems should be more the responsibility of other initiators** in Europe. " Dr. Trella specifically mentioned development of an advanced remote-sensing system .25 However, on the same occasion Michel Bignier, ESA'S Director of Space Transportation Systems, outlined a future program which emphasized materials processing, development of Ariane 3 and 4, and building and maintaining large space stations.[2b] Clearly ESA'S future mix of programs and overall emphasis remain to be determined.

Cooperation/Competition With the United States

Cooperation:

The bulk of European cooperative efforts with NASA have been scientific. With one major exception (to be discussed below) these have worked out well. A large number of cooperative missions, in which NASA provided free launch services in exchange for scientific experiments and data, have been conducted with ESRO and ESA.[27] In general, scientific cooperation is arranged directly between ESA and NASA; only Spacelab has required a formal intergovernmental agreement. (Lower level agreements, called

[22] "New Commercial Organization to Take Ariane Responsibility," *AW&ST,* **Apr. 7, 1980, p. 45.**

[23] Jeffrey **Lenorovitz, "Europeans Making Plans to Meet Long-term Goals?"** *AW&ST,* **Mar. 9, 1981, p. 88.**

[24] Peter Marsh, "What **Shou Id Europe Do in Space, "** *New Scientist,* **Jan. 29, 1981, pp. 290-292.**

[25] Massimo Trella, "ESA Policy **Directions—Collective** Versus **National Programmed," paper delivered at International Aerospace Symposium, Le** Bourget, **France, June 2-3, 1981.**

[26] Michel Bignier, **"Expectations for the Future," International Aerospace Symposium, Le** Bourget, **France,** June **2-3, 1981.**

[27] For **details, see** *United States Civilian Space programs, 1958-78,* **report by Science Policy Research Division, Congressional Research Service, for the House Committee on Science and Technology, January 1981, pp. 839-841.**

memoranda of understanding, are made with U.S. Department of State (DOS) concurrence, while letter agreements require no DOS action whatever.)

In the field of applications the cooperative record is somewhat more mixed. Serious strains arose when, in 1972, the United States withdrew a previous offer for the Europeans to produce a "Space Tug" as part of the Space Transportation System (see app. G). Further mistrust was aroused when the United States backed out of the Aerosat program in 1977. Aerosat was a combined ESA/U.S./Canadian project to develop an experimental air traffic control satellite system. Beginning in 1974, ESA and other partners invested considerable time and money only to have the Federal Aviation Administration (the U.S. participant) withdraw because of its inability to fund further development.

A third example is the recent deletion of the U.S. spacecraft from the joint International Solar Polar Mission (ISPM). Though ISPM is a scientific, not an applications project, this withdrawal has reinforced European doubts about general U.S. reliability. ISPM was to have involved two spacecraft, one United States and one European, which would simultaneously **fly** over the Sun's "north" and "south" poles. Without U.S. participation, much of ESA'S projected $150 million investment will have been wasted; nevertheless, the U.S. spacecraft was eliminated in Reagan administration cuts implemented in February 1981. Though ESA objected vigorously and member states protested at the ambassadorial level, additional funds were not appropriated.[28] These U.S. actions have raised questions about whether ESA can afford to trust future U.S. commitments, given the vagaries of annual executive and congressional budget decisions and the dependent position of ESA in most projected cooperative projects. Despite these problems, preliminary talks have begun on possibie major areas of future cooperation, including joint processing experiments, possible expansion of Spacelab into a modular free-flying platform, and joint development of a manned space station based on Spacelab modules.[29]

In general, the advantages of cooperation tend to diminish when the project requires much direct contact on a day-to-day level; it is preferable for work to be done as independently as possible, to avoid time-consuming joint decisions. A second difficulty with cooperation in space applications is that the prospect of eventual commercial competition between partners can cause suspicion and reduce its attractiveness to industrial participants.JO

Despite these difficulties, international cooperation was strongly stressed in Massimo Trella's June address, particularly for high-risk, high-expense programs: "ESA **intends to take the initiative in this direction in order to explore with all interested partners how a wider and** more ambitious international cooperation could be defined and implemented in a strategic R&D program me in space in the next decade."[31] It should be noted that the United States is not specifically mentioned; ESA has so far not engaged in cooperative programs with the Soviet Union, though some tentative offers were once made without success. Other European countries, notably France, have done so and it cannot be ruled out that ESA, partly out of frustration with U.S. unpredictability, may seek out the Soviets despite the difficulties involved in collaborating across the iron Curtain,

Competition

Although the total European civilian space budget is only a fraction of either U.S. or Soviet expenditures (Europe spends only 0.04 percent of its gross national product (GNP) on space to the United States' 0.2 percent), the areas in which European technology is commercially competitive with the United States are significant and growing. The competition from Ariane is perhaps most striking, insofar as launch vehicles are the true symbols of space capabilities and were for so long a U.S.-Soviet monopoly. Perhaps equal-

[28] Jeffrey Lenorovitz, "ESA Seeks Reinstatement of NASA Solar-Polar Effort, " *AW&ST,* Mar. 2, 1981, pp. 22-23; statement of Eric Quistgaard, Senate Commerce Committee hearing, Mar. 25, 1981, pp. 1-5.

[29] " Coming Next–A European Base in Space, " *New* Scientist, Nov. 51981, p. 356; see also Craig Covault, "NASA Mulls International Effort on Space Station, " *A W&ST,* Mar. 1, 1982, p. 20.

[30] " U.S.-Europe Collaboration Variable, " *AW&ST,* Sept. 1, 1980, p. 275.

[31] Trella, "ESA Policy Directions, " p. 7.

equally significant, however, are European successes in gaining contracts from INMARSAT and Arabsat for communications satellites, and plans to bid for future generations of INTELSAT satellites as well. The French SPOT remote-sensing system (discussed below), is scheduled to offer an alternative to U.S. Landsat data beginning in 1984. Though it can be argued that some of the European success may be attributed, not to superior technology, but to the desire of international organizations and non-U. S. purchasers to decrease their dependence on the United States, it is clear that European systems are in many cases equivalent, if not superior, in capabilities and cost effectiveness. However, U.S. objections that European space technologies, in particular Ariane, benefit from unfair financial practices, such as government-subsidized below-market financing for users, are likely to lead to strains between the U.S. and European agencies,

European success, despite lower expenditures, is related to several factors:

- focus on relatively few high-opportunity areas;
- assimilation of U.S. technology in key areas, avoiding unnecessary duplication;
- sustained support by the major countries, particularly France and West Germany; and
- the ability to compromise when necessary, founded on a strong perception that building and maintaining an industrial base in space technology is necessary for Europe's long-term economic vitality.

Though decisions made through ESA may take more compromise and negotiation than comparable U.S. program choices, they are less likely to be precipitously changed or canceled; the government-to-government character of agreements gives them considerable weight. As long as these conditions remain in effect, the United States can expect a high level of competition from ESA and its member states.

EUROPEAN NATIONAL PROGRAMS

In addition to their participation in ESA, which for most countries constitutes the bulk of their space spending, several European states have substantial separate national or bilateral programs. The activities of France, West Germany, Britain, and Italy are of particular interest.

France

The French space program is the largest and most comprehensive in Europe and the third largest in the world, after the United States and Soviet Union. The French have major programs in space science, applications, and launch vehicles. Activities are carried out in several ways: on a national basis; bilaterally with West Germany, other European countries, the Soviet Union, the United States and several third world countries; and multilaterally through ESA.

The French program has been characterized by: 1) an ongoing commitment to developing a comprehensive and independent space program while avoiding dependence on the United States or U. S. S. R., particularly for launch services; 2) extensive cooperation between government agencies and industry; and 3) the development of military capabilities associated with France's independent nuclear deterrent, including ongoing relationships between civilian and military programs.

The decision to cooperate with both the United States and the Soviet Union is indicative of France's longstanding desire to mediate between East and West and to avoid exclusive dependence on either superpower. The idea of France as a "third Force," separate from the United States and NATO (which France partially withdrew from in 1959), was strongly promoted by DeGaulle, who came to power in 1958. DeGaulle saw France as the natural leader of a resurgent Europe, and hence encouraged the formation of (presumably French-dominated) European multilateral associations. Space was an arena in which the French felt Europe needed to compete;

France was a major supporter of ESRO and ELDO (particularly the latter) and, eventually, of ESA. (For a description of France's initial space activities, see app. G.) In 1964, out of a total civilian space budget of $76.8 million, France spent $29.6 million on ELDO, and $1 million on ESRO. In 1975, the first year of ESA'S existence, $133 million out of a total of $254 million, or better than **50** percent, went to ESA,[32] and in 1981 France was ESA'S largest contributor with approximately $211.5 million, or 25.06 percent of ESA'S total budget (largely for the Ariane).

However, the percentage of CNES'S budget going to ESA, as opposed to national and bilateral programs, has dropped in recent years as ESA spending has slowed and a number of bilateral and national projects have begun to take shape. The total 1981 budget is Ffr 2,617 million, 37.2 percent larger than in 1980; national programs, however, are up 107 percent at 344.82 million, and bilateral expenditures increased by four times to Ffr 487.52 million.[33] In 1982, CNES plans to spend 82 percent more on national programs, within an overall budget that will increase by 18 percent.

The CNES budget comes primarily from the Ministry of industry and other civilian ministries; in 1981 Ffr 192.8 million came from the Ministry of Defense, while Ffr 596 million came from CNES'S own resources.[34]

Current Applications Programs

COMMUNICATIONS

France is currently involved in three major satellite communications programs. The first is a longstanding experimental bilateral effort with West Germany called "Symphonic," the two satellites of which, launched in 1974 and 1975, are still partially active. Each Symphonic is a geosynchronous satellite with a capacity of 200 telephone or 2 TV plus 18 telephone channels. Symphonic 1 and 2 were built by a consortium (CIFAS) made up of French and German companies and launched by the United States (after some objections regarding possible conflict with INTELSAT–see app. G).[35]

France and West Germany are currently engaged in another joint project for direct television broadcasting, with each country operating its own 3-channel satellite for domestic purposes. The satellites, designated TDF-1 for France and TV-Sat for Germany, are being developed by the Munich-based Eurosatellite Corp., made up of two French firms, Aerospatiale and Thomson-CSF, and two German ones, Messerschmitt-Blohm-Bolkow and AEG-Telefunken. The French contribution for development (divided between CNES and government communications agencies) is estimated at Ffr 980 million; the satellites are scheduled for Ariane launch in late 1984 and eariy 1985.36

The DBS joint effort was an outgrowth of a previously described ESA experimental communications project, H-Sat, which was initially backed by France, West Germany, and Italy. However, in 1978 France and Germany withdrew because of concern over the slow pace of H-Sat development. In particular, the two countries wished to compete in the foreseen European and global market for DBS satellites and groundstations, which they saw as expanding rapidly in the 1980's. An operational system was felt to provide greater economic opportunities than another experimental system. The agreement to develop TDF-l /TV-Sat was signed in 1979.37 **In addition to allowing it to enter foreign markets, French national television estimated that direct broadcast would enable it to provide 100 percent coverage of the entire country for less than half the cost of building additional terrestrial relays.**

Another cooperative venture is the SARGOS project, part of a joint U.S./Canadian program called SARSAT designed to provide emergency search and rescue for ships and planes. France is supplying three SARGOS units to fly on the U.S. NOAA E, F and G satellites. SARGOS is an outgrowth of another project, ARGOS, for collect-

[32] *World-Wide Space Programs,* p. 168.

[33] "Space Still a Growth Industry in France," *Interavia,* May 1981, p. 406.

[34] "Budget and Programs of CNES for 1981," CNES, p. 3.

[35] *World-Wide Space Activities,* p. 161.

[36] "Space Still a Growth Industry in France, " p. 406.

[37] See "The French Space Effort, " *Interavia,* June 1979, p. 51 O; also Roberto Grandi and Giuseppe Richeri, "Western Europe: The Development of DBS Systems," *Journal of Communication, v. 30,* spring 1980, p. 176.

ing and processing meteorological data from remote platforms, i.e., ballons, buoys, etc. The total French contribution in 1981 to both programs was Ffr 24.7 million.[38]

France is also engaged in a major national communications satellite program called Telecom 1 which is being funded by the Direction Generale de Telecommunications, with CNES project leadership, for a projected 1983 launch. Telecom 1 will provide domestic telephone and telex services within France as well as between France and its overseas territories, including some military traffic. A major use will be in providing internal business communications similar to those planned for the U.S. Satellite Business Systems Corporation .39

REMOTE SENSING

Since 1978, CNES has been engaged in a national program (with some support from Belgium and Sweden) to develop an operational land remote-sensing system called SPOT (Systeme Probatoire d' Observation de la Terre). Through the prime contractor, Matra, CNES is designing a two part satellite consisting of a multipurpose bus with power-supply and stationkeeping systems, and a sensor payload that can be altered as the system develops. The SPOT satellites will be placed in Sun-synchronous 832 km orbits designed to provide 26-day repetitive coverage of the entire Earth. **The initial design calls for two** types of coverage: 1) multispectral observation with 20 m resolution, and 2) black and white observation with 10 m resolution. (This compares with Landsat 3's multispectral resolution of 80 m, and Return-Beam-Vidicon of approximately 30 m). Both of SPOT's instruments can be pointed by remote control so as to cover any area of interest within a path 950 km wide; each individual swath is 60 km in width. This pointing capability makes it possible to provide semistereoscopic images, i.e., successive views of the same area from different angles, which are particularly useful for mapmaking and geological interpretation. It also allows for viewing a particular region more often than once every 26 days; such frequent coverage is necessary for agricultural purposes.

The SPOT images are produced by a linear array "push-broom" scanner that produces a continuous picture 60 km wide on the ground. The images are transmitted digitally from the satellite to ground receivers or they can be stored on tape recorders for delayed transmission. The central receiving and control station is located at Toulouse in southern France. Other countries will be able to build their own stations, subject to agreements directly with CNES; or, data and processed data products will be purchasable through Spotimage, a joint government-industry organization being set up to market SPOT services. In many respects Spotimage will be similar to the previously described Arianespace; CNES will hold 34 percent of the company's shares, with the remainder split between various French firms and government agencies.[40] SPOT transmissions are designed to be compatible with the U.S. Landsat and Landsat-D receiving stations, so that countries that already possess receivers for Landsat will be able to receive SPOT, with some adaptation,

Though each SPOT satellite has a design life of only 2 years, the system is planned to operate for at least 10 years, so that users can count on continuity of data for long-term remote-sensing programs. After the initial launch, scheduled for April 1984, additional satellites will be orbited to ensure continuous service. These satellites will be financed partly by Spotimage, and partly by CNES through its revenues from foreign receiving stations.[41]

The basic reasons for France's decision to build its own remote-sensing system are similar to those for its other space applications projects. These include: 1) to encourage national high-technology enterprises; 2) to gain independence from the U.S. civil remote-sensing system, Landsat, and to demonstrate French equivalence to U.S. and Soviet capabilities; 3) to reap the economic and political benefits of providing global coverage to other countries; and 4) to develop an indigenous remote-sensing capability for military purposes.

[38] "Budget and Programs of CNES for 1981 ," p. 23.
[39] "Space Still a Growth Industry in France, " p. 406.

[40] "French Marketing Services of Spot Satellite Network, " *AW&ST,* Jan. 11, 1982, p. 99.
[41] See "SPOT—Satellite-Based Remote Sensing System, " CNES brochure, 1980; Jean-Pierre Fouquet, "The SPOT Satellite, " paper presented at 19th Goddard Symposium, Washington, D. C., Mar. 26, 1981.

In line with this last motivation, a military reconnaissance version of SPOT, known as SAMRO, is already being evaluated. SAMRO would use the SPOT bus, but with higher resolution optics and secure communications links. Such a satellite would give France the ability to monitor military activities around the world on a continuous basis.[42]

The success of SPOT in gaining a large share of the global market will depend on several factors. First, how advantageous will users view SPOT's 10 to 20 m resolution, as opposed to Landsat-D's 80 m (MSS) and 30 m (TM)? Some users, particularly agricultural ones, will find the increased resolution helpful, while others may find it unnecessarily precise. One of the often mentioned reasons for SPOT's high resolution is to make it attractive to European agricultural observors, since European farms are typically smaller than U.S. or Soviet ones.[43] However, some countries may be concerned that SPOT's high resolution will provide foreign users with too much information. Political agreements on restricting dissemination of SPOT data may be required to avoid opposition from a number of states, and Spotimage has announced that it will abide by agreed-on international regulations regarding data dissemination.

The second and probably most important question is the status of competition from other remote-sensing systems, particularly the U.S. Landsat D and proposed D' satellites, which are planned to be operating at approximately the same time (see ch. 3).

SPOT remains unproven both technically and institutionally. However, the commitment to a long-term operational status through a private corporation, Spotimage, will help greatly in giving SPOT the credibility it needs to attract customers. In particular, worries about the continuity of the system (which are evident among Landsat users on account of Landsat's currently unresolved budgetary and institutional problems) should be much less than with Landsat. Spotimage plans to provide an across-the-board range of services, including the provision of baseline data for further processing; processed data products for specialized purposes; and aid, advice, and equipment for potential customers. As with Landsat, users can arrange directly with CNES to receive, archive, and distribute SPOT data through national or regional receiving stations. A smoothly functioning corporate entity, especially one heavily backed by the French Government, would provide strong competition to any future U.S. system.

A key question will be the prices charged by both SPOT and Landsat D-D'. Landsat prices are currently government subsidized and in no way reflect the true costs of developing, constructing, and operating either the ground or space segments. If Landsat or any equivalent is run by a private firm, the prices for clata would have to rise to reflect these costs. Spotimage prices, though not yet established, will also be substantially higher than those paid by today's users; however, it is not likely that either the U.S. or French governments, having invested heavily to build a prestigious remote-sensing system, would allow the other to substantially undercut its prices for equivalent service. To maintain a market share of commercial buyers, as well as the political gains of supplying data to third world and other countries, each operator will need to keep prices competitive with the other. Whether these prices will be heavily subsidized for political and public-service reasons, as at present, or come closer to reflecting the true costs of land remote sensing remains to be seen; all such decisions will depend at least as much on political as economic factors, including possible competition from future Soviet and Japanese systems.

MATERIALS PROCESSING

French MPS activities, at this time, are modest in scope, with a budget of approximately $1 million to $2 million per year. Bilateral materials processing experimentation agreements are in effect with Germany and the U.S.S.R. A Franco-Soviet crystal growth and solidification experiment was carried out aboard the Soviet manned laboratory, Salyut-6, and future cooperative MPS research is anticipated. In addition, French ex-

[42] "France Studies Reconnaissance Version of SPOT Spacecraft," *AW&ST*, Aug. 10, 1981.
[43] See "The French Space Effort," *Interavia*, June 1979, P. 508.

periments on crystal growth and the dynamics of metal alloy solidification are planned for Spacelab 1 and 3.

In general, the French effort is smaller and more research directed than German activities. CNES has funded a major study, however, on an ambitious program called "Solaris," an unmanned orbital space station which would be able to conduct MPS experiments and could be made available during the 1990's. Solaris would be orbited by an Ariane-4 launcher, operating for a lifetime of up to 15 years. Among its many purposes, the Solaris could serve as an automated orbital materials processing station, handling up to 2 tons of materials in its furnaces. Feedstock would be transported to the station by Ariane-launched unmanned spacecraft. Modules containing processed materials would be returned to Earth from Solaris via unpowered reentry vehicles. The project is still in the conceptual stage and no cost figures are currently available. It is conceivable that Solaris might be accepted as a major project for ESA during the 1980's, thereby spreading the costs and stimulating MPS research activities in a number of member countries not presently pursuing such investigation. Solaris not only represents a major potential French initiative utilizing the Ariane launcher, but is a direct challenge to the U. S./ESA and Soviet manned laboratories (Spacelab and Salyut, respectively) which currently plan materials-processing activities. CNES plans to study manned facilities before deciding on a space-station concept.

LAUNCHERS

The Ariane and its future development have been discussed previously. Among additional possibilities mention should be made of the Hermes manned reusable shuttle, a proposed 22,000-lb, 5-man vehicle that might be launched by the advanced Ariane V. Though only in a very preliminary design stage, the Hermes plan shows that the French have by no means resigned themselves to a completely unmanned role in future space activities .44

FOREIGN COOPERATION/COMPETITION

Aside from ESA, France has major bilateral cooperative programs with West Germany, the Soviet Union, and the United States; it is the only country besides India to deal extensively with both the major space powers. In 1981, France budgeted Ffr 379.8 million for German projects, almost all for joint TDF-1 /TV-Sat development. Thirty-seven million francs were spent with the United States, largely for the ARGOS/ SARGOS project described above, and for upcoming experiments on Spacelab.

Of the 56 million francs earmarked for projects with the Soviet Union, none are for applications projects per se.[45] However, the fact and extent of cooperative projects are politically significant in themselves. Furthermore, in light of the historical problems with U.S. commitments, it is clear that the French see access to Soviet launchers and facilities as a potential hedge against U.S. delays and vacillation. The most visible of upcoming France-Soviet ventures will be the scheduled 1982 visit of a French astronaut to the Soviet's Salyut 7 (or a reactivated Salyut 6) space station. Two French candidates have been training in the Soviet Union since September 1980.% The Soviets have made a practice of launching non-Soviets for brief orbital stays; to date, however, all such visitors have been from "fraternal Socialist countries," and the flight of an astronaut from a major Western power can be expected to provide the Soviets with a great deal of favorable publicity.

The French national space program, working closely with French industry, will be a major source of commercial competition for the United States in the 1980's. French competitiveness is the result of several factors:

- technically advanced programs in commercial areas such as DBS, land remote sensing, and launch vehicles;
- establishment of institutions (Arianespace, Spotimage) to market systems aggressively on a global basis;

[44] "The French Space Effort," *Interavia,* June 1979, pp. 508-509; "Solaris: France Proposes Large Unmanned Space-Processing Platform," *Interavia,* May 1981, p. 822.

[45] "Budget and Programs of CNES for 1981 ," CNES, p. 23.
[46] "French Cosmonauts Training for Mission With Soviets," *AW&ST,* Dec. 21, 1981, pp. 55-56)

- close government-industry collaboration as an accepted feature of French commercial practice;
- long-standing government commitment to building space capabilities on a par with the United States and Soviet Union; and
- support received through agreements with ESA and bilateral partners.

West Germany

The bulk of West Germany's space efforts are conducted in association with ESA or bilaterally with other countries. Germany is one of ESA'S major supporters, supplying almost one-fourth of its annual budget. The Ministry for Research and Technology (BMFT) coordinates and funds most German R&D efforts; projects are managed by the German Research and Test Establishment for Aeronautics and Space Flight (DFVLR), which manages Government engineering and test centers, and by the German Research Association (DFG), a self-governing organization that allocates funds from various public and private sources to universities and scientific societies.[45] Space-related expenditures in fiscal 1981 amounted to $371 million, of which $82 million went to DFVLR. Total funding from 1978 to 1982 is projected to be $1.7 billion .48

Germany's major aerospace firms also play a key role in initiating and funding research projects; these include Messerschmitt-Bolkow-Blohm (MBB) and VFW-Fokker, which recently merged, and several large electronics firms such as Siemens and AEG-Telefunken.

Unlike France, Germany has never aimed at achieving an across-the-board set of space capabilities, but rather at encouraging an indigenous aerospace industry, promoting potentially valuable scientific and industrial research, and supporting European efforts in various applications areas. Compared with France there has been greater emphasis on industrial and university initiatives and participation, with Government coordination through the Research Ministry. Despite—or perhaps on account of—the extensive German experience acquired during World War II, there have been no attempts to produce a German launcher, although Germany has been a major contributor to Ariane. Instead, Germany has launched numerous orbital and suborbital payloads on U. S., French, Swedish, and British rockets. The first German scientific satellite, called Azur, was launched by the United States in November 1969.

Applications Programs

Almost all of Germany's efforts in communications and remote sensing are being conducted through ESA or bilateral projects with France, described previously. In 1981, West Germany will provide the largest single share of ESA'S expenditures for Meteosat, OTS, ECS, and Spacelab.Ag

In addition to communications, Germany's strongest emphasis has been placed on materials science and processing. Since the German firm ERNO (a subsidiary of VFW-Fokker) is the prime contractor for Spacelab, and Germany is the major financial contributor (64.78 percent in 1981), German interest in Spacelab exploitation has been high. In addition, chemicals and materials processing have traditionally been areas of German technical and industrial leadership. The Ministry of Science and Technology provided approximately $57 million for MPS work from 1978 to 1980 and is authorized to spend $50 million more between 1982 to 1985. Additional funds are available from non-Federal sources. so

The German MPS program is intended to meet the as yet largely undefined needs of the user community. The ultimate goal of Government support is substantial involvement of German industry in such areas as chemistry, process technology, metals, composite materials, and crystals .51

Early West German experiments were carried on the 1975 Apollo/Soyuz manned mission. A

[47]" Review of National and Co-operative International Space Activities for the Calendar Year 1980," UNCOPUOS, A/AC.105/286/ Add. 1, Feb. 19, 1981, pp. 34-35.

[48]"Foreign Materials Processing Expenditures," internal NASA staff paper, May 1, 1981, p. 1.

[49]*Europe's Place in Space*, ESA, January 1981, p. 9.

[50]" Foreign Materials Expenditures, " p. 2.

[51]*Commercialization of Materials Processing and Manufacturing in Space*, position paper prepared for OTA by TRW, Inc., Apr. 14, 1981, p. 25.

variety of methods are now being followed, using suborbital sounding rockets, small self-contained payload packages (so-called "Getaway Specials") attached to the space shuttle, and full-scale Spacelab missions. Future flight opportunities using "free-flying" automatic experimental units for longer periods of time than can be attained with the present shuttle/spacelab system are also being examined. Primary elements of the German MPS Program are:[52]

- TEXUS (technological experiments under microgravity): Using British-built Skylark sounding rockets, certain experiments are being flight tested in advance of future Spacelab missions. Five TEXUS flights have been accomplished since 1977, and two launches per year are planned starting in 1981. TEXUS flight results to date indicate this approach is scientifically and technologically useful. West German experiments have also flown on U. S. SPAR sounding rockets.
- MAUS (materials science autonomous experiments under zero-G conditions) program: Instruments partially based on TEXUS program findings are to be carried in 25 German-purchased getaway special canisters. These autonomous packages provide experiments with much longer microgravity duration than attainable with sounding rockets.
- Spacelab: Germany is supporting major experiments on Spacelab, including a materials processing laboratory to be flown on Space-Iab 1 in mid-1983. Materials science experiments will be conducted in the materials science double rack, a largely German contribution to the first Spacelab mission. The facilities include the following: 1) high-temperature thermostat, 2) mirror heating facility, 3) isothermal heating facility, 4) capillarity measurement equipment, 5) cryostat, 6) fluid physics module, 7) gradient heating facility, 8) UHV chamber, and 9) common support equipment.

  A wholly German Spacelab mission, the D-1, is now scheduled for September 1984. The D-1 will carry the Biorack for investigations of cell and molecular biology, and an advanced fluid physics module. These will perform a mixture of open experiments, for which data will be freely disseminated, plus a number of closed experiments with potential commercial benefit. For these latter, Germany has proposed to pay a pro rata share of the normal Spacelab users' fee; the exact financial arrangements have not been concluded. Prime objectives for the mission are experiments in the fields of metals, monocrystals and materials for electronic applications, boundary layer and transport phenomena problems, and physical chemistry and processing.

The German program stresses involvement with the industrial sector in addition to purely scientific exploration. The Ministry of Science and Technology is working closely with both MAN, Inc., and Volkswagen. The work at MAN involves "skin technology"; this is a process by which complex refractory metal alloys used for turbine blades can be melted and resolidified in space with an oxide skin, which is a plasma sprayed on the surface of the container. New immiscible metal alloys for potential use as bearing materials are of interest to Volkswagen. sq

Although the German Government has not supported any launcher-related programs, aside from Ariane, mention should be made of a private German firm called OTRAG (Orbital Transport-und-Raketen Aktiengesellschaft), which has spent $65 miliion to $70 million since 1974 trying to develop a mass-produced expendable rocket for inexpensive satellite launches. To date, OTRAG has claimed four successful test flights and until recently planned to launch its first orbital flight in 1982.54 OTRAG hopes to attract private firms and third world countries by providing relatively simple services at prices that Ariane and, the space shuttle cannot match. The rockets would use off-the-shelf components and an extremely cheap fuel made of diesel oil and nitric acid.

'*See G. Greger, "Science and Technology of the German MPS Missions, " paper presented at 1980 AAS Annual meeting, Boston, Mass., Oct. 20-23, 1980.

[53]TRW paper, op. cit, pp. 25-26.

[54]" German Company Testing Launch Vehicle in Libya," *AW&ST*, Mar. 23, 1981, p. 25.

The political controversy surrounding OTRAG has been intense, largely as a result of the location of its test facilities. Until 1979, OTRAG operated out of a 39,000 mi^2 area in Zaire, where it had agreed to pay the Mobutu government $50 million per year or 10 percent of gross revenues, whichever was greater, once commercial operations commenced.[55] However there were numerous protests, not only from Zaire's neighbors, who feared the rockets might have military uses, but also from the Soviet Union, which was intensely concerned at any evidence of German development of an independent launch capability. The German Government was embarrassed and tried various means to put OTRAG out of business, including passage in 1978 of the so-called "Lex OTRAG" prohibiting the export of OTRAG rockets or components. Eventually international pressure forced Zaire to expel OTRAG; however, the company soon relocated its test facilities in Libya, partly, according to OTRAG president Frank Wukasch, because Libya's ruler Muammar Qaddafi "cannot be blackmailed" into expelling the company.[56] OTRAG'S presence in Libya reinforced fears that its missiles might be used for military purposes, perhaps against Israel. Recently, it was reported that OTRAG had withdrawn from Libya and would seek new facilities, perhaps in India or South America.[57]

COOPERATION/COMPETITION WITH THE UNITED STATES

The German attitude towards cooperative ventures with the United States has generally been more positive than the French, as shown by German willingness to take the lead in building Spacelab. A large number of cooperative space science projects are also underway. Cooperation with the Soviet Union has been negligible for political reasons.

Though there are few major areas where German projects will directly compete with the United States, German aerospace and electronics firms have been strong competitors for component and subsystem contracts on INTELSAT and other communications satellites. The Research Ministry is particularly interested in expanding German capabilities in this area.[58] The experience gained in ESA communications projects and particularly through joint TV-Sat development with France will give German industries the ability to compete for complete systems in the emerging DBS market.

Great Britain

During the 1970's British civilian space spending has been done almost exclusively as part of ESA projects. (For a brief description of early British space activities, see app. G). Even within ESA, Great Britain has chosen to concentrate on communications and general science, and has contributed relatively little to ESA'S two largest projects, Spacelab and Ariane. British choosiness has been a function in part of budget restrictions caused by generally poor economic performance compared with its continental partners, and to a fundamental historical uncertainty as to whether to opt for close ties with the United States, with Europe, or with the Commonwealth, Largely because of its traditionally close relationship with the United States, Britain has not favored development of a European launcher, whether the Europa or Ariane, considering it uncompetitive and unnecessary. With a strong university research base and relatively weak industries, Britain has preferred to concentrate on basic science and on a few areas, especially communications, in which British firms such as Marconi and British Aerospace could hope to become internationally competitive. In general, the above constraints have made the formulation and implementation of any coherent space policy very difficult. There is little public or political consensus as to Britain's proper role in space activities, and the major political parties often fail to follow through on initiatives begun by their predecessors. A September 1980 memorandum by the British Royal Society, which proposed establishing a National Council for Space, pointed out that: "The present U.K. efforts in space science and technology are fragmented and there is a serious lack of

55A *W&ST,* Sept. 12, 1977, p. 42.

56 Bradley Graham, "Rocket Firm's Third World Ties Test Bonn's Patience," *Washington Post,* Aug. 14, 1981, p. 17.

57 "Otrag Ends Libyan Launch Work," *A W&ST,* December 1981.

58 "West German Space Program, " *Interavia,* April 1980, p. 312.

cohesion to such an extent that there appears to be no overall domestic space policy."[59]

Organization and Funding

Government responsibility for space has been split between several organizations. The Department of Trade and industry has funded civilian programs, while the Space Research Council, part of the Department of Education and Science, has supported scientific projects, including cooperative ventures with ESRO and NASA. The Post Office (now British Telecom) has operated communications networks including INTELSAT receiving stations.

In 1972, the total budget was $55.1 million, of which $15.5 million went to ELDO and ESRO. By 1976, the budget had risen to $80,2 million, all of which was spent within ESA.[60] In 1981, Great Britain was ESA'S third-largest contributor with 14.88 percent of the total budget, amounting to $125.6 million, and was the majority contributor to the Marecs ocean communication satellite program.[61] Present plans call for a substantial increase in space spending, with emphasis on nationally funded communications satellites.[62]

Current Applications Programs

The area in which the British have been most active over the past several years is communications satellites. Within ESA, British Aerospace (BAe) has been the consortium leader for the OTS, ECS, and Marecs systems, and Britain was the prime mover behind ESA'S decision to develop the experimental L-Sat multipurpose communications platform. In addition, there has been considerable activity by British agencies and private firms, spurred by the Thatcher government's recent decision to open up private competition in telecommunications by removing British Telecom's monopoly over network operations.[63] I n June 1981, BAe announced formation of a company called Satellite Broadcasting Co., Ltd., to provide common carrier DBS services. Two satellites plus a ground spare would be required at an estimated cost of L100 million; services would be leased to British broadcasters such as the BBC and Granada television.

Another possible venture would involve BAe and IBM in a business communications service, similar to the newly created U.S. Satellite Business Systems, of which IBM is a major partner. It is not clear whether such a plan could succeed within Britain alone, and expansion into the European market, with the attendant difficulties of operating across national boundaries, may be envision ed.[64]

In a somewhat different field, BAe and Marconi have joined forces, after pressure from the Defense Ministry, to build the British Ministry of Defence's proposed communications satellite, Skynet IV/Satcom. Although both BAe and Marconi had initially sought out U.S. industrial cooperation, an all-British program was deemed preferable. Launch is estimated to be in early 1985.[65] British Telecom (formerly the Post Office) is planning its own Europeanwide business satellite system which will make use of nine transponders; two each placed on all four ECSs, and one leased from France's Telecom 1. The eight ECS transponders will cost approximately $150 million. Users will purchase ground stations that will provide access to any point in Europe; the system will be operated through an agreement with Interim Eutelsat.[66]

it is clear that British industry is eager to move into the potentially lucrative areas of DBS and satellite business communications, if necessary in conjunction with foreign partners who can provide financial and/or marketing support. A major question remains as to whether European operations will be possible given prospective competition from Eurosatellite (the manufacturer of TDF-l /TV-Sat) backed by national PTTs. In addition there are numerous regulatory pitfalls, as well

[59] *Spaceflight*, British I nterplanetary Society, Feb. 2,1981, p. 33; see also Johnny Hawkes (former Director of Space, Dept. Of Industry), "Britain in Space: Time to Consolidate, " New Scientist, Jan. 14, 1982.

[60] *World-Wide Space Activities*, p. 222.

[61] *Europe's Place in Space*, ESA, Paris, January 1981, p. 9.

[62] Peter Marsh, "Britain Plans Big Boost for Space Budget, " New *Scientist*, Feb. 23, 1982.

[63] Peter Marsh, "Communications in the 1980's—Satellites or Fibre Optics?" New *Scientist*, July 23, 1981.

[64] "BAe Aiming To Become Major Satellite Operator?" *Intera via*, August 1981, pp. 754-755.

[65] "Sky net IV-Now an All-British Military Satcom System," *Interavia*, September 1981, p. 859.

[66] "Satellite Business Communication Comes to Britai n," *Flight International*, Feb. 7, 1981, p. 342.

as possible challenges from INTELSAT, if the new services threaten to take business away from the Intelsat system.[67] It is still early enough in the evolution of satellite systems for any number of developments to occur, including joint ventures between British and European companies. BAe recently formed a partnership with the French firm Matra, called Satcom International, to bid on satellite hardware, and similar agreements may be made for services.

Italy

Italy has been a consistent supporter of European space activities and in 1981 contributed 9.94 percent of ESA'S budget, or around $82.9 million. Italy has not taken the lead in any major applications projects, but has chosen to support a variety of programs that would provide Italy's aerospace and electronics industries with contracts for advanced technologies. Difficulties in meeting its financial obligations to the Spacelab program in the face of large cost overruns led Italy to reduce its contribution from 18 percent of Spacelab funding in 1979 to 1 percent in 1981. The recent decision to use Italy's Sirio 2 communications satellite for ESA communications has given Italy the lead role in that project.

Aside from its European multilateral contributions, Italy has maintained a small national program centered around its unique off-shore launch platform, located on the Equator off the shore of Kenya in the Indian Ocean. The San Marcos platform has been the site of numerous small satellite and sounding rocket launches, mostly by U.S. rockets but including British and European ones as well, which have taken advantage of its equatorial position for experimental flights. The first Italian satellite, San Marcos 1, was launched by a U.S. Scout in 1964; subsequent San Marcos series satellites were launched from the San Mar cos platform, also by Scout.

In 1977, Italy orbited an experimental geostationary communications satellite, Sirio 1, on a U.S. Thor-Delta. The ground spare for that project, Sirio 2, will be launched in April 1982 by ESA to disseminate meteorological data; the Italian Compagnia Nazionale Satelliti di Telecomunicazioni is prime contractor on the project.

Unlike all other European states except Portugal, Italy's participation in INTELSAT is done through a private firm, Telespazio, rather than a national PTT. Since 1976, Telespazio has also operated a Landsat receiving station at Fucino.

The Italian space program has suffered from lack of central coordination and public support, as well as the strains of Italy's turbulent economic and political situation. Space activities have been coordinated and funded by the National Research Council (CNR), which began to fund space-related activities in 1960. Other ministries and agencies, such as the Post Office and the Defense Ministry, also play a role. In 1972, Italy spent $19.4 million on space, $9.8 million of which went to ELDO and ESRO; in 1976 this had risen to $60.5 million, almost all in ESA.[68] Recently, the government approved a plan to double Italy's space expenditures over the next 2 years; most of the increase will go to fund national programs. These may include a national communications satellite (Italsat) and a television DBS system, as well as several cooperative ventures with NASA: IRIS, a small booster for the shuttle payload bay; and the so-called "tethered satellite," which is designed to be attached to the shuttle in orbit by a long umbilical cord.[69] Italy has been a strong supporter of ESA'S experimental L-Sat communications platform, and will use one of the first satellite's 2 TV-channels for direct television broadcasting.

Recently the Italian Defense Ministry has proposed a domestic military communications system, SICRAL, for secure voice and data transmission and for use in civil emergencies. The satellite hardware will be designed and manufactured by Italian firms for eventual launch on either the shuttle or Ariane.[70]

Other European Programs

The space efforts of other countries in Europe have taken place almost entirely within the Euro-

[67] "Communications in the 1980' s," *New Scientist,* July 23, 1981.

[68] *World- Wide Space Activities,* p. 176.

[69] Peter Marsh, "Italy Joins the New European Space Race, " *New Scientist,* Apr. 1, 1982.

[70] Andrea Lorenzoni, "SICRAL: A Proposed Italian Defence Satellite System," *Interavia,* August 1981, p. 793.

pean agencies, ESRO, ElDO, and now ESA. A few non-ESA projects, however, deserve mention, particularly the proposed Nordsat regional communications system to provide television and radio broadcasting between Sweden, Norway, Denmark, and Finland. Under discussion since 1972, the system is designed to promote Scandinavian cultural unity–the details, which have been understandably difficult to arrange considering the many countries involved, are not as yet determined.[71] In connection with this proposal, Sweden is developing a satellite, known as Viking, for 1984 Ariane launch; it will investigate magnetospheric conditions preparatory to a possible communications satellite program. Saab-Scania is building the payload, while Boeing provides the satellite bus; Viking will provide Sweden with crucial experience in satellite communications operation, and will also further the Swedish goal of encouraging an indigenous commercial space systems industry. Studies have also been done for a second Swedish satellite, Tele-X, for a variety of experimental communications activities.[72]

Another potentially interesting development is Compagnie Luxembourgeosie de Telediffusion's (CLT) plan to provide multinational direct television programing via satellite by 1985. The company's potential difficulties illustrate the problems faced when operating across European boundaries. CLT is Europe's largest commercial (i. e., nongovernment) broadcaster, covering large portions of France, Germany, Belgium, Denmark, and the Netherlands. Since it is in direct competition with national broadcasters, foreign governments, particularly Germany, have opposed ClT's expansion plans, in part by trying to discourage investment in CLT stock. CLT is proposing a three-channel $250-million satellite that could broadcast simultaneously in French, German, and Dutch, reaching a potential 100 million viewers. Launch reservations have already been made on both Ariane and the Shuttle.[73]

[71] See R. Grandi, and G. Richeri, "Western Europe: The Development of DBS Systems, " *Journal of Communication*, spring 1980, pp. 175-176.

[72] " Sweden Moves Ahead on Research Satellite," *A W&ST*, Sept. 1, 1980, *p.* 49.

[73] "The No. 1 Broadcaster Fights Back From Space, " *Business Week*, May 4, 1981, pp. 66-67.

JAPAN

Organization and Policy

Japanese interest in space science and technology began in the mid-1950's, when multilateral planning was underway for the International Geophysical Year (1957). Alone among the major space-capable countries, Japan's space efforts were not initially prompted by military concerns. The postwar Japanese constitution specifically prohibited the buildup of large military forces, and public opinion has been consistently opposed to any signs of militarism and to large expenditures for military purposes. Because of the worldwide association of space programs with military capabilities, Japan carefully placed its first space establishment at the University of Tokyo, the country's foremost educational institution. The Institute of Space and Aeronautical Sciences (ISAS) was founded in 1954, and (though it recently became an independent institute) is still responsible today for Japan's scientific programs. Beginning in the late]9s0's and through the 1960's ISAS developed the Kappa and Lambda series of solid-fuel sounding rockets, which formed the basis for Japanese scientific and applications experiments. The difficulties of rocket development were enhanced by inadequate guidance and stabilization technology, which was in turn due partly to a self-imposed reluctance to fund technologies that might give the rockets enough accuracy to be perceived as having military capability.[74] ISAS went on to develop orbital rockets; the first successful 24-kg test satellite was launched by an advanced Lambda, after several years of failure, in February 1970. The Mu-class orbital launcher achieved its first success in 1971 and has been operated by ISAS since then from its Kagoshima test range.

[74] *World-Wide Space Activities*, p. 185.

In 1960, the National Space Activities Commission (NSAC, later SAC) was established in the Prime Minister's office to give advice on Japan's overall space program. It operates today as a major source of high-level planning, along with the Science and Technology Agency (STA). In 1964, the STA created the National Space Development Center to conduct rocket tests; this was due in part to dissatisfaction with ISAS'S purely scientific orientation. In 1969, this became the National Space Development Agency (NASDA), which is today the principal agency for civilian applications and test programs, launcher development, and tracking facilities.[75] NASDA operates the Tsukuba Space Center near Tokyo, Japan's main satellite test facility, as well as the Tanegashima launch site, located on an island in the south of Japan.

Other space-related activities are conducted by the Ministry of Posts and Telecommunications in satellite communications, and the Transport Ministry, which operates the weather service, in meteorological satellites. A private firm, Kokusai Denshin Denwa Ltd., is responsible for relations with INTELSAT. NASDA cooperates with other ministries and agencies in the research and design of applications programs, as well as conducting launches (see fig. 12).

The Japanese budget for space research was very small, though growing, through the 1960's.[76] With the establishment of NASDA annual funding has increased rapidly, from a total of $23.5 million in 1968 to almost $477 million in 1981. Of this the bulk, almost 80 percent, goes to NASDA, with the remainder split between ISAS and other government programs (see fig. 1 3).

The budget is drawn up by the SAC on a yearly basis. In addition, the SAC prepares long-range comprehensive plans. The latest 15-year proposal, drawn up in 1978, calls for a total 15-year expenditure of$14 billion to fund an across-the-board program in space science, applications, and launch-vehicle development. " The SAC stressed that "Japan should develop the necessary technical capabilities to carry out her comprehensive space program, although it is not necessary to produce everything domestically."[78] Active international cooperation and peaceful development were emphasized as guiding principles,

Current and Projected Applications Programs[79]

Communications

In December 1977, the Japanese orbited an experimental geostationary communications satellite, the CS-Sakura, aboard a U.S. Delta rocket. The Sakura has been used by the Radio Research Labs of the Ministry of Posts and Telecommunications for experiments in 30/20 GHz propagation (the first country in the world to do so), and to gain experience in the control and operation of communications satellites. An operational system consisting of two satellites, the CS-2a and CS-2b, is planned for launch in early and mid-l983, respectively (CS-2b will be an orbital spare); the recently developed N-11 launch vehicle will be used. The satellites themselves were built by a group led by Mitsubishi Electric and Ford Aerospace.[80] The operational system will provide emergency communications as well as links with remote islands; the signals will be receivable by small transportable Earth stations in either K or C band, and will represent the first operational use of 30/20 GHz technology, The satellites will be managed by the Telecommunications Satellite Corp. of Japan, established in 1979.

A parallel program in direct television broadcasting is also being conductecl, with the BSE-Yuri satellite launched in April 1978 by a U.S. Delta for geostationary experiments in audiovisual transmission. The operational system, with two satellites, BS-2a and BS-2b, is planned for N-11 launch in early 1984 and mid-1985. The Ministry of Posts and Telecommunications has funded the system, which will enable it to transmit images to mountainous and outlying areas. al

[75] See *World-Wide Space Programs,* p. 186; also *NASDA 80-81,* National Space Development Agency of Japan, pp. 3-4.

[76] See *World-Wide Space Activities,* p. 204.

[77] ''Japanese Commission Proposes Ambitious 15-Year Space Plan," *AW&ST,* Mar. 27, 1978, p. 23.

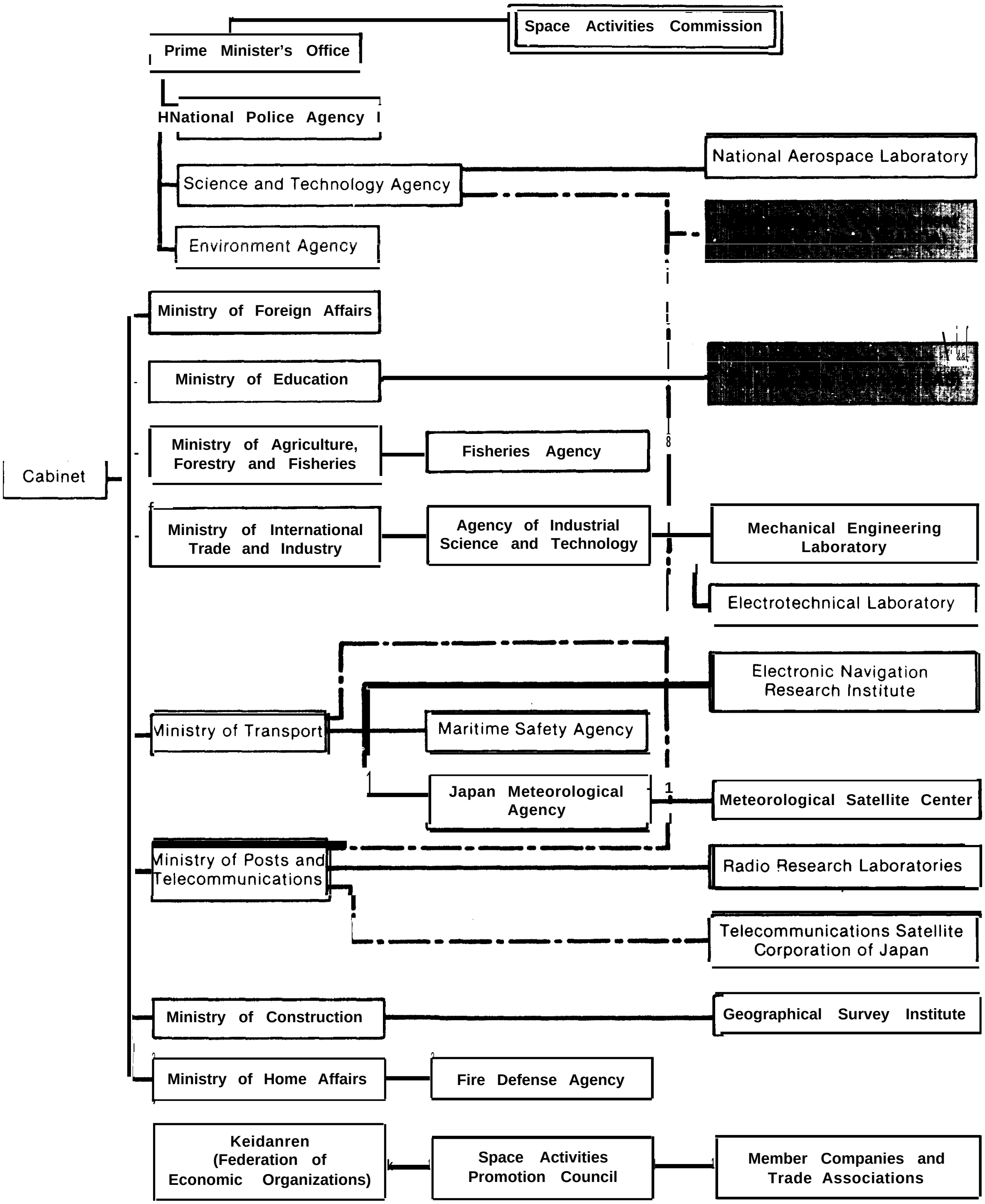
[78] Masao Yoshiki, Acting Chairman, SAC, "Japan's Space program, " paper delivered at International Aerospace Symposium, Paris, France, June 2-3, 1981, pp. 1-2.

[79] Information in this section, unless otherwise noted, is taken from *NASDA 80-81,* NASDA 1980.

"'Japan Gaining Maturity in Satellite Technology," *A W&ST,* Mar. 3, 1980, p. 92.

[81] "Japanese Gain Capabilities in Advanced"Space Effort," *A W&ST,* Mar. 9, 1981, p. 109.

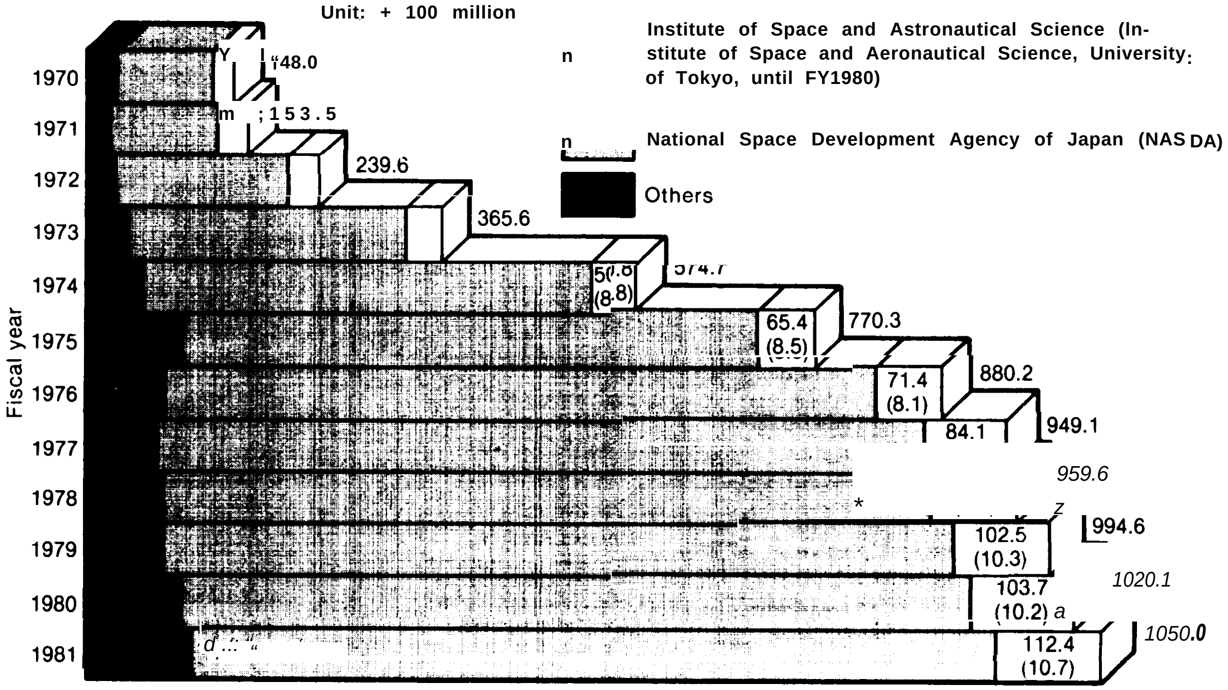
Figure 12.—Schematic Chart of National Organization for Space Activities



SOURCE Nat,ional Space Development Agency of Japan

94-915 0 - 82 - 14

Figure 13.—Japanese Budget for Space Activities[a]



NOTES: 1. The upper figure in each fiscal year shows the total budget for space actwlties,
2. Figures in parentheses indicate percentage (%) as against the total budget for each fiscal year

a"Space in Japan 1981 -1982," Keldanren, Tokyo, 1981, p. 4 (One dollar = approximately 225 yen, 100 million yen = 444,444 dollars at January 1982 exchange rate,)

SOURCE National Space Agency of Japan

The impetus toward operational development of these systems has come from a desire to develop expertise in the design and operation of communications satellites for commercial/industrial exploitation. Satellite broadcasting is particularly useful for communicating within Japan's mountainous and far-flung territory, which includes many small islands. They were preceded by extensive ground-based R&D during the 1960's, including cooperative experiments with NASA on signals propagation, and the assumption of control over NASA's advanced experimental communication satellite, ATS-1, in 1974.[82]

In connection with Japan's communications program mention should be made of a failed experimental program, the Ayame and Ayame 2 satellites. Designed to further test satellite control and communications facilities, both failed to achieve geostationary orbit when launched in 1979 and 1980 by the Japanese N-1 rocket. The first failure was due to a collision with the third stage motor after separation, the second to an apparent misfiring of the apogee engine. The repercussions from these consecutive mishaps, which cost the Japanese an estimated $100 million, have been great; not only was the chairman of NASDA forced to resign[83] but, more importantly, the Japanese were moved to accelerate their efforts to achieve independence from the United States in space capabilities. Both failures were traced to probable malfunctions of U.S.-supplied equipment. Though in the past the Japanese have relied heavily on the United States, dissatisfaction with U.S. technology can only mean fewer contracts for U.S. firms and more emphasis on indigenous

[82] *World-Wide Space Activities,* p. 200.

[83] "Two Mission Failures Force Space Official's Resignation," *AW&ST,* June 3, 1980, p. 26.

development and/or deals with European companics.[84]

In the area of ground stations for communications satellites, Japanese firms have long been leaders in the manufacture and sale of INTELSAT compatible stations and subsystems to developing countries. Both Mitsubishi and Nippon Electric have made extensive sales abroad; in addition, Japanese firms have obtained subcontracts from Hughes and other U.S. companies for work on INTELSAT payloads.

Remote Sensing

Japan has the world's largest fishing fleet and depends on the oceans not only for food, but for the transportation of vital raw materials and exports, to a greater extent than any other developed country. In addition, Japan is a frequent victim of typhoons formed in the Central Pacific, where meteorological facilities are poor and thinly scattered. Hence there is a special interest in the development of ocean-monitoring satellites, both for weather prediction and for exploitation of ocean-based resources.

Many of the early sounding rockets were used for meteorological experiments. The first dedicated Geostationary Meteorological Satellite, GMS-Himawari, was launched in July 1977 by a U.S. Delta. Still in operation, it has provided the Japan Meteorological Agency with cloud-images for public dissemination, along with infrared temperature information, and has disseminated data to other countries in the region. Himawari was also Japan's contribution to the World Meteorological Organization's Global Atmospheric Research Program (GARP). A second satellite, GMS-2, was launched in August 1981 on an N-l! vehicle; it was developed by a group led by Nihon Electric and Hughes Aerospace.[85] The GMS-3 is scheduled for launch in the summer of 1984.

Under development is a geodetic survey satellite, GS-1, for a possible launch in 1985. The GS-1 will be designed to be highly reflective, allowing ground stations to bounce lasers off it for measurement purposes.

The most ambitious current program is the Maritime Observation Satellite, MOS-1, which will be Japan's first satellite to provide continuous global Earth observation. It is designed to observe ocean surface phenomena and will include visible, infrared, and microwave scanning radiometers. The primary sensor will be the multispectral self-scanning radiometer, a charge-coupled device (CCD) providing 50-m resolution imagery. Hence MOS will provide operational experience with land remote-sensing data collection and data-processing, comparable to Landsat and Spot. It is currently scheduled for an N-11 launch in August or September 1986.

A proposed follow-onto MOS is the Earth Resources Survey Satellite, ERS-1, a 2,700-lb remote-sensing spacecraft currently in preliminary design. ERS-1 would be launched in 1988 aboard the new large-capacity H-1A launcher. Possible instrumentation includes synthetic aperture radar, stereo camera, and visible infrared measurement systems.[86] The ERS-1 would eliminate Japanese dependence on outside systems such as Landsat and SPOT, and could be used to further the search for foreign sources of energy and other raw materials. In addition, it would allow Japan to compete with these systems for the sale of remote-sensing data and data products. B'

Materials Processing

Japan is cultivating an on-going MPS program as an element of its 15-year space development policy. MPS work in developing alloys, compound materials, electronic materials, and medicines, as well as the life sciences, is going forward with experiments on both the U.S. Space Shuttle and the TT-500-A, a Japanese suborbital rocket:

- TT-500-A; This small two-stage suborbital rocket with recoverable payload sections provides approximately 7 minutes of microgravity (under 1o-4 G), comparable to the U.S. SPAR and German TEXUS. NASDA has

[84] "Japanese Gain Capabilities in Advanced Space Effort," *AW&ST*, Mar. 9, 1981, p. 108.
[85] "Japan Gaining Maturity in Satellite Technology," p. 92.
[86] "Japanese Gain Capabilities, " p. 107.
[87] "Japan Gaining Maturity," p. 92.

established a space experiment schedule for the IT-500-A of two flights per year. An early 1981 launch carried a metallic compound processing experiment, while an August flight evaluated semiconductor processing techniques.

- ***Space Shuttle:*** NASDA anticipates funding annual missions with Spacelab, inaugurating its use with a first material processing test (FMPT) in fiscal year 1985. The FMPT will make use of half or one-third of the available space in the shuttle-carried Spacelab. A Japanese payload specialist will join shuttle crews to conduct the FMPT and later shuttle-based experiments.[88]

Though the Japanese hope for major potential gains from MPS investments, they do not expect them in the near future. MPS experimentation is seen as a way of insuring a competitive position 10 or 15 years from now.

Launch Vehicles

The Japanese have not had an easy time developing their own launch vehicles. During the 1960's, ISAS was responsible for designing an orbital launcher; after several years of failure a Lambda sounding rocket was able, with the addition of a fourth stage, to launch Japan's first satellite in 1970. The Mu series of solid-fuel rockets was more successful, and the first orbit was achieved in 1971. The Mu launchers have been improved with radio guidance and are used by ISAS for scientific flights. Nissan Motors is currently designing an advanced version, the M-3-kai-l, which will be used for Japan's 1st planetary exploration flights in the mid-1980's, including a planned Halley/Venus mission in 1985.

in 1969, NASDA assumed primary responsibility for launcher development for applications satellites. Instead of attempting to develop further versions of the Mu launcher, NASDA decided to approach the United States for access to technology for the Thor-Delta launcher and licensing arrangements to manufacture parts of the Delta in Japan. The U.S.-Japanese Agreement on Space Activities, signed on July 31, 1969, gave Japan Delta technology, subject to an agreement not to transfer it to any third party. The first flight of the new N-1 launcher took place in September 1975, when an 85-kg test satellite, Kiku ETS-1, was placed in a 1,000-km circular orbit. Basically the N-1 consists of a Thor first stage, built under license in Japan by Mitsubishi Industries; a Japanese developed liquid-fuel second stage; and a U.S. Thiokol third stage. In all, approximately 67 percent of the N-1 is supplied by Japanese firms. The N-1 can lift 130 kg into geostationary orbit; in February 1977, it launched Japan's first geostationary satellite, making Japan the third country in the world, after the United States and Soviet Union, to do so.

An uprated version, the N-11, had its first successful test flight in February 1981. The N-ii can carry 350 kg, or over twice the N-l's payload, to geosynchronous orbit. Mitsubishi Industries is the prime contractor; the major differences from the N-1 are the use of additional solid-fuel strap-on boosters and the replacement of the Japanese-designed second stage by an improved version of the U.S. Aerojet second stage used on the Delta. As a result the Japanese contribution to the N-11 is only 56 percent, less than for the N-1.[89] The N-11 will replace the N-1 by 1983 and is planned for use through the mid-l 980's.

For the latter 1980's and 1990's a new booster design, the H-1A, is under development. The major innovation is a planned liquid oxygen/liquid hydrogen second stage, to be built by Mitsubishi. The initial version of the H-1A will be able to place 550 kg into geosynchronous orbit; a proposed follow-on version would be able to launch 800 kg. The H-1A will also use an inertial-guidance system instead of the radio guidance of the N-1 series. Projected development costs are $755 million; the first operational flight of the full three-stage rocket is scheduled for 1987.90 The H-1A is necessary for the launch of advanced heavy satellites such as the proposed ERS-1, and will give Japan a launcher roughly equivalent to ESA'S Ariane 1. However, there are currently no plans to market any projected launchers on a commercial basis.

[88] "Japan's Space Program," p. 16.

[89] "Japanese Gain Capabilities," p. 109; "Japan Gaining Maturity, " p. 96.

[90] "Japanese Gain Capabilities," p. 109.

Japan's launch capabilities have been severely restricted by agreements with the Japanese fishing industry that allow missiles to be fired only at two times of the year, January-February and August-Se ptember.[91]

To date the Japanese have no firm plans for developing a manned launched capability; Japanese payload specialists will fly on space shuttle missions during the 1980's, with the first Japanese astronaut scheduled to fly in fiscal year 1985. However, there have been very preliminary designs for a "mini-shuttle" capable of carrying a four-man crew plus 1,100 lb of cargo. Such a vehicle is seen as eventually necessary for full exploitation of the scientific and applications programs currently under way.[92]

Cooperation/Competition With the United States

As is clear from the preceding description of its major applications programs, Japan has in the past worked closely with NASA and with U.S. industry. The transfer of Thor- Delta technology has been the largest single result of that cooperation; in addition there have been numerous scientific exchanges. Many of Japan's applications satellites have been designed in part by U.S. firms engaged in joint ventures with Japanese companies. The Japanese plan to use Spacelab extensively.

At the same time it is clear that the Japanese intend to use the technology and expertise gained through cooperation to build up their own independent government and private sector capabilities. The immediately resulting systems have been developed to meet national and public needs in communications, meteorology, and remote sensing; the major commercial effect has been to begin to remove Japan as a market for U.S. systems and launch vehicles. Eventually, however, there is no doubt that Japan will attempt to export its equipment and services. There is a long and well-known pattern of rapid Japanese entry into foreign markets, following on successful assimilation of imported technology, development of domestic markets, and the mastery of techniques for mass production and marketing. Though most of these successes, as in consumer electronics and automobiles, have not been in advanced-technology areas, the government and industry have recently been emphasizing technically sophisticated products in the belief that Japan must compete there to sustain economic growth through the end of the century. Space technology is definitely a major area of interest, and government and industry have been working closely together to prepare for Japanese entry into world markets.

A recent study undertaken by Japan's influential Ministry of International Trade and Investment (MITI) predicts that by the mid-1 990's space will be a $4.5 billion per year industry (current sales of Japanese companies are $480 million, almost entirely to the government). The study emphasizes not only export potential but technological spinoffs; an indigenous space industry is vital since: "As unilateral introduction of technologies from foreign countries is getting more difficult, it is necesary to strengthen Japan's own bargaining power through accumulation of necessary technological know-how, " Recognizing that Japan is some 5 to 10 years behind the United States and Europeans in key areas, especially launch vehicles, there is emphasis on taking advantage of Japanese strengths in quality control, mass production, and marketing.[93]

Despite the disadvantages of a smaller economic and technical base to draw on than either the United States, Europe, or the Soviet Union, and the lack of major military programs to ensure political and financial support, Japan has succeeded in achieving a position of high technical and industrial competence in the entire range of space activities. Though not yet able to offer full-scale commercial products or services (with the exception of ground stations), the development of this capability is only a matter of time. Japanese success has been the result of a number of factors, including:

- a sustained commitment to civilian space development by government and industry

[91] "Japan Space Effort Moves Into Operational Phase," *A W&ST,* Mar. 8, 1982, p. 107.

[92] Masayoshi Kanabayashi, "Japan Sets Mini-Entry in Space Race, " *Wall Street Journal,* July 20, 1981.

[93] *Report of the Deliberation Council on Basic Problems in the Space Industry,* MITI, Apr. 20, 1981.

as an integral part of overall plans to keep Japan competitive in advanced technology;
- careful borrowing of technology, mostly from the United States, and assimilation of that technology by Japanese industry;
- close cooperation between government and industry, with general coordination by the Space Advisory Council;
- strong economic performance over the past two decades, together with a rapid maturation of national scientific and industrial skills; and
- willingness by both government and industry to make and adhere to long-range plans.

Competition from the Japanese appears assured during the coming decade and is likely to be particularly strong in Third World countries, where Japan's proven ability to provide high-quality products at low cost may give them an edge over less reliable European and American competitors. In addition, it cannot be ruled out that growing pressure on Japan to increase its military budget and regional defense responsibilities may bring about attempts to make use of its expertise in space technology for military purposes, with the additional boost that such a decision would give to indigenous aerospace and electronics industries. Recently, it was reported that Japan was considering the deployment of a military reconnaissance satellite system, which might be built alone or with U.S. cooperation.[94]

[94] "Japan Reported Making Plans for Reconnaissance Satellite," *Aerospace Daily,* Jan. 11, 1982, p. 45.

NON-WESTERN SPACE PROGRAMS: SOVIET UNION, PEOPLE'S REPUBLIC OF CHINA, INDIA

Soviet Union

The Soviet Union has for many years maintained a space program approximately equivalent to, and in some areas considerably ahead of, that of the United States both in terms of total resources allocated and the kinds of missions carried out. During the 15 years since it became clear that they would not win the race to land a man on the Moon, the Soviets have made incremental and continuing improvements to their launcher and manned-vehicle systems, as well as developing operational capabilities in domestic and international communications, meteorology, and remote sensing. Over the past several years the Soviets have launched many more satellites than the United States (see table 19).

Table 19.—Total (Civilian and Military) Successful Orbital Launches

	United States	U.S.S.R.
1978	32	88
1979	16	87
1980	13	89

SOURCE: Charles Sheldon 11, "United States and Soviet Progress in Space: Summary Data through 1980 and a Forward Look," Congressional Research Service Report #81-27 S, Jan. 15, 1981, p, 49.

Unfortunately, the extreme secrecy with which the Soviets have surrounded their programs makes it difficult to accurately evaluate their present capabilities and future plans. This secrecy is due to an unwillingness to acknowledge failures and/or technical backwardness for fear of damage to Soviet prestige; to concern that foreign countries might steal or imitate Soviet technology; and to the military nature of most of the Soviet space program and the lack of separation between civilian and military space institutions. It is estimated that 70 percent of Soviet space efforts are purely military, 15 percent are dual military/civilian, and the remaining 15 percent purely civil.[95] All launches are conducted by the Strategic Rocket Forces; the Soviet Air Force operates the Star City cosmonaut training center. Details of the internal organization are not generally available and are subject to controversy. important planning and advisory roles are played by the State Committee on Science and Technology and the Soviet Academy of Sciences.

[95] *Soviet Military power,* U.S. Department of Defense, September 1981, p. 79.

For these reasons, and because the Soviet program is not oriented towards commercial systems that would be competitive with U.S. or other space technologies, we will not examine the Soviet program in as much detail as the European and Japanese. Brief descriptions of major operational applications systems will be given, with emphasis on potential international implications.

Communications

Soviet satellite communications development initially took a different path than that of the United States. The U.S. satellite communications industry, after initial experiments in the early 1960's with low-orbit satellites and passive reflectors (such as the Echo series), soon turned to active geosynchronous satellites. Because of the relatively well-developed U.S. domestic communication network, satellites were at first aimed primarily at the rapidly expanding overseas market; the United States took the initiative in forming INTELSAT and designating the newly created COMSAT organization to provide the technology and management expertise to make INTELSAT function. In the Soviet Union, however, improving domestic communications, particularly to the less-developed central Asian and Siberian regions, was a high priority, while international traffic was minuscule. The Soviet Molniya 1 system began operations in 1965, using large satellites placed in elliptical 1 2-hour orbits. Such orbits are easier to attain than geosynchronous ones, allowing heavier satellites to be used; they also provide better coverage to areas far north of the Equator, though they require relatively expensive tracking antennas. Similar orbits have been used for the Molniya 2 and 3 series, first launched in 1971 and 1974 respectively. The Molniyas have provided domestic telephone and television services, including color TV transmissions; as more advanced Molniyas have become available, the Molniya 1 series appears to have been reserved for military requirements.[9G]

For a number of reasons the Soviet Union and its allies were reluctant to join INTELSAT when it was founded in 1964. The Soviets objected to U. S./COMSAT management, to the use of U.S. technology, and to the system of weighted voting whereby influence was determined by a country's overall use of the system; the Soviets used only 2 to 3 percent of global international traffic, compared with the United States' s 50 to 60 percent. Instead, in 1968 the Soviet Union and eight other socialist states (Poland, Czechoslovakia, East Germany, Hungary, Rumania, Bulgaria, Mongolia, and Cuba) proposed an alternative system, which in 1971 was formally agreed to and called Intersputnik. Although it is open to any state, few other countries (Syria, Vietnam, and Laos), have joined, for both political and technical reasons. There is relatively little commercial/private traffic between most Intersputnik members and the rest of the world; in addition, since the intersputnik network was initially based on use of the Molniya satellites, it was difficult and expensive for INTELSAT Earth stations, which are designed to work with fixed geosynchronous satellites, to make use of the moving Molniyas. in recent years, however, the Soviet Union has begun to orbit geosynchronous Statsionar satellites which are designed to be more acceptable to global users. In addition, as their international communications needs have grown the Soviet Union, Cuba, and Rumania, (to be followed soon by Poland) have begun to use INTELSAT through Earth stations on their own territories. Increasing de facto integration of global satellite communications appears to be occurring, even in the absence of formal agreements.[97]

The Soviets' first geostationary communications satellite was launched in 1974. A large system of geostationary satellites, called Statsionar, has been established to serve the Soviet Union and East Europe with a number of different kinds of satellites: the Raduga series, six satellites of which had been launched through 1980, for domestic TV and telephone relay; the Ekran series, with six satellites, for domestic television; and the Gorizont series of four satellites for international and domestic television transmission. The current lntersputnik system relies heavily on the Statsionar

[96] "U.S. and Soviet Progress in Space, " p. 52.

[97] See Nicholas Matte, *Aerospace Law: Telecommunications Satellites,* prepared by the Centre for Research of Air and Space Law, McGill University, for the Social Sciences and Humanities Research Council of Canada, 1980, pp. 118-123.

satellites, and more are expected to be launched in the near future; the Soviets are currently several years behind in their projections for overall system deployment.[98]

The Soviets have also announced plans for several new global communications systems designed to compete with western ones. The Loutch series of eight satellites is intended to provide services comparable to INTELSAT, using 14/11 GHz frequencies; the Volna mobile communications system of seven satellites plans to offer services to ships and planes similar to those of Marisat and Aerosat. To date none of these planned satellites have been flown.[99]

It would appear that the Soviets, after many years of concentrating on domestic and regional capabilities, are hoping to compete on a more global scale. Such an effort stems from: 1) increasing confidence in their technology, based in part on military experience gained in communicating with a rapidly expanding number of naval vessals and foreign bases and 2) an increase in international civilian communications with Western and third world states, due largely to expanded trade relations. Not enough is known about the critical factors to estimate whether Soviet competition will be effective: these include the system's technical characteristics and reliability, its compatibility with other global and regional systems, how the prices charged for services compare with Intelsat and other alternatives, the institutional characteristics of any potential user group, and political considerations.

Remote Sensing

The Soviets have no specifically designated civilian land remote-sensing system. Large numbers of short-term film-return Cosmos missions have been flown for military purposes, and some of these have undoubtedly provided civilian data. Ocean surveillance for the military has been carried out using nuclear-powered active radar satellites; two specialized nonnuclear oceanographic satellites are reported to be in operation. The latest such satellite, Cosmos 1151, was launched in January 1980.[100]

Perhaps the most ambitious civilian-oriented remote-sensing work has been done on manned missions, particularly the Salyut 6. Some 50,000 photographs have been taken using a large MKF-6m multispectral camera built by Carl Zeiss Jena in East Germany, and some of the data obtained has been shared with allied and developing countries, such as Cuba, Vietnam, Morocco, and Angola.[101]

The Soviets have been distributing weather photos from their Meteor series meteorological satellites since 1966; their first retrograde Sun-synchronous launch, capable of providing daily coverage of a particular area at the same time of day, was made in 1977. Meteor satellites have carried a variety of experimental sensors including, recently, advanced Earth resources instrumentation.[102] In July 1980, the Soviet Union launched a prototype remote-sensing satellite with three experimental multispectral sensors providing ground resolution up to 30 m, with data to be relayed to the ground via radio. It is planned to extend this to a full-scale operational system with 50-m visible-band resolution.[103]

In the U. N., the Soviets have proposed since 1979 that distribution of "local," i.e., 50 m or less, remote-sensing data be subject to the prior consent of the state being viewed; this does not affect Landsat 3 MSS imagery but would apply to TM data from Landsat D, as well as France's proposed SPOT system. The Soviet proposal is designed to restrict the usefulness of U.S. and other Western remote-sensing systems, as well as to limit the dissemination of potentially damaging information about the Soviet Union and its allies (e.g., agricultural data that might give foreign

[98] "Soviets Continue Aggressive Space Drive," *AW&ST*, Mar. 9, 1981.

[99] "Soviets Increasing Space Activities," *AW&ST*, Mar. 3, 1980, p. 83.

[100] "Review of National and Co-Operative Space Activities for the Calendar Year 1980," UNCOPUOS, A/AC'. 105/286/Add. 3, May 1, 1981, p. 11.

[101] "The Salyut 6 Mission," *Interavia*, November 1978, p. 1,084; "Relevance of Space Activities to Monitoring of Earth Resources and the Environment," prepared for 2d U.N. Conference on the Exploration and Peaceful Uses of Outer Space, A/Conf. 101/BP/3, Apr. 28, 1981, p. 8.

[102] "Craig Covault, "Soviets Initiating Program on Modular Space Station," *AW&ST*, July 21, 1981; "Review of Space Activities," p. 10.

[103] "National Paper: USSR," prepared for 2d U.N. Conference on the Exploration and Peaceful Uses of Outer Space, A/Conf. 101/NP/30, Sept. 2, 1981, p. 19.

firms a better bargaining position with Soviet purchasers). The United States opposes such a restriction. [104]

There are presently no known Soviet plans to distribute remote-sensing information outside the U. S. S. R.; entry of the Soviets into the global market, even on a selective basis, could have a significant effect on future Western commercial systems. The Soviets would be likely to sell/distribute data for political purposes, which could mean undercutting global prices while criticizing Western systems (especially those run as private commercial enterprises) for being too expensive for and/or violating the sovereignty of developing countries.

Materials Processing

Processing experiments have had a high priority on recent Soviet space flights, especially aboard the Salyut 6 orbiting laboratory.[105]o~ Two separate furnaces, the Splav-01 and Kristall, have been used to conduct experiments on semiconductors, crystal growth, alloys, glasses and metal oxides; samples have been taken to the ground for detailed analysis. Approximately 300 to 350 Soviet scientists are reported to be actively engaged in materials research related to space processing.[106]

As usual, details of Soviet results are not publicly available; activities appear to be at the basic science level, and can be expected to continue with future Soviet manned flights. Soviet spokesmen are characteristically optimistic about space manufacturing; a typical observation is cosmonaut Konstantin Feoktistov's recent claim that there will eventually be "whole plants for manufacturing products in zero-g. ''107

Launch Vehicles and Manned Operations

The Soviets have developed a number of expendable launch vehicles; the most commonly used is the Sapwood (A) launcher, a derivative of the original ICBM design dating back to the mid-l950s, which in present modified versions can launch Soyuz manned vehicles up to 6,575 kg. The larger Proton (D) launcher can carry 20,000 kg to LEO and has been used to launch the Salyut space stations; it is not considered reliable enough for manned launches. [108]

The Soviets have so far failed to produce advanced ELVS comparable to the U.S. Saturn V, which could lift 136,000 kg to LEO, or a reusable vehicle such as the space shuttle. This has been due in part to their inability to develop high-energy liquid hydrogen/liquid oxygen propulsion systems, without which launching heavy payloads requires a very large number of stages and strap-ens. The Soviets apparently attempted to launch a Saturn-size vehicle on at least three occasions from 1969 to 1972 as part of their manned lunar program, but were unsuccessful. There are currently unconfirmed reports that the Soviets are once again seeking to launch a very large ELV, as well as to develop a reusable vehicle somewhat smaller than the shuttle. Both advances would be useful in implementing the Soviet aim of developing large permanently manned orbiting Space stations.[109]

In recent years the main emphasis of the Soviet space program has been on developing and using the Salyut series of manned orbiting laboratories. The first Salyut prototype was launched in 1971; since then five more have been orbited, four successfully. Several (Salyuts 2, 3, and 5) have apparently been military in nature, mainly for high-resolution reconnaissance; Salyuts 4 and 6 have been civilian.[110] Salyut 6, still in orbit, has been by far the most successful. Weighing 42,000 lb, it has been visited by 13 separate 2- and 3-man Soyuz crews, including a large number of non-Soviet nationals. The Salyut 6 has also rendezvoused with unmanned Progress tankers, which can dock automatically to resupply the men aboard. This has enabled the Soviets to conduct long-duration missions, including the world

[104] James Kay, "The Legal Implications of Remote Sensing by Satellite, " prepared by Centre for Research of Air and Space Law, McGill University, for the Social Sciences and Humanities Research Council of Canada, March 1981, p. 73.

[105] B. Belitsky, "Soviet Manned Space Flight 20 Years on, " *Spaceflight,* vol. 23, No. 5, May 1981, pp. 154-155.

[106] *U.S. Must Spend More to Maintain Lead in Space Technology,* GAO Report FGMSD-80- 32, Washington, D. C., Jan. 31, 1980, p. 8.

[107] 'Soviets Show Assembly of Space Station Units," *AW&ST,* June 29, 1981, p. 21.

[108] '' U.S. and Soviet Progress in Space, " pp. 23-25.

[109] Craig Covau It, "Soviets Developing 12-Man Space Station, " *AW&ST,* June 16, 1980, pp. 26-29.

[110] Nicholas Johnson, "The Military and Civilian Salyut Space Programmes,'' *Spaceflight,* August-September 1979, p. 364.

record of 185 days in orbit recorded by Valery Ryumin and L. Popov in 1980. Numerous experiments and studies have been conducted to test the spacecraft themselves as well as the effects of weightlessness on human beings, other plant and animal life, and inorganic materials. Salyut cosmonauts have succeeded in working outside the spacecraft to make repairs and to deploy instruments, such as a 33-ft radio telescope.[111]

In June 1981 Salyut 6 was visited by a new large (30,000 lb) unmanned craft, designated Cosmos 1267, which is twice as large as the Progress/Soyuz vehicles. The automatic docking performed by the two vehicles appears to point the way to the construction of large modular space stations with many times the interior room of the current Salyuts.[112] The Soviets have consistently pointed to the establishment of such stations as the central goal of their space program and as a necessary step in conducting further space activities, including eventual manned missions to the Moon and planets. In March 1982 the Soviets launched a new station, Salyut 7.

Cooperation and Competition With Other Countries

The bulk of Soviet joint and cooperative projects have been conducted with allied socialist states. In 1967, the Interkosmos program was founded to coordinate activities between the Soviet Union, its East European allies, and other communist states such as Mongolia, Cuba, and more recently Vietnam. A number of scientific satellites have been flown using instruments, designed by member-states, under the overall direction of the Soviet Union. Instruments and experiments, such as East Germany's multispectral camera, have also flown on the Salyut series; many of these were associated with the flight of guest cosmonauts from participating states. To date, cosmonauts from Czechoslovakia, Poland, East Germany, Bulgaria, Hungary, Rumania, Mongolia, Vietnam, and Cuba have been trained in the Soviet Union and spent time on board Salyut 6. These missions have helped give the Soviet program a politically valuable international image; further such flights, including cosmonauts from non-l nterkosmos nations, such as France and possibly India, are being planned.

Soviet-U.S. space relations have had several ups and downs, generally mirroring the overall political climate. The period of initial rivalry from 1957 through the Apollo program was characterized by extreme competition and mutual claims of superiority, often made difficult to verify on account of the secrecy with which the Soviet program was conducted. The Apollo success was typically downplayed by the Soviets, who stressed the superiority of their unmanned Lunokhod lunar explorers and the "wastefulness" of the U.S. manned program, implying that the Soviets had never intended to send men to the Moon.[113] However, even during this period the two countries found it necessary to cooperate in establishing legal and regulatory principles for space activities. In the early 1970's, as the end of the Vietnam War allowed closer relations to develop and "detente" became the official policy of both the U.S. and Soviet leadership, planning began for a cooperative manned mission, the Apollo-Soyuz test project (ASTP). In May 1972, a comprehensive agreement was signed in Moscow as part of the Nixon-Brezhnev Summit. The agreement covered a variety of mutual scientific and technical exchanges in addition to ASTP.[114] The ostensible rationale for the mission was to develop a joint docking system so that, in case of emergencies, spacecraft from either of the two states could rendezvous with those of the other. However, the joining together of the two spacecraft became symbolic of the then current "thaw" in relations, and was seen by proponents as leading towards extended cooperation in future space (and nonspace) activities. Critics saw it as an expensive political stunt which was likely to give the Soviet Union greater benefits than the United States, in-

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[111] Craig Covault, "Radio Telescope Erected on Salyut 6," *AW&ST,* Aug. 13, 1979, pp. 54-55.

[112] James Oberg, "The Soviet Aim: a permanent base in space," New *Scientist,* Oct. 1, 1981.

[113] James Oberg, "The Moon Race Cover-Up," *Reason,* August 1979, pp. 34-37.

[114] *Soviet Space Programs 1971-75,* Staff Report for Senate committee on Aeronautical and Space Sciences, Aug. 30, 1976, vol. II, p. 105.

sofar as the perceived technical parity between the two systems would tend to elevate the public image of the Soviet Union as no longer "behind" in space technology. For various reasons the July 1975 rendezvous of Apollo and Soyuz 19, though spectacular, did not lead to further major cooperative activities; this was largely due to the different directions the two programs took in the second half of the 1970's, as well as to increasing political tensions. Some of the cooperative projects, such as U.S. biological experiments carried on Cosmos flights in 1975, 1977, and 1979, and exchanges of data from each country's planetary missions have continued, but there are no plans for a resumption of major scientific or applications exchanges. In 1977, a second agreement was concluded between NASA and the Soviet Academy of Science outlining cooperation in the development of a compatible sea search-and-rescue system, along with further cooperation in manned space flight. Although preliminary meetings were held, the studies were never completed; the Soviets blame the United States for not fulfilling this latter part of the agreement.[115]

The Soviets and United States are at odds in the U.N. over a variety of space issues, such as the proper restrictions to be placed on DBS and land remote-sensing systems. More importantly, the growing military importance of space technologies for surveillance, communications and navigation has made each side more concerned about the other's capabilities, and less prone to cooperate directly with the other. The Soviets have consistently criticized the shuttle as a space weapon while carrying out active tests of an antisatellite system.

Despite extensive publicity for space exploits, the Soviets have made only minor attempts to actively disseminate either space technology or its benefits to third-world countries, as the United States has done through NASA cooperative agreements and the Agency for International Development (Al D). Outside of allied socialist countries and the United States, significant cooperation has been pursued with only three countries–France, India, and to a lesser extent, Sweden. India's first satellite, called Aryabhata, was launched by the Soviet Union in 1975; in 1979 an Earth-observation satellite, Bhaskara-1, was launched, and Bhaskara-11 was orbited in November 1981. Cooperation with France, outlined earlier in the section on the French space program, has been pursued in materials processing, space biology, and manned flight.

The Soviet space effort is large and varied and the above has done no more than sketch their major programs. As opposed to the U.S. space effort, it seems fair to say that over the past decade, the Soviet program has been characterized by steady growth and extension of their capabilities. Despite slowness in meeting certain goals for communications services, ambitious programs in communications, remote sensing, and especially the construction and operation of orbital stations have been successfully implemented. However, it is still an open question whether increased Soviet capabilities, and increased confidence in their technology, will induce the Soviets to offer applications services to a broader range of global customers. Space technology is one of the few areas in which the Soviets could be competitive with the West, and the political and economic gains of supplying hardware and services would be attractive. However, Soviet inexperience at operating in a competitive business environment may prove, in this as in other fields, to be a major barrier. In addition, the marketing of services—as opposed to simple hardware—which require close cooperation between supplier and customer would run counter to the Soviets' long-cherished practice of maintaining maximum secrecy about their technical capabilities, especially in areas where the military is so closely involved. For these reasons it is likely that the Soviets will choose to compete selectively, for discrete political aims, rather than enter into general competition for satellite communications, remote-sensing, or launch service markets.

People's Republic of China (PRC)

The PRC'S launch technology has been derived from the Soviet Union, primarily the SS-4 (Sandal) medium-range liquid-fueled missile, designs for which were given to the Chinese in the late

'I'" National Paper: U. S. S. R," p. 110.

1950's before relations between the two countries broke down. The central impetus for the development of further launchers and satellites has been to meet security needs: to carry nuclear warheads to the population centers of the Soviet Union, and to provide military reconnaissance and communications.

The first Chinese satellite, the 173 kg China 1, was launched in April 1970 by a CSL-I (Long March 1) launcher. Since then 10 more satellites have been launched (including a recent three-in-one payload of scientific satellites). Little is known about their characteristics, though some were clearly for military reconnaissance and communications. Starting with China 3 in 1975, launches were made with the FB-1 (Storm) vehicle, a version of their CSS-X-4 ICBM, approximately equivalent in size to the U.S. Atlas. The FB-1 can launch a satellite of up to 2 tons into LEO.[116]

The Chinese are known to be working on a new launcher, the Long March 3, which would use the two stages of the FB-1 plus a liquid oxygen/liquid hydrogen upper stage. If successful, this would make them third in the world, after the United States and ESA (perhaps fourth if the Japanese succeed first), to use high-energy cryogenic fuels. The Chinese recently announced that the Long March 3 would be launched in 1983 or 1984 and would probably carry China's first experimental geosynchronous communications satellite.[117]

To date the PRC has no operational communications, meteorological or remote-sensing satellites, but plans are under way to develop all three technologies. Since 1972 and the United States-Chinese rapprochement, China has received significant data and know-how from the United States. INTELSAT-compatible receiving stations have been bought and established near Peking and Shanghai. An experimental COMSAT, the STW-2, is scheduled for a 1983 or 1984 launch over the Pacific, and indigenous Earth stations and transmitters have been built.118 Transmission tests using the France-German Symphonic have included video teleconferencing and high-resolution facsimile transmission. According to terms of the "1979 Understanding on Cooperation in Space Technology" (part of the ***United States-China Agreement on Cooperation in Science and Technology),*** the Chinese Communications Satellite Corporation indicated a desire to purchase a U.S. communications satellite (to be launched by NASA) including ground equipment, but plans have been postponed indefinitely due to financial constraints. Discussions also took place in 1979 and 1980 with non-U.S. partners such as West Germany's Messerschmitt-Bolkow-Blohm.119

PRC currently receives meteorological data from the U.S. Tires-N and NOAA- 6, and the Japanese GMS-1 satellites through indigenous receiving stations. The Central Meteorological Bureau had planned to launch a Sun-synchronous weather satellite in 1982, and a complementary geosynchronous satellite in 1985. The 1982 satellite's radiometer was to have a 4-km resolution (compared with the U.S. ITOS' resolution of 1 km). Due to cutbacks in Chinese R&D expenditures, the status of these plans is uncertain.

In remote sensing, the Chinese plan to use Landsat and SPOT data extensively before developing their own system; the "1979 Understanding" indicates China's intention to purchase a Landsat ground station from U.S. industry, and procurement activities are continuing. The Shanghai Institute of Technical Physics is reported to be working on various sensors including a multispectral scanner.[120] In January 1980, NASA and the Chinese Academy of Sciences concluded a memorandum of understanding giving the PRC direct access to Landsat data.

There have been several reports that the Chinese are planning seriously for eventual manned flights and have begun to train astronauts for future missions.[121] However, China's recent reassessment of internal economic and scientific

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1 [16]Edelson Haas et al., "Eyewitness Report on Chinese Satellite Work," *Aeronautics and Astronautics,* February 1980, p. 44.

"z" China Launches Three-in-One Satellite Payload, " *Aerospace Daily,* Sept. 22, 1981, pp. 113-114.

11[8]" Eyewitness Report," p. 41.

[119]"MBB, Chinese Discuss TV Satellite," *AW&ST,* Mar. 31, 1980, p. 63.

1[20]" Eyewitness Report, " p. 43.

"' See David Ritchie, "Dragon in the Sky: China's Space Program, " *Technology Review,* October 1981, pp. 53-54.

priorities has apparently resulted in a postponement of plans for manned flights in the 1980's.'22

Until recently China's space capabilities were barely known. Since the death of Mao and the determination of China's new leadership to modernize the country by increasing foreign trade and educational/scientific exchanges with the West, a number of official and unofficial foreign delegations have been allowed to visit Chinese space facilities. In turn, large numbers of Chinese have visited U. S., European, and Japanese facilities, and many Chinese students are now attending Western engineering and graduate programs in the sciences. Up to now, except for initial aid from the Soviet Union, Chinese efforts have been almost exclusively home-grown. Military requirements have been paramount, but there has also been recognition that satellites could play a large role in upgrading China's internal communications and television networks, in locating and managing mineral and energy resources, and in agricultural planning. Given the previous lack of access to outside technology, Chinese capabilities are impressive, and are likely to expand rapidly in the near future if outside contacts increase and internal constraints are relaxed. The major difficulties are likely to be a shortage of trained scientists and technicians, due to the educational disruptions of the cultural revolution; lack of capital and other strains caused by ambitious plans for rapid modernization of the entire economy; and lack of foreign exchange for the purchase of outside technology. Though Mao's absolute insistence on domestic self-reliance has been relaxed, China is likely to be interested in such purchases primarily as a way of gaining access to technology to be copied or otherwise appropriated; hence, although China will not in the near future be competing with foreign firms or governments for commercial contracts, it is also not likely to be a major buyer of space systems.

India

India has had a formal space program since the formation of the Indian National Committee for Space Research (l NCOSPAR) in 1962. In 1969, INCOSPAR was absorbed by the Indian Space Research Organization (ISRO), which in 1972 became the central body of the newly created Department of Space.

Unlike China's, India's space activities have not been motivated by military concerns (the military has a separate interest in antitank and antiaircraft missiles). Although India is an underdeveloped country, it has, because of its size and longstanding contacts with the West, a considerable pool of scientific and administrative talent. The space program is designed to use these resources to encourage development, to foster technical and scientific leadership, and to serve as an example (in accord with India's overall position of neutrality between East and West and a leader of the nonaligned movement) of indigenous Third World achievements in areas usually considered the preserve of advanced developed countries. Hence there is an emphasis on developing a comprehensive space capability, and especially systems for rural communications, land management, and weather forecasting. Foreign assistance has been welcomed from a number of countries, largely for demonstration projects and joint programs, with the intention of building on the experience gained to provide similar services with indigenous resources. Through 1979, India's total investment had amounted to some $230 million, with somewhat higher expenditures anticipated in fulfilling the latest 10-year plan.[123]

India has built and launched a large number of Rohini sounding rockets, in addition to providing a launch platform for U.S. and Soviet sounding rocket experiments.[124] In July 1980, India successfully tested its four-stage solid fuel SLV-3 launcher, orbiting the 76-lb Rohini I research satellite; in 1981, it launched a second Rohini, which failed to achieve orbit. Plans are under way to produce an augmented SLV, using strap-on boosters, that could place 330 lb into LEO, as well as to develop a new launcher capable of orbiting a 600-lb remote-sensing satellite by the mid-1980 's. Though strongly denied by India, there are fears, especially in Pakistan, that

122See "Chinese Astronauts Train in Simu lators,' A *W&ST,* Jan. 26, 1981, p. 63.

123H. P. Mama, "India's Space Program: Across the Board on a Shoe String," *Interavia,* January 1980, p. 60.

124" World-Wide Space Activities, " p. 119.

India's launchers may be used as, or be the precursor to, a delivery system for nuclear weapons.

India's first satellite, the Aryabhata, was launched by the Soviet Union in 1975; it was largely Indian-built and designed, with Soviet assistance. In 1979, the Soviets launched India's Bhaskara I remote-sensing satellite, which suffered a partial power failure. The Bhaskara 11, containing two television cameras and three microwave radiometers~, was launched in November 1981, and has provided television pictures of the sub-continent.

Another cooperative venture was the June 1981 launch of an experimental communications satellite, the Apple (Ariane Passenger Payload Experiment), on ESA'S third Ariane test vehicle. The satellite suffered a partial failure of its solar-powered electrical system but has continued to function with reduced capability.[125]

India plans to establish an operational communications system, called Insat, using two satellites purchased from Ford Aerospace and launched by the U.S. Insat-1 was launched in April 1982, and will relay messages and data between approximately 32 proposed ground stations, as well as provide direct television service to rural communities via several thousand inexpensive antennas.[126] Insat will also carry a VHRR to provide' meteorological information. Eventually, ISRO plans to produce its own follow-on system, building on experience gained with Apple and Insat.

India's commitment to Insat has been due largely to the positive experience gained with two major cooperative communications satellite projects, one with the United States and the other with Europe. The Satellite Instructional Television Experiment (SITE), which lasted for 1 year from August 1, 1975, to July 31, 1976, was a joint program with NASA using the ATS-6 large communications satellite to broadcast educational television programs to 5,000 Indian villages. India was responsible for maintenance of the ground equipment and for developing the programs; the overall reaction proved highly favorable and enabled the Government to disseminate important information on health care, agricultural techniques, and birth control to previously inaccessible areas. Additional experiments, including teleconferencing and emergency communications, were conducted through the Symphonic Telecommunications Experimental Project (STEP) from July 1977 to mid-l 979, using the French-German experimental Symphonic communications satellite.

In remote sensing, India is one of 11 foreign countries to have a Landsat receiving station. Located at Hyderabad, it is operated by the National Remote Sensing Agency. Current plans call for a remote-sensing satellite to be developed and launched sometime in the mid-1980's, building on experience with the Bhaskara series.

India has amassed a large amount of experience in designing, building and operating a variety of applications systems. The commitment to achieving an independent capability to use space technology is longstanding and based on the beneficial results of past usage. Though direct competition with Western or Japanese systems is not likely in the near future, Indian experience in adapting space capabilities to developing country needs could eventually give them an advantage in providing services and/or hardware to Third World countries.

[125]" Apple Satellite Operational Despite Panel Failure," *AW&ST,* Sept. 14, 1981, p. 19.
[126]Benjamin Elson, "U.S. to Launch Insat Satellite for India," *AW&ST,* Apr. 5, 1982, pp. 56-63.

OTHER SPACE PROGRAMS

Canada

Canada's space activities are coordinated by the Interdepartmental Committee on Space (ICS), with overall responsibility in the Minister of State for Science and Technology. Canada has participated in a large number of joint scientific projects with the United States, including the Canadian-built Alouette and ISIS ionospheric research satellites, launched by NASA. The Department of Communications cooperated with NASA and ESA in operating the experimental

Communications Technology Satellite (CTS) from 1976 to 1979, which pioneered operational use of the 14/12 GHz band. Spurred by the difficulties of communicating with remote regions in the North, Canada in 1972 became the first Western country to initiate operational domestic communications via satellite; the Anik A series of three comsats were built by Hughes and launched by the United States. In 1978, Telesat Canada began using RCA's Anik B for voice, data, and television transmissions. Three Hughes-built Anik C spacecraft are scheduled for launch beginning in November 1981.

Canada is also engaged in a major bilateral program with NASA to develop a remote manipulator arm for the U.S. space shuttle. Spar Aerospace Ltd. is developer for the $100 million project. The first arm flew on the second shuttle flight in November 1981. As with ESA'S Spacelab, Canada has agreed to pay for development of the arm and the first prototype, in return for a NASA commitment to purchase additional arms from Spar.[127]

Brazil

Brazil has had an active interest in space activities since 1961, especially satellite communications and remote sensing to manage its far-flung territories and to assist in the development of the Amazon Basin. The Centro Tecnico Aerospecial (CTA) has been responsible for developing the Sonda series of sounding rockets, which are launched from Brazil's launch facility at Natal in the northeast part of the country. The United States, Germany, and other countries have also used Brazil's facilities; a new launch center is now being prepared closer to the Equator.

In 1975, Brazil and NASA conducted the SACI (Advanced Satellite for Interdisciplinary Communications) experiment, using NASA's ATS-6 satellite to transmit television programs to remote primary schools. Brazil currently leases four transponders from INTELSAT for domestic use (with plans to increase this to 81/2 transponders by 1986), and plans to purchase its own comsat (with provision for technology transfer), to be launched in 1985.

Brazil is, after the United States, the largest user of Landsat data, and has operated a Landsat ground station since 1973, along with processing facilities. There are currently plans to design and build four remote-sensing and meteorological satellites, with the first one to be launched in 1988.[128]

[127] Craig Covault, "Remote Arm Aids Shuttle Capability," *A W&ST*, Sept. 7, 1981, pp. 57-58.

[128] Jim Brooke, "Brazil's Space Program Prepared to Launch 4 Satellites by 1993, " *Washington Post, Nov. 26, 1981*, p. A22.

DOMESTIC/REGIONAL COMMUNICATIONS SYSTEMS

In addition to the national programs outlined previously, there are a number of regional satellite communications systems that are either already in operation or in various stages of planning,

Indonesia has had the two Hughes-built satellites of its Palapa A system operating since 1976 to link its widespread island area. Spare channels have been leased by other countries in the region. The first Palapa B satellite is scheduled for launch in 1983 and will be used by the Philippines, Thailand, and Malaysia. The Arabsat system, with 21 Middle Eastern countries as participants, is scheduled for a first flight in December 1983. France's Aerospatiale is the prime contractor, with Ford Aerospace the major U.S. participate. Australia's Australsat is planned for the mid-1 980s. Regional systems have been discussed for Southern Africa and South America, particularly the Andean region, prompted by Colombia's well-developed plans for its Satcol telephone and TV system.[129] Currently, a large number of countries lease spare transponders from INTELSAT satellites and purchase ground stations for domestic use. This activity, along with the national and regional systems mentioned, in-

[129] See Theo Pirard, "Space Systems Operated and Prepared by Developing Countries, " *Spaceflight,* May 1981, pp. 137-139.

dicates the scale of global interest in satellite services. This is important, first because of the implications for the current international communications system, i.e., for INTELSAT; and also because, given the stakes, competition for sales of satellites, ground equipment, and launch services between U. S., European, and Japanese firms" is likely to be fierce. The proliferation of satellites for local and regional use threatens to take business away from INTELSAT, damaging its financial viability. As communications needs become greater and more specialized, and as it becomes progesssively more difficult to allocate scarce orbital slots and frequencies, many countries are determined to have their own system, or a share of a local system, regardless of whether such a move is warranted by local demand or by financial considerations. Such decisions are supported by increasingly competitive private and national suppliers of telecommunications equipment, who encourage the purchase of specialized services. The long-term effects on INTELSAT are unclear but may lead to higher prices or reduced service, which would be especially harmful to those countries that are too small or poor to purchase their own system.[130] A possible solution would bean expansion of the INTELSAT system to provide local and regional services. This would require a satellite-ground-station system designed to operate in low-density rural areas, perhaps including direct-broadcast capabilities.

[130] See John McLucas, "Global Cooperation in Satellite Communications in a Decade of Policy Divergence, " paper presented at International Aerospace Symposium, Paris, France, June 2, 1981.

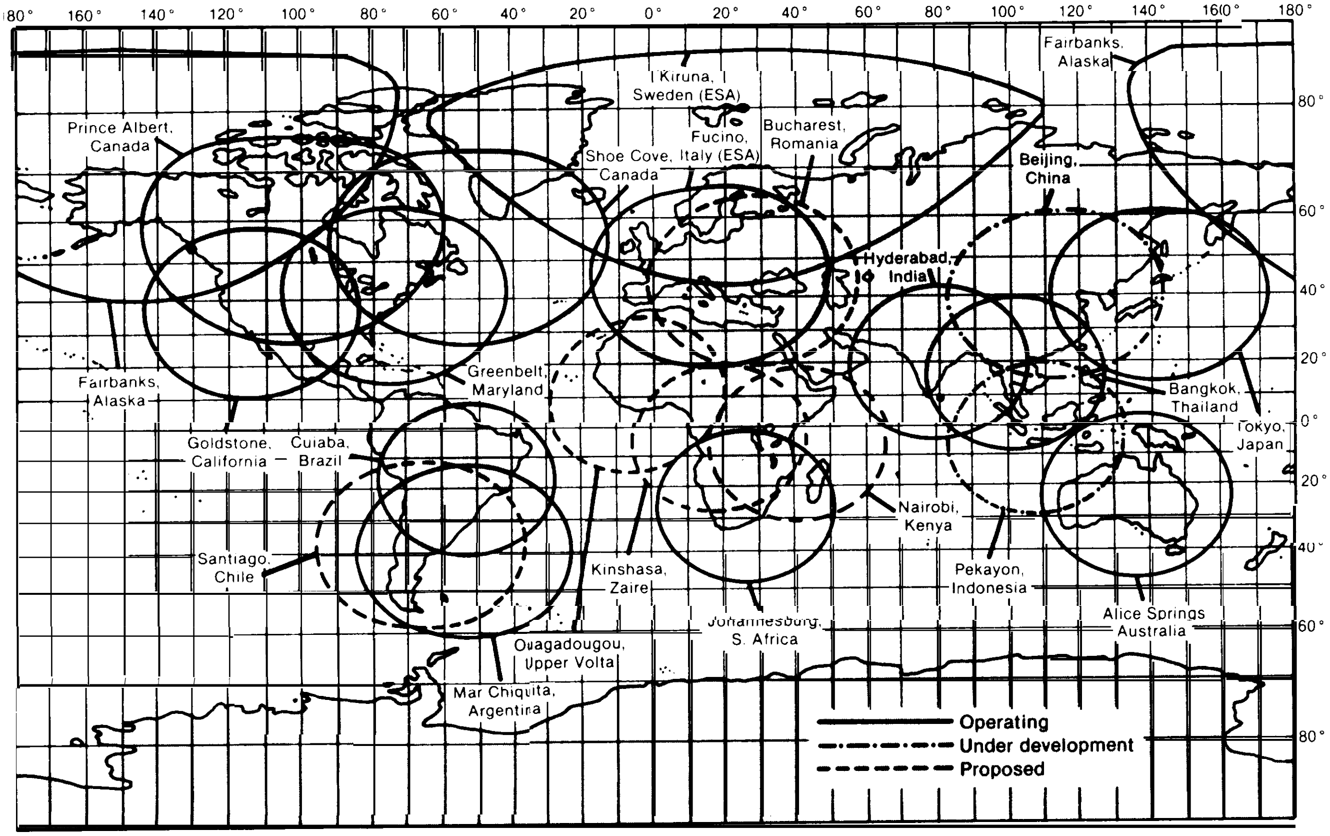
REMOTE SENSING IN DEVELOPING COUNTRIES

In the field of land remote sensing, the anaIogue to INTELSAT has been the U.S. Landsat system, which has provided black-and-white and multispectral photographs on a global basis for the cost of reproduction. U.S. policy was established in 1969, when President Nixon stated at the 24th U.N. General Assembly that "this program will be dedicated to produce information not only for the United States but also for the world community. " Foreign nations and agencies can either purchase data from the EROS Data Center, or receive it directly by establishing their own receiving station, which can (with the current Landsat satellites) provide images over a 2,700-km radius (see map). Especially in developing countries where maps are often incomplete and outdated, and information about land use, forest cover, drainage patterns, mineral deposits and the like is difficult and expensive to obtain, satellite imagery has been used extensively to aid in economic development.'s' Over the years, substantial assistance has been provided, largely by the U.S. Agency for International Development and also by other developed countries and international organizations, to enable various countries to use Landsat. Effective use requires skilled technicians and equipment to process the data, as well as integration of satellite information with many other information resources. Multilaterally funded training centers to encourage these capabilities are being established in Upper Volta, Kenya, and Thailand.

As was discussed above, other global land remote-sensing systems besides Landsat are planned for the mid-l 980's. Though such competition may eventually improve the quality of services available, much depends on whether the competition is political or commercial in nature. Private-sector operation of !-andsat, which could put remote sensing on a more commercial basis, is of concern to many developing countries who see such a move leading to higher prices as well as possible violations of their sovereignty by private companies outside effective government control. On the other hand, a "price war" between, say, politically motivated Landsat, SPOT, MOS, and possible Soviet systems might prove beneficial to users but might also undermine the willingness of the sponsoring governments to continue their operation. The multiplication of

[131] For a, outline of some of these uses, see "Relevance of Space Activities to Monitoring of Earth Resources and the Environment, " background paper for second U.N. Conference on the Exploration and Peaceful Uses of Outer Space, A/Conf. 101/BP/3, Apr. 28, 1981.

Figure 14.—Current and Probable Landsat Ground Stations



NOTE: Coverage circles based on Landsat-3 reception (altitude: 917 km)

SOURCE: National Aeronautics and Space Administration

remote-sensing systems could prove wasteful and make the integration of global and regional data, necessary for many applications purposes, more difficult. At the same time, many countries are concerned about the dangers of allowing information about their resources to be appropriated by a multiplicity of nationally owned satellites or, worse yet, sold to the highest bidder. For these reasons, some sort of international civilian remote-sensing structure has occasionally been proposed;[132] for a detailed discussion see the Globesat section in chapter 10 of this report. At the present, however, no country or organization has taken the lead in proposing such a system or in establishing the institutional and financial framework that would be needed. Discussion of ways to better use and integrate remote-sensing data, along with other issues of concern to developing countries, will be on the agenda at the upcoming second U.N. Conference on the Peaceful Uses of Outer Space (UNISPACE 1982) to be held at Vienna this coming August. A number of proposals to establish new U.N. bodies dealing with space activities and/or to expand the scope of existing ones will be proposed at the Conference and passed on by the General Assembly in the fall of 1982.

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[132] See Robert White, "Land, Sea and Air: The Global Implications of the View From Space," paper presented at Conference on Global Implications of Space Activities, Aspen, Colo., Aug. 30-Sept. 4, 1981, pp. 14-22.

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