NON-U.S. APPROACHES TO SPACE COMMERCIALIZATION

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ABSTRACT

This paper describes the approaches to the commercialization of space taken by the four foreign countries most active in the field -- Canada, France, the Federal Republic of Germany and Japan.

National space program elements with commercial potential are examined in the context of national industrial and science policies, with special attention to objectives, timetables, and budgetary priority relative to other sectors.

The role of the European Space Agency in attaining national and regional commercialization objectives is also examined.

TEXT

INTRODUCTION

Foreign space commercialization policies do not exist in a vacuum. Typically, the broad policy directions which influence the content of these policies are derived from national industrial policies, particularly those concerned with encouraging innovation and the development of internationally competitive high-technology industries.

Among the countries which are the focus of this paper, there is wide variation in policy approach. Since the post World War II recovery, the Japanese government has specified objectives and priorities for the economy , and has implemented its perceptions through what is, for the non-Socialist world, an unprecedentedly close business-government relationship.

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In the Federal Republic of Germany, on the other hand, and particularly in recent years, it appears that the government has made a fundamental decision to avoid the role of picking "winners," and to let the marketplace determine the success or failure of individual sectors. German officials acknowledge that there are many exceptions, particularly in the case of subsidization of troubled or declining industries, but argue that these measures represent a necessary adjustment to changing market conditions rather than a "positive" industrial policy.

France has historically adopted an approach somewhere between the German and Japanese patterns, combining pervasive government ownership in key sectors with, generally, a much less extensive government planning and coordinating role than practiced from Tokyo.

Canadian industrial policy, reflecting special factors of geography, relatively limited population and consequently restricted internal markets, has adopted a unique focus on the issues of industrial independence and development of indigenous capacity to meet special Canadian needs.

SPACE BUDGET TRENDS

To begin the discussion of non-U.S. space commercialization programs, a useful first approximation of the relative priority of space in the eyes of key foreign governments may be gained from a comparison of space budget levels over the last few years. The following table presents this comparison. Individual countries' currencies (or in the case of ESA, ESA Accounting Units) have been used instead of the more familiar US$ figures because the dramatic strengthening of the US$ over the last two years would have distorted the trends portrayed by the chart. For comparison purposes only, a US$ figure equivalent to the 1983 budget level, expressed in terms of the end-1983 exchange rate, is included in the entry for each country.

From the table, the most striking conclusion to be drawn is that when these budget levels are corrected for inflation, only the French space budget has actually increased in real terms since 1979. ESA, Japan and the Federal Republic of Germany more or less held their own, while Canada showed a real decline. The Canadian result is somewhat distorted, however, because Canada employs a rolling four year budgeting approach, and in December 1981 Canada increased its space budget by one third, to C$476M over the 1981-1985 period. This increase is not fully reflected in a statistical series ending in 1983.

Table 1.

Space Budgets

Country	1979	1980	1981	1982	1983*	% Chg.	1983(US$M)
Canada (C$M)	100.0	100.0	96.7	136.0	106.2	+6.2	84.1
France (MFFr)	1649.5	1907	2617	3098.5	3668.6	+122.4	434.7
ESA* (MAU)	636.6	625.8	603	673	788.6	+23.9	771.2
Japan (MYen)	99,498	102,005	104,995	108,468	113,389	+14.0	484.4
Germany (MDm)	653.7	726.4	805.6	847.3	768	+17.5	282.4

* The ESA budget is funded about 36 percent by France and the Federal Republic of Germany, hence the ESA line reflects double counting on the order of 280 MAU (US$274M).

FEDERAL REPUBLIC OF GERMANY

In his foreword to the Fourth Space Programme of the Federal Republic of Germany, Federal Minister for Research and Technology Dr. Heinz Reisenhuber said, "One goal of German space policy is to accelerate the utilization of scientific knowledge for the manufacture of commercial products ... The space policy of the Federal Government aims to secure future employment by supporting highly-developed space flight technology as a pace-maker for future innovations."

Budget Levels and Budget Priority

In 1982, the German budget for space activities constituted Dm 847M, or 12.9 percent of the budget of the Federal Ministry for Research and Technology (BMFT) . Of this sum, Dm 403M or 44 percent was the F.R.G. contribution to ESA.

In 1983, the BMFT's budget for space declined to Dm 768M; about 50 percent went to ESA. The 1983 BMFT budget presents a typical picture of the relative priority of space, with energy research allotted 39 percent of total funding, compared to 11 percent for space. No other sector received comparable emphasis, although both electronics/data processing and health/environmental research were budgeted to a share of about 7 percent each.

For 1984, BMFT's planned space budget allocation is Dm 810M. Reflecting the reduction in BMFT's involvement as communications satellite programs near operational status, R&D support in this field is to be cut by 41 percent, to Dm 68 million. Space accounts for 11.4 percent of BMFT's 1984 draft budget. Current BMFT policies favor increased industrial involvment in research and development, and changes in the tax structure and other indirect measures are being implemented to encourage such investment, rather than relying on increases in direct government support. BMFT's direct R&D project support (all sectors) is to be reduced from Dm 3.5 billion in 1982 to Dm 2.8 billion in 1984.

In 1984, for the first time, funding will be made available for space activities by agencies other than BMFT. The all-agency total is to be Dm 1008M. The German contribution to ESA will reportedly include Dm 39M from the Ministry of Transport for EUMETSAT. The 1984 national draft budget also reportedly includes funding by the Ministry of Posts and Telecommunications for communications satellites, totalling Dm 70M for TV-Sat and Dm 135M for development of the DFS (Postsat) operational communications satellite, which will be used mainly for telephone communications. Taken together, these non-BMFT contributions to operational programs constitute virtually the entire increase in the German space budget for 1984.

Space Commercialization Priorities and Efforts

Commercialization plays a significant role in the overall objectives of the Federal Republic's space program. The general objectives stated in the Fourth Programme are:

-- Promotion of fundamental research, partly as a contribution toward the cultural development of the nation and partly to guarantee the long-term efficiency of the economy.

-- Innovation by applying space technology above all to public services, primarily with satellite communications and earth observation.

-- Strengthening German industry's competitiveness by direct commercial application of space technology.

Central elements of the Programme with commercial implications include:

-- Improvements in the performance and economics of satellite communication and remote sensing systems until it has been demonstrated that they are ready for specific applications; introduction of fully-operational systems by State users;

-- Implementation of a trial phase using space as a laboratory for experiments concerning materials science, processing techniques, and bio-medicine, whether in the manned Spacelab or on re-usable space platforms;

-- Development and construction of the space transport and orbital systems needed to perform those tasks.

Reflecting these priorities, the BMFT space budget in 1982 committed Dm 70M to development and construction of communications satellites, and Dm 35M to Spacelab utilization. Communications satellite and Spacelab research together amounted to only 12.4 percent of the total (excluding, however, amounts for these purposes in the DFVLR budget, which runs about 25 percent of the BMFT total).

In discussing Germany's approach to space applications, the Fourth Programme dwells at some length on the practical benefits of space research.

> The space programme is intended to support industry in its efforts to develop space transport facilities and operational applications satellite systems capable of satisfying the economic and technical requirements imposed by the likely market and demand and, subsequently, to make those systems available to users for a variety of public services. It should help the German space industry to win a fair share of the world market, and thereby create jobs in high-technology industries displaying considerable potential for innovation.

To ascertain BMFT's commercialization priorities more clearly, it is useful to consider a few key program areas in some detail.

A. Spacelabs -- The largest single undertaking in BMFT's current space budget is the D-1 Spacelab mission, managed by DFVLR, the German Aerospace Research Establishment, and scheduled for flight in September 1985. Total cost of the D-1 mission is estimated at Dm 323.5M (1981 funds), of which Dm 61M is earmarked for materials science hardware and experiment support; Dm 110.7M for payload integration, payload operations and management costs; and Dm 128.4M as payment to NASA for STS services. A reflight, called D-2, and an all-pallet Spacelab science mission, D-4, are also being proposed. The payload for D-1 is divided between materials science, remote sensing (both microwave and visible light), life sciences and a navigation experiment, NAVEX. In order to secure exemption from the STS and Spacelab use fees (a non-trivial but proportionately minor part of the total cost of D-1), BMFT has elected to fly 93 percent of the D-1 payload (all but NAVEX) under a NASA policy which waives those fees for payloads without near-term commercial implications, while affording NASA access to the data from them.

B. Space transportation systems -- The F.R.G. supports the Ariane program through its ESA contribution and through 19.6 percent ownership of Arianespace, the quasi-private European launch vehicle firm. It also supports in a limited way the efforts of OTRAG to develop a commercial sounding rocket capability which may eventually evolve into a commercial launch capability for small payloads to low earth orbit.

A high priority in the German applications program is the development of reusable space platforms. EURECA, ESA's reusable carrier, is under development based on the SPAS technology of Messerschmitt-Boelkow-Blohm (MBB), and is scheduled for an October 1987 reimbursable Shuttle launch and retrieval in May 1988. In April, 1981, NASA and BMFT signed a Memorandum of Understanding on utilization of the STS, covering Spacelab missions and other future activities. In the Programme, BMFT noted that "the operational advantages of

manned transportation systems will be a key factor in the further development of orbital systems."

C. Materials science -- The Programme calls for the development of new manufacturing techniques and materials "by selective exploitation of the unique physical conditions encountered in space." In practical terms, however, BMFT apparently believes that materials processing in space is still in the stage of fundamental scientific research. The decision with regard to the handling of data from the D-1 mission seems to confirm this view.

The German materials science program includes sounding rocket flights, small Shuttle payloads, Spacelab experiments and future reusable carrier payloads. The sounding rocket program, called TEXUS, involves 1-2 launches per year from ESRANGE in Sweden, in cooperation with ESA and the Swedish government. Germany is also making active use of NASA's Small Self-Contained Payload (SSCP) program and has purchased its own SSCP containers for additional flights of MAUS (automated materials processing investigations payloads). NASA and BMFT have agreed to exchange results from NASA's Materials Experiment Assembly (MEA) and BMFT's MAUS.

D. Communications and Broadcast Satellites -- Germany and France jointly developed the Symphonie experimental communications satellite which was placed in orbit in December 1974. Germany and France are now cooperating in the development of TV-Sat and TDF-1 respectively, direct broadcast satellites scheduled for first launch in 1985 (aboard Ariane) and operational status in 1987. The Ministry for Posts and Telecommunications will operate TV-Sat, and has also begun development of the operational German telecommunications satellite (DFS).

In September. 1981, the French and German governments concluded an agreement on technical and industrial cooperation in marketing and exporting the TV-Sat/TDF-1 design. The TV-Sat/TDF-1 design was selected by Sweden for its Tele-X system, and is currently being actively marketed to the Chinese.

The TV-Sat direct broadcast satellite is reportedly planned to be the last BMFT-sponsored communications satellite project. As mentioned above, the Federal Ministry of Posts and Telecommunications is also contributing to TV-Sat, and full responsibility for the DFS system will rest with the PTT. BMFT reportedly intends to focus on new technology development.

E. Remote sensing -- Candidly, the Fourth Programme notes that "doubts about the economics of this type of satellite can be expected to persist for a long while to come. Nevertheless, Europe and the Federal Republic of Germany would be wrong to cut themselves off from these activities ..."

The German program gives priority to the development of long-term strategies for using satellite data in operational applications. A German national remote sensing center has been established at Oberpfaffenhofen, which will also form part of the European remote sensing data network.

Germany has developed several remote sensing instruments for flight on the Space Shuttle: The Microwave Remote Sensing Experiment (MRSE), the Metric Camera and the Modular Optoelectronic Multispectral Scanner (MOMS). The first two flew on Spacelab 1 and are scheduled for reflight on D-1, while MOMS flew on the first two flights of SPAS. SPARX, a joint venture involving MBB and the U.S. Communications Satellite Corporation, is negotiating for a flight of the SPAS/MOMS combination on an early STS flight, and plans to market the resulting data commercially.

F. Meteorology -- German involvement in this field is through the ESA Meteosat 1 and 2 programs, and through its participation in EUMETSAT, the European operational consortium.

Government-Industry Relations and Space Commercialization

There are only two primary aerospace companies in Germany: MBB (with which VFW-ERNO merged at government insistence, in an apparent effort to strengthen the German competitive position in bidding for contracts worldwide) and Dornier. German government space contracts are routinely reserved for these firms, and for German subcontractors. The BMFT in general favors initiative on the part of the German aerospace industry, and is willing indirectly to assist firms with such development efforts as MBB's SPAS, where BMFT funded experiment development and then leased space on the SPAS to fly those experiments.

There is a persistent rumor in the U.S. that German industry is actively pursuing materials processing research for near term industrial applications. In fact, while German industry is indeed participating in such research, the work is apparently being done with government, not industry, funds. Industry in Germany does not appear convinced as yet that the space environment offers sufficiently attractive opportunities for profit to warrant significant investment.

FRANCE

Since the establishment of the Centre National d'Etudes Spatiales (CNES, the French space agency) in 1962, French government policy has emphasized the industrial applications of

space research. As set forth by the French government in October 1981, the French space program has, as principal goals:

-- consolidating French industry's position in space applications;

-- improving France's share of international markets for launch services, satellites and associated ground services and equipment, and;

-- preparing France, through a major basic technology R&D effort, for changes that "are likely to profoundly modify the design and economics of space systems during the 1990-2000 time frame."

Budget Levels and Budget Priority

Late last year, CNES proposed to an Interministerial Council plans for a major expansion of French spending on space, from a level of FF 3.5B in 1983 to 4B in 1984 to about 5B in 1990. The plan, which remains under consideration by the French government, continues emphasis on telecommunications and direct broadcast satellites and remote sensing, as well as calling for the development of Ariane 5 under ESA auspices. Several configurations are under study, all relying on advanced hydrogen-oxygen technology. In a significant departure, the CNES plan also proposes the development of Hermes, a small reusable manned spacecraft to transport astronauts and supplies to and from an orbital platform; previously, the French had held that manned spaceflight was an expensive luxury, unnecessary to their space objectives.

Table 2.

French Space Budget, 1981-1983 (M FF)

Line Item	1981	1982	1983
Multilateral cooperation	1003	951.5	1286.2
Bilateral cooperation	485.1	475.9	463.6
National program	334.8	628.6	741
Program support (*)	555.1	802.5	882.3
R&D	55.3	95.1	125

Analyzing CNES's 1983 budget in other terms, its May 1983 publication "France in Space" gives the following breakdown of 1983 funding by objective:

Table 3.

1983 CNES Budget by Discipline

Objective	Amount (MFF)	percent
Sciences	325,700	9.38
Applications	1,735,971	50.02
o telecommunications	439,400	12.66
o earth observation, meteorology, etc.	778,471	22.43
o launch services/equipt.	515,100	14.84
o misc. applications	3,000	0.09
R&D	125,000	3.60
Program support	1,284,475	37.00

Two key trends are evident from these figures: the sharp increases in the French national program (principally related to the SPOT remote sensing program), and the heavy commitment to applications programs, a natural result of the French government's focus on the operational and commercial exploitation of space systems.

Space Commercialization Priorities and Efforts

A number of current programs are at the core of the French commercialization effort.

A. Launch vehicles -- ESA's Ariane launch vehicle program was begun at French initiative, and France contributed 62.5 percent of the required capital for the development of the Ariane 1-3 series; in return, under ESA's industrial participation principles, CNES was made prime contractor for the development effort.

Ariane currently is near the end of the "promotional series" of ten launches. Beginning in 1984, the Ariane 2 and 3 vehicles will become available, and will be operated by the quasi-private company Arianespace, which is energetically marketing their services, together with those of Ariane 4, expected to be available in 1986. The French controlling share

of Arianespace ownership is 59.25 percent, of which CNES alone holds 34 percent. France is also contributing 57.1 percent of the $241 million authorized development cost of Ariane 4. It is anticipated that France will carry a similar share of the cost of developing Ariane 5.

In addition, France operates the launch facility at Kourou, French Guiana, which is the dedicated launch site for the Ariane vehicles. That and other extensive interpenetration between CNES and Arianespace (the Director General of CNES, for example, is also President of Arianespace) underscores the French financial support of and commitment to the successful commercialization of the Ariane vehicle.

B. Communications and broadcast satellites -- CNES is prime contractor to the French PTT for the Telecom I national telecommunications satellite program, which is expected to become operational in 1985. The satellite system will provide C, X and Ku-band services, including digital communications, conventional telephone and video traffic, both within France and with neighboring countries and French overseas territories. The French government points with special pride to the selection of SNIAS (Aerospatiale) as prime contractor for the Arabsat regional communications satellites, citing that contract as the first break in U.S. dominance of the world market.

As already discussed, France and Germany are engaging in parallel development of the TDF-1/TV-Sat direct broadcast satellites, with Aerospatiale and MBB collaborating on the spacecraft proper while Thomson-CSF and AEG Telefunken are responsible for the communications payload. The consortium has already achieved one export success with its selection as prime contractor for the Tele-X DBS system. CNES is also an active participant in ESA's ECS and MARECS programs, and a moving force in the establishment of the EUTELSAT organization to operate the ECS satellites on a commercial basis.

C. Earth observation -- Using a CNES-developed multimission bus, the SPOT satellites, the first of which is scheduled for launch in 1985, will carry high-resolution pointable instruments to acquire multispectral earth resources data with 20m spatial resolution and panchromatic images with 10m resolution. SPOT will be capable of providing stereoscopic images through cross-track viewing. CNES has taken the initiative to establish Spot Image to market SPOT data collected by the French ground station or by direct reception. France is also providing the satellite bus and payload elements for the ESA ERS-1 microwave remote sensing satellite.

D. Materials processing -- Exploration of the potential of the micro-gravity environment has not been a major priority of the French program to date, although France supplied the gradient heating facility for Spacelab-1, and one of the tasks carried out during the first Franco-Soviet manned flight was the production of special alloys involving components of widely varying density which are not miscible on earth.

Government-Industry Relations and Space Commercialization

The French aerospace industry's total capacity is about 50 percent state-owned. SNIAS (Aerospatiale) is the centerpiece of the governmental sector, while Dassault-Bruguet, Engins Matra and Thomson-CSF remain in the private sector. French government space procurements are reserved to French firms.

The unique aspect of the French government's approach to space commercialization is the role that CNES has played since 1973 in the establishment of business organizations to pursue commercial opportunities arising from its space program. The following table, drawn from the French magazine Air et Cosmos, lists these CNES "filiales" (literally, subsidiaries or branches).

Table 4.

CNES's Commercial Subsidiaries

Organization	Founded	Ownership	Capital
Aerospace Remote Sensing Development Organization (GDTA)	7/1973	CNES 20%	--
PROSPACE	7/1974	CNES 12%, France 100%	--
Satel-Conseil	7/1978	CNES 33%, France 100%	--
Arianespace	3/1980	CNES 34%, France 59%	180M FF
Arianespace Inc. (USA)	12/1982	Arianespace 100%	--
Spot Image	7/1982	CNES 39%, France 90%+	25M FF

Spot Image Corp. (USA)	1/1983	Spot Image 100%	--
Intespace	1/1983	CNES 45%, France 100%	6M FF

Some of these organizations are familiar to American readers while others may require some explanation.

Prospace is a groupement d'interet economique (GIE), composed of CNES and 43 French industrial firms active in the space sector. Its objectives are the promotion of its members' products on the world market and the identification of new markets for French space products, through publications, trade missions, participation in space sector trade events, and an information service on current and future business opportunities. It also conducts and publishes market reports and surveys.

GDTA conducts training in remote sensing, distributes satellite data, performs value added data processing and interpretation, and carries out airborne surveys.

Satel-Conseil is an international satellite telecommunications consulting firm, which works closely with French industry in pursuing world market opportunities for space and ground segments.

Spot Image has been formed to carry out the commercial exploitation of the SPOT system through sale of data and value-added products.

Intespace, the newest CNES offshoot, offers environmental test services and facilities for development, qualification and acceptance testing, together with related engineering, design, training and consultant services.

Given the current controversy in the United States over the proposed commercialization of land remote sensing services, the case of Spot Image may deserve a closer review. The SPOT program is divided into two discrete responsibilities -- satellite development, launch and operation are the responsibility of CNES, while Spot Image is responsible for data processing, marketing and distribution on a commercial basis. CNES will provide direct readout services to Spot Image-operated stations, as well as to foreign facilities that have operating agreements with Spot Image/CNES.

CNES holds 39 percent of Spot Image, while Matra (SPOT spacecraft prime contractor) and SEP (the major French spacecraft propulsion firm that also specializes in SPOT/Landsat data reception and processing equipment) each hold 10 percent.

Reportedly, in the next 10 years Spot Image/CNES hopes to recover through the sale of data products and services an estimated $300 million in operating, maintenance and satellite replacement costs. The initial $400 million spent to develop, construct and launch the first satellite and construct the related ground facilities will be written off by the French government as a research and development investment.

The likely key to SPOT's commercial success or failure is the coordinated French government/industry marketing effort, which includes sponsoring SPOT simulation campaigns and workshops, the sale of SPOT/Landsat data receiving and processing equipment and the provision of assistance to developing countries for land remote sensing activities.

Since 1980, GDTA has been conducting simulation missions worldwide to acquaint potential users with SPOT data well in advance of the launch of the first satellite. In concert with these activities and with CNES authorization, SEP has been aggressively marketing SPOT/Landsat ground system hardware and data processing equipment, often with French government financing assistance. Spot Image estimates that approximately 20 facilities worldwide will be receiving SPOT data by 1986.

CNES's Centre de Rectification des Images Spatiales (CRIS) will be responsible for archiving raw SPOT data and producing standard image products. Based on customer requests, Spot Image will order from CRIS the required data which will be reproduced and processed to order. Spot-Image will also maintain a central catalog of data archived and available through both CRIS and foreign ground stations. Under joint agreement with Spot Image and CNES, foreign ground station operators will be granted exclusive rights to receive, process, archive and distribute SPOT data within "zones of commercialization" defined in the agreements. Customers outside these zones, or whose requests are not met by the relevant ground station operator, may order data from Spot-Image. Data will be made available to users on a non-discriminatory basis.

CNES/Spot Image are to receive revenue both from sale of data and from direct readout to foreign ground stations. Under current plans, three separate fees will be charged to foreign ground station operators -- a subscription fee, giving the customer the right to receive SPOT data; a basic program fee, covering a base amount of data to be transmitted from SPOT to the ground station; and a fee for any data request not within the basic program. To protect its commercial rights to SPOT data, CNES/Spot Image have claimed ownership of all copyright interests in SPOT data, regardless of the form in which they are transmitted or used. To date, the claim that SPOT data are copyrightable has only been supported under French law; enforceability in U.S. courts remains to be established.

THE EUROPEAN SPACE AGENCY (ESA)

Much of ESA's role in the commercialization of space has already been discussed in the context of the French and German national programs. By pooling the resources of its member states and allocating industrial participation in its projects on the basis of their contributions, ESA has contributed greatly to the development of space industrial capabilities in Europe. Moreover, its multinational character has provided a matrix for the development of multinational enterprises such as Arianespace, EUMETSAT and EUTELSAT.

Budget Levels and Budget Priorities

The ESA budget largely mirrors and complements those of member state national programs. Some 36 percent of ESA's budget was provided by France and the Federal Republic of Germany in 1982, and this "double-counting" must be taken into account in assessing Europe's total investment in space. The following table gives a sense of the distribution of these funds over time.

Table 5.

ESA Budget Summary (in millions of Accounting Units)*

Line Item	1979	1980	1981	1982
General budget	78.7	75.3	137.7	153.1
Science program	85.5	88.4	95.4	100.4
Earthnet	6.8	4.6	14.8	5.6
Other mandatory programs	37.0	10.3	----	----
Earth observation	36.6	36.2	29.0	35.4
Telecommunications	96.5	124.2	202.7	183.5
Spacelab	136.4	125.5	67.9	63.6
Ariane	159.1	161.1	214.5	134.7

* Figures derived by reconverting US$ figures using official exchange rates. May differ slightly from original ESA figures due to rounding errors.

A. EUTELSAT -- Other than Arianespace, the most significant regional commercialization initiative in Europe, reflecting the transfer of ESA assets to an operational mode, is EUTELSAT. Originally formed under an interim arrangement in 1977, EUTELSAT's Definitive Agreements were signed early in 1983 following negotiations among 24 European countries in mid-1982.

EUTELSAT's largest stockholders are the telecommunications administrations of France, the United Kingdom, Italy and the Federal Republic of Germany. Share allocations are based on projected traffic. Membership on an essentially commercial basis is open to all European countries whose telecommunications administrations are members of the European Council on Posts and Telecommunications (CEPT).

Using the ECS satellites developed by ESA, EUTELSAT will provide government telecommunications services and commercial services, including communications and television program distribution.

B. EUMETSAT -- In March 1983, the 17-nation Intergovernmental Conference on an Operational European Meteorological Programme reached agreement on a 12-year program for European meteorological services. The program established EUMETSAT as the future governing organization for European meteorological satellite services, and authorized ESA, acting in its behalf, to implement a program valued at 400 million AU (US$ 390M). The program includes:

-- procurement of three operational geostationary meteorological satellites, improved versions of ESA's Meteosat;

-- Ariane launch services for the three satellites in May 1987, August 1988 and November 1990;

-- continued operation of Meteosat until launch of the first operational spacecraft; and

-- operation of the three improved spacecraft until the end of the program in November 1995.

CANADA

To a greater degree than those of any other country in this review, Canada's space activities are decentralized. Canadian space program elements are scattered among ten

government departments. In 1980, primary responsibility for coordination of these activities, carried out through an Interdepartmental Committee on Space (ICS) was shifted from the Ministry of Communications to the Ministry of State for Science and Technology. Other primary participants in civil space programs with commercial implications are:

-- the Department of Communications, responsible for satellite communications

-- the National Research Council of Canada, responsible for basic scientific and technological research

-- the Department of Energy, Mines and Resources, which conducts research in remote sensing technology and applications

-- the Department of Fisheries and Environment, responsible for environmental remote sensing; and

-- the Department of Industry, Trade and Commerce, which promotes the development of the Canadian space, electronics and computer industries.

The Canadian program is conditioned by two main thrusts: a focus on satellite telecommunications and remote sensing, areas of activity which meet specific needs resulting from Canada's unique geography and demographics; and an emphasis on developing independent industrial capabilities, flowing from both economic interests and broader Canadian political-economic policies.

A 1968 Canadian government white paper on satellite communications concluded that "a domestic satellite system of even a few channels would make television service in both French and English available to any point in Canada ... sooner, and at a lower cost, than would any other known system of communication."

Given Canadian geography and the sparseness of population over much of its territory, remote sensing, both for environmental monitoring and for resource identification and management, has received considerable emphasis. Canadian efforts have focused particularly on the ground segment, from the standpoint of research interest and as an area in which Canadian industry has developed highly competitive capabilities in world markets.

The role of space in Canadian industrial development is perhaps the most striking element of Canadian space commercialization policy. Telesat Canada and SPAR Aerospace,

in particular, have achieved a high level of independent capability and competitiveness on world markets. This has been the result of a conscious policy, based on the judgment that a domestic space industry could not only meet Canada's requirements for space systems more economically than imports but could also generate significant export earnings and spin-off benefits, both in terms of technological inputs to Canadian industry and as an enhanced image for Canadian non-space products at home and abroad.

Budget Levels and Budget Priority

In December 1981, Canada increased its space budget by one-third to C$476 million, to be spent over the next four years in the following program areas:

Communications	C$103.6 M
Remote sensing	135.7 M
Space science	72.9 M
Technology development	156.1 M

Spending over time (actual and proposed) is given in Table 6.

Table 6.

Canada - Total space program expenditures (C$ millions)

Activity	81/82	82/83	83/84	84/85
Communications	22.8	29.3	32.8	18.7
Remote sensing	26.3	42.2	35.4	31.8
Space science	11.8	19.1	21.1	20.9
Technology development	34.1	44.5	44.8	32.7
ESA relationship	1.7	1.8	1.9	2.1
TOTALS	96.7	136.9	136.0	106.2

Space Commercialization Priorities and Efforts

The Canadian space program is notable for a particularly explicit inclusion, under the goals of individual projects, of industrial/commercial objectives.

A. Satellite broadcasting and communications -- Canada became the first nation to operate a domestic satellite communications system in January 1973 with the commissioning of Anik-A. Anik-B, in 1978, added Ku-band capabilities, which were leased

to the Canadian government for follow-on experiments after the end of the CTS/Hermes project. The first Anik-C and -D satellites were launched in 1982, bringing, respectively, operational Ku-band capabilities and greatly increased C-band capacity to the Telesat system.

Telesat Canada, which owns and operates the Aniks and their associated ground segment, is owned jointly by the Canadian government and the major Canadian telecommunications carriers. The Anik-A through C satellites were procured from Hughes Aircraft, with growing participation by SPAR Aerospace, while SPAR was the prime contractor for Anik-D. The imported content of Anik-A was about 87 percent, but the import content of the Anik-D's will be under 50 percent. In 1982, SPAR won its first international satellite competition to supply two satellites for Brazil's domestic satellite system. Although Hughes is a significant subcontractor, the Canadian share of the Brazilsat contract is about 60 percent.

In addition to domestic communications satellite activity, another significant thrust of Canada's communications satellite activities with great commercial implications is the M-sat program. Intended to provide exurban land mobile communications compatible with existing and planned cellular radio-telephone systems, M-sat began life as a planned government-funded experimental system proposed for development on a cooperative basis between the United States and Canada. This plan was overtaken by rising private-sector interest in providing this service, however, and in November 1983 a Memorandum of Agreement was signed between NASA and the Canadian Department of Communications (DOC) providing for a leading role by private industry in the two countries in supplying orbital capacity to meet the two agencies' needs, while also making capacity available for commercial sale. The eventual market for ground equipment for land mobile satellite service is projected in the billions of dollars, once the orbital capability becomes available. Both agencies are developing plans to engage specific industry participation, and are also awaiting frequency allocations from their governments.

A specialized adjunct of satellite communications is the Search and Rescue Satellite system (SARSAT), in which Canada participates along with the United States and France (the USSR provides a compatible, interoperable system called COSPAS). While the system uses existing emergency beacon transmitters to determine the position of aircraft and ships in distress, a 406-MHz evolution of the system, providing additional data and improved precision to rescuers, may open up a new ground sector market.

In another significant thrust, Canada has also joined ESA's L-Sat program, which is developing a large multipurpose

communications platform to provide FSS and DBS services at Ku-band, a Ka-band payload, and propagation research beacons at 12, 20 and 30 GHz. In exchange for its financial contribution, which accounts for a large part of the increase in the technology development line of the 1981 - 1985 Canadian budget, Canada will supply the solar array for L-Sat, and will support the prime contractor, British Aerospace Ltd., in spacecraft integration and test, using the facilities of DOC's David Florida Laboratory for spacecraft environmental testing.

B. Remote sensing -- As mentioned elsewhere, Canada was an early participant in the Landsat program, and currently operates two ground stations for direct reception of Landsat data. In part as a result of this early start, a Canadian firm is now among the leading contenders in the market for Landsat ground equipment and for upgrades of existing Landsat stations to receive higher-resolution Thematic Mapper data.

As a consequence of its interest in synthetic aperture radar for ice and ocean monitoring, Canada has identified a requirement for an active remote sensing satellite called RADARSAT. The Canadians define the project objectives specifically to include the development of industrial competence in SAR technology; technology development work is underway. Canada is also participating in development of ESA's first remote sensing satellite, ERS-1, scheduled for launch in late 1987. Its share of the ERS-1 effort is in SAR technology development, which will contribute directly to the Radarsat project.

Government - Industry Relations and Space Commercialization

Although Canadian space technology procurements are not limited to Canadian industry, an independent study predicts that Canadian industry will likely continue to receive first-round preferential treatment, as it did in the procurement of Anik-D, the first to be won by a Canadian prime contractor. Accordingly, the next generation of Aniks--three E-types (Ku-band) and two F-types (C-band)--is likely to be built by Canadian industry.

In addition to its role in Telesat Canada, the Canadian Government also owns 97 percent of SPAR Aerospace, the principal Canadian spacecraft manufacturer and maker of the STS Remote Manipulator System (or CANADARM).

JAPAN

Japan's National Space Development Agency (NASDA) was established in 1969 as a "special corporate entity" charged with prime responsibility for implementing "practical applications of space developments." Under this charter, NASDA divides its activities into five basic areas -- Earth

observation, communications and broadcasting, space transportation, space experiments, and basic technology. Interestingly Japan's First Materials Processing Test, a Spacelab payload scheduled for flight aboard the Space Shuttle in 1988, is carried under the space experiment heading, a classification which apparently reflects perception of the mission as a basic scientific investigation rather than an activity with near-term commercial implications.

Budget Levels and Budget Priorities

As indicated in Table 1 above, the overall Japanese space budget has remained essentially level in real terms since 1979, and in the last several years has declined in constant terms. The same is also true of NASDA's budget, which falls under the Japanese government's Science and Technology Agency.

The following table gives a sense of Japanese space budget priorities among the principal agencies involved.

Table 7.

Allocation of Japan's Space Budget (billions of Yen)*

Agency	JFY82	JFY83	JFY84
STA (NASDA)	87.66	87.43	85.74
Min. of Education (Space Sci.)#	12.92	15.18	NA
Min. of Transportation (Metsat operations)	4.54	7.06	NA
Min. of Posts/Telecomm. (DBS, FSS)	1.94	1.59	NA
Min. of Intl. Trade and Industry (remote sensing)	1.40	1.47	NA

* Figures in this table were reconverted from a US$ table. Figures may differ slightly from original Yen amounts due to rounding errors.

Budget for the Institute of Space and Astronautical Sciences (ISAS)

The following table gives a breakdown of NASDA's JFY 83 and 84 budget plan.

Table 8.

The Japanese Space Applications Budget (in billions of Yen)*

Line item	JFY83	JFY84
H-1 launch vehicle	24.47	30.87
BS-2 DBS satellite	6.485	6.742
GMS-3 geostationary metsat	5.086	0.895
MOS-1 marine observation satellite	11.962	11.052
ETS-V engineering test satellite	0.733	2.138
CS-3 domestic communications sat.	0.516	4.062
BS-3 DBS satellite	0.020	0.430
FMPT (Spacelab mission)	1.186	1.687
ERS-1 land observation satellite	1.795	0.854
Large rocket (studies)	0.556	1.347
U.S. space station studies	0.069	0.080

* This breakdown covers only the STA budget under which NASDA is funded; details of other government agency budgets for space applications in 1984 are not yet available, but in 1983 amounted to less than 18 percent of the total. For comparison purposes, an exchange rate of 230 yen/US$1.00 may be assumed.

Space Commercialization Priorities and Efforts

Since its inception, the Japanese space program has emphasized several parallel themes:

-- the development of a Japanese satellite launch capability, initially through the importation of technology but eventually through the maturation of a domestic technological base;

-- the development of meteorological, communications and direct broadcast satellites through teaming between Japanese and U.S. satellite manufacturers, with a gradually increasing Japanese share of the effort leading eventually to an independent Japanese industrial capacity.

-- development of remote sensing technologies, leading eventually to a commercializable program; and

-- basic experimentation in materials processing, zero-G life sciences and space technology.

A. Launch Vehicles -- From its beginnings, NASDA's launch vehicle program has been designed for a gradual transition from reliance on imported hardware and technology to entirely indigenous content. NASDA's first launch vehicle was the

three-stage N-I, based on Thor Delta hardware and technology with an indigenously-developed second stage engine and capable of placing approximately 130 kg. in geostationary orbit. Seven satellites were launched with the N-I from 1975 through 1982. Development of the N-II vehicle began in 1974; although still derived from U.S. Delta technology, the N-II uses domestic versions of the N-I's first stage engine with nine solid strap-ons, both manufactured in Japan. The second stage engine is an upgraded Delta second stage, as is the third stage solid motor, purchased from the United States. The Digital Inertial Guidance System of the N-II was also developed in the United States. There have been five successful N-II launches to date, with another three scheduled by the end of 1986.

Meanwhile, the H-I vehicle, begun in 1975, is expected to become NASDA's main launch vehicle for the last half of the 80's. The Delta-derived vehicle is designed to be capable of delivering 550 kg. to geostationary orbit. The first stage engine will be the same as the N-II, with the domestically-developed LE-5 cryogenic engine in the second stage and a domestically-developed solid third stage motor. Guidance will be provided by a NASDA-developed system. A two-stage test is scheduled for early 1986 and a full-scale test flight by early 1987. In July 1983, the Special Committee for Long-Range Vision of the Space Activities Commission submitted its report to the Commission on directions for the Japanese space program through the remainder of the century. Central in the Committee's recommendations was an ambitious call for the development of the next-generation H-II as a completely indigenous system capable of placing 2000 kg. in geostationary orbit by the early 1990s. Four different candidate configurations were discussed, with both first and second stages fueled by liquid hydrogen and oxygen. The report urges this development, and particularly the completely indigenous design, as a basis for entering the world launch services market, an option presently denied because of governmental agreements with the United States under which Delta technology has been transferred, as well as by the limited payload capability and high unit cost of the current Japanese vehicles.

The total cost of the H-II development is estimated at something comparable to the development of Ariane, or over 1983 US$ 1 billion. It is not reflected in the 1984 NASDA budget summarized above, because the recommendations of the Committee are reportedly still under review, for incorporation in revised space development guidelines to be formulated and released next year. It is not clear how and when it will appear, given conflicting priorities and apparently limited resources available to the Japanese program.

B. Communications and broadcasting satellites -- Since its beginnings in 1972, the Japanese communications satellite program has followed lines somewhat parallel to the launch

vehicle program, including extensive early procurements of foreign technology and an intended transition to entirely indigenous capabilities. A similar pattern has marked the direct broadcast satellite program which began in 1973.

The two spacecraft programs have been conducted in parallel with Japanese prime contractors supported by U.S. spacecraft manufacturers. Mitsubishi Electric Company has been given responsibility for the CS communications satellites (CS-2, CS-2a and CS-2b are currently on orbit, providing C-band and experimental Ka-band service, the first use of the latter band on a spacecraft), with major and slowly-declining technical assistance from Ford Aerospace. The BS series of direct broadcast satellites (the first operational Ku-band DBS satellite, BS-2a, was launched in January 1984), is built by Toshiba with similar assistance from General Electric. Follow-on satellites in each series, sized to fit the H-I vehicle, are scheduled for 1989 and 1990 launch. The Long-Range Vision report recommends large CS-4 and BS-4 satellites to utilize the proposed H-II large launch vehicle. While it is not clear that Japanese industry will be able to meet these objectives with entirely indigenous technology, the Japanese government has emphasized that its fundamental policy requires that these large satellites be procured from domestic contractors.

C. Remote sensing -- NASDA has been operating a Landsat ground station since January 1979, providing coverage of Japan, northeast China, and Korea. In addition, Japan plans an ambitious program of ocean and land remote sensing satellites for the remainder of this decade. The series includes:

> Marine Observation Satellite-1 (MOS-1): 1986 launch to sun-synchronous polar orbit. Multi-spectral CCD radiometer (50m. resolution), visible/thermal IR radiometer, microwave scanning radiometer.
>
> Earth Resources Satellite-1 (ERS-1): 1990 launch proposed to sun-synchronous polar orbit. Design studies began in 1982 and prototyping of instruments is underway. In addition to visible and near-infrared radiometers, primary instrument is to be an L-band synthetic aperture radar, with target resolution of 25 m. x 25 m. over a 75 km. swath width.

Japan has not yet announced any plans for dissemination of data from these satellites beyond experimental evaluation by research institutes and academic institutions. Commercialization seems likely, however, and perhaps as soon as ERS-1; in a recent publication NASDA obliquely stated:

> In the future, the results accumulated with ETS-III [an engineering satellite to evaluate high-power solar arrays, three-axis stabilization systems and active thermal control] and MOS-1, etc., will establish technical expertise that can be exploited in the development of an earth resources observation system. Active cooperation is being sought from domestic manufacturers, national experimental research institutions, and universities...

D. Materials processing and zero-G life sciences -- Since 1979, NASDA has been preparing for the First Materials Processing Test (FMPT), scheduled for early 1988 aboard Spacelab. The name aside, the mission's three-double-rack complement of experiments will include materials processing, life sciences and space technology experiments. Approximately thirty proposals from Japanese research institutes, universities and other institutions have been selected from over 100 submittals.

NASDA has also been conducting materials processing experiments on sounding rockets (six experiments since 1980), and some of the experiments performed have led to follow-on activities planned during FMPT. It is perhaps indicative of NASDA's judgment on the relative maturity of space materials processing that the FMPT mission has slipped from an originally proposed date of 1986 to its present schedule.

E. Technology development -- NASDA freely acknowledges its technological debt to foreign programs, notably that of the United States. At the same time, as mentioned above, Japan intends to reach independence and eventual parity in key space technologies. The ETS series of satellites has been produced domestically with this objective in mind. ETS-V, currently in the design phase and scheduled for launch in 1987 on the H-I full-scale test flight, is intended to establish Japanese understanding of the technologies required for large three-axis stabilized spacecraft, and to conduct mobile satellite communications, navigation and search-and-rescue experiments (with aircraft, with ships and between ships).

Government-Industry Relations and Space Commercialization

The extraordinarily close Japanese government - industry relationship has already been characterized above, both in general and in specific space program contexts. The allocation of government resources to space activites with commercialization potential suggests that this area enjoys a fairly high priority in Japanese economic planning. Investments have not been comparable, however, to those in the computer and terrestrial electronic industries. And, as mentioned above, the Japanese government's response to the ambitious recommendations of the Long-Range Vision report remains to be seen.

CONCLUSION

This survey has not attempted to argue any particular thesis on the directions being taken in space commercialization in the countries reviewed. Nevertheless, it may be useful in conclusion to attempt a few observations about the similarities and differences among the various programs.

All of the national programs surveyed count development of their domestic aerospace industry capabilities as an important motivation for conducting space activities. They see the benefit in terms of import substitution and export earnings, opening markets which until recently were the exclusive preserve of U.S. manufacturers, and in tangible and intangible spin-offs to terrestrial pursuits. Heightened national prestige and a bolstered reputation for high technology, adding luster to more prosaic products, are often-cited benefits from an active space program.

Budgets in all of the programs surveyed are small by comparison with the United States space budget, and their focuses are correspondingly narrower and more specialized. Most have felt, to some degree, the effects of the recent worldwide recession, but are now in a renewed growth phase.

While they vary widely in their budgetary allocations to materials science, none of these foreign programs is making the sort of investments to indicate that a major industrial push has begun. The Japanese and especially the German governments are prepared to make a substantial investment in basic scientific research in materials processing, against the day when commercial prospects emerge, but their industry apparently has not yet been persuaded of near-term profit potential worth investing significant amounts of private capital.

On the other hand, France and Japan are making major launch vehicle investments, determined to compete for the world markets for launch services, and all are investing substantially in communications satellite development.

To sum up, thinking on space commercialization in other countries, at least as reflected in their program plans and decisions, appears to be running generally parallel with that in the United States. As they see it, a few fields are here today, but the promise of most remains more tantalizing than real. The next decade or two will tell how much of the promise will be realized, and by whom.