Japanese-U.S. Space Policy Issues: Communications Satellite and Launch Vehicle Technology

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EXECUTIVE SUMMARY

In April 1985, Japan reversed its policy prohibiting the purchase of foreign-made satellites. This policy was intended to protect Japan's infant space industry from already mature foreign competitors, and to help the space industry stand on its own through the acquisition of technology.

— As desired, this policy has allowed Japan's National Space Development Agency, NASDA, to grow steadily and to acquire satellite technology. But it has also prevented potential business users from acquiring satellite operations experience. Estimates put Japan 10 to 15 years behind the U.S. in communications satellite applications.

-- Japanese satellites are not competitive in level of sophistication or cost-efficiency with state-of-the-art satellites built in the U.S.; they rely on technology transfer which is outdated unless sealed in "black-box" form. The Japanese try to avoid "black-box" technology transfers because they contribute virtually nothing to the learning process or to independence from foreign technology.

-- Japan's communications satellite needs are limited by the country's demographic features and industrial geography. Most of the Japanese population lives roughly along the Shinkansen line from Tokyo-Yokohama to Fukuoka in Kyushu, as most major industrial cities lie between. Optical fiber trunk lines may therefore best serve much of Japan's private-sector telecommunications needs.

-- Japan's industrial strength is in large-volume mass manufacture. This is well-suited to optical fiber production, construction of satellite ground stations, and the sophisticated electronics necessary for ground station operation. American companies are stronger in the specialized skills and expertise required to build satellites themselves.

-- In the near future the U.S. can expect to retain its lead in communications satellites. If Japan maintains its emphasis on micro-electronic miniaturization, it may be able to develop lower-end satellites more suited to Japan's needs than American "Cadillac-types." By the mid-1990s, NASDA is scheduled to have a domestically designed and built launch vehicle, the "H-II", capable of putting two-ton satellites into geostationary orbit. The H-II should give the Japanese ultimate decision-making power over their satellites' access to useful orbits.

-- Barring heavy subsidation, however, the H-II will be less flexible in accommodating near-future launch dates, and more expensive than the space shuttle and European and American boosters.

FOREWORD

This paper lays out the history of the development of Japanese capabilities in satellites, especially communications satellites, and launch vehicles. It concentrates on the larger of the two Japanese space groups, the National Space Development Agency (NASDA), which coordinates the country's applications space program. It also describes the goal that the Japanese government has followed to date: To develop, without foreign assistance, a capability in both satellites and launchers which is sufficiently strong to enable Japan to be an independent space power. Toward this end, the Japanese government has protected its space industry by refusing to permit purchases of foreign-made satellites. At the same time, Japan's Nippon Telegraph and Telephone Public Corporation (NTT) has held a monopoly on all telecommunications services, including any communications services by satellite. Since the cut-off date for the data base of this paper in fall 1984, several important events directly relevant to Japan's space policy have occurred. On April 1, 1985, Japan's Telecommunications Business Law took effect. On the same date, Nippon Telegraph and Telephone Public Corporation was "privatized" as the NTT Corporation. The Telecommunications Business Law permits competition in common carrier services, including satellites, as well as in optical fiber lines, microwave, and leased line services.

During the two-month period immediately following the opening of Japan's new competitive telecommunications era, joint ventures involving several of the largest Japanese trading companies and other firms were announced, with plans for 1987-88 orbits of several American-built communications satellites, using either Ariane or U.S. shuttle launches. C. Itoh & Co. teamed up with Mitsui & Co. and the Hughes Communications subsidiary of General Motors' Hughes Aircraft division, in a joint venture to orbit a pair of Hughes-built communications satellites. Japan Communications Satellite Co. tentatively plans to orbit "HS 393" model satellites with all K_u-band services in December 1987 and April 1988. Mitsubishi Corp. (trading company) and Mitsubishi Electric have formed the Space Communications Corp., a joint venture which seeks to launch two "improved INTELSAT-5B" satellites in February and November 1988. This pair of satellites will have K_u- and K_a-band transponders. These satellite-service joint ventures are seeking customers both within their traditional business families (the Mitsubishi group, the Mitsui group, etc.) as well as with outside companies.

In early 1985, an agreement on Japanese participation in the U.S. manned space station program was signed by representatives of the Japanese Science and Technology Agency and the U.S. National Aeronautics and Space Administration (NASA). This agreement and American efforts to open a broad range of protected Japanese industries to outside trade have exerted further pressure for competition.

The foreign orbiting of American-built communications satellites by Japanese business entities at least partially threatens the Japanese government-subsidized space technology development of NASDA. It reverses the Japanese policy of maintaining a totally protected space industry. With the Japanese space industry already lagging behind the American industry by 10 to 15 years, and in light of the limited funds available for space activities, it remains to be seen whether Japan will be able to maintain the goal of space independence.

Oswald H. Ganley

1. Background and Issues

More than two dozen satellites have been launched into orbit from the two Japanese launch sites, both in Kagoshima prefecture. Yet despite this record, Japanese private companies are only now evaluating their needs for communications satellites. Although American users of communications satellites have already begun competitive commercial service, the Japanese are lagging behind and are only now defining communications satellites' role in the Japanese telecommunications picture. Since Japanese companies are competitive in many fields of electronics and the nation possesses the world's second largest GNP, it is surprising that the Japanese are not farther along in communications satellite technology and services.

In the United States and many other advanced nations, communications satellites and newly emerging optical fiber line technology provide the means to convey large volumes of information efficiently. This technology is available to large corporations and to vast numbers of private citizens. But in Japan, where there has been no history of competition among common carriers, the user side of communications satellites has been slow to develop since potential private users have been prohibited from buying communications satellites. The prohibition, soon to be abolished, was intended to stimulate the nation's applications-oriented space agency, the National Space Development Agency of Japan (NASDA), and to protect Japan from foreign competition in the form of "imported" communications satellites.

NASDA was able to grow at a steady pace while gradually assimilating transferred American and other communications satellite technology. But such protection has discouraged, and indeed prohibited, the nation's dynamic business sector from gaining experience in communications satellites.

Mr. Hiroshi Tachibana, a high-ranking official in Keidanren (Federation of Economic Organizations), was quoted in the Asian Wall Street Journal of Hong Kong as saying that Japan is almost a decade behind the U.S. in the commercial use of communications satellites by industrial organizations.[1] Discussing general opinion of the Japanese telecommunications service sector, including communications satellites, Dr. Sachio Senmoto,* executive managing director of Daini Denden, Inc., remarked in June 1984 that Japan lags behind the U.S. by about 15 years in application of this advanced technology.[2]

Although potential corporate users in the information processing and telecommunications industries have not always agreed with the free-market-restricting policies of space development in Japan, they have only quite recently voiced their opinions (largely behind the scenes) in favor of a "partially open sky."

In 1970, Japan became the fourth country successfully to orbit a satellite, and in 1977 the third to launch a geostationary satellite.[3] Presently NASDA, with a budget of just over half a billion dollars a year, relies upon American technical assistance in rocketry and satellite technology, as well as in some support systems, and in

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* Dr. Senmoto, a former executive of Nippon Telegraph and Telephone Public Corporation (NTT), is currently working for one of its first major competitors.

particular upon assistance in communications and broadcasting satellite technology.* Technical assistance from American rocketry and satellite companies has been conducted through governmental channels under terms of a bilateral space agreement of 1969. The agreement restricts technology permitted to be transferred to Thor Delta systems which are far from state-of-the-art in nature. The transfer of sensitive technology, under U.S. law, must be approved by the Department of State's Office of Munitions Control (OMC), and some sophisticated technology sought by the Japanese has been denied. Under terms of the agreement the Japanese are limited to peaceful uses of space, and cannot use their American-based rockets to boost third country satellites (without the consent of the U.S.). There has been a strong reliance of Japanese space companies on leading American counterparts. But Japan's reliance upon American partners is diminishing.

The relatively expensive policy of promoting the acquisition of space applications technology has meant that Japanese-contracted satellites, such as the Communications Satellite-2a, are not as sophisticated or cost-efficient as state-of-the-art satellites built in the U.S. This is so because the technology transfer is limited to

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* Some examples of American assistance received by the Japanese in support systems include: 1) the thermal vacuum space simulation chamber for satellite tests at the Tsukuba Space Center, which was built with the technical assistance of specialists from NASA's Jet Propulsion Laboratory; 2) the proven architecture of the mobile service tower (MST) of Cape Canaveral's Thor Delta type tower for NASDA'S Osaki launch site's N-series tower, transferred from NASA to Kawasaki Heavy Industries (with some Japanese modifications); and 3) TRW's "Mission Analysis and Trajectory Simulation" (MATS) software system which was converted by TRW for use on a Japanese Fujitsu "Facom" computer at the Tsukuba Space Center. Normally this MATS system is used on an American Control Data Corp. (CDC) computer.[4]

somewhat dated equipment, unless the technology is sealed in closed packages known as "black boxes."

The Japanese government, through the Science and Technology Agency (STA), has concentrated upon hardware development (such as components of communications satellites) nearly to the exclusion of the commercial operations side. There has been no parallel policy of promoting independent commercial use of the hardware. Instead, government agency uses have been the focus of experiments in the technology. Electronics companies, trading houses, banks and other firms have participated in communications satellite services only within the confines of the protected and slow-moving government scheme.

While the government groups -- mainly NASDA and Nippon Telegraph and Telephone Public Corporation (NTT)* -- were overseeing the building and testing of experimental communications satellites, the private sector was for the most part excluded. Until April 1985, the private sector is prohibited from purchasing foreign-made satellites for its own use, according to a policy mandate of the governmental Space Activities Commission (1978). Thus the so-called governmental "space development" plan has largely undermined the very reason for communications satellites in the business sector of the free world: for commercial groups to use them.

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* Name prior to April 1985. After that date it is called Nippon Telegraph and Telephone Corporation.

In a speech given in February 1984, Kenneth W. Dam, U.S. Deputy Secretary of State, remarked that despite a renewal of an agreement with NTT to permit purchases of American equipment, the U.S. remains concerned:

> about the Japanese government's restrictive procurement policy on satellites -- a policy that prohibits Japanese end users from purchasing superior U.S. communications satellites.[5]

This statement, made directly prior to the agreement by the Ministry of Posts and Telecommunications (MPT), and other ministries, to permit the government and private sector to purchase foreign-built satellites, illustrated the extent of high-level American concern that once again a Japanese "infant industry" would remain protected at home and isolated from the competitive forces of the international marketplace. Such protection, of course, has allowed Japan to enjoy a tremendous bilateral trade surplus in telecommunications equipment with the U.S.

American assistance to NASDA, on a corporate level, is intended as a way of eventually making Japan independent in satellite communications technology. By the mid-1990s, the quasi-governmental NASDA, part of the ministerial-level Science and Technology Agency, is scheduled to possess its own domestically designed and built rocket, the "H-II," capable of launching two-ton satellites into geostationary earth orbit.[6]

In Tokyo there is not a consensus that the H-II is a desirable project. Indeed, some high-level government officials have privately said that the H-II will needlessly compete with Europe's advanced Ariane expendable booster and the U.S. space shuttle, and perhaps create political and economic international friction. Nevertheless, the H-II will give the Japanese the power of ultimate decision making over launching satellites into "useful" orbits. As in microelectronics and computer technology, space is an area in which the Japanese seek economic and technical autonomy. They simply don't want to rely upon other nations, because the international political scene may change and allow nations more advanced in rocketry to deny them access to geostationary earth orbits -- those most useful for communications and meteorological satellites -- or to low-earth orbits (LEO) for reconnaissance satellites.

Will the Japanese be capable of developing and marketing their own competitive launch vehicle, as the Europeans have, within the next decade? Or will they build a booster which is still too small to compete against the European Ariane, the shuttle, and American expendable boosters? Can the Japanese become competitive in space systems, either in satellite technology or in ground support systems, receivers for the U.S. Department of Defense "Global Positioning System" NAVSATs, and software? Conversely, will the Japanese private and government users become reliant upon foreign-made satellites once the "partially open sky" policy goes into effect? What will the new role of NASDA be when private companies and government agenices are allowed to purchase higher quality and less expensive satellites outside of the current NASDA-guarded monopoly structure? Will Japan be left behind when American companies deploy large unfurlable antenna units from space shuttles? With the growing need for communications in the Far East, in such economically advanced countries as Singapore, Taiwan, the Republic of Korea, the colony of Hong Kong, and emerging markets such as China, will Japan become a space power providing communications services to the region? How will communications satellites fit into Japan's fully digitized new telecommunications infrastructure known as the

"Information Network System," which is currently being designed and built? Can competition among Japanese corporations, through the purchase and operation of communications satellites, promote the domestic satellite-building industry?

Some sophisticated Japanese commentators, including Dr. Michio Nagai (former minister of Education, Science and Culture, and presently affiliated with the United Nations University) are quite skeptical about their nation's ability to compete in space. Dr. Nagai is optimistic about Japan's chances to compete in biotechnology, a field in which the U.S. and some European nations possess a lead, but he has singled out telecommunications satellites and other space-related fields as areas in which Japan cannot effectively compete. Not all senior-level Japanese industrial and cultural leaders agree with Dr. Nagai, but many are less than fully optimistic.[7]

The Japanese have yet to answer the major questions about their space communications policy. They are at a watershed. Either they pursue the new technology, or the Americans, the Canadians and the Europeans will leave them behind.

The Japanese are confident that they can develop some of their own launch vehicles. The Institute of Space and Astronautical Science (ISAS) has orbited more than a dozen small satellites with its solid fuel boosters. In 1985, ISAS is scheduled to put the nation's first deep-space missions (MS-T5 and Planet-A) into sun-centered orbits to collect information about Halley's Comet the following year.[8] ISAS, part of the Ministry of Education, Science and Culture (Mombusho), provides a model of purely Japanese-developed space-bound success, and its record makes NASDA's large-scale H-II project appear far from unrealistic. The history of ISAS should serve as an incentive for NASDA's long-term objective of establishing its own in-house technologies to be built by leading Japanese space firms. Six Japanese companies receive a large portion of NASDA's annual budget, which they use to purchase American assistance and develop their own systems. The technologies NASDA is presently nurturing, which revolve around liquid fuel rocket engines, inertial guidance systems, satellite three-axis control systems, and other sophisticated applications-oriented components, require more time and resources than the science-oriented technologies of ISAS. Hence, NASDA's annual budget is approximately 10 times as large as that of ISAS.

Professors of the autonomous ISAS group have trained some NASDA specialists and many persons in space business divisions of Japan's large corporations. Notably, the key cryogenic rocketry technology in NASDA's H-I (to be further enhanced in the H-II) was first proposed by ISAS professors. They later helped NASDA with that agency's 10.5-ton thrust "LE-5" cryogenic engine project which will serve as the second-stage rocket engine of the H-I.[9]

Although ISAS's technologies are modest, they are nevertheless of their own making. ISAS built its rocketry systems from very small pencil-size test rockets on up. Thus ISAS has near-independent decision-making power within its ministerial setting, and this is something NASDA covets.

At present, the U.S. is helping Japan to accelerate its learning process in rocketry manufacturing technology, and this enables the Japanese to focus their efforts on the building of domestically designed parts. The Japanese want to obtain their own technical capability in "black box" areas, not only in rocketry, such as inertial guidance systems, but also in satellites, such as three-axis control stabilization systems.

Japanese experts feel slightly threatened that under the provisions of the "black box" sales system some key technologies are hidden from their inspection. These "sealed box" technologies are typically installed by American workers and according to bilateral agreements guarding military-sensitive systems -- such as inertial guidance, which can be used for ICBMs -- the Japanese cannot look inside. NASDA and private companies are attempting to reduce and eventually to eliminate this dependence upon "black box" technologies. The Japanese fear that such dependence could result in whole projects grinding to a halt if a sensitive technology transfer is stopped.

An example of "black box" dependence was "three-axis control" for spacecraft in-orbit stabilization. Toshiba was not permitted to learn about the internal workings of this system from its traditional partner, General Electric. But the U.S. is not the sole source of this system, and thus the Japanese acquired the knowledge from a more willing source, the Federal Republic of Germany. NASDA's Marine Observation Satellite-1 (MOS-1), which has a shared-parts procurement plan among the three major domestic firms (with prime contracting duties conducted by NEC Corp.), will feature a three-axis control stabilization system of Messerschmitt-Boelkow-Blohm (MBB).[10] Significantly this system is not supplied direct from MBB. Instead it is transferred through Mitsubishi Electric, so that Mitsubishi Electric's engineers can acquire a working knowledge of it.

The goal of overcoming "black box" barriers illustrates the point that the Japanese would like to do almost everything themselves. Even though their volume of business cannot support this policy without large-scale government subsidies, they are striving to eliminate all reliance on others for satellite and rocketry technology.

Since the beginning of NASDA in 1969, the focus of the government space applications program has been on the development of satellites and launch vehicles. But unlike the U.S., Japan has not been able to cultivate private ventures in space businesses. Thus far, Japan's corporate expertise in space ground system technology (including big support systems on Tanegashima Island -- site of the Tanegashima Space Center -- and at the Tsukuba Space Center) has been used chiefly to develop supporting equipment for satellites planned by the government. This includes the Yamaguchi and Ibaraki INTELSAT stations, which offer support mechanisms for KDD (Kokusai Denshin Denwa) space services and expertise.

So long as Japan's space technology is kept alive merely by government funds, the commercial sector -- equivalent to RCA, Satellite Business Systems and Hughes Communications in the U.S. -- will find it difficult to initiate services. When such private-sector satellite companies do come into being they may well choose to launch elsewhere. Because European and American boosters and the American shuttle services are conducted in much larger volume, they will be less expensive than the H-II launcher (barring heavy Japanese subsidies).

Dr. Taro Nakayama, an influential member of Japanese parliament, was quoted in 1982 in a magazine of Japan's Science and Technology Agency as saying: "In this new era of space development, existing

Japanese space development projects appear rather alienated from reality."[11] This statement, made when Dr. Nakayama was a member of the Japanese House of Councillors (he was also the chairman of the Special Committee on Space Development of the ruling Liberal Democratic Party's Policy Affairs Research Council), illustrates high-level skepticism about NASDA's launch vehicle development schedule in existence immediately before the discontinuation of the H-Ib (800 kilogram class payload to geostationary earth orbit) and the adaption of the H-II-type plan. At about the time that Dr. Nakayama made this comment, his personal secretary asked to interview the author, so presumably Dr. Nakayama has surveyed a variety of people for information and opinions.

Despite the larger volume of satellite launches by the American firms, some specialists believe that the Japanese may be capable of catching up with Americans in at least some areas of technology. Most American specialists who directly deal with the Japanese program expect that their companies will always remain one step ahead, but there are some who are not so confident.

The Japanese are eager to obtain independence in space technology because they know all too well that outside nations can curtail Japanese aerospace activities. During the occupation of Japan from 1945-1952, Douglas MacArthur's administration prohibited aeronautical studies.[12] Engineers who had designed "Zero" fighters and other highly respected aircraft could not return to their field of expertise for many years.[13] Top policymakers have not forgotten those days.

Another important consideration of the shared mind set is that Japan is a densely populated island, much of it mountainous. Japan's days as an imperial power on land may be over, but Professor T. Obayashi of ISAS (chief investigator of "Space Experiments with Particle Accelerators" flown in the Spacelab 1 mission) frequently talks and writes on the subject of space colonies.[14] While Professor Obayashi's "space colony" ideas, along the lines of those proposed by Gerald K. O'Neill of Princeton University, are not officially supported, they are considered part of the national space community mind set and long-range dreams. Conventional rocketry is therefore just the first step.

Space specialists in Tokyo are acutely aware that the military satellite schedule of the U.S. space shuttle program can easily disrupt launch dates of both international and American satellites. According to a number of specialists, the Japanese therefore cannot afford to rely upon the shuttle. Nor do the Japanese feel that they can rely on the European Ariane launch vehicle. Although the term "targeting" appears to be over-used to portray Japanese acquisitions of technology, it is an appropriate description of the national strategy of space development. "Targeting" is most often used in connection with the activities of the Ministry of International Trade and Industry (MITI), but the term also applies to the policies of the Science and Technology Agency (STA).

In Tokyo it is no secret that some influential politicians want Japanese "defensive" reconnaissance satellites to collect information about the Soviets. This goal and a general build-up of the Self-Defense Forces are part of the underlying military motivation to strengthen Japanese space development.[15] While these military justifications are not officially cited in official documents about the "purely peaceful" efforts of NASDA, some parliamentary members are quite intrigued by the concept of spy satellites. However, commercial justifications are given as the major reasons for Japan's expensive space technology acquisition plan, rather than national security.

Two of the Self-Defense Force units, those of Ground (GSDF) and Air (ASDF), plan to begin joint analyses of data sent by the U.S. earth observation LANDSAT-type satellites, within the 1984 fiscal year (ending March 31, 1985).[16] LANDSAT data, which is public domain information, is currently being received and analyzed at NASDA's Earth Observation Center at Hatoyama town, Saitama Prefecture, located 50 kilometers northwest of Tokyo. The Center has been in operation since 1979, and receives data under terms of a government-to-government agreement.

The two forces within the Japan Defense Agency (JDA) are probably beginning to use this information, which covers an area around Tokyo that is 4000 kilometers in diameter, to learn how to examine satellite data so that they can conduct larger-scale operations in the near future. The territory surveyed would include Vladivostok (the site of a large Soviet submarine base), other defense-sensitive parts of the Soviet Union, such as Sakhalin Island and Kamchatka, some of China, and the Korean peninsula. The Maritime Self-Defense Force (MSDF) is apparently considering participation in the shared-information analysis of its brother armed forces.

The Japan Defense Agency has requested approximately $700 thousand for its 1985 fiscal year budget to permit the Maritime Self-Defense Force to equip five destroyers with reception devices to pick up signals from U.S. Navy FLEETSATCOM satellites. According to the Asahi Shimbun, which is critical of this development, the JDA did not consult with the Science and Technology Agency concerning an alleged possible contravention of the National Space Development Law of 1969 which allows only peaceful-use space applications.[17]

The large Japanese computer firms, including Fujitsu, Hitachi and NEC Corp., have become quite interested in developing both hardware and software for satellite data analysis. NEC Corp., which unlike Fujitsu and Hitachi does not build IBM-compatible machines, boasts of an innovative non-von-Neumann ultra high-speed computer which is used for LANDSAT data processing. This computer processes satellite-derived data at the Remote Sensing Technology Center of Japan, a processing and distribution center in Tokyo.[18] In any event, the Japanese are becoming increasingly interested in remote-sensing capabilities and by 1986 will be operating their own Marine Observation Satellite-1.

2. Communications Satellite and Optical Fiber Needs of Japan: Partially a Function of Geography and Production Preferences

Unlike the U.S., Canada, or Indonesia, the land area of Japan is quite small. Most of the Japanese population is situated on the Pacific coastline, roughly along the Shinkansen (bullet train) lines from Sendai to Tokyo-Yokohama to Fukuoka in Kyushu, with the major industrial cities of Nagoya, Osaka, Hiroshima, and Kitakyushu in between. Much of the domestic communications of Japan travel along this straight line.

NTT is an enthusiastic supporter of optical fiber technology, and indeed it appears that optical fiber trunk lines can best serve many of the telecommunications needs of both private companies and the Japanese public. Certain telecommunications services, such as simultaneous high-speed business information conveyed to large numbers of dispersed sites, can best be accomplished by communications satellites. Nevertheless, the predominantly "linear" demographic and industrial geography of Japan makes optical fiber lines suitable for many new telecommunications services. There may even be a competition with the new NTT in Type I services.[1] Reportedly, the president of NTT, Dr. Hisashi Shinto, welcomes competition.[2]

The big Japanese cable makers, Sumitomo Electric, Furukawa, and Fujikura, are proud of their optical fiber manufacturing process called "vapor-phase axial deposition" (VAD). They claim it is an improvement over Corning Glass "modified chemical vapor deposition" (MCVD) process. Producers of related electronic parts, including NEC Corp., Fujitsu, and Hitachi, view optical fiber as a major growth industry both at home and abroad.

The Japanese are highly enthusiastic about communications via optical fibers.[3] The mass-manufacturing of optical fibers seems to lend itself to traditional Japanese skills, while satellite manufacturing, involving small numbers of customized products with a good deal of software backing, is somewhat less compatible. Moreover, NTT's Electrical Communication Laboratories are devoting considerable resources to optical fiber studies.

Many of the original patents in optical fiber line manufacturing techniques are held by Corning Glass. A complaint filed by Corning Glass before the U.S. International Trade Commission (ITC) seeks to close the vast U.S. commercial market to Japanese optical line sales, on the basis of alleged patent infringements. Nevertheless, Japan's optical fiber industry, including optoelectronics, has attained such a high level of sophistication that a Pentagon group has put optical fiber technology on its list of five Japanese technologies sought under a military transfer agreement.[4]

Commercial sales of Japanese-built earth stations for satellite communications are not hindered within the U.S. market by the same legal disputes as are optical fiber lines. Ground stations and related equipment for INTELSAT access operations are built for its 100-plus member nations by a small number of advanced companies, and Mitsubishi Electric and NEC Corp. are among the most competitive. The U.S. signatory for INTELSAT, Communications Satellite Corp., formed a corporate connection with Mitsubishi Electric (through its COMSAT Technology Products, Inc. manufacturing subsidiary) for the building of K_u-band earth stations to be sold in the U.S. market. This agreement, concluded in September 1984, calls for Mitsubishi Electric to supply a number of parts, including amplifiers utilizing gallium arsenide (GaAs) microelectronics technology, and COMSAT to perform final assembly and marketing. The K_u-band satellite utilization market is expected to grow rapidly in the coming years within the U.S., and will soon emerge in Japan as well.[5]

Japanese internally developed technology in gallium arsenide microelectronics is another of the five items sought by the U.S. Department of Defense under terms of a technology transfer agreement.[6]

A stroll through the Yokohama plant of NEC reveals dozens of signs with names of countries from Algeria to the U.S. displayed in areas where microwave or satellite ground station electronics equipment is being assembled. I took particular notice of the sign labeled "Algeria" during a tour of this NEC Corp. plant in late July 1984, because a mid-July issue of Aviation Week & Space Technology had mentioned that the U.S. Export-Import Bank was in the process of assisting Scientific-Atlanta, Inc. to compete on an equal footing against a Japanese company in bidding to sell satellite communications network equipment to Algeria's State Telecommunications Administration. The New York-based aerospace magazine stressed in bold print the charge of the Export-Import Bank staff that the Japanese are attempting to acquire the multi-million dollar contract with the help of official development assistance (ODA) funds.[7] Although I asked specific questions in Tokyo about the practice of financing such satellite ground station sales with ODA funds, officials in electronics companies and banks apparently did not have the slightest idea about this sort of thing: They would not answer the questions. In the 1960s Mitsubishi Electric had connections with TRW, and NEC with Hughes Aircraft, in the specific arena of satellite ground station technology, according to Mr. Nobuyuki Arino, executive managing director of TRW Overseas in Tokyo.

Ground stations have tended to become smaller and satellites themselves have grown larger and increasingly powerful. The Japanese are gaining operational experience with their K_a-band transponders of the CS-2 series satellites, and they appear to be favorably positioned to expand their overseas market in K_a-band space station equipment, which may become popular in the 1990s (after saturation of C- and K_u-band frequencies). The Japanese domestic small dish antenna industry has already geared up as more than a dozen firms now offer dish antennas which are .6 meter to 1.2 meters in diameter for K_u-band services of the NHK broadcasting satellite "Yuri-2a." Since Japanese firms are able to produce such ground station equipment quite competitively, this component of the satellite system would seem to be a lucrative business for the major Japanese integrated electronics companies.

The satellite itself represents only one part of the satellite system, a part in which the Japanese do not currently possess technical strength. While American companies, such as Hughes Aircraft, RCA Astro Electronics, and Ford Aerospace, have advanced in state-of-the-art communications satellite technology as they competed to gain the next big contract from the Department of Defense, or from INTELSAT, COMSAT and other companies, Japan's development has followed a more sheltered course. Because NASDA/NTT, their single client, orders such a small number of small-capacity communications satellites, aspiring Japanese satellite makers (mainly Mitsubishi Electric and NEC Corp.) have not been capable of reaching the technical level of their comparatively high-volume American counterparts.

In contrast to the intense competition among many firms in the U.S., Japan has only two main bidders (Mitsubishi Electric and NEC Corp.) for communications satellite contracts. The three major applications satellite contract arenas (communications, broadcasting, and meteorological), have been apportioned among the three large firms, Mitsubishi Electric, Toshiba, and NEC Corp., up to the level of CS-3, BS-3, and GMS-3/GMS-4, respectively. This was apparently done by a gentlemen's agreement at the beginning of NASDA's self-development program. If this is true, it means that competition for most of the NASDA-ordered satellites has been "protected." These three firms do, however, scramble to obtain contracts for the Engineering Test Satellite (ETS) series and others, including the Marine Observation Satellite-1 (MOS-1).

In the new liberalized environment in which Japanese firms apparently will be able to freely purchase satellites, large American-built satellites could likely fit in well with a domestic Japanese system. Many of the ground-based electronics components could therefore be made domestically.

Optical fiber and satellite ground station technology will influence Japanese communications satellite options and decisions. For example, decisions by NTT or other government actors, including MITI, aimed at cultivating the domestic optical fiber industry could discourage Japanese corporations from purchasing communications satellites. Japan's optical fiber industry, including the manufacture of glass strands and the supporting electronics equipment, is at world-class level. It thus makes sense to continue to nurture the industry -- through NTT procurement policies, for example -- to encourage greater exporting. Traditionally, the Japanese are quite comfortable with mass-manufacturing industries, such as production of memory semiconductors or consumer appliances. Optical fiber manufacturing and production involving satellite ground stations essentially fit into the mass-manufacturing category, while the satellites themselves do not.

3. Public and Private Issues of Japanese-Used Communications Satellites

Japanese companies, including the soon-to-be restructured NTT Public Corporation, may choose to utilize communications satellites after legislative changes permit them to do so. By ordering the least expensive satellites on a per-transponder basis they can reduce systems costs to become or remain competitive. Communications satellites will comprise one of the most sizeable categories of general spacecraft (including scientific, meteorological, LANDSAT-type), to be used by the Japanese. Since Japan's government-sponsored program of launch vehicle development is relatively expensive, those who are concerned with development costs would like to see as many satellites as possible launched by domestic boosters. This would support the national rocket-building program both financially and spiritually.

Unlike the U.S., where different viewpoints are voiced openly, the Japanese tend to disagree only in private, at organizations such as Keidanren. The debate over satellites has largely taken place behind the scenes.

At least two such insiders' debates have been reported to occur in Tokyo, although both have been downplayed by those involved. The first major debate concerned NTT as the "private" or "free market" advocate and the Science and Technology Agency (STA), which is the parent industry of NASDA, as the guardian of the country's projected space development policy. The second reported debate involved two groups within Keidanren: the Data Processing Council, chaired by Daiyu Kobayashi, chairman of Fujitsu, which advocated unrestricted purchases of communications satellites and use of such foreign launchers as the shuttle and Ariane, and the Space Development Promotion Committee, chaired by Koji Kobayashi, chairman of NEC Corp., which stressed the need for domestic development.[1] The Data Processing Council is said to have suggested that outside purchases and launches be permitted if so desired by firms potentially interested in the field.[2] It should be noted that NEC Corp. builds most of the nation's satellites, including all of the ISAS scientific satellites, and that Fujitsu, as the largest domestic computer company, would have much to gain in related sales from a free satellite market.

This "debate" was reported in the main business and popular newspapers, which led observers to believe that there was a strong disagreement between the two corporate chairmen. In fact there was no such active debate because, according to Mr. Takaji Kuroda, general manager of NEC's Space Development Division, NEC Corp. chairman Koji Kobayashi believes that international cooperation must be promoted in Japanese space projects. Keidanren insiders support this view as well. Mr. Kuroda says that eager Japanese journalists engaged in deliberate sensationalism, and he reports that some of the Japanese newspapers later corrected their inaccuracies. But the damage was done, and many observers were led to believe that the "free-versus-closed" market debate actually occurred. (NEC Corp., which contributed sophisticated electronics components to the Hughes-built INTELSAT-IV and INTELSAT-IVA series and is currently contributing to the Hughes-built INTELSAT-VI series, would have much to lose in international satellite contracts if it officially supported a highly nationalistic domestic satellite procurement program, and then were to suffer from direct American reprisals.)

The first debate, transpiring during 1981 and early 1982, centered around the ambitious plans for large communications satellites as integrated parts of NTT's Information Network System infrastructure. There was a perception on the part of the Ministry of Posts and Telecommunications (MPT) and NTT that NASDA's gradual launch vehicle development program would culminate in boosters by the mid 1990s which would be too small to orbit their proposed big satellites. NASDA was expected to develop the "H-IA" launch vehicle (550 kilograms into geostationary earth orbit) by 1986, tentatively to be followed by a so-called "H-IB" launch vehicle (800-850 kilograms into geostationary earth orbit) during the early 1990s.[3] NTT had been talking about INS satellites of up to four tons.[4] Uninvolved parties have reported that this talk was essentially motivated by a wish to increase NTT's bargaining power relative to the STA. The Japan Economic Journal reported a high-ranking STA official as saying, "It's a complete mystery to us why NTT needs 4-ton satellites."[5] Without NTT's ambitions for large satellites, there would have been no tangible organizational actor outside of the STA to lobby for a larger launch vehicle and thus give NASDA the additional responsibilities it has wanted.

The CS-4 series or equivalent satellites are expected to take a quantum leap in technology over the CS-3 level (6,000 circuits). Indeed, it is said that the fourth generation NTT satellites will have at least 100,000 circuits. Such large satellites would need large-capacity boosters or shuttle launches. As early as the spring of 1981, NTT was considering outside launches for its proposed large satellites of the 1990s if NASDA could not meet their needs. And it appeared that NASDA could not possibly meet them.[6]

The MPT and NTT are not intrinsically interested in domestic mastery of launch vehicles. They simply want to have their satellites put into orbit, and would as soon have it done at low cost on the competitive market as at high cost to subsidize the national launch vehicle program.

The STA and NASDA, on the other hand, do not want to lose captive customers. It would be safe to say that the STA would prefer not to see any external launches of Japanese government-associated satellites past the start of the N-II phase. The Delta launches from Florida of three satellites fabricated in the U.S. during 1977-1978 were a planned deviation from the STA-guided national space development, since the three satellites were all of the 350-kilogram class (N-II size satellites) and could not be accommodated by NASDA's N-I.[7] It was necessary to have a precedent for using outside launch services. Thus NTT suggested that their needs be filled by outside launch services at some point in the future.

This MPT-and-NTT versus STA-and-NASDA debate was ultimately resolved by the Space Development Special Committee of the Liberal Democratic Party (LDP), which recommended that the 1978 policy of domestic development of the Space Activities Commission be followed.[8] The committee made a small compromise. Japanese launchers would still be used, but adherence to that policy would be partially offset by a proposed acceleration of funding for rocketry development, to keep the MPT side of the debate from losing face. But, in fact, the MPT clearly lost that round of the debate and the STA benefited most from the launch vehicle acceleration concession.

After these two discussions had subsided, NTT still maintained its 1990s requirement for a two-ton satellite configuration, though the national plan could still only offer the proposed 850-kilogram services of the H-IB. In answer to NTT's apparent disregard of national development strategy, the Ad Hoc Committee on Long Range Prospects of the Space Activities Commission issued a report, the Long Range Vision, in mid-1983 in which the following statement was made:

> Since Japanese space development is carried out based on its own technology, there will arise discrepancies between satellite users' needs and the available technology level in various factors such as launching capability and reliability, launch dates, cost effectiveness, etc. It is, therefore, required that both users and developers recognize the importance of meeting such needs for the promotion of practical applications and of own technology development for a self-reliant space program, and make an effort to harmonize technology development and its utilization from a long range view.[9]

This meant that commercial satellite users' needs were being relegated to second place behind domestic rocketry development.

In a section on "Space Transportation," the previously quoted Long-Range Vision report states that it is:

> indispensable that Japan possess independent decision-making over its own launching facilities,

and

> It is quite important for Japan to possess its own launching capability particularly for communications satellites....[10]

This Long-Range Vision committee report presented the initial official recommendation to develop the independently controlled H-II two-ton payload launch vehicle, apparently as a response to NTT's heavy launch wishes. Nevertheless, a ranking official in the MPT mentioned that the H-II is likely to produce some international tension, since it will compete directly with other nations' launchers and the shuttle.[11]

Following its privatization, NTT will not necessarily be called upon to support the nation's space development efforts. NTT believes transportation into space should be done in a reliable manner. The flag painted on the side of the launch vehicle is of little or no concern to NTT as long as its satellites are orbited successfully.

4. <u>CS-2 Era and Beyond</u>

Japanese would-be users of communications satellites are currently defining their needs within the domestic market while systematically monitoring the political scene. With an eye to the U.S. open sky, Japanese firms have witnessed the thus-far largely unsuccessful operations of Satellite Business System (SBS). According to an aerospace specialist in a major trading firm, the Japanese have therefore remained fairly cautious.

CS-2a, with a mere 4,000 circuits, and mostly used by government groups, including the National Police Agency, is quite expensive to operate and where these overlap cannot compete with conventional land services. Presently a group of at least 17 firms, including Mitsubishi Corp., Mitsui & Co., Hitachi, Toshiba, Fujitsu, NEC, and Dai-Ichi Kangyo Bank are using a limited number of circuits of CS-2a in small-scale experiments. These are meant to help them acquire the ability to conduct standard operations with the CS-3 generation satellites.[1]

Association of Communications Satellite Utilization Tests, using the 100 circuits (one-fifth of a K_a-band transponder of CS-2a) owned by the Ministry of Posts and Telecommunications, were begun in April 1984. Some related firms such as Mitsubishi Electric and Mitsubishi Corporation maintain joint participation. With the ground stations these firms have built, they are conducting tests of high-speed data transmission, teleconferencing, and various headquarters-to-factory communications. These tests are expected to give the firms hands-on services can fit into their particular corporate communications systems.[2]

This series of tests is coordinated by the Radio Research Laboratories of the Ministry of Posts and Telecommunications (MPT). According to Mr. Yuichi Otsu of the Radio Research Laboratories' Satellite Communications Division, this pilot program focuses on transmissions of digital computer data, the development of new protocols for satellite computer communication networks, and the "low bit-error rate" transmission of news materials (including newspapers photographs in the form of facsimile). The policy of the MPT which supports the pilot program has three major points: 1) to give user firms interested in satellite communications opportunities to accumulate working knowledge; 2) to help formulate future ministerial policy through the early anticipation of users' technical developments in satellite services and needs of the various users; and 3) to open the test data to the public at large to share the benefits of the program beyond the confines of the corporate participants.[3]

The experimenters are addressing three important problems. These concern channel quality (such as channel deterioration due to rain); protocols (devising new format and content conventions for multiple address communications and other types); and security (to ensure that sensitive data being transmitted can be used or understood only by authorized persons, especially in the case of banks and other financial institutions).

NEC Corp., which bid against Mitsubishi Electric for the CS-3 contract, is conducting tests among three ground stations in high-speed facsimile transmissions and teleconferencing.

After the start of this multiple users' testing program, additional companies joined, including industrial companies and financial services firms. Their purpose has also been to gain experience in the experimental use of the CS-2a spacecraft. In July 1984, four firms, including Oki Electric Industry Co. and Yasuda Trust and Banking Co., enlisted in the test program by signing agreements with the Ministry of Posts and Telecommunications, thus raising the number of corporate participants to 21.[4]

Half of the total transponder capacity of CS-2b will be used for commercial services by NTT for the remainder of the satellite's useful life, barring unforeseen problems. The other half of total capacity will be kept in reserve for emergency use. Both the CS-2a and its in-orbit spare are operating well, according to staff members of the operator, Telecommunications Satellite Corporation of Japan, and thus NTT has decided to make the most of the spare.[5]

Thus far, CS-2a has largely been used by government groups for non-commercial services. The underlying justification of the satellite and the spare is to enable NTT to provide regular telephone service connecting the main islands with smaller ones, such as Ogasawara Island.[6] The need for reliable communications for emergencies, especially in the event of major earthquakes, is another primary rationalization for the satellite system. The Japanese National Railways (JNR) is using the satellite as a back-up system for conventional wire lines, to cut off the power supplied to the Shinkansen trains in the event of a big earthquake, and secondly to help speed-up reconstruction projects if an earthquake were to destroy wire lines and microwave relay stations.[7]

Since the main islands of Japan are extensively covered by 6 GHz microwave communications, it was deemed necessary for the CS-2 series to use the K_a-band (30/20 GHz: uplink/downlink) for communications with this area. But experience in 30/20 GHz technology was considerably slowed by the loss of the two Ayame-class satellites. Six channels of CS-2a (and CS-2b) are K_a-band, and two channels are conventional C-band (6/4 GHz), the latter of which are used for communications with outlying remote islands.[8] NTT uses four of the six K_a-band channels and both of the C-band channels of the CS-2a.

Communications in the K_a-band allow approximately twice as many geostationary satellites to be positioned in orbit without interference, compared with regular C-band satellites. Since some parts of the geostationary belt are becoming quite crowded, notably over the Americas, K_a-band and multi-beam satellites will eventually emerge as increasingly attractive to supplement C-band and K_u-band satellites. The Japanese were the first to use the K_a-band with a standard operational satellite, although signal attenuation during rain is a problem. The experimental Sakura (CS) satellite orbited for Japan by NASA offered initial experience with K_a-band technology.

This does not necessarily mean that the Japanese have an effective jump on the U.S. in K_a-band communications technology. In reference to a planned Advanced Communications Technology Satellite (ACTS) to be built by RCA Astro Electronics for NASA, Robert R. Lovell, director of NASA's Communications Division, was quoted in Aviation Week & Space Technology as saying that the U.S. retains a five-year lead over the Japanese, due to microelectronics superiority.[9] The ACTS spacecraft is meant to help develop U.S. commercial technology covering K_a-band transmissions, which are expected to emerge as popular in the 1990s. (ACTS will probably be launched in 1989.) Nevertheless, some American space industry specialists have worried that the U.S. may fall behind in K_a-band satellite communications commercialization, despite the fact that the U.S. Air Force "Milstar" and the Hughes Aircraft "Galaxy" projects will use similar frequency bands.[10]

Immediately prior to the orbiting of CS-2a, NTT conducted its own independent survey of close to 2,000 organizations, including large companies, universities, and the media. Nearly half of them responded.[11] Seventy-seven percent of the responding companies indicated a very active interest in satellite digital communications services, with 74 percent interested in the high-speed facsimile multi-address calling service and 49 percent interested in the video multi-address calling service. More than two-thirds of the responding firms predicted their eventual entrance into satellite digital communications services.

NTT engineers at the Yokosuka Electrical Communication Laboratory designed the antenna and the transponders of the CS-2 series satellites which were manufactured by Mitsubishi Electric and NEC respectively.[12] Slightly over 60 percent of the satellite parts were supplied by Japanese firms, although the overall configuration is based on an old design of Ford Aerospace.[13]

In the autumn of 1983, Mitsubishi Electric was selected as the prime contractor for the CS-3 series satellites.[14] Even though the satellites are largely financed by NTT and operated by Telecommunications Satellite Corporation of Japan, NASDA makes the decisions about such contracts. Although it is not specified in Japanese law, according to Mr. Ryuji Shimoda, senior staff member of the STA's International Space Affairs Division, the Science and Technology Agency's policy necessitates the selection of a Japanese prime contractor even if the satellite will actually be built in the U.S. Thus the BS-2a NHK-utilized satellite, which was orbited in January 1984, was made in Valley Forge, Pennsylvania by the American "prime subcontractor" General Electric. Japanese hardware, mainly Toshiba's, represented less than one-third of the total.[15] When BS-2a went into operation in May 1984, only one television channel could be broadcast because neither a second transponder system, nor the back-up transponder, functioned properly. The faulty transponders were made by General Electric and Thomson CSF. Japan may become reluctant to rely on such lightweight foreign-built systems in the future. Similar problems with foreign-made elements fuel the Japanese self-reliance strategy, including the failures of apogee kick motors, and the separation of third-stage units with the apogee kick motor plus satellite unit of the two Ayame class satellites (in 1979 and 1980).

The competition for the CS-3 series contract pitted the Mitsubishi Electric/Ford Aerospace team against NEC Corp. and Hughes Aircraft. A Japanese-supplied share of about 80 percent was promised by Mitsubishi Electric in their bidding proposal, while NEC would have relied to a greater extent upon the transfer of American technology.[16] Specifically, NEC Corp. suggested the adaptation of the "platform despun" configuration of Hughes Aircraft -- a design superior to the one actually adapted -- and which would still have resulted in a Japanese portion of two-thirds.[17] One of the main reasons that Mitsubishi Electric was awarded the contract, according to NASDA, was that

Mitsubishi Electric was better equipped than NEC Corp. to serve the strategy of domestic development.[18] Although it lost the main contract, NEC Corp. was selected as the manufacturer of the transponders, which represent approximately 40 percent of the total value of the satellites.[19] The CS-3 series satellites will use Mitsubishi Electric's carbon fiber-reinforced plastic (CFRP) structure to lighten the cylindrical bus. This CFRP technology is one specific area which the Japanese are emphasizing, since satellite weight reduction is considered a high priority. Mitsubishi Electric is also supplying CFRP buses for the ISAS MS-T5 and Planet-A missions, the first Japanese-designed interplanetary probes.

Both Mitsubishi Electric and NEC Corp. supply sophisticated parts to state-of-the-art INTELSAT satellites, with Mitsubishi Electric serving as a subcontractor to Ford Aerospace in the INTELSAT V (fifth generation series) contract, and NEC Corp. supplying receivers and other electronic parts for the Hughes Aircraft-built INTELSAT VI satellites.[20]

As early as 1968, even before any Japanese satellites were orbited, Mitsubishi Electric supplied parts (power control units and others) for the TRW-built INTELSAT III satellites. Mitsubishi Electric has also supplied electronic components for the Ford Aerospace "Arabsat" regional communication satellite contract.[21]

The two 550-kilogram CS-3 satellites are scheduled to be launched by H-I boosters in early 1988 and the summer of the same year. Their K_a-band coverage will extend to Okinawa, whereas that of the CS-2 series is limited to the main four islands.

The CS-3 satellites are expected to meet, among other things, some of the emerging business needs in this field of data communications. But if the previously mentioned NTT 1982 preliminary users' survey is of any significance as a barometer of the future, the 6,000-circuit CS-3 pair will be quite limited in relation to true market needs, barring any purchases or major leasing of American-built satellites by Japanese firms. Significantly, Hughes Aircraft has informally stated in Tokyo that it will place Japanese-ordered satellites in orbit within approximately three years of the order.

The Hughes Communications subsidiary of the satellite manufacturer established a task force with trading companies C. Itoh & Co. and Mitsui & Co. in September 1984 to study the feasibility of operating a satellite for Japanese users. The Japan Economic Journal quoted Taketo Furuhata, managing director of C. Itoh & Co., as saying that the tripartite study group will be reorganized early in the 1985 fiscal year to set up a communications satellite operating company.[22]

5. Beyond CS-3

Preparations are currently being made within the confines of the country's space development plan for advanced satellites to enter into service toward the end of the seven-year lifespans of the CS-3 pair. According to an announcement made by Shigemichi Sonoyama, then executive director of NASDA (currently vice president), at a Keidanren forum in October 1983, the Engineering Test Satellite VI, or ETS-VI, will be a fully Japanese-designed and -manufactured two-ton combined experimental communications-and-broadcasting three-axis controlled satellite. This will partially pave the way for the establishment of domestic technology for the standard operational Information Network System (INS) satellites of NTT.[1]

However, there is not presently an industry-wide agreement that a jump should be made directly from 550 kilogram class satellites to the much larger two-ton class. Some space specialists believe that it would be prudent to gain some experience with one-ton class satellites before making a commitment to the large two-ton class. Others believe that two satellites each of about one-ton in size would be preferable to a single two-ton communications satellite. The reasoning is that it is better to lose a single one-ton satellite (and still have another operational one-ton unit) rather than to put all of one's eggs in a single two-ton basket and risk a parts failure which could cripple the entire two-ton spacecraft. Those who favor the intermediate one-ton phase know all too well that it is relatively easy to lose satellites for any number of reasons, and hence they would prefer to spread the risk.

The predecessor, ETS-V, to be launched by an H-I in the summer of 1987, will feature the first Japanese-developed three-axis control unit. This will be used for mobile-satellite communications tests by, among others, NASDA, the Radio Research Laboratories (RRL) of the Ministry of Posts and Telecommunications, and the Electronic Navigation Research Institute (ENRI) of the Ministry of Transport. At the time of the ETS-V satellite testing, NTT will still be under direct government ownership, and so NTT should be able, without much difficulty, to acquire the knowledge from the Ministry of Posts and Telecommunications for NTT's INS satellite design. After 1985, NTT will be similar to a private company, but it will most likely retain its favored status with its parent-like ministry. NTT will undoubtedly reap the gains from experimental satellites because of its higher status with NASDA above other private-sector companies.

NTT knows, however, that it cannot take full responsibility for total satellite design in its strategy of acquiring very large INS-type satellites, because NTT engineers must concentrate on overseeing the many ground-based systems comprising the innovative INS infrastructure. Conversely the STA/NASDA team appear to be more ambitious about cultivating Japanese skills in the communications satellite arena, for this is one of their main missions. NTT sees itself as a service organization and not primarily as a technology acquisition mechanism in the field of communications satellites.

Although the details of the first-generation INS satellites (CS-4 level) have not yet been determined, it is clear that NTT wants cost-effective large-scale units (unlike CS-2 and CS-3). According to Dr. Kazuhiro Miyauchi of NTT's Yokosuka Electrical Communication

Laboratory, early interest is being shown in multi-beam communications technology, which would include trunk transmission, digital business communications, mobile and maritime use. Such a multi-beam design would permit the reduction of dish antennas and thus result in ground systems savings. NTT has already experimented with 30-centimeter diameter antenna designs for use on ocean-going vessels.[2] The use of multi-beam technology would require very accurate pointing control of the antenna on board the satellite, which would most likely be done by star-sensors. An earth sensor for the accurate determination of satellite positions has already been developed by Matsushita Research Institute and will be used onboard NASDA's Engineering Test Satellite-V.[3]

As pointed out by Tadasu Murakami, director of NTT's engineering bureau, research and development activity on high-capacity satellites of the INS-type began in 1982.[4] NTT specialists will concentrate on building the sophisticated onboard equipment, including lightweight transponders and assorted electronics:

> Researchers at NTT's Yokosuka Electrical Communication Laboratory announced in October 1984 that they had developed a pair of integrated circuits on Gallium Arsenide (GaAs) substrates for use in transponders of multibeam satellites. These two monolithic ICs (for switching and amplifying) are claimed to be lighter in weight and higher in efficiency than contemporary devices, and their development illustrates NTT's serious interest in designing and building components for future large-scale communications satellites.[5]

More than 70 regular-use and some 35 spare transponders are probable requirements for an INS-type satellite.

6. Possible Regional Japanese-Financed Satellites

The Indonesian Palapa satellites, built by Hughes Aircraft, also serve some domestic needs of the Philippines, Thailand, and Malaysia. This raises the question: If Indonesia can lease transponders, why can't Japan? Thus far Japan's NASDA-dominated space strategy has ignored regional as well as commercial needs.

The Japanese government is now giving some consideration to a possible "inter-regional satellite system," as Dr. Nozumu Takasaki proposed in a report published by the Research Institute of Telecommunications and Economics of Japan (RITE).[1] Dr. Takasaki, now a senior advisor of Mitsubishi Electric, has proposed the purchase of two one-ton U.S.-made satellites to serve the Pacific island region, ASEAN countries and Australia, the West Coast of the U.S., and Japan. This tentative plan may eventually be adopted as a foreign aid package, flavored with some commercial involvement. The proposed project has been greeted by varying degrees of interest and resistance. It would most likely require the heavy support of political leaders and the Ministry of Foreign Affairs. Questions about potential conflicts with INTELSAT must still be resolved. Japan's INTELSAT representative, Kokusai Denshin Denwa (KDD, the international telephone company) would also become involved in this decision. Since KDD is generally very protective of its own turf, it is unlikely that its support could be obtained.

Nevertheless, this well-documented proposal does show that consideration is being given to Japanese management of systems built around U.S.-manufactured satellites.

Dr. Takashi Iida, a senior research officer in the Radio Research Laboratories of the Ministry of Posts and Telecommunications, and three of his colleagues described a possible regional broadcasting satellite system for the Asian-Pacific region in a paper submitted in June 1984 to the 14th International Symposium on Space Technology and Science (ISTS), a biennial space conference held in Tokyo. This paper asserts that many poor Pacific island nations and larger Asian nations need television reception to advance their educational opportunities and cultural awareness. The researchers proposed the sharing of a broadcasting satellite which would allow poor nations to receive some programs in their native languages. The researchers have given some fairly specific details of the proposal, including a description of the likely weight of the satellite as about 550 kilograms (suitable for an H-I launch vehicle), number of transponders estimated at 8 to 15, and probable cost as roughly $400 million. This project is characterized as one which would contribute to the "education, culture, and training of technical talents" of people in the under-developed nations of the Asian-Pacific area.[2]

Proposals such as Dr. Takasaki's regional communications satellite system and Dr. Iida and colleagues' regional broadcasting satellite system are not new as a sophisticated form of foreign assistance, for as early as 1979, Sunao Sonoda, former Foreign Minister, advocated the Japanese sponsorship of a regional telecommunications satellite for southeast Asian nations, and reinforcement of ties with the association of Southeast Asian Nations (ASEAN).[3] At the time of Foreign Minister Sonoda's advocacy of the regional telecommunications satellite proposal in the late 1970s, there was also considerable discussion in Tokyo on

Japan's possible leadership in forming a so-called Asian Space Agency (ASA), modeled after the European Space Agency.[4] But according to a leading NASDA official, nothing much has resulted from such talks.

Other proposals, in addition to those of Dr. Takasaki, Dr. Iida, and former Foreign Minister Sonoda, have been forwarded as well.

7. Broadcasting Satellite Series Technology

Private companies' interest in satellite television broadcasting is intense in Japan, and many firms are competing for the one channel of Broadcasting Satellite-3a's three-channel operational capacity that will likely be offered to a non-government group.[1] Originally one of the three channels of BS-3a, which is to be launched in 1989, was to have been used by the Ministry of Education's proposed "University on the Air" for study at home. But this plan has fallen through, thus opening the way for a private broadcaster to use the third channel.[2]

Like BS-2a, the next-generation satellite will provide two channels to NHK. More than a dozen enterprises -- individual firms or groups of firms — have applied to the Ministry of Posts and Telecommunications for consideration as the third-channel broadcaster.[3] Four of the most promising proposed candidates to become third-channel broadcaster are: 1) Nippon Satellite Information K.K. (N-SAT), led by Nihon Keizai Shimbun, the largest Japanese daily business newspaper; 2) Japan Satellite Broadcasting K.K., collectively led by the Asahi and Yomiuri newspapers; 3) a Kyodo News Service group; and 4) a group comprised of 17 Mitsubishi-related companies led by Mitsubishi Corporation, tentatively called All Japan Satellite Broadcasting Co.[4]

With all of these large corporations vying for the single slot, one solution might be some shared-access scheme. Perhaps these companies and groups could form their own commercial consortium to operate a competing satellite outside of the NHK (Japan Broadcasting Corporation)-NASDA framework. High level staff members of some of these corporations have only mentioned, however, that they are studying the potential market for these broadcasting services. If such a private-interest foreign-built broadcasting satellite were orbited, it would undoubtedly be more cost-effective than either BS-2a or BS-3a.

According to Mr. Koichi Yabashi, Director General of Engineering at NHK, the BS-3 series satellites are expected to be made more cost effective than their predecessors in that they will carry Japanese-built traveling wave tubes (TWTs) of at least 200 watts as transmitting sources as opposed to the foreign-made 100-watt TWTs carried onboard BS-2a (two out of three transponders failed within the first few months in orbit). Using these higher-power TWTs, to be designed and built by a private company in conjunction with NHK, the home-installed dish antenna units can be made smaller and thus less expensive, in order to improve the marketability of the NHK satellite broadcasting and ground pick-up equipment system.[5]

8. Communications Satellite Controversy and Rocketry Implications

What is the Japanese market for foreign-made communications satellites, and do such satellites fit into Japan's domestic political climate?

The Japanese government has traditionally seen the prospect of foreign-made commercially operated communications satellites as detracting from the policy of acquiring domestic technology. Japanese satellites are, as a matter of policy, to be launched by Japanese-developed launch vehicles. But the influence of the world telecommunications market appears to be shaking this monolithic policy.

Before the orbiting of CS-2a and CS-2b in 1983, the Japanese had not seriously considered corporate purchases of communications satellites — unlike in the U.S., where various companies have purchased such satellites. This was due in large degree to the amorphous definitions by Japanese firms of their needs. According to representatives of the major firms, precise definitions of user needs had not been made before the CS-2 era. Most companies had simply taken a wait-and-see attitude.

In September 1983, U.S. Secretary of Commerce Malcolm Baldridge officially requested MITI Minister Sousuke Uno to consider Japanese purchases of communications satellite hardware.[1] This was related to NTT's inquiry about American satellite control software. The request was made because NTT was interested in control software for the CS-4-type satellites for the Information Network System. The initial corporate reply was that this software was considered inseparable from hardware, thus hinting that NTT should buy complete satellite systems.

(It is, incidentally, unlikely that NTT's satellites beyond CS-3 will be called "CS-4." Instead the designation will probably be changed to something like INS-number or -letter series, because "CS" presents a strong connotation of foreign assistance.)

Since the CS-2 series and the scheduled CS-3 series satellites are quite limited in capacity, it would seem that some large companies or groups of companies may want to orbit their own larger satellites. They may possibly build a high-speed telecommunications system to circumvent NTT primary circuits after the restructuring of NTT.

A report by the Information Industry Committee, an advisory panel to MITI's Industrial Structure Council, recommended a deregulation of domestic telecommunications media. This was to include satellite communications to assure the vigorous competitive development of new services.[2] There was no shortage of official and quasi-governmental recommendations for the opening of Japanese skies, prior to the decision by the Ministry of Posts and Telecommunications to do so. (NTT and Fujitsu's Chairman Kobayashi were only two such advocates). The politically influential Second Ad Hoc Committee on Administrative Reform urged that satellite communications, among other fields, be opened up to private companies.[3]

In October 1983, a "high-ranking official" of the Ministry of Foreign Affairs was quoted by major Japanese newspapers as having said that the purchase of U.S.-manufactured communications satellites by Japanese private companies was not contrary to the national policy of satellite development.[4] No date was specified as to when such commercial purchases would be permitted, although mid-1984 was mentioned as a possibility. The Ministry of Foreign Affairs was immediately thereafter unable to confirm this new policy. Discussions among various ministries exacerbated the confusion: the STA tried to protect the monopolistic "development" -- or outright "protectionist" -- policy; the Ministry of Posts and Telecommunications and NTT expressed concern about future competition in space (American-made satellites owned by competitors would be extremely efficient compared to NASDA/NTT-developed CS-and-beyond subsidized satellites); and MITI and the Ministry of Foreign Affairs also got into the act. The latter two ministries wanted to settle the matter to avoid yet another conflict among technological industries, which at that time already included software, value-added networks and microelectronics. MITI had other pressing concerns and did not want to "give up" a trade concession over which they had jurisdiction in the government-to-government bargaining process.

In the U.S., the communications satellite controversy was largely tied politically to the issue of NTT procurement, the basic agreement on which was originally set to expire at the end of 1983. The Japanese believed that the satellite purchase question was not to be included as a sub-issue of a new NTT procurement agreement. The CS-series satellites are mainly used by NTT and other Japanese government groups; and with no chance of direct U.S. corporate bidding, U.S. corporate and government figures thought that this exclusionary policy was unfair. William Brock, U.S. chief Trade Representative, had been dissatisfied with NTT's rejection earlier in 1983 of the suggested purchase of American-made communications satellites.[5] U.S. Department of Commerce officials also entered the satellite procurement debate, treating it primarily as a political-economic matter. In a number of interviews with Japanese officials, it was apparent that the Japanese felt the American side behaved arrogantly in pressuring them to buy something that they perceived they did not need. On the other hand, the Americans saw the Japanese development planning as encompassing a policy of strategic industrial targeting, rather than as a domain important to national security. Throughout the controversy, it was apparent that the quasi-governmental NASDA, as an implementation group, had little or no say in these policy matters.

Due to intense pressure from the Department of Commerce, the Office of the U.S. Trade Representative, and other official U.S. actors, the Japanese policy of overtly excluding purchases of whole foreign-made satellites was changed to permit such purchases, as long as they do not detract from the self-development policy of the STA (through NASDA).

In April 1984, the new policy of allowing private and government purchases of satellites was agreed upon after a series of government debates. The STA had strongly opposed the open purchasing policy, but the new policy was scheduled to go into effect at the beginning of fiscal year 1985 (April 1, 1985), along with the restructuring of Nippon Telegraph and Telephone Public Corporation (NTT), to be privatized and called Nippon Telegraph and Telephone Corporation. The stock of Nippon Telegraph and Telephone Corporation was to be retained by the government (Ministry of Posts and Telecommunications), and after a few years 50 percent of the equity will be sold to Japanese investors.[6]

The major points of the new "open sky" policy are as follows: 1) Nippon Telegraph and Telephone Corporation will be permitted to purchase foreign-made satellites at its own discretion; 2) government-associated groups will be allowed to make similar purchases; and 3) private corporations will be allowed to buy foreign-made satellites as well.[7] It is understood by all major actors that any foreign-built satellites ordered by Japanese organizations would be launched by the shuttle or Ariane. The Japanese government position includes the provision that these purchases of foreign-made satellites (outside of the STA development plan) will be permitted as long as they do not disrupt the governmental development strategy. The meaning of this qualification is not immediately clear.

Sources in the American Embassy in Tokyo and appropriate officials in Washington hesitated about declaring the agreement a success upon hearing the precise wording of the new partially open sky policy. Approximately one week after the Japanese announcement, U.S. Trade Representative William Brock said:

> the language of the satellite statement needs further clarification before we can assess the market opening potential.[8]

Meanwhile, aerospace divisions of Japanese trading companies were considering the new opportunities they could generate through U.S.-made satellite purchases. During the course of the national development stages, Mitsubishi Corporation, for example, had witnessed a sizeable reduction of its intermediary importing business, as N-series rocket parts, largely supplied to Mitsubishi Heavy Industries, decreased from 70 percent American in the case of the first N-I to less than 45 percent American for the current fifth-and-sixth vehicle N-IIs.[9]

Trading companies and their affiliate firms, including banks, are expected to be major potential users of communications satellites in Japan. Mitsubishi Corporation is, however, unwilling to make any kind of guess concerning the probable number of transponders which it may use over the course of the next decade.

In March 1984, Hughes Aircraft arranged for C. Itoh & Company to serve as its "one-year period" agent for sales of communications satellites. Although Hughes had a widely respected satellite specialist in Tokyo already, C. Itoh became Hughes' first foreign agent for spacecraft.[10] More than likely, Hughes found it necessary to give one of the big "insider companies" a stake in the final sales. Since C. Itoh is a major trading house, it can conduct sales pitches from within the Japanese establishment, instead of Hughes fighting Tokyo's labyrinthine corridors of business power from the outside.

The leading Japanese business newspaper, Japan Economic Journal (Nihon Keizai Shimbun), quoted C. Itoh executives as saying five to ten Hughes satellites could possibly be sold or fully leased by the early 1990s. A better guess would be that two Hughes satellites could be sold by then.

Hughes hired C. Itoh just as it become apparent that NTT and private Japanese organizations would be permitted to buy U.S. satellites through the change in government policy. At about the same time, Sumitomo Corporation, Japan's fifth largest trading house, reached an agreement with Washington-based Communications Satellite Corporation (COMSAT) to jointly participate in the emerging commercial Japanese communications satellite hardware, software, and consulting services market. Fairly inexperienced in the space arena, Sumitomo Corporation will be able to draw on the resources of COMSAT. To clarify Sumitomo Corporation's involvement in the space and telecommunications area, it should be pointed out that NEC Corp. holds about five percent of the stock of Sumitomo Corporation and is related by sales and marketing with Sumitomo Electric, the nation's largest manufacturer of optical fiber glass strands.

NTT president Hisashi Shinto has gone on record as saying that the use of U.S.-made communications satellites would be the best way to reduce the big gap between long-distance and short-distance telephone rates, one of NTT's major near-term goals.[11]

The possibility of such purely commercial satellite services competing with the subsidized CS series of the government raises a question about the ultimate commercialization of the NTT INS-series satellites. Presumably, since the Japanese government by the 1990s will have invested considerable sums to subsidize the CS series, NTT will be encouraged to purchase Japanese-made satellites beyond the CS-3 level. However, in a similar case the outcome was different. Despite efforts of NTT to develop its own internal supercomputer technology, it has purchased an American-built Cray Research model.[12] This Cray Research supercomputer was purchased even though Hitachi, Fujitsu and NEC -- three Japanese firms within the traditional "Den Den telephone equipment sales group" -- each offered commercial supercomputers of higher optimum top-speeds. Thus NTT is not subsidizing domestic commercial supercomputers in the same way that it is exclusively subsidizing communications satellites. In supercomputers, NTT is following two courses of action. It is developing the ability to research and build telecommunications-oriented supercomputers and fifth-generation-type computers for the 1990s, while at the same time buying the best commercially available model from contemporary Japanese or foreign suppliers. There are exceptions to the NTT subsidies motivated by national security (communications satellites are loosely classified as important for long-term national security). The Cray Research supercomputer deal is one such example. However, according to STA government policy, Japan's communications satellite domain is categorized as an issue which is separate from NTT procurement matters.

In Japan, where advanced computer technology is considered no less strategically important than the space arena, a commercial U.S. supercomputer could be ordered by NTT before privatization, whereas the similar purchase of a communications satellite was prohibited by 1978 guidelines. At that time, the Space Activities Commission sought to unify Japan's space efforts. Nationwide support of the self-development policy was expressed by promoting shared self-development, including the government's nurturing of selected private industrial companies in the space manufacturing arena.

In addition, users, in the context of Japan's unique history of space development, had always meant government groups. Thus potential commercial users were overlooked and neglected. In August 1962, the Satellite Communication Experiment Committee was established to prepare for the satellite transmissions of the 1964 Tokyo summer Olympics.[13] The Ministry of Posts and Telecommunications, KDD, NTT, and NHK, which made up the committee, were the first Japanese groups to use American communications satellites. These four government-associated groups presently constitute the equity owners of Telecommunications Satellite Corporation of Japan, the operator of CS-2 and BS-2 series satellites.

In the U.S., the signatory organization to INTELSAT, the initially public Communications Satellite Corporation (COMSAT), became a private entity, whereas the Japanese signatory body, Kokusai Denshin Denwa (KDD, the international telegraph and telephone company) remained a public-controlled corporation. (NTT owns 10 percent of KDD's stock.) Unlike COMSAT, KDD has not served as a model for the development of other domestic satellite operators. Indeed, KDD never asked to conduct domestic satellite services, as this was perceived to be NTT's duty even though NTT lacked KDD's INTELSAT operations experience.

The Mitsubishi group and Ford Aerospace have maintained close relations. For example, Mitsubishi Corporation has extensive experience in importing Ford Aerospace parts for Mitsubishi Electric's CS series. Mitsubishi Corporation will undoubtedly be enthusiastic in its attempts to organize a satellite venture, and it may even be possible to combine Ford Aerospace and Mitsubishi Electric parts in satellites sold to outside firms or Mitsubishi-affiliated groups.

The Ariane launcher or the shuttle would be the logical choices for any privately financed Japanese communications satellites. The H-I is limited to 550 kilograms for geostationary satellite injections. C. Itoh serves as the sales agent of Arianespace, the parent company of the Ariane launcher.

It would not be at all surprising to see some form of European pressure for the Japanese to buy the Ariane, which is now billed as a non-subsidized launcher. NASDA will receive some European assistance in tracking services for the Marine Observation Satellite-1, and NASDA will likewise extend assistance to the French with their SPOT satellite. The Europeans and Japanese are thus familiar with each other's launchers.

In a formal address in May 1984 at Keidanren in Tokyo, Gaston Thorn, President of the European Community Commission, reminded his audience that European firms have much to offer in the field of space technology, hinting at sales in communications satellites and Ariane launch services.[14]

In June 1984, Wilhelm Haferkamp, Vice President of the European Community Commission, asked MITI Minister Hikosaburo Okonogi to consider purchases of European-built weather satellites and other aerospace hardware during Okonogi's visit to the Federal Republic of Germany. Also in June, representatives of the European Space Agency (ESA) explained the selling points of their weather satellite technology to Japanese officials in Tokyo. Early the next month, French Industry and Research Minister Laurent Fabius called upon Foreign Minister Shintaro Abe in Tokyo, requesting that the Japanese consider purchases of Ariane launch services, European-built weather satellites, and various aerospace items. Importantly, the Japan Meteorological Agency (JMA) would appear to have the final say concerning the possible purchase of a geostationary weather satellite, as the JMA is the principal user in Japan, but political conversations with influential ministries presumedly will not hurt the Europeans in their efforts to peddle such satellites.[15]

But ultimately the Japanese want to launch their own satellites with their own boosters. Since 1980, and following the losses of the two Ayame class satellites, significant efforts have been made to develop reliable Japanese-made apogee kick motors (AKMs). Nissan, which makes the solid-propellant launchers for ISAS as well as the small strap-on boosters for NASDA's N-series and H-I is developing an apogee kick motor for some H-I 550-kilogram class satellites.[16] The first Nissan-made apogee kick motor will be used for the Engineering Test Satellite-V, thus the initial domestically manufactured AKM will undergo flight testing with a test geostationary satellite, illustrating the cautiousness of NASDA's domestic technology promotion strategy. Mitsubishi Heavy Industries (MHI) is developing apogee kick motors for larger satellites of the one-ton or two-ton class (H-II size).[17] However, the CS-3 satellites will be launched into orbit by Thiokol apogee kick motors, according to Ford Aerospace.[18]

Japanese companies are also developing such key technologies as a cryogenic rocket engine -- the LE-5, to be used in the second stage of the H-I and to be upgraded in the form of the LE-X, for use in the second stage of the H-II.[19] They are also developing an inertial guidance system in which development is shared by Japan Aviation Electronics, NEC Corp., MHI, Mitsubishi Space Software Co., and Mitsubishi Precision Co., with a reported "check-out" by a British firm[20] and others. All of these key technologies are meant to culminate in the independently designed H-II and H-II class satellites.

Rather than relying on single companies in specific areas, the Japanese have spread rocketry and satellite work. Three major rocketry firms, MHI, Ishikawajima-Harima Heavy Industries, and Nissan, have extensive experience dealing with McDonnell Douglas and Rockwell International-Rocketdyne (MHI), TRW and Aerojet General (IHI), Thiokol (Nissan), and others. Honeywell and Motorola (Motorola Military and Aerospace Electronics, Inc.) have also been involved in early NASDA activities. While the hardware transfer program has typically involved equipment that is old by American standards, it has nevertheless enabled the Japanese to accelerate their development plans and to learn from seasoned American engineers.

Similarly, in satellite technology, the Japanese are nurturing three major firms: NEC Corp., Mitsubishi Electric, and Toshiba.[21] NEC Corp., which works with Hughes Aircraft in weather satellites and has a smaller scale relationship with RCA Astro Electronics (a manufacturer of three-axis control systems), is the largest Japanese satellite maker in sheer number of units. Mitsubishi Electric appears to be the most ambitious of the three. It participates with Ford Aerospace in Japanese CS satellites and INTELSAT V contracts. Toshiba is generally recognized as the distant third player. It is connected to General Electric, which is itself a small equity owner of Toshiba. Other Japanese companies, including Hitachi and Kawasaki Heavy Industries, are interested in entering into the satellite business. Kawasaki has already obtained its first contract for the Experimental Geodetic Payload passive satellite which will give the Japanese geodetic information using laser techniques.

In addition to satellite manufacturing, Japanese companies are interested in other types of space business, some of which are fairly long-term. For example, C. Itoh, the marketer of Hughes communications satellites, is a partner with Microgravity Research Associates in a semiconductor material processing business venture.[22] C. Itoh will serve as the agent of Microgravity Research Associates in Japan for gallium arsenide crystalline material to be manufactured aboard future space shuttle flights. Gallium arsenide manufactured in space is superior to that made on the surface of the earth, because it can be formed in a uniform fashion in microgravity conditions. Additionally NASDA will conduct a "First Materials Processing Test" aboard the European-built Spacelab in 1988, with a Japanese astronaut. The planned microelectronics and communications research projects include one investigating the manufacturing of high-purity glass for optical fiber use (sponsored by a laboratory under the Agency of Industrial Science and Technology of the Ministry of International Trade and Industry (MITI)), and another concerns high-quality silicon crystals growth in near-weightless conditions (sponsored by the Engineering Faculty of the University of Tokyo).[23] The Japanese are laying the foundation in future shuttle missions for advanced ULSI (ultra large scale integration) chip material processing in space, based upon their own technology developed in a half dozen small TT-500A two-stage rocket tests from the Tanegashima Space Center.[24]

The three major firms are assuming approximately 90 percent of the responsibilities for the 750 kilogram Marine Observation Satellite-1 (MOS-1), which is being assembled by NEC Corp. and, after some delays, is scheduled to be launched in 1986.[25] To acquire its own LANDSAT-type technology, MITI and the STA are developing Japan's Earth Resources Satellite-1 (ERS-1). An H-I will launch ERS-1 in 1991, and it will be built by the pooling of technological expertise of the domestic firms.[26] These two satellites are meant to help Japanese fishermen harvest schools of fish, and to enable Japan to scan the earth's surface for resources.

The Ad Hoc Committee on Long-Range Prospects has predicted that MOS-series satellites will be orbited at approximately two- to three-year intervals beginning in the early 1990s, with two units to be at the MOS-4 level and beyond. Two ERS-2 units and two ERS-3 units are likely to be orbited in 1996 and 1999.[27]

The committee also predicts a Mobile Communication Satellite series (MCS), a Navigation Aid Satellite series (NAS), and a Data Relay and Tracking Satellite series, all to be initiated from the mid-1990s.[28] A country would need data relay and tracking satellites of its own only if it plans to have a large amount of space-bound information traffic.

Funding above the current half-billion-dollar government budget will be required to finance these ambitious plans. It would not be surprising, therefore, to find MITI's role increasing beyond its support of ERS-1, and perhaps at the same time STA's influence will diminish. MITI may succeed in boosting space spending in the event that the STA fails. The STA acquires funding for development activities, whereas MITI gets funding for industrial promotion.

Referring to the Japanese space budget, of which NASDA receives about 80 percent, Mr. Kimio Fukushima, chief of the Research Coordination Bureau (for space) of the Science and Technology Agency, was quoted early in the 1984 fiscal year on the front page of the Asian Wall Street Journal as saying, "I'm ashamed to mention the figure."[29] Likewise, President Hiroyuki Osawa of NASDA was quoted in the New York Times as stressing, "We have a small budget...."[30]

The probable Japanese participation in NASA's manned space station program, along with the H-II project, will likely boost the space budget beyond its current plateau. The engineers in NASDA, NAL, and the domestic companies are anxious to join NASA's program, and to use it as a means to convince Japanese politicians that additional money is needed.

Many large Japanese corporate groups have shown early interest in possible participation in the space station program. Among the corporate study teams are the Mitsubishi group (Mitsubishi Electric, Heavy Industries, Corporation, and others); the Mitsui group (Mitsui and Co., Ishikawajima-Harima Heavy Industries, Toshiba, and others); and the Sumitomo group (Sumitomo Corp., NEC Corp., Sumitomo Electric, and others).[31] On the government side, a number of preparatory committees were established a year before President Reagan's early 1984 State of the Union speech announcement concerning the space station. Japan's Ad Hoc Committee on the Space Station Program,[32] a 23-member official group, has been studying possible participation. This committee has a smaller working group of six specialists representing NASDA, ISAS, NAL, and the University of Tokyo, according to the chairman, Professor S. Kobayashi of the University of Tokyo. There is also an ad hoc Space Station Task Team, which includes nearly all Japanese specialists who are interested in the topic. Even before President Reagan's formal political go-ahead announcement, at least one well-documented plan was suggested by Japanese specialists: the Space Energetics and Environment Laboratory, forwarded by professors Kyoichi Kuriki and Makoto Nagatomo of ISAS.

According to Dr. Tatsuo Yamanaka, a space technology research leader at NAL, a space station participation symposium was held at the NAL Mitaka Tokyo facility in October 1982, and the academic papers collected at this symposium were published in a 350-page report.[33] For the possible Japanese participation in the space station program, Japanese engineers, professors, and other specialists have done their homework early. Unlike either ISAS or NAL (which are government groups), NASDA is a quasi-governmental agency, and thus it is probable that participation with America's NASA will be either through the STA or some other fully governmental group. In any event, a vast amount of advance preparation has been devoted to Japan's probable participation in the space station program, and this may give the Japanese a good opportunity to experiment with materials processing, life sciences, and large communications antenna units or other near-future technologies before they would otherwise be able to do so using their own launch vehicles. The Japanese are now ready and able to propel themselves into new and ambitious projects, even including the proposed space station.

NASA and INTELSAT are not alone in considering the possibility of very large-scale platform-type communications equipment which can be refurbished and repaired in geostationary orbit by astronauts. Japan is developing some components of long-life satellites, and has plans for components of platforms, such as NAL's experimental ion engines aboard NASDA's Engineering Test Satellite-III (Kiku-4). All indications point to the flourishing of indigenous Japanese space technology, based on foreign experience, from the mid-1990s.

The nation's government-sponsored development plan shows few, if any, signs of being impaired by the new parallel "open sky" policy which permits Japanese organizations to purchase foreign-built satellites outside of the confines of the development scheme. The large corporate producers of satellites and rocketry systems are, in effect, guarding the government-sponsored programs. Not long after the open sky policy was announced, Soichiro Suenaga, chairman of the Society of Japanese Aerospace Companies (SJAC), reportedly urged the government to be careful so that the new policy would not disturb the country's traditional self-development program.[34] A few weeks after the policy announcement, in the wake of the breakdown of two of the three

American-French manufactured transponder systems of Broadcasting Satellite-2a (Yuri-2a), Posts and Telecommunications Minister Keiwa Okuda sternly told Vice President George Bush that the Japanese government took a "serious view" of the breakdowns.[35] Foreign assistance is obviously not always appreciated.

Interestingly, the transponders ordered by NHK (Japan Broadcasting Corporation) were extremely powerful, so much so that conservative American engineers warned that less powerful but more reliable transponders would be advisable. But NHK remained adamant because the powerful transponders would permit small-diameter dish antenna units -- as small as 60 centimeters in diameter -- to be sold to households, thus promoting the potential mass popularity of the new satellites services. In any event, the foreign-built transponder failures -- of a General Electric system with "traveling wave tubes" supplied by France's Thomson CSF -- appeared to give momentum to advocates of the national self-development plan.

In late July 1984, immediately prior to the successful launch of the NEC/Hughes Himawari-3 weather satellite by the Delta-based N-II launch vehicle number six, Michiyuki Isurugi, director-general of the Science and Technology Agency (parent of NASDA) and concurrently chairman of the Space Activities Commission, criticized the failures of foreign-made satellites parts. He was specifically referring to the recent BS-2a two transponder failure and Himawari-2 camera mechanism problems.[36] In a fit of obvious nationalistic pride at the Foreign Correspondents' Club of Tokyo, Isurugi said that there are many malfunctions of foreign-made satellite components, and stressed the need to develop 100 percent Japanese-made satellites.[37] Knowledgeable

Americans and Europeans residing in Tokyo were quite offended at Isurugi's remarks. Only a few days earlier, Moriyuki Motono, vice minister for International Affairs in the Ministry of Foreign Affairs, rejected the European proposal to sell Japan a METEOSAT weather satellite (for intended use in the late 1980s), saying that Japan needed to develop its own technology (meaning technology acquired from Hughes Aircraft).[38] But if, as Isurugi claimed, foreign-made satellite components are plagued with numerous failures, observers wondered why the Japanese were acquiring such "flawed" technology.

Thus far, with a total budget less than one-twelfth that of NASA, Japan's applications space budget has provided just enough resources for NASDA to get a taste of success while erecting a respectable and broad foundation. But this foundation has been established largely through the transfer of dated technology, mainly from U.S. companies. The Japanese have reached a turning point. From here they can be expected to use foreign technical assistance to increase the amount of domestically built parts for satellites and boosters, but also to design and build their own satellites and boosters. How the new parallel policy enabling Japanese skies to be "partially open" will affect the self-development plan remains to be seen.

The Japanese plan to go beyond the projects previously done by NASA, the European Space Agency (ESA), or other major international space organizations. The Planet-A probe to Halley's Comet, for which the U.S. has no counterpart mission, is one such example. Although they have historically been "followers" in space, the Japanese are not satisfied to be followers in the future.

9. Conclusion

The recent U.S.-Japanese confrontation over communications satellites sales are part of NASDA's growing pains. Since it is still not yet fully mature, NASDA (and the STA) felt threatened by the entrance of actors outside its direct control. NASA has not monopolized all space activities in the U.S. So too Japan's NASDA can no longer expect protection by a government policy which restricts commercial satellite operations; NASDA realizes that it cannot oversee the delivery of competitive systems.

At least for the near future the U.S. can expect to retain its lead. But this lead may not be entirely significant if Japan continues to emphasize microelectronics miniaturization. For the specific needs of Japan, Toyota-type satellites may not be inferior to Cadillac-type American satellites. The Japanese have tasted success in their modest space activities and can be expected to remain hungry for advancement. If the H-II launch vehicle is successful as a booster for privately financed Japanese satellites, then the threshold into space maturity will have been crossed. Conversely, if Japan cannot sustain a privately financed space industry outside of the government-subsidized development scheme, Japan's space efforts may stagnate. The key to success is stimulating a sizable private sector industry.

10. Appendix -- History of Rocketry and Communications Satellites

Japanese rocketry started in 1955, when Professor Hideo Itokawa of the University of Tokyo's Institute of Industrial Science test-fired dozens of small pencil rockets.

In the year of the formation of the International Telecommunications Satellite Consortium (INTELSAT), 1964, the National Space Development Center (NSDC) was formed by the Science and Technology Agency.[1] (Japan was one of the very few founding nations of INTELSAT, thus exhibiting its early interest in far-flung communications via spacecraft.) The NSDC group embarked upon the development of small two-stage launchers, the LS-C series (made by Mitsubishi Heavy Industries and boosted from 1967). This small rocket was meant to establish a foundation of experience in Japanese applications rocketry.

Interest in communications satellite technology research at Nippon Telegraph & Telephone Public Corporation's Electrical Communication Laboratory (at Musashino) dates back to 1967, according to Dr. Kazuhiro Miyauchi, a deputy director general for R & D at the Yokosuka ECL. Nippon Hoso Kyokai (NHK - Japan Broadcasting Corporation) began small-scale studies in broadcasting satellite technology in 1965, according to Ryo Takahashi, director general of engineering. Thus it is apparent that the Japanese have long prepared themselves for the advent of telecommunications satellite services.

The decision to build the Tanegashima Space Center, from which geostationary applications satellites are launched, was made in 1966, and in the following year the NSDC group recommended that Japan develop launchers capable of boosting applications satellites into geostationary orbit: the N-series rockets, to be preceded by experimental four-stage Q-series rockets. From 1966 to 1969, four attempts by ISAS (of the University of Tokyo) to orbit a small scientific test satellite resulted in four straight failures. In 1969, after three such failures, an agreement was reached with the U.S. government to permit the transference of "Thor Delta" technology to Japan's Science and Technology Agency.[2] To assure total systems reliability and to accelerate the developmental schedule, the Japanese government pursued this agreement.

Finally in February 1970, Japan entered the space age, beating China into orbit by a mere two months. Notably, the "Ohsumi" test satellite was Japanese-made (prime contractor: NEC) as was the Lambda four-stage, solid-fuel launch vehicle which boosted it.

NASDA, formed in 1969, launched some small experimental rockets called the JCR-series (Jet Controlled Rocket), to gain knowledge about guidance and control and other areas. During the early 1970s, many Japanese rocket specialists underwent extensive training at the Huntington Beach factory of McDonnell Douglas.[3]

In late 1973, the Space Activities Commission (SAC) announced the decision to procure experimental communications and broadcasting satellites (CS and BSE respectively).[4] (The SAC does not simply promulgate decisions from the top down, but rather decisions typically filter up from the middle levels, later to be announced publicly after a consensus is reached.) These satellites were made at Ford Aerospace's Palo Alto facility (then Philco Ford) and General Electric's Valley Forge Space Center in Pennsylvania (CS and BSE, respectively). The launches of these satellites, as well as the first Geostationary

Meteorological Satellite (GMS), were performed by NASA at the Eastern Test Range in Florida. NASDA's first experimental communications test satellite, Kiku-2, was successfully boosted by the third N-I vehicle in February 1977, establishing Japan as the third country capable of orbiting geostationary satellites.

Because the three NASA-launched American-built "Japanese" satellites were too heavy to be boosted by the N-I vehicle, they were launched by Delta rockets (the CS satellite was approximately 24 percent Japanese and BSE was roughly 15 percent Japanese).[5]

In 1979, the International Maritime Satellite Organization (INMARSAT) was formed with Japan as one of the founding members: indeed Japan has a sizable interest in communications to sea-bound vessels and in remote sensing of the ocean by satellite.

After losing a pair of 130 kilogram experimental communications satellites (Ayame series, approximately 50 percent Japanese-made) in February 1979 and February 1980, probably due to third-stage separation and/or apogee kick motor problems, in February 1983 NASDA orbited the nation's first operational communications satellite, Sakura-2a. This satellite, approximately 62 percent Japanese-made, was followed by the in-orbit spare, Sakura-2b, in August 1983.[6] Much of the communications capacity of these satellites is in the K_a-band (20 - 30 GHz) whereas most American satellies use the C-band (4 - 6 GHz). C-band and K_u-band terrestrial communications are used on the main Japanese island, Honshu, and thus the K_a-band was developed for satellite use. Americans warn that rain attenuation can be problematic with such K_a-band communications. Additionally, throughout the world, ground equipment for satellite communication in the C-band is more highly developed and less expensive. Within a decade or so, however, the big American firms like Hughes Aircraft, Ford Aerospace, RCA, and others will produce K_a-band satellites, but only after the C-band and K_u-band become crowded. Nevertheless the small-scale Japanese use of K_a-band equipment comprising a small amount of the communications gear aboard the CS-2 series will not be of great advantage to Japan in the worldwide satellite market of the 1990s. Undoubtedly some major subcontracting to Japanese firms for K_a-band transponders will be seen.

The CS-2a (Sakura-2a) and CS-2b pair were originally to have been placed in geostationary orbits at 130° East and 135° East, but the Soviet Union was likewise planning to put a satellite, Statsionar-15, at 130° East. To avoid interference, Japan's Ministry of Posts and Telecommunications agreed with Soviet counterparts (in mid-1982) to reposition all of the concerned satellites, including Statsionar-7, resulting in final orbit assignments for CS-2a and CS-2b of 132° East and 136° East, respectively.[7]

The estimated useful lifetimes of the CS-2 series is approximately five years (as opposed to about ten years for conventional state-of-the-art communications satellites). The short lifetime means that the satellites are comparatively expensive for many reasons (for example, less time between launches, more satellite units per given time). The 350-kilgram CS-2 series satellites each have a 4,000-circuit capacity, and the 550-kilogram CS-3 series will have 6,000 circuits (as a comparison, the Hughes HS-393 will typically after 1986, have 48,000 circuits.

The Broadcasting Satellite-2a, or Yuri-2a, was launched in January 1984. Its back-up, BS-2b, originally scheduled for launch in August 1985, has been delayed until 1986.

Japan's space development program is meant to follow an established schedule through the mid-1990s, at which time the H-II launch vehicle, capable of launching two-ton satellites into geostationary earth orbits, is expected to be available. NTT has been preparing for the era of large communications satellites (approximately two tons) for its fully digitized Information Network System, which features the conversion of conventional terrestrial cables to optical fiber cables and a bit-based rate structure, similar to the concept of the Integrated Services Digital Network.[8]

Glossary

ACTS: NASA's Advanced Communications Technology Satellite, to use K_a-band transponders.

AIST: Agency of Industrial Science and Technology, of the Ministry of International Trade and Industry. Parent organization of the Electrotechnical Laboratory.

Ariane: Commercial launch vehicle of the European Arianespace group.

Ayame: Two Experimental Communications Satellites (ECS and ECS-b). Contact was lost with both satellites shortly after their launches in 1979 and 1980.

BS: Broadcasting Satellite series, also known as Yuri, includes BS-2a and BS-2b, and BS-3 series.

BSE: Medium-Scale Broadcasting Satellite for Experimental Purposes, launched by NASA in 1978.

C-band: 4 - 6 GHz bandwidth conventionally used by communications satellites.

CFRP: Carbon Fiber-Reinforced Plastic, material used for some satellite bus structures.

CS: Communications Satellite series, includes Medium-Capacity Geostationary Communications Satellite for Experimental Purposes launched by NASA in 1977, and CS-2 and CS-3 series, also known as Sakura series.

COMSAT: Communications Satellite Corporation, U.S. firm and signatory of the U.S. for INTELSAT.

Daini Denden, Inc.: A private corporation established to compete against NTT, with more than 200 corporate investors led by Kyocera, Sony, Mitsubishi Corporation, to begin service in ca. 1987.

ECL: Electrical Communication Laboratories of Nippon Telegraph and Telephone Corporation (NTT), located at Musashino, Yokosuka, Ibaraki, and Atsugi.

ENRI: Electronic Navigation Research Institute of Japan, under the administration of the Ministry of Transport.

ERS: Earth Resources Satellite, to be launched ca. 1991.

ESA: European Space Agency.

ETL: Electrotechnical Laboratory of the Agency of Industrial Science and Technology (of the Ministry of International Trade and Industry) located in Tsukuba, Ibaraki Prefecture.

ETS: Engineering Test Satellite series of NASDA.

FACC: Ford Aerospace and Communications Corporation, participates with Mitsubishi Electric in many contracts including CS series.

GaAs: Gallium Arsenide, a compound material used for semi-conductor chips, which requires less power and operates faster than chips made of silicon-based material. It is expensive, and is a candidate for space materials processing businesses.

GMS: Geostationary Meteorological Satellite series, also known as Himawari series, including GMS, GMS-2, GMS-3, and GMS-4 (under development).

H-I: Third launch vehicle series of NASDA.

H-II: NASDA's large launch vehicle planned to inject two-ton satellites into geostationary earth orbits beginning in the mid-1990s.

IHI: Ishikawajima-Harima Heavy Industries, a manufacturer of rocket and jet engines.

INS: Information Network System of NTT, a digital telecommunications system featuring an integration of services and optical fiber lines (not to be confused with Inertial Navigation System).

INTELSAT: International Telecommunications Satellite Organization, a 100-plus nation group headquartered in Washington, D.C.

INTELSAT V, and INTELSAT VI: Fifth and sixth generation satellite series of INTELSAT, built by Ford Aerospace and Hughes Aircraft, respectively.

ISAS: Institute of Space and Astronautical Science of the Japanese Ministry of Education, Science and Culture, has orbited more than a dozen scientific spacecraft from its Kagoshima Space Center.

ISTS: International Symposium on Space Technology and Science, held in Tokyo every other year.

JDA: Japan Defense Agency, administers the Air, Ground, and Maritime Self-Defense Forces and the Technical Research and Development Institute.

JNR: Japanese National Railways, operates many train lines including the "Shinkansen" bullet train.

K_a-band: 20 - 30 GHz bandwidth (20 - 30 GHz uplink - downlink) used by most channels of CS-2 series.

KDD: Kokusai Denshin Denwa, literally means International Telegraph and Telephone, Japan's signatory to INTELSAT.

Keidanren: Federation of Economic Organizations, powerful meeting place or forum for Japan's big companies.

KHI: Kawasaki Heavy Industries, manufacturer of airplane industrial equipment, and prime contractor for EGP satellite.

Ku-band: 11 - 14 GHz band typically used by communications satellites after C-band crowding or saturation.

LDP: Liberal Democratic Party, controlling party of the Japanese national Diet, mainstream political party with many factions.

LE-5: NASDA's first cryogenic rocket engine, to be used in the second-stage of the H-I. It is also to be used as the second-stage engine of the H-II.

LE-X: First-stage cryogenic rocket engine to be used in the H-II. This large engine will be designed on the basis of experience in the smaller-scale LE-5 development project.

METEOSAT: European weather-watch satellite.

MHI: Mitsubishi Heavy Industries, prime contractor of NASDA's N- and H-series launch vehicles, largest Japanese aerospace and defense contracting firm.

MITI: Ministry of International Trade and Industry.

MOS-1: Marine Observation Satellite-1.

MS-T5: Japan's first interplanetary probe, to be followed by Planet-A, both are satellites of ISAS.

Mu: The solid-fuel rockets of ISAS are designated as Mu-series.

N-I and N-II: NASDA launch vehicles based on American technology.

NAL: National Aerospace Laboratory of the Science and Technology Agency, Mitaka, Tokyo.

NASA: U.S. National Aeronautics and Space Administration.

NASDA: National Space Development Agency of Japan, of the Science and Technology Agency, a quasi-governmental implementation group for applications space activities.

NEC: NEC Corporation, formerly Nippon Electric Company, manufacturer of all ISAS satellites and some NASDA satellites.

NHK: Nippon Hoso Kyokai, literally meaning Japan Broadcasting Corp., uses the BS-2a satellite.

NTT: Nippon Telegraph and Telephone Public Corporation, restructured as Nippon Telegraph and Telephone Corporation in 1985, uses the CS-2a and CS-2b satellites.

Planet-A: Halley's Comet probe of ISAS.

RITE: Research Institute of Telecommunications and Economics of Tokyo.

RRL: Radio Research Laboratories of Japan's Ministry of Posts and Telecommunications.

SAC: Space Activities Commission, highest body for space arena decisionmaking in the Japanese government structure, under the Prime Minister's Office.

SJAC: Society of Japanese Aerospace Companies, a Tokyo-based lobbying and interest group of aviation and space companies.

STA: Science and Technology Agency, parent ministerial-level organization which supervises NASDA.

TSCJ (or TELESAT-Japan): Telecommunications Satellite Corporation of Japan, operating organization of communications and broadcasting satellites, owned by the Ministry of Posts and Telecommunications, NTT, KDD, and NHK.

Tsukuba: Special science city in Ibaraki Prefecture, site of the Tsukuba Space Center of NASDA.

Footnotes

1. Background and Issues

[1.1] "Japanese Space Program is Ready to Take Off and Project Industry," Asian Wall Street Journal, April 4, 1984, p. 15.

[1.2] "Daini-Denden, 1st Competitor of NTT Set Up," Mainichi Daily News, June 1, 1984, p. 1.

[1.3] NASDA 83 - 84, booklet published by the National Space Development Agency of Japan, October 1983; and The Institute of Space and Astronautical Science, booklet published by Japan's Ministry of Education, Science and Culture (Mombusho), 1982.

[1.4] Justin L. Bloom and Shinsuke Asano, "Tsukuba Science City: Japan Tries for Planned Innovation," Science, 12 June 1981, p. 1245; Interview with Mr. Itu Hiraki, NASDA Engineering Consultant (formerly Executive Director in charge of launching); Interview with Mr. Nobuyuki Arino, Executive Managing Director of TRW Overseas Inc. (Tokyo).

[1.5] Speech by U.S. Deputy Secretary of State Kenneth W. Dam, entitled "America's 'Near West': U.S.-Japan Relations in Perspective" (Delivered before the Japan Society in New York City, February 6, 1984) in Speaking of Japan, Tokyo: Japan Institute for Social and Economic Affairs (Keizai Koho Center), June 1984, p. 29.

[1.6] Interviews with Dr. K. Yamawaki, Manager of NASDA's Planning and Management Department; Mr. A. Kubozono, Director of NASDA's International Affairs Department; and other specialists in NASDA; and various articles, including: "Powerful Rocket Development Urged," The Japan Times, July 21, 1983, p. 2; and "Japan's Future in Space," The Japan Times (editorial), July 27, 1983.
See also Neil W. Davis, "Tanegashima: Japan's Largest "Space Port," Journal of Japanese Trade and Industry (published by the Japan Economic Foundation in collaboration with the Ministry of International Trade and Industry), September/October, 1984, pp. 58-60.

[1.7] "Educating People, Not Resources," Journal of Japanese Trade & Industry July/August 1984, p. 34.

[1.8] Neil W. Davis, "Japan's Halley's Comet Probes," Spaceflight (The British Interplanetary Society) June 1983, pp. 272 - 274; and Neil W. Davis, "The Space Race: Here Comes Japan," High Technology, May 1983, pp. 27 - 33.

[1.9] Neil W. Davis, "Japan's New Rocket Engine," Spaceflight July/August 1983, p. 319; and Neil W. Davis, "Japan in Space," Space World March 1983, pp. 9 - 13.

1.10 Marine Observation Satellite-1 (MOS-1) to Ground Station Interface Description, booklet published by NASDA, April, 1982 (code number DE-4052.)
and "Earth Sensors Further Japan's Efforts," Aviation Week & Space Technology, Vol. 120, No.6, June 25, 1984, p. 152.
"The Future of Space Society - An Expansion of the Human Activity into Space" (unpublished manuscript of Obayashi dated November 1981); and T. Obayashi "Space Colony - The Future of Space Explorations," Applied Physics, Vol. 45, No. 1, 1976.

1.11 "Interview" page, Science & Technology in Japan, October/December (Vol. 1, No. 4) 1982, p. 35.

1.12 Dr. Allen E. Fuhs, "A Rising Sun in Aircraft," Astronautics & Aeronautics June 1978, p. 52; and various interviews, including an interview with Dr. Hideo Itokawa.

1.13 Neil Davis, "The Father of Japanese Rocketry: Dr. Itokawa," Space World, March 1983, pp. 14 - 15.

1.14 Interview with Professor T. Obayashi of ISAS, and other interviews.

1.15 "Defense Forces Want Reconnaissance Satellite," The Japan Times January 3, 1984, p. 2; and "Defense Agency Wants to Orbit Own Spy Satellite," Mainichi Daily News, January 3, 1984, p. 1.

1.16 "SDF to Use Landsat for Surveillance," Asahi Evening News, June 15, 1984, p. 1.

1.17 "Use of FLEETSAT," (reprinted editorial of the Asahi Shimbun), The Japan Times, September 9, 1984, p. 12.

1.18 "New Ultrahigh-speed Computer Goes to Work," The Japan Times, June 22 1984, p. 7; and Neil W. Davis, "The Supercomputer Stakes," PHP (published by Matsushita/National), May 1984, pp. 15 - 25.

2. Communications Satellite and Optical Fiber Needs of Japan: Partially a Function of Geography and Production Preferences

2.1 "Deficit-Plagued JNR Eyes Telecommunications Field," The Japan Times, February 29, 1984, p. 7.

2.2 "JNR May Advance Into Telecommunications Field," Mainichi Daily News, December 23, 1983, p. 12.

2.3 Neil W. Davis, "Fiber Optics Technology," The Oriental Economist, December 1983, pp. 6-7.

2.4 "U.S. Specified Five Areas of Military Technology," Japan Economic Journal, August 21, 1984, p. 1.

2.5 "COMSAT, Mitsubishi Team Up on Satellite Equipment," The Japan Times, September 30, 1984, p. 5; and "COMSAT, Mitsubishi Team on Earth Stations, Aviation Week & Space Technology, October 8, 1984, p. 23.

2.6 "Pentagon Interested in Japan's Gallium Arsenide for Chips," The Japan Times, August 13, 1984, p. 3.

2.7 "Washington Roundup" Page, Aviation Week & Space Technology, July 16, 1984, p. 15.

3. Public and Private Issues of Japanese-Used Communications Satellites

3.1 Takao Tsumiji, "Debate Arises," Asahi Evening News, February 17, 1984, p. 5; and interviews with H. Morikawa, Director of Keidanren's Science and Technology Department, and Y. Anzai, Assistant Director of the same department.

3.2 "Plans of Rocket Makers and Users of Satellites Often Tend to Conflict," The Japan Economic Journal, July 13, 1982, p. 15.

3.3 Neil W. Davis, "Japan's Space Industry: A Big Promise," The Oriental Economist, November 1982, pp. 24-29 and "Speed-up of Japan's Space Program," The Japan Economic Journal, June 8, 1982, p. 12.

3.4 "Space Shuttle—" The Japan Economic Journal, March 2, 1982, p. 16; "NTT Plans to Use Space Shuttle to Make New Semiconductor Alloy," The Japan Economic Journal, September 14, 1982, p. 13; and elsewhere.

3.5 "Plans of Rocket Makers and Users of Satellites Often Tend to Conflict," (see Note 3.2).

3.6 Ibid.

3.7 Dr. Hideo Shima, Space Activities in Japan, (Dr. Hideo Shima is consultant to NASDA and is its retired first president.) May 19, 1983, p. 12.

3.8 "Plans of Rocket Makers and Users of Satellites Often Tend to Conflict," (see Note 3.2).

3.9 Space Activities Commission, Ad Hoc Committee on Long-Range Prospects, "Long-Range Vision for Japanese Space Development," July 1983, p. 13.

3.10 Ibid, p. 24.

3.11 Interview with an official of the Ministry of Posts and Telecommunications (asked not to be identified).

4. CS-2 Era and Beyond

[4.1] "Seventeen Firms Will Launch Satellite Circuit Tests," The Japan Times, November 15, 1983, p. 4.

[4.2] "Mitsubishi Electric Uses Satellite," The Daily Yomiuri, March 29, 1984.

[4.3] Yuichi Otsu, et. al., (Radio Research Laboratories, Ministry of Posts and Telecommunications, Tokyo), "Japan's CS-2 Pilot Program," paper submitted to the International Astronautical Federation (for IAF-Geneva conference of October 1984), p.3.

[4.4] "Consortium Plans to Use Satellite," The Japan Times, July 6, 1984, p.7.

[4.5] "NTT Eyes Reuse of Idle Satellite," The Daily Yomiuri, 19 January 1984, p. 2.

[4.6] "Communications Satellite-2 (Revised Edition)" NASDA booklet, December 1982; and "Japan Enters the Satellite Communications Age with Launching of Practical Communications Satellite, CS-2," NTT Press Information, March 1983.

[4.7] "JNR Links to Satellite for Earthquake Signals," The Daily Yomiuri, June 24 1983, p. 2.

[4.8] "Communications Satellite-2," (see Note 4.6).

[4.9] "Satellite Communications Tests Restart at NASA," Aviation Week & Space Technology, August 6, 1984, p. 24.

[4.10] "Acts Test Linked to Lead in Technology," Aviation Week & Space Technology, April 9, 1984, pp. 76-77.

[4.11] "Japan Enters the Satellite Communications Age with Launching of Practical Communications Satellite, CS-2," NTT Press Information, March 1983 pp. 13 - 14.

[4.12] Neil W. Davis, "Japan's First Operational Communications Satellite - CS-2a," The Oriental Economist, February 1983, pp. 8-9.

[4.13] Interviews with specialists from Ford Aerospace & Communications Corporation.

[4.14] "Mitsubishi Electric Named Main Comsat Contractor," The Japan Times, October 1, 1983.

[4.15] Neil W. Davis, "World's First Standard Operation 'Direct Broadcasting Satellite'," The Oriental Economist, January 1984, pp. 4 - 5.

[4.16] "NEC, Mitsubishi are Vying for Communications Satellite Order," The Japan Economic Journal, August 16, 1983, p. 13.

[4.17] "Mitsubishi Elec. is Selected as Main Contractor for New Satellite," The Japan Economic Journal, October 4, 1983, p. 3.

[4.18] "NEC, Mitsubishi are Vying for Communications Satellite Order," (See Note 4.16).

[4.19] "NEC, Mitsubishi Elec. is Selected as Main Contractor for New Satellite (see Note 4.17).

[4.20] Hughes Aircraft Company (Space and Communications Group) News Release, Tokyo, April 9, 1982, pp. 1 - 2.

[4.21] "Space Activities" Brochure of Mitsubishi Electric Corporation, p. 4.

[4.22] "C. Itoh and Mitsui & Co. to Begin Commercial Satellite Business," Japan Economic Journal, September 25, 1984, p. 15.

5. Beyond CS-3

[5.1] "Japan to Build Large-Scale Communications Satellite by '92," The Japan Times, October 29, 1983.

[5.2] Tadasu Murakami, "Domestic Satellite Communications in NTT," Japan Telecommunications Review, January 1983, p. 14.

[5.3] "Matsushita Makes Earth Sensor to Control Satellite Position," Japan Economic Journal, October 23, 1984, p. 13.

[5.4] Tadasu Murakami, (see Note 5.2), p. 16.

[5.5] "NTT Develops IC for Use in Future COMSAT Transponder," The Japan Times, October 19, 1984, p. 8.

6. Possible Regional Japanese-Financed Satellites

[6.1] Nozomu Takasaki, A Study on the Pacific Regional Satellite Communications System, Tokyo: Research Institute of Telecommunications and Economics, January 1983.

[6.2] Takashi Iida, Sachio Shimoseko, Ken Iwasaki, and Masaaki Shimada, "On Future Missions of Satellite Communications," academic paper presented at the Space Communication Technology section of the 14th International Symposium on Space Technology and Science (Tokyo, May 27 - June 1, 1984.)

6.3 "Japan to Host Joint Gov't - U.N. Sponsored Space Conference," The Japan Times, September 13, 1979, p. 2.

6.4 Ibid.

7. Broadcasting Satellite Series Technology

7.1 "Government Allots BS-3's Single Channel to Private Sector," The Japan Economic Journal, November 29 1983, p. 10.

7.2 "Only One Satellite Station Granted to Commercial TV," The Japan Times, November 19, 1983, p. 2.

7.3 "LDP Group Proposes 3 Stations Use Satellite," The Japan Times, November 12, 1983, p. 6.

7.4 "17 Mitsubishi Group Companies Eye Satellite Broadcasting Service," The Japan Economic Journal, September 27, 1983, p. 10; and "LDP Group Proposes 3 Stations Use Satellite," (see Note 7.3).

7.5 Koichi Yabashi, "Technical Aspects of Satellite Broadcasting in Japan," Space Communication and Broadcasting Volume 1, no. 3, 1983, p. 270.

8. Communications Satellite Controversy and Rocketry Implications

8.1 "U.S. Demand to Focus on NTT Satellite Import," The Daily Yomiuri, December 18, 1983, p. 1.

8.2 "Deregulate Telecommunications: Panel," The Japan Times, December 21, 1983, p. 7; and "Council Urges Deregulation of Communications Circuits," The Japan Economic Journal, December 6, 1983, p. 3.

8.3 "Keidanren Plans To Establish NTT Competitor," The Japan Times, January 1, 1984, p. 9.

8.4 "Imports of US Satellite Equipment OK," Mainichi Daily News, October 27, 1983, p. 5; "Private Concerns Will Be Able to Buy U.S. Satellites," The Japan Economic Journal, November 1, 1983.

8.5 "U.S. Demand to Focus On NTT Satellite Import," The Daily Yomiuri, December 18, 1983, p. 1.

8.6 "Ministries Agree on NTT Stock," The Japan Times, March 23, 1984, p. 10.

8.7 "External Economic Measures," (Provisional Translation from the Foreign Press Center-Japan) Ministerial Conference for Economic Measures - April 27, 1984.

8.8"Brock Hails Changes in VAN Services," Mainichi Daily News, May 9, 1984, p. 5.

8.9Interviews with members of Mitsubishi Corp., and Ford Aerospace.

8.10"C. Itoh to Sell Hughes Satellites In Japan," The Japan Economic Journal, March 13, 1984, p. 1.

8.11"Revise Phone Rates, NTT President Says," The Daily Yomiuri, May 9, 1984, p. 4.

8.12Neil W. Davis, "NTT Buys U.S. Supercomputer," The Japan Times October 12, 1983, p. 14.

8.13Space in Japan - 1964, Science and Technology Agency, 1964, p. 46.

8.14"Message From Europe" (Gaston Thorn speech) Asahi Evening News, May 15, 1984, p. 5.

8.15"EC Asks Japan to Buy Airbuses, Satellites," The Japan Times, July 1, 1984, p. 4; "European Selling 'Meteosat' To Replace Troubled Himawari," The Japan Times, July 4, 1984, p. 3; "French Minister Urges Aviation, Nuclear Imports," The Japan Times, July 7, 1984, p. 6.

8.16Interview with Akira Kubozono (NASDA).

8.17"MHI Makes Apogee Motor for Geostationary Satellite," The Japan Economic Journal, January 17, 1984, p. 13.

8.18Interview with Mr. Susumu Takahashi, Ford Aerospace, Business Development Manager (Tokyo).

8.19"Space Development Division and Products," booklet of Ishikawajima-Harima Heavy Industries, December 1981, p. 7.

8.20"NEC Develops Tiny Satellite Computer," The Daily Yomiuri, March 9, 1984, p. 4.

8.21Neil W. Davis, "Japan's Space Industry: A Big Promise," The Oriental Economist, November 1982, cover story.

8.22"C. Itoh to Manufacture Material in Space Shuttle," The Japan Times, August 2, 1984.

8.23"Space Agency Decides on List of Experiments for Shuttle," Asahi Evening News, August 9, 1984, p. 3; and "Committee Announces List of 34 Space Experiments," The Japan Times, August 9, 1984, p. 2.

8.24Interview Dr. Masafumi Miyazawa, senior staff Engineer of NASDA's Launch Vehicle Design Group (N-II group.)

8.25"Marine Observation Satellite-1 To Ground Station Interface Description," NASDA booklet (April 1982); "Development of Microwave

Scanning Radiometer for Marine Observation Satellite-1," International Astronautical Federation paper (IAF-80-b-93) by NASDA specialists, Ishizawa and others.

8.26 "MITI Proposes New Formula For Satellite Development," The Japan Economic Journal, September 6, 1983, p. 13; and Interview with Mr. Sano, chief of MITI's space office.

8.27 Space Activities Commission, Ad Hoc Committee on Long-Range Prospects, "Long-Range Vision for Japanese Space Development," July 1983, Appendix, pp. 1-6.

8.28 Ibid.

8.29 "Japan Space Program Ready to Take Off," Asian Wall Street Journal, April 4, 1984, p. 1.

8.30 "Japan's Space Race Struggle," New York Times, July 24, 1984, p. D1 (Business Day page.)

8.31 "Sumitomo Group to form Study Council on U.S. Space Station," The Japan Times, July 5, 1984, p. 5.

8.32 Neil Davis, "Japan Rushes to Climb Aboard Space Station," Aerospace America (Davis - Aerospace Asia Column), April 1984, p. 42.

8.33 Kyoichi Kuriki, "Proceedings of The Space Station Symposium," Tokyo: Keidanren, October 21, 1982.

8.34 "Technical Failures Hit Japan Satellite," Asian Wall Street Journal, May 9, 1984, p. 3.

8.35 "Japan Complains About Yuri-2a," The Japan Times, May 23, 1984, p. 10.

8.36 "100% Japanese Satellites Needed, Isurugi Stresses," The Daily Yomiuri, July 28, 1984, p. 1.

8.37 Neil W. Davis, "Foreign Space Assistance," The Japan Times, August 1, 1984, p. 16.

8.38 "Japan Turns Down European Request to Purchase Satellite," The Japan Times, July 25, 1984, p. 7; and "Govt Rejects ESA Offer to Sell Its Satellite," The Daily Yomiuri, July 25, 1984, p. 1.

10. Appendix -- History of Rocketry and Communications Satellites

10.1 Space in Japan 1978 - 79, Tokyo: Keidanren, 1979, p. 20.

10.2 "U.S. and Japan Sign Space Cooperation Agreement," U.S. Information Service, Press Release (American Embassy - Tokyo), July 31, 1969; and Y. Takenaka, NASDA Executive Director, et al., "Development

Status of Japan's Future Launch Vehicle," International Astronautical Federation paper (IAF-81-12) Rome, Italy 1981.

10.3 Interviews with McDonnell Douglas, Thor-Delta Technical Services Inc. engineers at Tanegashima, and Nagoya (Mitsubishi Heavy Industries Oye plant).

10.4 Space in Japan (see Note 10.2) p. 21.

10.5 "Increased Use of Japanese Hardware Urged," Aviation Week & Space Technology, Vol. 115, No. 6, August 10, 1981, p. 61.

10.6 Neil W. Davis, "Japan's First Operational Communications Satellite-CS-2a," The Oriental Economist, February 1983, pp. 8-9.

10.7 Neil W. Davis, "Japan's First Operational Communications Satellite - CS-2a," The Oriental Economist, February 1983, pp. 8-9.

10.8 Dr. Y. Kitahara, "Information Network System - Infrastructure for an Advanced Information Society," Japan Telecommunications Review, Vol. 25, No.1, April 1982, pp. 96 - 103; and interviews with NTT specialists.