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TECHNICAL
REPORT

Japan's Space Program

A Fork in the Road?

Steven Berner

RAND NATIONAL SECURITY RESEARCH DIVISION

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JAPAN'S SPACE PROGRAM: A FORK IN THE ROAD?

Steven Berner

Preface

This report presents the results of an internally funded RAND study to explore the current status and possible future directions of Japan's space program. In the 25 years from 1969 to 1994 Japan went from a country that had not yet successfully launched a satellite to an emerging space power. Ten years later, in 2004, the Japanese space program has been described by some as undergoing a crisis of confidence in the face of a succession of satellite and launcher failures. This paper examines what has brought these changes about. It explores whether Japan's space program is confronting a crisis, or whether it is merely experiencing the growing pains that all space programs must eventually confront. It provides a brief historical overview of Japan's space program. It explores the organization of the program and how that organization has changed. It reviews the status of Japan's satellite reconnaissance program. It examines several key factors that are affecting Japan's space program. Finally, it explores the possible future directions for Japan's space program over the next several years, and some of the possible implications of different paths.

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INTRODUCTION

In the 25 years from 1969 to 1994 Japan went from a country that had not yet successfully launched a satellite to an emerging space power. The National Space Development Agency (NASDA) had launched 30 rockets without a failure, and had a string of successes with its satellites. They were developing the indigenous H-2 launcher that would allow Japan to compete in the international launch-services market. NASDA was a significant player in international space activities, having flown its first astronaut on the space shuttle in 1992, and having development responsibility for the Japanese Experiment Module (JEM) for the International Space Station. The Institute for Space and Astronautical Science (ISAS) had successfully developed a family of smaller solid propellant launchers and, on a budget on the order of 20 to 25 billion yen (about $200 million) was developing an international reputation for its space science program. Japanese industry was consistently increasing its role as a subcontractor in international procurements of communications satellites.

Ten years later, in 2004, the Japanese space program has been described by some as undergoing a crisis of confidence. NASDA has had a succession of satellite and launcher failures. ISAS's Mars probe, Nozomi, failed to reach orbit around Mars. Japanese companies have yet to compete successfully as prime contractors in the international satellite communications market. The space program has been reorganized, and a new Japanese space policy is expected soon. At the same time Japan has launched its first military/intelligence reconnaissance satellites.

What has brought about these changes? Is Japan's space program confronting a crisis, or is it just experiencing the growing pains that all space programs at some point must confront? And what future directions might the Japanese space program take?

This paper attempts to address these questions. We first provide a brief historical overview of Japan's space program. (Exhibit 1 provides a summary overview of the program's evolution.) We explore the organization of the program and how it has changed recently. We review the origins and status of Japan's satellite reconnaissance program. We then examine several factors that are affecting Japan's space program (e.g., budgetary constraints, limited staffing). Finally, we explore the possible directions the program may take in the next several years.

Timeframe	**1955-1969**	**1970's**	**1980's**	**1990-2003**
Key Achievements	• Establishment of ISAS, NASDA • 1969 agreement allowing transfer of unclassified U.S. launch vehicle technology to Japan	• First successful satellite launch • N-1, N-2 launchers developed • Teaming with U.S. firms to develop satellite capabilities	• Increased Japanese input on launchers (H-1) and satellites • Initiation of H-2 program for indigenous launcher • Agreement to participate in space station • First remote sensing satellite	• Japan achieves independent space capability • Major development programs for launchers and for space station • Military/intel space program initiated
Key Issues	• 1969 agreement prohibited re-exporting launchers	• Dependant on U.S. firms for space capabilities	• Approaching independent status • Forced to open domestic satcom market to competition (lose protected market for Japanese aerospace firms)	• Series of failures in satellite and launcher programs • Japanese firms not successful in commercial competitions • China challenges Japan's position as leading Asian space program • Space program reorganized • Policy review underway (2004)

Exhibit 1: Summary Overview of the Evolution of Japan's Space Program

HISTORY OF JAPAN'S SPACE PROGRAM

This section provides a brief historical overview of Japan's space program, and how it has evolved over the last 50 years.

1955 – 1969: BEGINNINGS

The Japanese space program got its start in 1955 at the University of Tokyo, where the Institute of Industrial Science began work with sounding rockets. In 1964 the Institute of Space and Aeronautical Science (ISAS) was founded at the University of Tokyo. (In 1981 its name was changed to the Institute for Space and Astronautical Science.) ISAS would go on to be the lead agency for Japan's space science programs. It maintained its close affiliation with the University of Tokyo, operating in a largely academic environment. The period from 1966 to 1969 saw four failed attempts by ISAS to launch Japan's first satellite.

On October 1, 1969 the National Space Development Agency of Japan (NASDA) was established. NASDA was to take the lead in the development of space capabilities in Japan. This included development of satellites for remote sensing, communications, and meteorological observation, development of launch vehicles for launching those satellites, and development of facilities for producing, testing, and tracking the satellites. Also in 1969, Japan and the United States signed an agreement allowing the transfer of unclassified technology for launch vehicles from U.S. firms to Japan. The terms of the agreement prohibited re-exporting of the technology by Japan, which effectively precluded Japan from marketing any of the resulting launchers in the international market for launch services.

1970's: FIRST STEPS: ACQUISITION OF U.S. TECHNOLOGY

During the 1970's Japan pursued a strategy of acquiring launcher technology from U.S firms. They similarly teamed with U.S. firms to develop capabilities for satellite communications systems.

February 1970 saw the first successful launch of a Japanese satellite, OHSUMI, launched by ISAS. 1970 also saw the beginning of development of the N-1 launcher by NASDA. The N-1 was a modified version of the McDonnell-Douglas Delta launcher. As indicated in Exhibit 2, U.S. firms provided technical assistance, production licenses, or actual hardware for virtually all elements of the launcher. The first N-1 launch was in September 1975. The payload capability of the N-1 to geosynchronous transfer orbit (GTO) was only 260 kg. In 1976 NASDA began development of the N-2, a somewhat more capable version of the N-1 with a payload of 715 kg to GTO. Again there was major input from U.S. suppliers.

Japanese input to the communications satellites they launched during the 1970s was similarly limited. For example, Japanese input on the first CS satellite, launched in 1978, was only 24 percent, with the remainder coming from Ford Aerospace (now Space Systems/Loral).

	N-1 **(1^{st} launch 1975)**	**N-2** **(1^{st} launch 1981)**	**H-1** **(1^{st} launch 1986)**
VEHICLE INTEGRATION	**McDonnell Douglas**	**McDonnell Douglas**	**McDonnell Douglas**
1^{ST} STAGE			
Airframe	**McDonnell Douglas**	**McDonnell Douglas**	**McDonnell Douglas**
Main Engine	**Rockwell**	**Rockwell**	**Rockwell**
Vernier Engine	**Rockwell**	**Rockwell**	**Rockwell**
Strap-on boosters	**Thiokol**	**Thiokol**	**Thiokol**
2^{ND} STAGE			
Airframe	**McDonnell Douglas**	**McDonnell Douglas**	**Japanese**
Engine	**Rockwell**	**Aerojet**	**Japanese**
Reaction Control System	**TRW**	**Aerojet**	**TRW**
3^{RD} STAGE			
Airframe	**McDonnell Douglas**	**McDonnell Douglas**	**Japanese**
Engine	**Thiokol**	**Thiokol**	**Japanese**
Fairing	**McDonnell Douglas**	**McDonnell Douglas**	**Japanese**
Guidance/Control	**Honeywell, McDonnell Douglas**	**McDonnell Douglas**	**Japanese**

Exhibit 2: U.S. Firms Providing Technical Assistance, Production License, or Hardware for Japanese Launch Vehicles

Japan provided about 40 percent of the content of the ETS II satellite launched on 1977, and only about 15 percent of the content of the BS satellite launched in 1978.[1]

Thus, Japan had to largely depend on U.S. suppliers for its space capabilities during the 1970s. This would begin to change in the 1980s.

1980s: INCREASING INDIGENOUS CAPABILITIES

A main aspect of Japan's space activities in the 1980s was the development of the H-series of launch vehicles. The limited payload capability of the N-1 and N-2 was insufficient for the launch of most anticipated applications satellites. To address this, development of the H-1 started in 1981, and the first launch was in 1986. The vehicle was capable of launching a payload of 1,100 kg to geosynchronous transfer orbit (GTO), more than 50% greater than the N-2 and 4-times the capability of the N-1. The H-1 represented a major step forward for Japan's space industry. Mitsubishi Heavy Industries (MHI) and Ishikawajima-Harima Heavy Industries (IHI) developed the cryogenic second stage engine using Japanese technology; with IHI developing the turbopumps and MHI responsible for all other elements of the engine. Nissan Motors developed the solid propellant third stage. The inertial guidance system was also developed in Japan by a combination of Japan Aviation Electronics Industry, NEC, Mitsubishi Precision Company, and MHI. However, the H-1 still used the same first stage technology and solid strap-on as the N-1 and N-2, including the MB-3 engine produced in Japan by IHI under license from Rockwell International. Thus, while the H-1 could be used to launch larger Japanese satellites, it still included U.S. technology and hence was restricted from competing for international launch contracts.

[1] "Assessment of Free World Economic Competition in Space Related Fields", SPC/Berner Lanphier and Associates, July 1985.

Anticipating the need for even greater lift capability, and anticipating a growing international market for launch services in which it wanted to compete, Japan initiated the development of the H-2 launcher in 1986. The goal was to develop a fully indigenous launcher capable of placing a 4,000 kg payload into GTO. The H-2 had two cryogenic core stages and two solid booster strap-ons. The upper stage was powered by the LE-5A engine, a modified version of the liquid oxygen / liquid hydrogen LE-5 engine developed by MHI and IHI for the second stage of the H-1. The most technologically challenging development for the H-2 was the LE-7 engine for the first stage. This represented the first closed-cycle, staged combustion engine developed by Japan. Both the Space Shuttle main engine and the Russian RD-0120 engine are closed-cycle, staged combustion engines. Development of the LE-7 was not without its difficulties. First, problems were encountered with the liquid hydrogen turbopump. Then a number of problems were encountered during static test firings of the engine, including two large explosions. These led to the need to improve welds throughout the engine. Overall, problems with the development of the LE-7 led to a two-year delay in the H-2 program, with the first launch occurring in February 1994. As we will discuss later, the LE-5A and the LE-7 each contributed to launch failures of the H-2.

Japan also improved its indigenous satellite communications capabilities during the 1980s. The ETS-IV satellite, launched in 1981, was the first indigenously developed Japanese communications satellite (comsat). The ETS series, however, is for technology demonstration and testing, not provision of operational service. Japan's progress in operational satellites was slower. Japanese content on the CS-2 satellite was 60%, a marked improvement from the 24% on CS-1. Mitsubishi built the satellite with help from Ford Aerospace. CS-2 was the world's first operational satellite in the Ka band (30/20 GHz). Still, the CS-2 was a small (350 kg on orbit mass), low power (480 W beginning of life) spacecraft.

Toshiba did not fare as well in their learning from General Electric (GE; the aerospace portion of GE is now part of Lockheed Martin) on the BS satellite series. Japanese content on the BS-2 satellites increased to only 30%. The BS-2A satellite, launched in

1984, was the first operational demonstration of direct-to-home television broadcast. However, two of the three transponders failed within three months, and full service was not restored until BS-2B was launched in 1986.[2]

The late 1980s also saw a change in Japan's policy regarding its domestic satellite communications market. Prior to 1989 the domestic market was considered a captive market for Japanese suppliers, and was used to develop Japanese communications satellite capabilities. The U.S. protested the closed nature of the Japanese satellite communications market, and in 1989 the Diet removed restrictions on the domestic market and opened competition for operational satellites to non-Japanese suppliers on a non-discriminatory basis. As we discuss later, Japanese firms have not fared well in these open competitions, or in similar open competitions in the international satellite communications market.

The 1980s also saw the launch of Japan's first remote sensing satellite. The Marine Observation Satellite (MOS)-1 was launched in 1987 on the last launch of an N-2 booster. Designed for a 2-year life, MOS-1 actually operated until April 1995. The Multi-Spectrum Electronic Self-Scanning Radiometer (MESSR), obtained imagery in four spectral bands at a spatial resolution of 50 meters. MOS-1 also carried a microwave scanning radiometer and a visible/thermal infrared radiometer.

1990 to 2003: JAPAN'S REACH EXCEEDS ITS GRASP

The period from 1990 to 2003 saw the development of the indigenous H-2 launcher, development of the H-2A launcher, development of the Japanese Experiment Module (JEM) for the International Space Station, and the start of Japan's satellite reconnaissance

[2] Jane's Space Directory, Fifteenth Edition, 1999-2000.

program. Starting in 1994 that period also saw a string of failures affecting Japanese satellites and launch vehicles.

At first, the failures involved satellites. The first significant problem actually occurred in December 1993 when the short-wavelength infrared (SWIR) sensor on the JERS satellite was lost due to a malfunction of the cooler. However the visible-band sensors and the synthetic aperture radar (SAR) sensor on JERS continued to operate until the satellite ceased operation in October 1998, so the loss was not catastrophic. In August 1994 the second launch of an H-2 rocket successfully placed the ETS-6 satellite into an elliptical geosynchronous transfer orbit, but the bipropellant apogee kick engine on the satellite failed, and the satellite did not reach its intended geosynchronous orbit. The next satellite failure involved the Advanced Earth Observing Satellite (ADEOS), which was successfully launched in August 1996, but failed after only 10 months in orbit due to problems with the solar array. ADEOS-2, launched in December 2002, had a similarly short life, failing in October 2003.

In 1997 the failures spread to Japan's flagship launch vehicle, the H-2. Development of the H-2 represented the culmination of Japan's desire to have a launcher that was completely "made in Japan." The H-2 thus was not subject to the 1969 agreement with the U.S. that restricted any re-exporting of launchers utilizing U.S. technology, and could be used to compete in the international market for launch services. As events developed, however, the H-2 had a short and notably unsuccessful life.

To start, Japan is limited to two 90-day launch windows a year from the Tanegashima launch center to ensure that launches do not unduly interfere with the local fishing industry. As launch rate is one of the greatest factors affecting launch cost, any commercial launcher operating from Tanegashima has a built-in competitive disadvantage. Adding to this the H-2, with a nominal cost of about 19 billion yen, was significantly more expensive that comparable U.S., European, Russian, and Chinese launchers. No commercial payloads were ever launched on the H-2.

While not competitive on the international launch market, the H-2 had five successful launches of Japanese payloads from February 1994 to November 1997, a launch rate of about once per year. (The failure of ETS-6 to reach the proper orbit, as mentioned above, was due to a failure of the satellite's apogee propulsion system, not a failure of the H-2 launcher.) Then, in February 1998, an H-2 failed to place the Communications and Broadcasting Engineering Test Satellite (COMETS) into geosynchronous transfer orbit. The failure was traced to an early cutoff of the LE-5A cryogenic second stage engine. The next H-2 launch, in November 1999, failed due to a failure of the LE-7 cryogenic first stage engine. The failure resulted in the loss of the Multi-functional Transport Satellite (MTSAT). Thus, on successive launches each of the cryogenic engines developed by Japan failed. In December 1999 Japan decided to cancel the last remaining launch of an H-2, and to delay the introduction of the H-2A.

Recognizing that the H-2 was not commercially competitive, Japan had started development of the H-2A launcher in September 1995. The H-2A was designed for lower-cost production and operation. The target launch cost for the H-2A was 8.5 billion yen, but NASDA noted that costs could be further reduced for batch purchases. In 1996 Hughes Space and Communications (now part of Boeing) placed an order for ten H-2A launchers. Space Systems/Loral also placed an order for ten H-2A's. However these orders were cancelled in 2000 after the back-to-back failures of the H-2. Through spring 2004 Japan had failed to launch a single commercial satellite, despite the investment of over 320 billion yen for the development of the H-2 and H-2A launchers.

The first launch of the H-2A was in August 2001, and was a success. The second launch, in February 2002, was a partial success. The Mission Demonstration Test Satellite-1 was successfully launched, but ISAS's Demonstrator of Atmospheric Reentry System with Hyper Velocity (DASH), did not successfully separate from the payload mount. Two successful launches followed, of ADEOS-2 in December 2002 and of Japan's first two reconnaissance satellites in March 2003. Then in November 2003 an H-2A carrying the second pair of Japanese reconnaissance satellites failed, and both satellites were lost. Further launches were placed on hold. While the official position is that the H-2A will return to service by the end of 2004, Japan Aerospace Exploration Agency (JAXA) officials indicated that the return to service probably would not be before January 2005.[3]

Problems were not limited to NASDA programs; ISAS and the National Aerospace Laboratory (NAL) also suffered setbacks. In February 1995 the Hypersonic Flight Experiment (HYFLEX) test vehicle, which was to gather hypersonic data to support design of the HOPE-X reusable space shuttle, could not be successfully recovered after splashdown. In August 2000 Japan decided not to proceed with development of the HOPE-X. In February 2000 ISAS suffered a failure of the M-V rocket, and it was not returned to service until May of 2003. In December 2003 the Nozomi spacecraft, Japan's first attempted Mars mission, was abandoned when it could not successfully achieve orbit around Mars.

The causes for the failures encountered by the Japanese space program have been varied: coolers for sensors, apogee kick motors, solar arrays, loss of spacecraft communication, cryogenic first stage and second stage engines, solid rocket motors. There has not been a common technological cause that has resulted in multiple failures. The varied nature of the problems suggests there are not underlying design flaws that plague Japan's space program. Rather, it suggests that the common element may be a pervasive lack of rigorous testing, quality control and quality assurance. As we discuss later, such a lack may be the result of a space program that is under-funded and under-staffed, and a Japanese aerospace industry that lacks adequate incentives to invest in improved manufacturing and test facilities.

[3] The H-2A actually returned to service on February 26, 2005 with the successful launch of the Multi-functional Transport Satellite-1 Replacement.

ORGANIZATION OF JAPAN'S SPACE PROGRAM

Until recently NASDA and ISAS had separate programs overseen by different Ministries. Recent changes have sought to consolidate the space program and provide more efficient management and oversight. These organizational changes are reviewed below.

The organization of Japan's space program prior to 2000 is presented in Exhibit 3. The National Space Development Agency (NASDA) and the National Aerospace Laboratory (NAL) were under the Science and Technology Agency, while the Institute of Space and Astronautical Science (ISAS) was under the Ministry of Education. The Space Activities Commission (SAC), reporting directly to the Prime Minister's Office, was responsible for space policy for all elements of Japan's space activities.

Other agencies had space-related elements of their budget. The Ministry of International Trade and Industry (MITI) was primarily involved in aspects of Japan's remote sensing program and microgravity-utilization experiments. MITI was responsible for development of the synthetic aperture radar (SAR) and the optical sensor on the JERS-1 remote sensing system, as well as a number of sensors for environmental monitoring. The Ministry of Transport oversaw activities for meteorological satellites and satellite-based navigation and air traffic control. The Ministry of Posts and Telecommunications funded research and development of long-term satellite communications technologies. Other agencies with space-related elements of their budget were the National Police Agency, Environment Agency, Ministry of Agriculture, Forestry and Fisheries of Japan, Ministry of Construction, and the Ministry of Home Affairs.

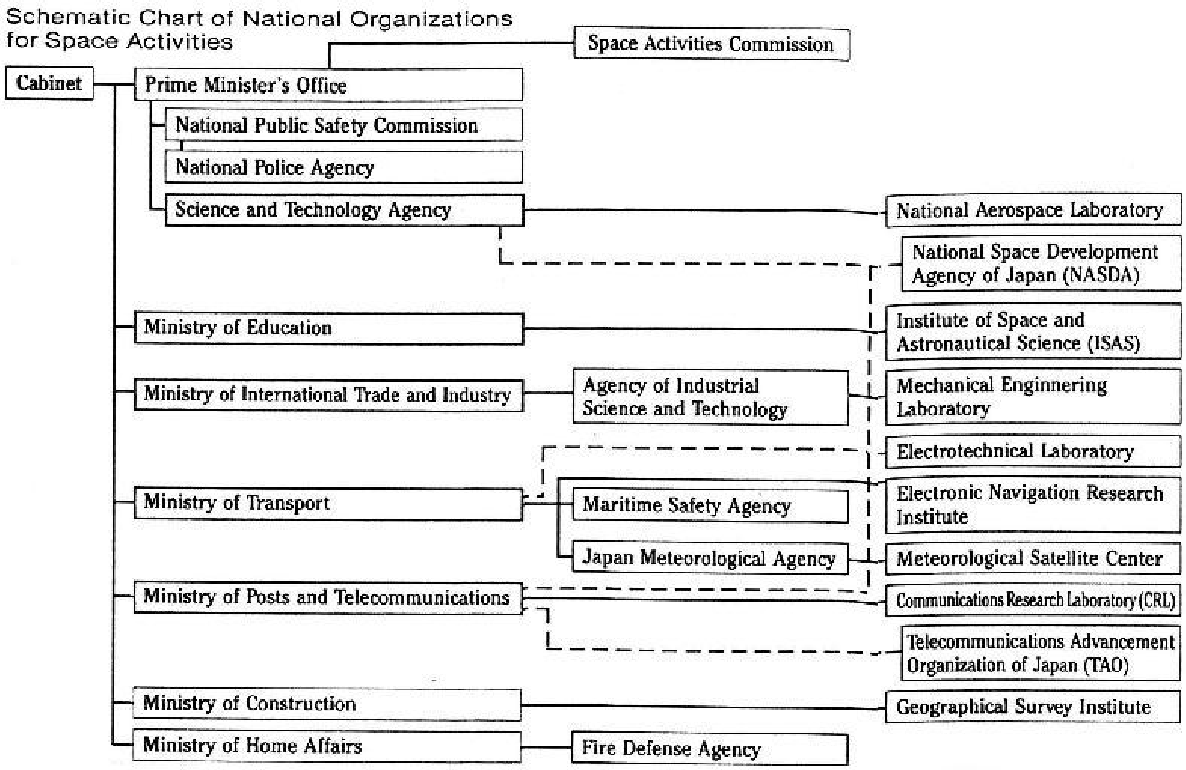

Exhibit 3: Organization of Japan's Space Program, Pre-2000

In 2000 a reorganization of Japan's Ministries occurred. The Science and Technology Agency and the Ministry of Education were combined in the Ministry of Education, Culture, Sports, Science and Technology (MEXT). This put the three major agencies executing Japan's space program, NASDA, ISAS, and NAL, under the same Ministry. This was the first step in consolidating the space program. The Space Activities Commission now oversaw the space-related activities of MEXT. A new body, the Council for Science and Technology Policy, was responsible for Japan's overarching space policy, reporting to the Cabinet Office. Other ministerial changes affecting the funding and oversight of the space program were combining the Ministry of Transportation and the Ministry of Construction in the Ministry of Land, Infrastructure and Transport; combining the Ministry of Posts and Telecommunications and the Ministry of Home Affairs in the Ministry of Public Management, Home Affairs, Post and

Telecommunications; changing the Environment agency to the Ministry of Environment, and changing MITI to the Ministry of Economy, Trade and Industry (METI).

On October 1, 2003, Japan's space program was further consolidated. NASDA, ISAS and NAL were combined in a new agency, the Japan Aerospace Exploration Agency (JAXA). The Ministry of Finance had sought this consolidation as a means of improving the efficiency of the space program, with expected annual saving of about 10 billion yen.[4] The current organization of Japan's space program, reflecting both the Ministry reorganizations and the creation of JAXA, is presented in Exhibit 4. As will be discussed later, Japan's satellite reconnaissance program is run from the Cabinet Secretariat, with technical management by JAXA.

The creation of JAXA provided an opportunity to truly try to develop a unified culture for Japan's space program as well as a unified organizational structure. NASDA and ISAS historically had different cultures arising in part from the differences between their parent Ministries and in part from the fact that ISAS grew from and maintained an academic culture while NASDA came from more of an applied engineering environment.

A review of Exhibit 5, which presents JAXA's internal organization, suggests that the opportunity to reconcile these two approaches was not taken. JAXA's Institute of Space and Astronautical Science is essentially the old ISAS. Similarly, the old NAL resides in the Institute of Space Technology and Aeronautics, although there also are elements of NASDA here. The Office of Space Flight and Operations and the Office of Space Applications are all comprised of portions of what was NASDA. Thus, each pre-existing culture remains largely intact within JAXA. At the functional level there has been very little actual merging of the old organizations.

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[4] http://in.news.yahoo.com/031001/137/284sj.html.

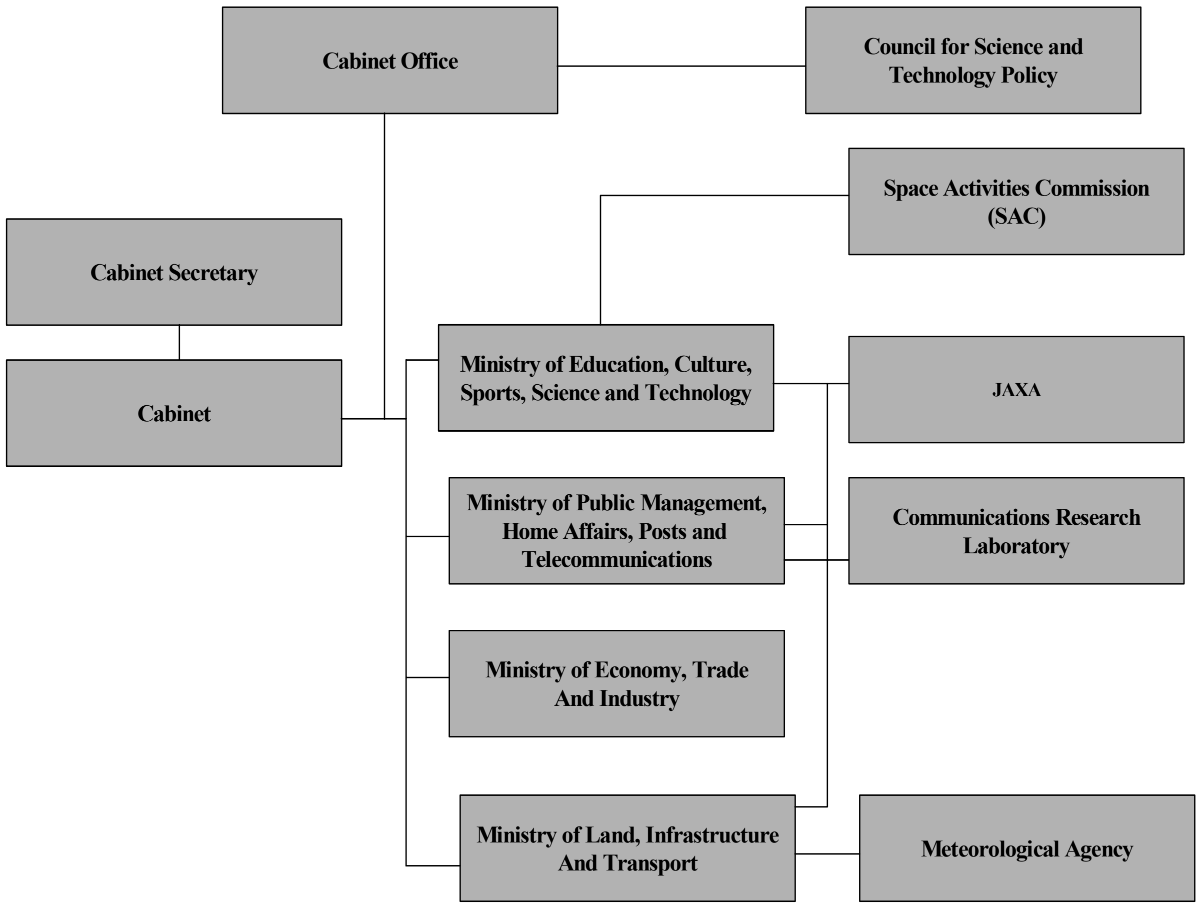
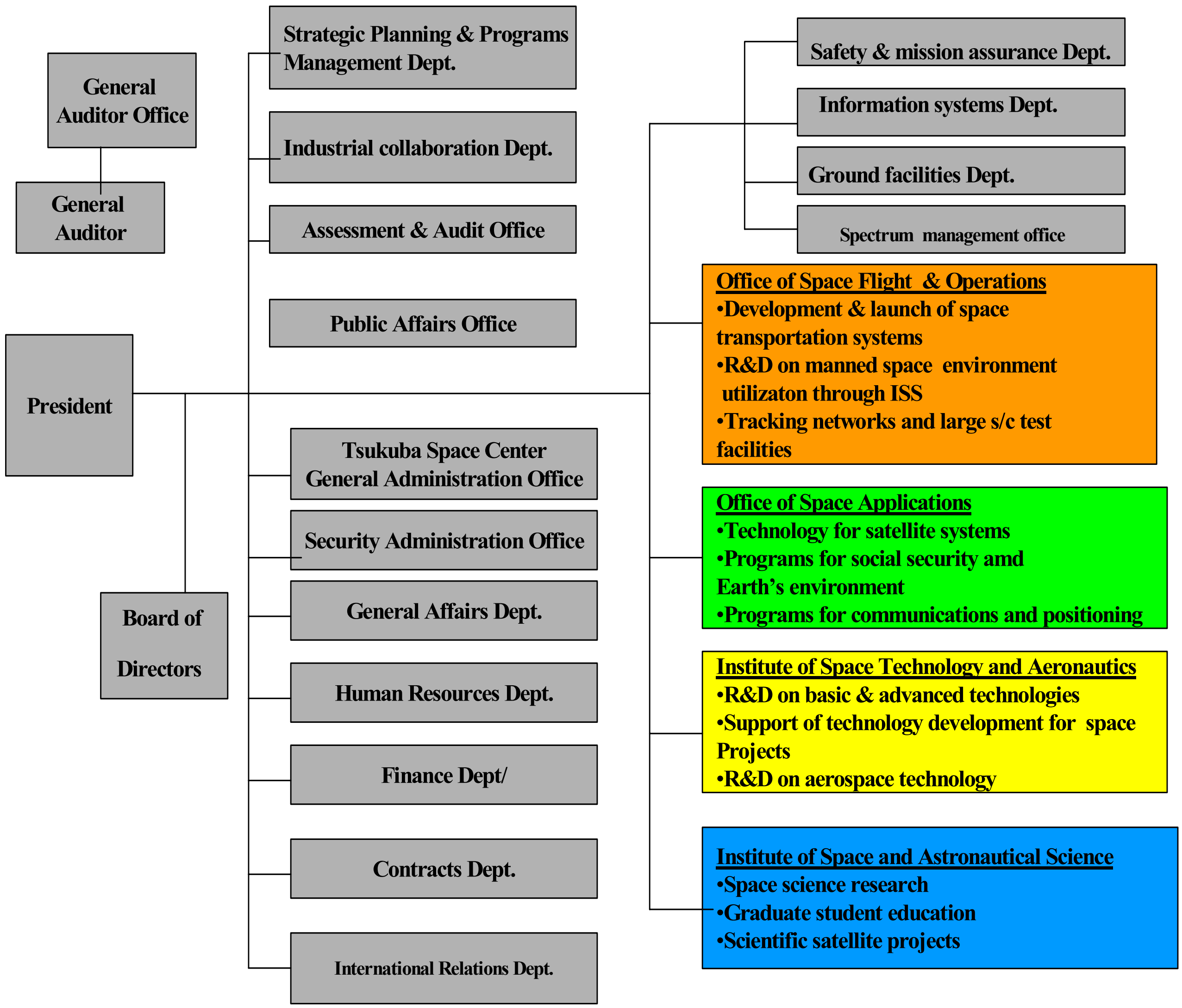


Exhibit 4: Current Organization of Japan's Space Program

Exhibit 5: Organization of JAXA



JAPAN'S SATELLITE RECONNAISSANCE PROGRAM

While Japan has consolidated its civil space program, it also has started a military space program that will compete with the civil program for available resources. We review the military space program below.

In late 1998 Japan publicly announced its plans to develop and deploy a military/intelligence satellite reconnaissance system. The proximate cause for this decision was the August 1998 launch by North Korea of a Taepo Dong missile on a trajectory that over flew Japan. The North Korean launch prompted unanimous support in the Diet for development of an indigenous Japanese reconnaissance system. Prior to the Korean launch Japan had studied various options for satellite reconnaissance systems. As far back as 1993 a defense advisory panel had recommended that Japan should develop its own satellite reconnaissance system; and feasibility studies were funded in 1997.[5] However, Japan appeared content to plan on buying 1-meter-quality imagery from U.S. commercial suppliers of satellite imagery. Toward that end Hitachi had agreed to purchase and supply imagery from Earth Watch's (now DigitalGlobe) satellites, and Mitsubishi had partnered with Space Imaging to distribute their products. The Taepo Dong launch, however, convinced the ruling Liberal Democratic Party that Japan needed its own reconnaissance system.

Mitsubishi Electric was awarded a contract in March 1999 to begin system design for the program. In September 1999 a government-to-government agreement was signed between Japan and the U.S. to allow participation of U.S. firms in the program as suppliers of subsystems or components. However, Japan opted not to buy a complete satellite from the US.

The reconnaissance program, referred to as the Information Gathering Satellites, is run from the Cabinet Secretariat, which reports directly to the Cabinet. The Cabinet Satellite

[5] Japan Economic Institute, No. 33, August 27, 1999.

Intelligence Center was established in March 2003 with a staff of 320, including approximately 100 imagery analysts.[6] (Japan has sought training for as many as 150 imagery analysts from the United States.) Technical management of the program is handled by JAXA. Through 2003 a total of 261.469 billion Japanese yen, or about 2.29 billion U.S. dollars, has been spent on the program.[7]

The reconnaissance system is to consist of electro-optical satellites with 1-meter resolution and synthetic aperture radar (SAR) satellites with resolution of 1 to 3 meters. A total of eight satellites are planned to be launched by March 2009.[8] There also had been discussion of launching a geosynchronous data relay satellite. Japan has since launched the DRTS data relay satellite. This satellite had been in development prior to the announcement of the reconnaissance program. It is scheduled to relay data from the ALOS satellite and JEM. It is not clear whether it also will relay imagery from the reconnaissance satellites.

An H-2A rocket successfully launched the first pair of reconnaissance satellites, one optical and one SAR, on March 28, 2003. Their operational altitude is about 500 kilometers. However the second pair of satellites was lost in November 2003 when their H-2A launcher had to be destroyed about 10 minutes after launch. The failure has since been traced to a hole that burned through the nozzle of one of the solid rocket boosters, allowing hot gas to cut through electrical wiring that carried the command for the booster to separate from the main fuselage.[9]

There has been no indication that the November launch failure has caused any lessening of political support for the reconnaissance program. In discussions with personnel from JAXA, they did not see any likelihood that the program would be reduced. In fact, these individuals talked about an upgraded version of the H-2A launcher that may be developed. At present the only planned payload that would require an upgraded H-2A is

[6] Kyodo News, March 28, 2003.
[7] Information provided by JAXA.
[8] Kyodo News, March 28, 2003.
[9] Description of the current findings of the investigation into the launch failure was provided by JAXA.

the H-2A Transfer Vehicle (HTV) for re-supplying the International Space Station. However a more capable launcher also would expand the design envelope for future Japanese military/intelligence satellites.

Japan has used its civil space program to develop some of the key elements of its reconnaissance program. An assessment of Japan's remote sensing capabilities performed in 2000 found that a modified version of the PRISM sensor developed for the ALOS system could achieve 1-meter resolution from an altitude of about 500 kilometers[10]. That assessment also found that the AVNIR-2 sensor could provide close to 1-meter-resolution multispectral imagery from a similar altitude. Thus, Japan had successfully developed through its civil remote sensing program the sensor technology needed for the 1-meter-resolution class optical imagery for its first generation optical reconnaissance satellites.

Japan's space-based SAR experience is at L-band. It flew an L-band SAR on the JERS-1 system, and has developed an L-band SAR for the ALOS system. The previously referenced assessment concluded that the Japanese SAR reconnaissance satellite would likely be based on the technology developed for the PALSAR on ALOS. The PALSAR is capable of realizing about 4.5-meter single-look azimuth resolution and about 7-meter range resolution. Improvements to the system were needed for Japan to realize its stated objective of 1-to 3-meter SAR imagery.

Thus, Japan has successfully used its civil remote sensing program to develop the jumping-off sensor capabilities for its satellite reconnaissance program. However Japan has not demonstrated the same level of capability for attitude determination and control systems or on-board storage systems. These may be among the areas where Japan received assistance from U.S. firms. In a broader context the reconnaissance program, along with an increased commitment to playing a role in theater missile defense, may be

[10] "Worldwide Capabilities and Demand for Remote Sensing Systems", Berner, Lanphier and Associates, September 26, 2000.

part of a nascent but growing willingness by Japan to begin assuming a greater military role in the region.

FACTORS AFFECTING JAPAN'S SPACE PROGRAM

Several factors may lie behind the recent spate of problems Japan has encountered in its space program. These factors also are likely to affect the future direction of the program. We address them below.

BUDGETARY CONSTRAINTS

Perhaps the single greatest factor restricting Japan's space program is the limited funding the program receives. In 1998 the Committee for NASDA's Evaluation cited the shortage of budgetary resources and the need to increase those resources as one of the basic problems confronting NASDA.[11] A review of historical and recent funding trends indicates that under-funding of the space program has been a long-standing problem, and one that has gotten worse in recent years. (See Exhibits 6 and 7, which are discussed later.)

One measure of the importance attached to space is the percent of Gross Domestic Product (GDP) dedicated to space. Since the 1970s NASDA's budget has varied from 0.025% to 0.04% of Japan's GDP. As NASDA's budget typically represented about 75% of the Japanese government's total spending on space activities, the corresponding numbers for total Japanese space expenditures would be between 0.033% of GDP and 0.053% of GDP. By contrast, NASA's 2002 budget represented about 0.14% of U.S. GDP; and this number does not include the substantial sums the U.S. spends on national security space programs.

[11] A summary of the committee's findings and recommendations can be found at www.nasda.go.jp/press/1998/11/hyouka_981125_a_03_e.html.

It also is instructive to compare Japan's space expenditures with those of France, the leading European space power. In 2003, the budget for the Centre Nationale de Etudes Spatiale (CNES), the French space agency, was approximately 1.31 billion Euros. This represented about 0.095% of French GDP, well above the percentage of GDP invested by Japan.[12] Furthermore, during the mid- to late 1990s, when France was developing the Helios 2 reconnaissance system, the total French space budget exceeded 1.9 billion Euros, an even more pronounced spread relative to Japan.

NASDA's budget is roughly one-tenth that of NASA, and about one-third that of the European Space Agency (ESA). Exhibit 6 provides a comparison of U.S., European, and Japanese space budgets from 1980 to 2003.[13] Japan's funding is seen to be well below that of competing Western programs. Thus, both in absolute terms and as a percent of GDP, Japan's investment in its space program significantly lags that of the United States, France, and ESA. At the levels of funding the program has received there is reason to question whether space has ever held the highest level of importance to the Japanese government, despite its ambitious objectives.

[12] Figures for the CNES budget are from France in Space #225, accessed at www.spaceref.com/news/viewsr.html?pid=+7735. Figures used for French GDP are from the U.S. Department of State, and were accessed at www.state.gov/r/pa/ei/bgn/3842.htm.
[13] The Exhibit is from Space Daily, December 11, 2003, accessed from www.spacedaily.com/images/govt-spend-1980-2003-chart.jpg.

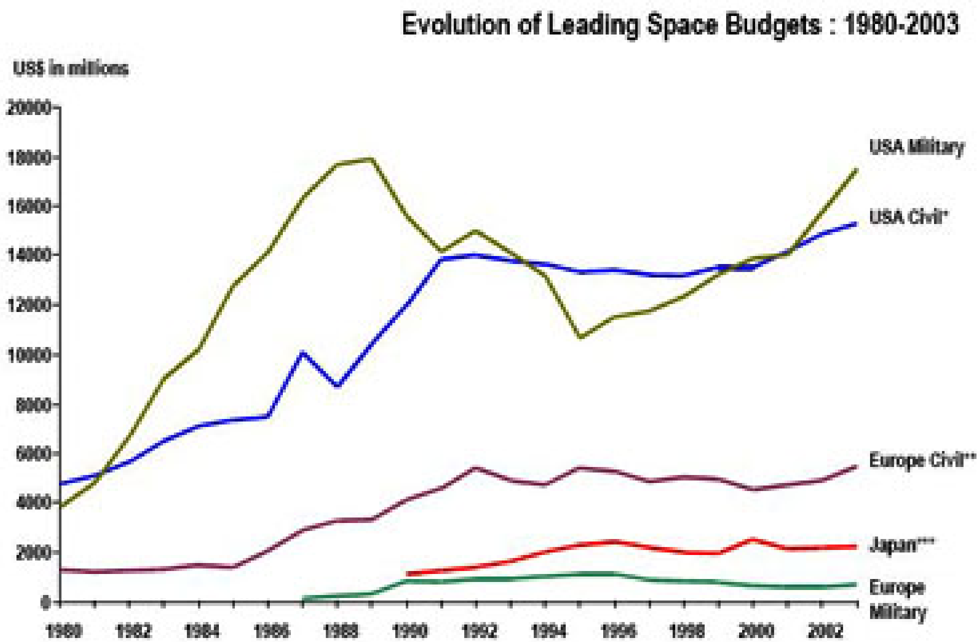


Exhibit 6: Comparison of Space Budgets

Exhibit 7 presents a more detailed view of Japanese space expenditures for the Japanese fiscal years from 1995 to 2003.[14] Not only has NASDA's budget not received the increases recommended by the 1998 Evaluation Committee, the combined budgets of NASDA, ISAS, and NAL have been sharply reduced starting with the 2000 fiscal year. The increase in total Japanese space expenditures from 2000 to 2003 is almost totally traceable to the "Information Gathering Satellite" program funded through the Cabinet Secretariat. As noted previously, this is Japan's satellite reconnaissance program. The Exhibit also illustrates the reorganization of government ministries in 2000, which has been discussed previously.

Reductions in Japan's space expenditures are traceable to overall weakness in the Japanese economy. The economy first went into a two and a half year recession starting in 1991, but began recovering in late 1993. However in late 1997 the Japanese economy again went into recession. The Koizumi administration has been committed to structural

[14] Information provided by JAXA.

reform of the Japanese economy. The FY 2003 budget sought to prioritize areas that would contribute to a private sector-led recovery, citing such areas as urban renaissance

Ministry	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Cabinet Secretariat	0	0	0	0	1,374	50,644	77,333	67,678	64,440	
Science & Tech Agency (NASDA & NAL)	177,072	178,297	180,741	182,532	187,320					
Min. of Education (ISAS)	21,414	22,072	21,970	22,446	19,378					
Total NASDA, ISAS, NAL	198,416	200,369	202,711	204,978	206,698					
MEXT (NASDA, NAL, ISAS)						191,640	175,468	191,426	184,322	179,233
MITI	12,754	11,017	11,566	9,752	13,263					
METI						11,477	12,093	11,928	2,434	
Min. of Transport	12,328	13,722	20,646	23,872	20,565					
Min. of Construct.	1,487	1,566	1,640	1,666	2,021					
Min of Land, Infra. and Transport						16,506	17,428	19,581	18,359	
Other										
TOTAL (Million Japanese Yen)	228,508	231,245	243,920	247,429	251,421	274,264	285,871	295,006	273,201	

Exhibit 7: Japan's Space Budget (Numbers are in millions of Japanese yen)

and science and technology.[15] However, space does not appear to be one of the areas of science and technology being given prominence. In its description of the promotion of science and technology in the FY 2002 budget, the Ministry of Finance (MoF) noted that "Priority is given to four research areas which are studies on life science, information technology, environmental technology, materials and nanotechnology whereas expenditures for big projects, such as those in the area of space development, decreased."[16] In its similar discussion of the promotion of science and technology in the FY 2003 budget the MoF again cites life science, info-communications, environment, and nanotechnology and material as priority areas. Space development is not even mentioned.[17]

In this economic and fiscal environment the likelihood that JAXA will get any significant budget increases in the near future seems remote. The Japanese space program, which was never the beneficiary of particularly generous or robust funding, may well have to get by with less. It is questionable whether there will be funding for any major new initiatives, and the ability to successfully complete what is currently on the table may be called into doubt. One area that may, however, see continued and possibly increased funding is Japan's nascent military/intelligence space program, depending on Japanese leadership's perception of trends in regional security in Northeast Asia and elsewhere.

LACK OF A CLEAR STRATEGIC VISION OR MISSION FOR THE SPACE PROGRAM

During the late 1980s and early 1990s there was a view among many in the U.S. space community that Japan had a well thought out strategy for their space program. The model many thought was in play was that Japan would start learning on first generation

[15] For an overview of Japan's fiscal situation see www.mof.go.jp/english/budget/brief/2003/2003-06.htm.
[16] www.mof.go.jp/english/budget/brief/2002/2002-12.htm.
[17] www.mof.go.jp/english/budget/brief/2003/2003-10.htm.

systems that would largely be built by U.S. suppliers; would increase Japanese content on second generation systems while continuing to benefit from U.S. assistance; and would field indigenously developed third generation systems that then would compete with U.S. suppliers while benefiting from a captive domestic Japanese market. The fact that the Ministry of International Trade and Industry (MITI) was involved in Japan's remote sensing program was taken as an indication that Japan saw large commercial applications in that field. Similarly, the facts that Japan was the first country to field an operational Ka-band satellite and a direct broadcast satellite were seen as strategic steps towards developing new satellite communications markets. A joint NASA / NSF panel on satellite communications reported in 1993 that "the key element of Japanese development policies with regard to critical new technologies can be summed up by 'integrated thinking and planning.'"[18]

It is unquestionably true that Japan had a strategy to acquire launcher and satellite technology from the U.S., and to eventually become independently capable in leading-edge space technologies. What is not clear is why Japan has sought to develop such capabilities, and why they have sought to be on a par internationally in space. When questioned about the purpose and benefits of the space program JAXA officials noted that space gives dreams and hopes to the public.[19] (As we note later, those dreams and hopes do not appear to have translated to broad-based public support for the space program.) Those same officials noted that economic benefits from the program are unclear.

In some ways, Japan appears to be pursuing its space program more because "that is what great powers do" than because there is a compelling strategic vision behind the program. Several knowledgeable individuals interviewed during this study expressed this view, and noted the apparent lack of an overall strategy that guides the program. And, as

[18] "NASA/NSF Panel on Satellite Communications Systems And Technology (1993)"; study can be found at www.wtec.org/loyola/satcom/toc.htm.

[19] Interview with Masato Koyama, Director of JAXA's Washington Office, Motoyasu Abe, Deputy Director, and Hitoshi Tsuruma, Deputy Director, May 12, 2004.

noted previously, the size of Japan's space budget is not commensurate with a major strategic effort.

A review of the Fundamental Policy of Japan's Space Activities also fails to find an articulation of an overall vision or rationale for the space program. The Fundamental Policy of Japan's Space Activities was first developed by the Space Activities Commission in March of 1978. It was revised in February 1984, June 1989, and January 1996.[20] Several assumptions in the 1996 version seem to have been overtaken by events. The document holds out the promise of space technology yielding new industrial technologies and new industrial sectors. There is little evidence of such developments to date. It also calls for emphasis on civilian use and international cooperation in space; yet the most significant new development in Japan's space program arguably is its military/intelligence program.

The Basic Policy cites seven underlying goals:

- Promotion of creative science research and technology development
- Encouragement of development to meet social needs
- Realization of economical space activities
- Active promotion of international cooperation
- Well-balanced development of manned and unmanned space systems
- Development of space industry
- Preservation of space environment.

Within these broad goals five priority areas for space development are discussed:

- **<u>Promotion of Earth Observation and Earth Science</u>**. Within this area three types of earth observing satellites are developed: atmospheric and ocean, land observation, and meteorological.
- **<u>Promotion of Space Science and Lunar Exploration</u>**. Activities in this area are largely carried out by ISAS. Japan takes great pride in its space science program. The policy calls for launching medium-size science satellites about once a year,

[20] A provisional translation of the 1996 version can be found at www.mext.go.jp/english/kaihatu/aerosp01.htm.

and large science satellites on an unspecified but presumably less frequent basis. The policy calls for unmanned exploration of the moon, and holds out the prospect of future scientific observation from the moon in the context of international cooperation.

- **Consolidation of Space Utilization Activity**. This area largely focuses on utilization of the Japanese Experiment Module (JEM) as part of the International Space Station.
- **Sophistication of Generic Satellite Technology and Utilization.** This broad area encompasses development of generic technologies such as those developed through the ETS series of satellites as well as the development of advanced application missions and hardware in the areas of telecommunications, broadcasting, and navigation. It includes such areas as millimeter-wave and laser communications technology, mobile digital multimedia broadcasting, and gigabit-rate satellite communications. The Quasi-Zenith GPS augmentation system also would fall into this category.
- **Development and Operation of New Space Infrastructures**. As written, this area encompasses the H-2A, an upgrade to the M-V launcher, development of the J-1 launcher, development of the HOPE-X, development of the H-2 Transfer Vehicle, initiation of studies for a reusable unmanned vehicle, and studies of a reusable manned vehicle.

In its current form, the policy does not provide a clear mission or a coherent vision for Japan's space program, and does not provide a basis for setting priorities among or within multiple programs. Some of the programs for new space infrastructure specifically cited in the policy already have been cancelled or put on hold. Within programs there often are conflicting objectives. The same program might be intended to meet operational user needs, demonstrate new technologies, and be a demonstration of potential new applications. The Committee for NASDA's Evaluation noted this lack of a clear focus for many ongoing programs, and cited the need for clarification of program objectives, goals and priorities.

China's emerging role as a significant space power and as the third country to have its own manned space program may provide a new stimulus to focus Japan's space program. Indeed, the recent success of China's manned space program has been cited as one of the factors behind the ongoing review of Japan's space policy by the Council for Science and Technology Policy.[21] Given the current fiscal situation, however, it seems unlikely that Japan will commit the resources to engage in a head-to-head contest with China for the role of overall space leadership in Asia. The likelihood that Japan will pursue an independent manned space program as an answer to China's seems low.

STATUS OF JAPAN'S SPACE INDUSTRY AND ITS RELATIONSHIP WITH JAXA

Japan's space industry rose to a status where, by the early 1990s, it led U.S. commercial suppliers in 5 of 20 key satellite communications payload technologies, and were roughly even in 5 more.[22] While these growing capabilities at the component level manifested themselves in Japanese firms gaining an increasing portion of work as subcontractors on some international comsat procurements, they have not translated to successfully competing as prime contractors on the international market. This weakness in international competitions even extends to the domestic Japanese market. Non-R&D Japanese communications satellite systems, which since 1989 must be open to full competition, to date have not used Japanese suppliers for their spacecraft. The Superbird C satellite, launched in 1997, was built by Hughes Space and Communications using their HS-601 bus. Space Systems/Loral built the two preceding Superbird satellites. Space Systems/Loral also built the two NSTAR satellites for Nippon Telegraph and Telephone.

[21] See, for example, the Japan Times, January 31, 2004.
[22] See "Implications for U.S. Competitiveness in Launch Vehicles and Communication Satellites", Berner, Lanphier and Associates, November 1992.

The failure of Japanese aerospace firms to successfully compete as prime contractors on the global market is frequently attributed to weakness in the area of system integration. Such a weakness is consistent with the fact that JAXA (and its predecessors) has been the main customer for Japan's space industry. JAXA, not industry, has developed design requirements for most of their satellites. JAXA serves as the prime contractor and system integrator, and is responsible for acceptance testing and quality assurance. Japanese aerospace firms build to JAXA's specifications, and provide JAXA with the completed system or subsystem. Contracts tend to be of a fixed-price nature, with little dynamic interaction between the customer (JAXA) and the companies.[23] Thus, the structure is undercutting Japanese aerospace companies' chances to gain important experience. Japanese firms are acting more as subcontractors than as prime contractors. These factors may explain some of the difficulty Japan's space industry has in converting its prowess in particular subsystems and components to similar strength as prime contractors in the global market.

Officials from JAXA noted that they are trying to improve their relationship with industry.[24] JAXA has a new Industrial Collaboration Department. The purpose of the department is to improve the transfer of technology both from JAXA to industry and, where possible, from industry to JAXA. The same officials also noted, however, that there is virtually no investment from industry in space. For the two major Japanese aerospace firms, Mitsubishi and NTSpace (formed by the merger of the space units of NEC and Toshiba), space represents a small part of their overall business, and is not strategically important to their success. This may explain why, as a co-chairman of the Committee for NASDA Evaluation's Subcommittee for Space Transportation observed, there is no tradition of Japanese industry making the investments needed for high reliability space systems.[25]

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[23] Interview with Joan Rolf and Rebecca Spyke Gardner, Code I, NASA Headquarters, May 7, 2004.
[24] Interview with Masato Koyama, Director of JAXA's Washington Office, Motoyasu Abe, Deputy Director, and Hitoshi Tsuruma, Deputy Director, May 12, 2004.
[25] Interview with John Logsdon, Director of the Space Policy Institute, George Washington University, May 5, 2004.

Japanese industry has been notably more successful in penetrating the ground segment and user terminal markets than they have been at penetrating the satellite or launcher markets. Receiver systems for Very Small Aperture Terminal (VSAT) satellite communications networks, Direct Broadcast Satellite (DBS) systems, and Global Positioning Satellite (GPS) consumer units are manufactured in large numbers, not the very small numbers that characterize satellites. The receiver markets play to the strength of Japanese industry in large-volume production for consumer applications. The satellite and launch vehicle markets, by contrast, do not.

LACK OF BROAD BASED PUBLIC SUPPORT

The space program does not appear to have widespread support among Japan's general population. In a 1997 survey by the National Institute of Science and Technology Policy of the Science and Technology Agency fourteen areas were surveyed to assess the degree of importance attached to them. Space had the next-to-lowest rating, exceeding only "urbanization and construction". Of the top 100 topics, only two were space related.[26] Space does not seem to have captured the imagination of the public.

More recently there has been much editorial and political criticism of the failures of the space program.[27] The program lacks a champion at the highest levels of the government. The Japanese public is becoming increasingly skeptical of claims that the space program will produce major economic benefits. This skepticism particularly applies to the benefits of materials processing in space. JAXA officials also noted that the economic benefits of the space program are not always evident, and that JAXA needs to do a better job of developing and explaining those benefits to the public.[28]

[26] See "The Sixth Technology Forecast-Future Technology in Japan Toward the Year 2025", Fourth Policy-Oriented Research Group, National Institute of Science and Technology Policy, Science and Technology Agency, Japan, June 1997.
[27] See, for example, The Wall Street Journal, May 6, 2004, The Japan Times, January 31, 2004, and Japan Space, April 11, 2001.
[28] Interview with JAXA officials..

LIMITED STAFFING LEVELS

Exhibit 8 presents staffing levels for NASDA, ISAS, and NAL for the period 1994 to 2004.[29] Despite significant increases in program activities during that time, including development work on the H-2A and JEM, and technical management of the Japanese reconnaissance program that started in 1998, staffing levels have been fairly constant. As of 1998, staffing levels for NASDA represented approximately 1/20th the number of government employees at NASA. With a budget of about 1/10th of NASA's, NASDA thus had roughly ½ the staffing per dollar of spending. At the same time, the percent of work dedicated to administrative tasks has increased. Thus the number of engineers actually engaged in technical work is decreasing.[30] One result is that there is less staff time dedicated to quality control and quality management. This may have been a contributing factor to the failures NASDA has experienced since 1994.

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
ISAS	298	299	298	299	299	296	300	297	294	291	288
NAL	436	434	431	428	427	425	424	413	408	409	409
NASDA	967	973	979	1019	1038	1057	1079	1088	1090	1090	1076
Total	1701	1706	1708	1746	1764	1778	1803	1798	1792	1790	1773

Exhibit 8: Staffing Levels

ABSENCE OF MAJOR DEFENSE AEROSPACE INVESTMENTS

With its pacifist constitution, Japan's defense budget has been limited. The Japanese defense budget in 2004 is 4,903 billion yen, or about 45.8 billion dollars. By comparison the U.S. defense budget for 2004 is about 400 billion dollars. The major U.S. aerospace firms, Boeing, Lockheed Martin, and Northrup Grumman, also are leading defense

[29] Information provided by JAXA.
[30] Discussions with JAXA personnel.

contractors. Significant portions of their space capabilities derive from government investments in national security space programs. Some capabilities, including most historical U.S. launch vehicles, are directly traceable to earlier military programs. The new generation of Evolved Expendable Launch Vehicles is being developed with government funding. U.S. Department of Defense (DoD) spending on space in 2003 was over $17 billion, and is projected to grow to $25 billion in 2010.[31] The $17 billion figure represents about 4% of the defense budget. To a lesser but still significant extent Europe's leading space firm, Astrium, has benefited from the defense aerospace work of its parent company EADS. European space firms also have been able to leverage their space investments through jointly funded ESA programs.

The Japanese space industry largely lacks these benefits. Until 1998 there was no direct defense contribution to Japan's space program. The space sector had to get along on the basis of a civil space budget of around $2 billion or less. That has changed with the start of Japan's satellite reconnaissance program. However spending to date on the program has averaged only about $570 million per year for the period from 2000 to 2003. Should Japan increase their defense space funding to 4% of the defense budget, as the U.S. currently does, funding of the Japanese military space program would be at about $1.8 billion. This would roughly triple the current funding level, and put funding of the military space program at the same level as the current civil program. Japanese space firms still would not begin to approach the levels of government funding their U.S. counterparts receive, but would approach a level similar to the French space industry. Japan also is seeking to play a larger role in the area of theater missile defense, and some of the technologies for missile defense also can be of benefit to their space program. As we discuss below, a significant increase in its military space program is one of the options that may emerge from Japan's space policy review.

[31] SpaceDaily, December 11, 2003.

FUTURE DIRECTIONS

Japan's space program is at a crossroads. Funding for the civil program has been decreasing. At the same time Japan is seeing China embark on a manned space program. The U.S. is calling for a reinvigorated space exploration initiative. North Korea continues its ballistic missile and nuclear weapons programs. Decisions made by Japan in the near future, starting with a new policy statement planned for release soon, will go a long way toward determining Japan's future direction in space.

Four broad alternatives that Japan may pursue are the following:

1. Maintain current funding levels and maintain current programs, commitments, and plans (i.e., status quo).
2. Maintain current funding levels, but scale back programs, commitments, and plans so that ambitions are more consistent with funding.
3. Pursue a primarily civil/commercial focus, with increased funding and staffing for the program.
4. Pursue a military/intelligence focus for the program.

Under either Option 1 or Option 2 total funding for the space program would remain flat at about the current 275 billion yen level. Any increases in spending on Japan's reconnaissance program would come at the expense of the civil program. Under Option 1 there would be no major reductions to current and planned programs. Within the flat funding (or less if the military space program is increased) all applications-oriented programs would go forward. An augmented version of the H-2A launcher would be developed. In the areas of space science and lunar exploration the SELENE and Lunar-A programs would go forward together with the Planet-C mission to Venus and an average of one small space science mission per year. JAXA would thus continue to be over committed. Quality control likely would remain one of the areas under-funded and under-staffed. Likewise Japanese industry would have little incentive to invest in improved manufacturing and testing facilities for high reliability space systems. Under Option 1 the performance that has characterized Japan's space program over the last ten years likely would continue; a record of significant accomplishments interspersed with notable and recurring failures.

Under Option 2, Japan would reduce its space ambitions to more accurately reflect the funding the program receives. There likely would be no major new program starts for the next several years. Space exploration would be limited to the SELENE and Lunar A programs, perhaps tied in with the U.S. space exploration initiative. Some current or planned programs may be delayed, cut back, or eliminated. However the options for savings are limited. Among major remote sensing applications-oriented programs, ALOS is built and waiting for launch. GOSAT, planned for launch in 2007, is to measure greenhouse gases. These measurements are to support understanding and monitoring of global warming, an area that has great political support in Japan, as evidenced by the 1997 Kyoto protocol. It seems unlikely that GOSAT will be cut. There is thus limited potential for savings in the remote sensing area.

Among major communications/navigation applications programs, the Wideband InterNetworking engineering test and Demonstration Satellite (WINDS) is being jointly developed by JAXA and the National Institute of Information and Communications Technology, and is part of the government's e-Japan Priority Policy Program for information technology. It thus is likely to continue going forward. The ETS-VIII satellite is largely completed. This would leave the Quasi-Zenith Satellite System as the applications-oriented program potentially most vulnerable to delays, stretch-outs, or possible cancellation under Option 2.

Another potentially vulnerable program under Option 2 is the H-2 Transfer Vehicle (HTV), which is intended to transport cargo to the International Space Station. The HTV requires an augmented version of the H-2A launch vehicle, a launcher already facing problems. At present the HTV is the only payload requiring such an upgrade. At the same time, Japan has voiced concerns that it may not get as much utilization of the space station as planned.[32] In a tight budget environment and with reduced expectations of the payoff they will get from their investments in the International Space Station program, Japan might conclude that delaying or deferring the HTV is an attractive cost-saving option.[33]

As in Option 1, there would be little incentive in Option 2 for Japanese industry to invest in space. Delays or cancellation of the Quasi Zenith Satellite Program would be a further setback to Japanese space commercialization. Another on-again / off-again commercial space effort, the Galaxy Express low-Earth orbit launch vehicle, also would be a likely victim in this fiscally-constrained environment.

Under Option 3 Japan would decide to make major new investments in their civil/commercial space program. This would bring funding of the program more in line with its stated ambitions. JAXA's budget would be significantly increased, and a renewed emphasis would be given to the civil space program. To begin with, JAXA's programs would not be cut as would happen under Option 2. Quality control would receive increased attention and funding. An enhanced version of the H-2A would be developed, and the HTV would be completed. Japan would more aggressively proceed with the Quasi Zenith Satellite System. An expanded lunar program, beyond SELENE and Lunar-A, would be pursued, and Japan might seek to join U.S. space exploration efforts in an expanded role. The most ambitious version of Option 3 would have Japan pursue an independent manned space program to directly compete with China for leadership among Asia-Pacific space powers. (As noted earlier, we judge such a manned program to be unlikely under prevailing economic conditions.)

Finally, Japan may decide to shift the focus of its space expenditures from the civil space program to the newly emerging military/intelligence space program. North Korea's current and evolving ballistic missile and WMD capabilities may convince Japan that it needs its own launch detection system, in addition to improved reconnaissance

[32] See for example, "NASA Advisory Council Meeting Minutes, December 6-7, 2001", NASA Headquarters, Washington, D.C.
[33] Given this option, Japan could be receptive to a changed role in the ISS.

capabilities. China's continuing military build-up also may fuel Japanese desires for greater independent reconnaissance and surveillance capabilities. The push towards independence is illustrated by Shuichiro Yamanouchi, President of JAXA, who was quoted in March 2003 as saying regarding the Information Gathering Satellite program: "It's a kind of technological independence. Information independence. For the Japanese it's very important."[34]

Should Japan increase its military space program it would be part of a gradual but continuing shift of government policy and public acceptance regarding the use of military forces. The deployment to Iraq of elements of the Self Defense Force is merely the most recent example of such changes.[35] These shifts will present new challenges and opportunities for U.S. policy-makers. In the near- to mid-term Japan will continue to look to the U.S. for some key satellite components. Perhaps as important, Japan will continue to seek training for imagery analysts, mission planning, and related hardware and software. This will provide the U.S. with some degree of leverage over the pace of Japanese developments. It also will present opportunities for cost sharing on some programs, such as a theater missile defense system for East Asia, as well as economic opportunities for U.S. aerospace contractors who may supply Japan with subsystems or components for satellite systems.

Assisting Japan in their military space program, however, is not without its risks. Many Asia-Pacific countries remain concerned about any increased military role by Japan. China and Indonesia, for example, have expressed concerns that Japan's role in a missile defense system could spark a regional arms race. An independent Japanese

[34] BBC News World Edition, Friday, 28 March 2003. Similar sentiments were expressed in an editorial in the March 29, 2003 *Sankei Shimbun*, which stated "A country that has to rely on information from abroad when it comes to deciding whether to go this way or that cannot be said to have true sovereignty."

[35] Arguably the shift dates to at least 1992 when Japan passed a law allowing participation in UN peacekeeping efforts. More recent examples include the sinking in 2001 of a North Korean espionage ship that was in Japanese waters, the 2003 White Paper on Defense that talks of a historic turning point in Japan's security policy, and the decision in December 2003 to join the US in a missile defense network for the Asia-Pacific region. Attitudes of Japan's emerging generation of leaders, who have no direct memory of the Second World War, appear particularly receptive to these changes. For example, the February 6, 2004 Christian Science Monitor cited a recent poll showing that 90 percent of Diet members under the age of 50 supported revising Japan's pacifist Constitution.

reconnaissance program, even one of limited technological and analytical capability, also will reduce the leverage of U.S. intelligence sharing in future dealings with Japan. Another risk is that technologies transferred to Japan may find their way to third parties. Government-to-government agreements restricting the re-exporting of systems using U.S. technology, similar to the 1969 agreement regarding launcher technology, are a good starting point for preventing such proliferation. Additionally, adequate security safeguards will be needed for hardware, software, and expertise transferred to Japan. Over the longer term, however, Japan may well seek to repeat in its military/intelligence space program the pattern demonstrated in their civil space program: one of acquiring needed technologies and expertise until they are able to develop them indigenously.

The new policy statement due out soon will provide the first indication of which of these paths Japan has chosen to pursue. It is an opportunity for Japan to decide whether it will make the investments needed to reach the top tier of space powers; whether it will make a commitment to compete more successfully with U.S. and European firms on the international market; and whether it will they respond to the challenge of China's manned space program by pursuing its own manned space program, or perhaps respond with an expanded space exploration program. It also may provide an indication whether Japan is shifting from a civil/commercial focus for its space program to more of a military/intelligence focus. Should the latter be the case, it may presage a more general shift to a greater military role for Japan in East Asia and, possibly, beyond.