The Space Congress® Proceedings

1978 (15th) Space - The Best Is Yet To Come

Apr 1st, 8:00 AM

NASDA Space Program In Japan

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Abstract

The National Space Development Agency of Japan, NASDA, was established on October 1, 1969, under the NASDA Law as the nucleus of the nation's space development effort in order to promote space development and utilization for peaceful purposes. NASDA, in a sense, is the equibalent of NASA in the United States, or ESA (European Space Agency) in Europe.
In accordance with the basic program for space development decided by the Prime Minister, NASDA is undertaking (1) the development, launching and tracking of satellites and satellite launch vehicles and (2) the development and consolidation of software, equipment and facilities needed for launching and tracking.
So far, NASDA has succeeded in launching four satellites by means of its N Launch vehicle from the Tanegashima Space Center, three of them into 1,000 km circular orbit and one into geosynchronous orbit.
NASDA succeeded also in the insertion of three satellites into geosynchronous orbits at their projected positions after having been launched by US NASA's Delta 2914 from ETR under the reimbursable launch contract.
NASDA activities in general will be overviewed in this report.

1. Introduction

1.1 Establishment of NASDA

Space activities can be classified into two categories : the scientific exploration of outer space and the practical application of satellites to such fields as communications, meteorological measurements, navigation, and geodetic surveys. In Japan, these two types of space activities have been carried on both by universities and Government Agencies along the lines set forth by the National Space Activites Council, and now by the Space Activities Commission.

The Space Activities Commission was established in 1968, replacing the National Space Activities Council. The main line of its business includes, among others, deliberation and decision on important policies for space development, estimation of expenditures, and coordinating and adjusting activities among related administrative organizations. (Fig. 1)

In October 1969, the Commission formulated the first " Space Development Program " (Decision for Fiscal 1969) which was accepted and decided finally by the Prime Minister.
Space Development Program is annually reviewed by the Commission and necessary modifications are introduced in accordance with changes that take place in the international environment surrounding Japan's space development and the progress in Japan's domestic space research and development.

As the result of the review made in 1970, the Commission incorporated necessary amendments to the program drawn up in fiscal 1969 and formulated the " Space Development Program " (Decision for Fiscal 1970).

In the following years, amendments have been made every year. In fiscal 1972, 1973, 1974, 1975, 1976 and 1977, a revised Space Development Program was decided upon.
NASDA was established on October 1, 1969 under NASDA Law as the central organ for the development of launching vehicles and applications satellites.

In accordance with basic program for space development decided by the Prime Minister as mentioned above, NASDA is undertaking the following tasks.

(1) Development of various types of satellites, especially those for practical applications such as communications, meteorological observation, navigation, geodetic surveys, etc.

(2) Development of satellite launch vehicles.
(3) Development of ground support equipment and facilities for satellites and launch vehicles.
(4) Maintenance and consolidation of tracking and data acquisition network.
(5) Operations for launching, tracking and data acquisition.

1.2 Organization and main location

NASDA's organization chart is shown in Fig. 2 and total personnels is about 800 at present time.
Also locations for NASDA Headquarters and related ground facilities, which are later explained, are shown in Fig. 3.

1.3 Funding

Funds necessary for NASDA's activities are covered mostly by appropriations made by the Government. In addition, NASDA may obtain investments from non-governmental organizations, including satellite users and private industries.

NASDA's budget appropriated for fiscal 1977 totals about 800 Oku Japan yen, or about 330 million US dollars, which corresponds to about 83 percent of the total space budget of Japan. As shown in Fig. 4, there has been a remarkable increase in the space budget of NASDA as well as Japan, in recent years, but just a small increase is anticipated for the next fiscal year.

2. Development of satellites

2.1 Engineering Test Satellite-I (ETS-I), " Kiku "

NASDA's first satellite, ETS-I, was successfully launched into orbit by the first N launch vehicle from the Tanegashima Space Center on September 9, 1975. (Fig. 5)
As September 9 is a day to celebrate chrysanthemum according to the traditional lunar calendar, ETS-I was given the nickname " Kiku ", which means chrysanthemum in Japanese.

" Kiku " has the shape of a 26-face polyhedron with 80 cm diagonal and a weight of 82.5 kg. The initial parameters of the injected orbit were almost the same as those of the planned 1,000 km circular orbit : an apogee height of about 1,105 km, a perigee height of about 977 km and an inclination angle of about 47 degrees.

The main objectives of " Kiku " were to acquire launching, tracking and control technologies for Earth orbiting satellites. " Kiku " was also aimed to measure vibration and shock at the time of launching and record temperatures within and outside the satellite while in orbit. Having accomplished all of these objectives, " Kiku " is still functioning very well beyond its design life of three months. (Fig. 6)

2.2 Ionosphere Sounding Satellite (ISS), " Ume "

NASDA's second satellite, ISS, was launched by the second N launch vehicle from the Tanegashima Space Center on February 29, 1976. The 139 kg cylindrical satellite was successfully placed into an orbit having an apogee height of 1,011 km, a perigee height of 991 km and an inclination angle of about 70 degrees. The satellite was given the nickname " Ume ", which means plum or apricot, an early spring seasonal flower in Japanese.

The main objectives of the ISS were to make daily observation of the world-wide distribution of critical frequencies of the ionosphere by radio waves, to make measurement of plasma characteristics and positive ion density in the upper ionosphere and to utilize the result of such observations and measurements in forcasting and warning necessary for efficient operation of world short-wave communications. (Fig. 7)

Having continued to operate normally and acquire valuable data for about one month, " Ume " suddenly terminated its communication linkage with ground stations due to a malfunction which occured in its on-board power supply unit. Investigations to determine the probable causes and countermeasures to the malfunction were conducted by NASDA and, based on those results, it was decided to launch a revamped spare satellite of the original ISS in February 1978.

The revamped satellite was named ISS-b and launched on February 16, 1978 by means of the fourth N launch vehicle (the third N was used for ETS-II, as described later). The ISS-b was placed into about the same orbit as the original ISS and is currently working quite satisfactorily.

2.3 Engineering Test Satellite-II (ETS-II), " Kiku-2 "

NASDA's third satellite, weighing about 254 kg at lift-off and about 130 kg in orbit, was launched by the third N launch vehicle from the Tanegashima Space Center on February 23, 1977 and given the nickname " Kiku-2 ".

" Kiku-2 " has a cylindrical shape with three parabolic despun antennas on the top : S band, X band and K band. The main objectives of " Kiku-2 " are to acquire technology necessary for launching, tracking and control of geostationary satellites and also to make tests for the propagation of radio waves in the region of millimeter and quasi-millimeter from the satellite to ground stations.

Having been lift off from the Tanegashima Space Center, " Kiku-2 " was first injected into a parking orbit and then into a transfer orbit by firing its perigee solid motor. With the firing of the apogee boost motor at the 7th apogee, " Kiku-2 " was inserted into a drift orbit and then finally placed into a geostationary orbit over the equator at 130 degrees East longitude on March 5. Initial parameters of the orbit were : an apogee height of 35,787 km, a perigee height of 35,783 km, an inclination angle of 0.568 degrees and a period of 23 : 56 : 00.
In order to maintain " Kiku-2 " geostationary position within 0.5 degrees allowance, hydrazine thrusters are to be actuated every 8 weeks.

It must be mentioned that although technologies necessary for placing the satellite into a geostationary orbit were developed principally by NASDA's efforts in many years, US support, based on the US-Japan Space Agreement signed in 1969, has made a great contribution to the accomplishment of the Japan's first geosynchronous satellite " Kiku-2 ". (Fig. 8, 9)

2.4 Experimental Communications Satellite (ECS)

The ECS has about the same dimensions and weight as the ETS-II. The main objectives of the ECS are to conduct via-satellite communication tests in the area of the millimeter wave band. The ECS is scheduled to be launched by an N launch vehicle from the Tanegashima Space Center in February 1979 to the geostationary orbit. (Fig. 10)

2.5 Engineering Test Satellite-III (ETS-III)

The ETS-III is being developed with the objectives of acquiring technology, such as three-axis stabilization, deployable solar paddles and active thermal control which are commonly required for satellites consuming much electric power. It is also aimed to conduct a series of tests for the function of on-board devices, including an ion propulsion unit.

The ETS-III is scheduled to be launched by an N launch vehicle from the Tanegashima Space Center during fiscal 1981 into a circular orbit having an altitude of about 1,000 km and an inclination angle of about 50 degrees.

2.6 Geostationary Meteorological Satellite (GMS)

The GMS is intended to help the advancement of the Global Atmospheric Research Program (GARP) to be jointly undertaken by the World Meteorological Organization (WMO) and the International Council of Scientific Union (ICUS) and to contribute to the improvement of worldwide meteorological services. For these purposes, the GMS is designed for photographing cloud pictures and collecting and distributing other meteorological data in the Western Pacific region.

The GMS has a cylindrical shape with a weight of about 699.5 kg at life-off and about 315 kg in orbit. This satellite was launched beautifully by a NASA Delta 2914 from the Eastern Test Range at Cape Canaveral on a reimbursable basis on July 14, 1977. After being injected into a transfer orbit under NASA's responsibility, the GMS was placed into a geosynchronous orbit at about 140 degrees East longitude under NASDA's responsibility.

After completion of pre-operational check outs, the GMS was handed over to the Japanese Meteorological Agency (JMA) for its mission operation while operations such as station and house keeping are being kept under NASDA control. (Fig. 11, 12)

2.7 Medium-capacity Communications Satellite for Experimental Purpose (CS)

The CS is intended for transmission experiments of telephone and television signal by means of a satellite system in the 4/6 GHz and the 20/30 GHz frequency ranges.
The 4/6 GHz frequencies cover all the Japanese territorial region including Okinawa and Ogasawara, while the 20/30 GHz frequencies cover the main part of Japan. These experiments are intended to establish the technology to operate a via-satellite domestic communication system as a transitionary step toward the launching of large-capacity communications satellites in order to meet increasing demands for such communication services in the future.

The CS, weighing about 673.6 kg at lift-off and about 350 kg in orbit, was launched by a Delta 2914 from the Eastern Test Range on a reimbursable basis on December 14, 1977 and then placed into a geostationary orbit at about 135 degrees East longitude under NASDA's responsibility. (Fig. 13, 14)

After completion of pre-operational check outs, the CS is to be handed over to the Ministry of Posts and Telecommunications (MOPT) for its mission operation.

2.8 Medium-scale Broadcasting Satellite for Experimental Purposes (BSE)

The BSE is intended for image and transmission experiments of voice and color television signals by means of a satellite system in the 12/14 GHz frequency ranges, covering remote and urban areas of the Japanese mainland and offshore islands. These experiments are intended to establish the technology to operate a via-satellite domestic broadcasting system as a transitionary step toward the launching of large-scale broadcasting satellites capable of individual reception that are necessary for meeting an increase in demands for such broadcasting services in the future.

The three-axis stabilized BSE, weighing about 662.7 kg at a lift-off and about 350 kg in orbit, is scheduled to be launched into a transfer orbit by a Delta 2914 from the Eastern Test Range on a reimbursable basis in late March, 1978 and then placed into a geostationary orbit at about 110 degrees East longitude under NASDA's responsibility. (Fig. 15, 16)

After completion of pre-operational check outs, the BSE is also to be handed over to the Ministry of Posts and telecommunications (MOPT) for its mission operation.

2.9 Engineering Test Satellite IV (ETS-IV)

The ETS-IV is planned to be launched by an N-II launch vehicle (NLV-II), an improved version of the N launch vehicle (NLV-I), from the Tanegashima Space Center by the end of fiscal 1980 into an elliptic orbit having a perigee altitude of about 190 km and an apogee altitude of about 36,000 km.

It is intended to confirm the flight performance of the NLV-II and conduct a series of tests for on-board equipment.

2.10 Geostationary Meteorological Satellite-2 (GMS-2)

The GMS-2 is planned to be launched by an NLV-II from the Tanegashima Space Center during fiscal 1981 for placement in a geostationary orbit at about 140 degrees East longitude. This satellite, with objectives of enhancing

the observation function of weather satellites and contributing to the improvement of Japan's meteorological services, is required to have about the same performance as that of the original GMS.

2.11 Other Satellites

Conceptual studies are being made on various types of satellites such as geodetic satellites, Maritime observation satellites, etc., in cooperation with user organizations.

3. Development of Satellite Launch Vehicle

3.1 N Launch Vehicle (NLV-I)

The satellite launch vehicle developed by NASDA is called the N Launch Vehicle (NLV-I) or N Rocket. It is a three-stage radio-guided vehicle with a propulsion system employing LOX and RJ-1 for the first sate, N_2O_4 and A-50 for the second stage and solid propellant for the third and strap-on to the first stage. The overall length of the NLV-I is about 33 meters, maximum diameter is about 2.4 meters and lift-off weight is about 90 tons.

With this configuration, the NLV-I has the capability of launching a satellite of about 145 kg into a geostationary orbit or of several hundred kilograms into a low Earth orbit.

In planning the development of the NLV-I, factors such as the level of technology in Japan and the limited time available for development were taken into consideration, and efforts were made to speed up development capability by importing technology. However, while importing necessary technology, independent development was carried out as much as possible. In particular, for the purpose of developing a liquid propellant engine for the second stage of the NLV-I, development of fundamental technology such as propulsion, guidance and control of liquid propellant rockets, was carried out by flight experiments using small size rockets over the past several years.

The NLV-I#1 was completed in May 1975, and on September 9, 1975, it was used to launch the ETS-I (or " Kiku "). Then on February 29, 1976, February 23, 1977 and February 16, 1978, NLV-I#2, #3 and #4 were used to launch the ISS (" Ume "), ETS-II (" Kiku-2 ") and ISS-b (" Ume-b ") respectively.
The fact that all these satellites have been successfully placed into planned orbits showed the excellent performance and high reliability of the NLV-I.
Further launchings of satellites including ECS, are being planned.
The dimensions of the NLV-I in detail are shown in Table 1.

3.2 N-II Launch Vehicle (NLV-II)

NASDA is currently engaged in the development of the N-II Launch Vehicle (NLV-II), an improved version of the original NLV-I, which will have a capability of launching a geostationary payload of about 350 kg as a desirable target.

This uprated payload capability is anticipated to be achieved by such manners as increasing the number of strap-on rockets, extending the length of the first stage liquid propellant tankage, improving the accuracy of guidance system, etc.

It is currently planned to use the NLV-II for launching ETS-IV from the Tanegashima Space Center by the end of fiscal 1980 and the second NLV-II for the GMS-2 during 1981. (Fig. 17)

3.3 Cryogenic Propulsion Systems

NASDA is also engaged in the development of cryogenic (LOX and LH_2) Propulsion systems in collaboration with the National Aerospace Laboratory and the Institute of Space and Aeronautical Science of the University of Tokyo.

An engine having a thrust level of 10 tons in a vacuum condition is currently being studied and equipment and facilities for static firing test of this engine, as well as overall test of propellant feeding systems, are also being planned. Employment of this engine system for the second stage of the NLV-I, together with other techniques such as increasing the number of strap-on solid rockets, is expected to considerably uprate the geostationary payload capability, over 500 kg.

4. Development of tracking and data acquisition systems

4.1 Systems for vehicle flight safety

NASDA's tracking and data acquisition systems can be classified into two categories. The one is for vehicle flight safety purpose and the other is for satellite tracking and data acquisition purpose.
The system for vehicle flight safety is composed of the Tanegashima Space Center (Range Control Center) and down range stations at Ogasawara Islands (Chichijima Island) and either Marshall Islands (Kwajalein Island) or Line Islands (Christmas Island).

Equipment at the Tanegashima Space Center and Chichijima Island are installed on permanent basis, while those at Kwajalein or Christmas Island are transportable and used at either one island according to mission requirements.

4.2 System for satellite tracking and data acquisition

The system is for tracking and data acquisition of a satellite after separation from a launch vehicle. It consists of the Tsukuba Space Center (Tracking and Control Center/ Computer Center), tracking and data acquisition stations at Katsuura, Masuda and Okinawa, as well as the Kagoshima Space Center (Institute of Space and Aeronautical Science, University of Tokyo) and down-range stations at either

Kwajalein or Christmas Island (for the initial launch phase only).

Data obtained at all the stations of the network are centralized at the Tsukuba Space Center for data processing, and data related to orbit determination are transmitted back to the stations for improving data acquisition operations. Processed data will also be distributed to satellite utilizing organizations for their mission analysis. As for data which are necessary for satellite tracking but not directly obtainable at NASDA's network stations because of their geographical locations, NASDA receives support from NASA STDN stations. NASDA is most appreciative of NASA's extensive work.

As for satellite tracking and orbit determination, NASDA is currently employing two different methods : the orbit observation system with azimus-elevation angle and Doppler frequency and the range and range rate system using a secondary radar which receives response from the transponder carried on board the satellite. By the use of these two systems, NASDA has virtually perfected its technology for shortening the time necessary for precise distance measurement and orbit determination to inject a satellite into geostationary orbit. (Fig. 18)

5. Ground Facilities and Equipment

5.1 Tanegashima Space Center

The Tanegashima Space Center consists of launch complexes for launching vehicles and satellites, optical stations for observation and tracking of vehicles and satellites at the time of launching, telemetry stations, radar stations, tracking and data acquisition stations and static firing test facilities for testing rocket motor engines.

Construction of the Tanegashima Space Center was started in 1966, and at present, the construction of facilities for the " N Program (ETS-I, ISS, ETS-II and ECS mission) " has been nearly completed.
The total area is about 8,650,000 square meters.

5.2 Tsukuba Space Center

The Tsukuba Space Center was constructed as an overall testing center for launch vehicles and satellites and also as the Tracking and Control Center for satellites launched into space.

Construction was started at a 510,000 square meter area in the Tsukuba New Town for Universities and Research Institutes. Up to now, construction of testing facilities and tracking and data acquisition facilities for N Program have been nearly completed. (Fig. 20)

5.3 Others

Among others, one of the most urgent projects for NASDA today is construction of a ground receiving station for NASA's Landsat. This planning is currently proceeding as a first step toward the accomplishment of via-satellite remote sensing technology.

In conclusion, NASDA has made and is making steady progress in the execution of its assigned duties.
For this achievement, NASDA is deeply appreciative of the support given by the many government and industrial space-related organizations inside and outside of Japan.

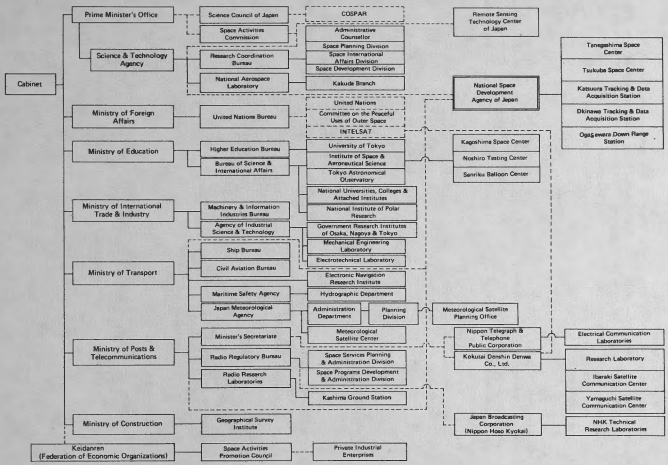

Fig. 1 ORGANIZATION - CHART OF SPACE - RELATED ORGANIZATIONS IN JAPAN

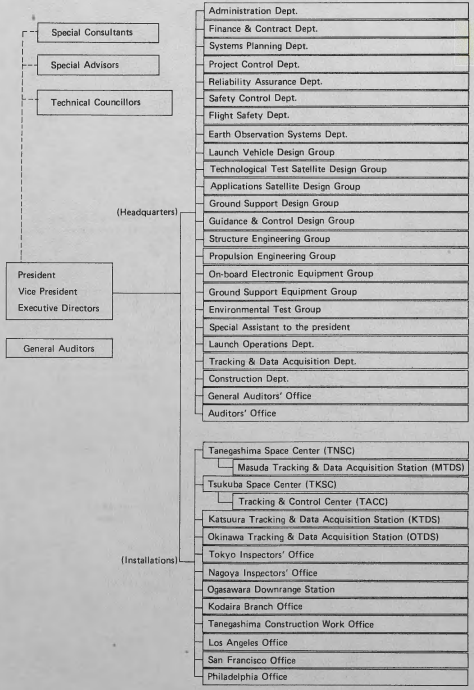

Fig. 2 NASDA ORGANIZATION

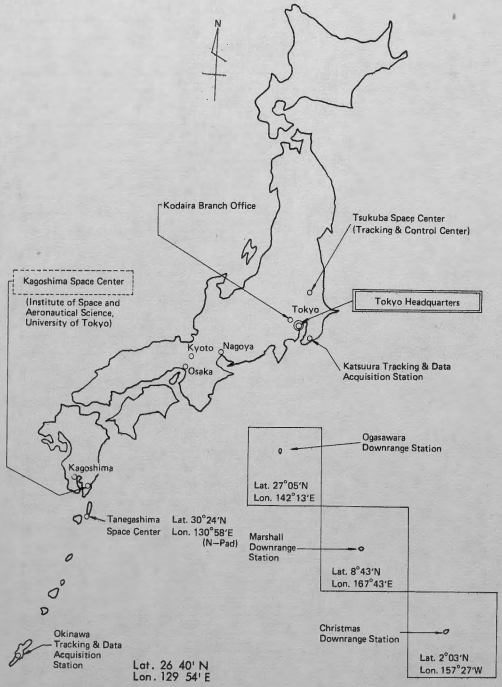

Fig. 3 LOCATION OF NASDA FACILITIES

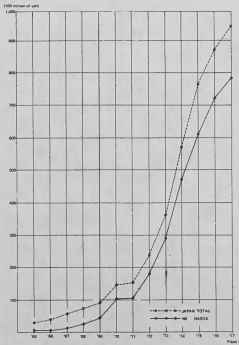

Fig. 4 GROWTH OF SPACE BUDGET

Fig. 5 N LAUNCH VEHICLE LIFT-OFF

Fig. 6 ETS-I, " KIKU "

Fig. 7 ISS, " UME "

Fig. 8 ETS-II, " KIKU-2 "

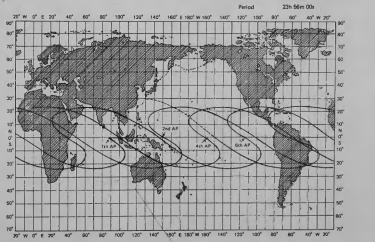

Fig. 9 ORBIT OF ETS-II

Fig. 10 ECS

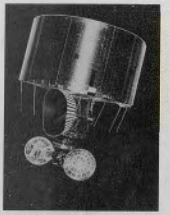

Fig. 11 GMS

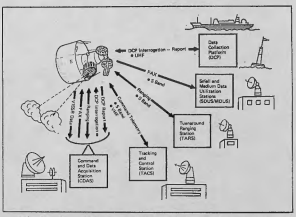

Fig. 12 GMS : SPACE-GROUND STATIONS LINKAGE

Fig. 13 CS

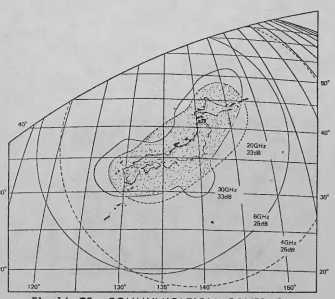

Fig. 14 CS : COMMUNICATION COVERAGE

Fig. 15 BSE

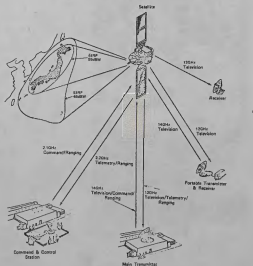

Fig. 16 BSE : SPACE-GROUND STATIONS LINKAGE

		1st stage	SOB (3 motors)	2nd stage	3rd stage
Size	Length (m)	21.44	7.25	5.44	1.74 (5.69,length of Faring)
	Overall length (m)	32.57			
	Diameter (m)	2.44	0.79	1.62	1.18 (1.65,diameter of Fairing)
Weight	Weight (t)	70.42	13.42	5.86	0.92 (1.17–Include Fairing)
	Overall weight (t)	90.88 (Exclude Space Craft)			
Engine	Type	Liquid Engine	Solid Motor	Liquid Engine	Solid Motor
	Propellant (Oxidizer/Fuel)	LOX/RJ-1_6	Polybutadiene	N_2O_4/A-50	Polybutadiene
	Propellant weight (t)	66.35	11.24	4.74	0.56
	Thrust (t)	77.11 (sea level)	70.97 (sea level)	5.44 (Vacuum)	3.95 (Vacuum)
	Fuel feed system	Turbo pump		Pressure feed	
Control System	Pitch, yaw	Gimbal		Gimbal (powered flight) gas jet (coast flight)	Spin stabilize
	Roll	Vernier Engines		Gas jet	

Table 1. MASTER DIMENSIONS OF N LAUNCH VEHICLE (NLV-I)

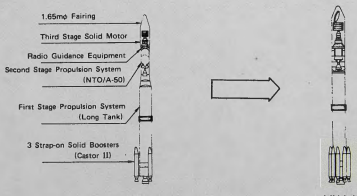

Fig. 17 IMPROVEMENT OF N LAUNCH VEHICLE

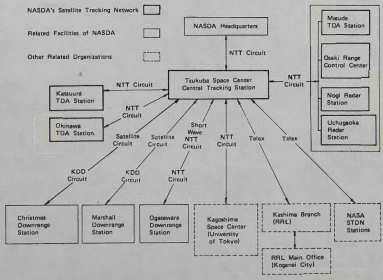

Fig. 18 NASDA SATELLITE TRACKING AND DATA ACQUISITION SYSTEM

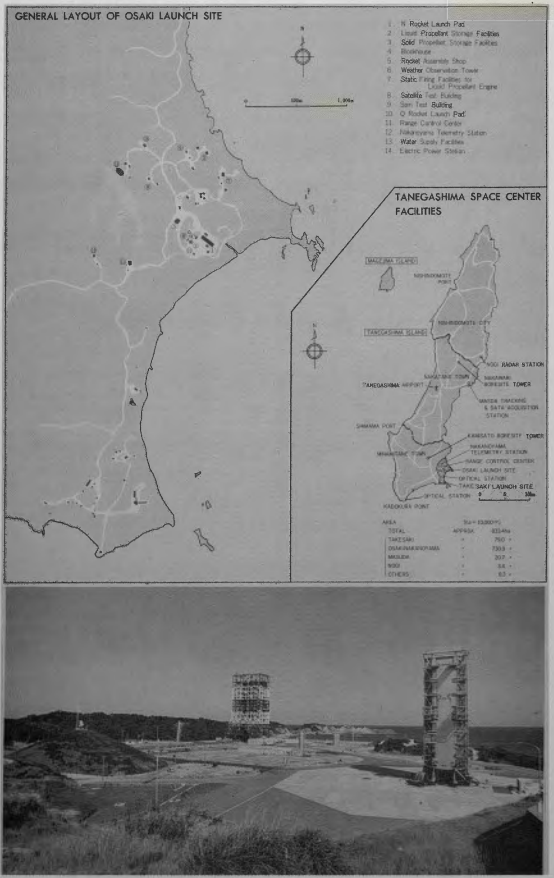

Fig. 19 TANEGASHIMA SPACE CENTER

Fig. 20 TSUKUBA SPACE CENTER