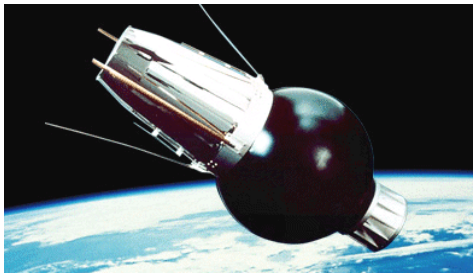
Space Programs

A. History of Development and Launch

The challenge for Japan in developing space vehicles started with the launch of the “Pencil” rocket in 1955 by Professor Itokawa of the University of Tokyo. The launch led to the subsequent development of larger rockets, such as “Kappa” and “Lambda,” both of which used solid fuel and were mainly used in the scientific research field.

In 1970, the University of Tokyo succeeded in launching Japan’s first satellite “Ohsumi” into orbit using the four-stage solid propellant “Lambda” rocket. Later, bigger M (Mu)-family launch vehicles were developed, primarily for the launching of scientific satellites into orbit.
In the M-family, the M-V was a three-stage solid propellant launch vehicle. It was the biggest solid propellant rocket in the world, and was developed by JAXA (ISAS) to launch various scientific satellites. The M-V played an important role in the development of X-ray astronomy and infrared astronomy, however, its role was terminated with the launch of the SOLAR-B “Hinode” in September 2006. As the succeeding system, a next solid-propellant rocket concept is being considered.


Ohsumi (Source: JAXA)

To launch application satellites, the National Space Development Agency of Japan (NASDA) was established in 1969, and the N-I rocket was developed with U.S. cooperation. In 1975, NASDA succeeded in launching its first satellite using the N-I rocket. Since then, development of the modified N-II and later the H-I rocket, which employs a liquid oxygen liquid hydrogen propellant motor for the second stage, continues.
Since 1986, efforts have focused on developing a liquid oxygen/liquid hydrogen propellant motor for the first stage. In February 1994, the two-stage H-II rocket succeeded in launching a satellite.
Furthermore, the H-IIA rocket, a significant improvement over the H-II, was developed. The first launch of the H-IIA in August 2001 was a success.
In March 2003, NASDA made a successful lift off with the H-IIA #5, and secured the record of its five consecutive successful launches. Unfortunately, JAXA failed to launch the H-IIA #6 in November 2003, but the H-IIA #7 successfully launched the MTSAT-1R in February 2005 after improvements were made in the solid propellant system (solid rocket booster), and thereafter every launching of the H-IIA has been successful, in succession. H-IIA #18 was launched in September 2010.
JAXA succeeded in developing the H-IIB rocket with much improved performance over the H-IIA rocket. On September 2009, they successfully launched the HTV (Demonstration Flight Vehicle) on TF#1 (Test Flight #1). In addition, JAXA succeeded in launching of the H-IIB #2 in January, 2011.



H-IIB Rocket (Source: JAXA)

In satellites, SingTel Optus Pty contracted its communication satellite “OPTUS C1” to Mitsubishi Electric Corporation (MELCO), which launched in June 2003. MELCO was awarded the contracts related to the MTSAT-2 and Superbird #7 for Space Communication Corp. It was the first time for a Japanese company to win these contracts in the world market. These successes show the possibility that Japanese space components and systems can enter into the world space market. In addition, Superbird #7 was launched in August 2008 and became Japan’s first domestic commercial communications satellite. MELCO accepted an order for the “ST-2” satellite from Singapore/Taiwan companies to be used as their next communications satellite in 2008, and was awarded the contract to deliver the Turksat 4A and Turksat 4B

communications satellite to Turkish satellite operator “Turksat Satellite Communication and Cable TV Operation AS” in March 2011.

Japan is in fourth position amongst satellite-launching countries, coming after Russia, the U.S. and France. As of March 2011, a total of 33 scientific and experimental satellites have been launched in Japan. The missions of these satellites are controlled by JAXA. A total of 49 application satellites have been developed and launched in Japan as of March 2011. These are used for a diverse range of purposes, such as meteorology, communications, broadcasting, marine observation, resource exploration and technological experiment.
The space industry in Japan is actively committed to the ISS program, in which 15 countries participate, as well as other international joint development programs as a part of its comprehensive space development.

Along the course of overall restructuring of administrative organizations, the Japanese government decided in August 2001 to consolidate three space-related R&D agencies —NASDA, ISAS and NAL— and to newly start up an independent administrative organization. JAXA began operations on October 1, 2003.
In November 2002, NASDA decided to commercialize the launch services of the H-IIA, and transferred the necessary technologies to MHI. As of April 2007, MHI is responsible for the launching and transport services of the H-IIA. In January 2009, MHI received an order to launch the Korea Multipurpose Satellite-3 (KOMPSAT-3) from KARI. This was the first satellite launch contract from an overseas company.

The government established the Basic Space Law on May 2008. This law will determine the basis of future space development plan. The Basic Plan for Space Policy that outlines Japan’s strategy in space development was created for the purpose of implementing the spirit of the Basic Space Law.

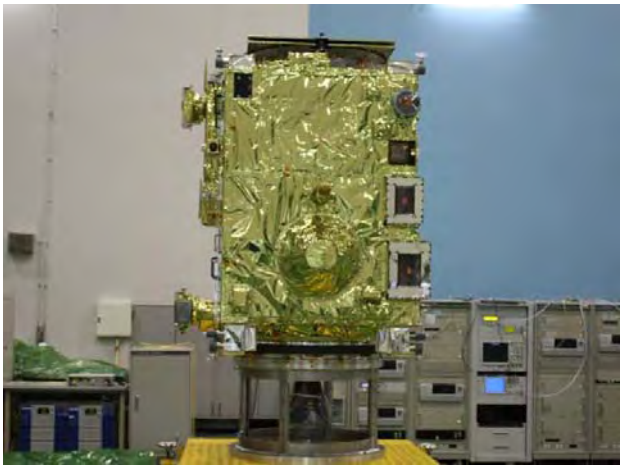
After 2006, the main satellites launched in Japan are as follows.

a. Advanced Land Observing Satellite (ALOS) “DAICHI” (January 2006, launched by H-IIA #8)
ALOS is used for precise land observation. The main missions of ALOS are mapping, precise land observation, disaster monitoring and resource survey. One of the objectives of the ALOS project is to provide regional observation of the Earth’s surface.
b. An Infrared Astronomy Satellite (ASTRO-F) “AKARI” (February 2006, launched by M-V #8)
ASTRO-F is Japan’s first infrared-ray astronomical satellite to observe at infrared wavelengths stars and galaxies.
c. Multi-functional Transport Satellite (MTSAT-2) “HIMAWARI” (February 2006, launched by H-IIA #9)
MTSAT was developed as the dual mission satellite performing an air traffic control and navigation function as well as a meteorological function with the Ministry of Land, Infrastructure and Transport (MLIT) and the Japan Meteorological Agency (JMA), and is now operated.
d. Solar Physics Satellite (SOLAR-B) “HINODE” (September 2006, launched by M-V #7)
SOLAR-B, which was jointly developed by the U.K., the U.S. and Japan, is successor to the orbiting solar observatory YOHKOH (SOLAR-A). JAXA and MELCO developed the satellite systems.
e. Engineering Test Satellite VIII (ETS-VIII) “KIKU #8” (December 2006, launched by M-V #7)
ETS-VIII is one of the largest geostationary satellites in the world to develop the technology associated with mobile communications that will enable audio/data communications with hand-held terminals. Japan has launched various types of engineering satellites to study the technological needs of its time. ETS-VIII was launched by the H-IIA 204 type rocket on December 2006.
The satellite, with a weight of three tons and a diameter of 40 m, is equipped with two large deployable antenna reflectors (LDARs) and two solar array paddles. The LDAR is the size of a tennis court and allows for more reliable direct communications with a geostationary satellite.
f. SELenological and ENgineering Explorer (SELENE) “KAGUYA”
(September 2007, launched by H-IIA #13)
SELENE was launched by the H-IIA rocket in September 2007 and was the first large lunar explorer made Japan. It began observation in December. This project attracts attention as the largest lunar mission since the Apollo program. NEC Corporation (NEC) participated in the development, manufacture and operation of “KAGUYA” as prime contractor. In addition, after the transfer to MHI of the H-IIA, “KAGUYA” became the first satellite to be launched on a commercial sale basis.
g. Wideband Internetworking Engineering Test and Demonstration Satellite (WINDS) “KIZUNA”
(February 2008, launched by H-IIA #14)
The WINDS program proceeds under joint development by JAXA and NICT, as part of the e-Japan Priority Policy Program of the Japanese government’s IT strategy headquarters. The project aims at developing and verifying the key technologies for future ultra-high data rate satellite communication (up to 1.2Gbps), creating and demonstrating new utilizations for satellite communication through

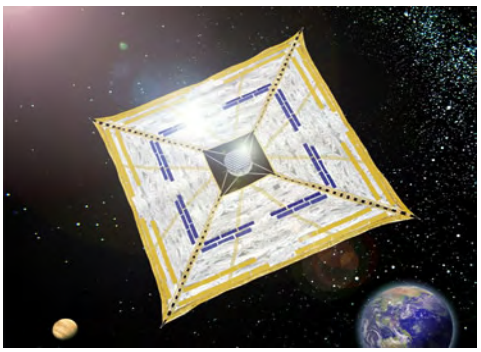
various space experiments. WINDS can achieve ultra-high data rate communications throughout Japan as well as major cities in the Asia–Pacific region.

h. Greenhouse gas Observing SATellite (GOSAT) "IBUKI" (January 2009, launched by H-IIA #15)
Global warming has become a very serious issue for human beings, and developed nations are required by the Kyoto Protocol to reduce carbon dioxide emissions, which are a greenhouse gas, to protect the environment. GOSAT will enable the precise monitoring of the distribution of the density of carbon dioxide by combining global observation data sent from space with data obtained on land, and through simulation models. GOSAT jointly developed by JAXA and the Ministry of Environment. In addition, the collection of observation data has been started by TANSO (Thermal And Near Infrared Sensor for Carbon Observation), which is the greenhouse gas observation sensor installed in the "IBUKI."

i. Venus Explorer (PLANET-C) "AKATSUKI" (May 2010, launched by H-IIA #17)
The Venus exploration project aims at two planetary meteorology missions, the first of its kind ever. The missions are to research the mechanisms of winds generated on the surface of Venus, and to understand the role that atmosphere circulation serves for the formation of a planet's climate. Venus Explorer probe vehicle named "AKATSUKI" was launched successfully with the Small Solar Power Sail Demonstrator "IKAROS" in May 2010; however, its mission to enter the orbit of Venus in December unfortunately failed.



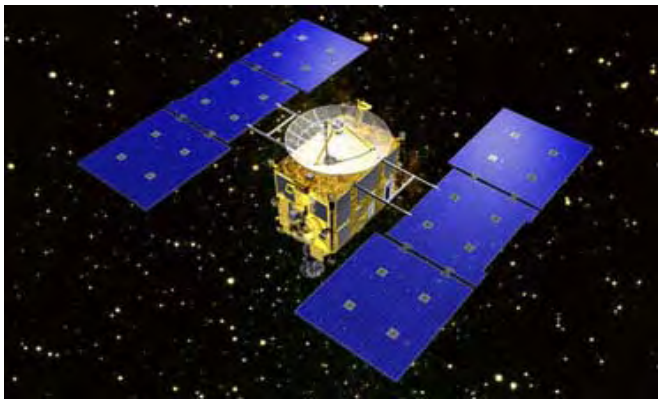
Planet-C (Source: JAXA)



IKAROS (Source: JAXA)

j. Quasi-Zenith Satellite System (QZSS) "MICHIBIKI" (September 2010, launched by H-IIA #18)
The Cabinet Office, MEXT (the Ministry of Education, Culture, Sports, Science and Technology), METI, MLIT and MIC (the Ministry of Internal Affairs and Communi- cations) jointly aim at establishing the foundation technology for the development of the QZSS, and launched its first satellite in September 2010. The QZSS easily enables high-speed communication and highly precise pinpointing without obstruction in urban and mountain areas by a constellation of several identical satellites.

HAYABUSA (MUSES-C) was developed to explore asteroids, and M-V #5 was sent to space on May 2003. Through this mission, JAXA (ISAS) is to confirm the technology to retrieve samples from an asteroid surface. HAYABUSA successfully touched-down on the surface of an asteroid called "ITOKAWA" on November 2005, and collected samples from its surface and it returned home from planetary probe of seven years in June of last year.



MUSES-C/HAYABUSA (Source: JAXA)

Capsule of HAYABUSA (Source: JAXA)

B. Ongoing and Future Programs

(1) Launch Vehicle

- H-IIA/-IIB Launch Vehicle

H-IIB Rocket (Source: JAXA)

The H-IIA is a large-scale launch rocket equipped with high-performance engines with liquid oxygen (LOX) and hydrogen (LH_2) as propellants, and has been developed to meet various mission demands for many types of spacecraft and payloads by JAXA as one of the most advanced rocket systems in the world. Currently, the technologies acquired through its development have been transferred to MHI to improve reliability and reduce cost. The H-IIA has been maintained and operated as the national-flag rocket system. JAXA has three types of standard launch vehicles for different payload weights. The H-IIA standard type can put a satellite of approximately four tons into geostationary transfer orbit (GTO), and the H-IIA 204 type with two additional solid rocket boosters (four SRB-As) can put a satellite of approximately six tons to GTO.
The development of the H-IIB, capable of carrying eight tons of payload, is now proceeding. The H-IIB has two liquid rocket engines in the first stage and four SRB-As attached to the body. In addition, the H-IIB has the mission to launch the HTV to the ISS. On September 2009, HTV (Demonstration Flight Vehicle) was launched by H-IIB rocket. We are proud to say that HTV was successful at docking to the International Space Station at first try. We believe that this mission confirmed the outstanding technical capabilities possessed by the Japanese companies. Also, the H-IIB #2 rocket was successfully launched in January 2011.

- H-II Transfer Vehicle (HTV)

Japan's transfer vehicle, called the H-II Transfer Vehicle (HTV), is an unmanned orbital carrier designed to deliver equipment and supplies to the ISS. The waste materials, such as spent equipment, used clothing and others will be incinerated when the HTV makes re-entry into the atmosphere. The HTV demonstration flight vehicle was successfully launched by the H-IIB rocket developing in September 2009. HTV #2, "KOUNOTORI 2", was successfully launched in January 2011."

HTV (Source: JAXA)

- Epsilon Launch Vehicle

Epsilon Launch Vehicle is a successor to the M-V rocket, currently in development, designed to launch small sized satellites with low cost and efficiency. The first stage of the rocket is constructed with rocket boosters from the H-IIA, and the second and upper rockets use the integrated design from a solid rocket from the M-V rocket.

(2) Satellites – International Program

- International Space station (ISS)

In 1988, NASDA started development of the Japanese space experiment module under a space station treaty agreed upon by Japan, the U.S., Europe and Canada. Currently, 15 nations are participating in the ISS project.
The launching of the space station began in 1999. Japan has been producing some of the main components of the ISS, and the most important "KIBO." Japanese Experiment Module (JEM) was carried out into space by the Space Shuttle, and docked with the ISS in March 2008. "Exposed Facility" was installed in July, 2009, and "KIBO" Japanese Experiment Module was completed.
KIBO consists of "Pressurized Module," "Exposed Facility," "Experiment Logistics Module Pressurized Section," "Experiment Logistics Module Exposed Section" and "Manipulator."

KIBO (Source: JAXA)

- Mercury Explorer “BepiColombo”

“BepiColombo” is jointly planned by JAXA and the European Space Agency (ESA). This project consists of two orbiters—the Mercury Magnetospheric Orbiter (MMO), led by JAXA, and the Mercury Planetary Orbiter (MPO), led by ESA. The MMO will observe the magnetic field and the magnetosphere, and the MPO will observe the surface and interior of Mercury. Both spacecraft will be launched together by the Soyuz-Fregat 2B in 2013.

- Global Precipitation Measurement (GPM)

GPM is a project to observe rainfall (rain and snow) on Earth as a continuous and expanded mission of the Tropical Rainfall Measuring Mission (TRMM). Its plan is to observe the Earth through the use of multiple satellite groups, comprised of the main satellite and sub-satellites.
GPM is one of the Earth observation satellite programs, which has been initiated mainly by JAXA, the National Institute of Information and Communications Technology (NICT) and the National Aeronautics and Space Administration (NASA). GPM is to be launched in 2013.

- Earth Clouds, Aerosols and Radiation Explorer (EarthCARE)

EarthCARE is the Earth observation satellite that JAXA and ESA have been jointly developing, and will observe clouds and aerosols on a global scale using its four sensors, and so will further improve the accuracy of climate change predictions. One of the sensors is Cloud Profiling Radar (CPR), which will be the world’s first W-band (94GHz) Doppler radar aboard a satellite. CPR is developed by JAXA and NICT, and NEC participates in this project as the systems contractor. The satellite will be launched by the PSLV rocket, Dnepr rocket or Soyuz rocket in 2013.

(3) Satellites - Domestic Programs

- Global Change Observation Mission (GCOM)

GCOM aims to research global climate change and water circulation mechanisms, and will be comprised of the GCOM-W (Water) and GCOM-C (Climate). The GCOM-W (Water) satellite will observe precipitation, wind velocity above the ocean and sea water temperatures. Climate change observation will be performed by the GCOM-C (Climate) satellite on clouds, aerosol, snow and ice. The GCOM-W1 is planned for launch in 2011 and the GCOM-C1 is planned for launch in FY2012.

GCOM-C1 (Source: JAXA)

- Next Generation Space Radio Telescope (ASTRO-G)

ASTRO-G is a next-generation space radio telescope that enables high-resolution celestial observation using an onboard radio telescope, and is a successor to VSOP (VLBI Space Observatory Program), which was used to observe deep space. ASTRO-G is planned to be launched in 2012.

- Advanced Satellite with New system Architecture for Observation (ASNARO)

ASNARO is the project that USEF (Institute for Unmanned Space Experiment Free Flyer) plans to establish the architecture technologies to produce the next generation small satellite by the reduction of the cost and the development period with the adoption of current electronics technologies. This mission is expected to be launched in 2011.

- X-ray Astronomy Satellite (ASTRO-H)

X-ray Astronomy Satellite (ASTRO-H) is being developed for searching deep space and observing galaxy cluster to understand the contexture and evolution of outer space, and it is scheduled to launch in fiscal year 2013.

- Advanced Land Observing Satellite (ALOS)

For the purpose of acquiring and processing/delivering high resolution observational data extensively in large-scale natural disasters at home and abroad, and to collect diversified data of soil and resource management, ALOS-2 and ALOS-3 are scheduled to be launched in 2013 and 2014 respectively

ALOS-2 (Source: JAXA)