NEC's 30 Years of Space Activities and Recent Satellite Programs

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ABSTRACT As a prime contractor, NEC has integrated 47 satellites in 30 years. That accounts for about two-thirds of the whole spacecraft market share in Japan. NEC has been acting as the leading company in the Japanese space program. NEC has built both Geostationary and Orbiting satellites in various sizes and missions such as scientific, communications & broadcasting, earth observation and engineering tests. Currently, NEC is integrating seven satellites, which will be launched from 2001 to 2004. This paper introduces the history of NEC's space activities in 30 years, and recent major programs with the state of the art technologies.

KEYWORDS Satellite, MDS-1, OICETS, MUSES-C, LUNAR-A, ALOS, SELENE, ASTRO-F

1. INTRODUCTION

In 1970, the Japan's first satellite "OHSUMI" was launched for the purpose of demonstrating orbit-injection launches for future launch vehicles. Since that time, NEC has integrated and launched one or two satellites every year with a wide range of missions consisting of scientific, communications & broadcasting, earth observation and engineering tests.

On July 14, 1977, the first GMS (Geostationary Meteorological Satellites), named "HIMAWARI," was launched from Kennedy Space Center. Its observation data is widely used in weather forecasting. NEC also launched the first operational broadcasting satellite named "Yuri-3" in 1990. It opens the sky to the new era of DTH (Direct To Home) broadcasting. Those satellites have become familiar in Japan and a part of our lives.

In the scientific mission area, NEC has integrated almost all of the Japanese scientific satellites as a prime contractor. Those satellites including deep space programs have contributed to the exploration of the universe and planets.

NEC built NASDA's first engineering test satellite "KIKU" and first Japan's Earth observation satellite "MOMO-1." Those satellites created remarkable milestones in Japanese space programs. Table I shows Japanese satellites integrated by NEC.

Now, we have been integrating seven satellites as a prime contractor. These will be launched from 2001 to 2004. An overview of those satellites, MDS-1, OICETS, MUSES-C, LUNAR-A, ALOS, SELENE and ASTRO-F, is given in the following sections.

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2. RECENT SATELLITE PROGRAMS

2.1 MDS-1

The objectives of the MDS-1 (Mission Demonstration test Satellite-1) are to verify the function of commercial parts in orbit, to verify minimization technology for components, and to measure space environment data. It will be launched in 2001 by H-IIA rocket from Tanegashima Space Center.

In 1996, NASDA decided to make a mission demonstration satellite program in which advanced parts, elements and components will be tested in space. The program required low cost and short delivery. NEC's small satellite technology has given a solution to the requirement.

The SSR (Solid State data Recorder) and the PCS (Parallel Computer System) of mission equipment are supplied by NEC. SSR is a space data recorder with higher capacity and lower volume. It consists of a control unit and stack memory module as a memory unit. PCS accomplishes high performance and high reliability with commercial MPUs on orbit.

The MDS-1 will be operated in the geostationary transfer orbit and suffer more than ten times radiation. Figure 1 shows an image of MDS-1. Table II shows the main characteristics of MDS-1.

2.2 OICETS

The objective of the OICETS (Optical Inter-orbit Communications Engineering Test Satellite) is to conduct with ARTEMIS geostationary satellite under the international cooperation with the ESA (European Space Agency), on-orbit demonstrations of pointing, acquisition and tracking technology, and other key technology elements for optical inter-orbit communications, which will be essential technique for future space activities.

The mission equipment carried on the OICETS is

the LUCE (Laser Utilizing Communications Equipment). This system is used for development of technology such as beam acquisition, beam tracking, beam pointing and point ahead angle. NEC achieves the pointing accuracy of 0.5μrad by the low thermal strain material, coordination control technology and so on.

Table I Japanese satellites integrated by NEC.

Number	Program	Customer	Launch
1	OHSUMI	ISAS	1970
2	TANSEI	ISAS	1971
3	SHINSEI	ISAS	1971
4	DENPA	ISAS	1972
5	TANSEI-II	ISAS	1974
6	TAIYO	ISAS	1975
7	KIKU	NASDA	1975
8	TANSEI-III	ISAS	1977
9	HIMAWARI	NASDA	1977
10	KYOKKO	ISAS	1978
11	JIKIKEN	ISAS	1978
12	HAKUCHO	ISAS	1979
13	TANSEI-IV	ISAS	1980
14	HINOTORI	ISAS	1981
15	HIMAWARI-2	NASDA	1981
16	TENMA	ISAS	1983
17	OHZORA	ISAS	1984
18	HIMAWARI-3	NASDA	1984
19	SAKIGAKE	ISAS	1985
20	SUISEI	ISAS	1985
21	FUJI	JARL	1986
22	GINGA	ISAS	1987
23	MOMO-1	NASDA	1987
24	AKEBONO	ISAS	1989
25	HIMAWARI-4	NASDA	1989
26	HITEN-HAGOROMO	ISAS	1990
27	MOMO-1b	NASDA	1990
28	FUJI-2	JARL	1990
29	ORIZURU	NAL	1990
30	YURI-3a	NASDA	1990
31	YURI-3b	NASDA	1991
32	YOHKOH	ISAS	1991
33	GEOTAIL	ISAS	1992
34	ASCA	ISAS	1993
35	HIMAWARI-5	NASDA	1995
36	FUJI-3	JARL	1996
37	HALCA	ISAS	1997
38	KAKEHASHI	NASDA	1998
39	NOZOMI	ISAS	1998
40	ASTRO-E	ISAS	2000
41	MDS-1*	NASDA	2001
42	OICETS*	NASDA	2002
43	LUNAR-A*	ISAS	2002
44	MUSES-C*	ISAS	2003
45	ALOS*	NASDA	2003
46	SELENE*	NASDA/ISAS	2004
47	ASTOR-F*	ISAS	2004

* Under development
NASDA: National Space Developmet Agency of Japan
ISAS: The Institute of Space and Astronautial Science
JARL: The Japan Amateur Radio League, Inc.
NAL: National Aerospace Laboratory, Science and Technology Agency

The overall system for optical inter-orbit link experiments consists of OICETS, DRTS (Data Relay Test Satellite), Tracking and Control Center and domestic Tracing and Control Stations, and ESA's ARTEMIS and ground stations. The OICETS will be controlled mainly via S-Band inter-orbit link with ARTEMIS or S-Band direct links with Tracking and Control Stations using conventional radio frequency signals to transmit and receive telemetry, command and mission data.

The OICETS will be launched in 2002 by J-1 rocket from Tanegashima Space Center. Figure 2 shows an image of OICETS. Table III shows the main characteristics of OICETS.

2.3 MUSES-C

The MUSES-C is the first sample return mission in Japan. It will collect surface sample of the asteroid 1998 SF36 and bring it back to Earth for laboratory analysis. The MUSES-C will be launched in 2002 by M-V rocket and arrive at the asteroid in September 2005. Departing from the asteroid in January 2006, it will return to Earth in May 2007. To achieve the mission, the spacecraft performs a large amount of mass reduction with light-weight material and small-sized and light-weight electronics technology.

The MUSES-C employs several new technologies such as; 1) ion engines for the interplanetary orbiting

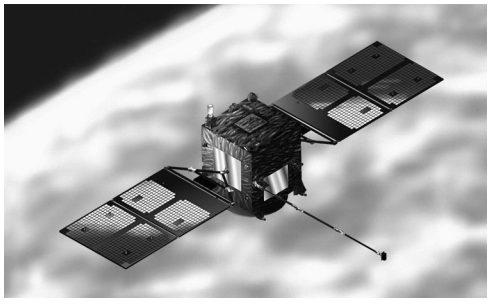

Fig. 1 MDS-1.

Table II MDS-1 characteristics.

Items	Characteristics
Configuration	Structure $1.2 \times 1.2 \times 1.5$m
Mass at lift-off	480kg
Generated power	More than 900W (EOL)
Launch	2001

main engines, 2) navigation of the spacecraft to the asteroid with optical navigation system, 3) autonomous touch & go with optical camera and laser range sensors, 4) original mechanism for sampling the fragments and housing them to the reentry capsule, and 5) heat shield technology of high speed reentry directly from the interplanetary Earth return trajectory. Figure 3 shows an image of MUSES-C. Table IV shows the main characteristics of MUSES-C.

2.4 LUNAR-A

The Japan's first lunar probe, LUNAR-A, will be launched in 2003 by the M-V rocket from Kagoshima Space Center. The LUNAR-A investigates the internal constitution of the Moon using seismometers and heat-flow probes installed in the Penetrators.

After entering orbit around the moon, the LUNAR-A will drop two Penetrators. The Penetrators will force their way down about two meters into the moon surface. As to the Penetrator, the important technologies are the attack-angle control in driving into the moon and the structure that withstands shock of 10,000G. NEC solves the former by the attitude control system with high accurate carried on the spacecraft and each Penetrator, and the latter by the special potting technique.

For about one year, heat and temblor measuring equipment in the Penetrators will determine the Moon's constitution. The data they observe will be preserved in the Penetrators' memory and relayed back to Earth via transmissions made to the mother ship orbiting the moon. The LIC (Lunar Imaging Camera) on the mother ship is also planned to observe the moon surface formations. Figure 4 shows an image of LUNAR-A. Table V shows the main characteristics of LUNAR-A.

2.5 ALOS

The ALOS (Advanced Land Observing Satellite) is one of the largest Earth observing satellites in the world. It was developed for cartography, regional observation disaster monitoring, resources surveying around the world and the technology development necessary for future Earth observing satellites.

Three remote-sensing instruments are onboard in the ALOS: the PRISM (Panchromatic Remote-sensing Instrument for Stereo Mapping), the AVNIR-2 (Advanced Visible and Near infrared Radiometer type 2) and the PALSAR (Phased Array type L-Band Synthetic Aperture Radar). NEC is contributing to the development of PRISM and PALSAR as well as satellite system integrator. The PRISM is a panchromatic radiometer with 2.5m spatial resolution. Precise land information can be obtained frequently using three optical systems for forward, nadir and backward view. NEC achieves this accuracy

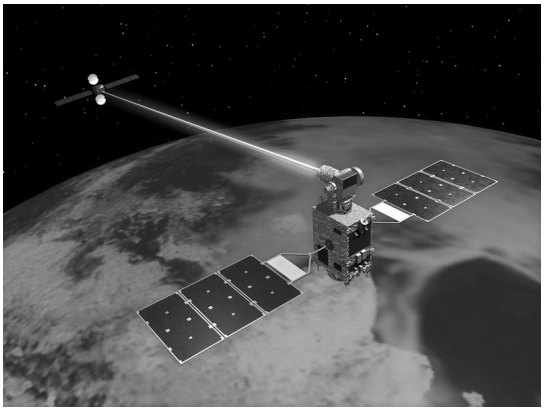

Fig. 2 OICETS.

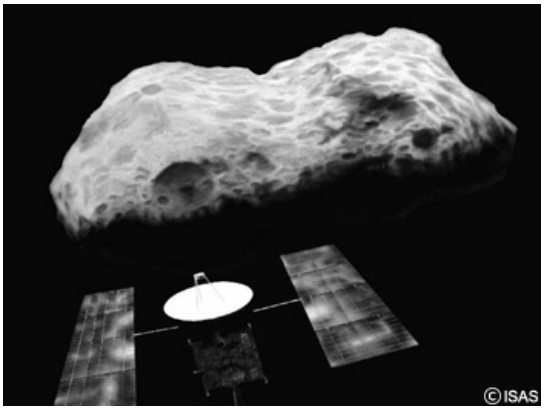

Fig. 3 MUSES-C.

Table III OICETS characteristics.

Items	Characteristics
Configuration	Structure $0.78 \times 1.1 \times 1.5$m
Mass at lift-off	Approx. 570kg
Generated power	More than 1,220W (EOL)
Launch	2002

Table IV MUSES-C characteristics.

Items	Characteristics
Configuration	Structure $1.0 \times 1.6 \times 1.1$m
Mass at lift-off	513kg
Generated power	2,573W@1AV (EOL)
Launch	2002

by the zero thermal distortion structure and the kinematic-mount technology. The PALSAR is an active microwave sensor for day and night and all weather land observation. This sensor has a beam steerable in elevation and the ScanSAR mode, which allows us to obtain a wider observation width than conventional SARs.

The ALOS is scheduled for launch in summer 2003. Photo 1 shows the thermal test module of ALOS. Figure 5 shows an image of ALOS. Table VI shows the main characteristics of ALOS.

2.6 SELENE

The SELENE (Selenological and Engineering Explorer) is a Japanese moon orbiter mission jointly developed by NASDA and ISAS. It will be launched in 2004 by NASDA's H-IIA rocket from Tanegashima Space Center.

The SELENE spacecraft consists of a lunar orbiter, which goes around the moon at about 100km altitude near a polar circular orbit, and two small satellites in elliptical orbit at 800km and 2,400km. SELENE will carry 14 scientific instruments for mapping of lunar topography and surface composition, measurement of the gravity and magnetic fields, and observation of the environment.

The engineering objective of the mission is to develop the technology for future lunar exploration. The scientific objectives of the mission are; 1) study of the lunar origin and evolution, 2) measurement of the lunar environment, and 3) observation of the solar terrestrial environment. The scientific data will be also used for exploring the possibility of future utilization of the Moon. Figure 6 shows an image of SELENE. Table VII shows the main characteristics of SELENE.

2.7 ASTRO-F

The ASTRO-F, originally named IRIS (Infrared

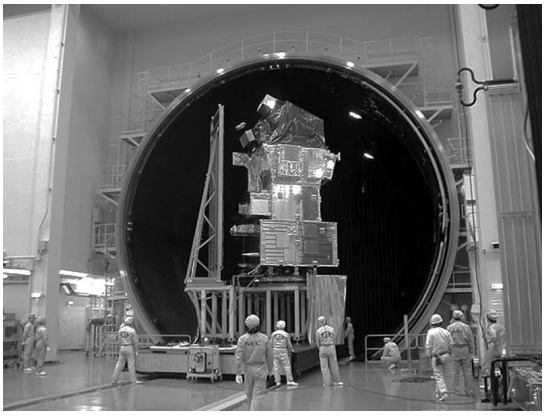

Photo 1 ALOS thermal test model.

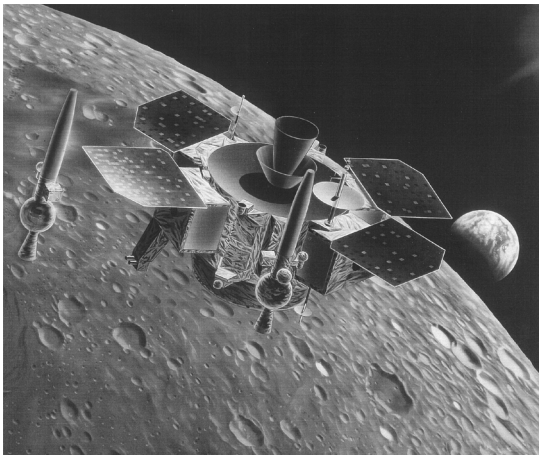

Fig. 4 LUNAR-A.

Fig. 5 ALOS.

Table V LUNAR-A characteristics.

Items	Characteristics
Configuration	Structure 1.2m (diameter) × 1.1m
Mass at lift-off	540kg
Generated power	400W
Launch	2003

Table VI ALOS characteristics.

Items	Characteristics
Configuration	Structure 3.6 × 4.0 × 6.2m
Mass at lift-off	Approx. 4 ton
Generated power	Approx. 7kW (EOL)
Launch	2003

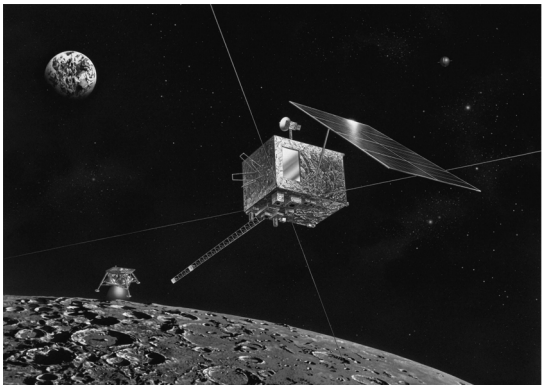

Fig. 6 SELENE.

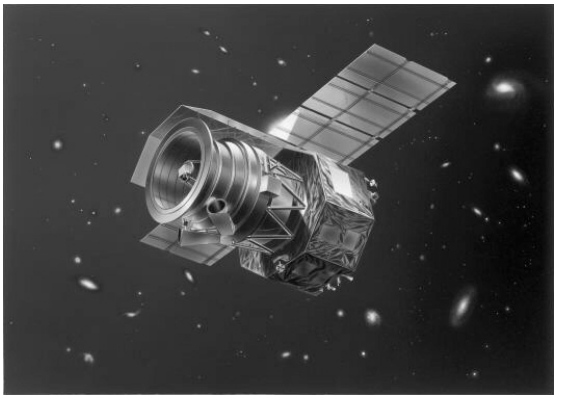

Fig. 7 ASTRO-F.

Table VII SELENE characteristics.

Items	Characteristics
Configuration	Structure $2.1 \times 2.1 \times 4.8$m
Mass at lift-off	2,885kg
Generated power	More than 3,480W (EOL)
Launch	2004

Table VIII ASTRO-F characteristics.

Items	Characteristics
Configuration	Structure $1.9 \times 2.0 \times 4.2$m
Mass at lift-off	960kg
Generated power	More than 900W (EOL)
Launch	2004

Imaging Surveyor), is Japan's first infrared astronomy mission employing a cooled telescope 70cm in diameter.

The IRTS (Infrared Telescope in Space), which was launched in 1995, was a small cooled telescope onboard the multi-purpose satellite SFU (Space Flyer Unit). The new ASTRO-F mission was planned on the basis of IRTS's results. The spacecraft investigates the formation and evolution of the galaxies, stars, and planets. The entire optical system is cooled by super-fluid liquid helium. The 550-day holding time with 170-liter liquid helium is achieved by mechanical coolers (two-stage Stirling refrigerator).

The ASTRO-F is scheduled to be launched in 2004 by M-V rocket from Kagoshima Space Center. Figure 7 shows an image of ASTRO-F. Table VIII shows the main characteristics of ASTRO-F.

3. CONCLUSION

NEC space activities in the past 30 years and recent programs have been introduced. As described above NEC is integrating satellites with a wide range of missions using the state of the art technologies. We are also evolving the technologies based on the experience of over 30 years focusing on space development in the next 30 years. We will continue to play a major role in Japanese and world space programs.

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