

Nice to meet you. I am SDS-1.

Advantages of small demonstration satellites

The Small Demonstration Satellite (SDS) program is one of several activities of JAXA, the Japan Aerospace Exploration Agency, to improve the reliability of practical artificial satellites by demonstrating a range of new technologies, from elemental to system-wide, for space. The Small Demonstration Satellite type 1 (SDS-1), the first satellite in the SDS program, has been under development since 2006. One of the objects in the development efforts for SDS-1 is to coordinate the systems expected to be applied by the Space Technology Demonstration Research Center of the JAXA Institute of Aerospace Technology. Small satellites can be developed more quickly and inexpensively than large satellites. This is quite useful, as it allows aerospace researchers to demonstrate and experiment with various technologies in orbit within short time frames. The IAT plans to serialize 100 kg-class small demonstration satellites with this SDS-1 as the forerunner. In phases of the SDS program seeking to improve the abilities of young engineers, JAXA researchers and others are carrying out diverse work operations, from system design analysis to satellite system assembly and various kinds of system tests.

Tasks of SDS-1

JAXA launched a 50 kg-class small satellite (Micro-Labsat) in 2002. The experiences and actual achievements gained

from the work with Micro-Labsat, from development to operation, are now being applied in the development work for the SDS-1. The SDS-1 is a box-type satellite with a mass of about 100 kg and approximate dimensions of 70 by 70 by 60 cm. If plans go as scheduled, it will be launched as a piggyback satellite (refer to here) on the H-II A rocket and stationed in a sun-synchronous orbit*¹ in 2008. The attitude control of the satellite is based on the spin stabilization method, but with success it will be possible to stop the satellite spin and apply three-axis attitude control during the experiment*². The satellite is also designed to deploy two solar cell panels in order to provide a margin of electric

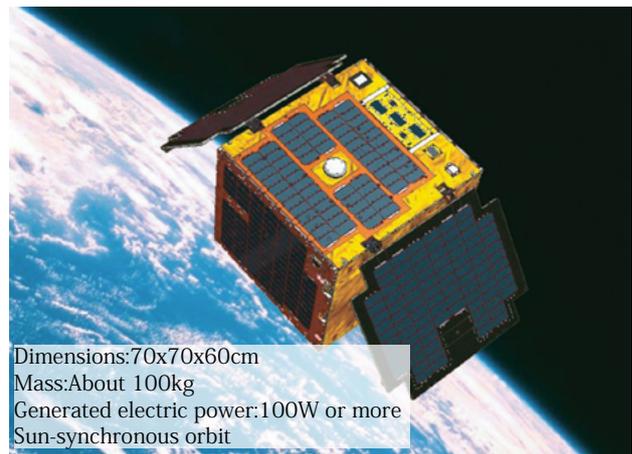


Fig.1 In-orbit conceptual diagram of the SDS-1

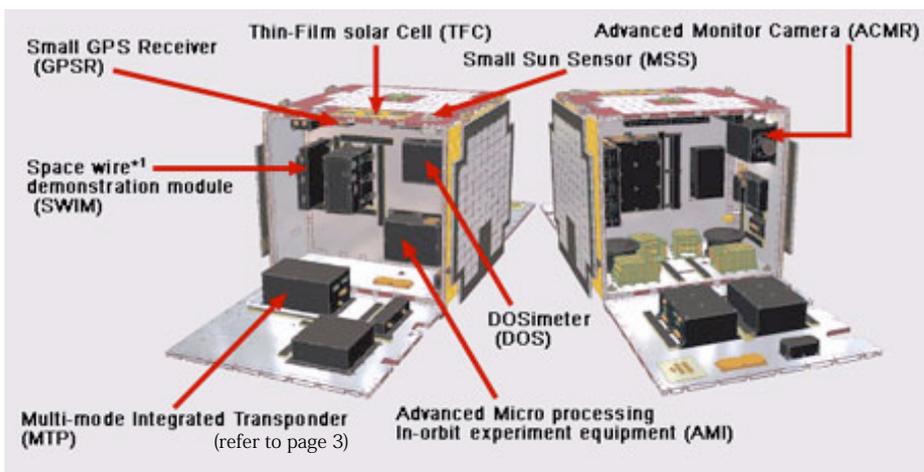


Fig.2 Mission equipment loaded on the SDS-1

Space wire*⁴ demonstration module (SWIM)

- A next-generation network-type data-processing technology was established by advancing a new international standard called the Space Wire standard. This technology was demonstrated using a high-speed MPU*⁵ developed by JAXA for space.
- Measurement experiment of gravity variations using an ultra-sensitive accelerometer that relies on advanced data-processing technology.

Advanced Micro processing In-orbit experiment equipment (AMI)

- In-orbit operation experiment on a high-performance procession board composed of

*⁴ Space Wire : Communication network equipment loaded on artificial satellites and other space vehicle.

*⁵ MPU : Micro processor unit. The data-processing-chip serving as the nerve center of a calculator.

The Development of the Small Demonstration Satellite-type 1 (SDS-1)

power (Fig. 1). To demonstrate the performance of the new technologies, the satellite is loaded with three main kinds of mission equipment (Multi-mode Integrated Transponder, Space Wire Demonstration Module, and Advanced Micro processing In-orbit experiment equipment). The satellite is also loaded with various other kinds of equipment for the demonstration of new technology. (Fig. 2).

JAXA's young engineers and researchers play a central role for developing satellite system. They handle thermal-structural analyses for systems, assembly works, environmental testing of the Bus equipment^{*3}, thermal balance testing for the systems, vibration testing, and so forth (Fig. 3). Through developmental activities of these sorts, JAXA has also been studying effective techniques for development management to ensure that reliability, quality, etc. of small demonstration satellites meet the requirements for low cost and short-term development.

Towards launch

Based on designs verified through the tests and analyses that have so far been carried out, JAXA plans to start assembling and testing from the end of this year in preparation for the launch scheduled in 2008. In parallel with assembly and testing, JAXA will also move forward with preparations for operation, including the maintenance and upgrading of ground operating equipment and facilities.

Based on our experiences with the SDS-1, we expect to steadily collect technologies on a timely and short-cycle basis, and by doing so to improve reliability and reduce costs for our spacecraft system.

(Keiichi Hirako)

*1 Sun-synchronous orbit : An orbit in which the satellite orbit plane remains at the same angle relative to the sun. When viewed by a satellite in sun-synchronous orbit, the rays of the sun striking the earth are reflected at a constant angle.

*2 Three-axis attitude control is attitude control in one vertical direction and two horizontal directions. The artificial satellite

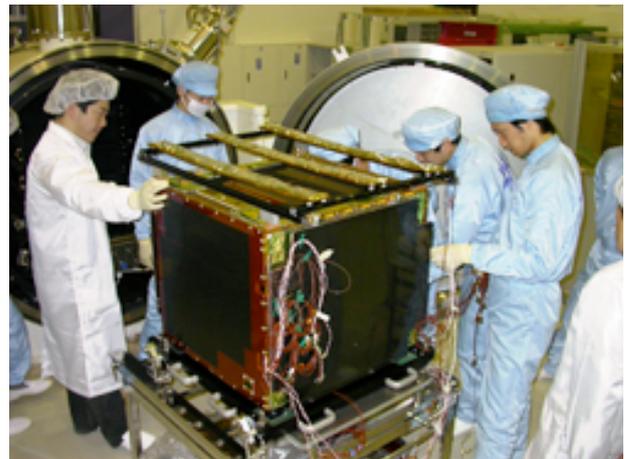


Fig. 3 System structure model assembly (Top) / thermal balance testing (Bottom)

spins like a top (spin stabilization) and changes rotating angles in response to the torques of a wheel turning, accelerating, and decelerating from within.

*3 Bus equipment : The communication systems, power supply system, attitude control system, and other systems designed to support a satellite's missions. Every satellite is loaded with Bus equipment.



[Space Technology Demonstration Research Center]

SDS-1 development members (Author: Third from the right in the rear row)

Communication equipment linking satellites with the ground

All satellites are remotely controlled from the ground

All artificial satellites are monitored from ground stations and remotely controlled by radio transmission until their missions are accomplished.

The equipment used to receive operation commands from the ground and to transmit the operation conditions (telemetry) to the ground is thus essential for any kind of satellite. While sending and receiving radio signals to and from the ground (i.e., ranging), this equipment also calculates the distance between the satellite and ground by measuring the time required for ranging (Fig. 1). This function of distance measurement is essential for determining the position of a satellite's orbit. The satellite communication channels with transmitting and

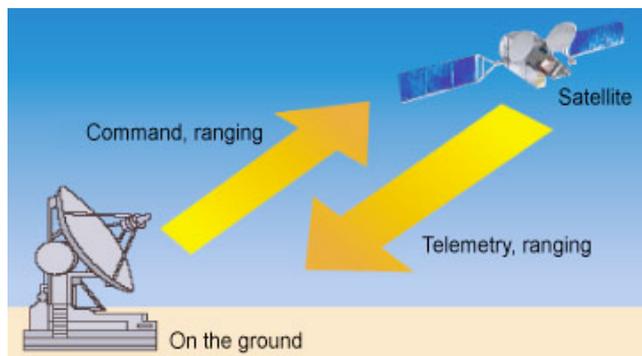


Fig. 1 Remote control and distance measurement

responding functions are described as "transponders" (channels that "transmit" and "respond").

The transponder designed for remote control and distance measurement is one of the most important pieces of equipment on a satellite.

Developing small and high-performance communication equipment capable of controlling satellites easily

The transponders now in service in satellites have already reached extremely high levels of reliability. But requirements for enhanced functionality, smaller sizes, and lighter weights have been increasing year by year. JAXA is working to meet those requirements in a project to develop a next-generation transponder it calls the MTP (Multi-mode Integrated Transponder).

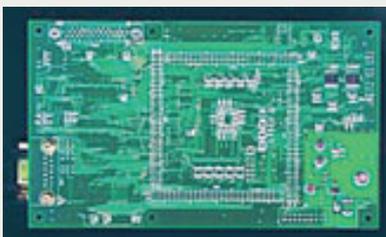
The MTP is designed to function in four operation modes (modulation methods).

1. PSK/PM (conventional modulation method)
2. UQPSK (inter-satellite forward link modulation method) / SQPN (inter-satellite return link modulation method)
3. QPSK (modulation method for high-speed data transmission)
4. UQPSK (modulation method when two or more satellites are operated)

The conventional transponder model functions in only mode (1) or in modes (1) and (2). The MTP is designed to additionally work in modes (3) and (4) as a multi-functional (multi-mode) device. The ability to switch from mode to

With the conventional technology

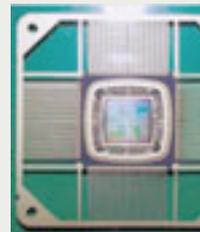
- Realized in an analog (partially digital) circuit



- The many analog parts mounted on the substrate increase both the mass and electric power consumption.
- The measures to deal with EMI^{*1} and EMS^{*2} demand many man-hours.

With the latest technology

- From analog technology to digital technology
- Adoption of large-scale gate array



- Size, weight, and power consumption are all greatly reduced.
- The measures to deal with EMI and EMS are fast and easy.

*1 EMI : Electromagnetic interference. EMI is the electromagnetic noise leaking out from electronic equipment. If excessive, it may interfere with the operation of other electronic equipment.

*2 EMS : Electro Magnetic Susceptibility. The EMS influences how well a device withstands the electromagnetic noise leaking out from other electronic equipment.

Fig. 2 Comparison between the conventional technology and the latest technology

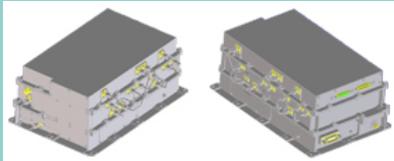
Development of Multi-mode Integrated Transponder (MTP)

mode expands the range of functional requirements that can be met.

In mode (3), the transponder can transmit data (data from experiments, for example) at ten times the speed of a conventional transponder, or even faster. In mode (4), two or more satellites can be operated at the same frequency without interference.

The size and weight reductions of the MTP are also remarkable. Compared with the most advanced transponders made in foreign countries, the conventional Japanese transponder has about double the 'mass per function' at maximum. But by incorporating all of the above functions into a semiconductor device (gate array)

Table 1 Major specifications of the MTP

Function	Four modulation modes (PSK/PM, UQPSK/SQPN, QPSK, and UQPSK)
Size	W: 180 x D: 270 x H: 118 mm (TBD)
Mass	4.0 kg (nominal) or less
External appearance	

used as the digital signal processing section of the central portion, JAXA reduced the mass per function for the MTP to less than half of that of the overseas transponders (Fig. 2 and Table 1).

The MTP will be loaded on the SDS-1 and launched for in-orbit demonstration experiments in preparation for use on practical satellites.

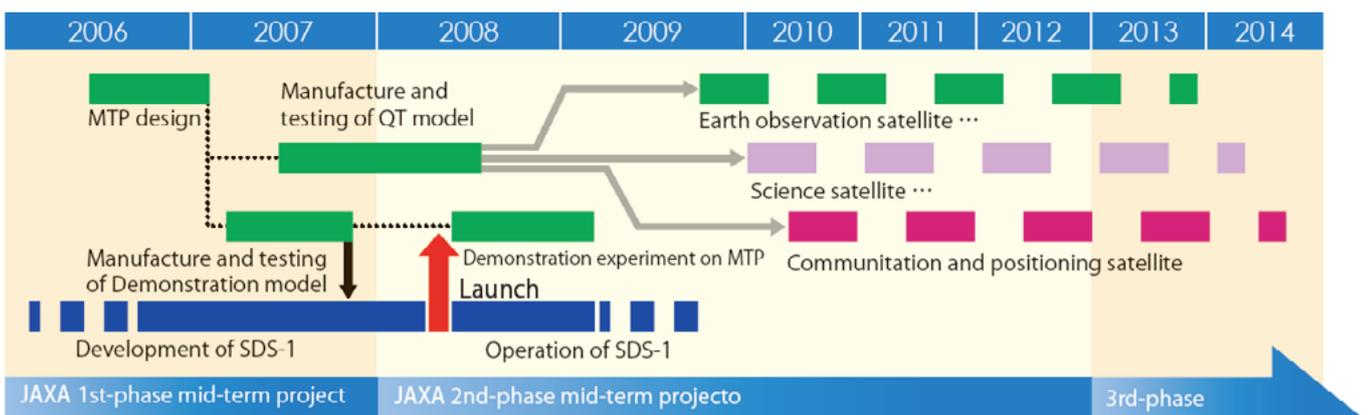
An active role in various satellites of the future

JAXA began developing the MTP and completed the design in the same year, FY2006. In FY2007 we will manufacture and test a demonstration model to be loaded on the SDS-1 for experiments and a QT model for qualification tests on the ground. The demonstration model to be launched with the SDS-1 in FY2008 will be used in experiments to demonstrate the performance in orbit. The qualification tests on the QT model will also be carried out in FY2008.

Once the development and demonstration are complete, the MTP will be installed in satellites of various types to be launched in the JAXA second-phase mid-term project and subsequent projects in the future (Table 2).

(Noboru Takata)

Table 2 MTP-related schedule



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