The results of Small Satellite technology transfer from JAXA

Hiroaki Kawara, Naomi Murakami, Yuuta Horikawa, Koji Nakaya, Keiichi Hirako, Hidekazu Hashimoto

Space Technology Demonstration Research Canter, JAXA
Tsukuba space center 2-1-1 Sengen, Tsukuba City, Ibaraki Prefecture, Japan; +81-50-3362-3888
Kawara.Hiroaki@jaxa.jp, murakami.naomi@jaxa.jp, horikawa.yuuta@jaxa.jp, nakaya.koji@jaxa.jp
hirako.keiichi@jaxa.jp, hashimoto.hidekazu@jaxa.jp

ABSTRACT
The satellite named MAIDO-1 finished its 9-month life, on October 15, 2009. The MAIDO-1 was developed by Space Oriented Higashiosaka Leading Association (SOHLA). Japan Aerospace Exploration Agency (JAXA) transferred their space technology to small and medium-sized enterprises (SMEs) and local universities in the Kansai area. The purpose of this activity is to contribute to socio-economic development by returning JAXA research and development results to society. The MAIDO-1 is one of its program achievements. This paper shall explain the matter of the technology transfer, the SOHLA-1 satellite system, on-orbit experimental results, and the results of technology transfers.

INTRODUCTION
Since the start of R&D activity on small satellites in 1995, JAXA has been engaged in developing a suite of small satellites and their components. These satellites and components paved the way for a faster, cheaper, and better means to access space. Our first small satellite, MicroLabSat, was launched on December 14, 2002 [1]. Following the success of this satellite, the potential of small satellites began to be recognized at JAXA. Many enterprises and organizations are also interested in small satellites and their future. In 2003, a group of small and medium enterprises (SMEs) established the Space Oriented Higashiosaka Leading Association (SOHLA) to enter the space business. Since the SOHLA had no space development experience, it started by developing its first satellite, SOHLA-1, with valuable technical support from JAXA. To keep development inexpensive and effective, SOHLA-1 utilizes the components and bus technologies established by MicroLabSat.

PROJECT OVERVIEW
Project Frame work
SOHLA-1 is the first satellite in SOHLA’s 5-year project involving the research and development of a Panel Extension Satellite (PETSAT) system. The project, proposed by the University of Tokyo [2], has been funded since 2003 by the New Energy and Industrial Technology Development Organization (NEDO) as a key technology research promotion program.

In this project, JAXA discloses its technological information related to small satellites and provides technical support to SOHLA so that they can acquire fundamental space technologies through system management and satellite design, manufacturing, testing, and operation. Osaka Prefecture University is participating in satellite system design and analysis with the support of JAXA. Furthermore, the University of Tokyo, Osaka University, and Ryukoku University are developing their own experimental components.
This collaboration with industry and universities is a first for JAXA, opening a door to new options in the space industry and remarkable development of the small satellite business in Japan.

**JAXA’s Space Technology Transfer Program**

Recently, to strengthen the space industrial foundation and to stimulate the economy in Japan, JAXA was required by the public to disseminate its accumulated space technologies to industry and universities. For this reason, transferring space technology is one of JAXA’s motivations in the project. JAXA’s Space Technology Transfer Program is based on a contract they held with SOHLA for “Arrangements Related to Collaborative Efforts in Small Satellite Technologies,” that concluded in May 2004 [3]. JAXA set up a new office and clean room equipped with a space chamber in Higashi-Osaka City in western Japan for this project with SOHLA.

SATELLITE DESCRIPTION

**Satellite Overview**

The mission of SOHLA-1 is to develop a 50kg class micro satellite for space demonstration in a short period of time and at low cost, utilizing JAXA’s MicroLabSat bus technology and SME’s potential manufacturing abilities. Figure 2 illustrates the on-orbit image of SOHLA-1. SOHLA-1 is an octagonal prism and has two deployable booms. Table 1 presents its main specifications. The satellite is controlled through both amateur band and JAXA’s S-band operation systems, as shown in Figure 3.
BASIC POLICY ON SATELLITE DESIGN

The design concept of the satellite is simple and low cost. The following basic strategies are adopted to following policies.

(1) Applying as much MicroLabSat bus technology as possible. The list below shows bus technologies applied to SOHLA-1. These efforts significantly reduced the number of new components needed to be developed for SOHLA-1, subsequently decreasing both the development period and cost. In addition, the SOHLA-1 bus is designed to achieve a general-purpose 50-kg-class demonstration satellite. This effort will lead to:

Adoption of the same components

- S-band transponder / diplexer
- S-band coupler / antenna
- Ni-MH battery

Component design transfer

- Central and extended control unit
- Power control unit

System technology transfer

- Peak power tracking control algorithm
- Spin-axis control algorithm
- System design and development software
- S-band operation system

(2) Keep the relationship between the design and manufacturing floors closer and apply SME’s low-cost manufacturing techniques. In the main structure of the satellite, aluminum isogrid panels
are used instead of honeycomb panels, enabling the reduction of manufacturing costs by half. Isogrid panels are also effective as radiation shields, facilitating the adoption of commercial off-the-shelf (COTS) parts.

(3) Apply a redundant and fail-safe configuration to the system’s critical components. As presented in Figure 3, the communication subsystem combines the amateur band and the S-band transceiver/receiver. In case of attitude loss, solar cells mounted on every panel provide the minimum survival power. Figure 4 shows the SOHLA-1 bus data flow. For set predetermined time, if SOHLA-1 is not operated, the program of SOHLA-1 automatically moves its system into the survival mode. Under this mode, SOHLA-1 is able to achieve the main missions and collect necessary telemetry.

Technology Demonstration Experiments

SOHLA-1’s mission is to carry out eight technology demonstration experiments to exhibit the high potential of small satellites. The experiments, most of which are already planned for future small satellite applications [4], are described below:

JAXA missions

1. Orbit determination technology experiment shown in and its components (JAXA)

The GPS receiver was developed based on car navigation systems to meet space requirements. The body structure, GPS antenna, and firmware were modified for endurance in space. The position and orbit of the satellite are decided precisely by SLR (Satellite Laser Ranging) technology to evaluate the accuracy of the GPS receiver.

2. Small Dosimeter(DOS): Demonstration of the space environment measurement experiment and its components (JAXA)

A radiation-sensitive field-effect transistor (RadFET) is located near the semiconductor devices of mission components to measure radiation in space.

3. Demonstration of the CIGS solar cells experiment (JAXA)

Two types of thin-film solar cell, which are candidates for use as next-generation space solar cells, are demonstrated in orbit.

4. Advanced Micro processing In-orbit experiment (AMI): Demonstration of the 64-bit MPU at a 50-MIPS level (JAXA)

The microprocessor operates at (50 MIPS) to provide on-orbit, high-speed operation data for future applications.
Mission for PETSAT

5. Small monitor camera (MCMR) demonstration (JAXA/SOHLA)

An experiment to prove space of small monitor camera that JAXA is used consumer product and developed.

6. Deployable boom demonstration (Ryukoku University)

7. Fudai (Furitsu University) Sun Sensor (FSS): Demonstration of the sun sensor (Osaka Prefecture University):

An experiment aimed at acquiring basic technology of space proof and spacecraft component development for the sun angle calculation algorithm developed by Osaka-prefecture university students.

8. Broadband Measurement for Waveforms of VHF Lightning Impulses (BMW): Demonstration of a component for broadband measurement of waveforms for VHF lightning impulses used in PETSAT (Osaka University)[5]:

The electric wave generated by thunder is observed on orbit using the BMW.

**OPERATION RESULTS OF SOHLA-1**

In mission operation, all components are working well, and obtaining successful data. All missions have achieved success above and beyond expectations. Table 2 summarizes mission operation results in the nominal operation phase.

<table>
<thead>
<tr>
<th>Mission</th>
<th>Conducted operations and results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orbit determination technology demonstration</td>
<td>All functions were working well.</td>
</tr>
<tr>
<td>DOS</td>
<td>Radiation absorbed dose was measured with propriety</td>
</tr>
<tr>
<td>CIGS</td>
<td>Degradation of Si solar cell (reference) and thin-film solar cells are compared</td>
</tr>
<tr>
<td>Advanced Micro processing In-orbit experiment (AMI)</td>
<td>All parts were working well. - MPU is functioning in 50MIPS SEUs are observed MPU cache area. - Error detection and correction is also working well.</td>
</tr>
<tr>
<td>MCMR</td>
<td>All functions were working well. Use this camera, Deployable boom can be confirmed</td>
</tr>
<tr>
<td>Deployable Boom</td>
<td>Function was working well</td>
</tr>
<tr>
<td>FSS</td>
<td>All Functions were working well.</td>
</tr>
<tr>
<td>BMW</td>
<td>All functions were working well.</td>
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**Bringing the satellite operation an end**

After finishing nominal and operation phase, SOHLA would like to concentrate on building the next satellite. They decided to continue satellite operation until October 15, 2010. Thus, SOHLA’s first challenge will end in success.

**CONCLUDING REMARKS**

SOHLA-1 is a 50-kg-class spin-stabilized demonstration satellite. The satellite was developed based on space-proven MicroLabSat bus technology with JAXA’s space-technology transfer program. To achieve its design concept of obtaining higher reliability with lower development cost, several strategies and ideas were presented. In addition, apart from technical matters, the utilization of university students and the dispatch of satellite engineers from JAXA were also important contributing factors in lowering the cost of development.
This technology transfer program of small satellite bus technology established by MicroLabSat has been an important test case for JAXA’s future space technology spin-off program and for its collaborative programs with industry and universities. This project is just a starting point, and we recognize how important it is for JAXA to continue disseminating its accumulated space technologies to industry and universities.

SOHLA-1 might have become the step of space by the success of development and operation.

References


