Report

SmartSat-1: On Orbit Experiment Plan Using Mini-Satellite

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1. Introduction

Recent progress of commercial communication and sensor technologies are very rapid. The effective use of the latest technologies in space should greatly contribute to our space communication infrastructure and to space and earth observations.

Furthermore, the maturation of several technologies for small satellites should enable us to make quick demonstrations. There has also been a steady increase in the number of launch opportunities for small satellites, such as auxiliary or piggyback-style launches, with advances in launch services.

In cooperation with space-related organizations and private sector, The National Institute of Information and Communications Technology (NICT) has been promoting a timely and cost-effective on-orbit demonstration series using small satellites, called SmartSat

NICT and Mitsubishi Heavy Industries (MHI) have been planning a unique small-satellite mission called SmartSat-1. SmartSat-1 consists of about 250kg weighted mini satellite, which can be launched in a piggyback manner. SmartSat-1 will be launched into a geo-synchronous transfer orbit (GTO). We plan to demonstrate basic technologies for satellite communications such as advanced satellite communications and high-performance on-board image processing technologies.

In this paper, the mission and design outline of SmartSat-1 are introduced.

2. Overview

Table 1 shows the target specification of the system. The bus module is shaped roughly as an octagonal cylinder with the diameter of 1m and the height of 0.6m. The mass including mission payload module is around 150kg. This comes from the ASAP 5 (Arian Structure Auxiliary Payload) service in ARIANE-V and H-IIA is currently planning to provide the same type of service Moreover the mass of around 150kg is judged to be a proper balance between technical performances and demands for technology demonstration satellite from wide range of users. Since the main application of the present bus system is demonstration of new technologies and components in space, it is designed for more-than-6-month mission life in Geosynchronous Transfer Orbit (GTO).

Table 1 Target Specifications

Bus Mass	Less than 170 kg (WET)
Payload Mass	Less than 90 kg
Total Mass	Around 260 kg
Bus Size	φ1m x H 0.6m Octagonal Cylinder
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Orbit	GTO, SSO, LEO
Attitude Control System	Zero Momentum 3 axis Stabilized
Pointing Accuracy	Better than 0.1deg
Payload Power	Maximum 150W (GTO)
Solar Array Panel	2 deployment wings GaAs triple-junction cells
Nominal Voltage	28V
Propulsion	1 tank 12 thrusters
Propellant Capacity	Maximum 24kg (Hydrazine monopropellant)
Total Impulse	47000Nsec
Downlink	S-band, X-band(Option)
Uplink	S-band
Mission Life	More than 6 month in GTO

Functional block diagram of the present system are shown in figure 1. The On-Board Computer (OBC) handles attitude control, data processing, and telemetry command processing. The Power Control Unit (PCU) manages the power, thruster and latch valve drive, and heater control according to the design policy to reduce the number of equipments. As for other bus components, existing off-the-shelf and flight-proven ones are selected to minimize non-recurring costs, development period, and risks.

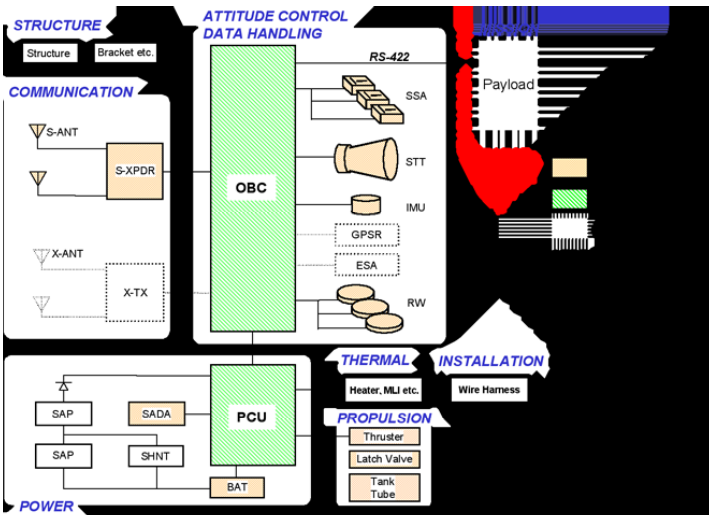

Fig. 1: Functional block diagram

To reduce launch costs as well, the present bus system is designed to use auxiliary launch capability of H-IIA instead of dedicated launchers. One or two satellites ride inside payload attach fitting (PAF) of primary satellite..

3. Missions

Using the SmartSat-1, two missions, which are 1) reconfigurable communications experiment, and 2) orbital experiment for space weather observation and forecasting, are planed to be demonstrated on GTO. (Fig. 2)

3.1 Reconfigurable communications experiment,

Expanding the capacity of satellite communication systems requires the use of onboard switching and regenerative relay techniques. However, there are obvious difficulties in applying new communication technology that has appeared since a launch if a new modem and base-band switch are required to be loaded on a satellite. Currently, the lifetime of a communications satellite in orbit is from 10 to 20 years, and it is impossible to exchange or upgrade mission equipment loaded on a satellite after its deployment in space. A reconfigurable communication equipment is plan to be loaded on the SmartSat-1. The reconfigurable communication equipment includes an onboard software radio system that consists of reconfigurable devices. New functions can be added by installing new configurations sent from a ground terminal after launching. The performance of S-RAM type FPGA under the radiation condition was successfully verified in previous work.

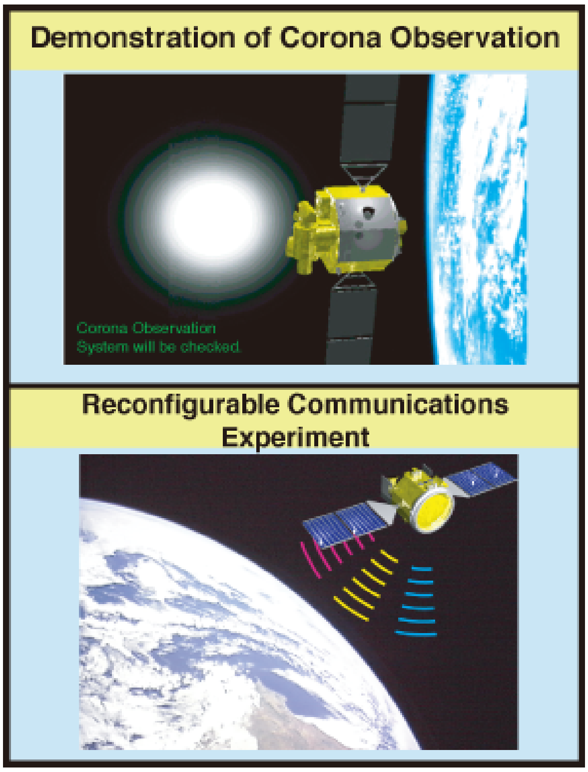

Fig. 2: SmartSat-1 Missions

3.2 Demonstration of Corona Observation

It is known that the high-energy radiation such as Solar Energetic Particle is emitted, when solar flare occurs. This phenomenon causes malfunctions of computers and sensors on satellites and jamming to radio wave communication or broadcast. In order to predict and elucidate it, the “Space Weather Forecast” project has been initiated by NICT in Japan. In this project, Coronal Mass Ejection (CME) propagation between sun-earth space is to be observed from the 5th Lagrangian point. (L5 mission) The present bus system could carry the newly developing corona observation system composed of a camera, a detector, and data processors. In this way, it could provide the precedence space demonstration opportunity of the L5 mission. In this demonstration, the performance of the corona observation system can be checked and the new image-processing algorithm will be established through observation data analysis.

4. Conclusion

In this paper, the SmartSat-1, which is a mini satellite developed by NICT and MHI, is introduced on its the missions and satellite design outline. Using the SmartSat-1, two missions, which are 1) reconfigurable communications experiment, and 2) orbital experiment for space weather observation and forecasting, are planed to be demonstrated on GTO. NICT and MHI continue detailed design of SmartSat-1 and are seeking launch opportunities.