Abstract for 11th Low Cost Planetary Missions Conference
June 9-11, 2015, Berlin, Germany

Development and Initial Operation Results of a Low-cost 50kg-class Deep Space Exploration Micro-Spacecraft PROCYON

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Development and initial operation results of 50kg-class deep space exploration micro-spacecraft PROCYON (PRoximate Object Close flYby with Optical Navigation) will be presented. PROCYON was jointly developed by the University of Tokyo and Japan Aerospace Exploration Agency (JAXA). Two major missions of PROCYON are (1) demonstration of 50kg-class deep space exploration bus system and (2) demonstration of high-resolution observation of an asteroid during close and fast flyby. PROCYON was launched directory into Earth departure trajectory together with Japanese second asteroid sample return spacecraft Hayabusa-2 on December 3, 2014.
Most of the bus system of PROCYON is based on that of 50kg-class Earth-orbiting micro satellite, excluding the communication system, propulsion system and mission components which were newly developed for the deep space mission. The communication system of PROCYON consists of X-band transponder (XTRP), GaN-based solid state power amplifier (SSPA), tone generator for DDOR orbit determination, and other passive components (antennas, switches, diplexer and band pass filters). Miniaturization was made possible by utilizing COTS (Commercial Off The Shelf) components. Micro propulsion system was developed, which unifies an ion thruster and multiple cold-gas jet thrusters for RCS (Reaction Control System). The ion thruster provides 300 μN of thrust with a specific impulse of 1000 s, which is used for low-thrust DSM (Deep Space Maneuver). The cold-gas jet thrusters, which can provide about 22 mN of thrust with 24 s of specific impulse, are used for both the reaction wheel desaturation and the asteroid flyby trajectory correction maneuver. The weight of the propulsion system is less than 10 kg including about 2.5 kg of propellant (Xenon). Such lightweight property is realized by sharing the gas system for both ion thruster and cold-gas thrusters. As of February 2015, the first mission (demonstration of the bus system) has been conducted during initial operation phase. After the completion of initial checkout operation, PROCYON will perform DSM using the ion thruster so that the spacecraft will be injected into asteroid flyby trajectory via Earth swingby at the end of 2015. The flyby target asteroid will be a near-Earth asteroid. PROCYON will perform close flyby trajectory guidance by optical navigation relative to the asteroid, and will pass within 50 km distance from the asteroid. During the close flyby, automatic tracking observation of the asteroid will be conducted using a camera with a scan mirror and onboard image feedback control, which enables LOS (Line Of Sight) maneuver while maintaining the spacecraft attitude. The observable surface resolution will be several meters.
This paper describes the system design of the spacecraft and how we developed the spacecraft with very low cost and short period. Also, initial operation results will be reported, focusing on the micro-spacecraft bus system demonstration results.