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MISSION AND SYSTEM DESIGN OF OPENS-0 MISSION: OUTER PLANET EXPLORATION BY MICRO-SPACECRAFT

Abstract

The Institute of Space and Astronautical Science (ISAS) of the Japan Aerospace eXploration Agency (JAXA) plans to explore the outer solar system using micro-spacecraft under the concept of the Outer Planet Exploration by Novel micro-Spacecraft (OPENS) program. OPENS aims to revolutionize exploration technologies and achieve first-class scientific results through frequent micro-spacecraft missions to explore outer planets, taking risks that cannot be taken by larger missions. The realization of outer planet exploration by micro spacecraft will allow us to take advantage not only of dedicated launch opportunities using large launch vehicles, but also of a variety of launch options, including low-cost launch vehicles and ride-share/piggyback to larger missions.

The OPENS-0 mission, the first in the OPENS program, aims to demonstrate outer planet exploration technologies, including a solar sail-based power generation system and a hibernation system, launched on the low-cost Epsilon S rocket. Upon successful completion of the technology demonstration, OPENS-0 plans to attempt a high-speed flyby of Saturn's ring system, and if successful, it will be the world's first solar-powered Saturn probe. The main scientific goal is to provide detailed image analysis of individual ring particles as well as unprecedented direct observations of the complex structure within the rings, thereby increasing our understanding of the Saturn ring system in the post-Cassini era. Imaging at visible wavelengths will provide information on the structure and dynamics of the rings and, in some cases, the size of the largest particles or agglomerates.

The OPENS-0 spacecraft will use multiple Earth and Venus gravity assists to obtain the high V-infinity required to explore Saturn, and will take approximately 10 years to ultimately reach Saturn. One of the biggest challenges for OPENS-0 is to keep the spacecraft operational for 10 years before it reaches Saturn while using small spacecraft technologies. To prolong the life of the small spacecraft components, we employ hibernation operation with minimal power-on time to the components. While taking advantage of the operational experience with Hayabusa2, we are considering an AOCS operation policy that will enable interplanetary cruise with only the minimum number of components required for survival in operation.

This paper presents an overview of the mission and system design of the OPENS-0 mission, including the trajectory design, concept of hibernation operations, and trade-off considerations between system designs to achieve a low-cost Saturn probe. The results of this study will also contribute to the consideration of future micro-spacecraft for outer planet exploration.