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DEVELOPMENT OF MULTIFUNCTIONAL LIGHTWEIGHT MEMBRANE WITH HIGH SPECIFIC POWER GENERATION SYSTEM AND ANTENNA

Abstract

This paper outlines the development status of the on-orbit demonstrator for the multi-functional membrane space structure "Harvesting Energy with Lightweight Integrated Origami Structure" (HELIOS), which will be attached to the JAXA's Rapid Innovative Payload Demonstration Satellite-3 scheduled for launch in 2022. The use of small satellites has rapidly grown in recent years for various applications including Earth observation and communication. In the future, the combination of large-scale Earth observation data from small satellites with artificial intelligence is expected to be utilized for various social problems. However, power and communication resources are extremely limited for such satellites, especially for CubeSats, primarily due to weight and volumetric constraints. Therefore, the HELIOS mission proposes a lightweight and large membrane structure with a power generation system and antenna capabilities. By demonstrating this technique, the performance of small satellites will be drastically improved while maintaining their advantages of being low-cost. Thus, high-capacity communications and high-resolution observations using large antennas based on a mass-efficient power generation system will become possible with CubeSats. HELIOS consists of a 1-by-1 m square polyimide membrane, with thin-film solar cells and antennas attached. The membrane is folded and stowed for launch. After launch, the membrane will be deployed by a set of diagonal tubular carbon fiber reinforced plastic booms, controlled by a 1U bus module. The mission objectives of HELIOS consist of three categories as follows. The first objective is to demonstrate a 200 W/kg-capable deployable solar paddle. This will be the highest power to weight ratio demonstrated to date. The second objective is beamforming with a 24 GHz multi-beam phased array antenna for 5G-capable satellite communications. This will be the first space demonstration of an array antenna transmitter that does not require a high degree of flatness for beamforming. The third objective is to demonstrate interferometry using thin-film antennas. This interferometer will be able to monitor the membrane shape, demonstrating the feasibility of aperture synthesis on a membrane. This will lead to array antennas with an extremely large surface area at a reasonable weight, leading to high spatial resolution microwave radiometers in the future. The development of HELIOS has begun in May of 2020. Integrated tests including membrane deployment, power generation experiments using a pulsed solar simulator, beamforming, and interferometry experiments, have been conducted with breadboard and engineering models. The success of the HELIOS mission will promote innovations for the utilization of large-scale Earth observation data from small satellite groups.