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STATUS OF HELIOS-R MEMBRANE-DEPLOYED MICROWAVE INTERFEROMETER DEMONSTRATION MISSION

Abstract

With the recent surge in the utilisation of small satellite platforms comes new demand for reliable, large-scale power and communication solutions that are light-weight and compact enough for such platforms. To meet this demand, JAXA is developing the "multi-functional membrane" concept, whereby thin-film solar cells and antennas are attached to flexible membrane structures, realising metre-scale flexible panels with power generation and communication functionalities. To demonstrate this concept, an on-orbit demonstration component Harvesting Energy with Lightweight Integrated Origami Structure (HELIOS) was launched on JAXA's Rapid Innovative Payload Demonstration Satellite 3 (RAISE-3) satellite. The launch was unfortunately unsuccessful due to launch vehicle failure. As a result, a new demonstration component HELIOS-R is currently being developed for RAISE-4. HELIOS-R will demonstrate 200W/kg class solar array, a membrane-deployed single-board microwave interferometer, and membrane-deployed 5G beamforming technology.

This paper describes the HELIOS-R Interferometer mission, which aims to demonstrate the feasibility of deploying a single-board Active Integrated Antenna (AIA) on board a flexible membrane structure. This is realised by a small 2x2 receiving array attached on the membrane, which is illuminated by a transmitter on board the satellite bus. The AIA detects the phase offsets between the receiving elements, from which the orientation of the receiving AIA, and thereby the membrane deformation, is deduced. When successful, the mission will demonstrate two new capabilities: aperture synthesis on a flexible membrane structure, and active measurement of membrane deformation.

Several improvements have been made to the previous iteration (RAISE-3 HELIOS), most notably thermal stability and frequency stability. Thermal control is one of the unique challenges of operating an AIA on flexible membrane structures. Since there is no meaningful thermal connection available to

the satellite bus, the AIA must independently and passively control its temperature. By careful control of surface properties, HELIOS-R AIA is expected to operate within component specifications. Other challenges include radiation shielding and prevention of static-charge buildup. Currently the flight model of HELIOS-R has been completed, awaiting satellite integration.

The technology demonstrated by HELIOS-R Interferometer directly contributes to the realisation of the world's lightest phased array antenna for small satellites. When scaled up, the world's largest space-borne antenna can also be realised. The antenna can be applied to communication, instrumentation (radar or radiometer) for Earth, lunar and planetary exploration, and membrane shape detection for solar sails. One exciting application is cubesat-based Synthetic Aperture Radar (SAR), where both power and antenna are made available by the multi-functional membrane.