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ON-ORBIT DEMONSTRATION OF MICROWAVE APERTURE SYNTHESIS ON DEPLOYABLE
MEMBRANE STRUCTURE: STATUS REPORT

Abstract

While the rapid miniaturisation of instruments has allowed cubesats to become versatile and cost-effective alternatives to traditional satellites, high-gain antennas remain a significant challenge for such small platforms. This is because microwave instruments are fundamentally limited by the diffraction limit, where the achievable beam width (i.e. gain) is limited by the ratio of wavelength to the antenna diameter. Phased arrays are light-weight alternatives to traditional single-feed antennas demonstrated and applied on cubesats. However, with rigid panel structures, cubesats will be able to achieve at best 1 m apertures. To further increase the achievable antenna sizes for cubesats and small satellites, much lighter deployment mechanisms are required.

Harvesting Energy with Lightweight Integrated Origami Structure (HELIOS) is a multi-functional membrane space structure demonstrator to be attached to JAXA's Rapid Innovative Payload Demonstration Satellite 3 (RAISE-3) satellite, to be launched in late 2022. On this program, the authors are developing a membrane-deployed Active Integrated Antenna (AIA), which integrates an array of patch antennas, receivers and downconverters on a single printed circuit board. This will demonstrate an ultra-light phased array antenna, by mounting a 2x2 AIA on a flexible membrane structure much like solar sails. The application proposed for this particular mission is membrane shape detection: the antenna is illuminated by a separate transmitter antenna attached on the host satellite, allowing the membrane-mounted AIA to measure the relative positions of antennas.

The technology demonstrated in this mission has a large number of potential applications, not limited to small satellites. In communications, the high gain this approach enables for cubesats enables low-power high-bandwidth multi-beam communications, allowing the satellite to communicate with multiple stations simultaneously with a single array. In Earth observation, the narrow beam width opens the possibility to low frequency microwave radiometry for cubesats, with observables including soil moisture, ocean salinity, surface wind, surface and atmospheric temperature and precipitation. The technology can

be directly applied to large-scale solar sails (e.g. the upcoming 40 m solar power sail OKEANOS) to realise the world's largest monolithic space antenna for the highest spatial resolution. The technology can also be applied for planetary exploration: microwave radiometry for the exploration of the deepest layers of the atmosphere of Jupiter and other gas giants.

At the time of proposal (March 2022), flight model of HELIOS has been completed and handed over for satellite system integration. RAISE-3 will be launched in late 2022.