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Author: Dr. Ahmed Kiyoshi Sugihara El Maghraby
Japan Aerospace Exploration Agency (JAXA), Japan, sugihara.ahmedkiyoshi@jaxa.jp

Mr. Takehisa Wada
Japan, takew10@gmail.com
Dr. Tamotsu Suda
Japan Radio Co., Ltd, Japan, suda.tamotsu@jrc.co.jp
Prof. Shigeo Kawasaki
JAXA, Japan, kawasaki.shigeo@jaxa.jp
Mr. Yuichiro Nada
University of Tokyo, Japan, nada.yuichiro@ac.jaxa.jp
Mr. Masahiro Fujita
University of Tokyo, Japan, fujita.masahiro@ac.jaxa.jp
Dr. Osamu Mori
Japan Aerospace Exploration Agency (JAXA), Japan, mori.osamu@isas.jaxa.jp

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 cubesats as 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 suitable and light-weight alternatives to traditional single-feed antennas for cubesaats. However, complex deployment mechanisms mean that cubesats will be able to achieve at best 1 m apertures with the present approach. To further increase the achievable antenna sizes for cubesats and small satellites, much lighter deployment mechanisms are needed.

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 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. HELIOS mounts a 2x2 AIA on a flexible membrane structure much like solar sails to demonstrate microwave interferometry on a membrane structure for the first time. This 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. By doing so, these antennas can be used in the future to synthesise a single aperture the size of the deployed sail.

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.

The authors will present the development status of HELIOS interferometer, with the hardware developed and tested for launch in 2022.