National Aeronautics and Space Administration

FY24 Strategic Initiatives Research and Technology Development (SRTD)

Deployable Antenna Technologies for Radars at Extreme Frequencies

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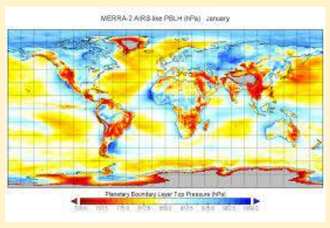
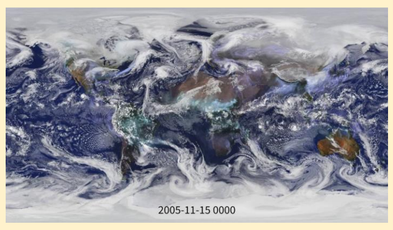
Strategic Focus Area: Radar Advances to Accelerate Earth and Planetary Missions | **Strategic Initiative Leader:** Darmindra D Arumugam

Objectives: To design and prototype a deployable high gain antenna technology for frequencies from 90-300 GHz that enables future JPL Earth Science radars

Background: HGAs used for radar measurements of the Planetary Boundary Layer (PBL) as well as radiometer science missions related to climate and weather. Typical solid reflectors (like CloudSat) are expensive, have long procurement times, and aren't deployable. Need low cost >1.6 m diameter aperture deployable for PBL measurements.

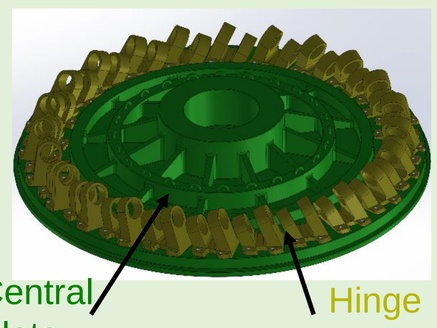


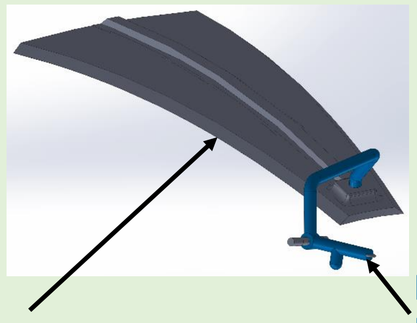


Approach and Results: We focused on developing the Petal Antenna concept that was selected in Year 2 of this project.

Petal and Hinge Assembly and Testing

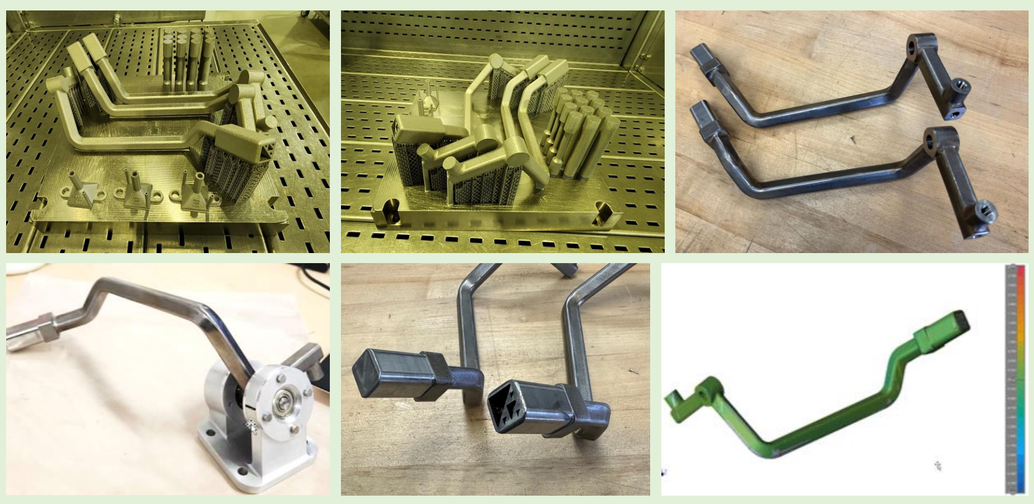
- Petals are opened and closed with hinge bodies
- Petal is connected to hinge with titanium Dogleg Rod





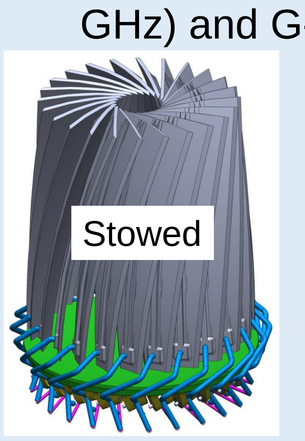
Additive Manufacturing of Titanium Hinges

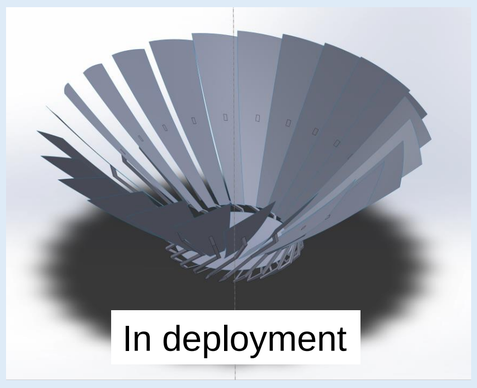
- Metal 3D printing was used to produce Ti-6-4 hinges for dogleg rod at JPL
- Parts are ~250 mm long. Critical interfaces are machined post-print to achieve required precision.

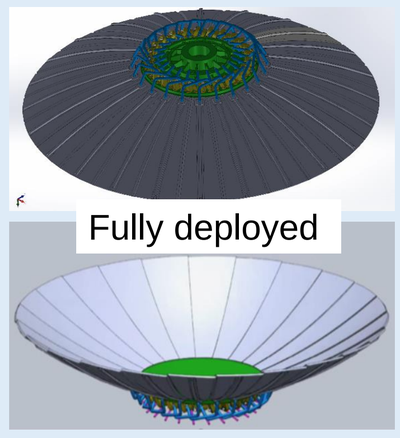


Key Elements of the Petal Antenna Design

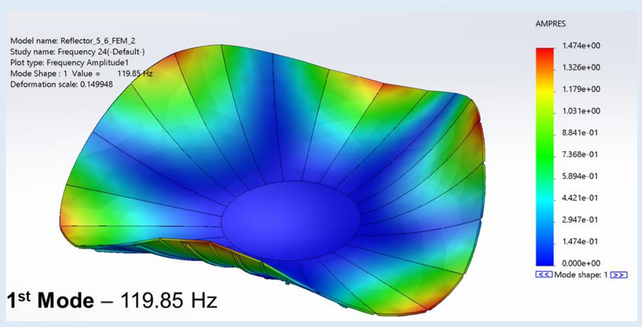
- 24 pedals, 2 m deployed diameter, 0.5 m center, 0.8 m focal
- Stows onboard a small spacecraft (i.e. ESPA, SpaceX)
- Sufficient accuracy and stability for operation at W-band (94 GHz) and G-band (180 GHz)





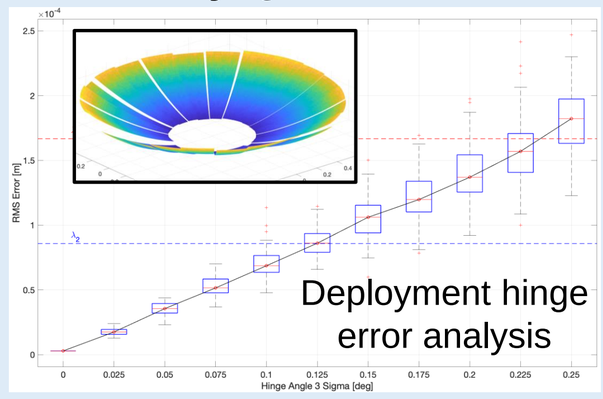


Mechanical Analysis & RF Uncertainty Quantification

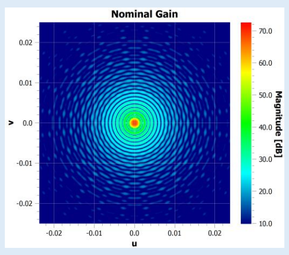


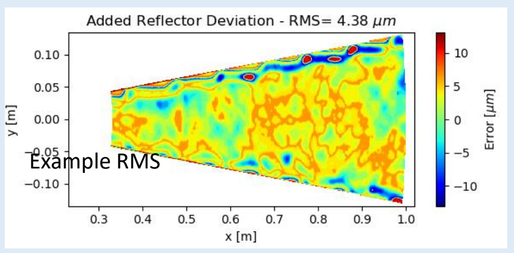
1st Mode – 119.85 Hz

FEA prediction of first vibration mode

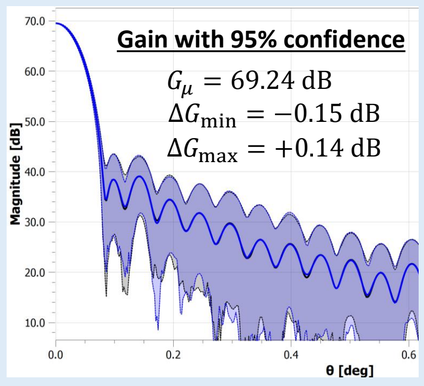


RF Performance Analysis



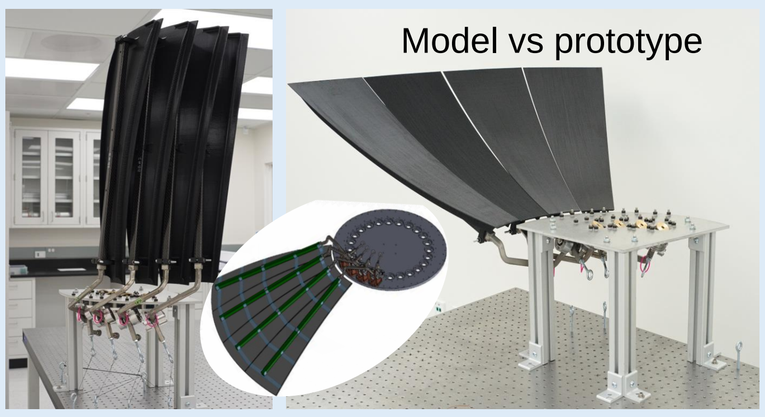


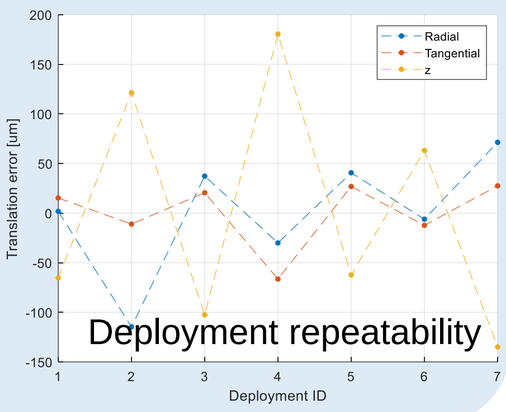
Evaluate impact of surface RMS, deployment error and hinge position on RF performance



Four-Petal Prototype Deployment and Analysis

Petals were deployed and repeatability was measured at Stanford





Significance/Benefits to JPL and NASA: This work directly supports JPL's Quests to (1) understand how Earth works as a system and how it is changing and (2) to understand our solar system and how it formed. It directly addressed ESD's technology roadmap for Earth Science (SmallSat technologies, instrument manufacturing technologies) and well as Remote Sensing for Planetary Science. The work enables designated Earth Decadal Survey science.

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Publications:

1. L. Csilik, J. Kao, K. Aaron, D. Hofmann, P. Bordeenithikasem, A. Cheng, J. Sauder, R. Hodges, and M. Arya, "Deployable Petal-Type Millimeter-Wave Radio Reflectors for Small Spacecraft," accepted for AIAA SciTech 2025 Conference, Orlando, FL, Jan. 6-10, 2025.

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