National Aeronautics and Space Administration

FY24 Topic Areas Research and Technology Development (TRTD)

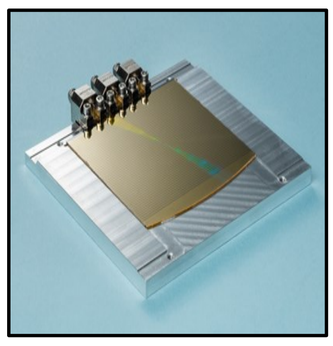
Metasurface-Based Multi-Frequency Antennas for Telecommunication and Earth Science Applications

Principal Investigator: Nacer Chahat (337) **Co-Investigators:** Kristy Hecht (337B), Goutam Chattopadhyay (386H), Gaurangi Gupta (337B), Curtis Jin (337H)

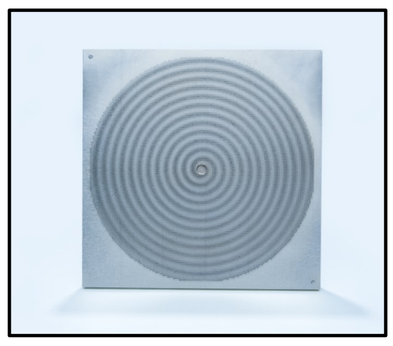
Introduction

Dual-band circularly polarized metasurface (MTS) antennas provide a low-profile, lightweight solution without the need for a polarizer or duplexer making it ideal for small platforms. We developed a dual-frequency design with isolated uplink and downlink ports for DSN applications.

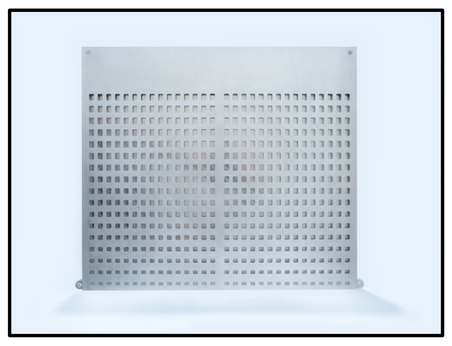
JPL MTS Antenna Profile



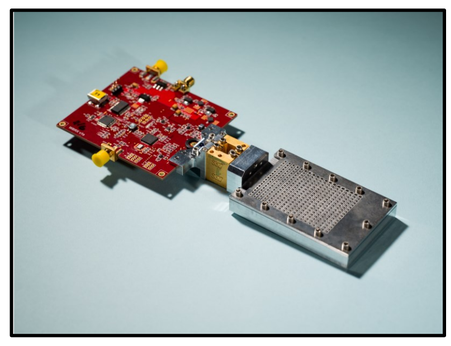
ACT-17: W-band LP MTS (TRL4)



ACT-17: Ka-band MTS LP & CP (TRL5) ➔ toward dual-freq



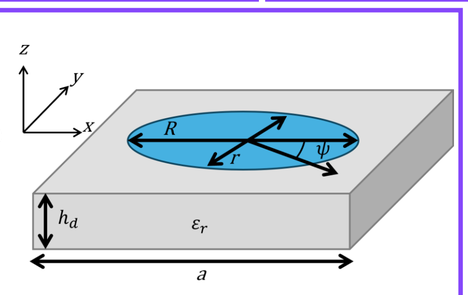
IIP-19: W-band MTS LP (TRL 5) ➔ toward dual-pol



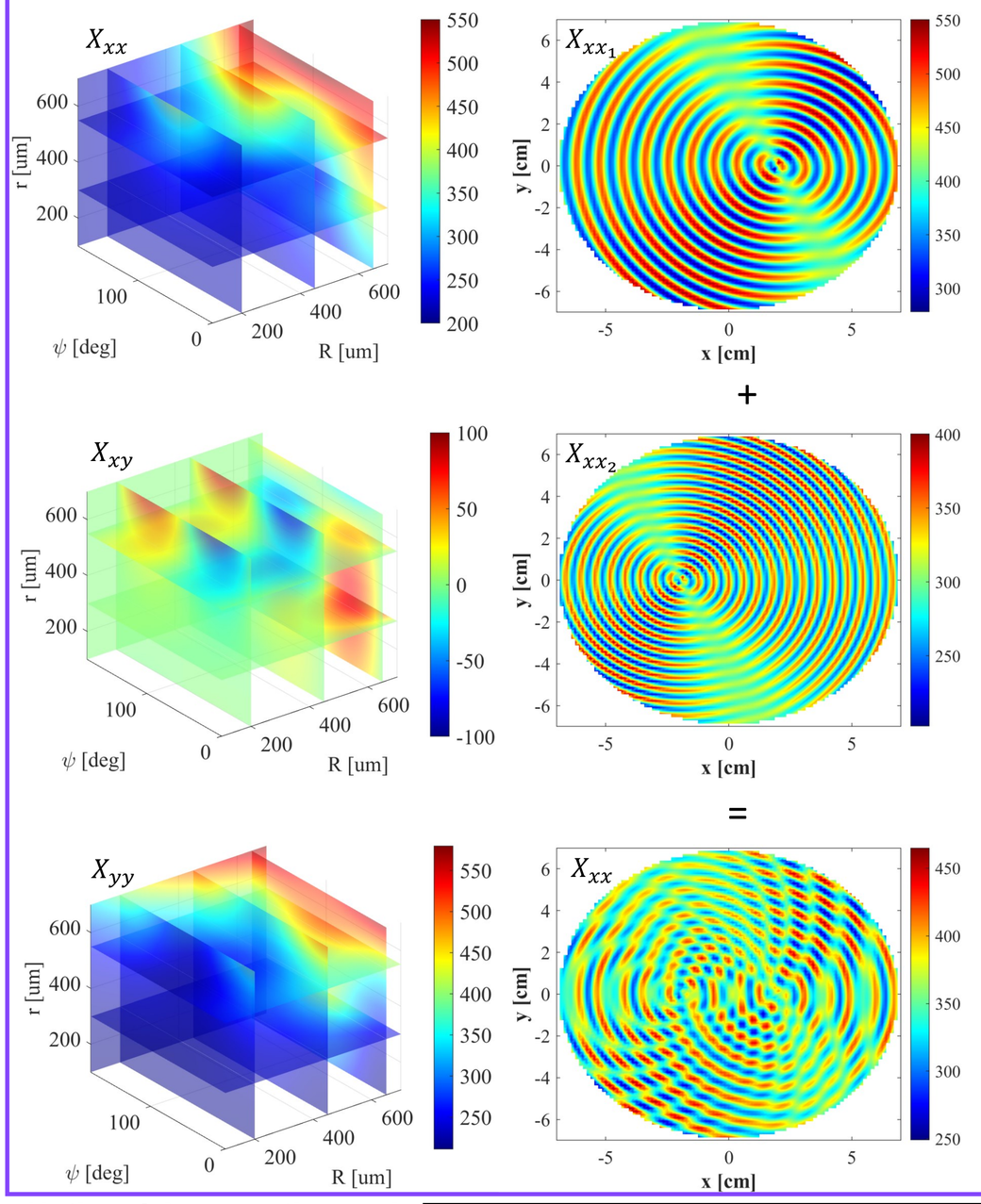
ACT-20: W-band MTS LP (TRL 4)

Approach

- Create a database of impedance values using an elliptical patch on a grounded dielectric slab

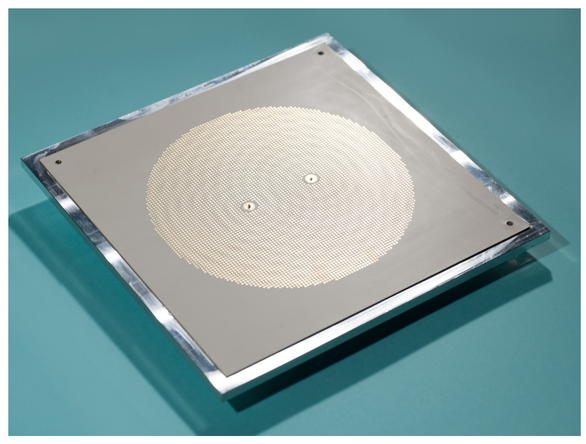


- Design two independent antennas for downlink (31.8 – 32.3 GHz) and uplink (34.2-34.7 GHz) using one unit cell impedance database found at $f_c = 33$ GHz.
- Introduce a scaling factor to the phase component of the impedance to accommodate the database offset so the antennas will radiate centered at their design frequencies: $f_1 = 32.05$ GHz and $f_2 = 34.45$ GHz
- Superimpose the individual designs' impedance profiles together and offset the centers to be able to individually excite either band with isolated ports

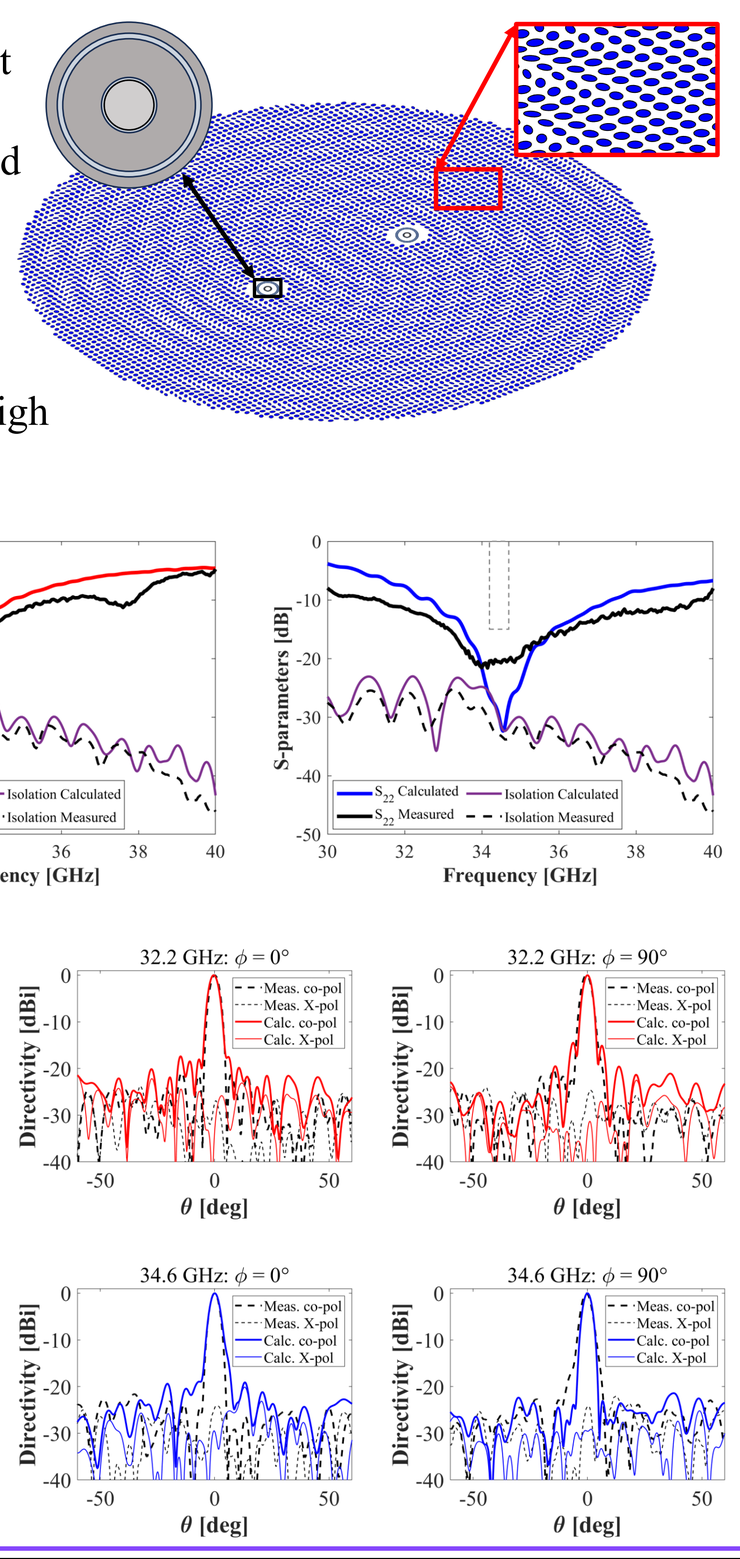


Fabrication and Measurement

- Design a matching network for the feed at each frequency using a structure of concentric circles to ensure full coupling to the surface
- The antenna is excited with a 2.92mm connector with the center pin extended 1mm above the surface
- The antenna is fabricated with copper patches on Rogers 3006($\varepsilon_r = 6.5$) with a height of 640 μm



- The antenna's reflection coefficient, port isolation, and radiation patterns were measured and compared to the calculated values.
  - Design requirements shown in grey, dashed lines
- Measured and calculated results show high agreement



National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

RPD-052 Clearance Number: CL#00-0000

Publications:

[A] K.Hecht, N. Chahat, "Ka-band Dual Frequency Single Aperture Metasurface Antenna for Deep Space Missions," IEEE Trans Antenaa and Propagation, in press
[B] K. Hecht, N. Chahat, G. Chattopadhyay, E. Martini and M. J. Mencagli, "Dual-Frequency Metasurface Antenna for Earth Science Remote Sensing," 2024 18th European Conference on Antennas and Propagation (EuCAP), Glasgow, United Kingdom, 2024
[C] K. Hecht, N. Chahat, C. Jin, G. Chattopadhyay, and M. J. Mencagli, "High-Efficiency All-Metal Metasurface Antenna Design for Space Applications," 2024 IEEE Wireless Antenna and Microwave Symposium (WAMS), Visakhapatnam, India, 2024
[D] K. Hecht, N. Chahat, G. Chattopadhyay, E. Martini, and M. J. Mencagli, "A new strategy for designing dual-band antennas based on double-layer metasurfaces," submitted to IEEE Trans. Antennas & Propag., 2023.
[E] K. Hecht, N. Chahat, G. Chattopadhyay, E. Martini, and M. J. Mencagli, "Dual-Layered Metasurface Antennas for Dual-Band Operations", URSI EMTS, Vancouver, Canada, May 2023.
[F] Chahat and Hecht, Patent CIT-8923-P, "Orthogonally Selected Multi-Band Metasurface Antenna for Next Generation Telecommunication and Remote Sensing Applications", filed on11/21/2022.
[G] Chahat et al., Patent CIT-8849-P, "Metal-only flat metasurface antenna for single or multiple beams", filled on July 7, 2022.

PI/Task Mgr. Contact Information: Nacer Chahat nacer.e.chahat@jpl.nasa.gov