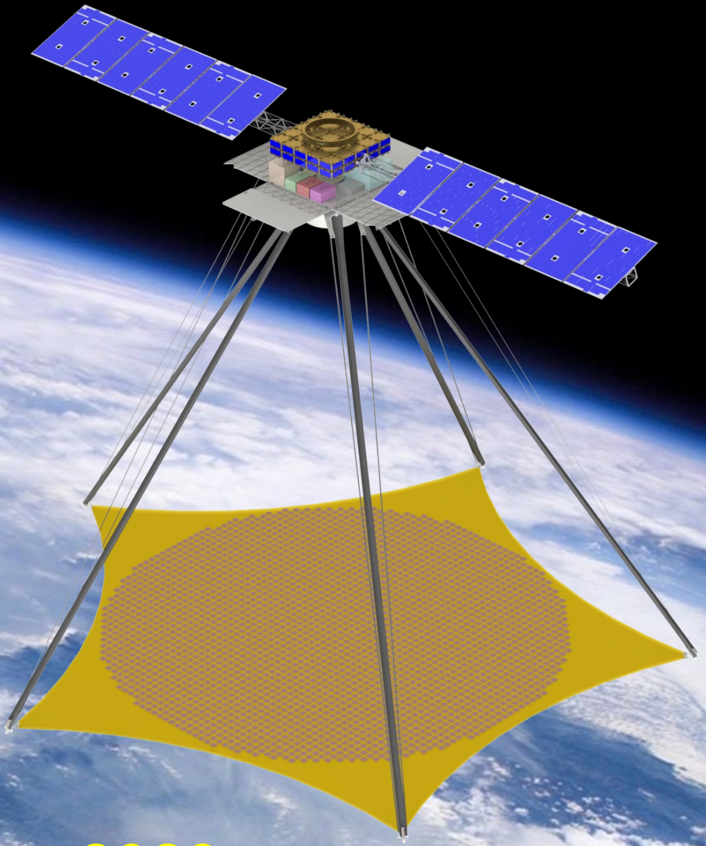
GLOWS:

Global L-band Active/Passive Observatory for Water Cycle Studies



Enabling Big Science in a Small Satellite

Earth Science Technology Forum 2023

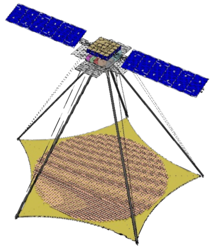
June 20, 2023

MICROWAVE BRIGHAM YOUNG UNIVERSITY EARTH REMOTE SENSING

NASA

MMA Design

ARS Agile RF Systems LLC

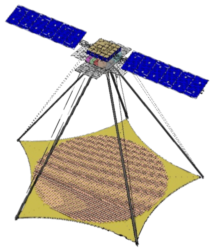


GLOWS IIP Objectives

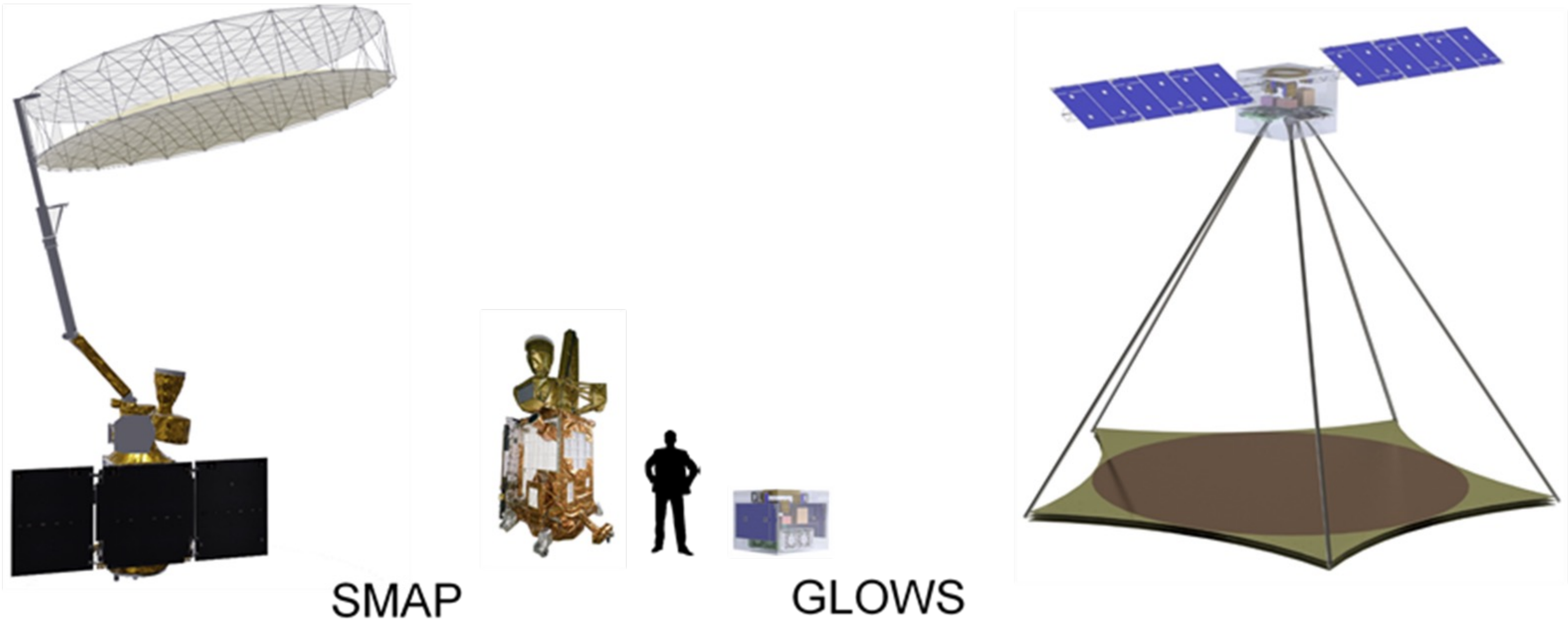
- Create SMAP-like capability
  - Science (resolution/swath/etc.)
  - Radar and radiometer
  - CONOPS
  - Design Life
- Stow within a rideshare volume
  - Use Meta-Lens as a refractor
  - Use multi-element patch array feed
  - Update Radiometer to reduce volume and/or improve performance
  - Leverage SOA commercial radar technologies
- Enable an Earth Venture Class mission

MMA Design

Agile RF Systems LLC



GLOWS - Comparing GLOWS and SMAP



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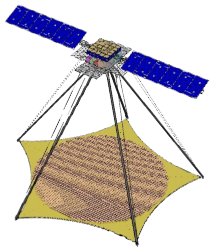
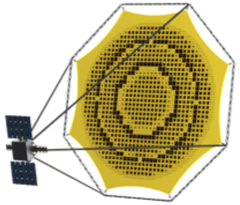


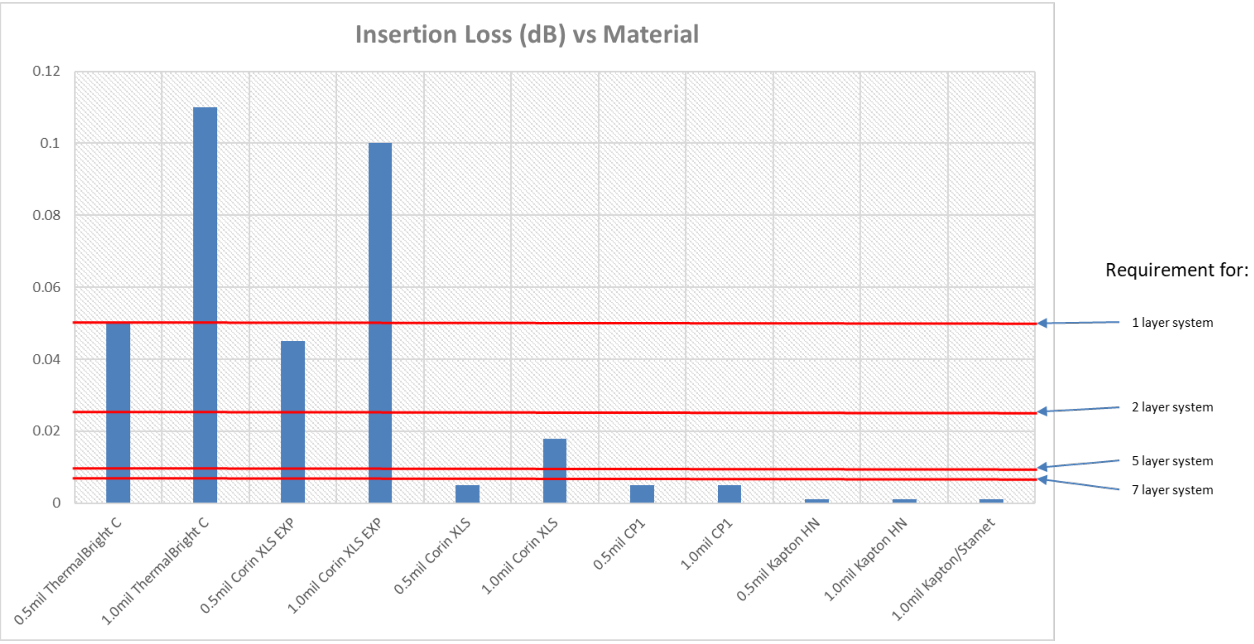
GLOWS Instrument Development Status – Completed Testing

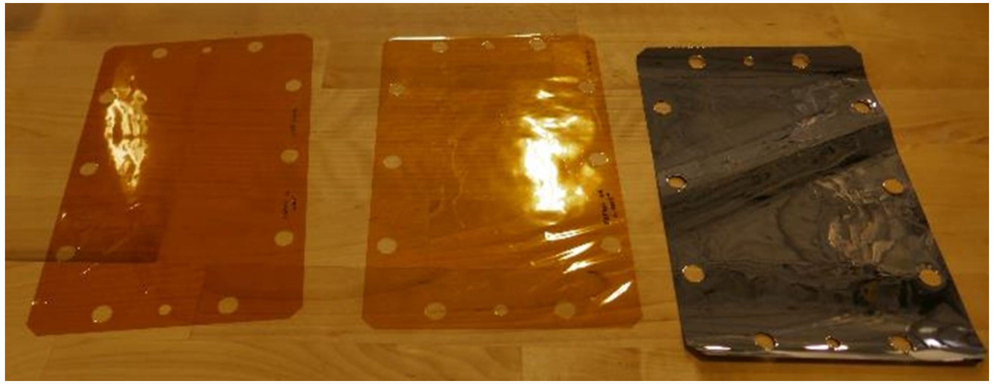
- Lens RF Design
  - Base materials L-Band waveguide transmissivity testing at NASA
  - Lens design and model validation – 2 m x 4 m full scale slice
- Feed Design
  - 1/6 scale testing in 2022 validated feed design
- Lens Structural Design
  - 6 m prototype deployment demonstration
  - 6 m positional deployment stability testing - +/- 2 inches with bread board components
  - Satellite packaging Study completed – Instrument will fit on EPSA Grande
  - Completed buckling test of slit tube struts to validate FEA subassembly model
- SMAP Diplexer redesign
- Radiometer front-end design with Arena digital receiver
- Completed Instrument study at GSFC in 2022

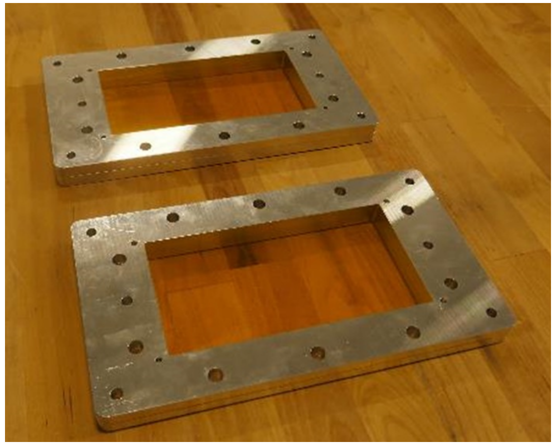


Lens Meta Material Waveguide Testing 2021

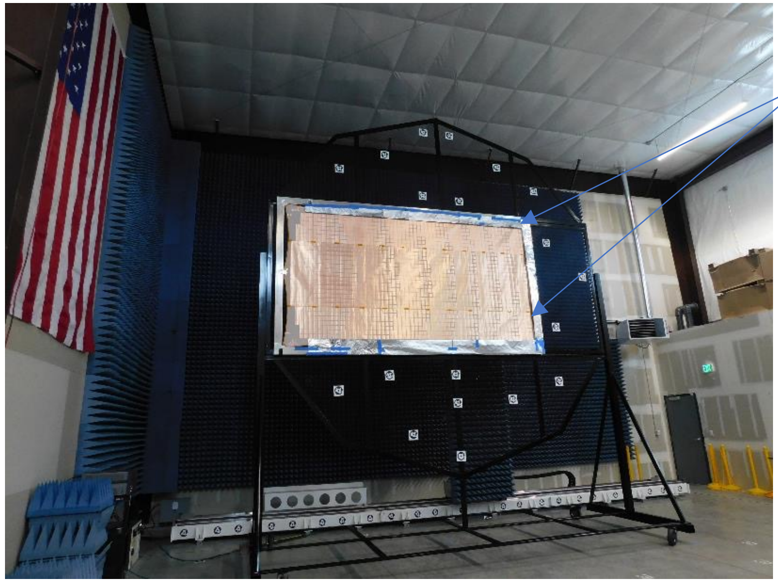
- NASA was given 11 membrane material samples to test for insertion losses in a waveguide
- Kapton was the clear winner as the material to use for the Meta Lens



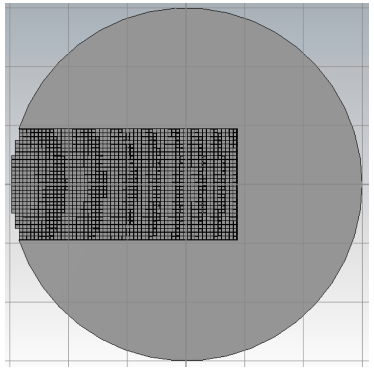




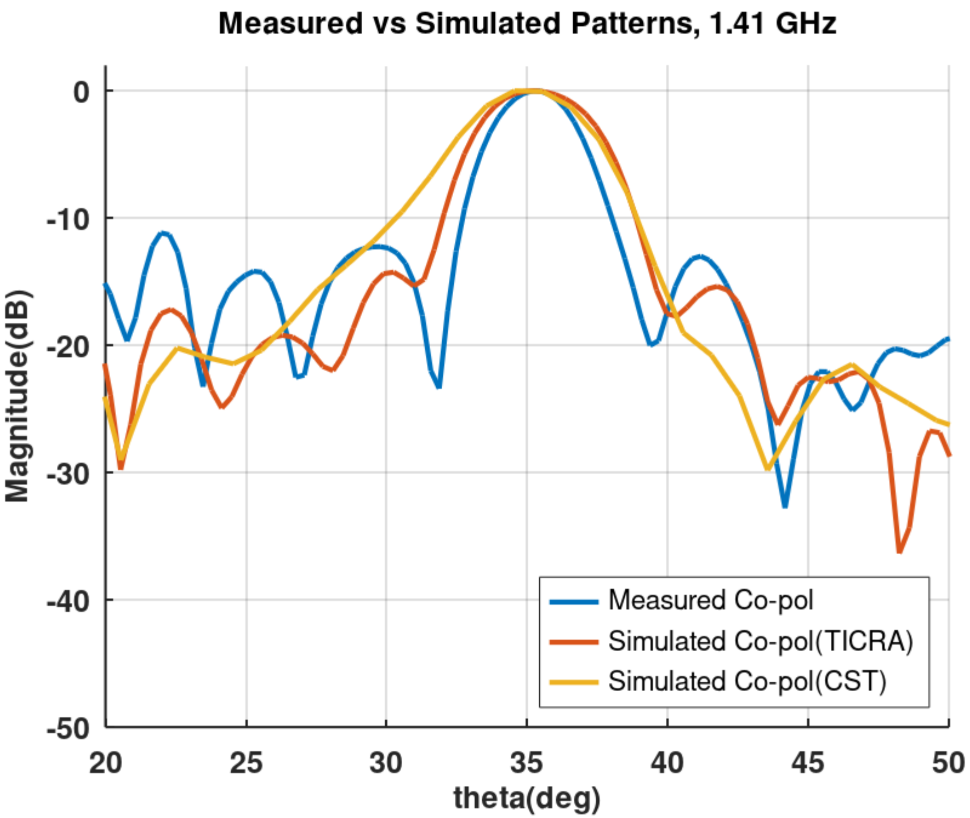
Lens Validation Testing – 2 Meter x 4 Meter slice

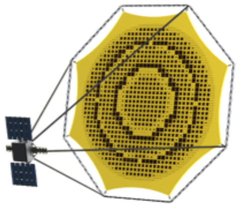


Transition to ground plane has gaps not captured in the Ticra model



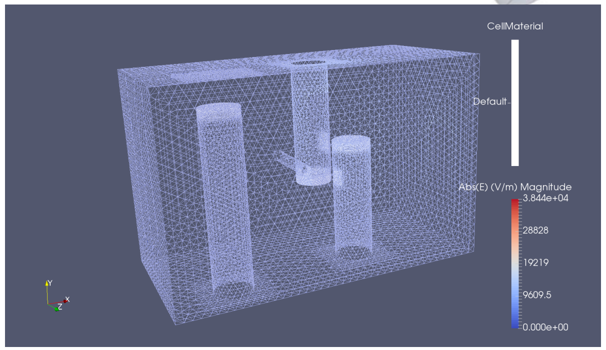
Ticra QUPES Simulation Model



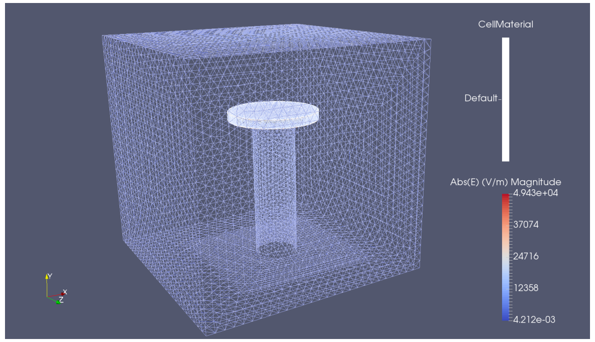


GLOWS Diplexer

- In February 2023, Sierra Microwave Technology (SMT) completed a redesign of the SMAP diplexer, replacing materials and improving the filter design that were the root cause of multipaction breakdown failures during SMAP's pre-launch Observatory Integration & Test. The GLOWS diplexer design features the following improvements:
  - The Antenna and Radar sides now use a modified combline BPF design to improve power handling
  - Mushroom caps used to increase gap from resonators to the housing/cover
  - The Antenna and Radar ports dielectric interface changed to Boron Nitride, and no longer penetrates the diplexer cavity.
- SMT simulated RF performance by E-M analysis in CST Microwave Studio Fest3D
- SMT analyzed critical gap regions for multipaction using Spark3D, assuming an SEY of aluminum, a worst-case assumption given that diplexers would feature silver plating
- The GLOWS diplexer will be smaller than SMAP diplexers, due to "serendipitous cross coupling" of several resonators, which allowed SMT to meet SMAP requirements using fewer resonators.
- Future work: Completion of mechanical design and testing of breadboard unit to achieve TRL-6

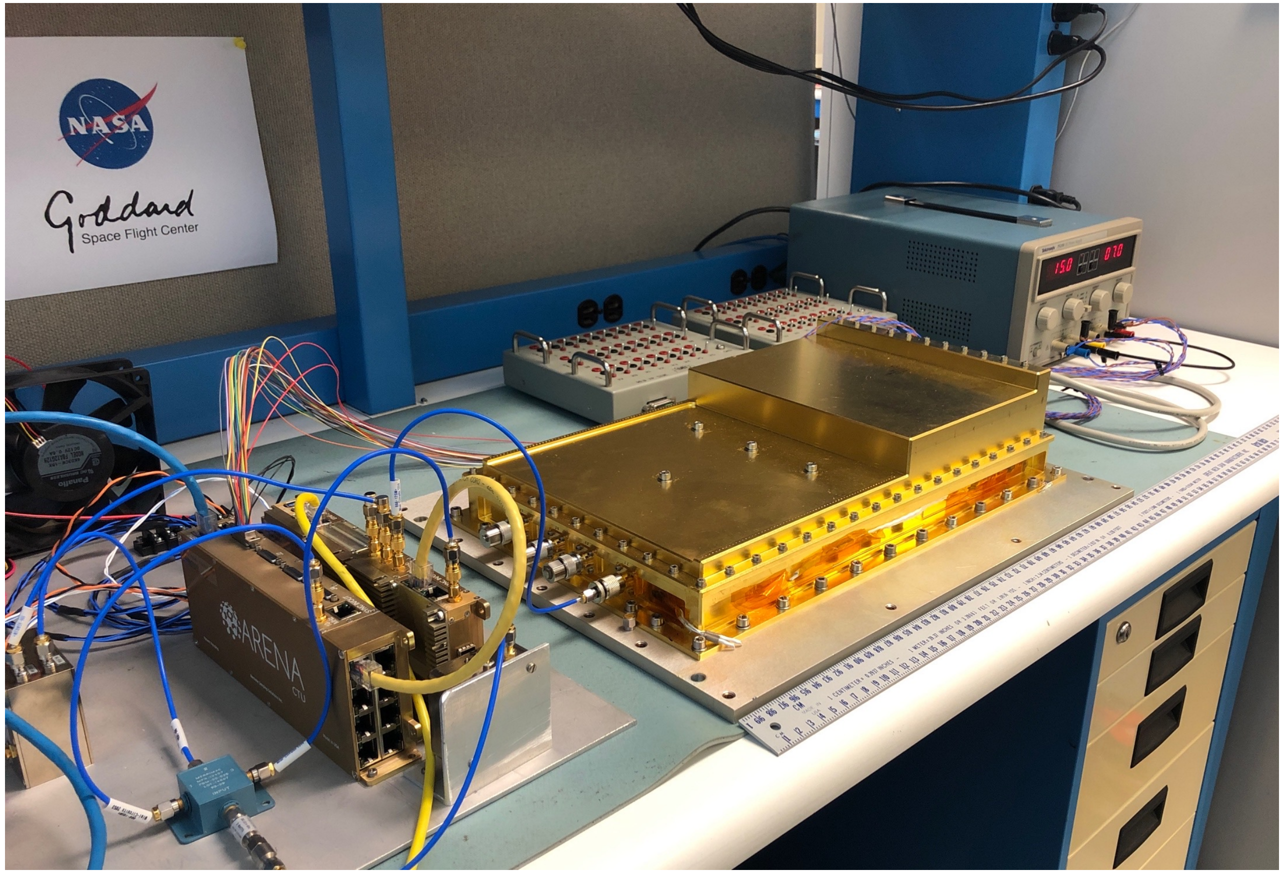


Electric Fields used in Multipaction Analysis
Antenna Port T-Junction



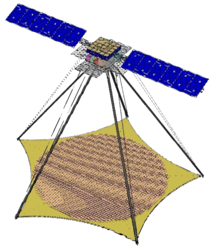
Electric Fields used in Multipaction Analysis
TX Filter Second Resonator (Worst Case)

SMAP RFE w/ ARENA Digital Receiver



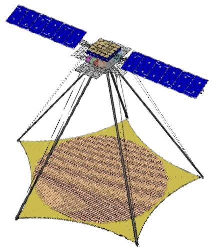
SMAP EM Radiometer Front End with ARENA Digital Back-End

- This Summer, the GLOWS team will test the SMAP Engineering Model (EM) Radiometer Front End (RFE) mated to a Tomorrow.io ARENA digital back end, comprised of a 313 digital receiver and a Command Timing Unit (CTU).
- In April 2023, Tomorrow.io launched a similar digital receiver in their pathfinder mission. In parallel to their internal efforts, they are also developing (under a Phase II SBIR) a flight receiver (ARENA 542) to meet the needs of future NASA Earth and planetary missions, as well as airborne demonstration and science programs that support NASA missions and/or mission risk reduction.
- The ARENA 542 will consume less than half the power and require less than quarter the mass/volume of 16-channel SMAP Radiometer Digital Electronics (RDE)
- Goddard is also developing a new GLOWS RFE to mate with ARENA, but will temporarily use our SMAP EM RFE to verify VNA-based insertion loss measurements of MMA/ARS lens membrane



GLOWS Instrument Development Status – Future Work Planned

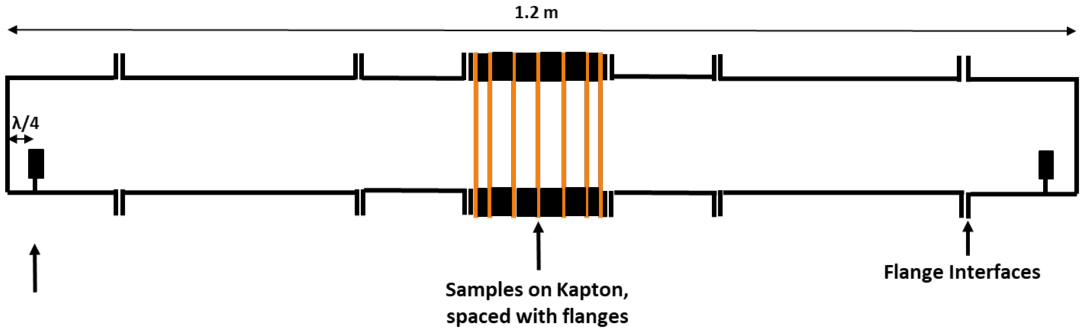
- Lens RF Design
  - Custom waveguide test with unit cell copper artwork
  - Radiometer and custom waveguide test
    - Connector Radiometer and cold source to above waveguide
  - RFID Temperature Sensor Development
- Feed Design
  - Improve feed design to increase aperture efficiency along with aperture size and f/D optimization study.
- Lens Structural Design
  - Improve FEA model
  - Validate modeling with sub-scale dynamic prototype
- Goddard is developing a new GLOWS RFE to mate with ARENA

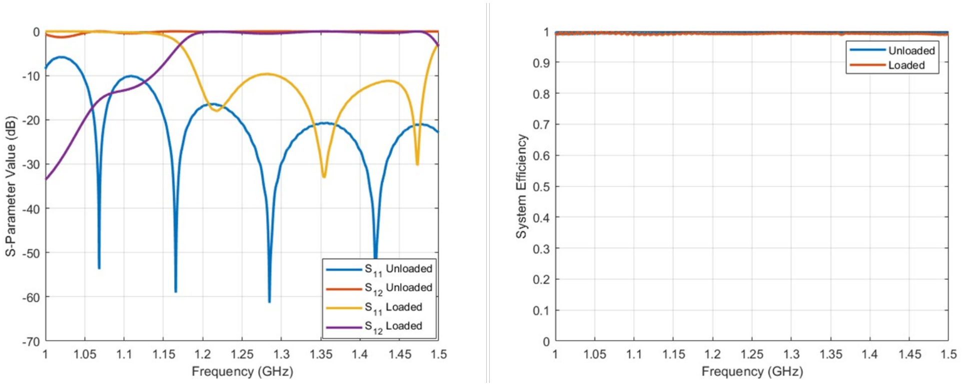


Custom Waveguide Test

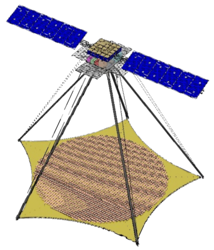
- TRL calibration will be performed, followed by a reference measurement, then characterization of two different unit cell geometries.

TRL Waveguide Calibration: Thru → TRL Waveguide Calibration: Reflect → TRL Waveguide Calibration: Line → Reference Measurement: non-Metallized Kapton Sheets → First Unit Cell Geometry Measurement → Second Unit Cell Geometry Measurement



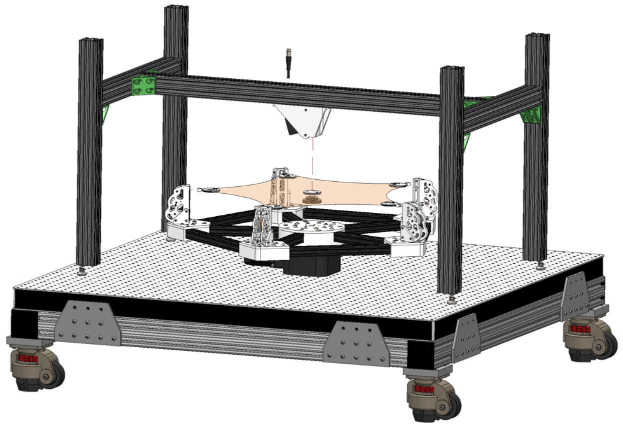


Predicted Performance

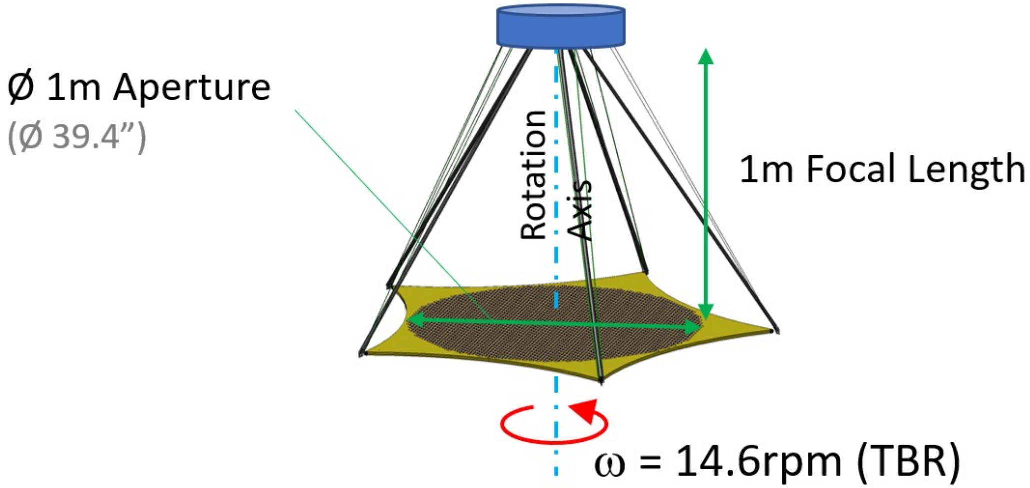


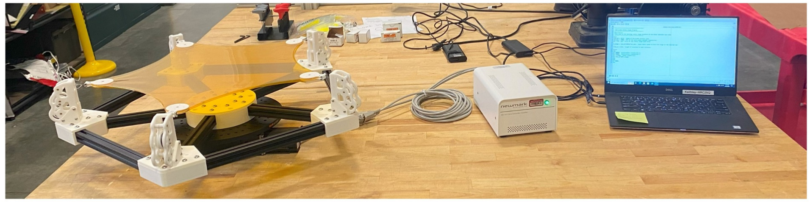
Sub-Scale Prototype Dynamic Test

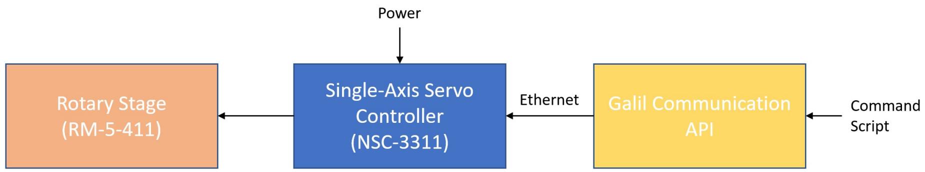
- A 1/6 subscale dynamic prototype will be developed
- FEA will be created to match the sub scale mode
  - Testing of dynamic prototype will be used to validate the sub scale model
- Subsystem prototype and FEA models will be developed first for a step-by-step approach to the fully integrated model and test.



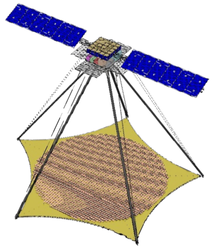
Displacement and Frequency Test concept



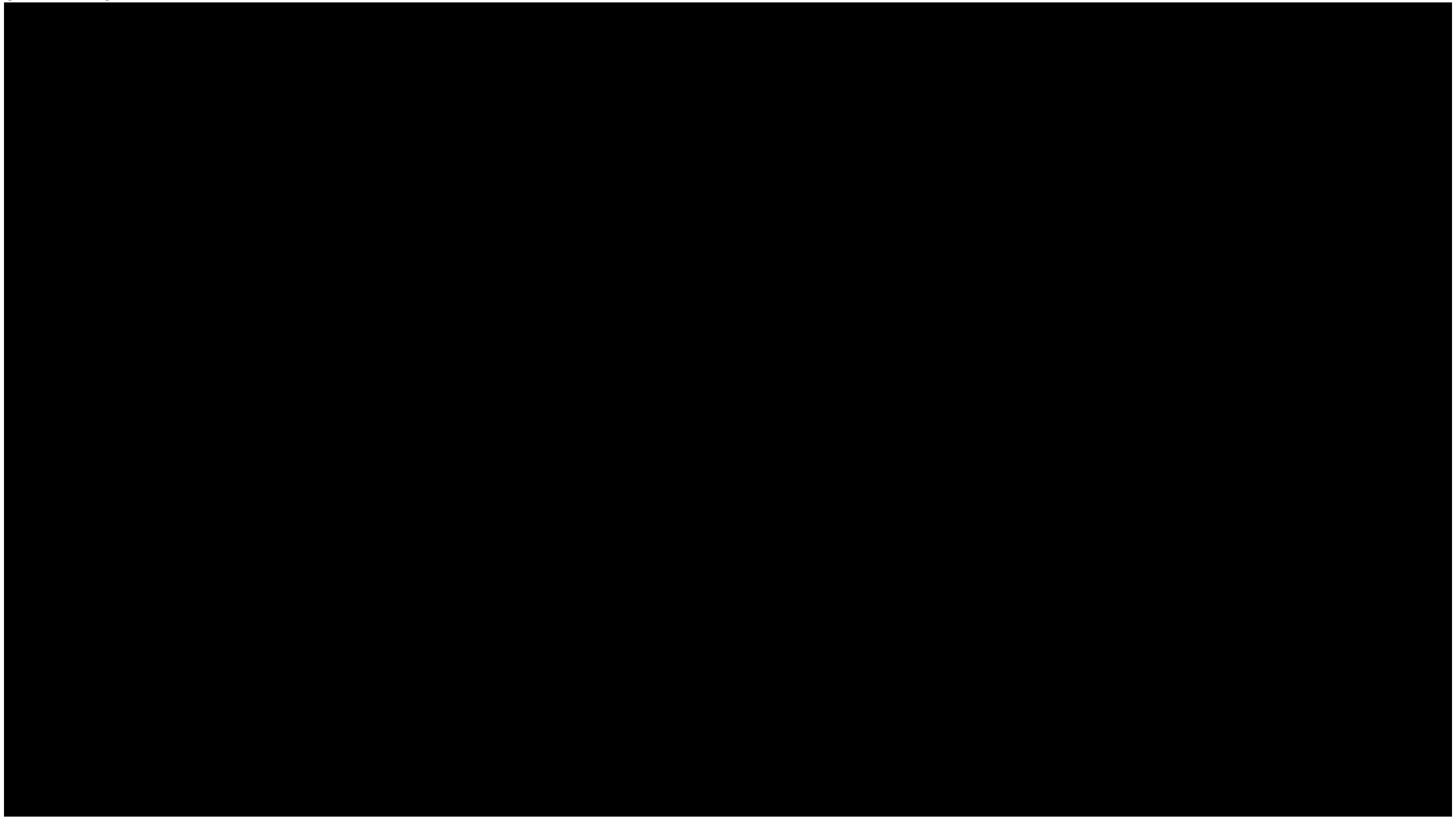


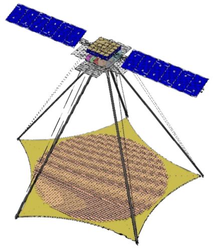


Spinning Steady State Response Test

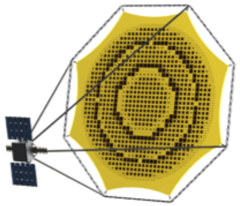


Deployment Video EDU-01



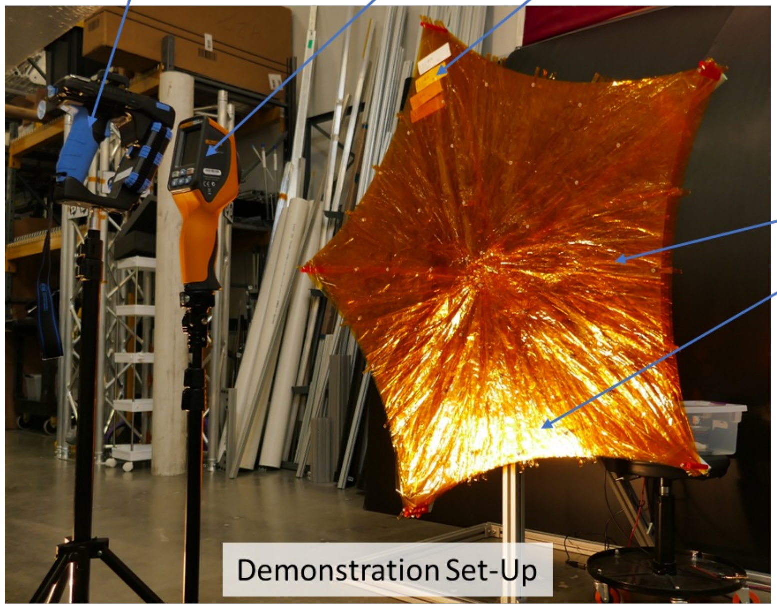


Questions?



RFID Temperature Sensor Development

- It is important for calibration of the Radiometer to know the temperature of each layer of the Meta Lens through the entire orbit.
- IT cameras do not work well below 0 degrees C and would only be able to see one layer.
- The program is looking into using RFID temperature sensors on each layer of the Meta lens with a RFID reader imbedded in the feed.
- Lab testing of RFID temperature sensors was successful
- Currently working with a RFID sensor company to develop space qualified solution.



Setup:

- Assembly spins at ~14.6 RPMs
- Each layer has a RFID Temp Sensor
- Heat Lamp used to provide radiation
- IR camera used to compare to sensor readings

Results:

- All tags read through 7 layer spinning prototype at once
- Successfully measured up to 20 ft (6.1 m) away
- IR camera and RFID temperature tag successfully measures the same temperature for the outside layer

Agile RF Systems LLC