National Aeronautics and Space Administration

FY23 Topic Areas Research and Technology Development (TRTD)

Ka/W-Band Deployable Modularized MetaLens Antennas for SmallSat Applications

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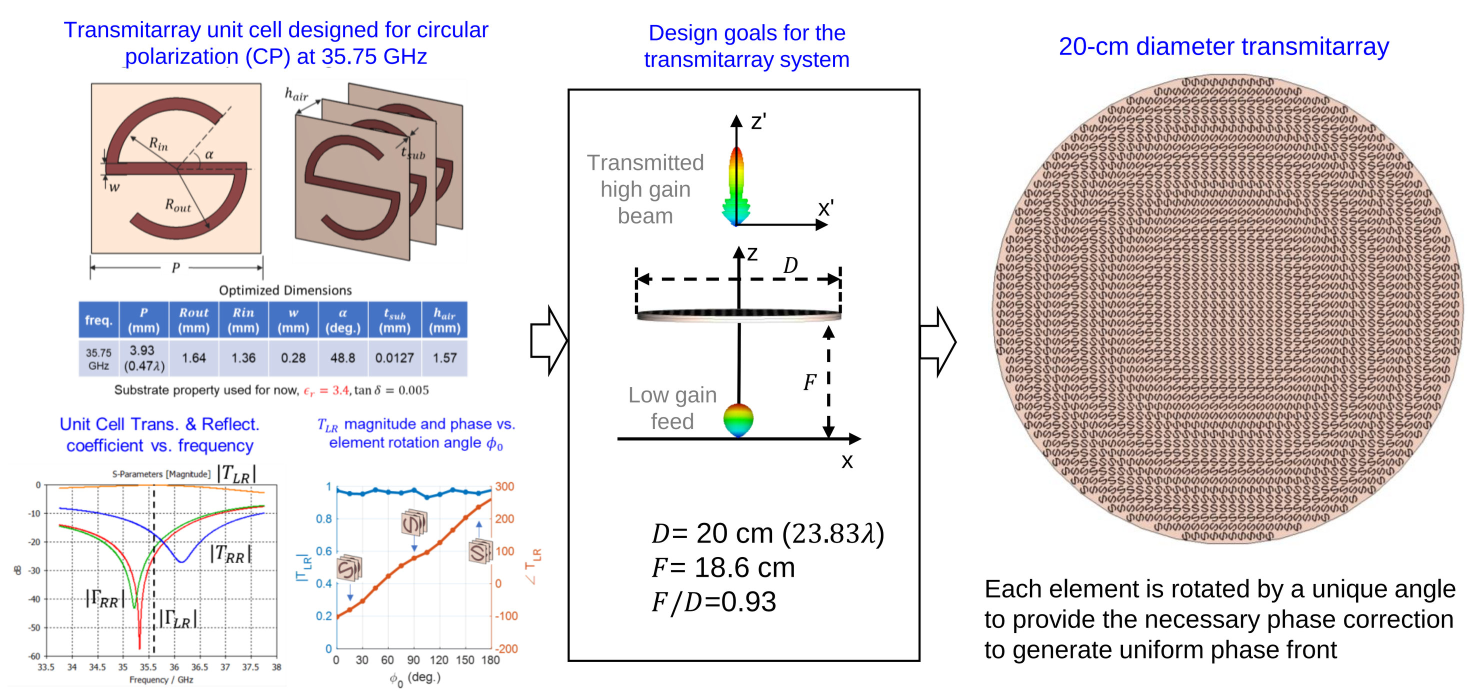
Strategic Focus Area: Direct/Coherent Detectors and Arrays

Objectives:

The objective of this research was to develop a new low mass deployable lens-type antenna that may offer advantages compared to a reflector-type antenna system for mm-wave applications. This lens antenna concept is based on a tensioned membrane system comprised of multiple layers of Kapton, each of which has a pattern of variable sized copper patches that create an artificial dielectric. Varying the size and geometry of the patches controls the dielectric constant, and provides a practical way to realize an inhomogeneous lens. This flexible MetaLens can be folded and rolled for compact stowage. To minimize the number of layers, it was decided to focus on a type of lens known as a transmitarray along with the fabrication technology necessary to realize it. Thus, the primary objective of this work was to design, build, and test a breadboard transmitarray to demonstrate that the concept works. A secondary objective is to evaluate potential for a conical scan at Ka-band using a transmitarray or lens antenna.

Background:

Future Earth Science missions are currently being planned that require sensors within the mm-wave regime (35-250 GHz). These missions address Earth Science Decadal Survey science targeted observables related to climate and weather. To support these mission concepts, several radar instruments are currently being developed for the Planetary Boundary Layer, or PBL, observable (e.g. CloudCube, VIPR), as well as a range of radiometer instruments related to climate and weather. High gain antennas are critically important to meet these science objectives. The only high-TRL antenna option in this frequency regime is the solid composite reflector, a custom designed antenna that is expensive and has a long procurement cycle. The only deployable antenna design at 94 GHz is a hinged composite reflector, which does not support the cost and SmallSat stowage goals of a low-cost Earth Science mission. This research addresses antenna technology that that holds promise for construction of large deployable mmWave apertures. Moreover, the conical scan provides a potentially useful way to obtain large coverage area at low cost.



The novel three-layer S-ring transmitarray unit cell for circularly polarized wave designed at the center frequency of 35.75 GHz. Rotation of the S-ring creates a linear change in transmitted phase. C`enter: 0ptical prescription for the test lens. Right image shows the rotation map of the transmitarray.

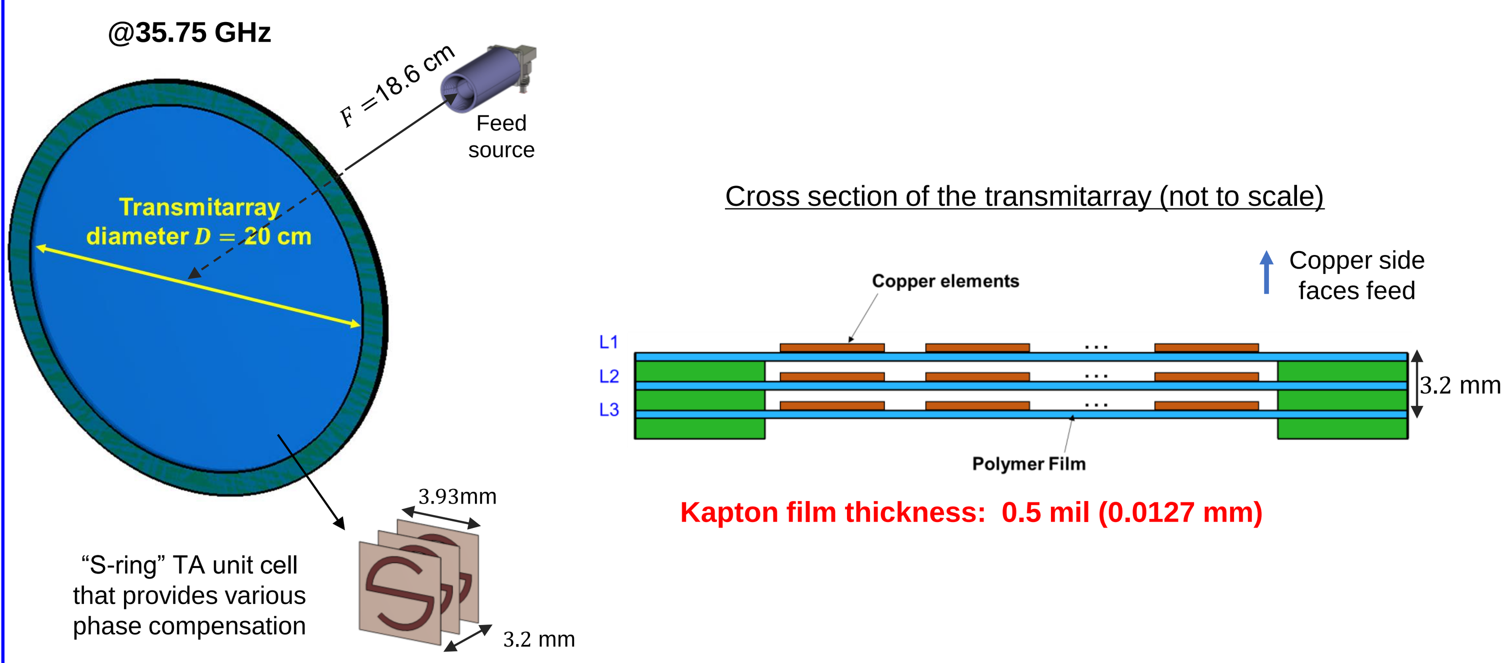
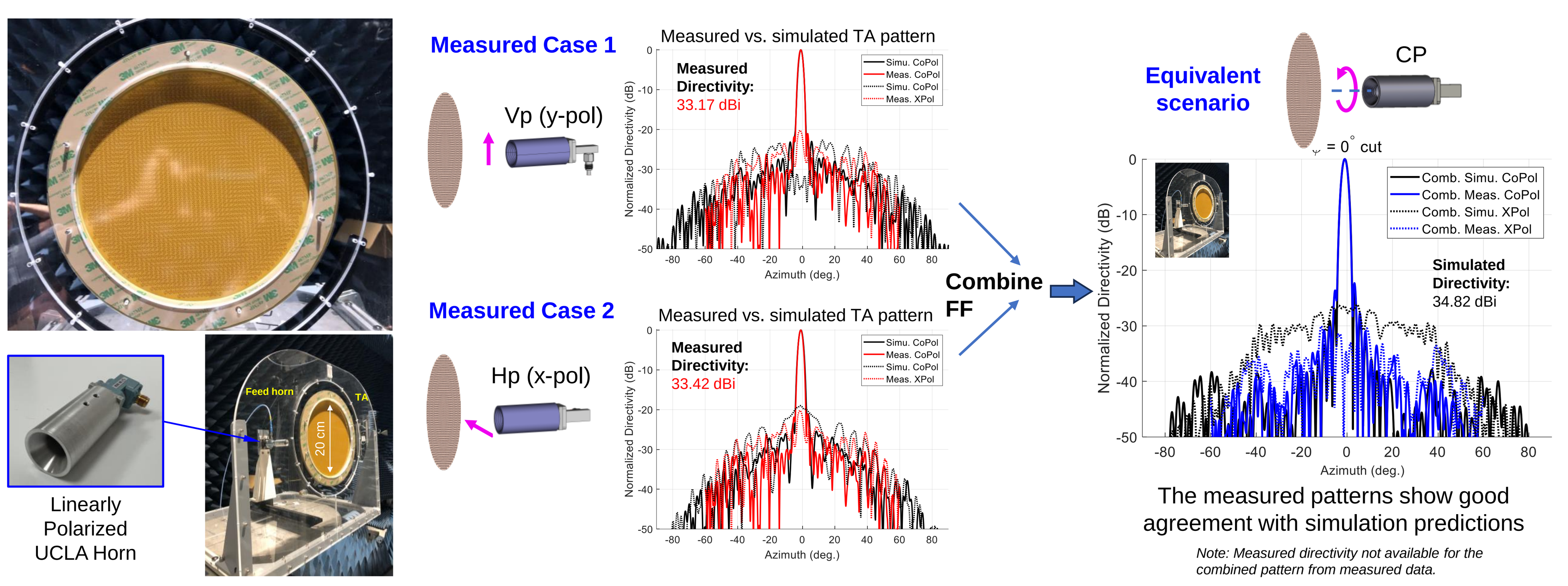
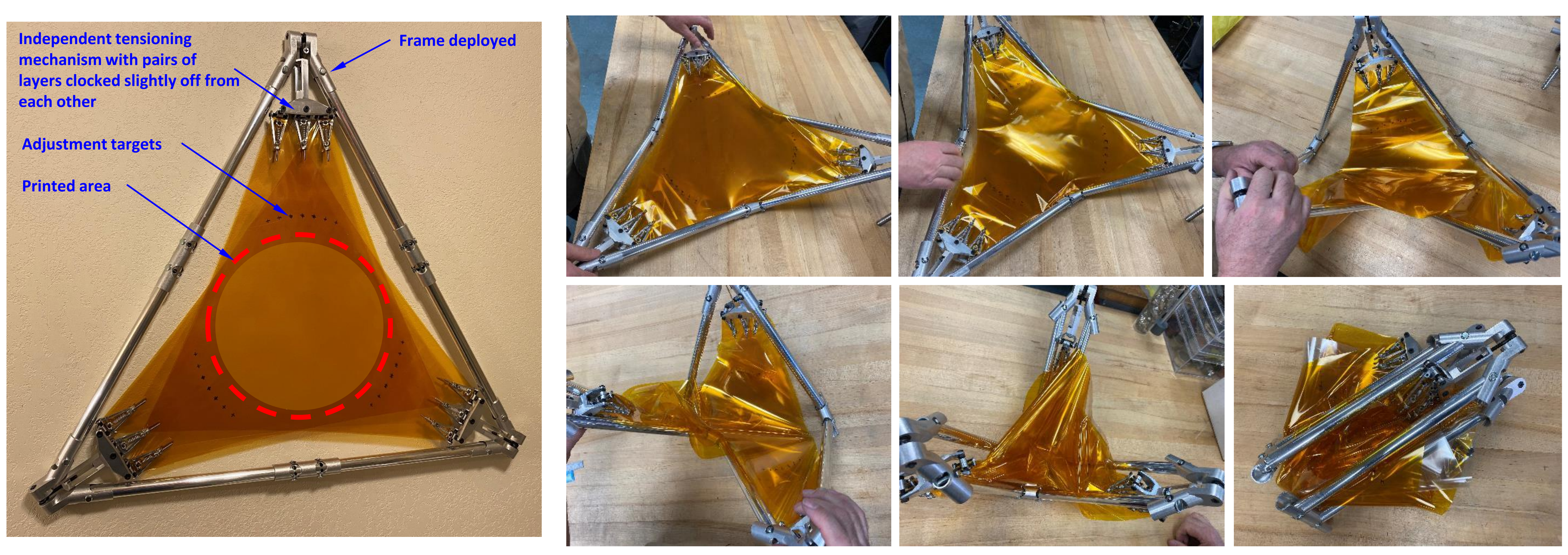


Illustration of 3-layer transmitarray design that was built and tested. Image on left shows the overall optics of the antenna. Image on the right shows a schematic cross-section of the layering structure. The non-deployable transmitarray used fixed 20 cm diameter ring spacers, which are represented by green blocks in the image on the right. The deployable version only uses a few spacers at discrete locations.

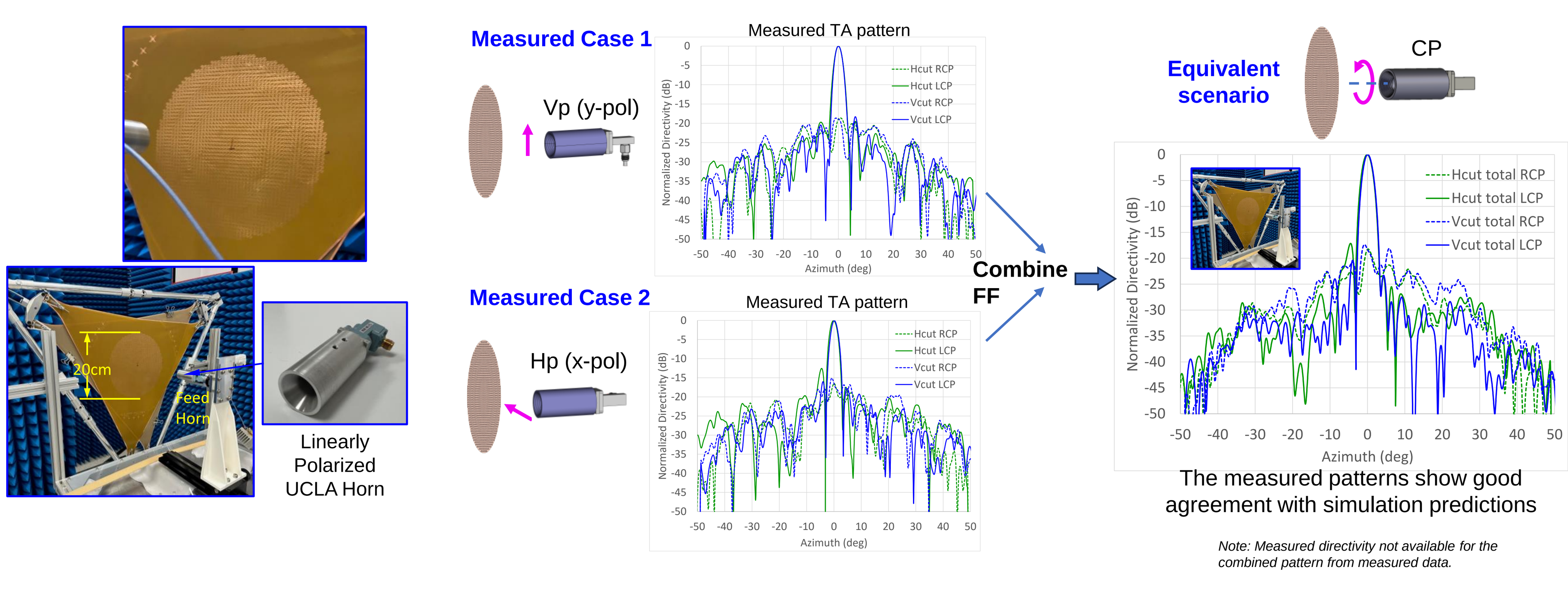
RF Demonstration of Fixed Non-Deployable Transmitarray



Three Layer Tensioned Membrane Transmitarray Deployment Mechanism



RF Demonstration of Deployable Transmitarray



Significance/Benefits to JPL and NASA:

mmWave antennas are needed to achieve Earth Science goals stated in the Decadal Survey, We devised the tensioned membrane deployable MetaLens operating in mmWave bands as a novel, deployable method for achieving these goals. This can provide very large ground coverage at low cost for Earth Science missions.

Publications:

none

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