Deployable Microwave Antennas for CubeSats, NanoSats, and SmallSats

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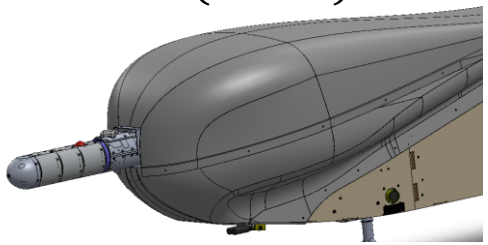
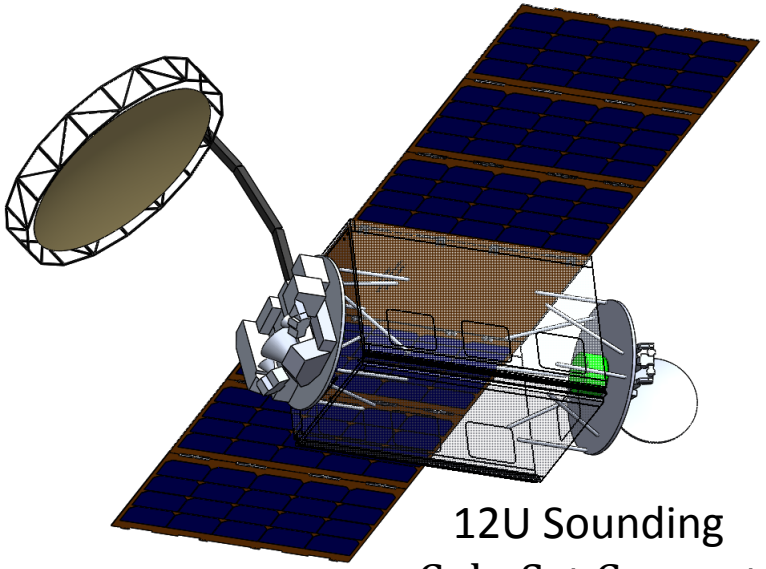
Boulder Environmental Sciences and Technology
2019 American Meteorological Society Annual Meeting

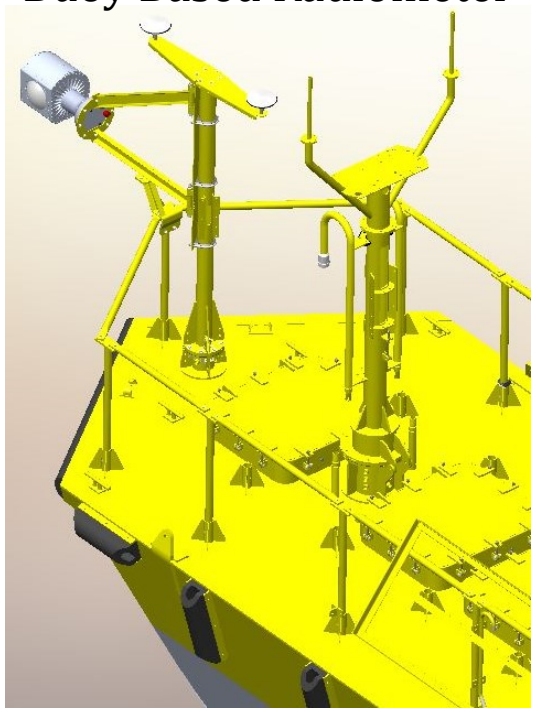
Arctic Shark UAV integration (PAMR)





12U Sounding CubeSat Concept

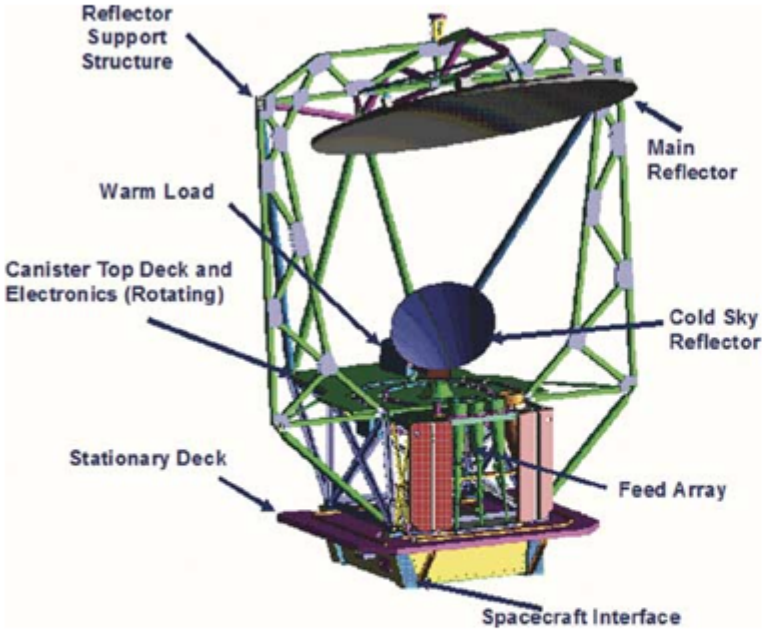
Buoy Based Radiometer



We design microwave radiometers that are small, lightweight, and low power for a variety of platforms

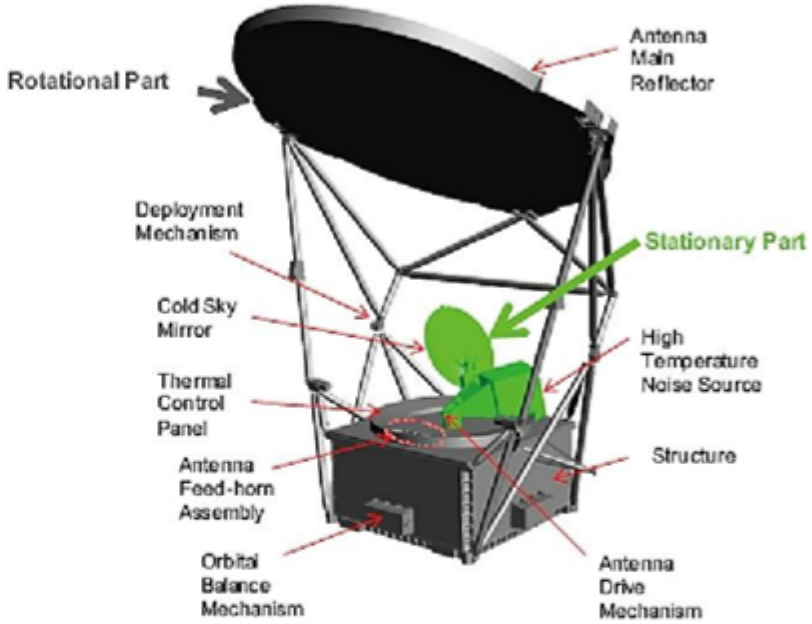
Space-Based Observations

WindSat Radiometer



Main reflector diameter	1.83 m
Mass	341 kg
Power consumption	350 W
Earth Incident Angle	~53°
IFOV @ 35 GHz	8 x 13 km

AMSR2 Radiometer



Main reflector diameter	2.00 m
Mass	405 kg
Power consumption	400 W
Earth Incident Angle	55°
IFOV @ 35 GHz	7 x 12 km

Space-Based Observations

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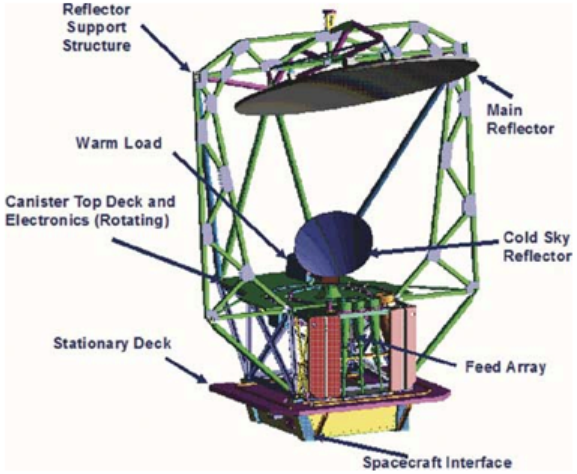

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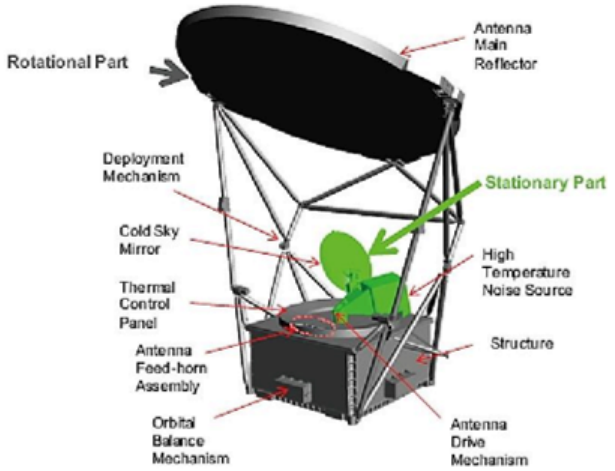

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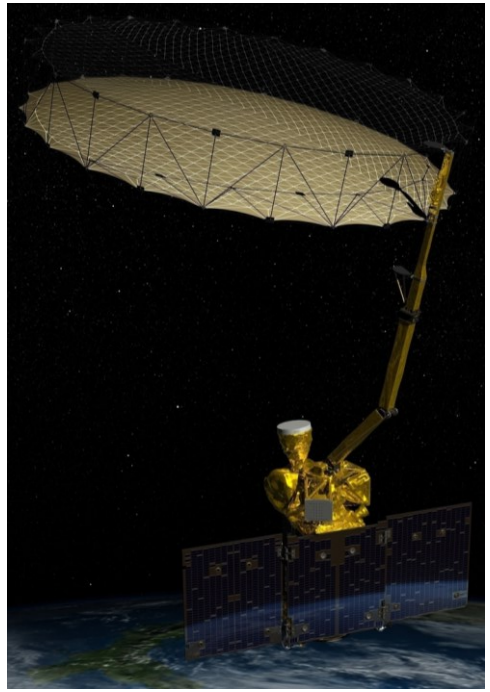

Main reflector diameter	6.00 m
Mass	944 kg
Power consumption	1,450 W
Earth Incident Angle	40°
IFOV @ 1.41 GHz	38 x 49 km

Space-Based Observations

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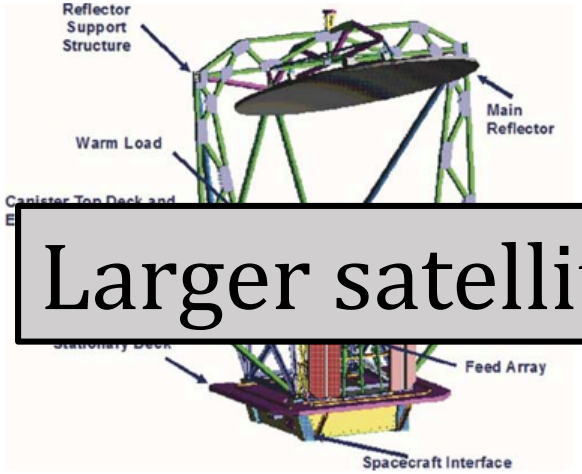

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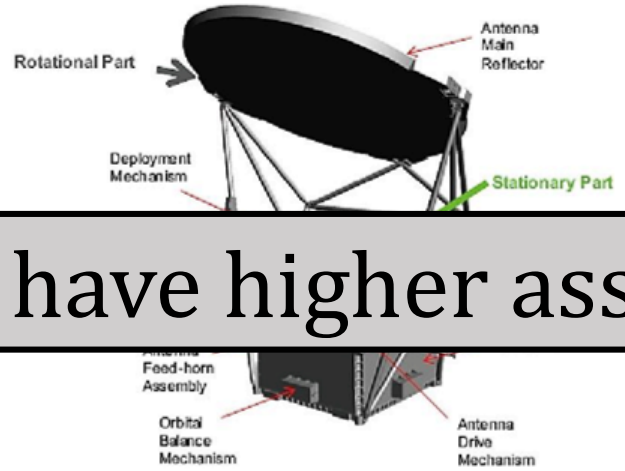

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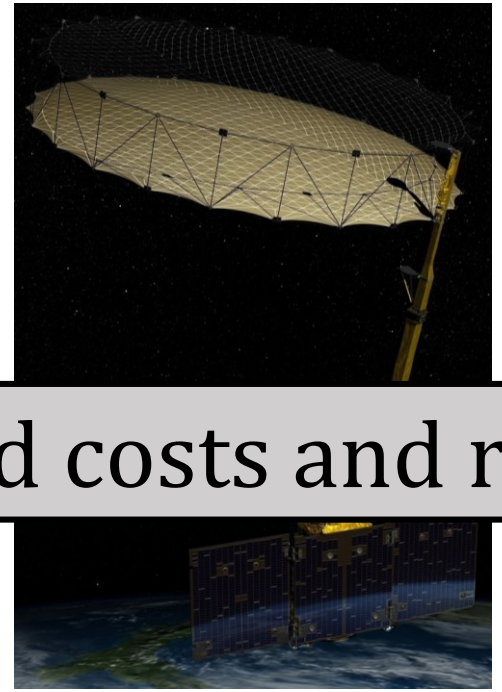

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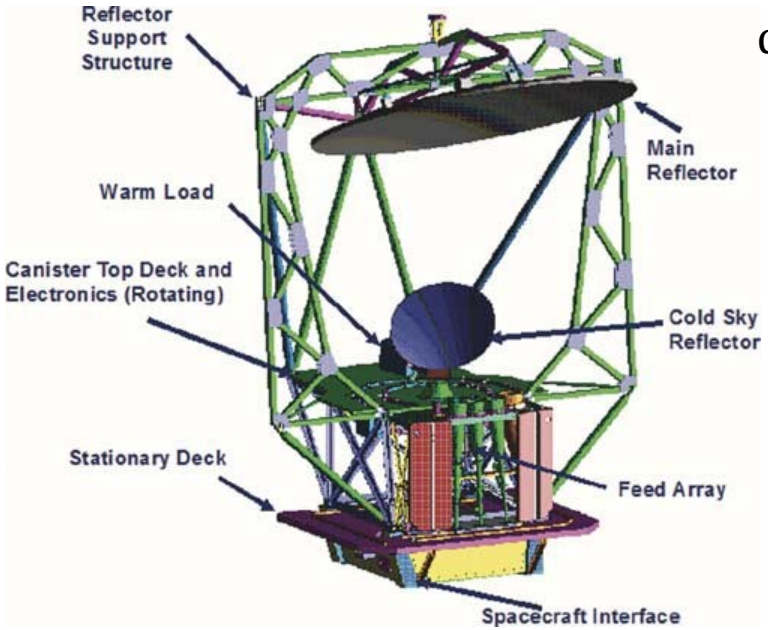
Larger satellites have higher associated costs and risks!

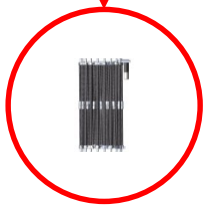
Space-Based Observations

Smaller platforms can reduce costs and risk, but require deployables to compete with legacy ground resolution

WindSat Radiometer

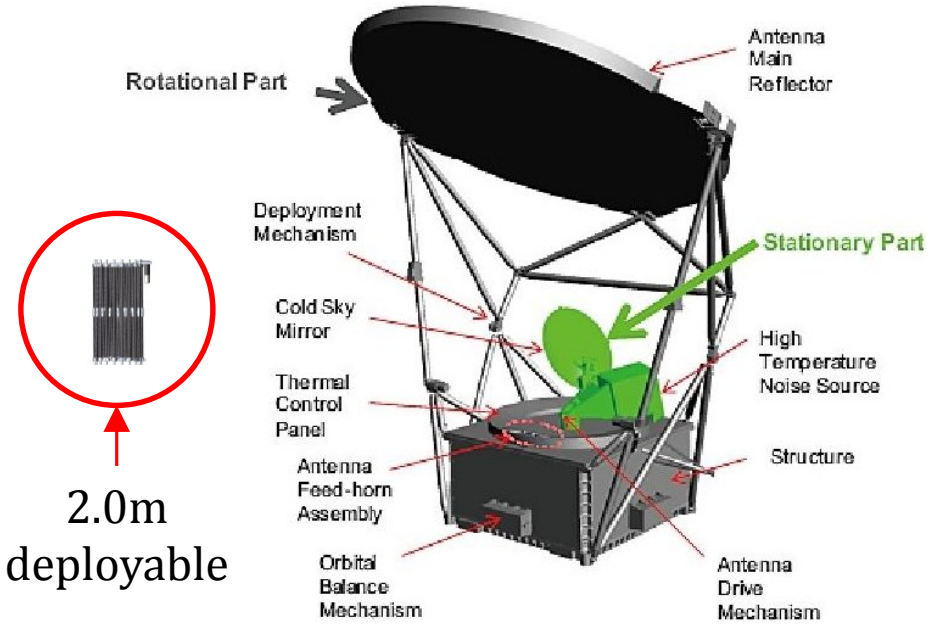


1.83m deployable



Main reflector diameter 1.83 m

AMSR2 Radiometer



2.0m deployable

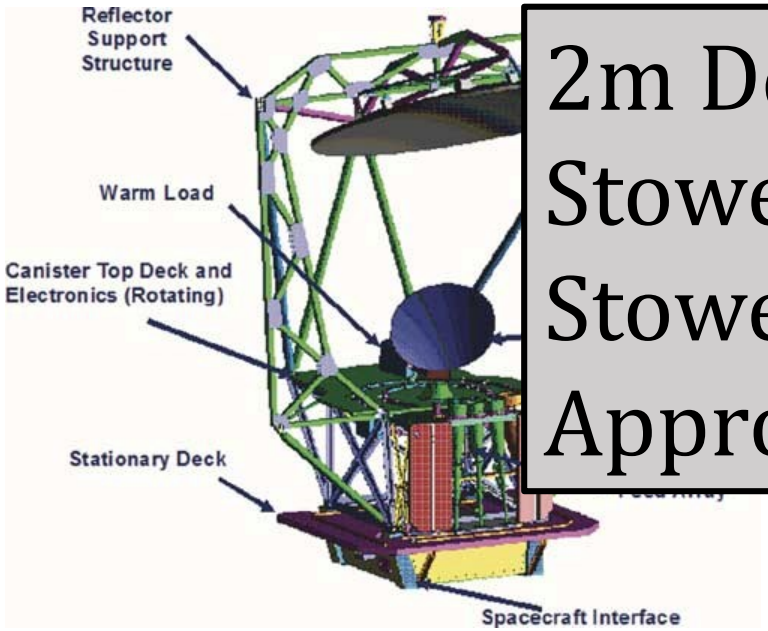
Main reflector diameter 2.00 m

Space-Based Observations

Smaller platforms can reduce costs and risk, but require deployables to compete with legacy ground resolution

WindSat Radiometer

1.83m

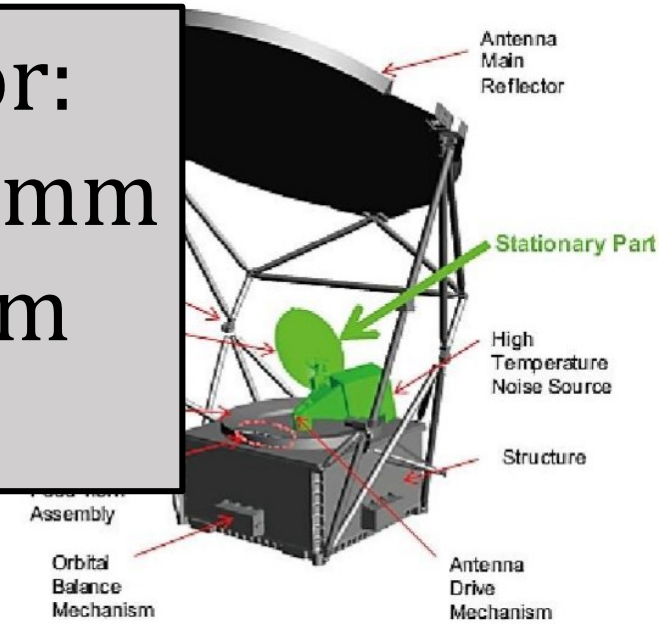


Main reflector diameter 1.83 m

2m Deployable Reflector:
Stowed Diameter – 102mm
Stowed Height – 323 mm
Approx. Mass – 436 g

AMSR2 Radiometer

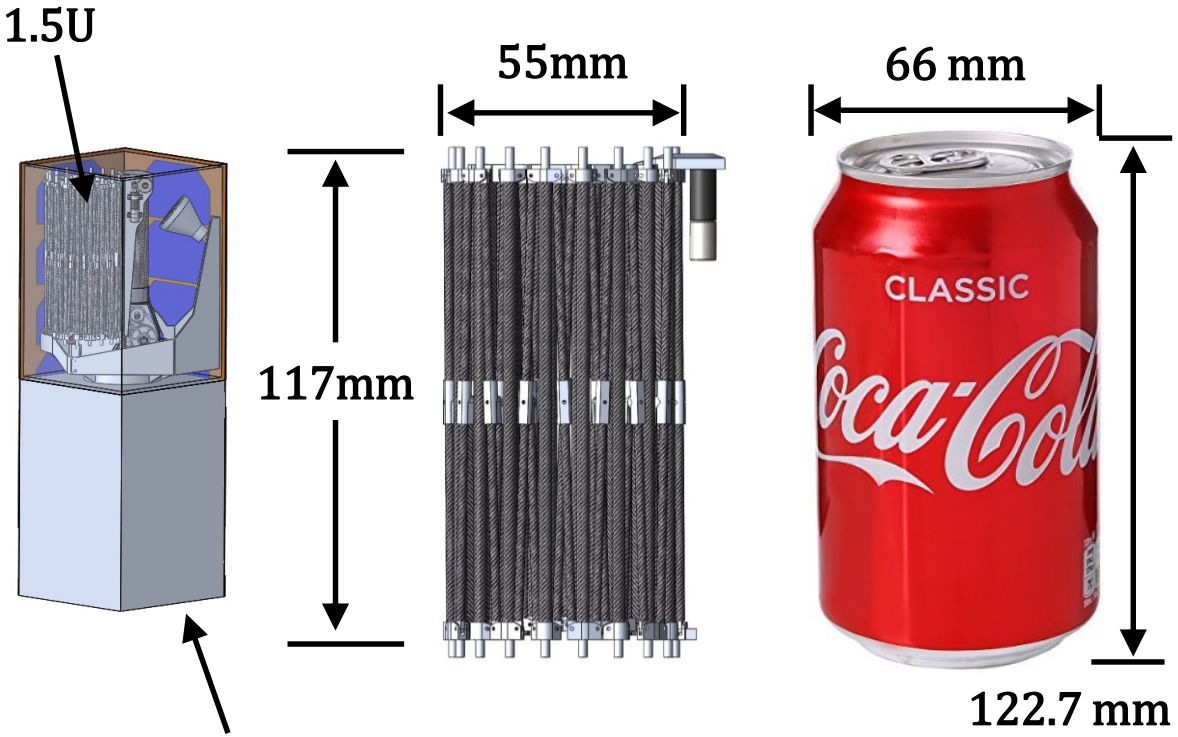
2.0m deployable



Main reflector diameter 2.00 m

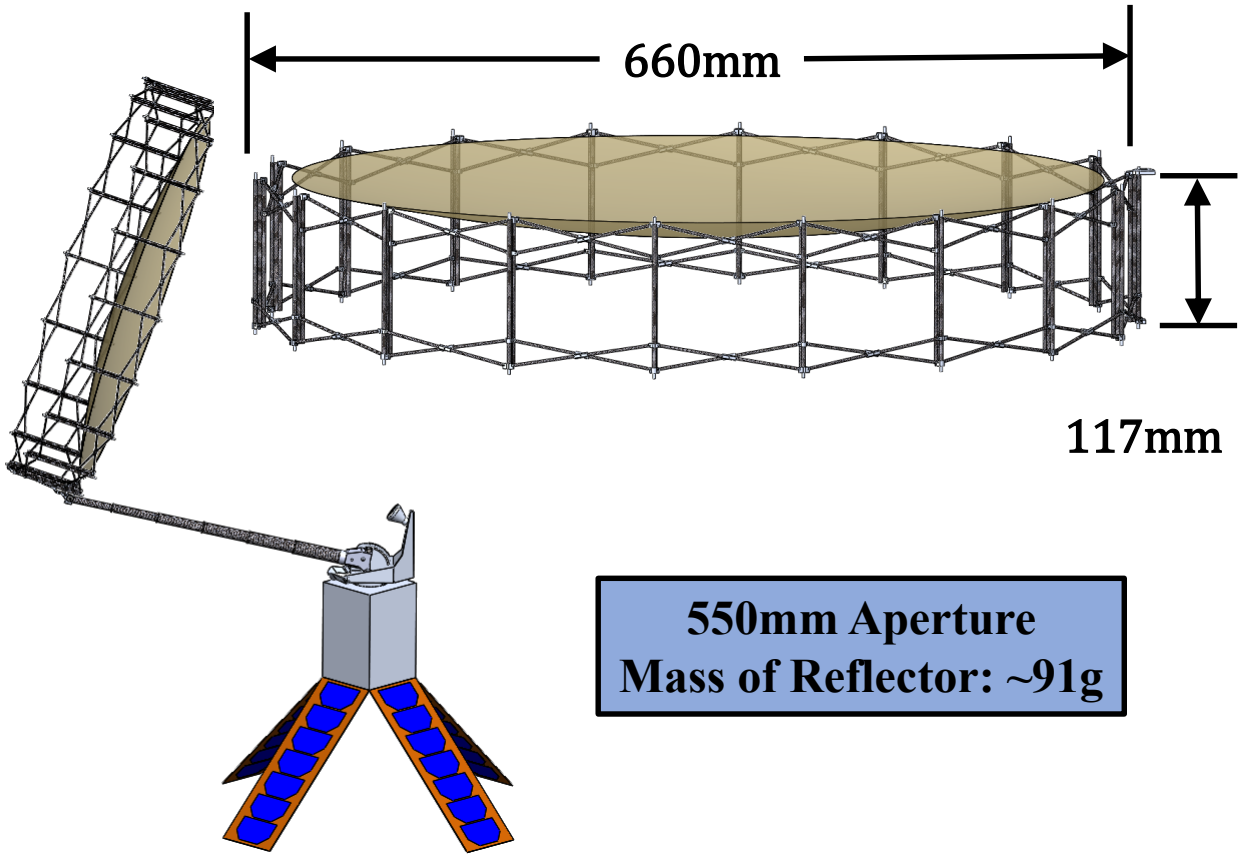
Deployable Reflector Antenna

Stowed



3U Concept
(Front Solar Panels Removed)

Deployed



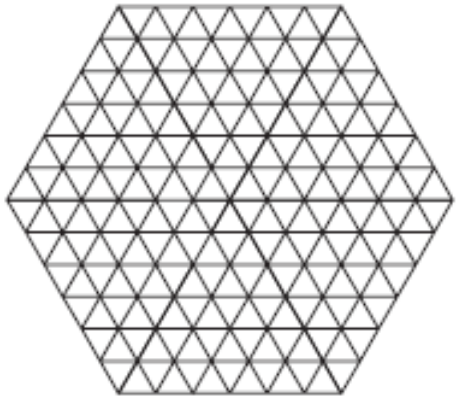
3U Concept w/ cross-track scanning

550mm Aperture
Mass of Reflector: ~91g

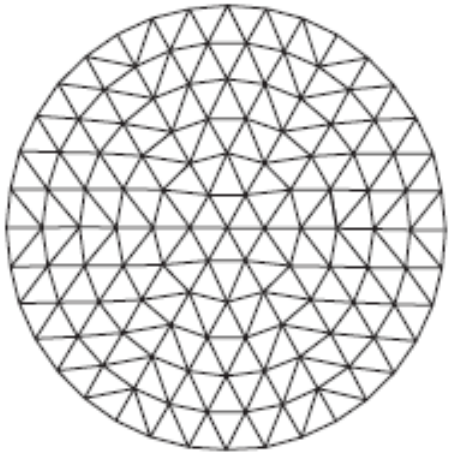
Support Net Generation

W-Band operation requires a highly accurate surface!

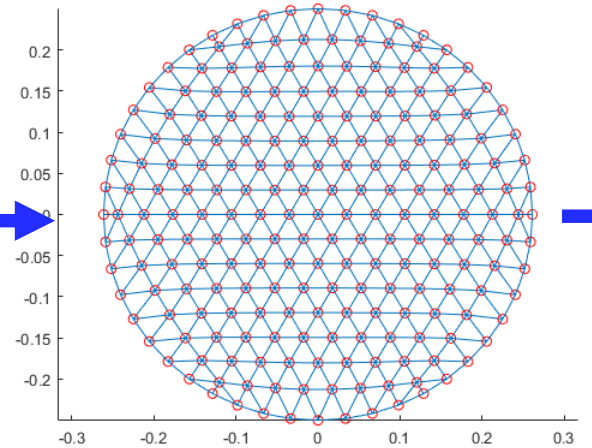
Triangulation



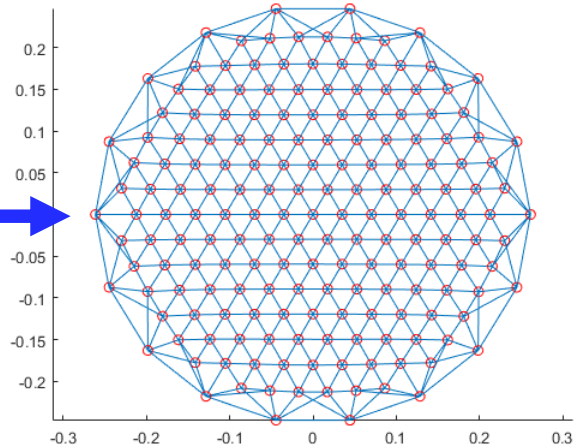
Projection



Optimization

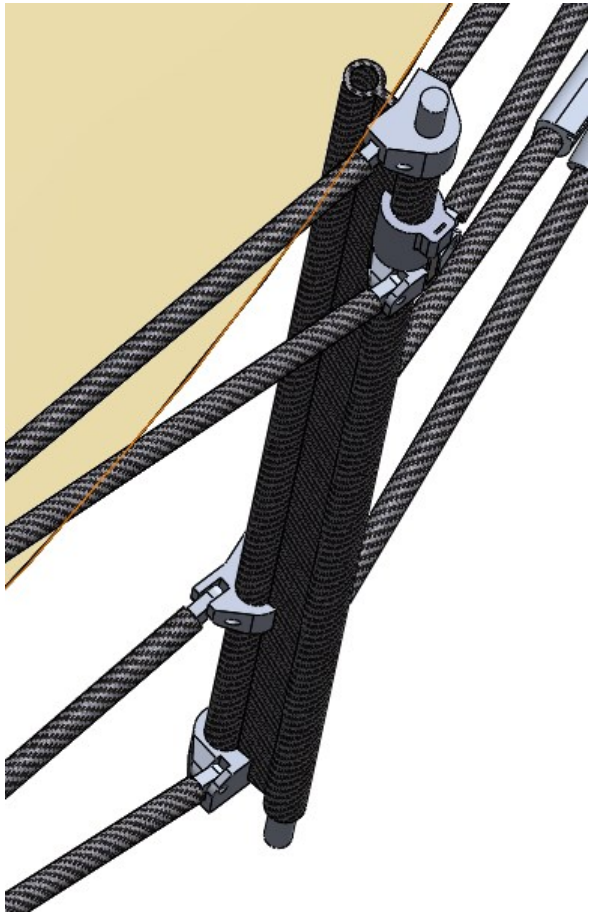


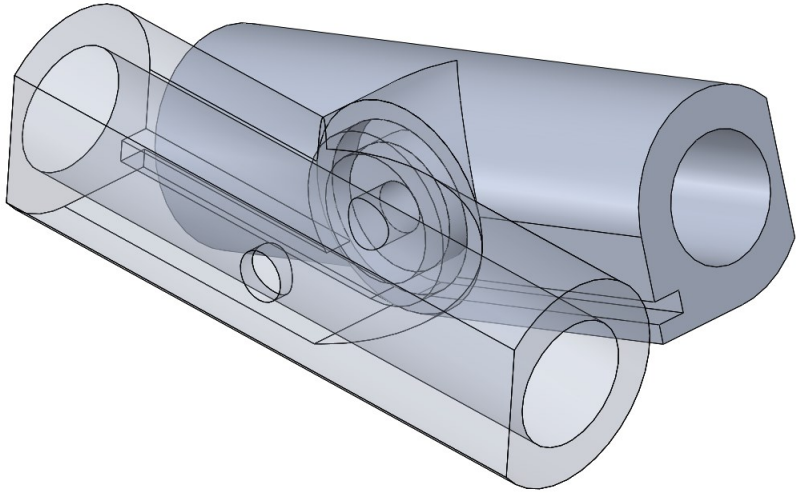
Bay Adjustment



Features of Reflector

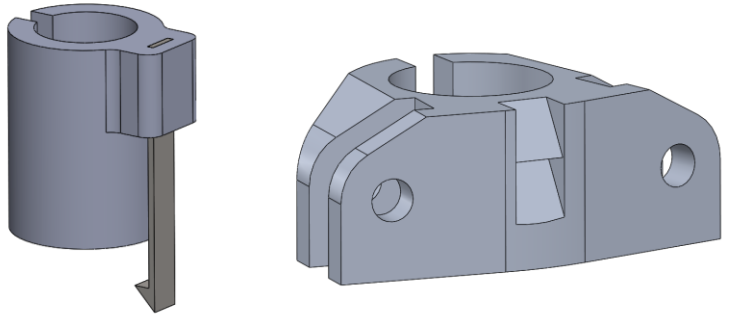
Dual scissor truss increases stowing efficiency and synchronized deployment

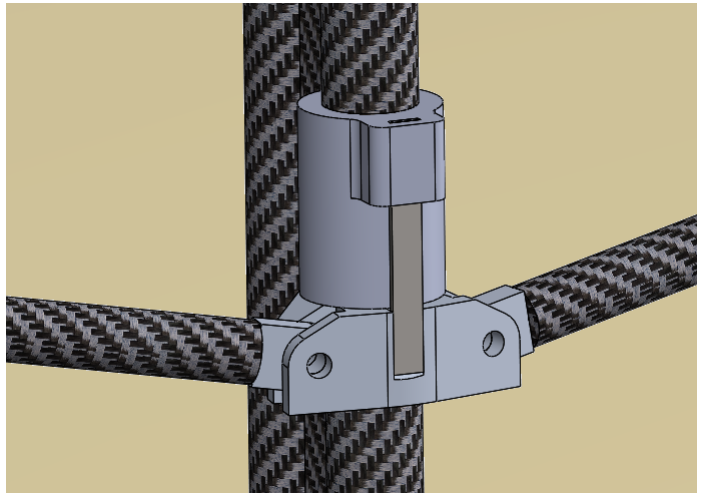




Cross-struts assisted with torsion springs to reduce deployment power (spring not pictured)

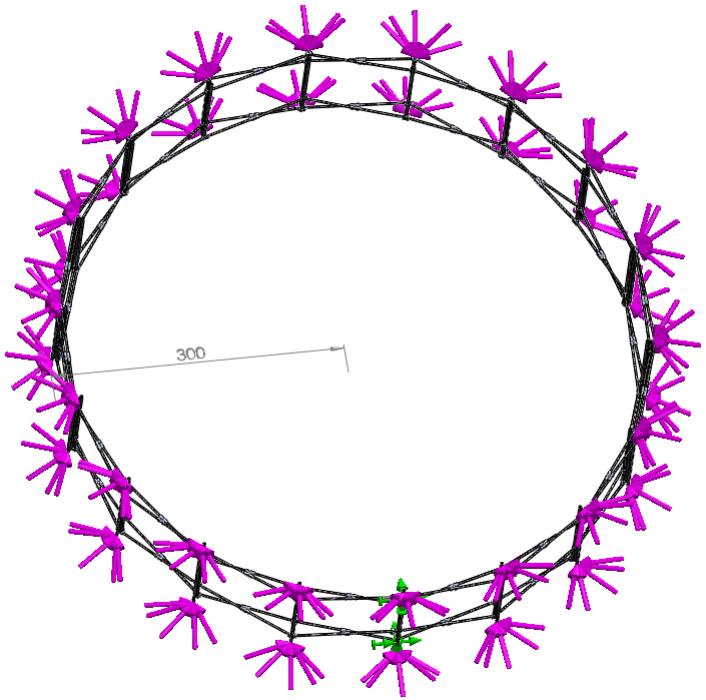
Passive locking mechanism locks deployed reflector in place, eliminating need for sustained power



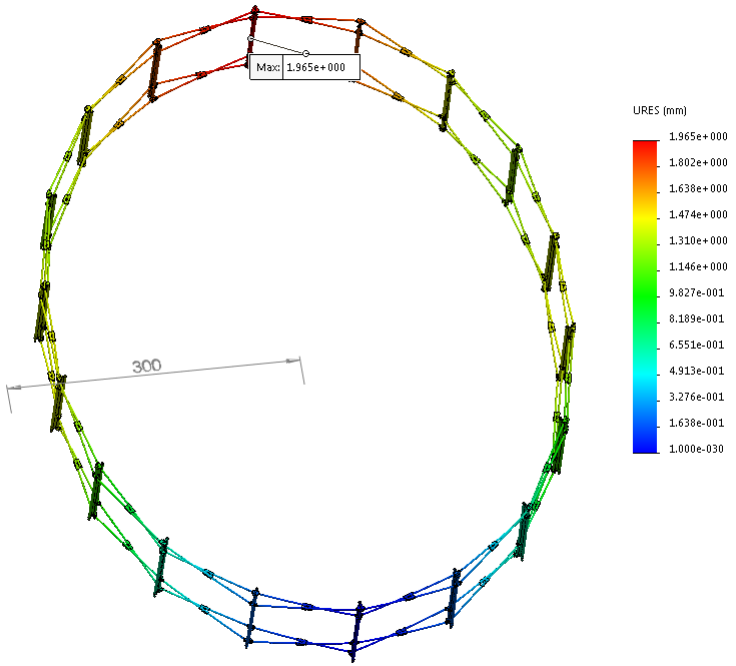


Stress Testing of Structural Rim

Forces and BCs

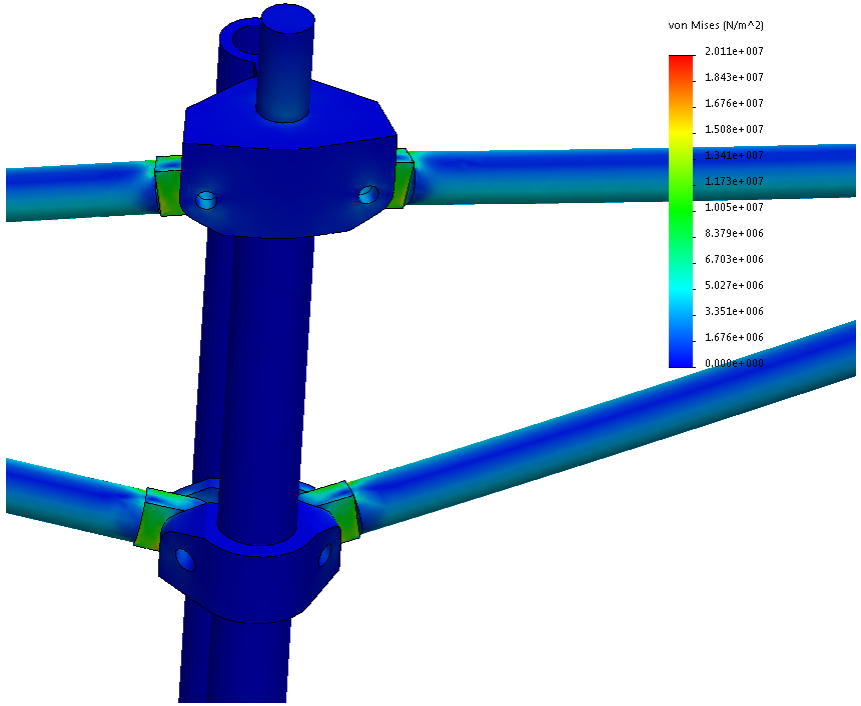


Deformation



Maximum deflection ~.01x Diameter

Stresses



Minimum factor of safety = 14

Reflective Mesh

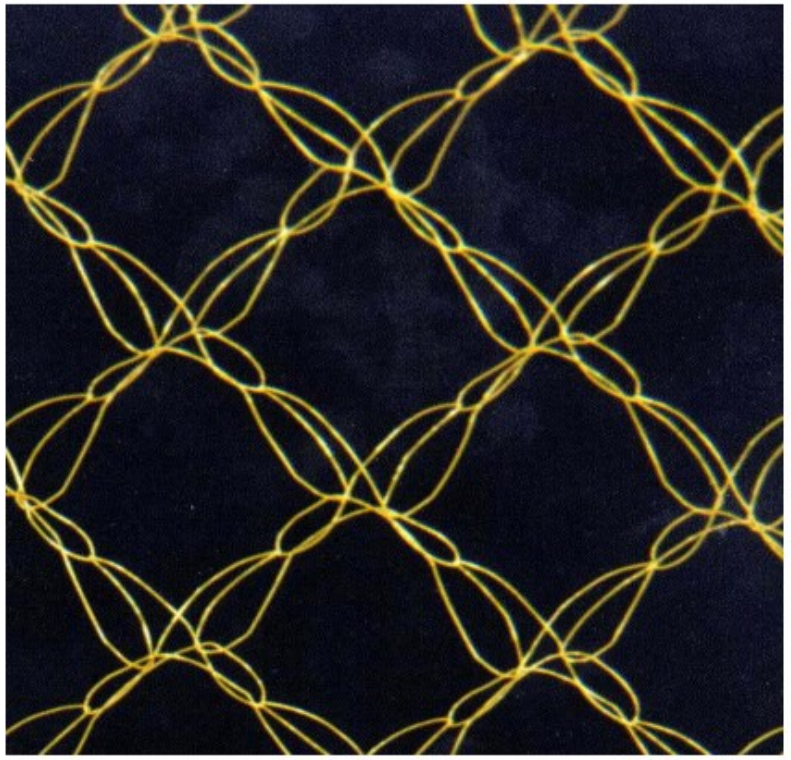
Requirements

- Gold plated molybdenum wire
  - 10 to 30μm diameter
- Tricot warp weave for elasticity
- Maximum pore size – $\frac{a}{\lambda} < 0.1$
- Approximately 34 openings per cm (OPC) @ 100 GHz

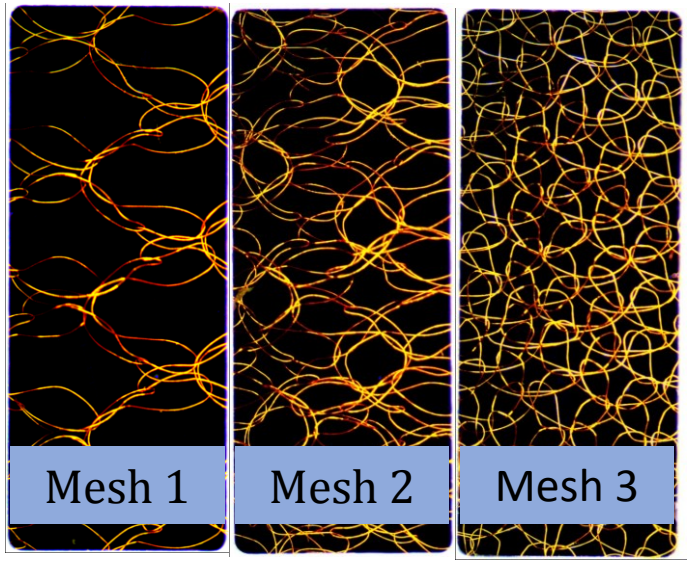
Supplier

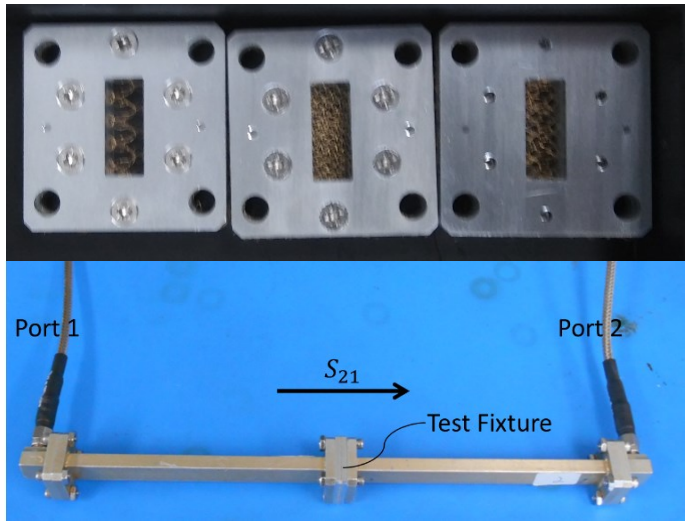
- Three knit patterns currently being manufactured
- Manufacturer confident of achieving an OPC of greater than 24

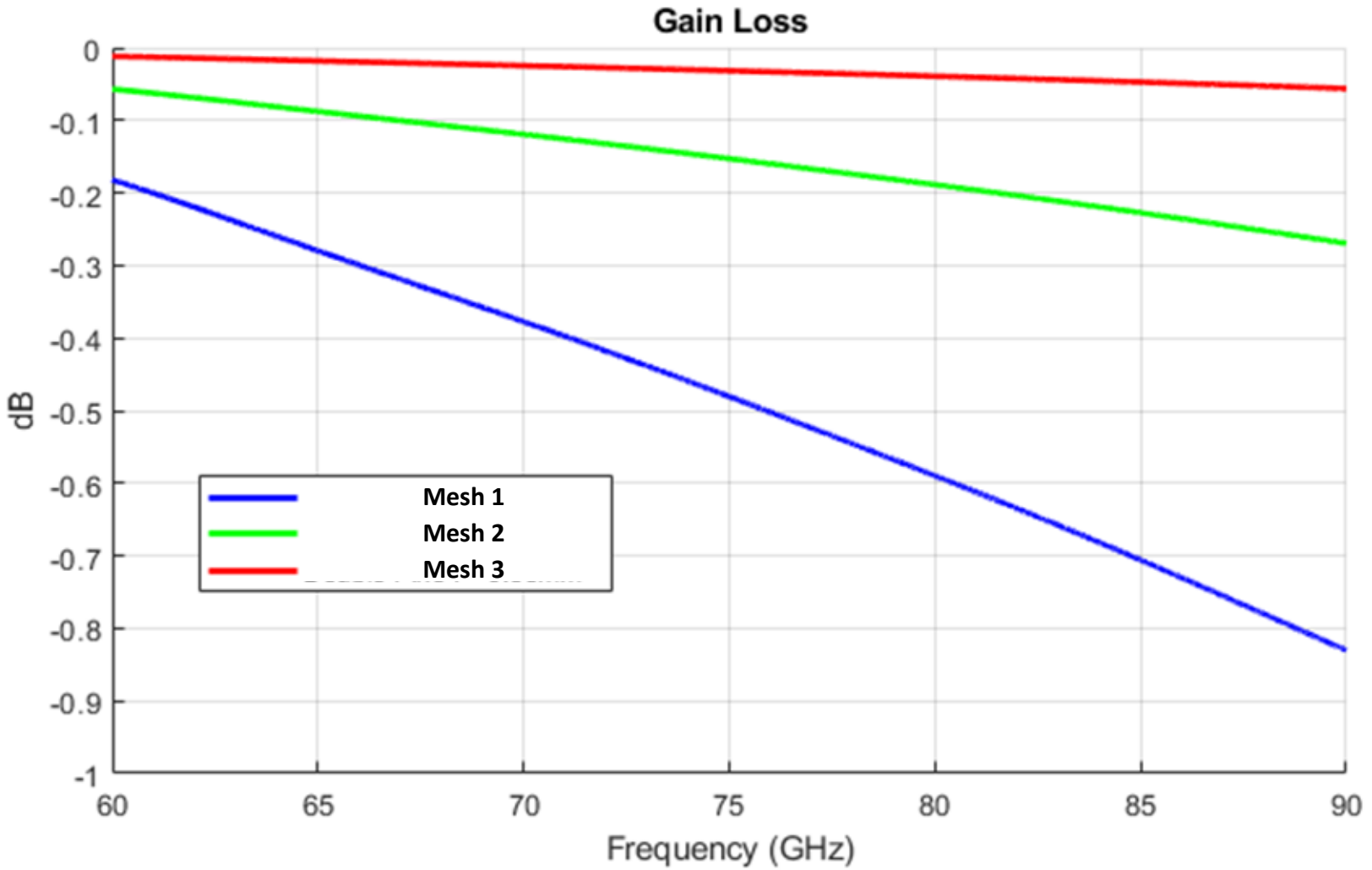
Example of Tricot Weave Pattern



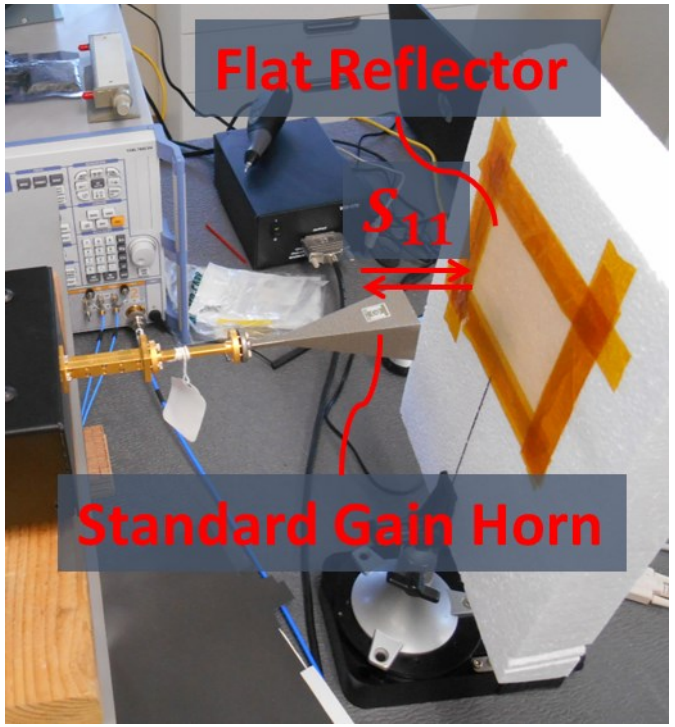
Mesh Characterization – pore size

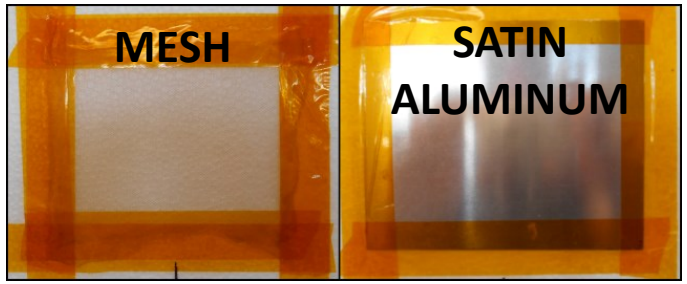




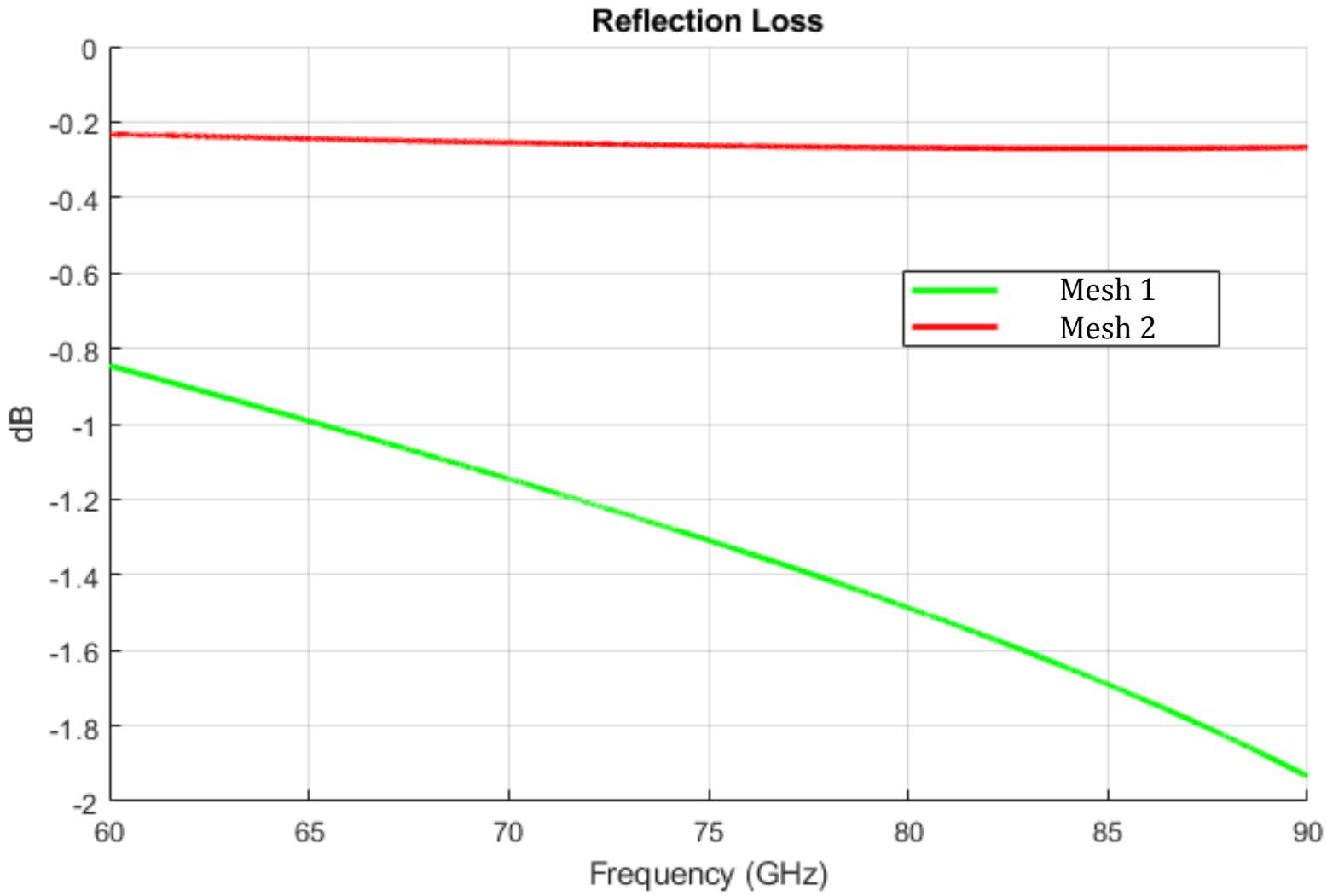


Mesh Char. – surface roughness

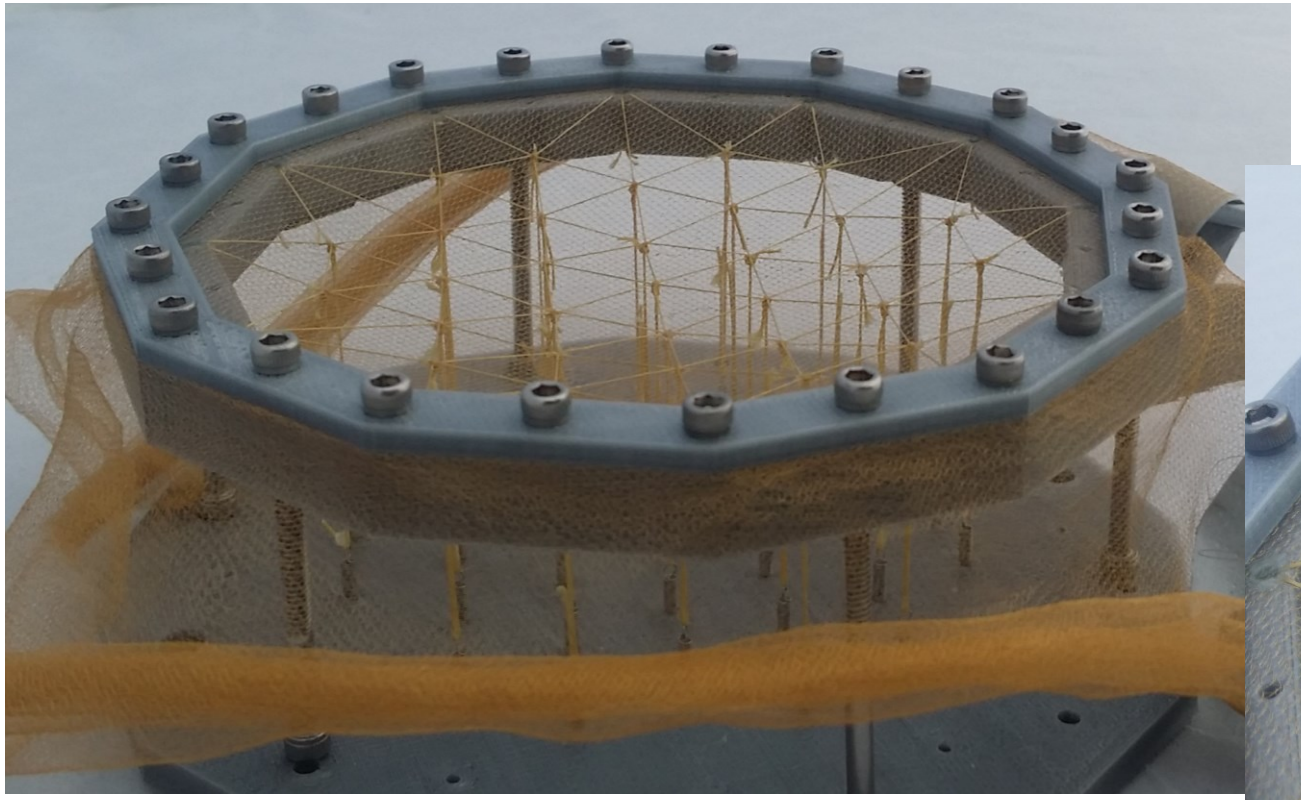


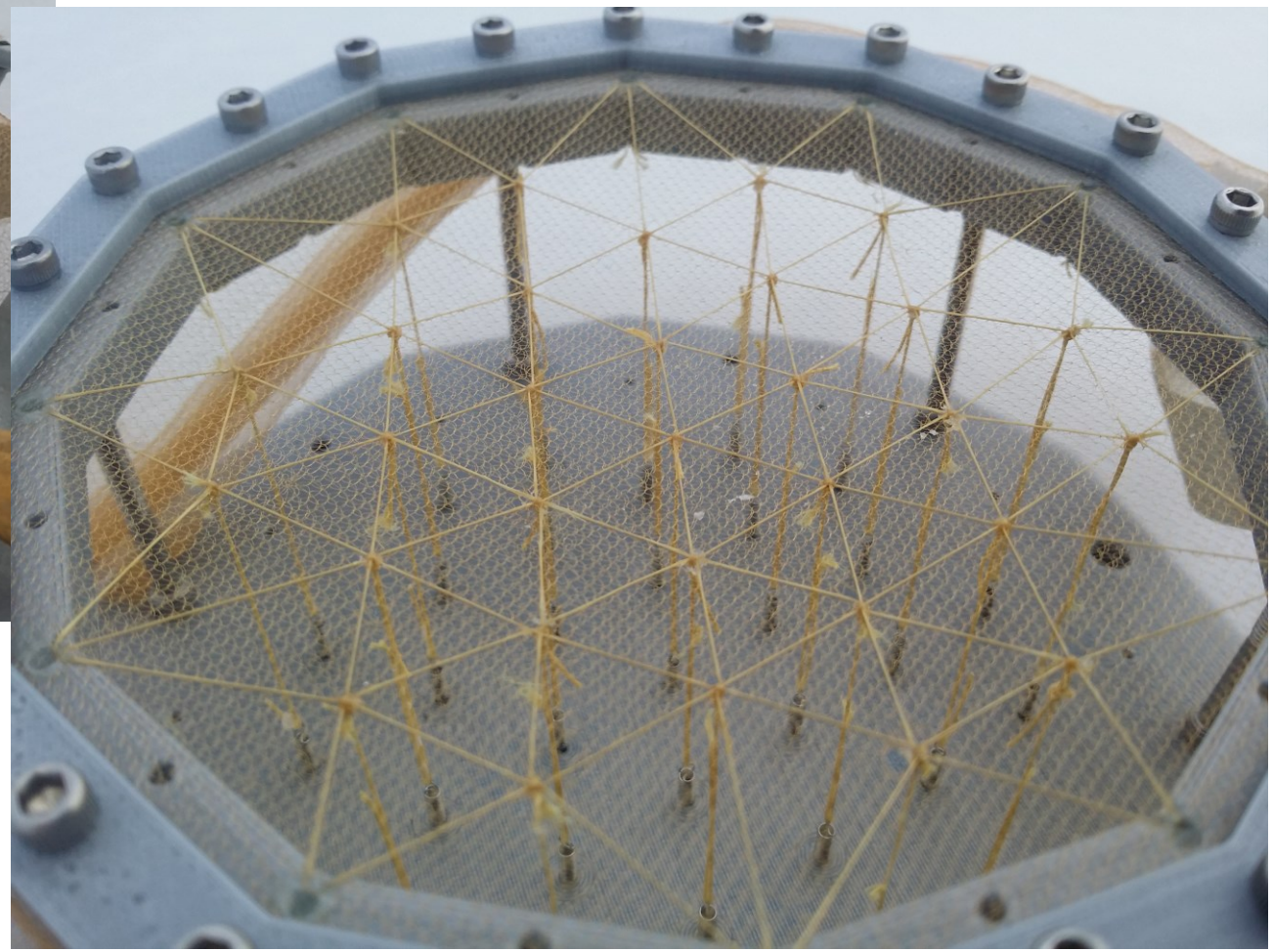


125 X 100 mm reflectors



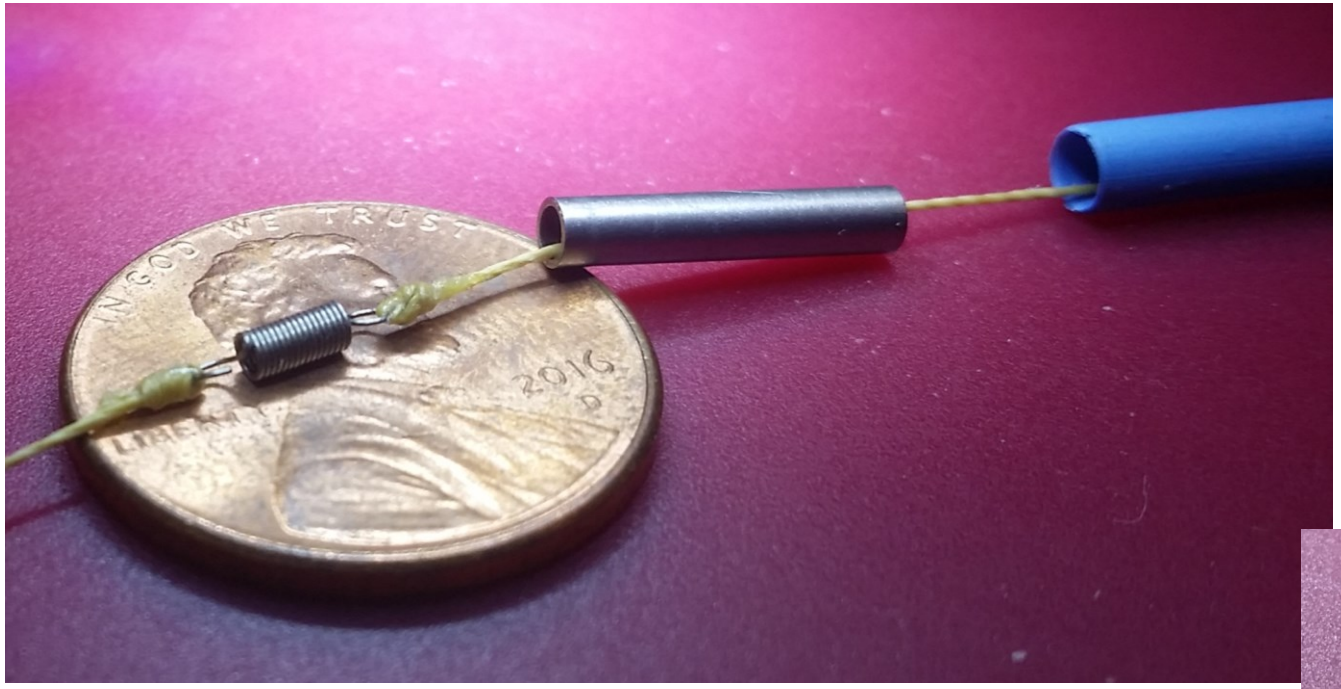
Scaled Reflector Assembly





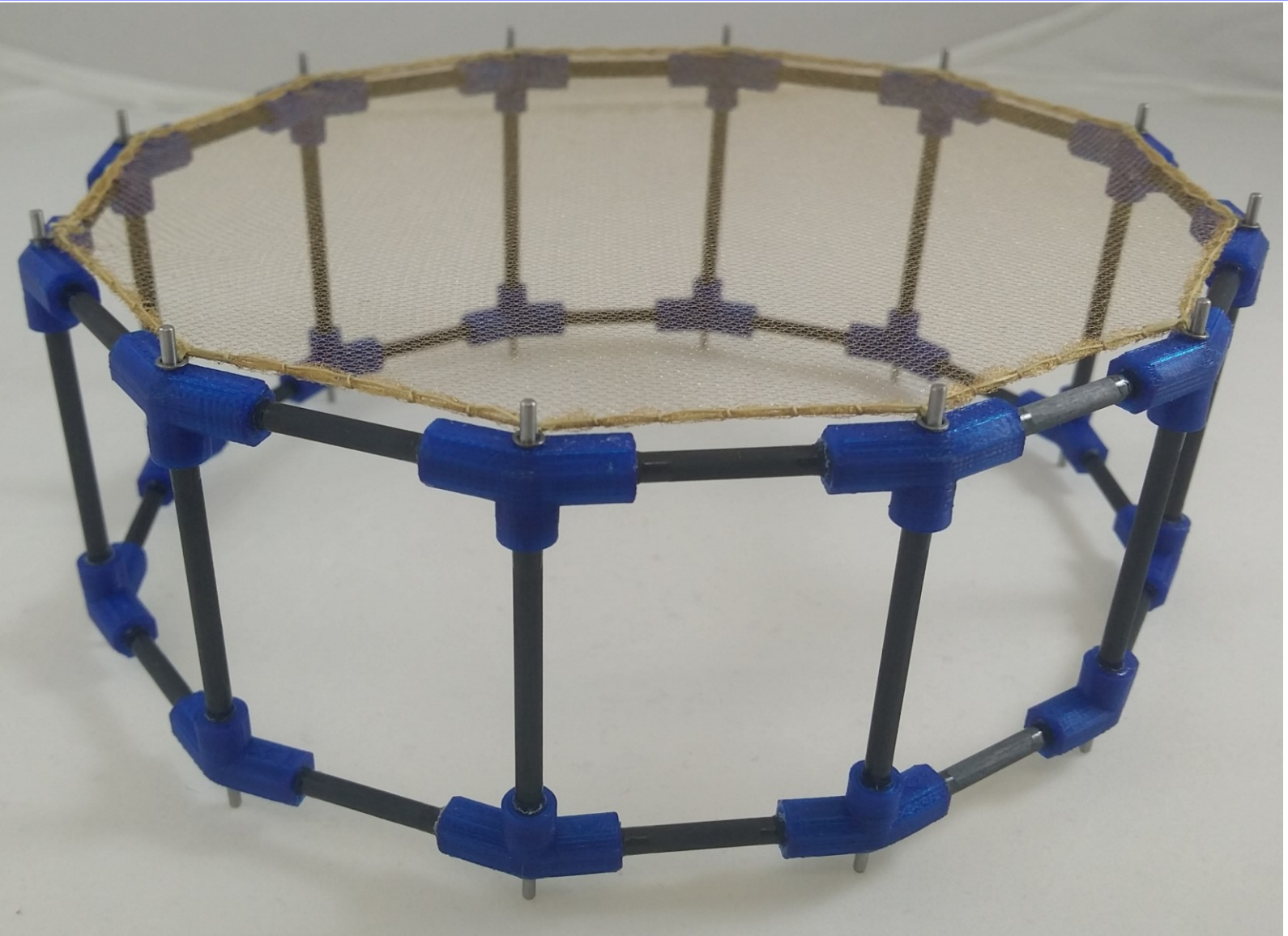
Adhesive Testing
and First Assembly

Scaled Reflector Assembly



Tension Ties and Deployment Motor

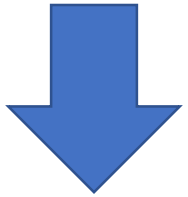
Scaled Reflector Assembly



Rigid Rim Test and Mesh Transfer

Summary

Larger satellites are costly and can pose a high degree of risk!

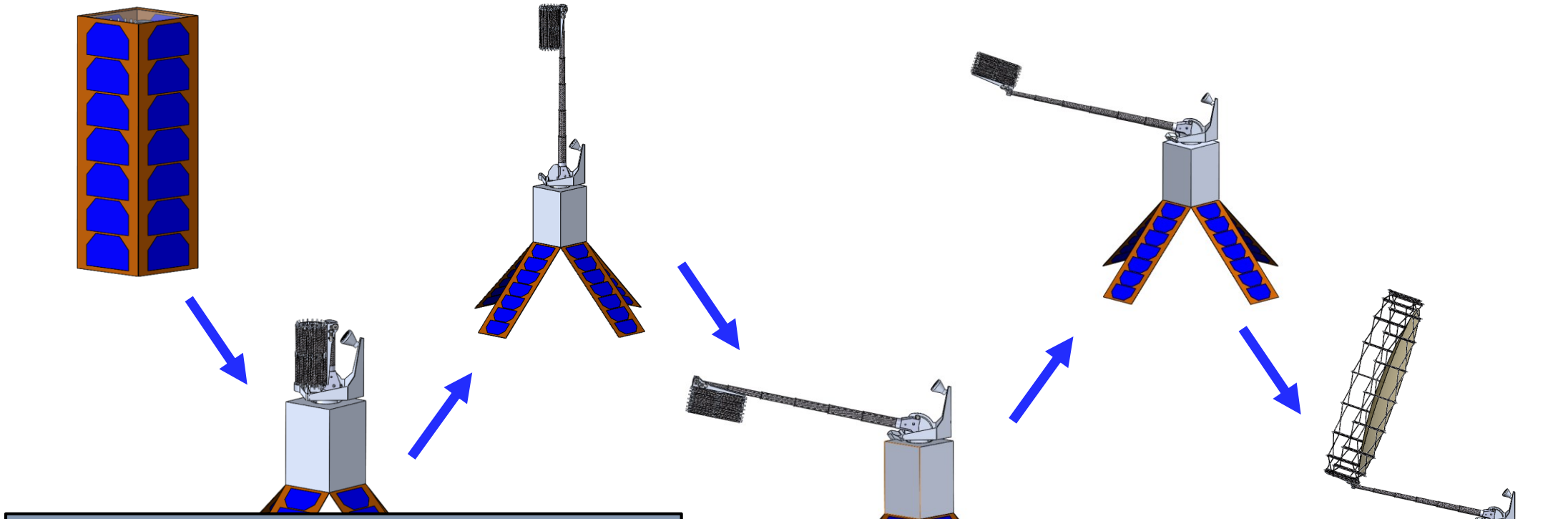


Deployable reflector antennas are a potential solution to EO needs!

- Operation up to 100 GHz
- Custom Software for optimization and design
- 0.55m prototype under development
- Scalable design
- Deployment based on proven technology
- Manufacturing improved mesh
- Testing procedures developed with promising initial results

Potential Deployment Sequence

3U cross-track scanning CubeSat concept with 0.55m aperture



Questions?