T-DaHGR X-Band Antenna for CubeSats – 1-meter diameter aperture deployed from 1U

Tape-Spring Deployable High-Gain Reflectarry (T-DaHGR)

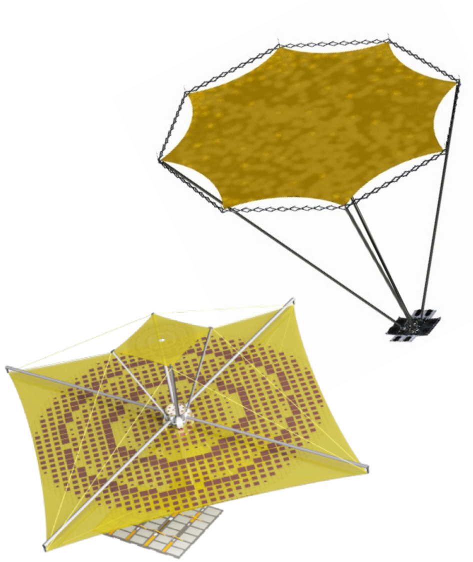
2019 CubeSat Workshop

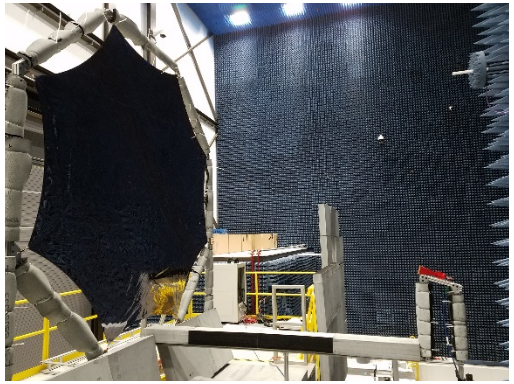
San Luis Obispo, California

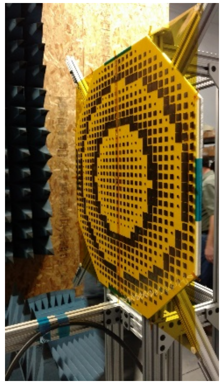
April 2019

MMA's Thin-film Membrane Reflectarray Systems

- Membranes lend themselves to reflectarray applications
  - Reflector can be a flat surface
  - Only passive elements required for reflector
- MMA has been developing membrane-based reflectarray technology since 2013 including Center-fed, offset, and Cassegrain
- Based on industry-proven concepts
- R&D has retired risks pertaining to thin-film problems and constraints
  - Stowage and deployment
  - Environmental protection
  - Manufacturing
  - System architecture optimization

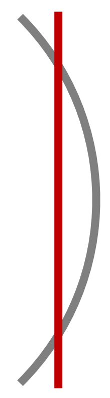




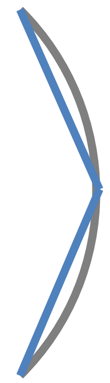


Reflectarray Bandwidth Considerations

- Bandwidth
  - Radiating elements must be tailored to a specific frequency
  - Performance falls off as frequency differs from design center
- Methods for Recovering Bandwidth
  - High bandwidth element design
  - Reducing differences in path length between elements
  - Closer approximation of parabolic surface (i.e. less phase shifting required)
  - Faceted reflectarray



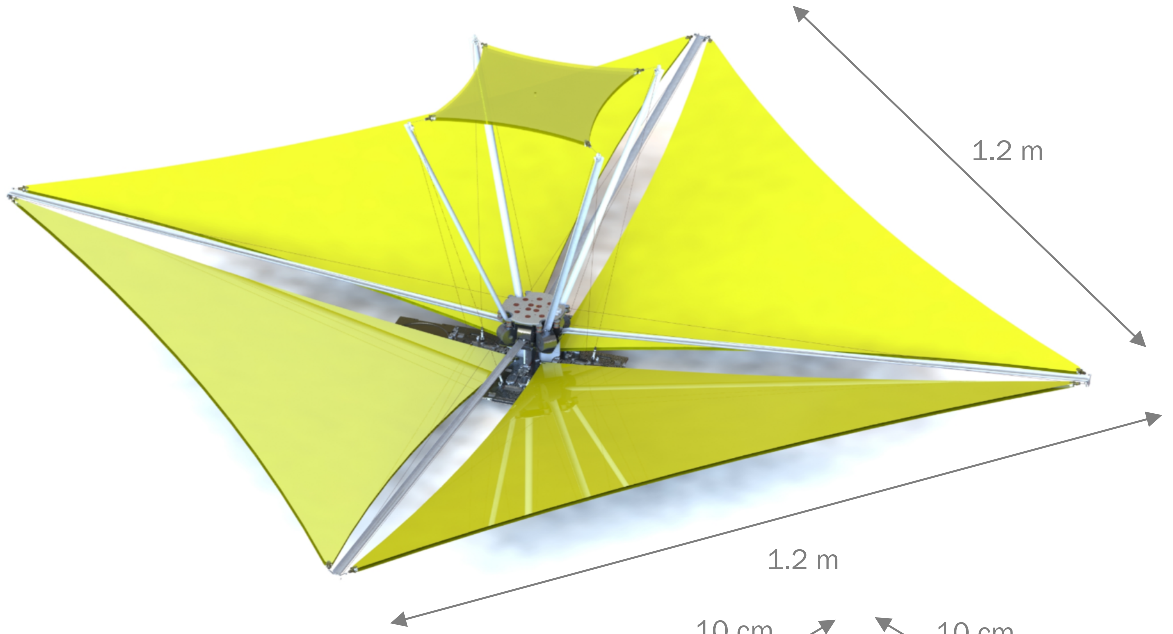
Single Facet Approximation

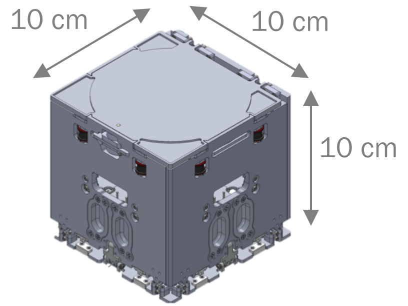


Two Facet Approximation

T-DaHGR System Attributes

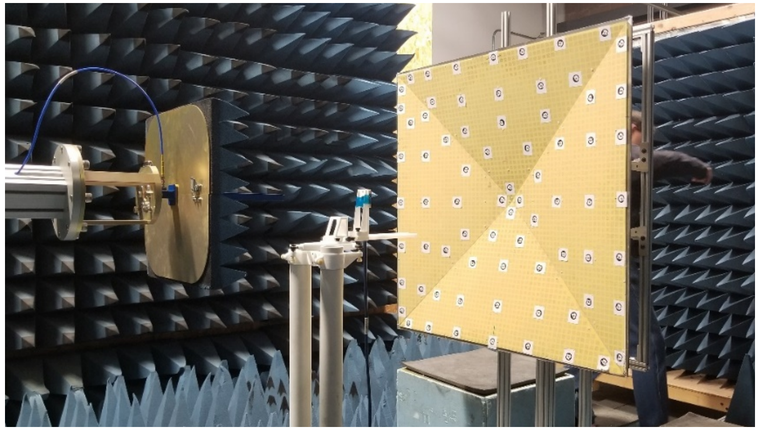
- Cassegrain configuration
- Four independent primary reflectarray facets
  - Dual-layer polyimide thin film membranes
- Fiber-reinforced polymer tape boom structural elements
- 1 m diameter aperture
- 1U stowed volume
- 1.5 kg mass
- 35dB gain at 9.6GHz
- Bandwidth up to 40% for X-band operation

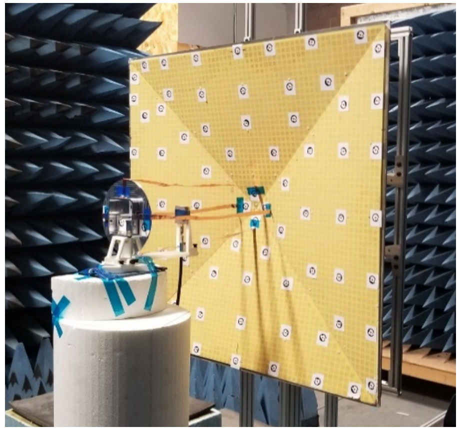


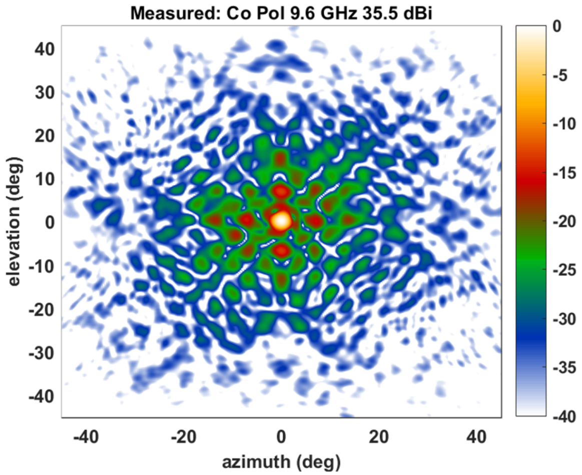


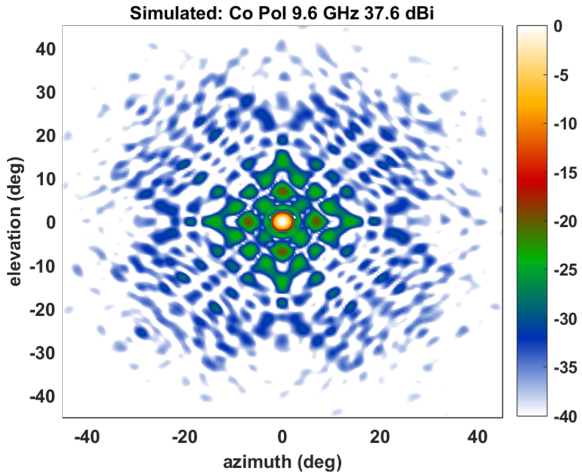
T-DaHGR Performance Testing

- Near Field Range Testing
  - 9.6 GHz center frequency
  - Two configurations
    - Direct center-fed (no subreflector)
    - Cassegrain (idealized subreflector)
- RF Design Verification
  - Bandwidth, collimation, and pattern shapes matched simulations
  - Achieved 30% bandwidth at X-band (3 dB gain bandwidth)
- Future Testing
  - Update and test design for 8.2-8.45 GHz (MAXWELL requirements)
  - Implement membrane-based primary and secondary reflectarrays



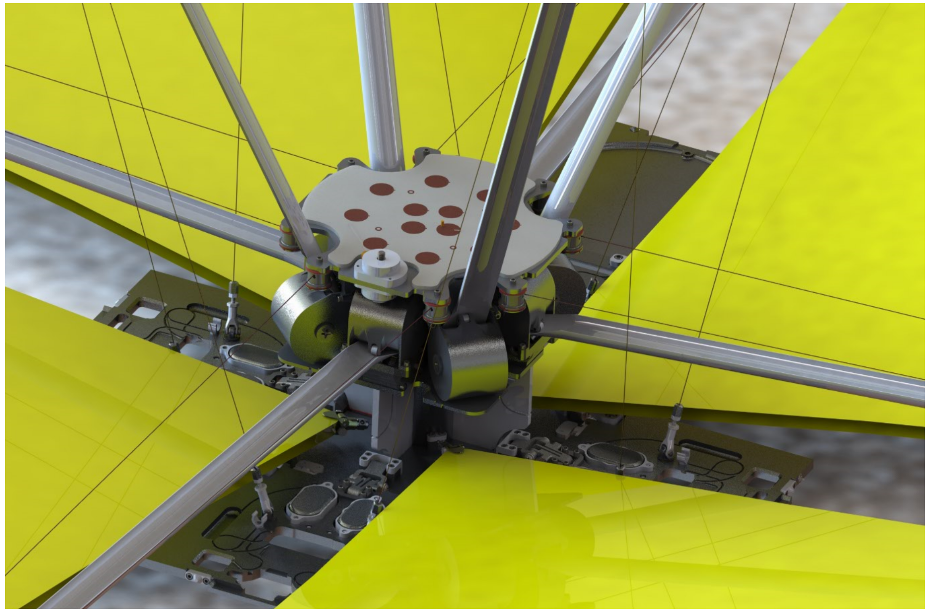


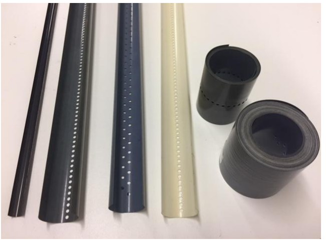




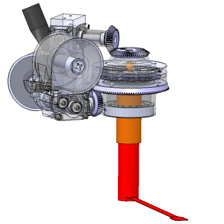
T-DaHGR Mechanical Design

- Leverages MMA's high-TRL enabling technology
- Requires innovative deployment concepts and mechanism design to fit allocated volume
  - MMA's high strain composite tape booms (QTY = 8 ea.)
  - Single-motor high-torque drivetrain which synchronizes deployment
  - Origami-inspired membrane folding and stowage strategies
  - Membrane acts as a reflector and a structural element





High strain composite tape booms



Drivetrain quadrant

T-DaHGR System Deployment

T-DaHGR Current Status

- Early prototypes and testing completed for higher risk subsystems
  - RF Design
  - Membrane
  - High-strain composites
  - Drivetrain
- Mechanical and electrical interfaces to spacecraft bus established
- Engineering unit deployment testing in progress, RF testing to follow (Q2 2019)
- Flight unit delivery Q4 2019

MAXWELL Flight Unit

- T-DaHGR chosen as a payload on MAXWELL mission
  - University of Colorado team
  - 6U bus
  - Demonstration of high data rate downlink at 8.3 GHz
  - Technology demonstrator for future deep space communications
  - Special thanks to AFRL and SMC for their sponsorship
  - Delivery in late 2019

Questions

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