Space-Deployed Inflatable Dual Reflector Antenna: Design and Prototype Measurements

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Large Aperture Space Based RF Applications

1. Small satellite deploys
2. Image region of interest with X-Ku band radar
3. Data downlink to ground/surface station

- Several RF space applications such as SAR imaging, deep space comms and radio navigation
- Inflatable provide large apertures in small packed volumes, required surface precision is challenging
- Goal: Demonstrate the feasibility of precision large inflatable apertures at X-Ku band for small satellites
Novel dual-reflector Gregorian inflatable antenna, designed, fabricated, and characterized.
Key Design and Fabrication Insights

- Gregorian layout removes satellite body beam obscuration
- Three independent inflation chambers allow for post-fab antenna tuning
  - Tuned pressures for optimal surface quality
  - Adjustable focal lengths for secondary
  - Reverse thermoforming to correct fab defects
  - Post-deployment primary-secondary alignment
- Pragmatic mechanical design obviates need for high precision design/fab

RF-Transparent Sections at Interfaces
Wrinkling contained to RF-transparent sections

Az/El alignment lanyards
Co-alignment of Reflective Surfaces
Post-Fabrication Reverse Thermoforming
Before
After
Deployed Area vs. Stowed Volume

Spacecraft Deployed Reflectors (In Orbit & Lab Models)

- L/Mesh
- L/Inflatable
- S/Mesh
- X/Mesh
- Ku/Mesh
- Ku/Inflatable
- Ku/MIT LL
- Ka/Mesh
- Ka/Solid
- V/Solid
- NA/Solar Sail

Demonstrated: Inflatable X-Ku band antenna with stowed volume similar to solar sails.
Simulated and Measured Gain at 10 GHz

- Measured antenna gain shows good performance at X-band
  - 37.6 dBi gain, ~1° beamwidth at 10 GHz
  - Peak directivity within 4 dB of ideal
- Improvement in primary reflector design and fabrication required to achieve directivity within 1 dB of ideal
Simulated and Measured Gain (2 of 2)
Inflatable Gregorian Reflector Antenna

- 3D laser scans of prototype and root mean square (RMS) surface error analysis helped identify error sources
  - All errors associated with primary surface shape
- Improvements in primary fab design and integration fixtures expected to bring performance within 1 dB of ideal
Summary and Path Forward

• Designed, prototyped, and characterized a novel dual-reflector Gregorian multi-chambered inflatable antenna for X-Ku band
  – Successfully demonstrated good RF performance at X-band, very high deployed area to stowed volume ratio

• Identified opportunity for improvements in mechanical design and fabrication design

• Implementation of identified improvements expected to bring X-Ku band inflatable antenna within 1 dB of ideal performance

• Aperture diameters up to 10 meters likely feasible with these design and fabrication approaches at X-Ku band

Enabling technology for SAR imaging, deep space communications and radio navigation on small satellites