Miniature Deployable High Gain Antenna for CubeSats

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The Boeing Company
Boeing Defense, Space & Security (BDS) / Phantom Works
Advanced Network & Space Systems Group
Huntington Beach, CA

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# Miniature Deployable High Gain Antenna

- **Applicable to High-Speed Communications and a Variety of Missions**

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**Miniature High Gain Antenna Opens up New Mission Opportunities and Represents a Game Changing Capability for CubeSats**

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<table>
<thead>
<tr>
<th>Requirement</th>
<th>Value</th>
<th>Rationale / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Frequency</td>
<td>S-Band</td>
<td>Represents common and popular satellite communications frequency</td>
</tr>
<tr>
<td>Gain</td>
<td>~18 dBi</td>
<td>For 400 km orbit and 5.4m Diameter Ground Terminal, supports up to 28.5 Mbps</td>
</tr>
<tr>
<td>Deployed Diameter</td>
<td>&gt; 50 cm</td>
<td>Maximizing diameter for the given minimal stowed volume is the primary design goal</td>
</tr>
<tr>
<td>Mass</td>
<td>&lt; 1.0 kg</td>
<td>Initial Design Goal. Mass minimized</td>
</tr>
</tbody>
</table>

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*Enables Direct Communication with End User*
S-Band Antenna Geometry and Nomenclature

- **Antenna Simulation and Analysis Performed on a Wide Array of Different Geometries**
  - Performance Driven by Small Packaging and Mechanical Deployment Requirements (not vice versa)
  - Multiple iterations to come up with feasible mechanical solution that yielded best performance

### Predicted Performance of Baseline Design

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>Peak Directivity (dBi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>16.96</td>
</tr>
<tr>
<td>2.1</td>
<td>17.74</td>
</tr>
<tr>
<td>2.2</td>
<td>18.28</td>
</tr>
<tr>
<td>2.3</td>
<td>18.12</td>
</tr>
<tr>
<td>2.4</td>
<td>18.59</td>
</tr>
<tr>
<td>2.5</td>
<td>18.95</td>
</tr>
</tbody>
</table>
Final Baseline Design (Continued) - Stowed

Mounting Adapter Can be Modified to Accommodate Other CubeSat Frames

92.0 mm
50.5 mm
4.0 mm
Mesh Dish Prototype Hardware

- Utilizes Conductive Mesh Fabric
Stowed Packaging

- Feed Tube and Splash Plate Removed to Show Internal Packaging

- Enclosure Box Integrated with CubeSat Structure Frame

• Stowed Dish Packaging Efficiency was Better Than Expected
  – Allows for Dish Diameters Greater than 0.50 m
Deployable Feed Element Assembly RF Testing

- RF Test Results Showed Excellent Performance
Mechanical Deployment Testing

- **Verified Initial Deployment Motions**

- **Enclosure Box Testing Successfully Demonstrated That:**
  - Boeing “standard” burn wire PCB consistently cut monofilament restraint line
  - Enclosure Box doors consistently open when restraint line is cut
  - “First Motion” of hub moving out of box and dish arms deploy without entanglement

- **Deployment Tests of Feed Tubes Performed**
  - Manually testing identified areas for minor improvement that can easily be incorporated in next design revision
Mechanical Deployment Test
- Slow Motion Frame Sequence of Hub and Mesh Dish Deployment

BDS | Phantom Works

Total Deployment Time
Approx 3 seconds
Summary

- Development Proved Very Successful

- Developed Deployable Antenna Design from Initial Concept to a Working Prototype
  - Proved that design concept is fundamentally sound
  - Validated deployment approach and that packaging of a high gain antenna is possible within CubeSat shape and size restrictions
  - New novel RF Balun design shown to provide excellent performance
  - Packaging efficiency of mesh dish and radial arms is better than expected

- Deployable Feed Tube Design Represented Significant Portion of Development Effort
  - Telescoping Tube approach is straightforward
  - Stowed packaging height a function of feed length

Current Design Lays Successful Foundation for the Final Design to Support Flight Demonstration