Lightweight Integrated Solar Array and anTenna (LISA-T)

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LISA-T: The problem

- Small-sat surface area, internal volume, and mass are limited resources
- Most limited to 10’s of watts electrical power.

2-7W body mounted to 35W deployable

72W deployable

- … can we increase this to 100’s of watts?
LISA-T: The Solution

- Thin-film, large area, flexible assemblies: solar sail meet thin-film solar cell

- LISA (Lightweight Inflatable Solar Array) was born
LISA-T: The Solution Part 2

- Add the T (anTenna) by relocating the antenna(s) to deployed blanket

  - Spherical coverage
  - Electronically steered arrays
  - Higher gain design

- Reduced mass, volume, and surface area requirements

*LISA-T emerges*
LISA-T was inspired by the confluence of emerging technologies.

LISA-T is a launch stowed - orbit deployed small-satellite array with embedded lightweight power and communication devices.

- NanoSail-D Solar Sail
- Thin-film IMM PV
- Custom made axial mode helical antenna
• Rapidly advanced through to Technology Readiness Level 6
• Currently testing for environmental longevity
• Actively pursuing a flight demonstration
Providing High Power and Comm to small spacecraft

LISA-T is a launch stowed, orbit deployed structure on which lightweight flexible photovoltaic and antenna elements are embedded

**Larger, Lighter, and Better Stowage** to improve power generation and communications capabilities in small spacecraft
LISA-T: Omni, planar, and other configurations

- Omni for GN&C simplicity: Higher power @ similar stowage and mass rates
- Planar for high performance: Much higher power @ higher stowage and lower mass
LISA-T: Omni, planar, and other configurations

- Array web as well as deployment backbone can be reconfigured…
CubeSat solar array SOA:

- Rigid panel with triple-junction solar cells; cost tends to increase with larger, more complex arrays.

<table>
<thead>
<tr>
<th>Generation Axes</th>
<th>BOL Power (W)</th>
<th>Stowed Power (kW/m³)</th>
<th>Specific Power (W/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clyde Space 3U Body Mounted</td>
<td>2-axes</td>
<td>7.3</td>
<td>~33</td>
</tr>
<tr>
<td>MMA HaWK</td>
<td>1-axis</td>
<td>36</td>
<td>~99.0</td>
</tr>
<tr>
<td>Clyde Space 3U Deployable</td>
<td>1-axis</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Tether Unlimited SunMill</td>
<td>1-axis</td>
<td>80</td>
<td>~83</td>
</tr>
<tr>
<td>Pumpkin Turkey Tail</td>
<td>1-axis</td>
<td>56</td>
<td>~142</td>
</tr>
<tr>
<td>NASA iSAT (2016)</td>
<td>1-axis</td>
<td>72</td>
<td>~45</td>
</tr>
<tr>
<td><strong>LISA-T pointed</strong>*</td>
<td>1-axis</td>
<td>&gt;250</td>
<td>&gt;400</td>
</tr>
<tr>
<td><strong>LISA-T omnidirectional</strong>*</td>
<td>3-axes</td>
<td>&gt;125</td>
<td>&gt;125</td>
</tr>
</tbody>
</table>

*Note: The LISA-T calculations assume a high efficiency >25% thin film cell; lower cost cells can also be used to generate >100W in the pointed and >50W in the omnidirectional configuration.
CubeSat Antenna State of the Art

### CubeSat antenna SOA:
**Panel mounted structures**

<table>
<thead>
<tr>
<th>Antenna Type</th>
<th>Band</th>
<th>Main Beam Gain</th>
<th>Type</th>
<th>Directionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISIS Deployable</td>
<td>UHF/VHF</td>
<td>0 dbi</td>
<td>Monopole/Dipole</td>
<td>Near omni</td>
</tr>
<tr>
<td>NanoCom ANT430</td>
<td>UHF</td>
<td>1.5 dbi</td>
<td>Turnstile monopoles</td>
<td>Near omni</td>
</tr>
<tr>
<td>Clyde Space S-Band</td>
<td>S-band</td>
<td>8 dbi</td>
<td>Patch</td>
<td>Pointed</td>
</tr>
<tr>
<td>SpaceQuest AC-2000</td>
<td>S-band</td>
<td>2 dbi</td>
<td>Turnstile</td>
<td>Pointed</td>
</tr>
</tbody>
</table>

### LISA-T antenna targets:
**Deployed structure integrated arrays**

<table>
<thead>
<tr>
<th>Array Type</th>
<th>Band</th>
<th>Main Beam Gain</th>
<th>Type</th>
<th>Directionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitinol Dipole Array</td>
<td>UHF</td>
<td>1 dbi</td>
<td>Dipole</td>
<td>Spherical w/array</td>
</tr>
<tr>
<td>Nitinol Helical Array</td>
<td>S - X</td>
<td>10 dbi</td>
<td>Axial helical</td>
<td>Spherical w/array</td>
</tr>
<tr>
<td>Planar Spiral Array</td>
<td>S</td>
<td>4 dbi</td>
<td>Planar spiral</td>
<td>Spherical w/array</td>
</tr>
<tr>
<td>Patch Array</td>
<td>S - X</td>
<td>7 dbi</td>
<td>Patch</td>
<td>Spherical w/array</td>
</tr>
</tbody>
</table>
LISA-T: Omni, planar, and other configurations

Omnidirectional

- Bread plate
- Stowed petal stack
- Stowed central deployment
- 1U CubeSat
- Top hat

Planar

- Bread plate
- Stowed petal stack
- Petal
- 1U CubeSat
- Mast boom
- Top hat
- Cross brace
LISA-T: Convertible Configurations

Omni

Planar

Planar deployment progression
LISA-T Cartridge: System Concept

- Payload package in ≤2.4U; everything for LISA-T

  1. Single LISA-T configuration

  2. All unique, supporting hardware for demo:
     - Array regulation and power management.
     - Communication management
     - Supporting Avionics