Space Laser Communication Terminals Today and Tomorrow

BridgeSat Inc.

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The Problem: Limited Satellite Bandwidth

- RF spectrum is becoming increasingly competitive, especially in bands which allow high-density of data.
- Today: approximately 27% of Small Satellite Earth Observation missions can generate more data than they are able to downlink.
- Limited by RF Spectrum and Ground Station Availability.

The Future: It’s only going to get worse!
The Solution: Space-Based Optical Comms

• Space-based optical communications can solve the RF spectrum data downlink bottleneck

• Proven technology that offers:
  – High data rates
  – Satellite hardware that is smaller, lighter, cheaper, and consumes less power than RF
  – Secure communication links
  – No ITU spectrum issues
  – Heritage from numerous on-orbit demonstrations

• BridgeSat will overcome the cloud attenuation limitation by building a large optical comm ground network
History of Space-Based Optical Comm

- Space based optical communications has a long history with on-orbit demonstrations:
  - Science missions demonstrated by NASA, ESA, NICT, JAXA, DLR, The Aerospace Corporation, JPL, and many others
  - Multiple classified missions
  - Multiple terrestrial free-space optical communications projects, such as Terabeam
- Major development for projects that weren’t launched:
  - Transformational Satellite Communications System (TSAT), started in 2004, terminated in April 2009
  - Teledesic, a large satellite constellation in the 1990s, with laser intersatellite links
## Notable Optical Comm Satellite Missions

<table>
<thead>
<tr>
<th>Launch Date</th>
<th>Agency</th>
<th>Country</th>
<th>Satellite or Program</th>
<th>Mission</th>
</tr>
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<tbody>
<tr>
<td>August 28, 1994</td>
<td>NICT</td>
<td>Japan</td>
<td>Engineering Test Satellite VI (ETS-V)</td>
<td>1 Mbps bi-directional optical links to the NICT optical ground station</td>
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<td>May 21, 2001</td>
<td>National Reconnaissance Office (NRO)</td>
<td>US</td>
<td>Geosynchronous Lightweight Technology Experiment (GeoLITE)</td>
<td>High rate optical communication links at both LEO and GEO altitudes</td>
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<tr>
<td>July 12, 2001</td>
<td>European Space Agency (ESA)</td>
<td>Europe</td>
<td>Advanced Relay and TTechnology MIsSion (Artemis)</td>
<td>Optical inter-satellite link with CNES's Earth observation satellite, SPOT 4, and an aircraft</td>
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<tr>
<td>August 1, 2005</td>
<td>JAXA</td>
<td>Japan</td>
<td>Optical Inter-Orbit Communications Engineering Test Satellite (OICETS)</td>
<td>Both inter-satellite link and satellite-to-ground downlink</td>
</tr>
<tr>
<td>April 24, 2007</td>
<td>Missile Defense Agency (MDA)</td>
<td>US</td>
<td>Near Field Infrared Experiment (NFIRE)</td>
<td>LEO-to-ground optical communication tests at up to 5.6Gb/s, and for optical crosslink tests with the TerraSAR-X satellite</td>
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<tr>
<td>Sept 6, 2013</td>
<td>NASA</td>
<td>US</td>
<td>Lunar Laser Communication Demonstration (LLCD)</td>
<td>622 Mbps downlinks from the Lunar Atmosphere Dust and Environment Explorer (LADEE)</td>
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<tr>
<td>April 18, 2014</td>
<td>NASA</td>
<td>US</td>
<td>Optical Payload for Lasercomm Science (OPALS) Space Optical</td>
<td>50 Mbps downlink from the International Space Station (ISS)</td>
</tr>
<tr>
<td>May 24, 2014</td>
<td>NICT and JAXA</td>
<td>Japan</td>
<td>Communications Research Advanced Technology Satellite (SOCRATES)</td>
<td>Satellite to ground links from a small satellite on the SOTA (Small Optical TrAnspounder)</td>
</tr>
</tbody>
</table>
The Future of Optical Comms

- 2017 will be the year that space-based optical communications breaks through
- Many new missions underway, including ESA’s European Data Relay System (EDRS), NASA’s Laser Communications Relay Demonstration (LCRD), and Japan’s Optical Data Relay Satellite
- Numerous companies are exploring optical comms for commercial programs, including Facebook, SpaceX, Laser Light, and LeoSat
BridgeSat’s Role

• BridgeSat was formed in early 2015 with the goal of bringing optical communications technology to the commercial satellite industry.

• BridgeSat is developing a global optical ground network that will be compatible with all the major Space Laser Communication Terminals.

• Formed and fully funded by Allied Minds, a leader in transforming U.S. invention into innovation.

• Working with NASA, The Aerospace Corporation and Draper to leverage the latest in optical comm technology for commercial application.
BridgeSat’s Ground Optical Comm Network

- BridgeSat is building out an expansive Optical Comm Ground Network, controlled through a central Network Operations Center
  - Located in low-cloud areas with good data access, and high latitude locations for sun-synchronous orbits
  - One site in 2016, ten sites in 2017, over thirty sites in 2018
Satellite Optical Communications Terminals

• BridgeSat is working with existing space laser communication terminal suppliers to encourage development of a commercially viable solution

• Our mutually beneficial goal: the widespread adoption of optical communications by the commercial satellite industry

• BridgeSat is engaged with these manufacturers to ensure compatibility to the BridgeSat Ground Network

• Plan to deploy a fully functional ground network by late 2017
  – 2016 - Initial ground terminal checkout tests
  – 2017 - Pathfinder satellite missions demonstrated
Conclusions

• Optical communications will remove the RF data bottleneck and provide a perfect solution for new satellite operators.

• BridgeSat is developing this optical comm infrastructure to speed adoption of this enabling technology for the benefit of the satellite industry.

• Thank you for your kind attention.