The Laser Communications Relay and the Path to the Next Generation Near Earth Relay

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The NASA Space Network or Tracking and Data Relay Satellite System is comprised of a constellation of Tracking and Data Relay Satellites (TDRS) in geosynchronous orbit and associated ground stations and operation centers.

NASA is currently targeting a next generation of relay capability on orbit in the 2025 timeframe.
Current Space Network Architecture
Optical Relay Architecture

SpaceOps 2014: An Optical Communications Pathfinder
User-to-User Relay Services

SpaceOps 2014: An Optical Communications Pathfinder

Network Ops Center
• If an operational relay network were to include an optical space-to-ground link or trunkline, how could the network meet user availability requirements with the impact of clouds and atmosphere?
  – Multiple ground stations and/or crosslinks
  – Hybrid RF and Optical trunklines
  – Routing, prioritizing, and rate-buffering user data streams using DTN protocols
• Dedicated relay spacecraft or hosted payload?
Laser Communications Relay Demonstration
Mission Architecture

**LCRD Payload and Host Spacecraft**

**LCRD Flight Payload**
- 2 Optical Relay Terminals
  - 10.8 cm aperture
  - 0.5 W transmitter
  - DPSK and PPM
- Space Switching Unit

**Mission Concept**
- Orbit: Geosynchronous
  - Longitude TBD between 162ºW to 63ºW
- 2 years mission operations / 5 years goal
- 2 operational GEO Optical Relay Terminals
- 2 operational Optical Earth Terminals
- Optical relay services provided
  - Ability to support a LEO User
  - Potential ISS demonstration
- Hosted Payload
- Launch Date: 2019

**Relay Link Features:**
- Coding/Interleaving at the link edges
  - Rate ½ DVB-S2 codec (LDPC)
  - 1 second of interleaving for atmospheric fading mitigation

**LCRD Ground Station 1**
- 1 m transmit and receive aperture
- 20 W transmitter

**LCRD Ground Station 2**
- 15 cm transmit aperture
- 20 W transmitter
- 40 cm receive aperture

**Table Mountain, CA**

**White Sands, NM**
Integrated Modem (qty 2)
- 0.5 W transmitter; optically pre-amplified receiver
- DPSK and PPM modulation
- 27 kg, 130 W
- Supports Tx and Rx frame processing
  - No on-board coding and interleaving

Optical Module (qty 2)
- Gimbaled telescope (elevation over azimuth)
  - 12° half-angle Field of Regard
- 10.8 cm aperture, 14 kg
- Local inertial sensor stabilization

Controller Electronics (CE) (qty 2)
- OM control/monitoring
- Interface to Host Spacecraft
- 7 kg, 151 W
Anticipated LCRD Products

- Understanding of necessary requirements for future NASA systems
  - Resolution of Future System TBD/TBRs
  - Data for trade studies
  - Optimized operational procedures
- Demonstration of ability to procure, integrate, test, and operate space optical communications hardware
- Demonstration of NASA development of optical communications systems based MIT LL designs
- NASA owned and operated optical communications ground systems and network operations center
- Atmospheric measurements and model development
- Link performance measurements and model development
- Flight hardware performance characterization and flight hours
- Demonstration of optical communications benefits for a variety of mission scenarios
Space Mobile Network 2040

Ground & Space Extensible to 2M Km
Conclusion

• LCRD will address key remaining questions beyond “will optical communications work?” and a wealth of data will be available for the development and deployment of future systems

• Future users and providers of optical communications services will also be able to see an operational system, in order to understand how the services will enable their missions

• The NASA experience in procuring, integrating, testing, and operating the flight terminal will inform the procurement activities of future systems
  – NASA will be more capable to develop the specifications and manage system deliveries
  – The technology, knowledge, and experience will all be shared with Industry and will improve the design proposals

• Hosted payload experience will benefit both NASA and commercial operators

• NASA continues to progress toward a future Near Earth Architecture