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
Mission Architecture

SpaceOps 2014: An Optical Communications Pathfinder
Remaining Challenges for an Optical TDRSS

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

**LCRD Payload and Host Spacecraft**

**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
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

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

Space Switching Unit (qty 1)
- Flexible interconnect between modems to support independent communication links
  - High speed frame switching/routing
- Command and telemetry processor
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
SCaN Optical Communication Technology Development & Infusion Mission Roadmap

2013: Done
- LLCD - LADDEE Demo
- Near Earth Flight Terminal

2017: In Work
- GEO Demo - LCRD
- Second Generation Terminal

2020: Candidate Deep Space Host Demo Mission Discovery 2020
- Other Deep Space Missions

2025: Near Earth Missions
- Next Generation TDNS

- Deep Space Flight Terminal
  - Key Deep Space Technology Identification & Development
  -镊 IN WORK
- Integrated RF/Optical Teletenna
- Flight Demonstration

- Commercialization
  - Done
  - Optical Module

- Optical Ground Infrastructure
  - Done
  - Optical Comm Ground Stations (LLGT, OCTL, TENERIFE)

- Optical Comm Network Build-Out (Added as Mission Needs Require)
- SCaN Operational Optical Ground Stations (Including International Space Agency Sites)

- New 12-M Integrated Telescope
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.