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

[Diagram of space network architecture showing satellites, ground stations, and user equipment connected by arrows indicating data flow.]
Optical Relay 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

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

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
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

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
Space Mobile Network 2040

- Lunar / L1 / L2
- Optical
- RF
- Optical
- Commercial Spacecraft
- Optical
- LEO ARC
- Optical
- RF
- Customer Spacecraft
- Optical
- GEO ARC
- Optical
- ERNEST Node n
- Optical
- Customer Spacecraft
- Optical
- MEO ARC
- Optical
- ERNEST Node 2
- Optical
- Commercial Spacecraft
- Optical

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