National Aeronautics and Space Administration

NASA

LASER COMMUNICATIONS RELAY DEMONSTRATION

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

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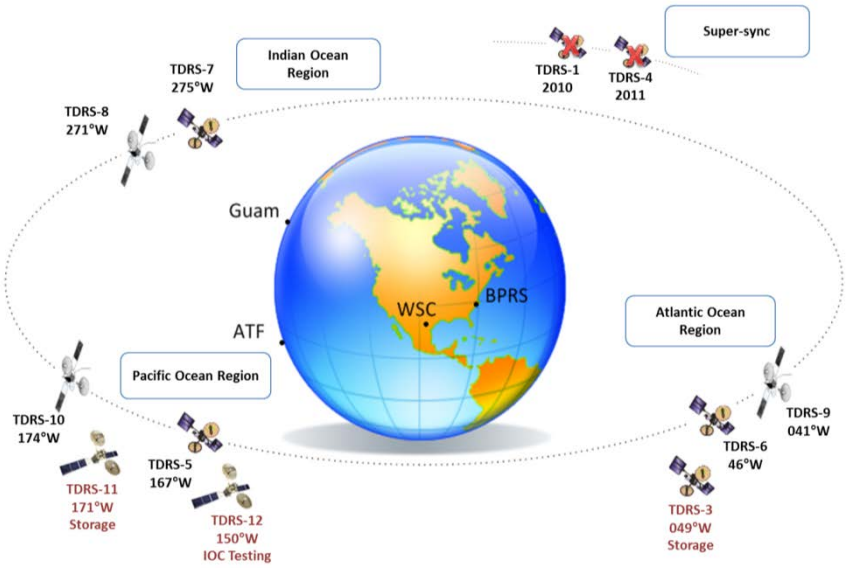
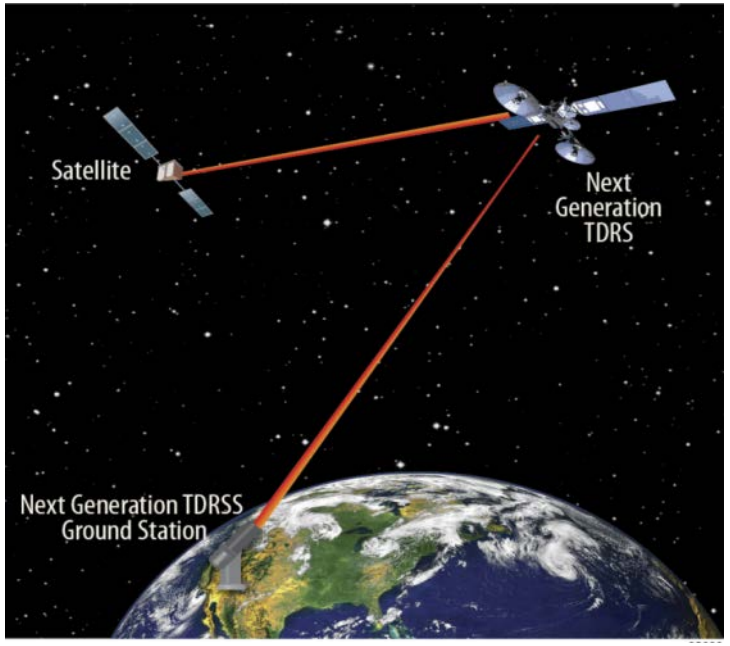
Goddard SPACE FLIGHT CENTER JPL SSL

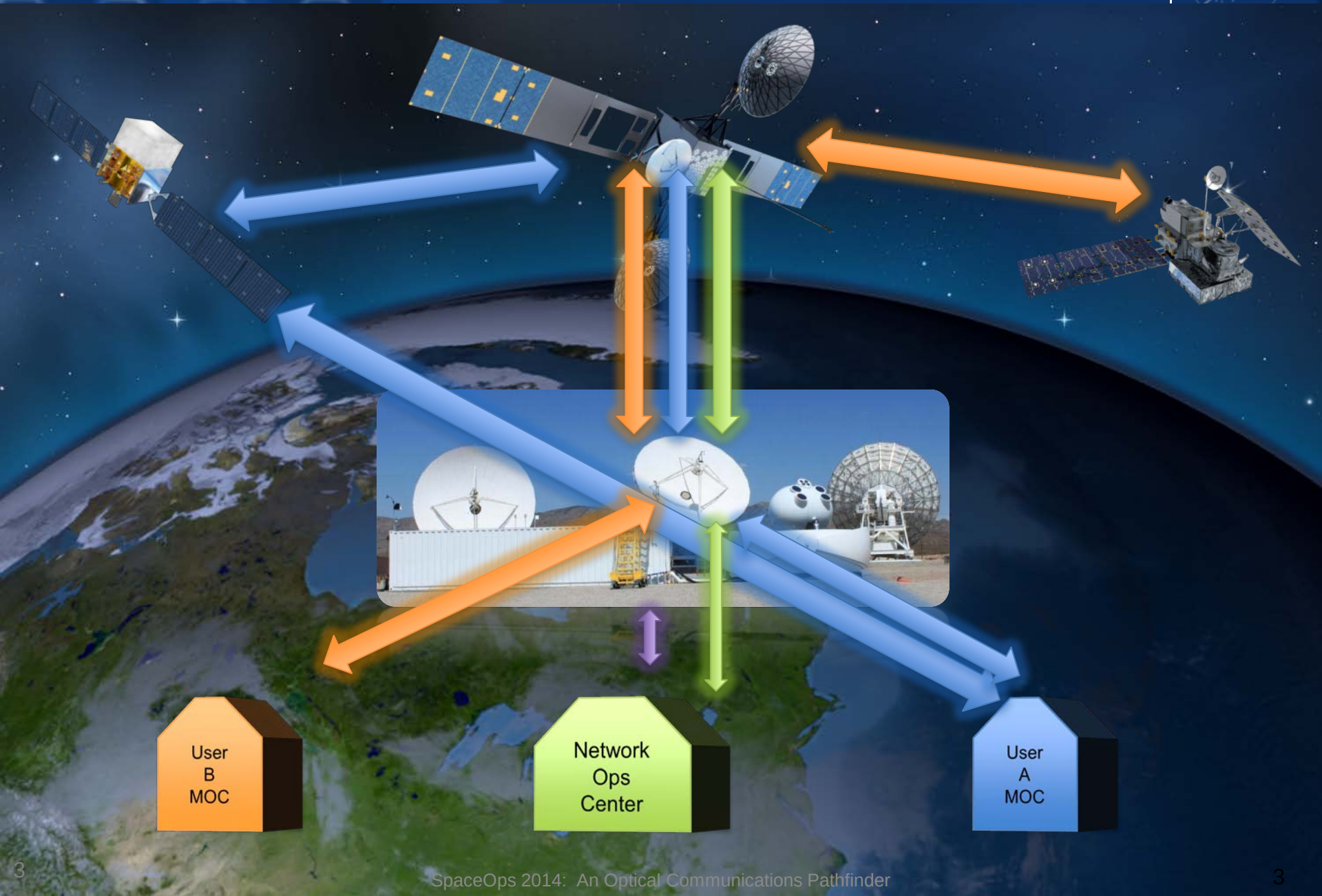
Introduction



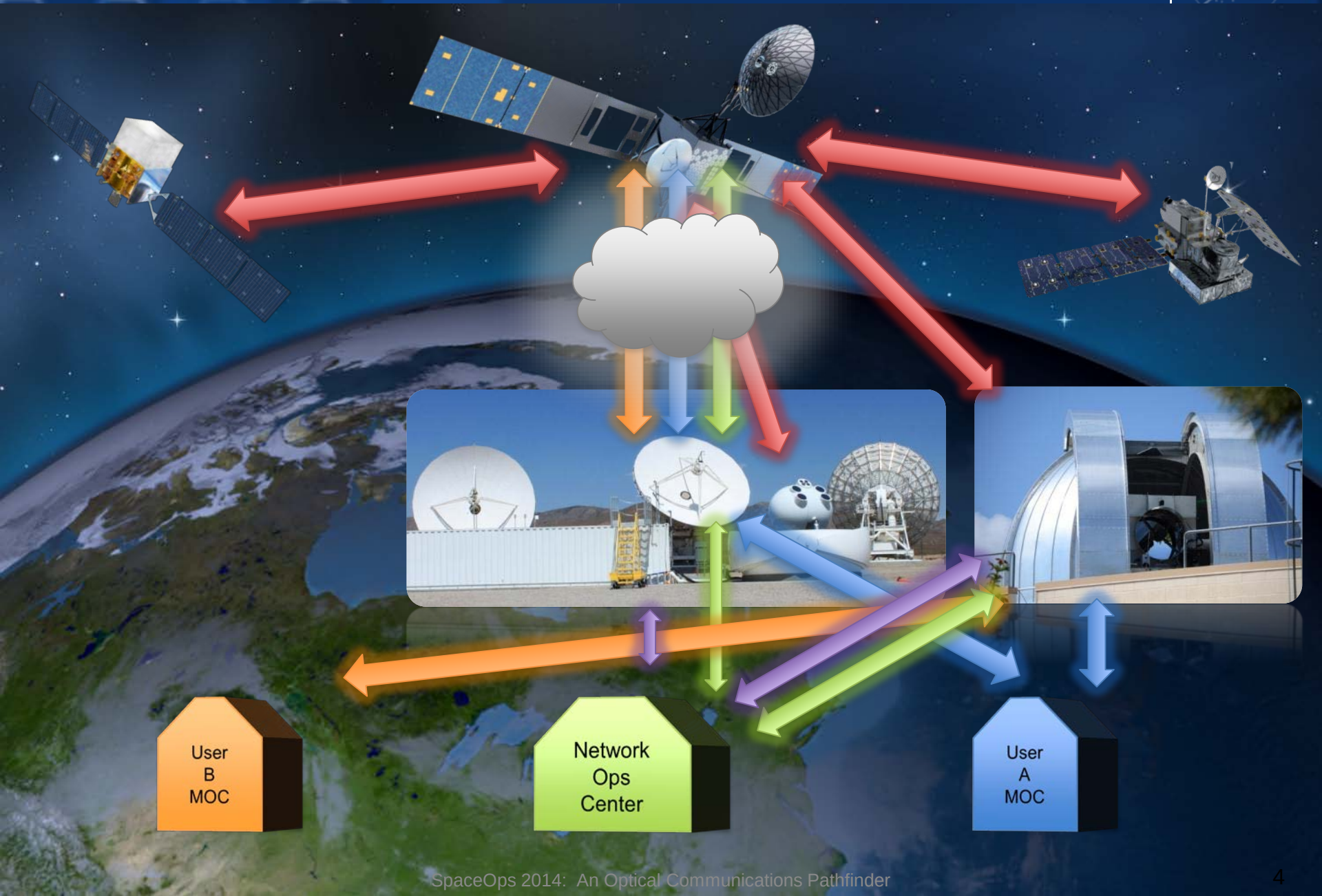


- The NASA Space Network or Tracking and Data Relay Satellite System is comprised of a constellation of Tracking and Data Relay Satellites (TDRS) in geosynchronous orbit and associated ground stations and operation centers.
- NASA is currently targeting a next generation of relay capability on orbit in the 2025 timeframe.

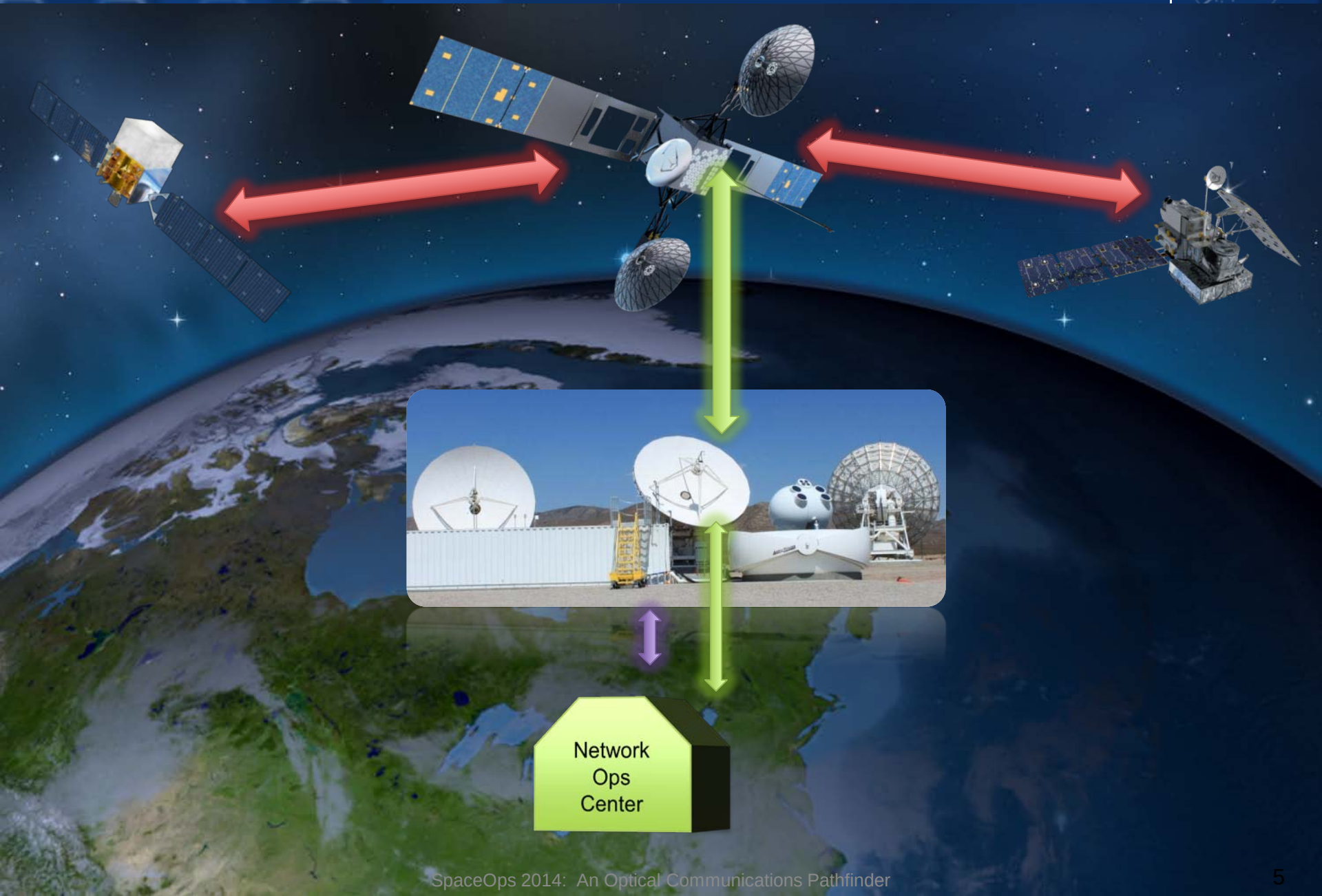
Current Space Network Architecture



Optical Relay Architecture



User-to-User Relay Services



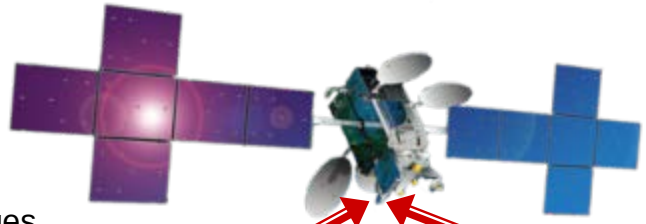
Mission Architecture

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 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

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

1244 Mbps DPSK
311 Mbps 16-PPM

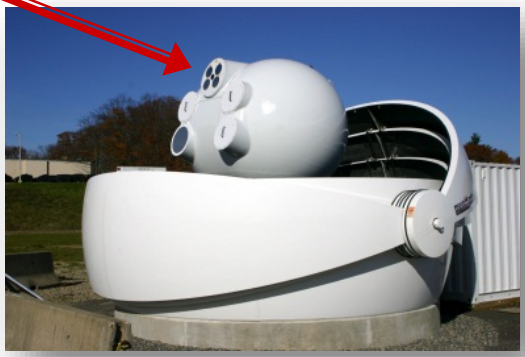
1244 Mbps DPSK
311 Mbps 16-PPM

Table Mountain, CA

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

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



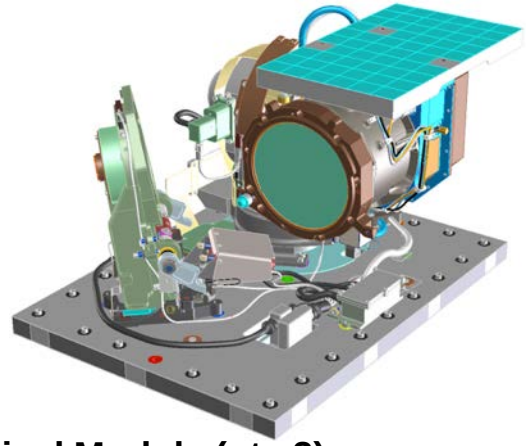
White Sands, NM

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

40 cm receive aperture

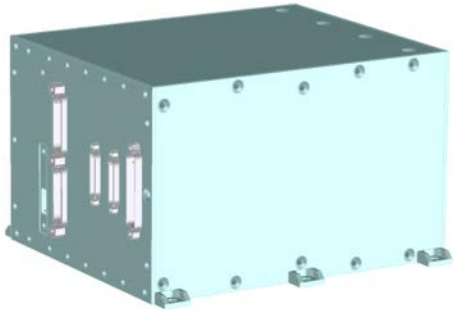
8

LCRD Payload Hardware Overview



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

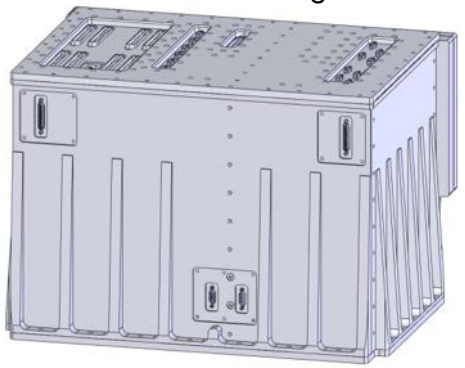


Controller Electronics (CE) (qty 2)

- 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

LCRD | NASA

2013 | 2017 | 2020 | 2025

NEAR EARTH FLIGHT TERMINAL

DONE

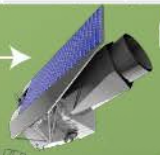
LLCD - LADEE DEMO

SECOND GENERATION TERMINAL

IN WORK

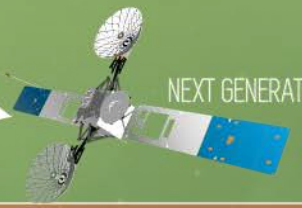
GEO DEMO - LCRD

COMMERCIALIZED



NEAR EARTH MISSIONS

COMMERCIALIZED



NEXT GENERATION TDRS

COMMERCIALIZATION

DONE

OPTICAL MODULE

DPSK MODEM

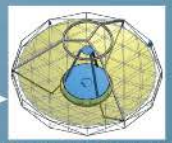
SECOND GENERATION TERMINAL

DEEP SPACE FLIGHT TERMINAL

KEY DEEP SPACE TECHNOLOGY IDENTIFICATION & DEVELOPMENT

IN WORK

CONTINUED TECH DEV



INTEGRATED RF/OPTICAL TELETENNA

FLIGHT DEMONSTRATION

CANDIDATE DEEP SPACE HOST DEMO MISSION DISCOVERY 2020

OTHER DEEP SPACE MISSIONS

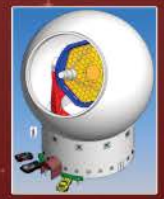
SCaN OPTICAL GROUND INFRASTRUCTIRE

DONE

OPTICAL COMM GROUND STATIONS (LLGT, OCTL, TENERIFE)

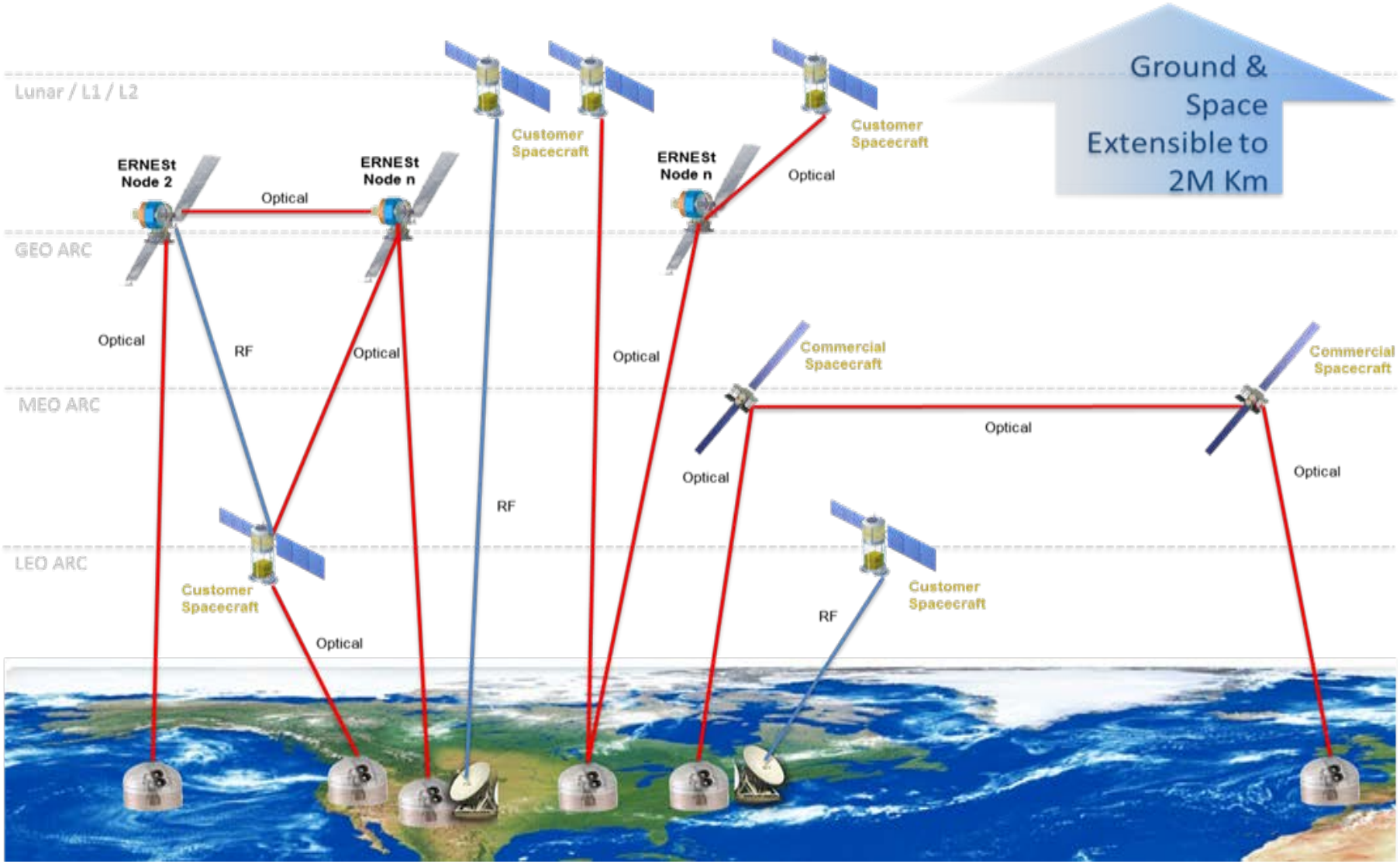
OPTICAL COMM NETWORK BUILD-OUT (ADDED AS MISSION NEEDS REQUIRE)

SCaN OPERATIONAL OPTICAL GROUND STATIONS (INCLUDING INTERNATIONAL SPACE AGENCY SITES)



NEW 12-M INTEGRATED TELESCOPE

Space Mobile Network 2040



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