

National Aeronautics and Space Administration



SCaN Optical Communication Update

May 2023

Optical Communications Path Forward

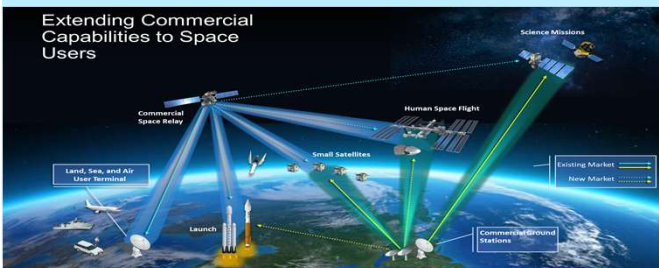
Near Earth

SCaN Foundation / Accomplished:

- T-BIRD demonstration 2022
- LCRD in demonstration operations
- ILLUMA-T ready for ISS demo in 2023
- Commercial SATCOM optical demos awarded
- Low-Cost Optical Terminal (Ground) advancement

Forward Strategy:

- Transfer optical DTE capability to commercial
- Bring commercial space-to-space optical services into operations



Lunar

SCaN Foundation / Accomplished:

- Lunar Laser Comm Demo (LLCD) 2013
- Optical demo on Orion on track for 2024 (O2O)
- Coherent optical modem in progress

Forward Strategy:

- Pursue optical trunk and local optical relay capability
- Leverage O2O terminal into future Orion flights
- Diversify optical Earth ground sites with partners and industry, build on LCOT



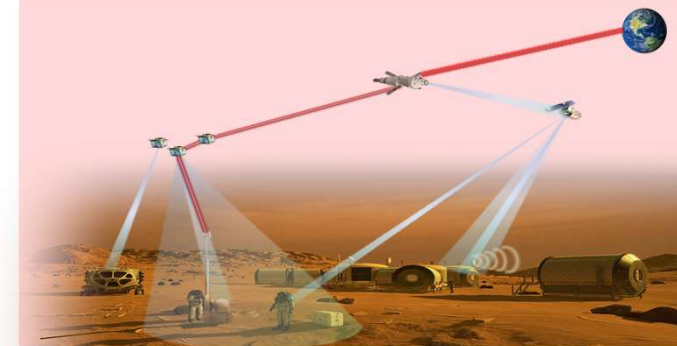
Mars and Deep Space

SCaN Foundation / Accomplished:

- Deep Space Optical Comm (DSOC) terminal ready for flight
- DSN hybrid RF/optical progress – 7 segment mirror installed on DSS-13

Forward Strategy:

- Psyche demo to validate architecture
- Optical infusion essential for human Mars – implement 64 segment (8m) hybrid RF/optical on DSN





Near Earth Optical (1 of 3)

Direct-to-Earth User and Ground Terminals – Investments Paving the Way for Future Ops

COTS-based Small User Terminal is demonstrated on the TeraByte InfraRed Delivery (TBIRD) mission

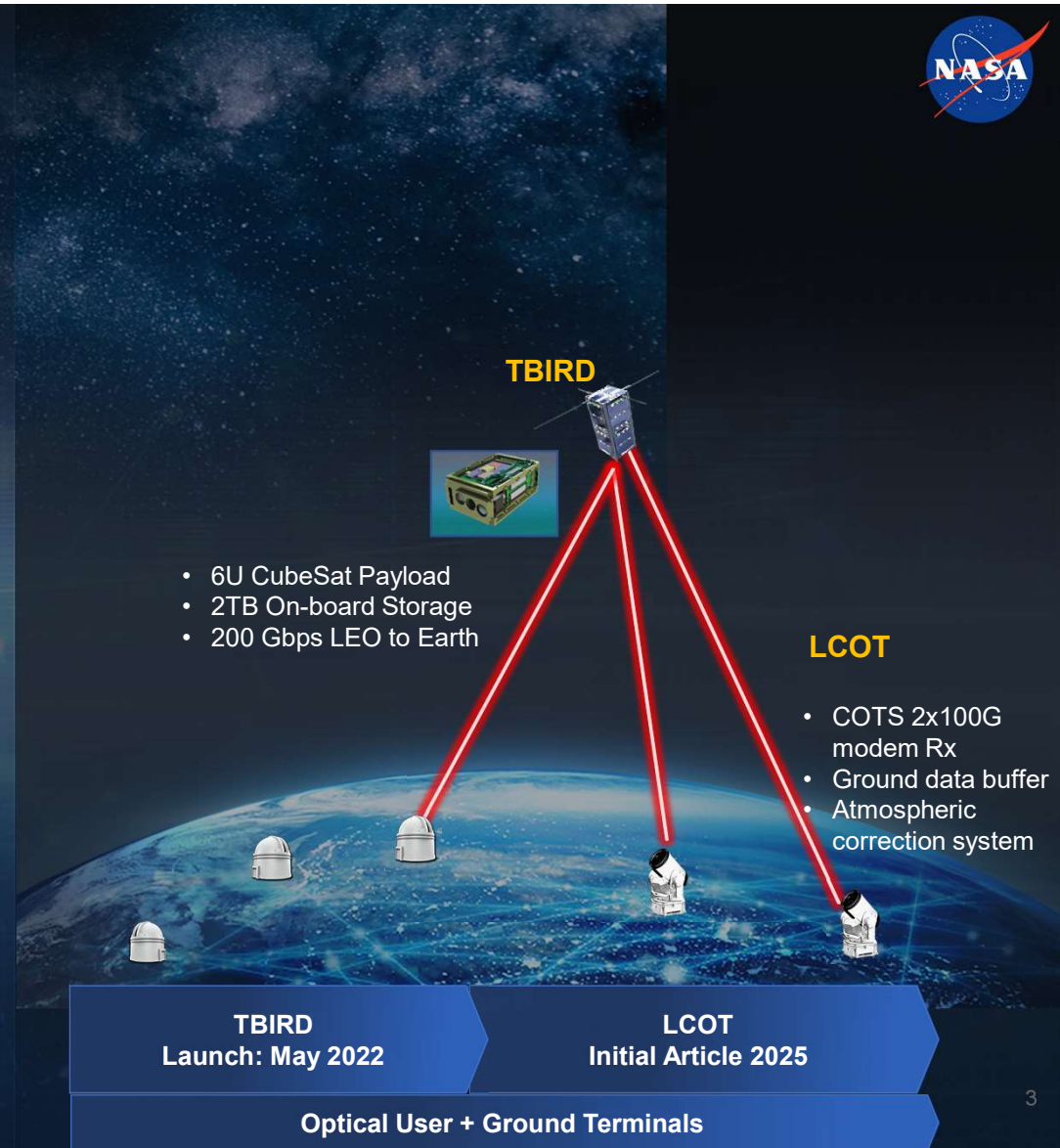
- Launch: May 2022, 6-month primary mission
- Data rate: 200 Gbps
- Collaboration with STMD/SST
- Ready for operational infusion once TBIRD has completed full capability testing

Low-Cost Optical Terminal (LCOT)

- Support range of DTE links (multi-mission capable)
- Addresses challenges of atmospheric effects and weather
- 1 m aperture capable of coherent lunar DTE support
 - International collaboration target
- Capability not yet commercially available
- Enables proliferation to address site availability due to weather

Optical Ground Terminals – Need minimum set of ground locations until commercial service providers ready their optical service offerings

- *Experimental* optical grounds stations in HI, CA and NM



Near Earth Optical (2 of 3)

Relay optical terminal successful ... and still producing!

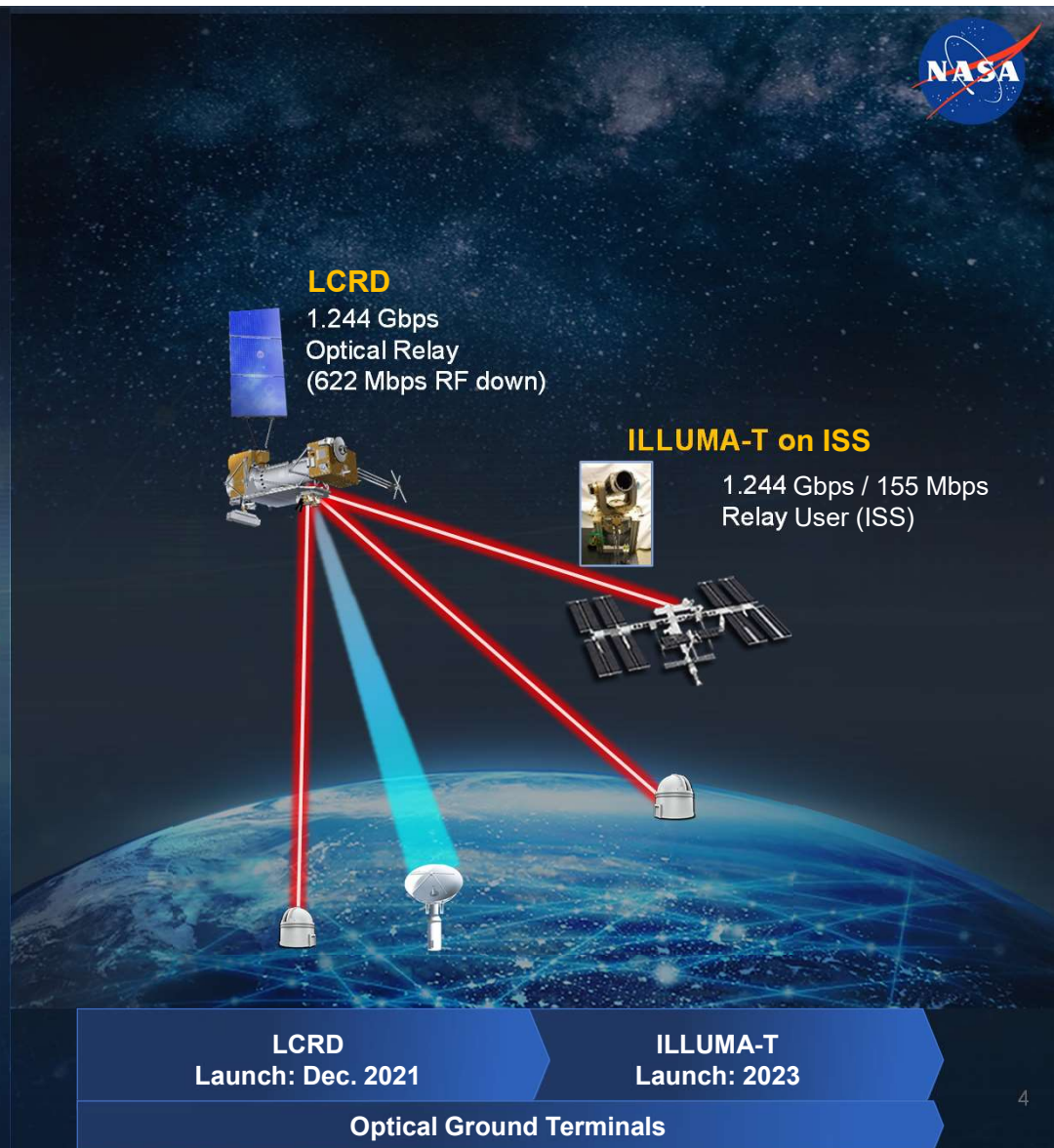
Laser Communications Relay Demonstration (LCRD)

- Launch Date: December 2021
- Purpose: Demonstrate GEO optical relay (Similar to TDRS for RF)
- Hosted payload: US Air Force; STPSat-6 (GEO satellite)
- Data rate: 2.88 Gbps (1.244 Gbps coded user rate)
- Collaboration: STMD/GCD, external partners

LEO User Relay Terminal ready for demonstration

Integrated LCRD LEO User Modem and Amplifier Terminal (ILLUMA-T)

- Launch Date: Early 2023 on SpaceX-27 to ISS
- 6-month primary mission
- Purpose: Demonstrate optical communication via GEO relay with ISS/ILLUMA-T as the LEO user



Near Earth Optical (3 of 3)

Six SATCOM vendors were selected in June 2022 for the first cycle of development and demonstration activities, laying the groundwork to replace TDRS with commercial services; two of the six will demonstrate optical communication

Numerous commercial communications service providers and aerospace companies are developing optical communications with primary focus on intersatellite links

U.S. Government Interest: Space Development Agency: U.S. Air Force, U.S. Space Force, other Government Agencies



- Commercial GEO L-band relay network
- Low-rate SATCOM services
- Support to routine missions, contingency operations, launch, ascent, and early operations



Kuiper Government Solutions

amazon | project kuiper

- Optical LEO network
- High and low-rate services
- Supporting routine, contingency, and early operations



SES
GOVERNMENT SOLUTIONS

- GEO and MEO network with C-band and Ka-band
- High and low-rate services
- Supporting routine, contingency, launch and ascent, and early operations



SPACEX

- Optical LEO network
- High-rate services
- Routine, contingency, launch and ascent, and early operations support



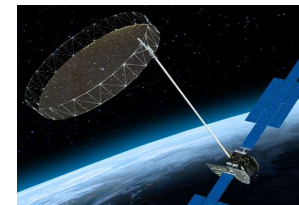
TELESAT
U.S. SERVICES

- RF relay networks offering C- and Ka-band services for high and low-rate communications
- Support to routine missions

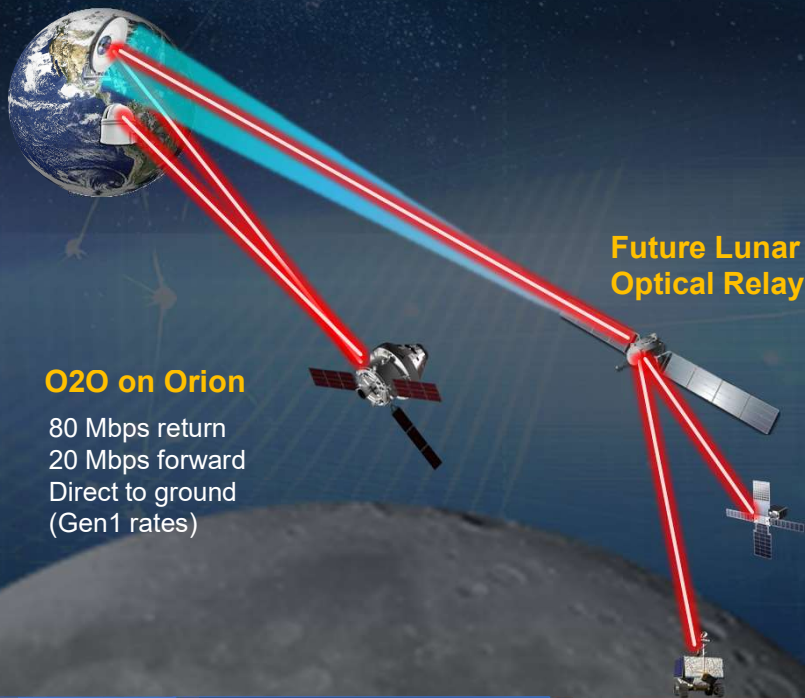


Viasat

- GEO Ka-band relay network
- High- and low-rate communications services
- Routine launch and mission support



Lunar Optical



O2O on Orion

80 Mbps return
20 Mbps forward
Direct to ground
(Gen1 rates)

Future Lunar Optical Relay

LLCD
2013

O2O
2024

Coherent Modulation for
lunar trunk links
2024 - 2025

Expand Network
Optical Ground
Terminals

Optical Ground Terminals

Lunar Optical Capabilities ready for infusion with investment and user commitment

Lunar Laser Communications Demonstration (LLCD)

- Launch Date: Sep 2013
- Demonstrated fundamental concepts of laser communications from Moon for Direct-to-Earth links at 622 Mbps

Lunar user optical terminal demonstration on Orion Artemis II Optical (O2O)

- Launch Date: 2024 (Artemis II)
- Demonstrate crewed DTE optical link capability from Moon
- Enables return of all onboard data before vehicle Earth return

Higher data rates for lunar trunk links

- Current deep space optical links support data rates < 1 Gbps
- Coherent optical links enable 5–10 Gbps from Moon
- Could be available for lunar demo in late 2020s

Lunar Optical Ground Terminals for Artemis

- Existing *experimental* optical ground terminal in HI, CA, and NM
- Working with Australia and South Africa to place additional 3-4 optical ground terminals around the globe to support Artemis, where southern hemisphere coverage is essential

Deep Space Optical

Deep Space Optical Capability is ready to be demonstrated; deep space mission adoption to follow

Deep Space Optical Communications (DSOC) on Discovery Psyche Mission

- Launch Date: Delayed pending SMD Oct 2022 review due to Psyche flight software V&V issues
- Purpose: Demonstrate deep space optical links on outbound trajectory to 2.6 AU (Mars-far-like distance)
- Collaboration with STMD/GCD and SMD

RF/Optical Hybrid Antenna

- Lowest cost option for large, 8m, ground terminals
- Two can be arrayed for 11.3m aperture
- Maximally leverages existing DSN infrastructure

Optical will be essential for future human missions to Mars

- RF insufficient even for first missions to collect planning data/imagery
- Up/down-link rates needed for crewed operations





LCRD Mission Architecture with SCaN-Provided Ground System Directly Integrated into NASA's Space Network

Two Terminals at 1550 nm
1.244 Gbps User Rate
Full Duplex (Bi-Directional)

LCRD Flight Payload
On USAF/STPSat-6

- 1M transmit and receive aperture
- 20W transmitter



Table Mountain, CA

Optical Ground Station 1
(OGS-1)

622 Mbps
Ka-band RF
Downlink
to WSC



Haleakala, Hawaii

Optical Ground Station 2
(OGS-2)

- 15-cm transmit aperture
 - 20 W transmitter
- 60-cm receive telescope with adaptive optics to couple received light to single-mode fiber

White Sands,
NM

STPSat-6 Mission
Ops Center

Remote LCRD Mission
Ops Center (R-LMOC)

NASA Goddard Space Flight Center

LCRD Mission
Ops Center (LMOC)

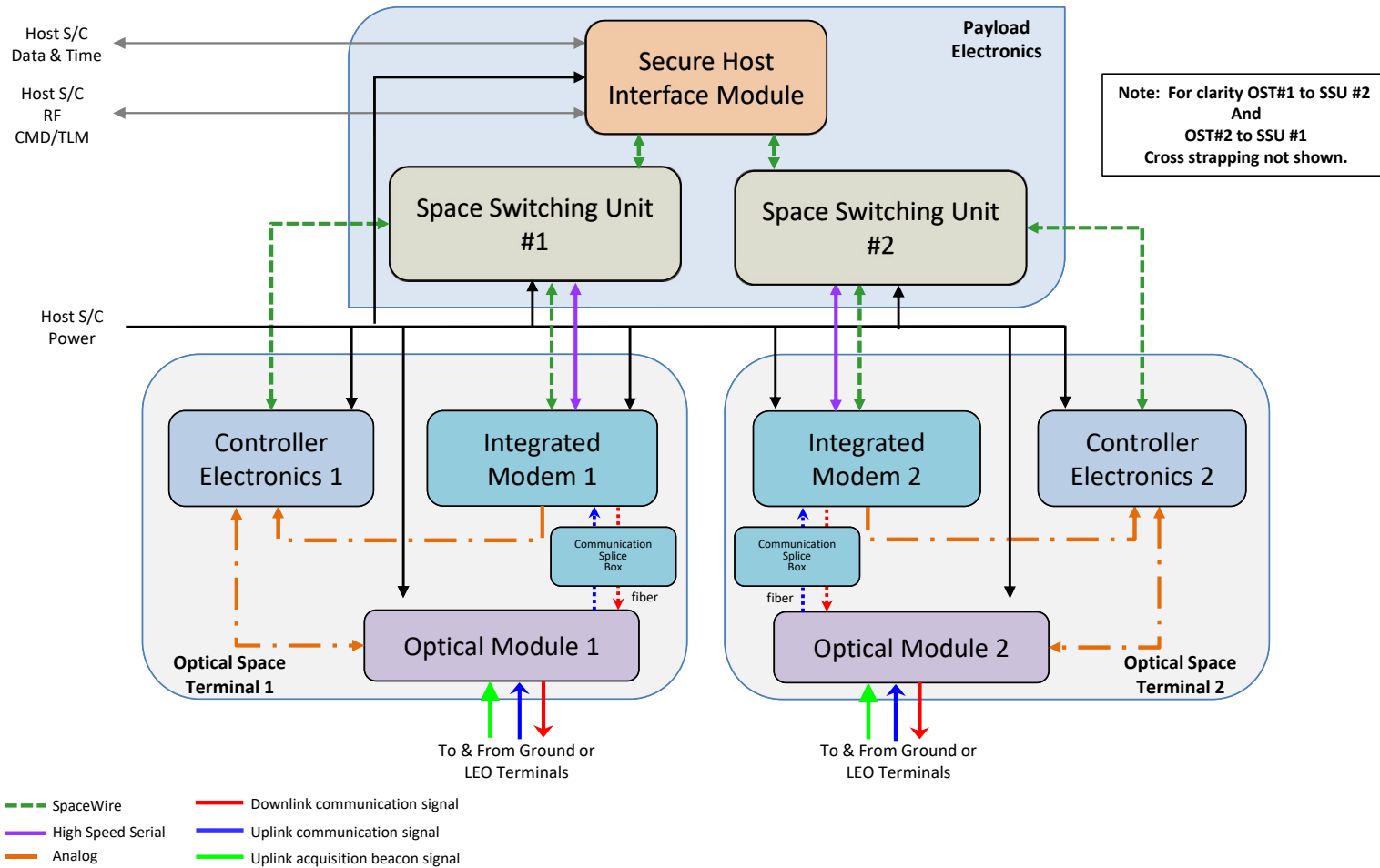
White Sands, NM

Legend:

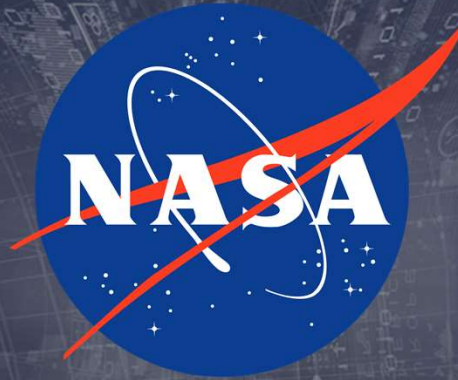
- LCRD Developed
- OGS-X Developed
- Joint LCRD/OGS-X Developed
- Space Network Developed



LCRD Flight Payload Functional Diagram



Approved for Public Release



Thank You for Your Attention

Contact

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