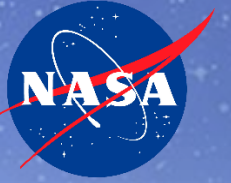


National Aeronautics and Space Administration



2023 NASA Optical Communications Update

Dr. Ben Ashman

Space Communications and Navigation Program

NASA Space Operations Mission Directorate

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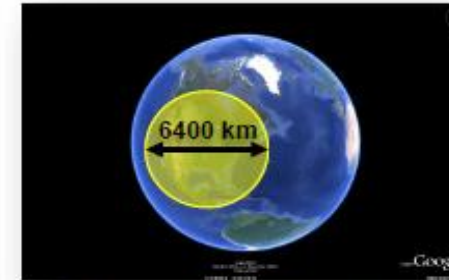
August 2023

Benefits of Optical Communications

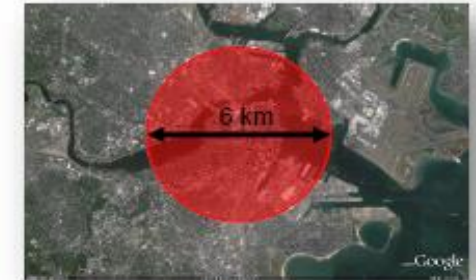
- Extremely narrow beams with small apertures
- Small, low power terminals
- Unlimited, unregulated spectrum
- High data rates
 - Provides high speed real-time data (e.g. for video)
 - Enables shorter contact times
 - Delivers large data volume over the duration of mission

Historic Challenges:
beam pointing, efficient transmitters and receivers, high bandwidth processing, atmospheric effects

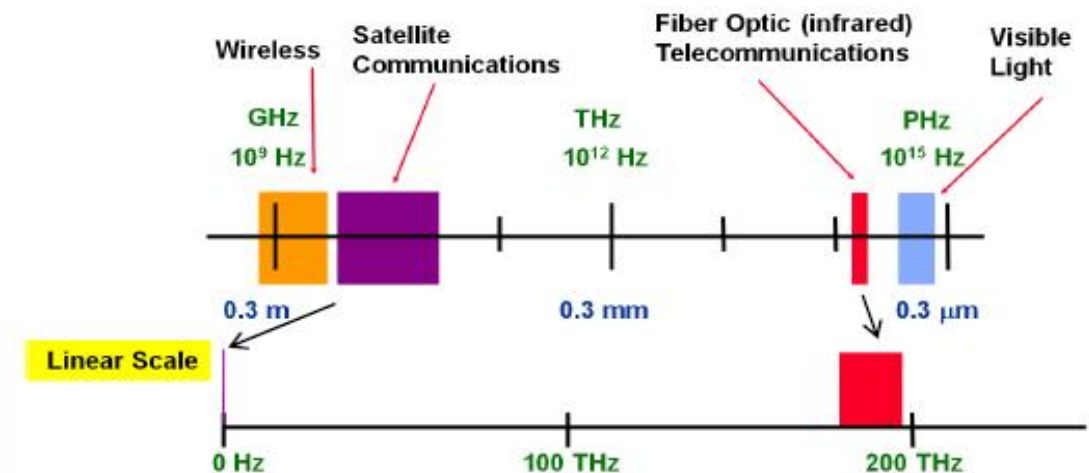
Beam Size From Moon



RF Ka Band (26 GHz)
75-cm Antenna → 6400 km Spot



Optical C-Band (1550 nm)
10-cm Antenna → 6 km Spot



NASA to build upon the success of the 2013 Lunar Laser Communications Demonstration (LLCD) and previous efforts



Lunar Laser Communications Demonstration (LLCD)

- Launched Sep 6, 2013
- Flown on Moon on the Lunar Atmosphere and Dust Environment Explorer (LADEE)
 - Goal: demonstrate fundamental concepts of laser communications beyond GEO
- Led by NASA GSFC, space terminal and primary ground terminal (Lunar Laser Communication System) built by MIT/LL
- LLCD resulted in record-breaking achievement using broadband lasers for space communications
- Used pulsed laser beam to exchange data and high-definition video between lunar-orbiting terminal and ground station at White Sands, New Mexico



LLCD system:

- ✓ 50% less mass
- ✓ 25% less power
- ✓ 6x data-rate than comparable (LRO) RF system

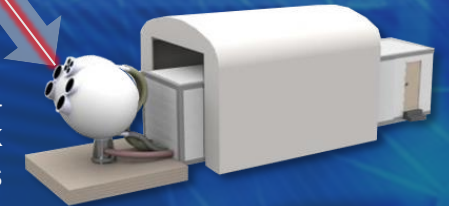
● IMMEDIATE LASER CONTACT on October 17, 2013

● LLCD returned data by laser to Earth at a record 622 Megabits per second (Mbps)

● = Streaming 30+ HDTV Channels Simultaneously

● Ended Nov 22, 2013

Data received via four 40 cm downlink telescopes (0.50 m² surface area)



2014 Popular Mechanics Breakthrough Award for Leadership and Innovation for LADEE



2014 R&D 100 Winning Technology in Communications category



Nominated for the National Aeronautic Association's Robert J. Collier Trophy



Winner of the National Space Club's Nelson P. Jackson Award for 2015

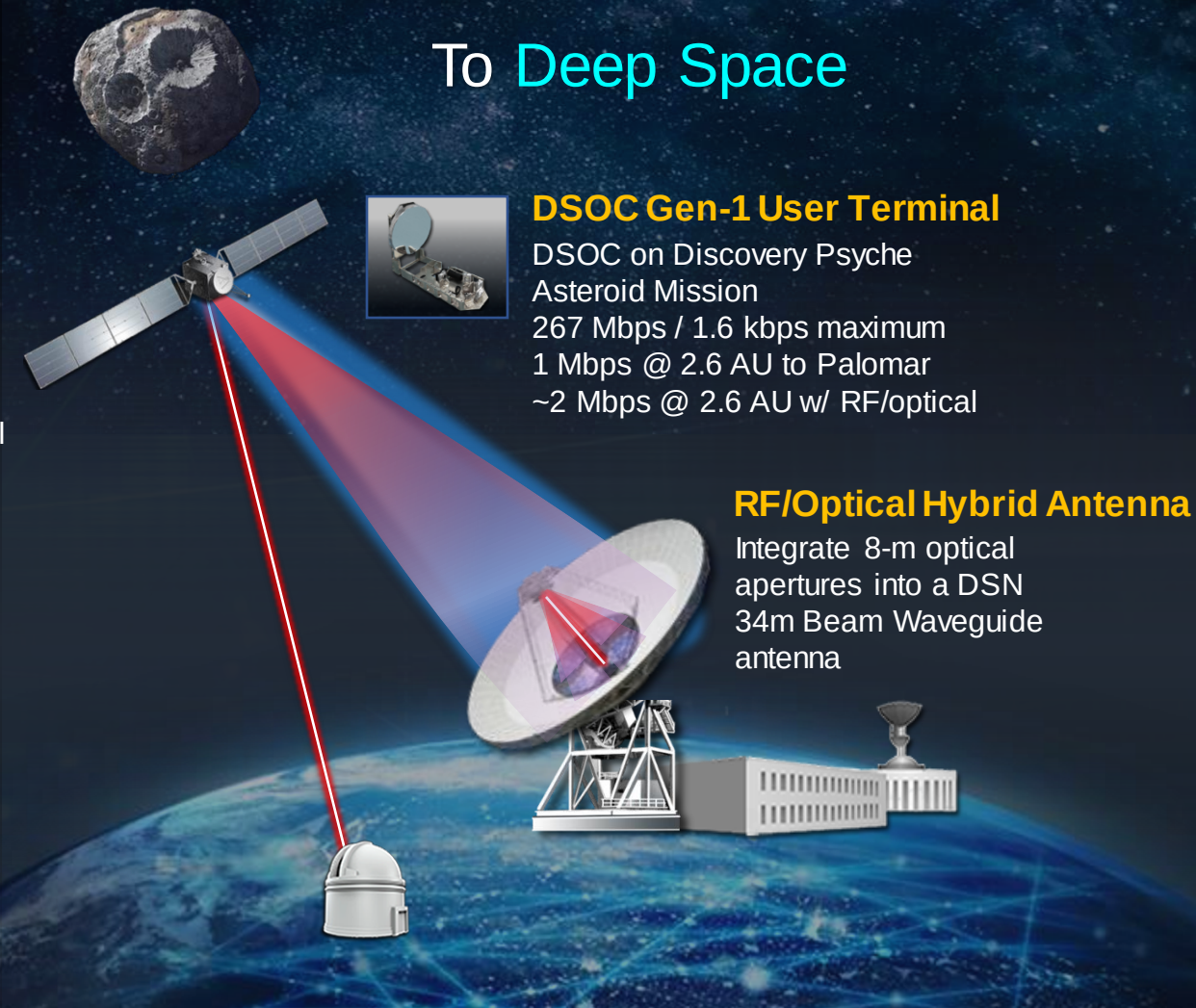
Revolutionary capability for space users

Optical Communications Technology Demonstrations

From Near Earth/Moon



To Deep Space



LCRD
2021

TBIRD
2022

ILLUMA-T
2023

O2O
2024 (Artemis II)

Lunar Relay
TBD

Psyche/DSOC Optical User
Terminal
(2023)

Advanced DSOC Optical User
Terminal (2026+)



2021 Laser Communications Relay Demonstration (LCRD)

Launched December 2021

Mission duration:

- Two-year ops demo

**Hosted payload: US Air Force
Space Test Program Satellite – 6 (STPSat-6)**

Ground stations:

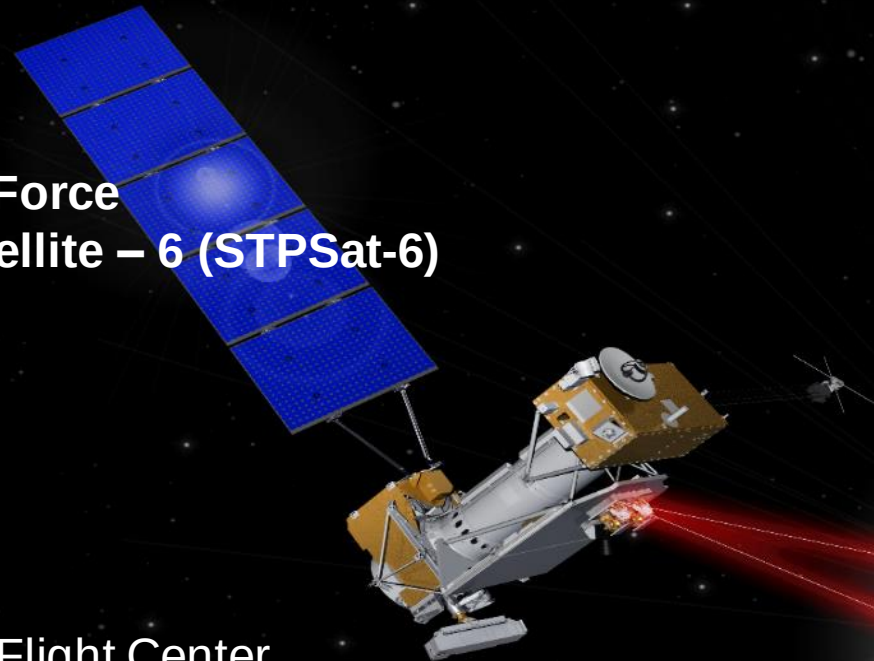
- California
- Hawaii

Partnership:

- NASA Goddard Space Flight Center
- NASA Jet Propulsion Laboratory
- MIT Lincoln Laboratory
- STMD/Technology Demonstration Missions
- Space Communications and Navigation

Flight payload:

- Two 10.8 cm Optical Modules and Controller Electronics Modules
- Two software-defined DPSK Modems with 2.88 Gbps data rate (1.244 Gbps coded user rate) that can also support PPM
- 622 Mbps Ka-band RF downlink
- New High Speed Switching Unit to interconnect the three terminals



Guest investigators welcome!

URL: <https://esc.gsfc.nasa.gov/projects/LCRD>

Email: lcrd-experiments@nasa.onmicrosoft.com



Laser Communications for Human Space Exploration

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

1.2 Gbps return
155* Mbps forward
To ground via LCRD relay

Completed system level vibe
and TVAC – July 2023

November 1, 2023 Launch
on SpaceX-29

~6 Month Mission



O2O (Orion AM-2 Optical Comm)

80 Mbps return
20 Mbps forward
(Gen1 rates)

Direct to ground (WSC, TMF)

8-21 day mission on first crewed
Artemis Mission (AM-2)

Handover and mechanical integration to Orion
completed July 2023

2024 Launch on Orion/SLS



Optical Communications Path Forward

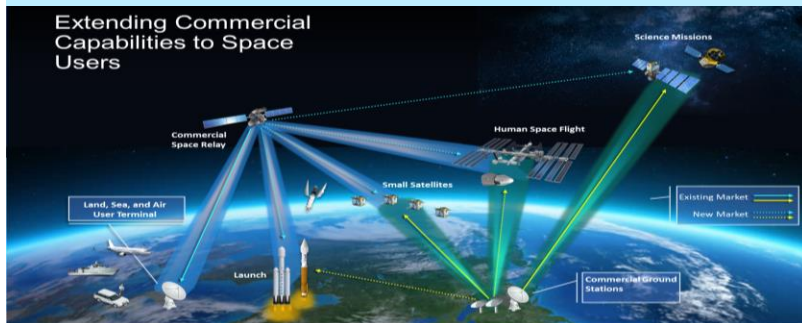
Near Earth

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



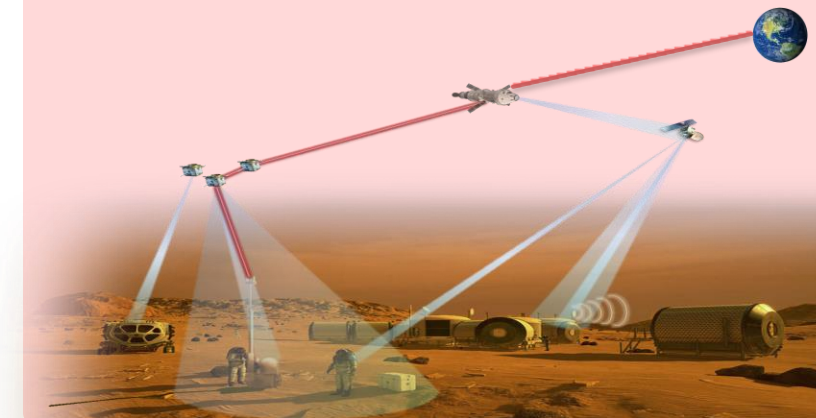
Mars and Deep Space

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





Potential Laser Communications for Future Artemis Missions

