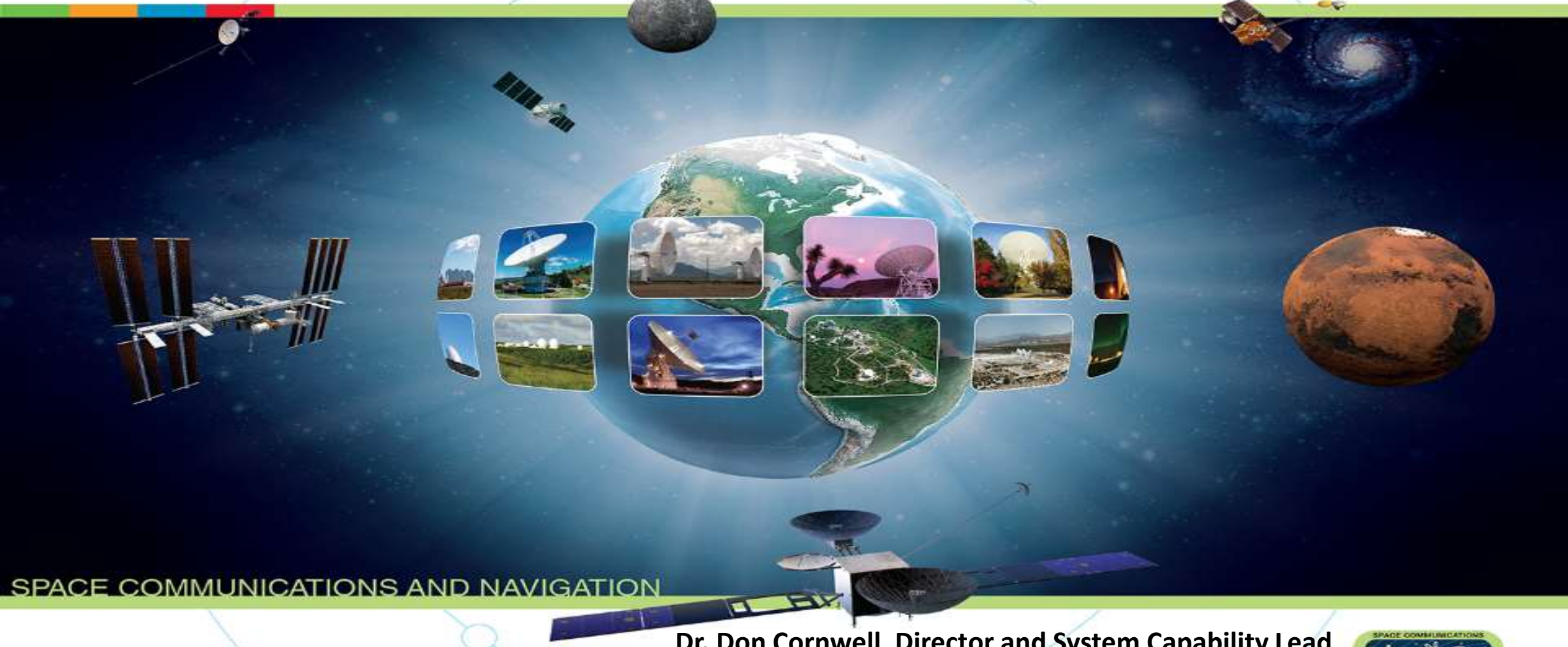
Laser Communications and Astrophysics in 2030: A NASA Perspective



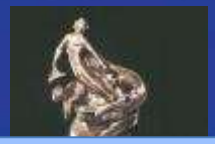
Dr. Don Cornwell, Director and System Capability Lead
Advanced Communications and Navigation Division
SCaN Program, NASA HQ

2013: NASA's First, Historic Lasercom Mission

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

LLCD returned data by laser to Earth at a record 622 Megabits per second (Mbps)
= streaming 30+ HDTV channels simultaneously!

Laser Communications Relay Demonstration (LCRD) for 2020

Scheduled launch: August 2020

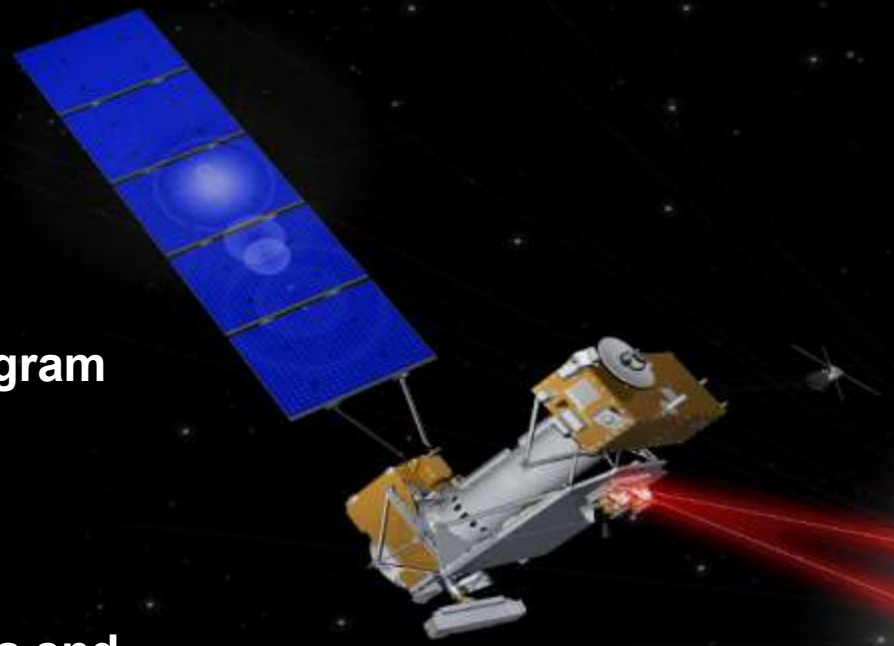
Mission duration:
Two year ops demo
Six years ops

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

Partnership:
STMD/Technology Demonstration Missions and SCaN

Ground stations: California and Hawaii

Guest investigators welcome!

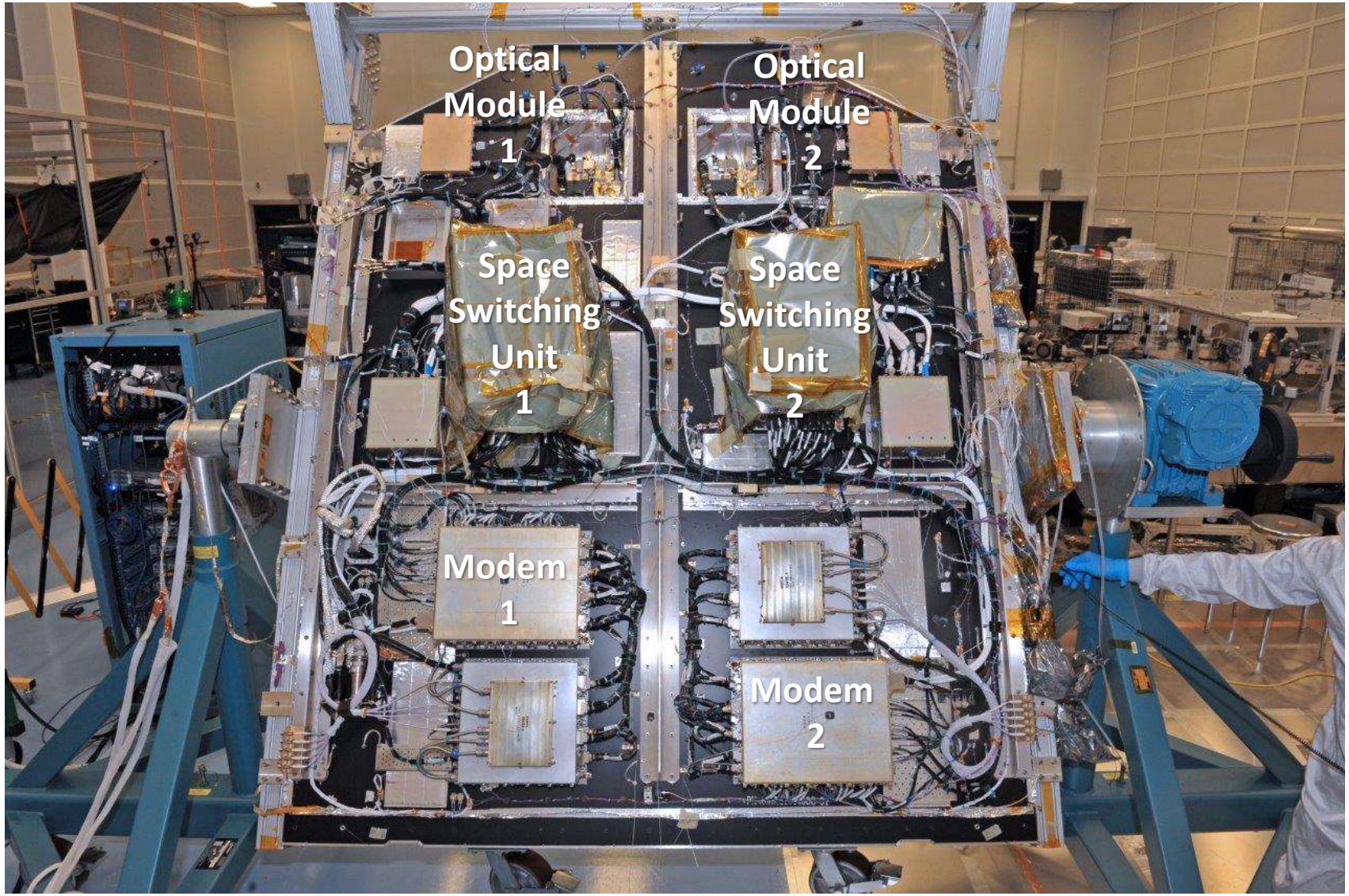


Flight payload:

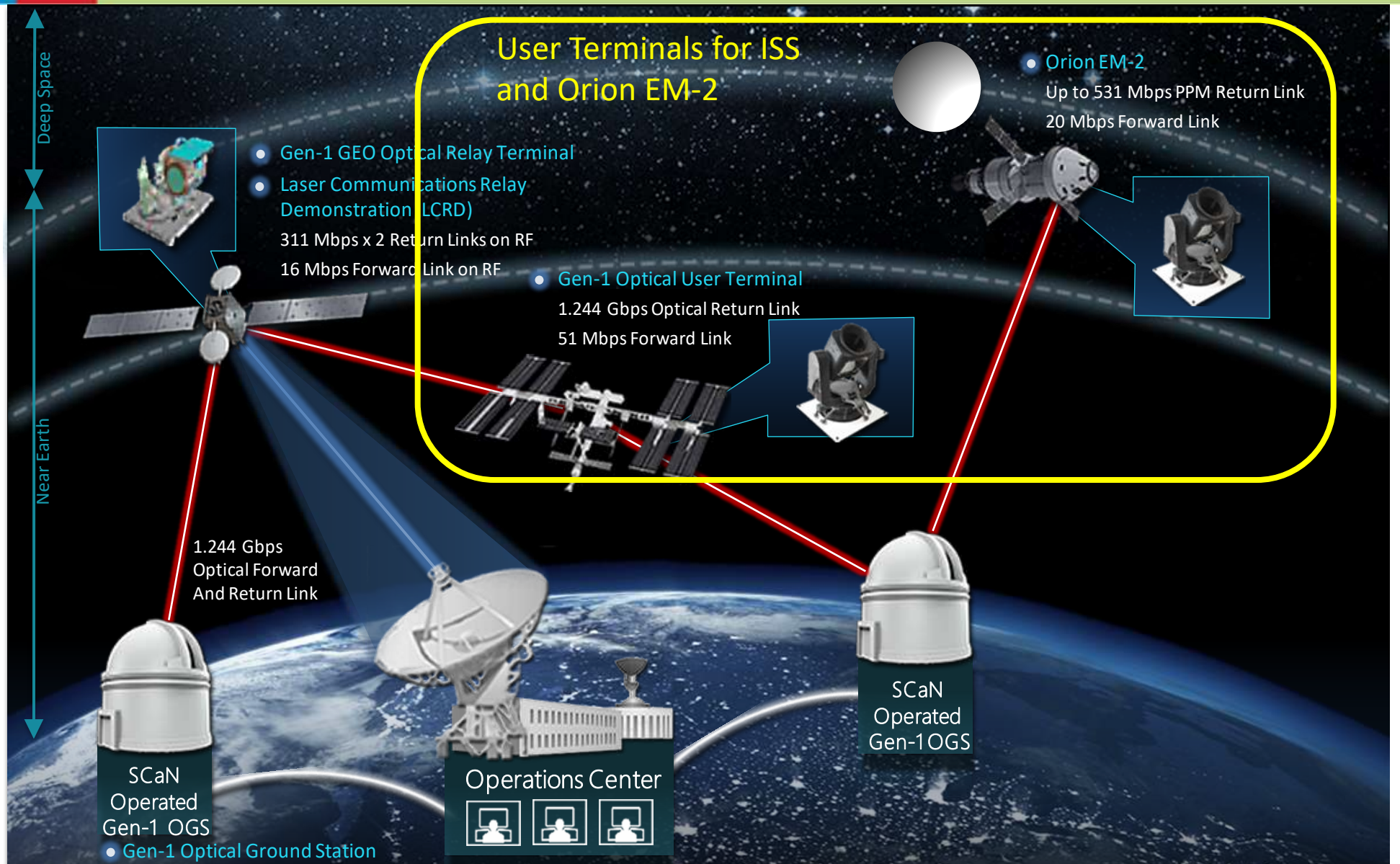
- Two LLCD-heritage Optical Modules and Controller Electronics Modules
- Two software-defined DPSK Modems with 2.88 Gbps data rate (1.244 Gbps user rate)
- 622 Mbps Ka-band RF downlink
- New High Speed Switching Unit to interconnect the three terminals

Key for NASA's Next-Gen Earth Relay in 2025 timeframe

Integrated Laser Communication Relay Demonstration Payload at NASA Goddard Space Flight Center



NASA's Optical Plan Forward: User Terminals for LEO and the Moon



LEMNOS Project: Lasercomm for ISS and Lunar Missions

(Laser Enhanced Mission Communications Navigation and Operational Services)

ILLUMA-T on the ISS (2021)

ISS (LEO) User Terminal on JEM-EF for Operations with NASA Laser Communication Relay Demonstration (LCRD) in GEO

NASA Goddard | NASA Johnson Space Center | JAXA 宇宙航空研究開発機構 Japan Aerospace Exploration Agency

O2O on Orion EM-2 (2022)

High-rate optical communication link Supporting Orion EM-2 crew exploration vehicle

NASA Goddard | LOCKHEED MARTIN | NASA Johnson Space Center | NASA Marshall Space Flight Center

PFU Subassemblies

Optical Module (OM):

- Latch & Gimbal Assembly (LGA)
- Telescope & Relay Assembly (TRA)
- Backend Optical Assembly (BOA)

Control Electronics (CE)

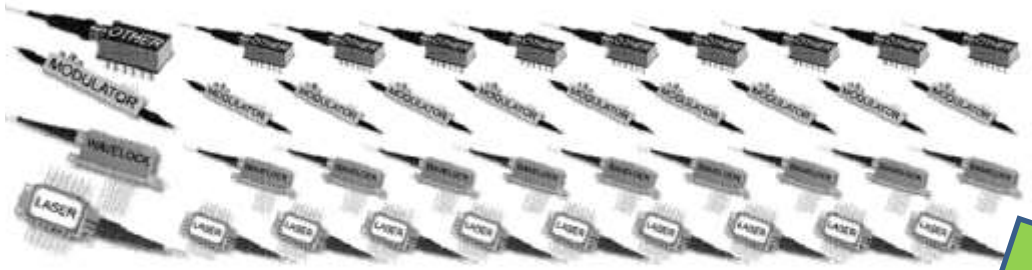
ILLUMA Modem (IM)

Modem Module (MM)

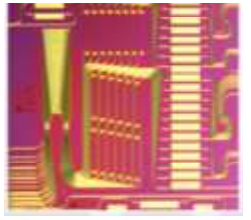
Power Converter Unit (PCU)

The Key to Reducing SWaP and Cost: Photonic Integrated Circuits

US Industry has commercialized "Integrated photonics" to allow many electro-optical components, even glass fibers, to be "squeezed down"…..

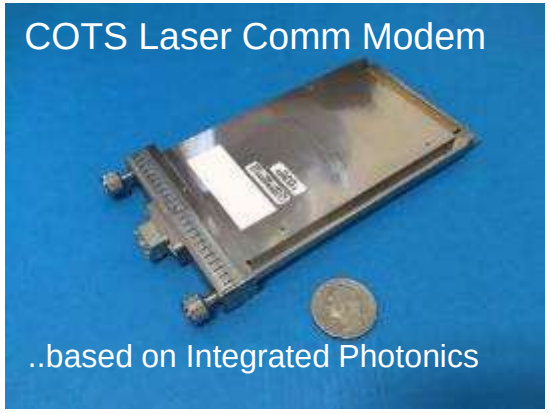


…into the optical equivalent of a micro-electronics "integrated circuit"

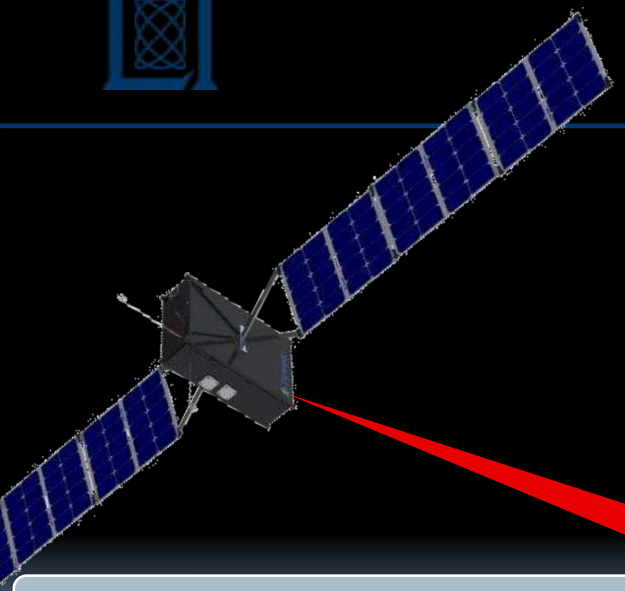


1 cm

For NASA, this means that optical systems for communications and sensors can be reduced in size, mass, and cost by >> 100x by leveraging this commercially-available technology (some customization may be required)



TeraByte InfraRed Delivery (TBIRD)
200 Gbps Cubesat Demo in Early 2020



100+ Gbps optical link enables delivery of many TeraBytes/day from low-Earth orbit

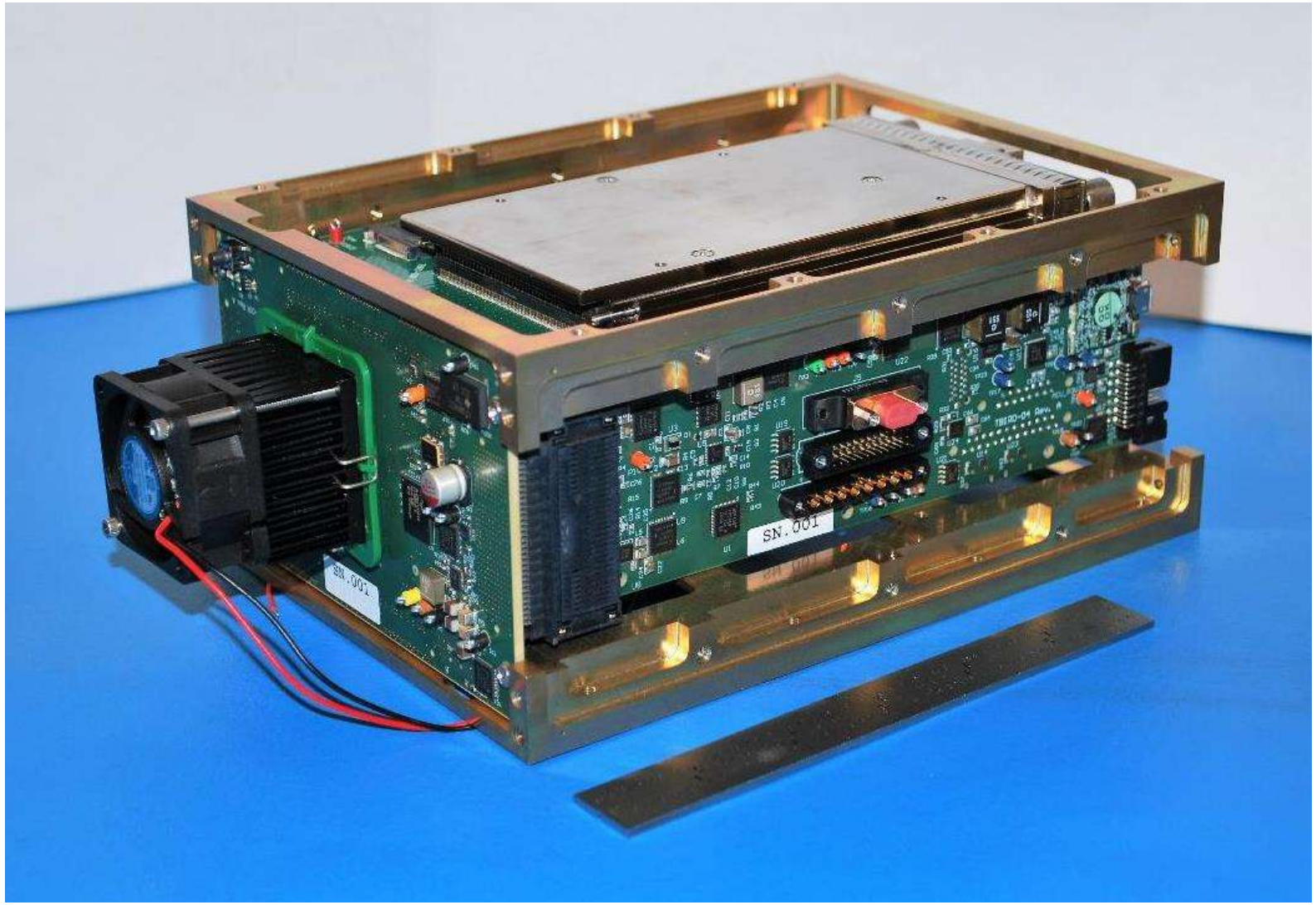
Space terminal based on telecom optical components, small enough for CubeSat

~Foot-class ground terminal aperture is low cost and widely deployable

MIT
Lincoln Laboratory

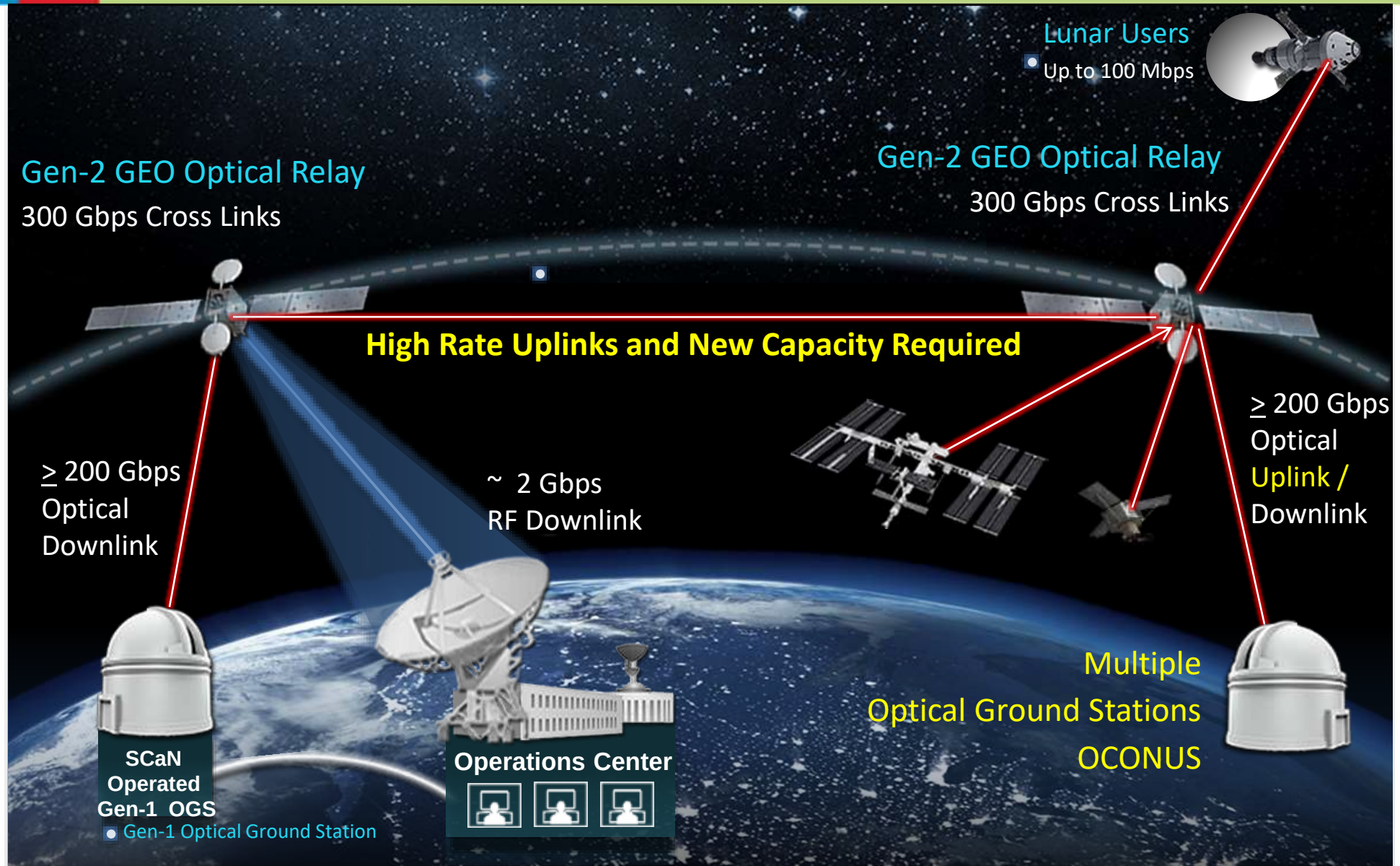
TBIRD Proto-Flight HW at MIT Lincoln Laboratory based on Integrated Photonics and Coherent DSP ASIC

TBIRD
Mass: 2.24 kg
Power: 120W
(5 minute ops)
Volume: 1.8 U

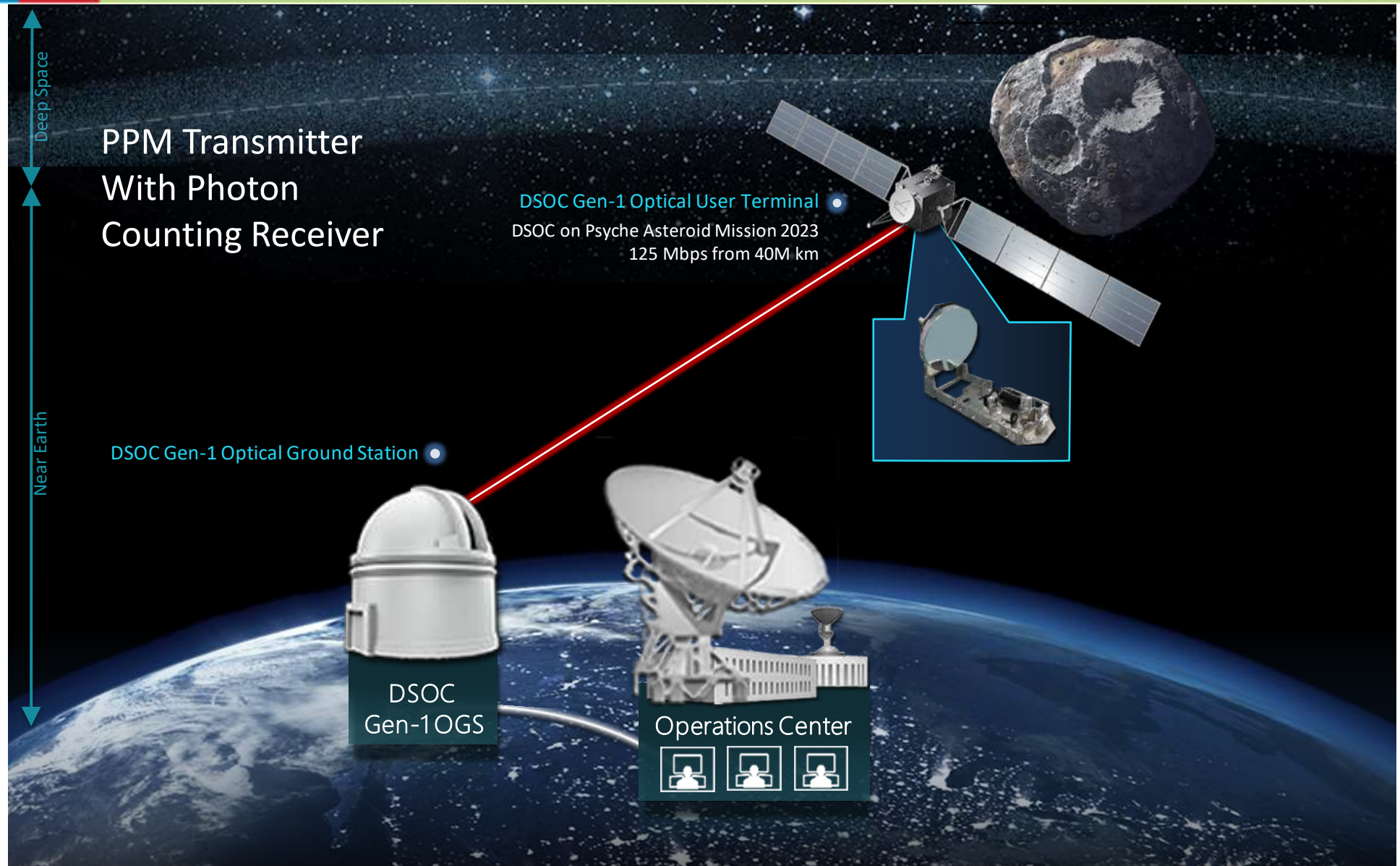


MIT
Lincoln Laboratory

NASA's Next Generation Space Relay Concept
10G Users and 300G Crosslinks GEO-GEO



NASA's Optical Plan Forward: Deep Space Optical Communications (DSOC in 2022)



Laser Communications for Lunar Orbital Platform-Gateway

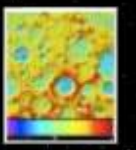
Optical Data Trunk to/from Earth

20+ Mbps Forward
1000+ Mbps Return

Gateway-Enabled Lunar Network

High-rate, low-latency data
Positioning, navigation and timing

CubeSat
4 – 500 Mbps



e.g. high-res multi-spectral imaging

e.g. low-latency tele-robotics; In-situ analysis

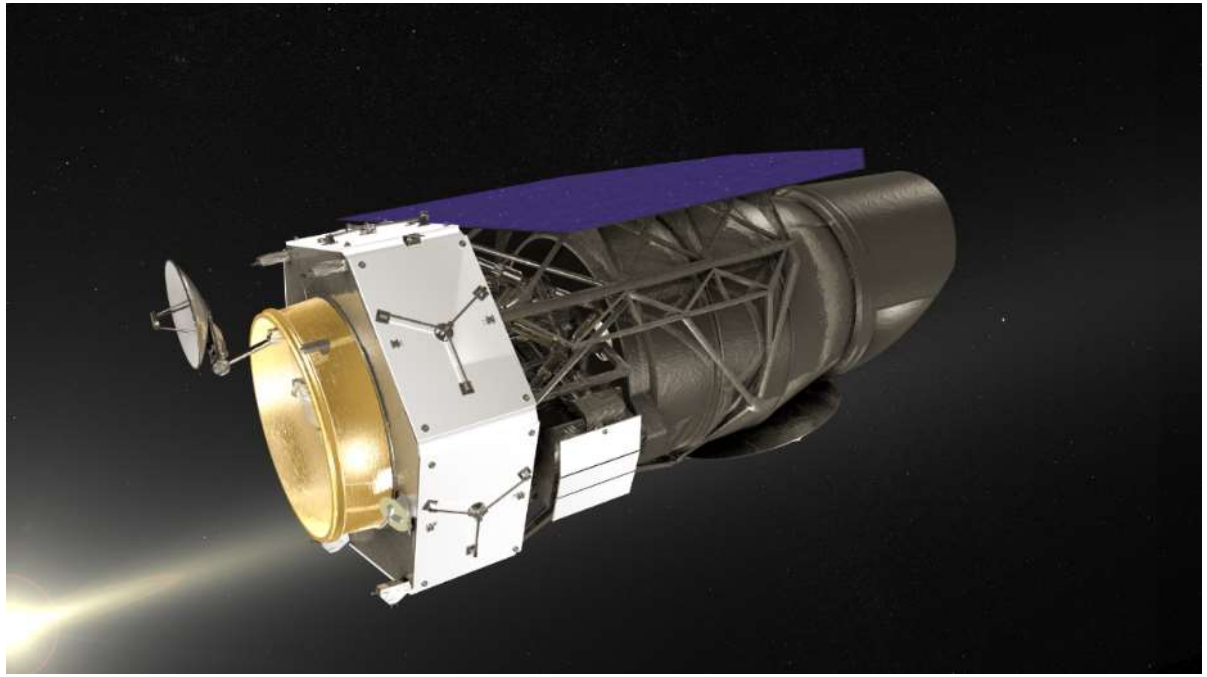
Lunar Surface
100 Mbps – 2.1 Gbps

Orion MPCV
233 Mbps – 2.1 Gbps

Laser communications enables data returns from Gateway comparable to today's ISS and high-rate proximity links for an optical lunar network

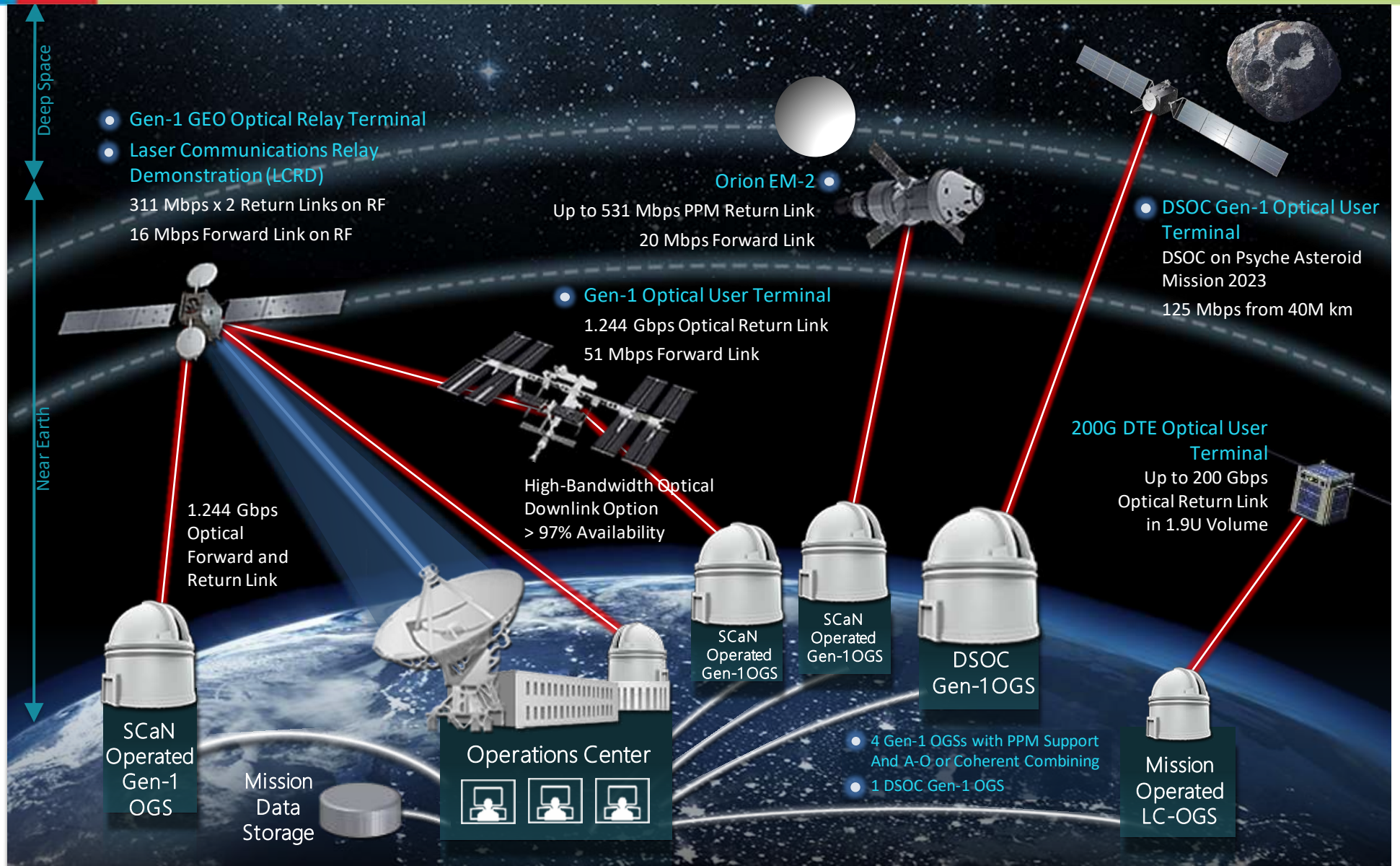
Lasercomm Opportunity for Astrophysics: NASA's WFIRST in 2025

- NASA's next astrophysical telescope beyond James Webb Space Telescope (JWST) with 2.4 meter aperture
- Will map dark energy and dark matter by its gravitational impact on galaxies
- 2.4Low-noise, high-data rate imager generating 2 TB/day
- Feasibility study to accommodate 10 cm lasercomm terminal found could delivery 1 Gbps from 1,500,000 km (RF limited to 300 Mbps due to power-aperture limitations)



MAScOT 10 cm Terminal with hemispherical + 30 degree Field of Regard

Summary:
NASA's Future Space Optical Network

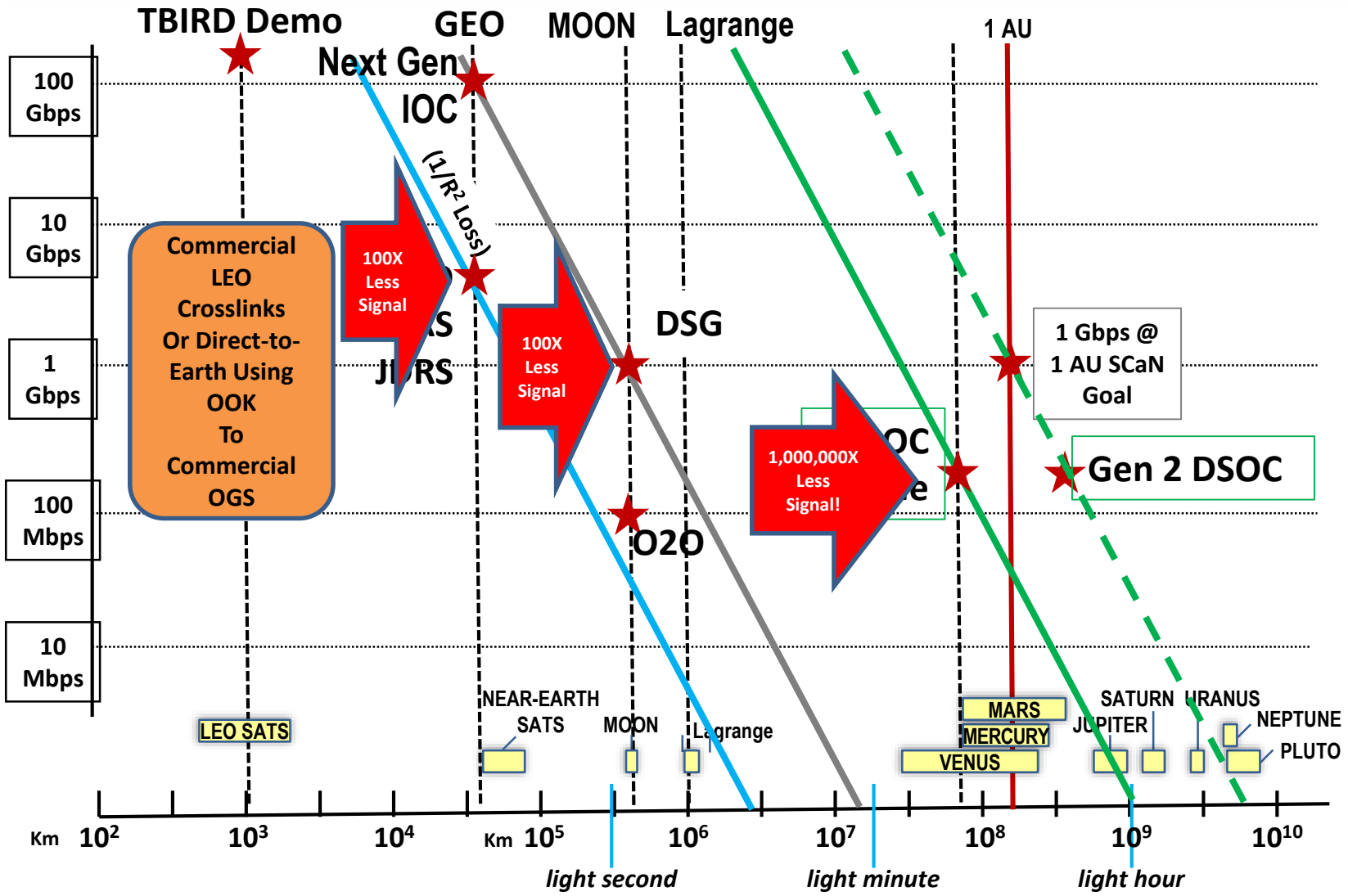


Questions?

Please feel free to contact me at:

Dr. Donald Cornwell
NASA Headquarters SCaN Program
Donald.M.Cornwell@NASA.gov
202-358-0570
410-336-2473 (cell)

NASA and Commercial Optical Communication Systems: Different Designs for Different Scenarios



NASA's Optical Plan Forward: Commercial Optical Ground Station Expansion

OVERVIEW

- Initially two SCaN-managed facilities at TMF and HI for Gen-1 GEO relay demo in June 2019 (LCRD)
- Slew at LEO rates with Adaptive Optic (AO) correction for single-mode fiber coupling; initially deployed with LCRD-compatible modem
- OGS-1A (TMF 2), OGS-3 (WSC) and OGS-4 (Livermore) baselined as 60 cm "Hawaii" design with CCSDS HPE support

PROGRAM STATUS AND NEXT STEPS

- OGS-1 and OGS-2 in final development for site I&T in 2018 to support flight demo in 2019

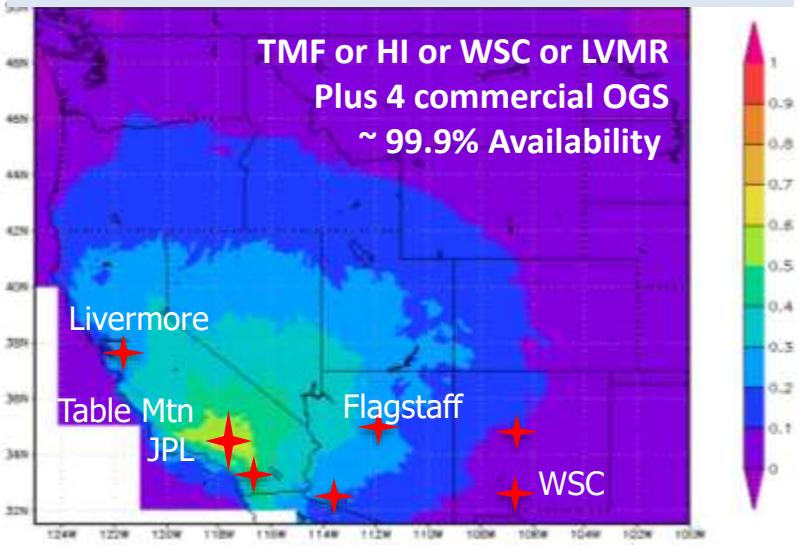
COMMERCIALIZATION

- Work through RSAAs with commercial OGS providers to provide additional stations for >99% availability

OGS-1 TMF in CA

OGS-2 in Hawaii

Cloud-Free Correlation of New Sites to OGS-1 Table Mtn



	Segment	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
NEAR EARTH RELAY	SPACE	Gen-1 GEO Optical Relay Terminal					Gen-1 Optical User Terminal				
	GROUND				Gen-1 OGS						
Orion EM-2	---------						Orion EM-2				