National Aeronautics and Space Administration

NASA's Optical Communications Programs

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Overview

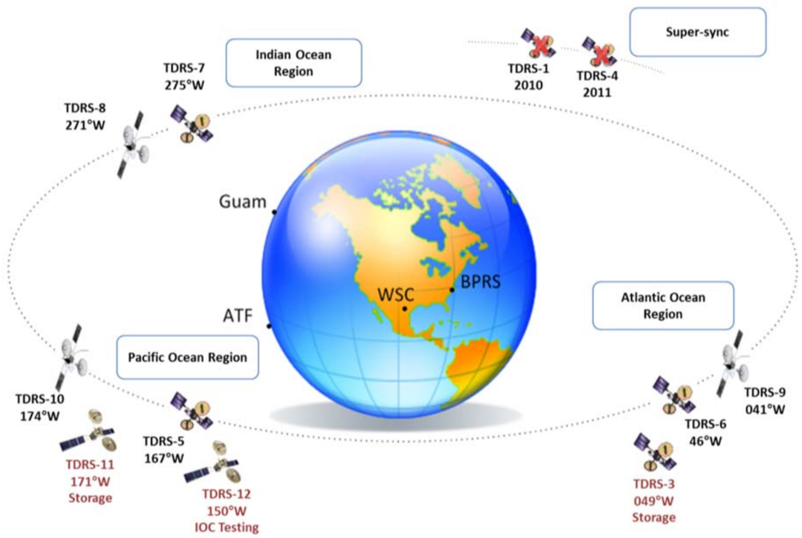
Resiliency is the ability of a mission to endure the loss of one or more nodes, satellites or ground system elements — perhaps degraded but still operational. The mission may continue to function by use of augmented capabilities available from other sources.

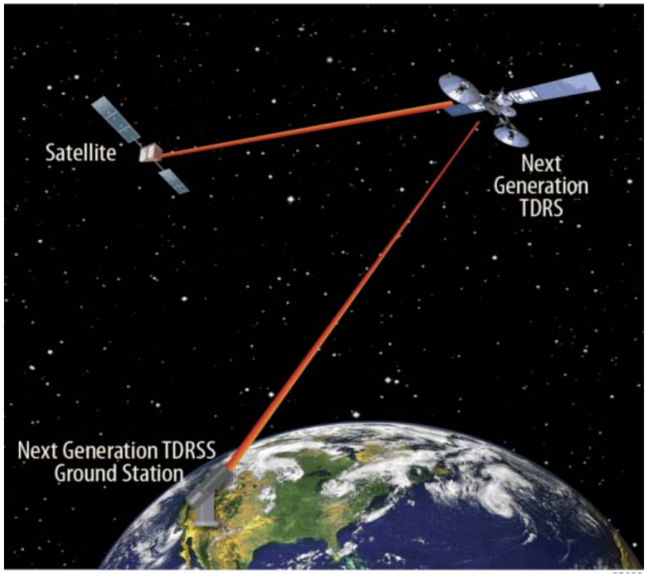
Resilience drives:

- **Disaggregated systems**
- **Affordability to allow sparing and system redundancy**
- **Interoperability with other missions/systems**
- **Density of the constellation**

Small optical communication systems can lead to large affordable constellations providing resilient communications in space

NASA's Space Network Today





- **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 developing technologies for the next generation of relay satellites.**

Laser Communications Relay Demonstration (LCRD) for 2020

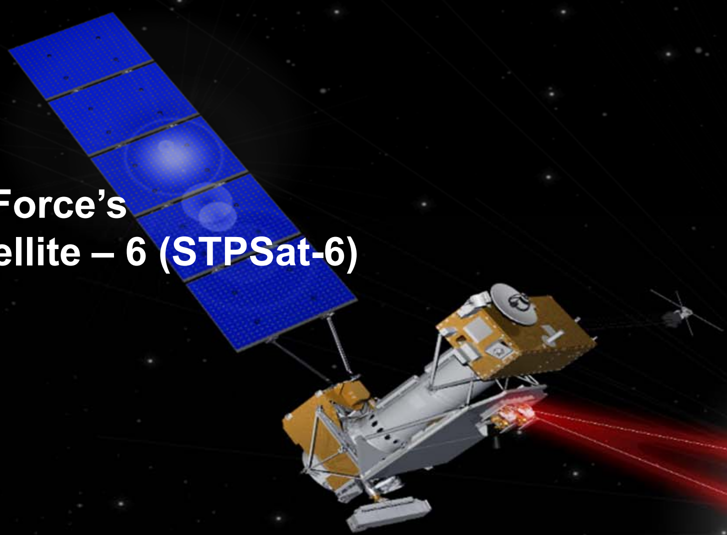
Scheduled launch: August 2020

Mission duration:
Two year ops demo
Six years ops

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

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



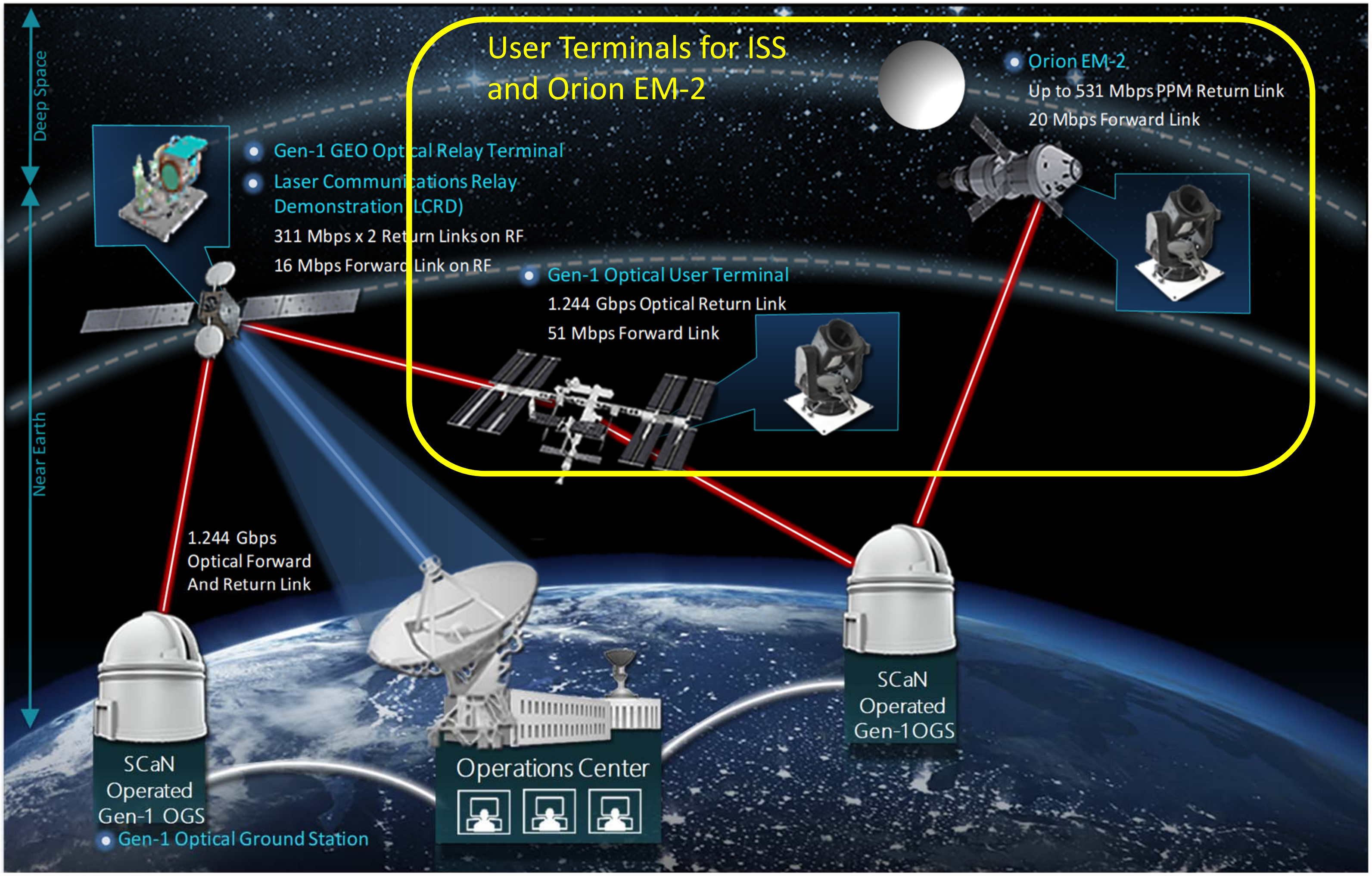
Flight payload:

- 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)
- 622 Mbps Ka-band RF downlink
- New High Speed Switching Unit to interconnect the three terminals

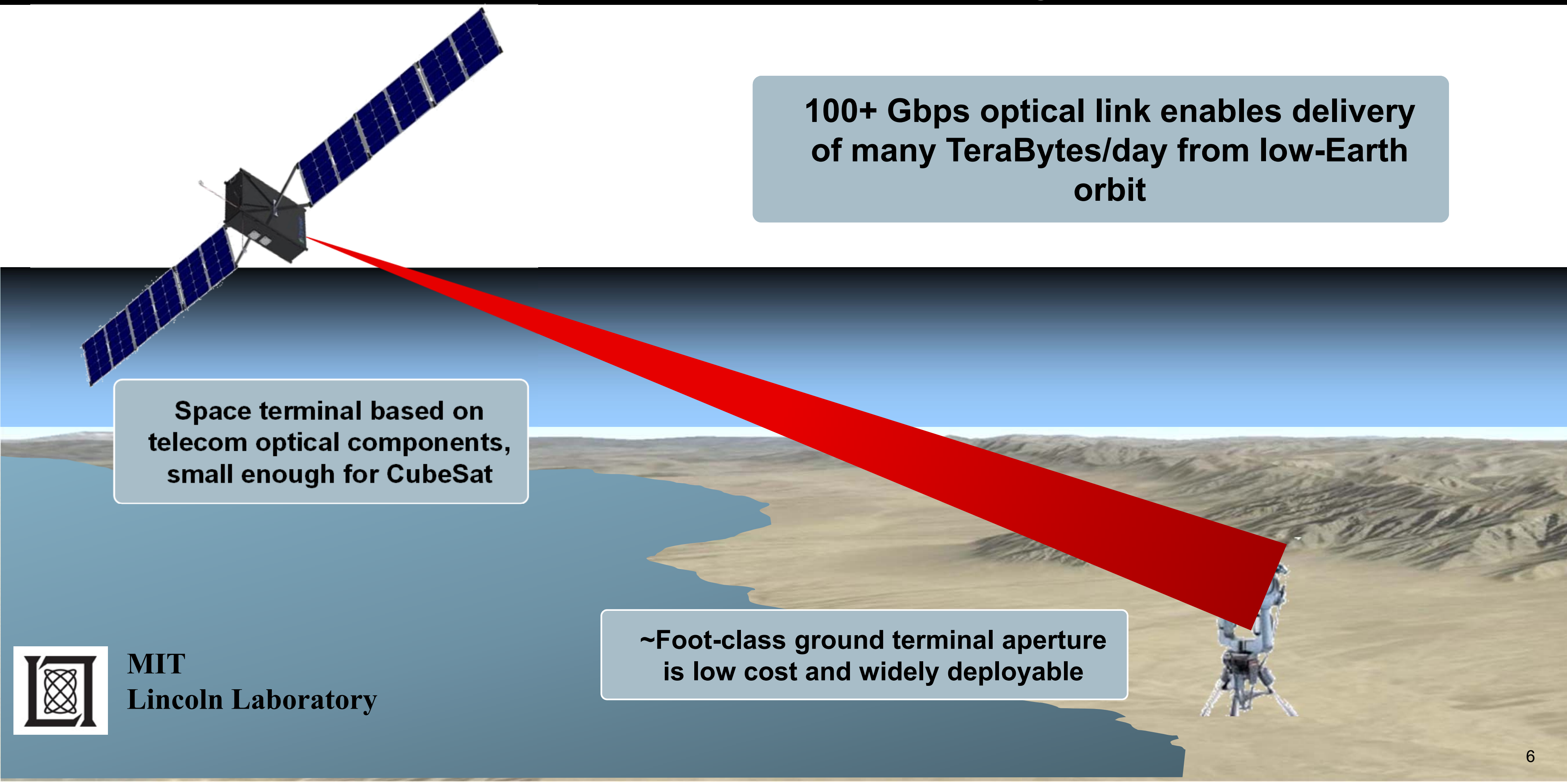
Key for NASA's Next-Gen Earth Relay

Guest investigators welcome!

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

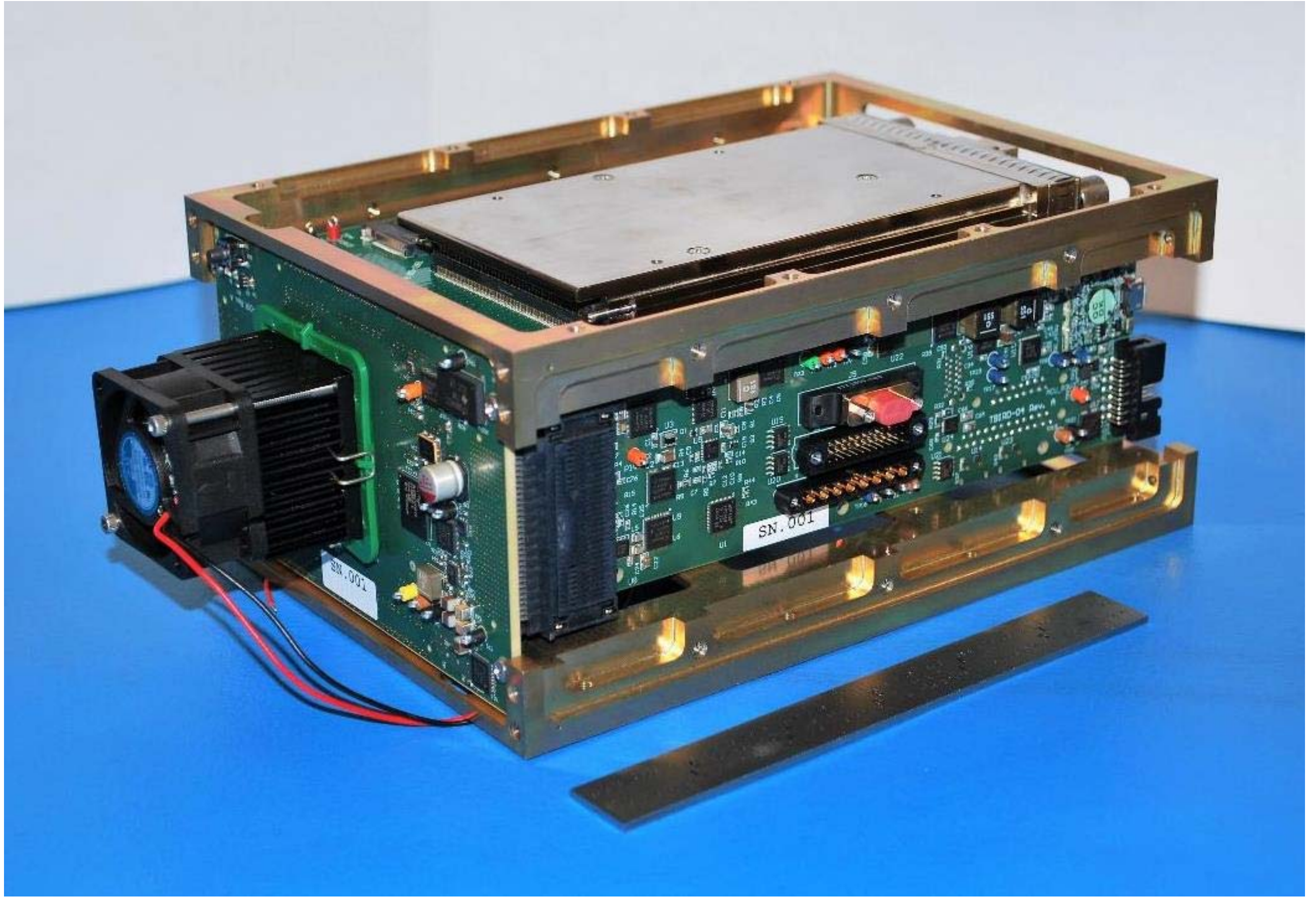


TeraByte InfraRed Delivery (TBIRD)
200 Gbps Cubesat Demo in Early 2020



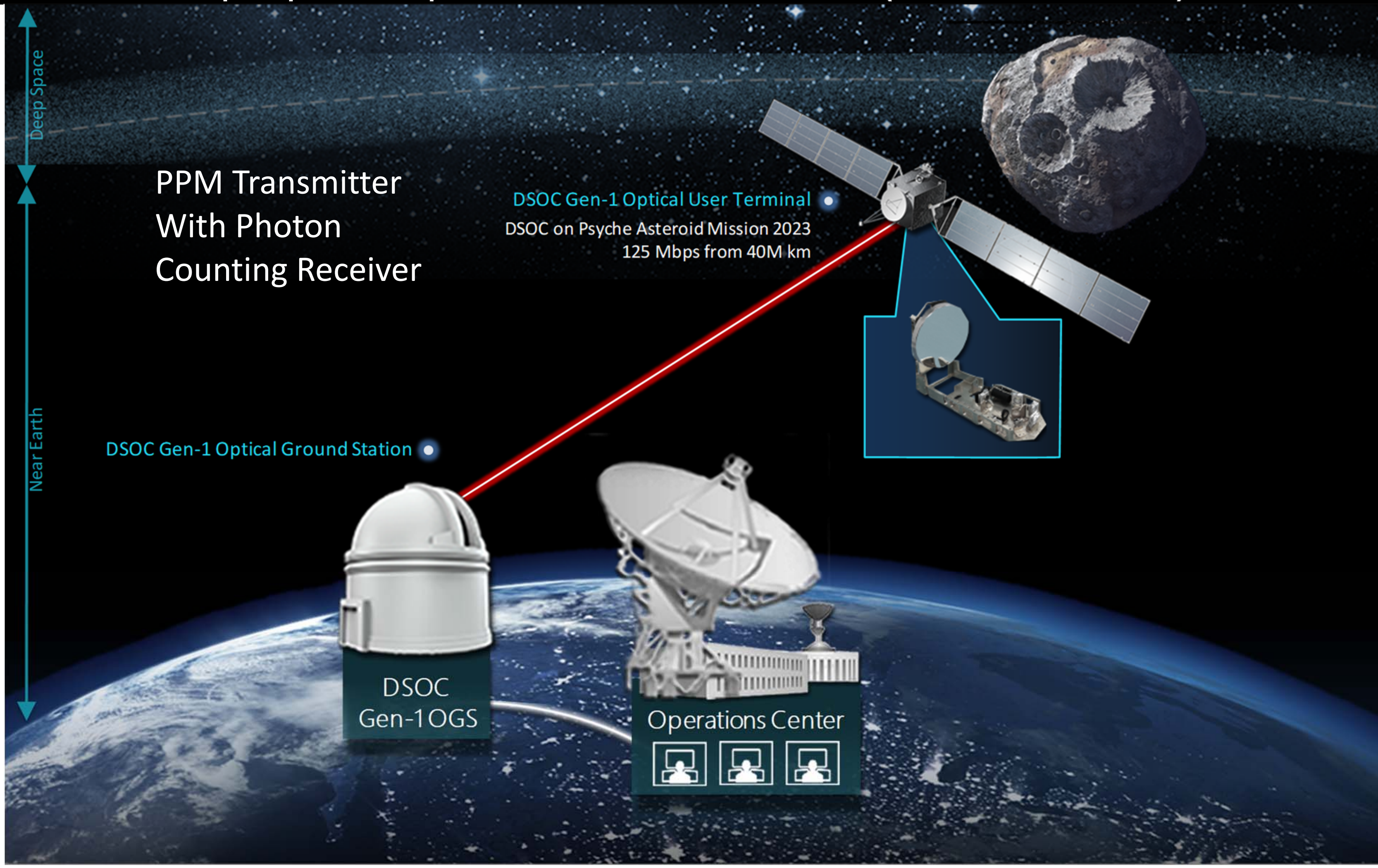
TBIRD Proto-Flight HW at MIT Lincoln Laboratory based on Integrated Photonics and Coherent DSP ASIC

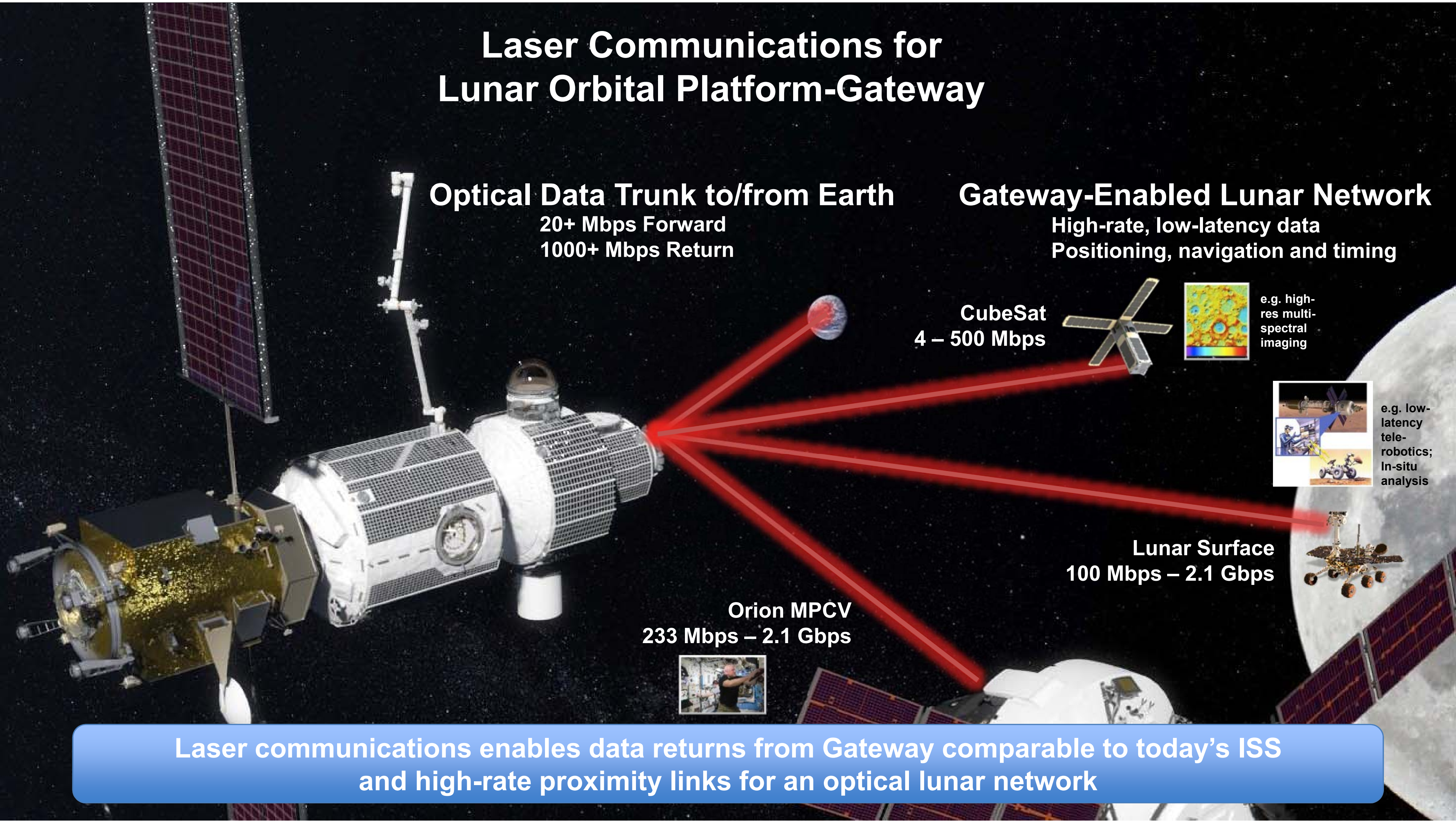
TBIRD
Mass: 2.24 kg
Power: 120W
(5 minute ops)
Volume: 1.8 U



MIT
Lincoln Laboratory

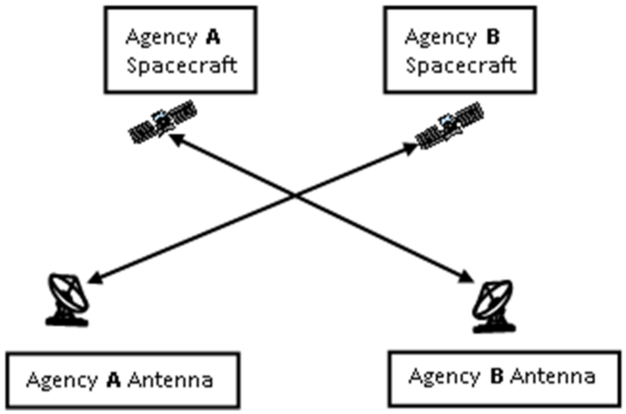
NASA's Optical Plan Forward:
Deep Space Optical Communications (DSOC in 2022)




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

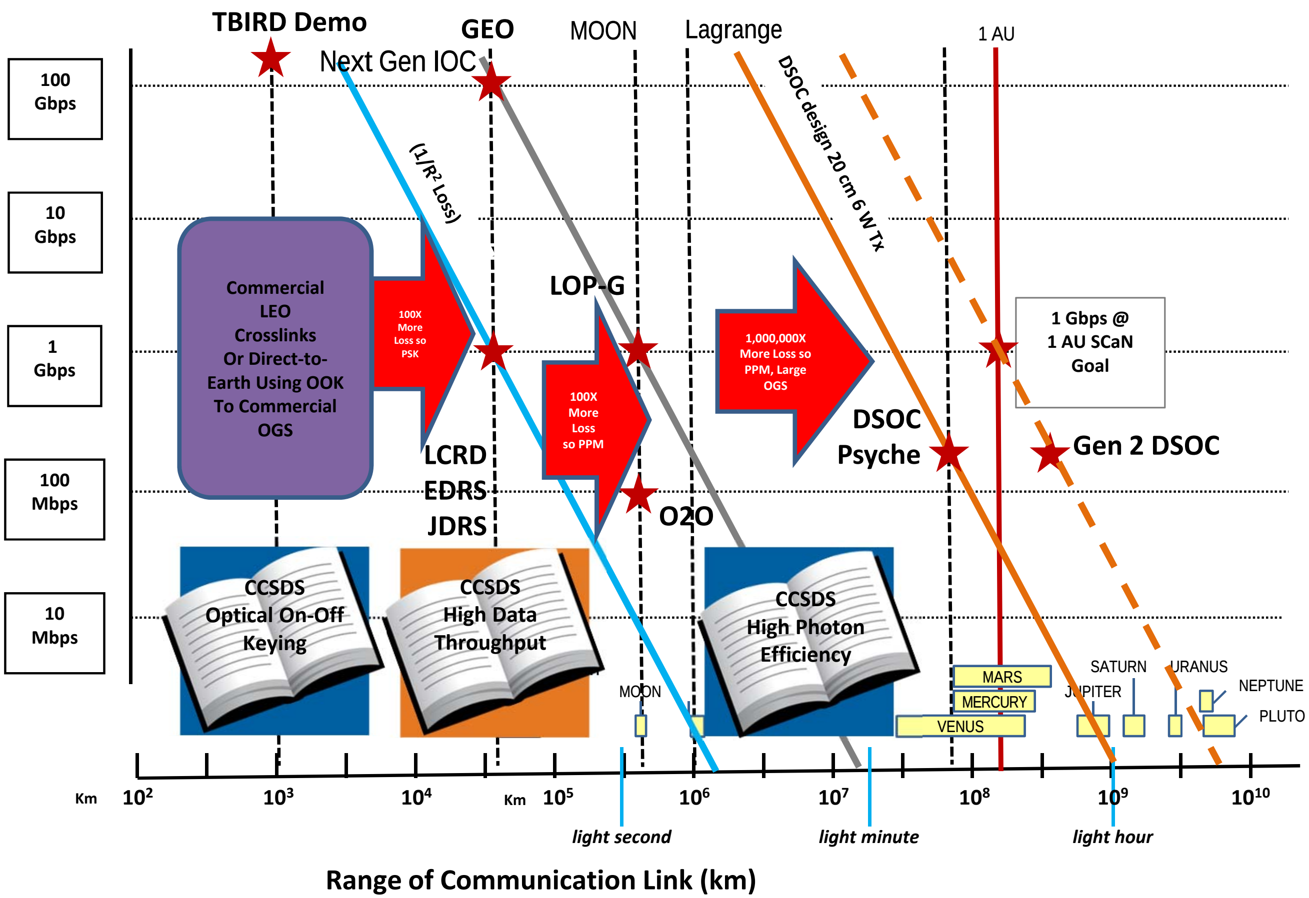
Increasing Communications Resiliency Through Standardization and Resource Sharing

- **Resiliency in both space and on the ground can be increased by sharing communications resources**
- **Sharing optical communication ground stations or relay satellites would also allow agencies to share the cost of the communications infrastructure.**
  - For example, due to cloud blockage, it is critical to have multiple ground stations in use during space-to-ground optical operations to provide high availability.
- **International cross support for civil space agencies is being worked within the Interagency Operations Advisory Group (IOAG) and the Consultative Committee for Space Data Systems (CCSDS).**
- **The goal is to develop optical communications cross support by various agencies as we have today in traditional Radio Frequency (RF) communications.**

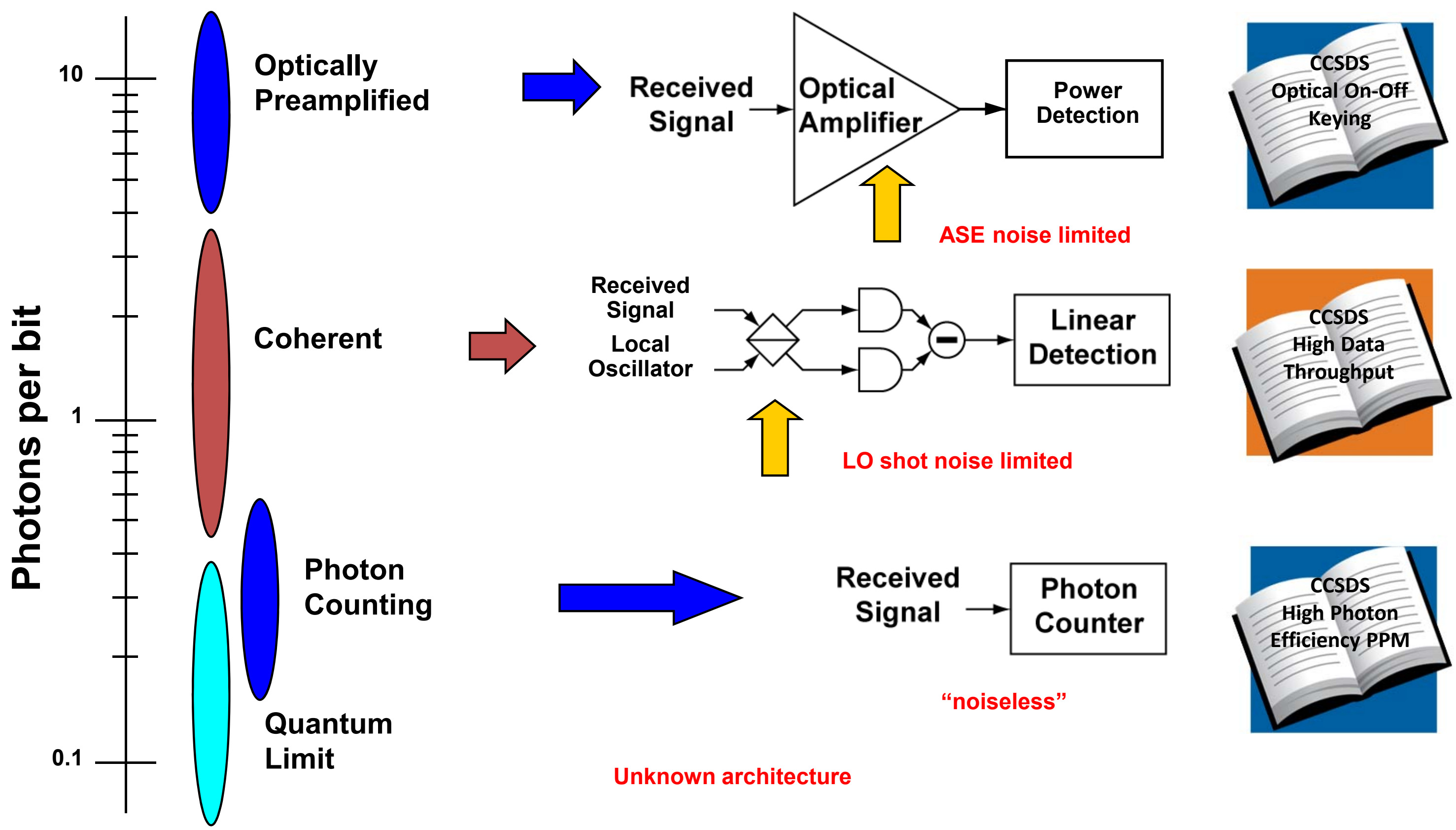


Traditional International RF Cross Support

NASA and CCSDS International Optical Communication Standards in Development



Detection Sensitivity in Optical Communications

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Questions?
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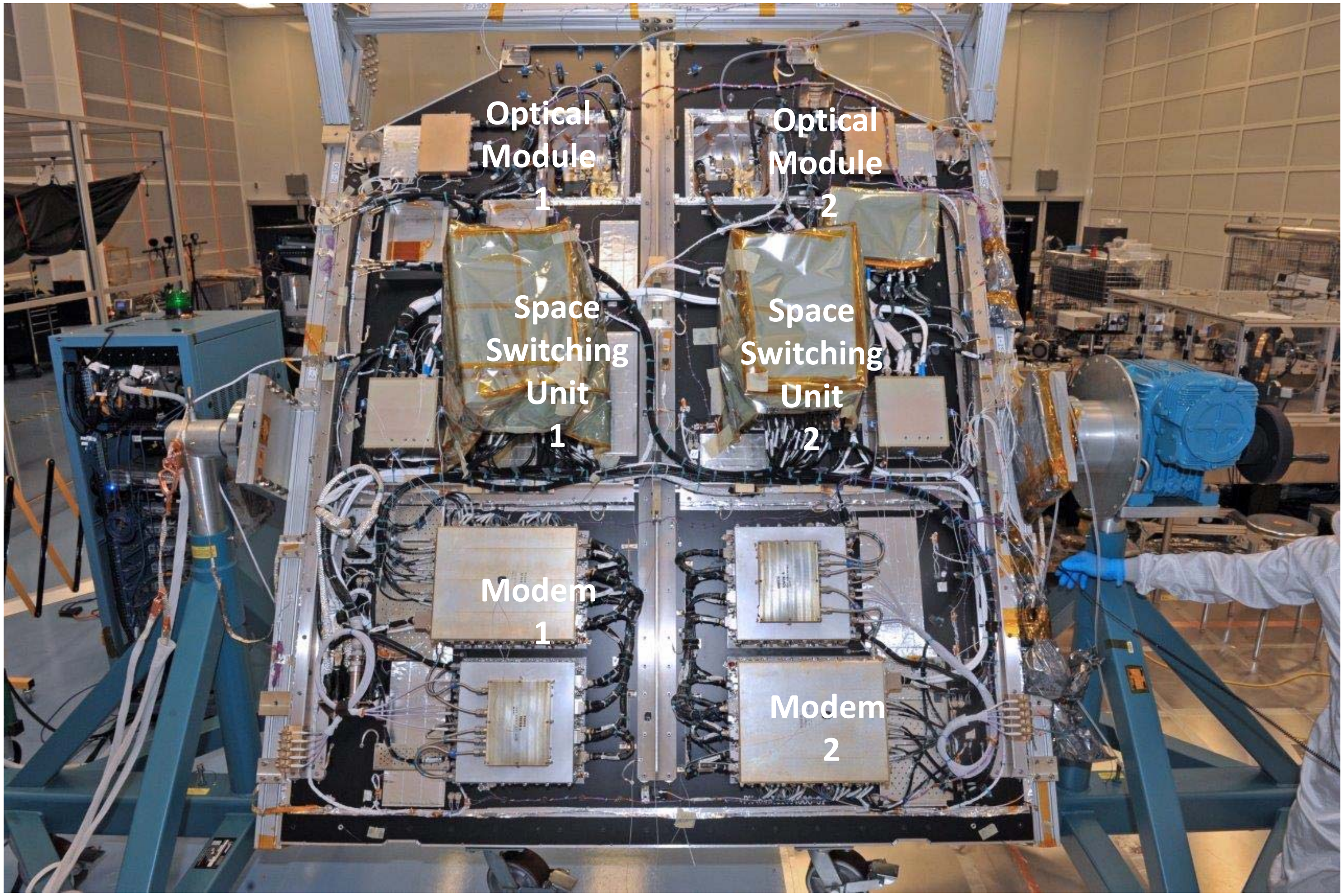
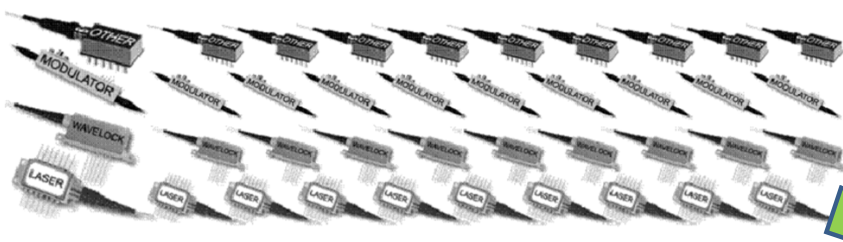
BACKUP

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

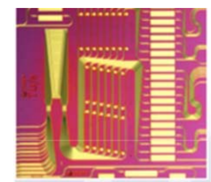


The Key to Reducing SWaP and Cost: Photonic Integrated Circuits

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

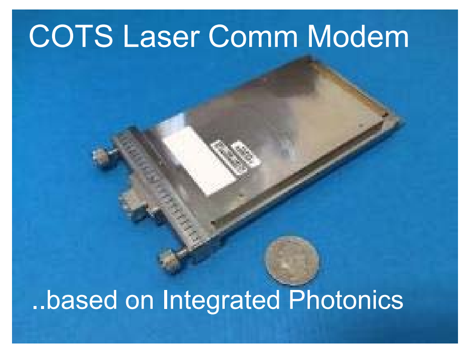


…into the optical equivalent of a micro-electronics "integrated circuit"



1 cm

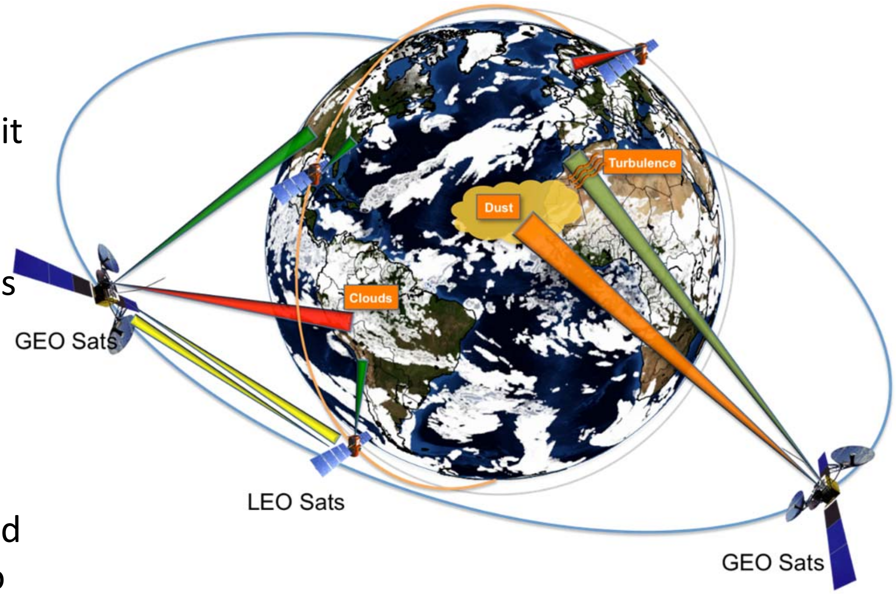
For NASA, this means that optical systems for communications and sensors can be reduced in <u>size</u>, <u>mass</u>, and <u>cost</u> by >> 100x by leveraging this commercially-available technology (some customization may be required)



Atmospheric Characterization and Prediction for Optical Communications

CCSDS Books will:

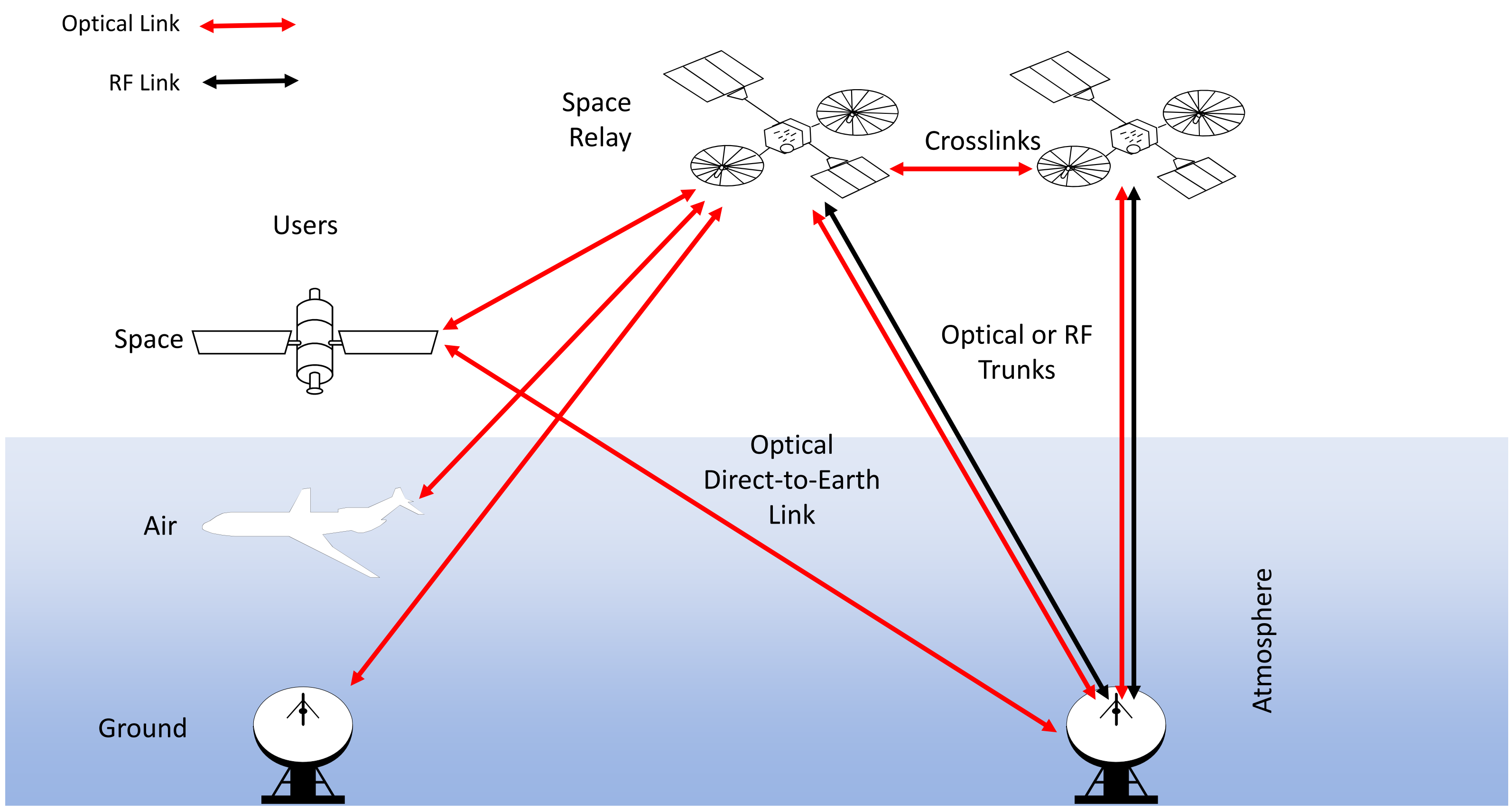
- Provide a narrative on atmospherics and explain why it is critical to accurately characterize
- Explain how long-term statistics of atmospherics are used to choose an optimal network of geographically diverse ground sites
- Provide content on the required instruments and parameters to support long-term site characterization and real-time decision making



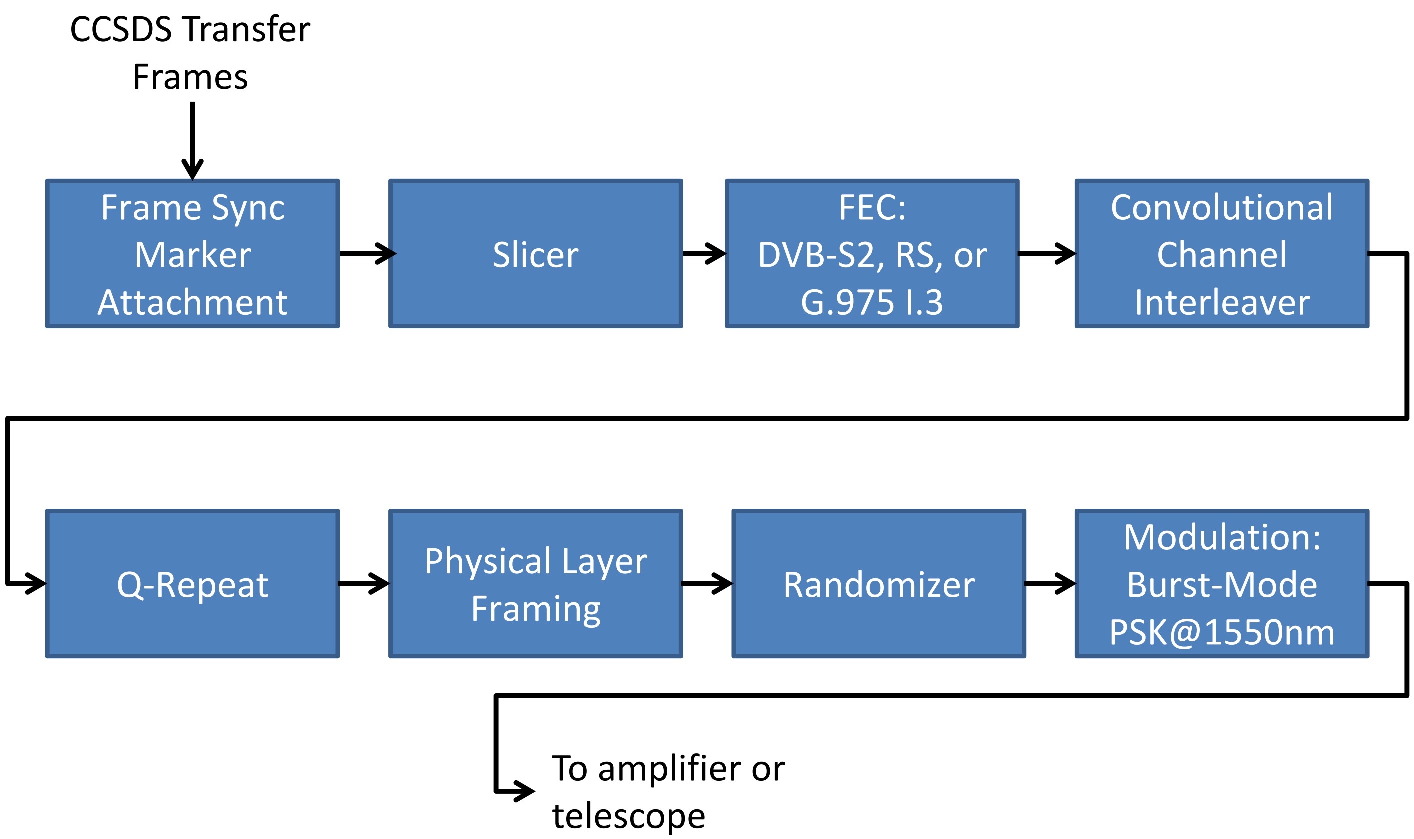
Clouds are primary source of attenuation

Characterization and prediction of the atmospheric channel are critical to inform space link handovers, select ground sites, and to maximize system availability

High Data Throughput 1550 nm Link Scenarios



High Data Rate 1550 nm Signaling Overview



High Data Rate 1550 nm Relay Link Example