

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.**

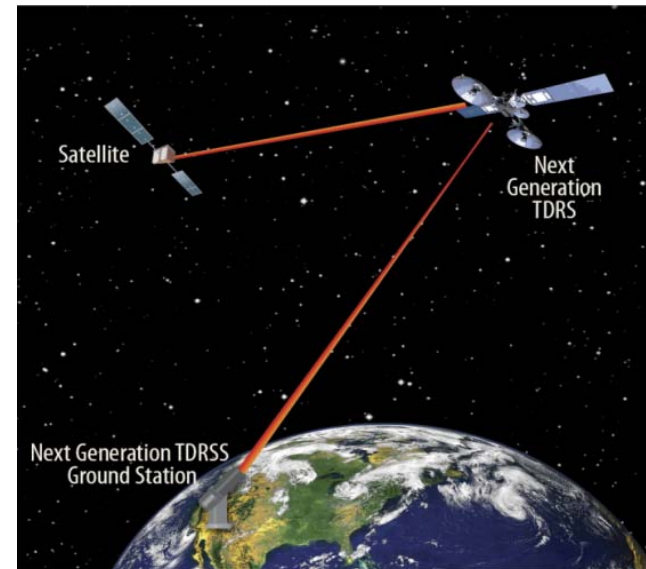
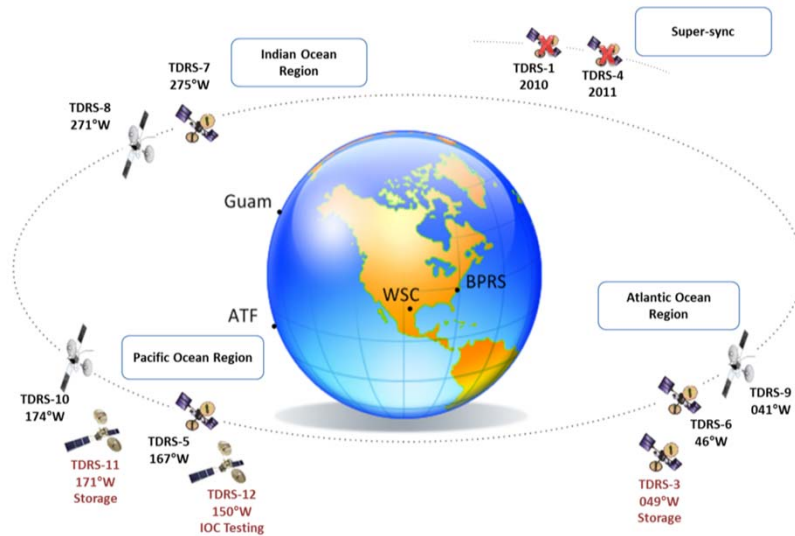
**Resilience drives:**

- **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

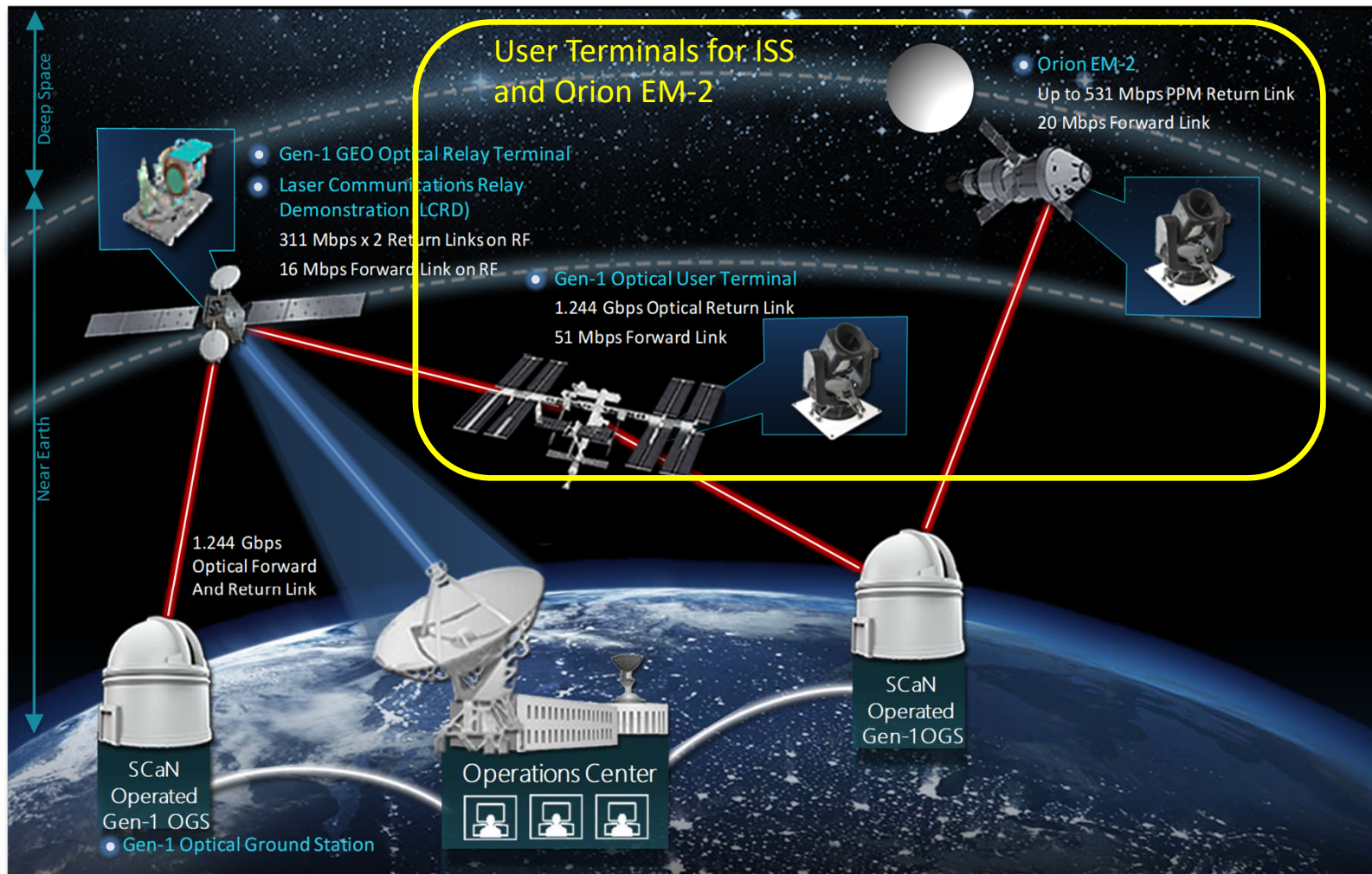


**Key for NASA's Next-Gen Earth  
Relay**

**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



**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

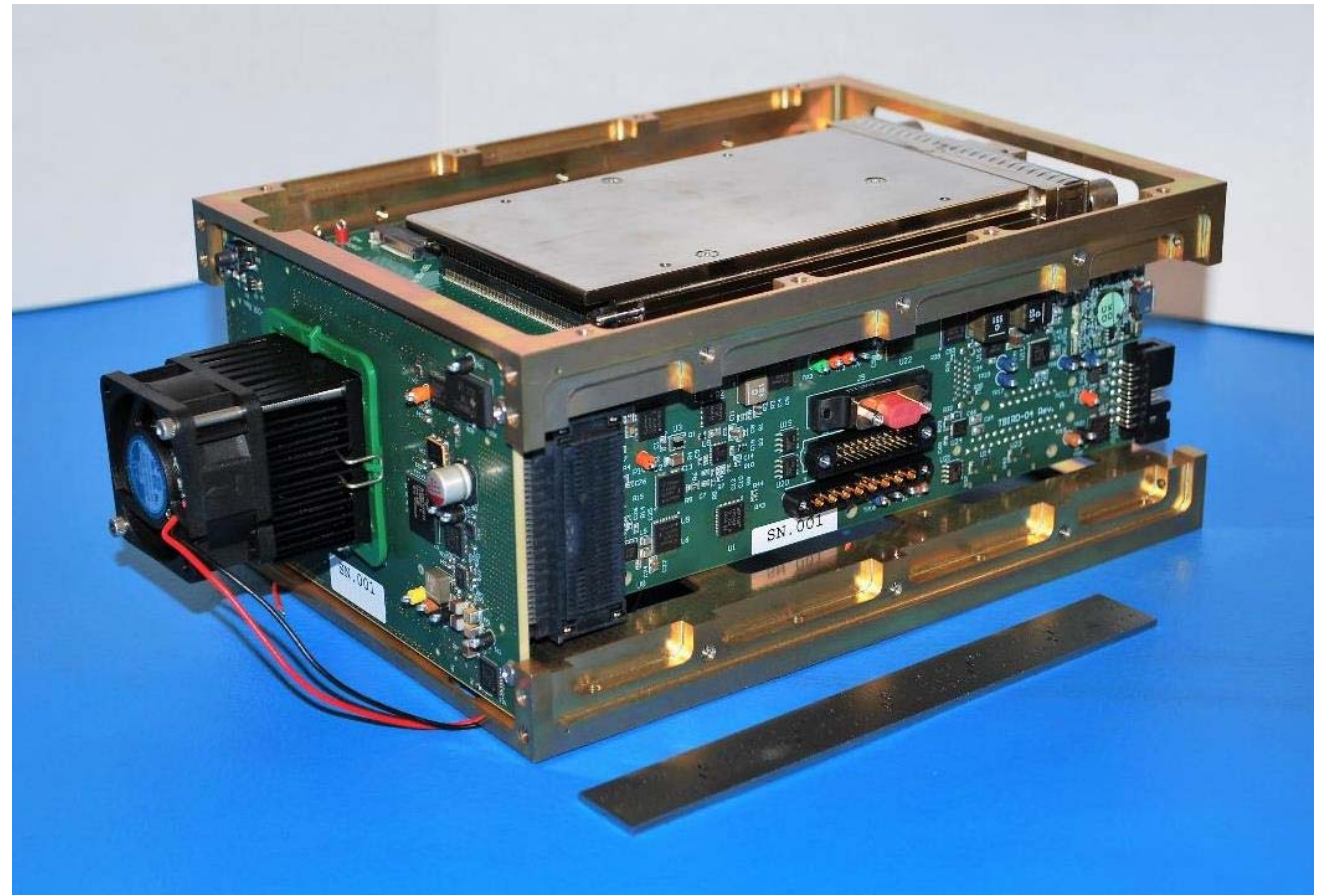


**TBIRD**

**Mass: 2.24 kg**

**Power: 120W  
(5 minute ops)**

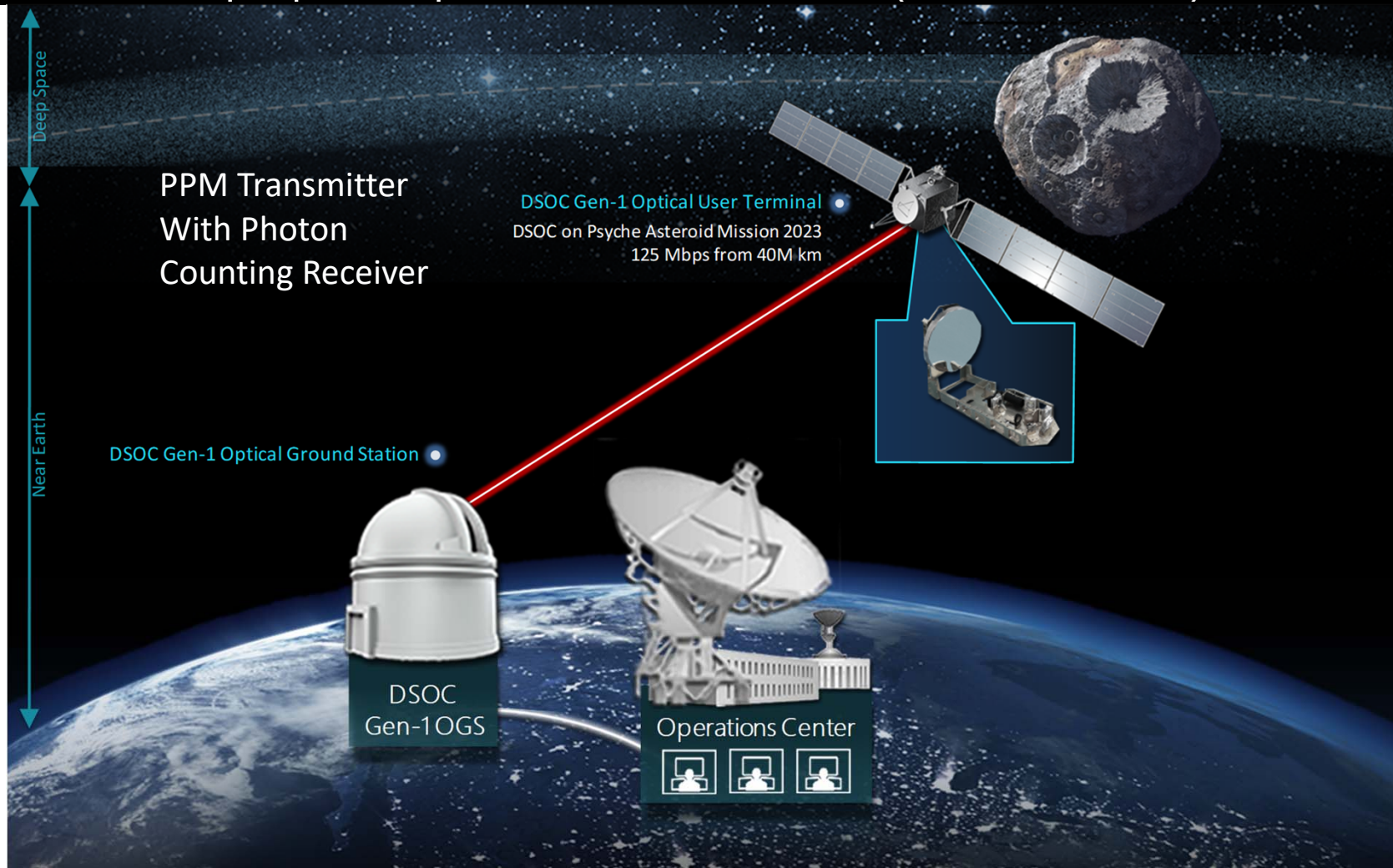
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**MIT  
Lincoln Laboratory**



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





# Laser Communications for Lunar Orbital Platform-Gateway

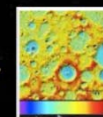
## Optical Data Trunk to/from Earth

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

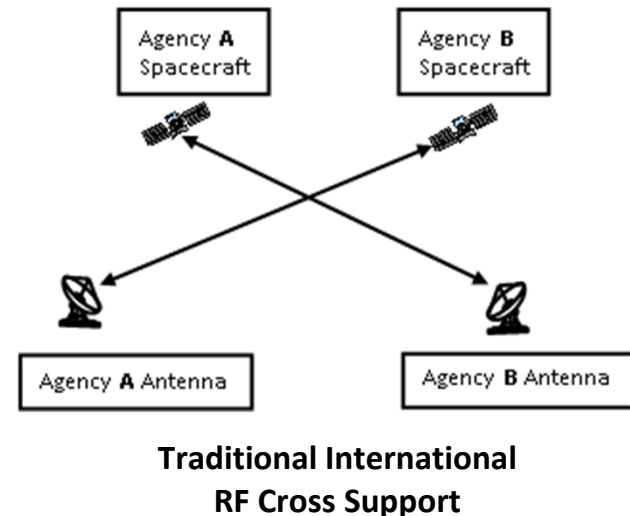


Laser communications enables data returns from Gateway comparable to today's ISS and high-rate proximity links for an optical lunar network

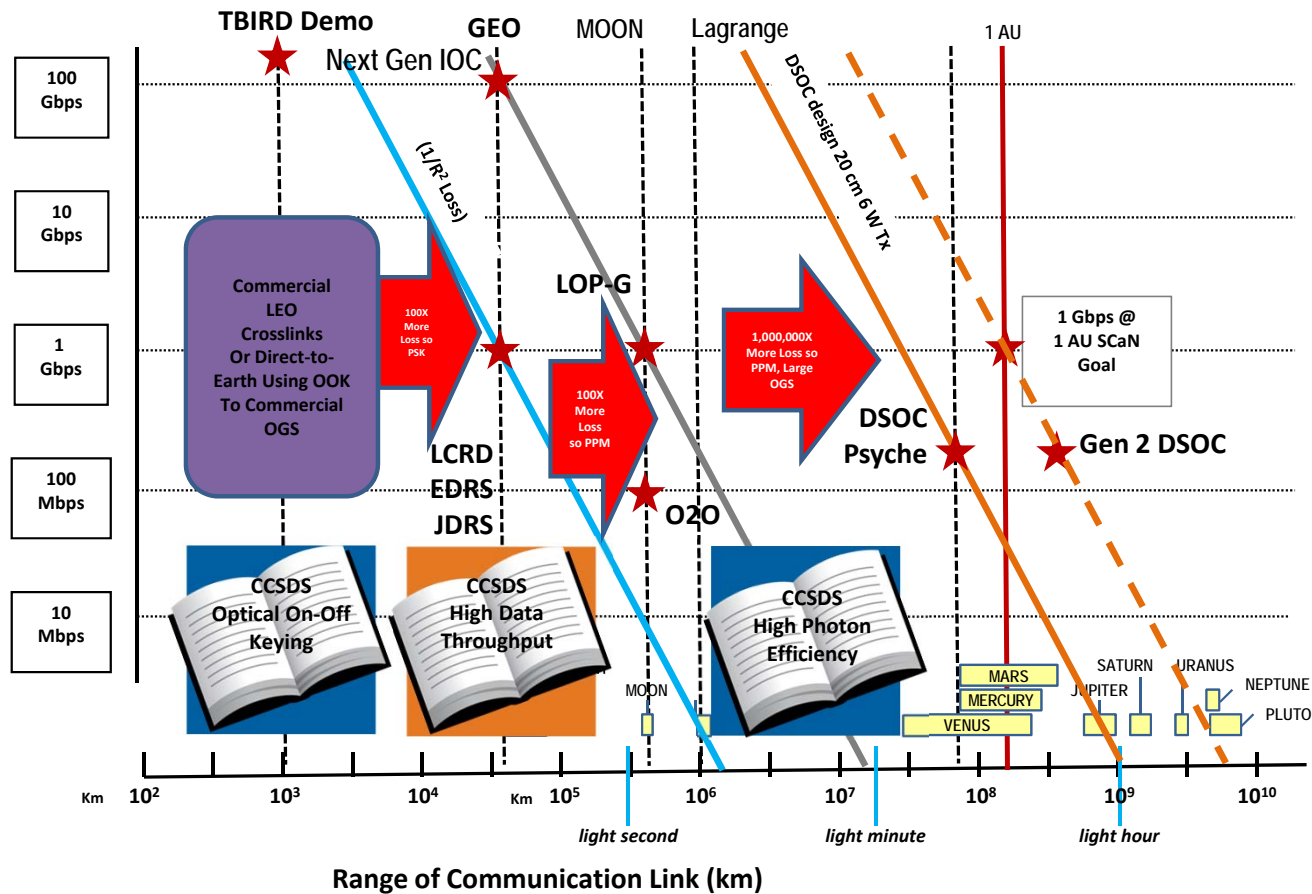
## Increasing Communications Resiliency Through Standardization and Resource Sharing



- **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.**

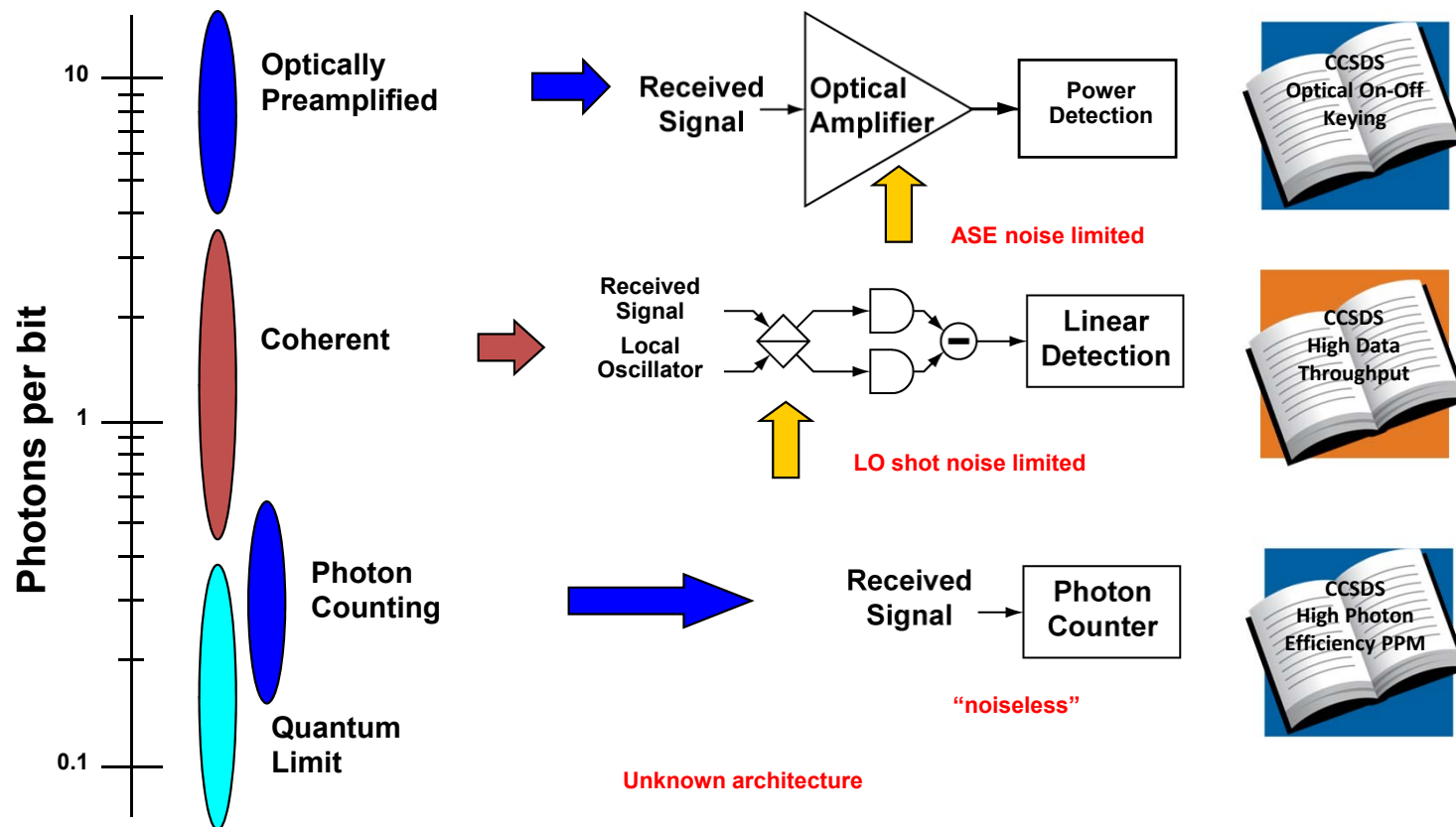


# NASA and CCSDS International Optical Communication Standards in Development





# Detection Sensitivity in Optical Communications





# Questions?

**Please feel free to contact me at:**

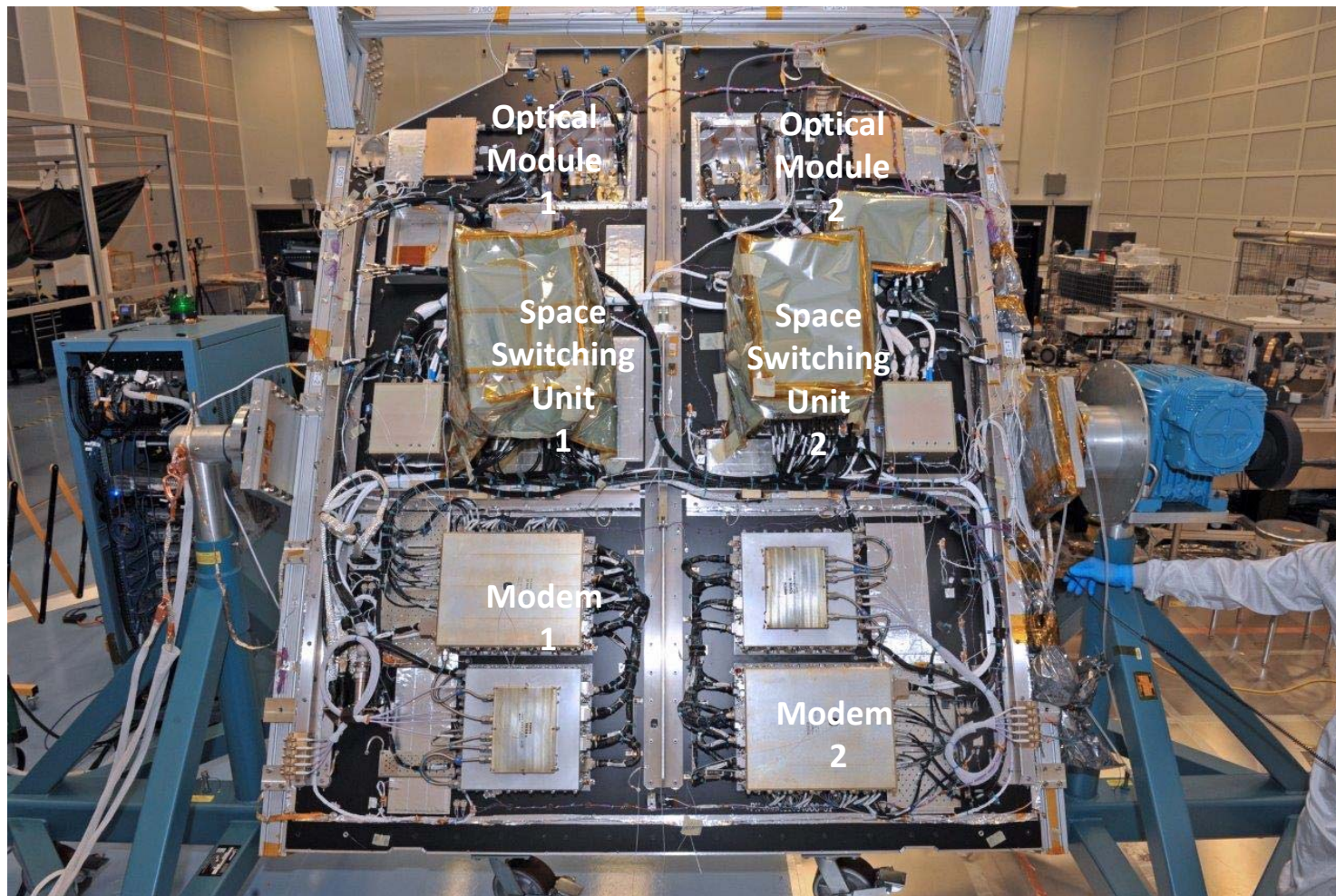
**Bernie Edwards  
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# BACKUP



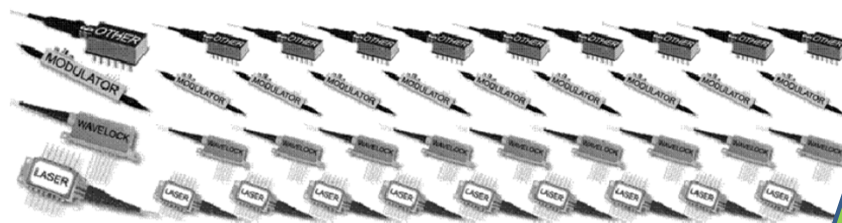
# Integrated Laser Communication Relay Demonstration Payload at NASA Goddard Space Flight Center





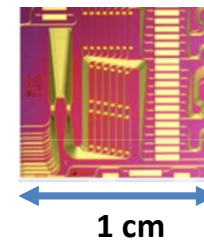
## The Key to Reducing SWaP and Cost: Photonic Integrated Circuits

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”

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



COTS Laser Comm Modem



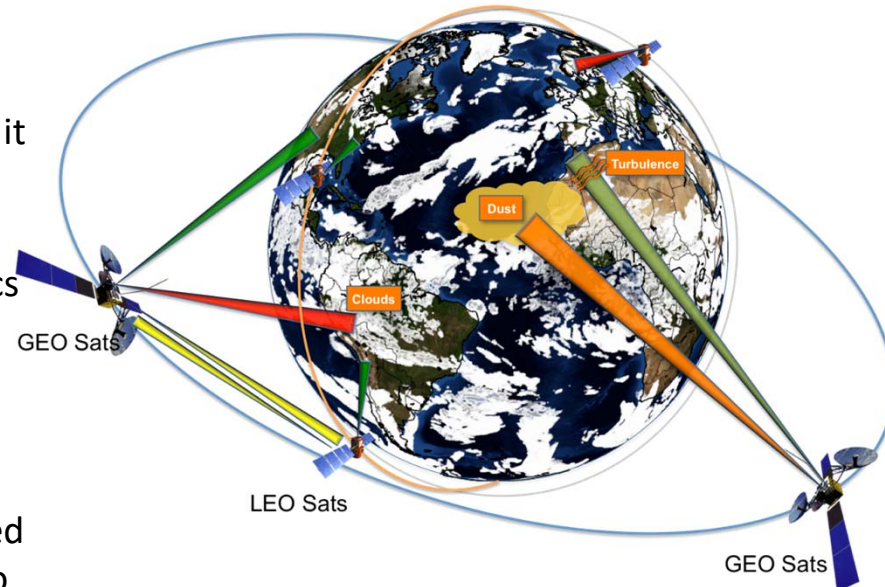
...based on Integrated Photonics

# 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

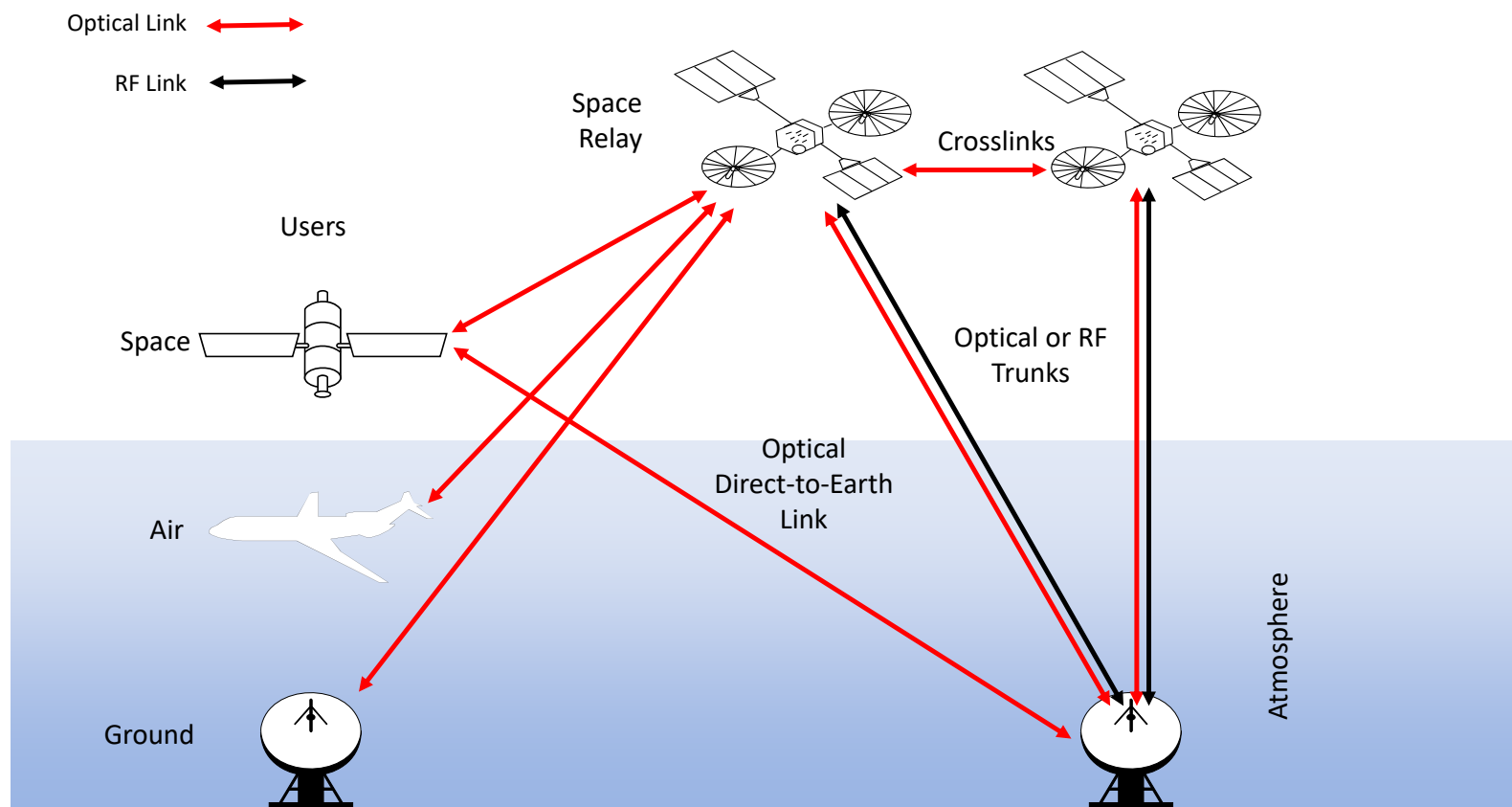


Clouds are primary source of  
attenuation

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

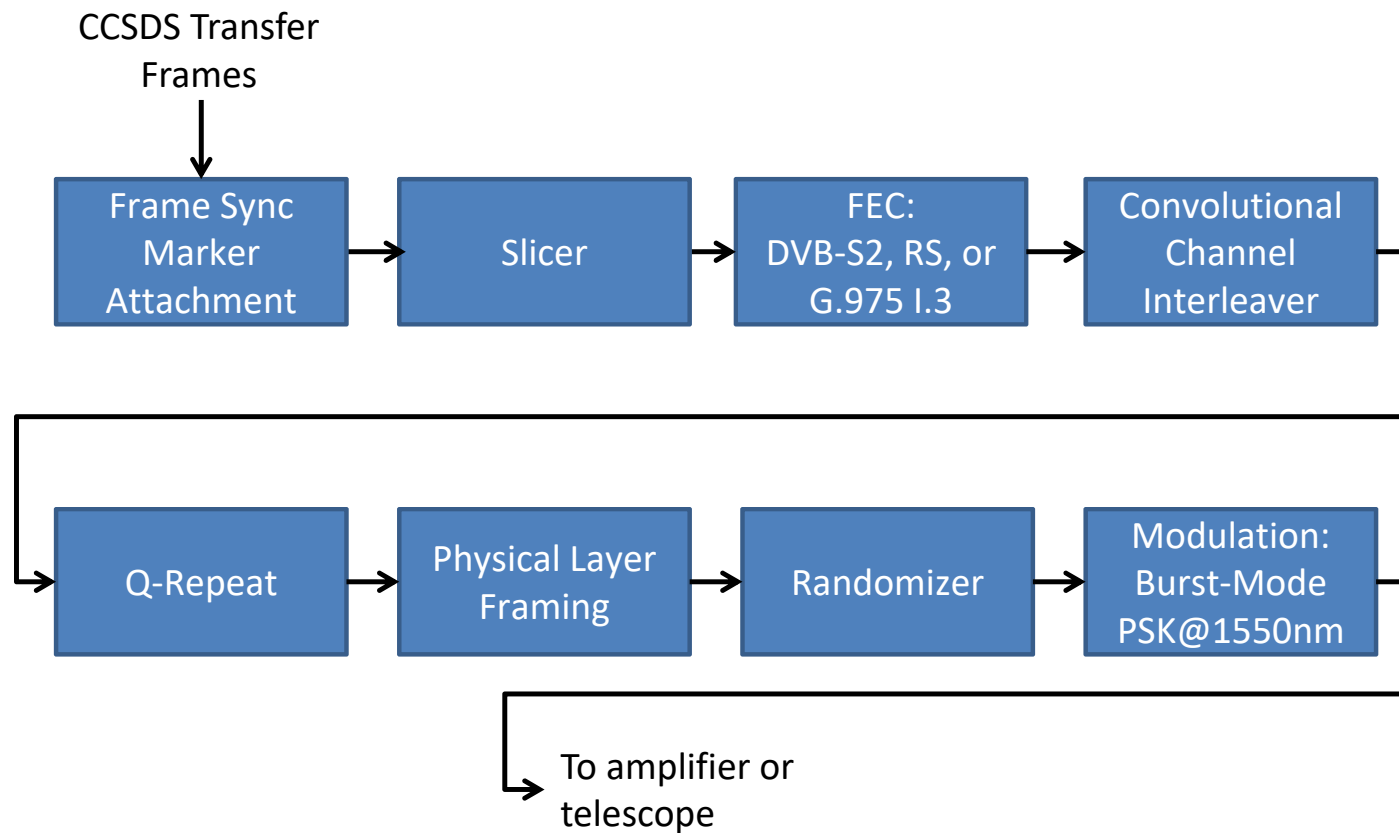


# High Data Throughput 1550 nm Link Scenarios





## High Data Rate 1550 nm Signaling Overview





# High Data Rate 1550 nm Relay Link Example

