National Aeronautics and Space Administration

*Space Technology Mission Directorate*
*Game Changing Development Program*

# Deep Space Optical Communications for Discovery Technology Day

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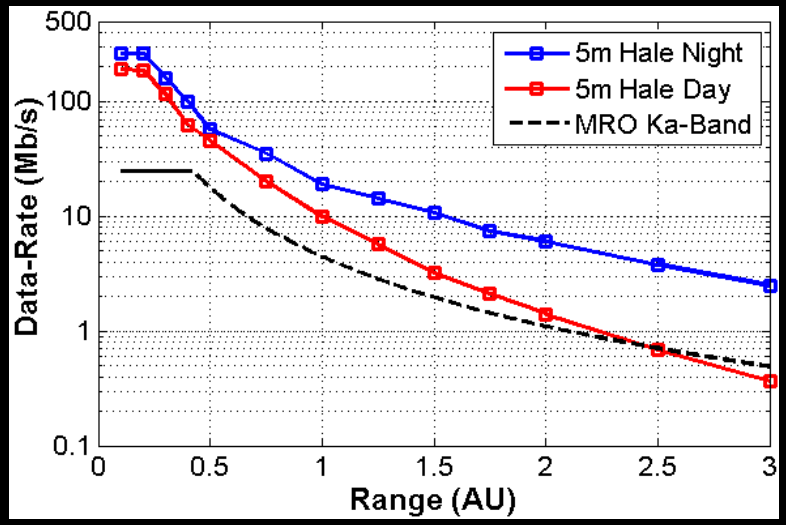
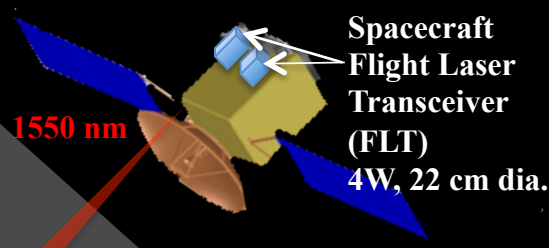
***This document has been reviewed and determined not to contain export controlled technical data.***

# Deep-Space Optical Communications (DSOC)
## Overview, Capabilities and Footprint




Performance using 4W average laser power w/22 cm flight transceiver to 5m ground telescope




1550 nm

**Beacon & Uplink**
**1030 nm**
**292 kb/s**
**@ 0.4 AU**

| | |
|---|---|
| **CBE MASS (kg)** | 28 |
| Mass margin (%) | 30 |
| **CBE POWER (W)** | 76 |
| Power Margin (%) | 31 |
| **Optical Head: 45 x 45 x 49 cm** (95E3 cc) | |
| Elect. Box: 29 x 23 x 23 cm (15E3 cc) | |

**Ground Laser Transmitter (GLT)**
**Table Mtn., CA**
**5kW, 1m-dia. Telescope**

**Deep Space Network (DSN )**

**Ground Laser Receiver (GLR)**
**Palomar Mtn., CA**
**5m-dia. Hale Telescope**

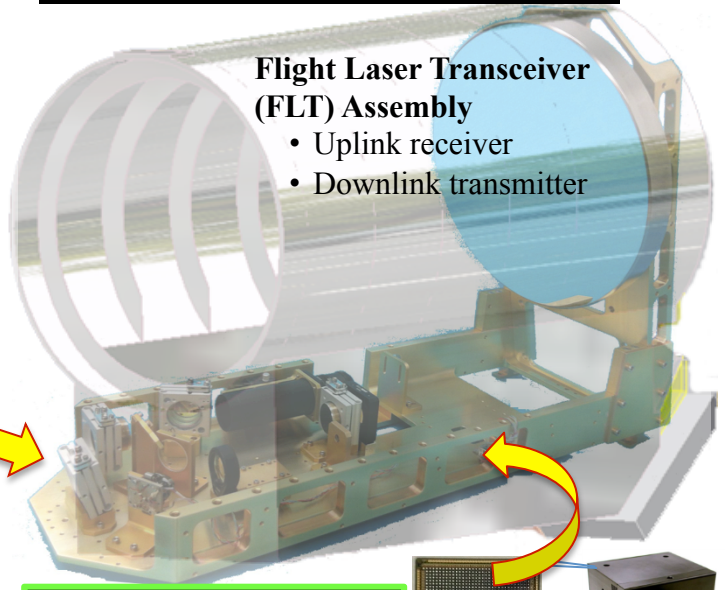
**Optical Comm Ops Ctr.**
**JPL, Pasadena, CA**

**TBD MOC**

# DSOC Key Characteristics

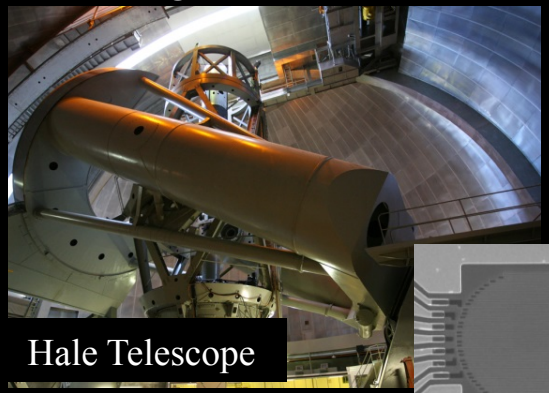
- **Deep-space optical communications characteristics**
  - ***Photon-efficient communications***
  - ***Pulse-position modulation w/ Near capacity achieving codes***
  - ***Laser beacon + Earth image assisted pointing from space***
  - ***Integrates new technologies*** *green outline*

Silicon Carbide Telescope & Optics
(Front cover not shown)

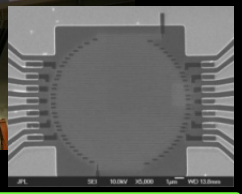


**Flight Laser Transceiver (FLT) Assembly**
- Uplink receiver
- Downlink transmitter

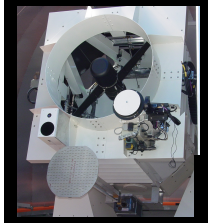
## Ground Segment



Hale Telescope



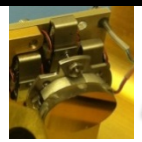
Ground Laser Receiver(GLR)
- Photon-counting ground detectors
- 60% Eff. WSi nanowire arrays

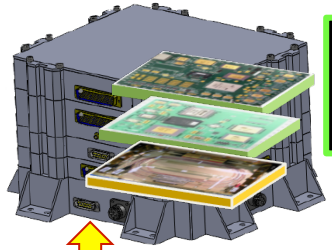


Ground Laser Transmitter (GLT)
- 1030 nm Ground Lasers

OCTL Telescope

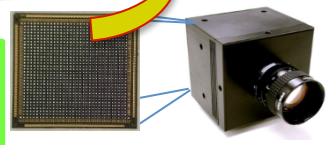
Point-Ahead Mirror



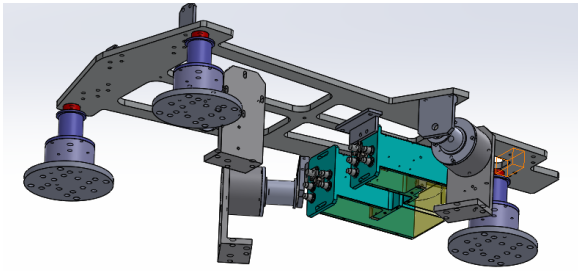


Laser Transmitter

Electronics Box
- 1550 nm Space Laser Transmitter
- Electronics processing & control cards, firmware, software, clock



Photon-Counting Space Receiver
- 40% QE Rad Tolerant

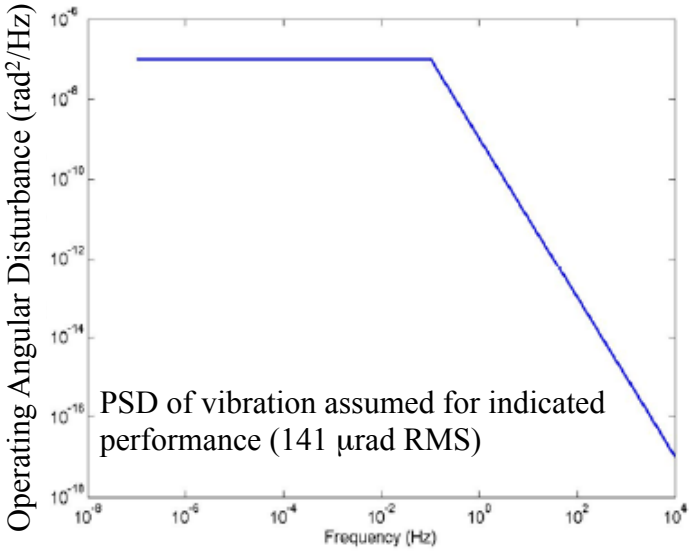


Spacecraft Disturbance Isolation Assembly
- 50 dB rejection

# Implementation:
## Spacecraft/Launch Assumptions

- **Deep-Space Optical Communications**

| | | |
|---|---|---|
| RMS Disturbance power spectral density (PSD) | PSD shown in figure on right | |
| RMS Instrument interface attitude knowledge error, roll about LOS to ground **(1σ)** | 150 μrad | TBC |
| Spacecraft cross-range velocity knowledge error **(1σ)** | 5 m/s | TBC |
| Spacecraft Pointing Control **(3σ)** | 5mrad | Comparable S/C pointing<br>MRO : 2.1 mrad (Ka/X)<br>JUNO: 4.4 mrad (Ka/X)<br>Kepler: 2.1 mrad (Ka)<br>DAWN: 11 mrad (X) |
| Contamination Control | CL 300 | TBC |
| User Data Interface | GigE | TBC |



# Implementation: FLT & Ground Station Assumptions

- **Flight Laser Transceiver (FLT)**
  - **Based on JPL-design that had Concept Review in August 2010**

    - Interface to spacecraft C&DH for downlinking user data over optical link
      - Data-rates shown on p.1
      - Point-ahead angles of **± 400 μrad** (TBC)
      - Doppler of **50 ppm** (TBC)

    - Beacon assisted pointing architecture presumed (i.e. no "handshaking")
      - Support uplink commanding max rate of **292 kb/s @ 0.4 AU**
      - 2-way ranging precision of **30 cm** (TBC)

    - Sun-angle limitations
      - Sun-Earth-Probe angle **> 12°**
      - Sun-Probe-Earth angle **> 3°** for operations (survive sun-pointing)

    - Designed for TID of **20 krad**

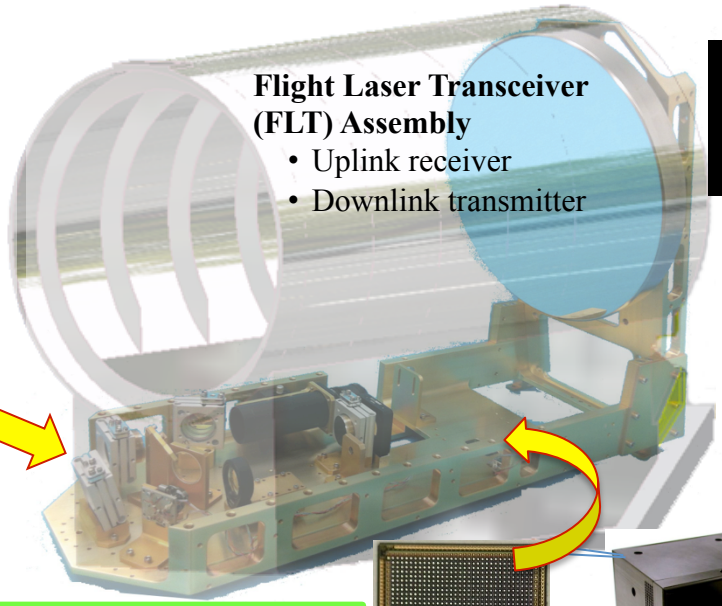
# FLT TRL-Status

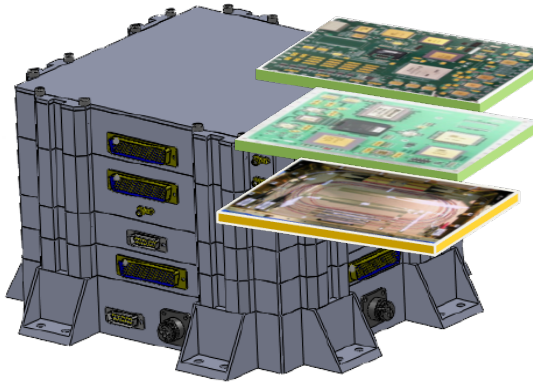
- **All technologies advance to TRL-6 prior to EO FY17**

**Flight Laser Transceiver (FLT) Assembly**
- Uplink receiver
- Downlink transmitter

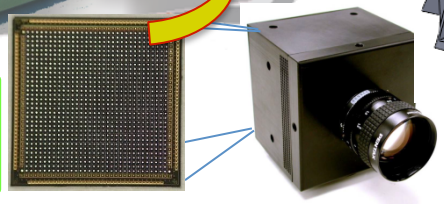
Silicon Carbide Telescope & Optics (Front Cover shown)
TRL-6

Point-Ahead Mirror
TRL-6

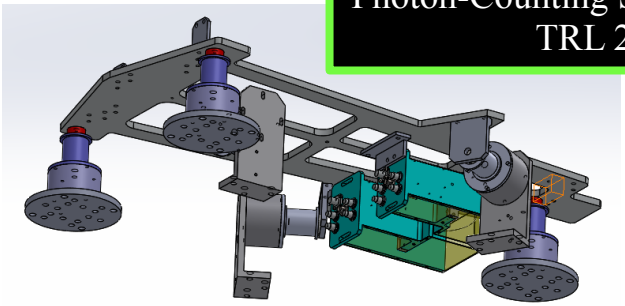


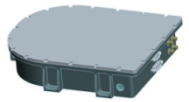


Photon-Counting Space Receiver
TRL 2-3



Flight Electronics
TRL 4-5

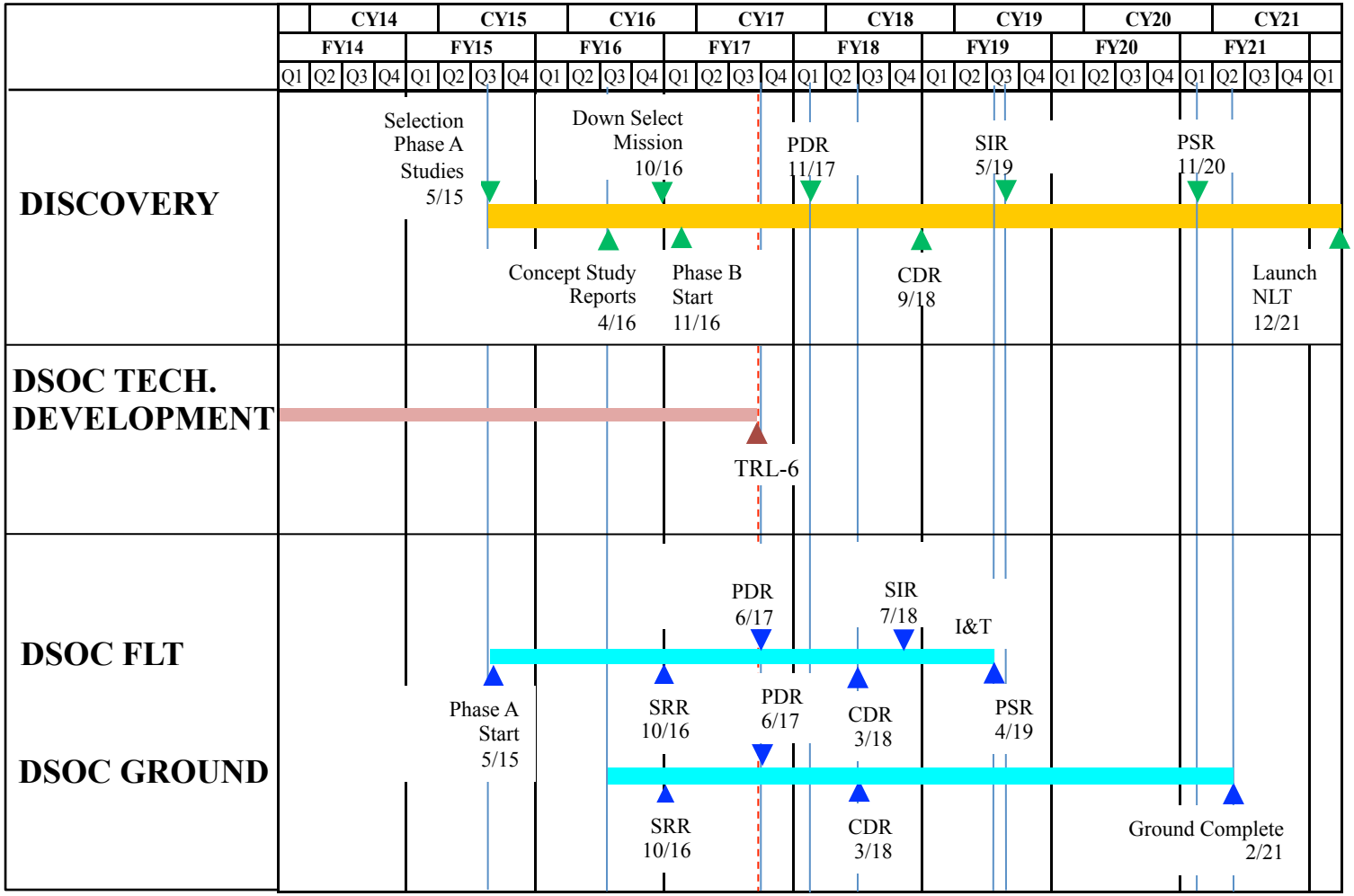




Laser Transmitter
TRL 4-5

Spacecraft Disturbance Isolation Assembly
TRL-4

# NOTIONAL SCHEDULE



# Planned AO Library Content

- Fact Sheet for Deep Space Optical Communication
- Technology Day Charts
- Published papers/reports on Deep-Space Optical Terminals (DOT)
- Technology characteristics
- Laser communication terminal interface details as they mature
- Joint weather statistics Palomar Mountain & Table Mountain, CA
- Contact information for queries and questions regarding interfaces

# Point of Contact

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