National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology
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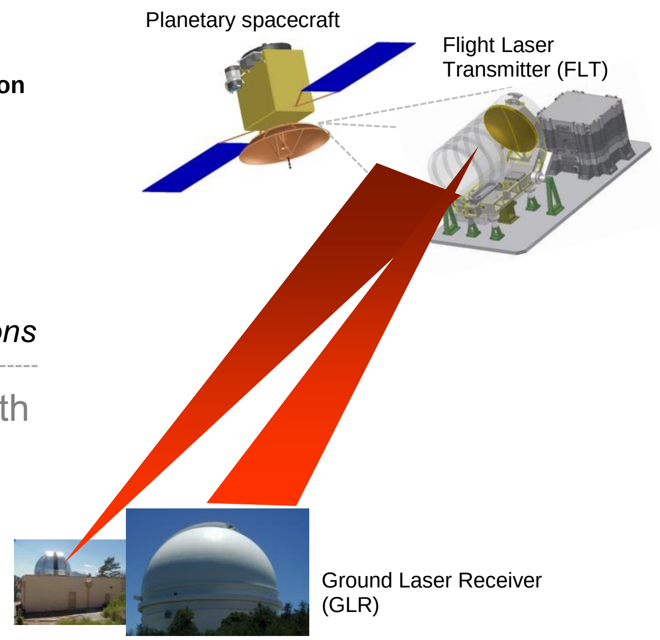

Deep-Space Optical

Future high-rate inter-planetary communications

Order of magnitude higher data-rates with same mass and power as state-of-art telecommunication systems and no additional demand on spacecraft

TECHNOLOGY OBJECTIVES

Demonstrate deep space optical communication to retire the risk of implementation in future inter-planetary missions

- At least 10 × downlink data-rate with equivalent mass and power Ka-band terminal to an existing ground telescope (MRO class telecom to 34 m antenna)
- Link operations over diverse atmospheric and link conditions

SCIENTIFIC RELEVANCE

Optical communications will enhance data-exchange rates and volumes from future deep-space spacecraft. Streaming back high-definition imagery and enabling human missions to deep-space are noteworthy benefits to be derived from the higher communication capacity of optical communications.

With technology maturation high-precision (sub-cm) ranging and light science will further enhance the benefits of optical communication.

IMPLEMENTATION HIGHLIGHTS

Deep-space link difficulty from Mars ranges are 30-40 dB higher than the successful Lunar Laser Communication Demonstration recently concluded with resounding success. The increased difficulty cannot be bridged by scaling but needs innovative technologies that conform the resource limits of typical deep-space missions.

Flight transceiver mass (kg)	**22 + Cont. + Margin.**
Electrical power (W DC)	**61 + Cont. + Margin.**
Laser pointing accuracy (μrad)	**<1**
Max. downlink date rate (Mb/s)	**264**
Comm efficiency (bits/photon)	**2**

The Flight Laser Transmitter (FLT)

- ***22-cm*** *diameter off-axis Gregorian*
- ***4-W*** *average power* ***1550 nm*** *laser*

The Ground Laser Transmitter (GLT)

- ***5 kW*** *average power* ***1030 nm*** *laser*
- ***1m*** *Optical Communication Telescope Laboratory (OCTL) Table Mtn., CA*

The Ground Laser Receiver (GLR)

- ***5m*** *Hale Telescope, Palomar Mtn.,CA*

– ***>50%** detection efficiency photon-counting detector Optical Receiver*
– ***1 dB** near-capacity serially-concatenated pulse-position modulation (SCPPM) coding/modulation*
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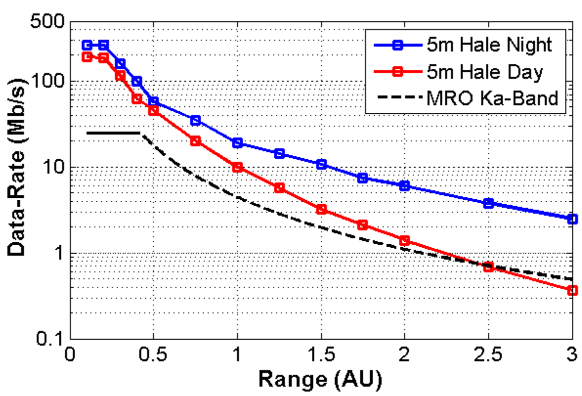
TECHNOLOGY HIGHLIGHTS

Lightweight pointing architecture
- Spacecraft disturbance isolation
- Space photon-counting camera
- Earth transmitted dim beacon

Power-efficient communications with faint deep-space signals
- Pulse-position-modulated (PPM)
- High-peak-to-average power master-oscillator power amplifier (MOPA) laser
- Tungsten silicide (WSi) superconducting nanowire single photon-counting detector (SNSPD)

Performance example of FLT hosted by a Mars Orbiter



OPERATIONS

Day and night links whenever cloud-free-line-of-sight is available. Earth laser beacon assisted acquisition and link operations. Link demonstrations down to 12° sun-earth-probe angles due to existing ground telescope limitations

POC (JPL)

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SCHEDULE

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Technology Maturation to TRL-6 by 3/17