NASA SBIR 2018 Phase I Solicitation

H9.01 Long Range Optical Telecommunications

Lead Center: JPL

Participating Center(s): GRC, GSFC

Technology Area: TA5 Communication and Navigation

The Long Range Optical Communications subtopic seeks innovative technologies in free-space optical communications for increased data volume returns from space missionsÂ in multiple domains: >100 gigabit/s cis-lunar (Earth or lunar orbit to ground), >10 gigabit/s Earth-sun L1 and L2, >1 gigabit/s per AU-squared deep space, and >100 megabit/sÂ planetary lander to orbiter.

Proposals are sought in the following specific areas (TRL3 Phase I to mature to TRL4 to 5 in Phase II):

Flight Laser Transceivers:

- Low-mass, high-effective isotropic radiated power (EIRP) laser transceivers: 30 to 100 cm clear aperture diameter telescopes for laser communications. Â Targeted mass less than 65 kg/square-meter with wavefrontÂ errors less than 1/25th of a wavelength at 1550 nm.Â Cumulative wavefront error and transmission loss not to exceed 3-dB in the far field. Advanced thermal and stray light design so that transceiver can survive direct sun-pointing and operate while pointing 3-degrees from the edge of the sun; wide range of allowable flight temperatures by the optics and structure, at least -20Â° C to 50Â° C operational range, wider range is preferred.
- Diffraction limited field-of-view at focal plane of at least 1 milliradian radius, provision for point-ahead implementation from space.
- Beaconless pointing subsystems for operations beyond 3 A.U.: Point 20 to 100 cm lasercomm transmitter aperture to an Earth-based receiver with a 1-sigma accuracy of betterÂ than 100 nanoradians with an assumed integrated spacecraft micro-vibration angular disturbance of 150 micro-radians (<0.1 Hz to ~500 Hz) without requiring a dedicated laserÂ beacon transmission from Earth; lowest subsystem mass and power is a primary selection factor.
- Low mass/low power/cold survivable optical transceivers for planetary lander to orbiter links [7]: bi-directional optical terminals with data rates from >100 megabit/second at aÂ nominal link range of 1000 km, with an individual terminal mass <5 kg and operational power < 25W, including a pointing system for at least full hemisphere coverage.
- Terminals shall be capable of operationally surviving >500 cycles of unpowered temperature cycling from -40Â° C to +40Â° C and a 100 krad TID. Discussion of acquisition andÂ tracking con-ops and requirements is a must.

Flight Laser Transmitters and Receivers:

- High-gigabit/s laser transmitter and receiver optical-electronic subsystems: space qualifiable 1550 nm laser transmitter and receiver optoelectronic modulator, detection, and forward-error-correction (FEC) assemblies for data rates from 1 gigabit/s to >200 gigabits/s with power efficiencies better than 10W per gigabit/s and mass efficiencies better thanÂ 100 g per gigabit/s.
- Radiation tolerance better than 50 Krad is required.
- Technologies for efficient waveform modulation, detection, and synchronization and on-boardÂ low-gap-to-capacity forward-error-correction decoding are of interest.
- Also of interest are hybrid RF-optical technologies.
- Integrated photonic circuit solutions are stronglyÂ desired.
- High efficiency (>20% DC-to-optical, including support electronics) space qualifiable (including resilience to photo-darkening) multi-watt Erbium Doped FiberÂ Amplifier (EDFA) with high gain bandwidth (> 30nm, 0.5 dB flatness) concepts will be considered. Detailed description of approaches to achieve the stated efficiency is a must.Â High peak-to-average powers for supporting 7-aryÂ to 8-ary pulse position modulation (PPM).Â
- Space qualifiable wavelength division multiplexing transmitters and amplifiers with 4 to 20 channels and average output power > 20W and peak-to-average power ratios >200Â with >10 Gb/s channel modulation capability are also desired.

Narrow Band Pass Optical Filters:

- Flight qualified optical narrow band pass filters with 1 to 2 cm clear aperture and 0.5 1 nm noise equivalentÂ bandwidth with less than 1 dB transmission loss around 1064 nm or optical c-band are also required.

Ground Assets for Optical Communication:

- Large aperture receivers for faint optical communication signals from deep space, subsystem technologies: Demonstrate innovative subsystem technologies for >10 m diameter deep space ground collector capable of operatingÂ to within 3 degrees of solar limb with a better than 10 microradian spot size (excluding atmospheric seeing contribution). Desire demonstration of low-cost primary mirrorÂ segment fabrication to meet a cost goal of less than $35K per square meter and low-cost techniques for segment alignment and control, including daytime operations.
- 1550 nmÂ sensitive photon counting detector arrays compatible with large aperture ground collectorsÂ with integrated time tagging readout electronics for >5 gigaphotons/s incident rate. Time resolution <100 ps 1-sigma and highestÂ possible single photon detection efficiency, at least 50% at highest incident rate, and total detector active area > 0.2 mm^2. Integrated dark rate < 5 megacount/s.
- Cryogenic optical filters for operation at 40K with sub-nanometer noise equivalent bandwidths in the 1550 nm spectral region, transmission losses < 0.5 dB, clear aperture >35Â mm, and acceptance angle >40 milliradians with out-of-band rejection of >65 dB from 0.4 to 5 microns.

For all technologies, lowest cost for small volume production (5 to 20 units) is a driver. Research must convincingly prove technical feasibility (proof-of-concept) during Phase I,Â ideally with hardware deliverables that can be tested to validate performance claims, with a clear path to demonstrating and delivering functional hardware meeting allÂ objectives and specifications in Phase II.