This subtopic seeks innovative technologies for long range Optical Telecommunications supporting the needs of space missions. Proposals are sought in the following areas:

Systems and technologies relating to acquisition, tracking and sub-micro-radian pointing of the optical communications beam under typical deep-space ranges (to 40 AU) and spacecraft micro-vibration environments, as follows:

- **Small lightweight two-axis gimbals:** Flight qualifiable, less than 2 kg in mass capable to actuating payload mass of approximately 3 kg at rates up to 5 degrees/second, less than 30 micro-radian jitter, 30 micro-radian rms error and blind-pointing accuracy of less than 35 micro-radian. Proposals should come up with innovative pragmatic designs that can be flown in space.

- **Photon counting Si, InGaAs, and HgCdTe detectors and arrays:** For the 1000 to 1600 nm wavelength range with single photon detection efficiencies greater than 60% and output jitters less than 20 pico-second, active area greater than 20 microns/pixel, and 1 dB saturation rates of at least 100 mega-photons (detected) per pixel and dark count rates of less than 1 MHz/square-mm.

- **Single-photon-sensitive, high-bandwidth, linear mode photo-detectors:** With high bandwidth (>1GHz), high gain (>1000), low-noise (<1kcps), large diameter (200 micron), HgCdTe avalanche photodiode and/or (small diameter) arrays for optical detection at 1060 nm or 1550 nm.

- **Uncooled photon counting imagers:** With >1024 x 1024 formats, ultra low dark count rates and visible to near-IR sensitivity.

- **Ultra-low fixed pattern non-uniformity NIR imagers:** With large format (1024x1024), non-uniformity of less than 0.1%, low noise (<1e- read, <1ke/pix/s dark) and high (>0.7) quantum efficiency.

- **Radiation hard photon counting detectors and arrays:** For the 1000 to 1600 nm wavelength range with single photon detection efficiencies greater than 40% and 1dB saturation rates of at least 30 mega-photons/pixel and operational temperatures above 220K and dark count rates of <10 MHz/mm. Radiation levels of at least 300 krad (unprotected).

- **Isolation platforms:** Compact, lightweight, low power, broad bandwidth (0.1 Hz -3 kHz) disturbance rejection.

- **Laser transmitters:** Space qualifiable, greater than 20% wall plug efficiency, lightweight, 20-500 pico-second pulse-width (10 to >100 MHz PRF), tunable (~0.2 nm) pulsed 1064-nm or 1550-nm laser transmitter fiber or planar-waveguide MOPA sources with greater than 1 kW of peak power per pulse (over the entire pulse-repetition rate), with Stimulated Brillouin Scattering suppression and >10 W of average power, near transform limited spectral width, and less than 10 pico-second pulse rise and fall times. Also of interest for the laser transmitter are: robust and compact packaging with radiation tolerant electronics inherent in the
design, and high speed electrical interface to support output of pulse position modulation encoding of sub nanosecond pulses and inputs such as Spacewire, Firewire or Gigabit Ethernet. Detailed description of approaches to achieve the stated efficiency is a must.

- **Low-cost ground-based telescope assembly:** With diameter greater than 2-m, primary mirror with f-number of ~1.1 and Cassegrain focus to be used as optical communication receiver optics. Maximum RMS surface figure error of 1-wave at 1000 nm wavelength. Telescope shall be positioned with a two-axis gimbal capable of 0.25mrad pointing. Combined telescope, gimbal and dome shall be manufacturable in quantity (tens) for ~$3 M each.

- **Daytime atmospheric compensation techniques:** Capable of removing all significant atmospheric turbulence distortions (tilt and higher-order components) on an uplink laser beam; and/or for a 2-m diameter downlink receiver telescope. Also of interest are technologies to actively compensate for the static and dynamic (gravity sag and thermal) aberrations of 2-m diameter telescopes with a surface figure of 10's of waves (down to less than 1-wave at 1000 nm).

Research should be conducted to convincingly prove technical feasibility during Phase I, with clear pathways to demonstrating and delivering functional hardware, meeting all objectives and specifications, in Phase II.

Phase I Deliverables:

- Feasibility study, including simulations and measurements, proving the proposed approach to develop a given product (TRL 3-4)
- Verification matrix of measurements to be performed at the end of Phase II, along with specific quantitative pass-fail ranges for each quantity listed.

Phase II Deliverables:

- Working brassboard model of proposed product, along with full report of development and measurements, including populated verification matrix from phase II (TRL 5).
- Opportunities and plans should also be identified and summarized for potential commercialization.