Design, Development and Supply of Mini-OCT
- Specification Document

I. Scope

The scope of this procurement is

1. The party shall Design, Develop and Supply the Engineering Model (EM) of miniaturized Optical Communication Terminal (Mini-OCT) with integrated coarse and fine pointing system for Direct-To-Earth free space optical downlink from a satellite to ground with data rate of 1 Gbps, complying to detailed specifications given in below.
2. The party shall also supply the associated test checkout system, design documents, test reports etc. as listed in deliverables section of this specification document.
3. The party shall demonstrate the functional performance and specification compliance of Mini-OCT in lab and field tests using its own facilities, measuring equipment and its own scaled, counter-OCT mimicking as optical ground station.

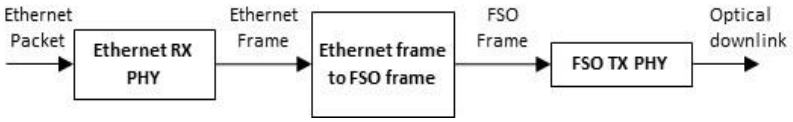
Further sections in this document, provide the technical specifications for this design configuration.

II. Configuration

1	Configuration	• **Link Configuration**: Downlink only. Direct to Earth (DTE) free-space Optical downlink from a Low Earth Orbit (LEO) satellite to optical Ground Station • **System Configuration**: Consist of free-space optical transmitter for data downlink; Beacon receivers, Coarse pointing gimbal and fine pointing mechanism for beacon acquisition and tracking.
2	Free space link distance	500 km to 1000 km (LEO orbit: 500 km, Circular)
3	Model	**Engineering Model using COTS components.**

III. Transmitter specifications

1	Transmit Wavelength	1550 nm band
2	Tx. maximum optical output power	≥ 1 W (30 dBm)
3	Tx. optical Beam Divergence ($1/e^2$)	± 0.3 milliradian (tolerance: ± 10%)
4	Data Rate	Configurable data rate: 500 Mbps and 1Gbps
5	Modulation	On-Off Keying Non-Return-to-Zero (OOK-NRZ)

6	High Speed Data Handling	• Ethernet Interface. Typically, mini-OCT data handling logic shall suitably convert Ethernet packets to Free Space Optical (FSO) frames for transport across optical downlink as follows –  • This scheme permits the mini-OCT to carry almost any form of Ethernet traffic transparently between a pair of OCTs. The presence of the mini-OCT is transparent to the endpoints. • Typically, FSO frame consists of frame header, fixed length data packet and CRC. • The party may define its custom structure of FSO frame format such as header content, width, length of the data packet and CRC. The party shall design & develop this frame conversion logic and provide the details of the same as part of design document.
IV. Beacon sensor Specifications		
1	Sensor Configuration	Shall consist of 1. Wide FOV coarse beacon sensor 2. Narrow FOV fine beacon sensor
2	Receive Beacon Wavelength	NIR band, ~ 850 nm (Typ.)
3	Beacon irradiance at the plane of receive aperture	5µW/m^2 (Typ.)
5	Beacon Modulation	Modulation Type : Amplitude Modulation (AM) Modulation Index (MI): 10% to 50% Modulation Frequency: Typ. 1kHz, Sine wave
6	Coarse Beacon Sensor FOV	± 17.4 milliradian (tolerance: ± 10%)
7	Fine Sensor	Shall have coherent beam tracking for modulated beacon (Typ. frequency: 1 kHz)
V. Pointing, Acquisition and Tracking Specification		
1	Configuration	• Closed loop system having Coarse and fine beacon sensors with corresponding coarse and fine pointing mechanisms • Shall facilitate terminal coarse and fine pointing, beacon acquisition and tracking.
2	Coarse Pointing Mechanism	2-axis gimbal with encoder feedback: Azimuth and elevation (independent movement)
3	Coarse pointing Range	Azimuth : ± 110 degrees (typ.) Elevation : ± 45 degrees (typ.)

4	Max. Angular speed (both axes)	≥ 5 degree/s
5	Max. Angular acceleration/deceleration (both axes)	≥ 1 degree/s^2
6	Fine Sensor optical path	Shall share the common optical path with Tx beam incorporating dichroic splitter (1550nm/850nm)
7	Beacon Acquisition	Autonomous with time tagged command planning
8	Beacon Acquisition time	Within 5 seconds. (after initial pointing to downlink start)
9	Overall pointing/tracking accuracy in closed loop	< ± 30µrad (1/10^{th} of Tx beam divergence)
10	Fine Tracking control Bandwidth	>= 100 Hz
VI. Electrical Interfaces		
1	Power interface	• Single isolated power supply (28 to 42 VDC Raw Bus) on 9-pin D-sub connector • Mini-OCT shall have in-built latch-up protection circuit.
2	Housekeeping interface	1. SPI and MIL-STD-1553B 2. ON/OFF TM status 3. Current Monitoring (Analog or digital) on D-sub Connector
3	High Speed data interface	Ethernet PHY on compatible connector
VII. Mass, Power, Volume		
1	Mass	≤ 6 kg
2	Power	≤ 40 W
3	Volume	Compact, typically 200mm x 200mm x200 mm
4	Operating Temperature	0 °C to +40 °C
5	Storage Temperature	-40 °C to +60 °C
VIII. Checkout Test Console specification		
The party shall design, develop and supply GUI based checkout test console operating on Windows/Linux platform for control, monitoring and logging the various parameters of Mini-OCT through SPI and MIL-STD-1553B interface. The required hardware and software shall be part of this checkout test console. The checkout test console shall have following features-		
1.	High Speed Data transfer	The software shall be able to select the Ethernet packets, text file, image file or video file for transferring to Mini-OCT over Ethernet PHY using the appropriate hardware.

2.	Controls	The software shall provide commands to control/configure – 1. Mini-OCT Mode of Operation: a. PAT enable/disable b. Data transfer enable/disable 2. Data rate: 500 Mbps or 1 Gbps 3. Output Optical Power: 100 mW to 1W 4. Open-loop Gimbal pointing over complete range 5. Coarse Beacon Sensor controls 6. Any other controls as per action generated during Detailed Design Review
3	Monitoring/Telemetry	• Checkout console shall typically monitor following parameters at every 192 ms or lesser interval, with real time graph wherever applicable 1. Optical power 2. Gimbal encoder parameters 3. Coarse Beacon sensor parameters 4. Fine Beacon Sensor parameters 5. Thermistors, typically two 6. ON/OFF status 7. Mini-OCT: Mode of operation a. Pointing/Acquisition/Tracking mode b. Data transfer Status 8. Any other parameter as per actions generated during Detailed Design Review • Shall have option to log all the parameters at every 192 ms or lesser interval for offline data analysis.
IX. Acceptance Test Plan		
1	**Lab Tests at subsystem level shall comply to the following -** • 1550nm Laser source modulation at 1 Gbps • Tx divergence measurement: $\pm$ 0.3 milliradian (tol: +/-10%) • Closed loop beacon pointing and tracking within $\pm$ 30μrad, 100 Hz bandwidth • Coarse and fine Beacon sensor FOV measurement within $\pm$ 10% tolerance of design value • Coarse Beacon sensing accuracy within $\pm$ 10% tolerance of design value, rejection of other light sources	
2	**Field Tests** • The party shall carry out field tests with their own scaled, compatible counter-OCT to demonstrate end-to-end functional performance over the link distance of at least 3km. • The party shall establish Mini-OCT operation over link distance of 500 km to 1000 km, either by calculation or simulation using field test data.	

X.	**Reviews by LEOS Team**
1	**<u>Detailed Design Review</u>** • To consolidate the system specifications, interfaces and to validate the electronics, opto-mechanical and optical design in terms of adequacy and testability, a detailed design review will be carried out. All actions generated as part of this review shall be recorded and complied before the start of fabrication. • The party shall intimate their readiness for review at least 1 week in advance with relevant document and ensure that it is conducted **within 8 weeks from the release of Purchase Order.**
2	**<u>Critical Design Review</u>** • To review the lab test results and validate the specification conformance of the various sub-systems of Mini-OCT with respect to design tolerance, a critical design review will be carried out. All actions generated as part of this review shall be recorded and complied before going for field trials. • The party shall intimate their readiness for review at least 3 weeks in advance with relevant document and ensure that it is conducted **within 24 weeks from the release of Purchase Order.**
3	**<u>Pre-Dispatch Review</u>** • To review the field test results, non-conformances/deviations and their closeouts prior to shipment of the unit, a pre-dispatch review will be carried out. All actions generated as part of this review shall be recorded and complied before the shipment. • The party shall ensure that it is conducted at least **2 weeks prior to scheduled shipment**.
XI.	**Mandatory Requirements**
1	The party shall have the expertise in design, development, realization and testing of free space optical communication terminals. As a part of technical bid, the party shall mandatorily submit documentary evidence such as publications/patents/design report/purchase orders etc., which ascertains their expertise in realization of free space optical communication terminal.
2	The party shall have all the facilities and measuring equipment to carry out Lab tests at subsystem/system level.
3	The party shall have their own scaled, compatible counter-OCT to demonstrate the performance during field/lab tests

XII. Deliverables	
1.	One Unit of Engineering Model (EM) of Mini-OCT along with mating connectors and accessories.
2.	One unit of checkout test console as per specifications listed in section VIII. This shall include power sources, necessary test systems, software, Laptop, harness, fixtures etc.
3.	Mechanical 3D CAD model, FE model and Thermal Model of the unit.
4.	User manual having operating, handling, storage and transport instructions.
5.	Detailed Design Document (Soft Copy/ Hard copy), with Bill of Materials (BoM)
6.	Critical Design Document (Soft Copy/ Hard copy)
7.	Consolidated Test Report –encompassing all tests such as PCB level, subsystem level, system level and field test results.
XIII. Delivery Schedule and Warranty	
1.	Delivery of all the above, shall be completed **within 32 weeks after the release of Purchase Order.**
2.	The party shall provide the warranty for a period of 1 year from the date of acceptance of Mini-OCT at LEOS.
XIV. Quotation Format	
1.	The party shall note that this is **two-part public tender** wherein, technical bid and commercial/price bid have to be separately uploaded. The technical bid shall contain the compliance against all the specifications along with terms and conditions to execute the purchase order. **Any indication of price in the technical bid will lead to rejection.**
2.	As a part of technical bid submission, the party shall necessarily upload following documents 1. Point by point specification compliance report, which shall include compliance against each of the above sections and sub-sections 2. The compliance shall be supported with documentary evidence and technical datasheets/datasets wherever applicable. Simple duplication of specifications will lead to rejection of the offer. 3. The party shall provide documentary evidence such as publications/patents/design report/purchase orders etc., which ascertains its expertise in realization of free-space optical communication systems
3.	The price bid shall include the pricing information for all the deliverables as listed in section XII.