SPECIFICATION SHEET

SUPPLY, INSTALLATION AND STARTING-UP OF AN OPTICAL GROUND STATION FOR SATELLITE CONNECTIONS FOR ICFO, FUNDED BY THE <NATIONAL HUB OF EXCELLENCE IN QUANTUM COMMUNICATIONS> PROGRAM OF THE MINISTRY FOR DIGITAL TRANSFORMATION AND THE PUBLIC SERVICE IN THE EUROPEAN UNION-NEXTGENERATIONEU/PRTR.

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CLAUSE 1. Object of the contract

The object of the contract is the supply, installation and starting-up of an Optical Ground Station (OGS) for satellite connections at ICFO capable of operating quantum communication protocols in the metropolitan area of Barcelona.

CLAUSE 2. Needs to satisfy

ICFO Optoelectronics Group (OptoGroup) actively participates in the development and demonstrations of quantum communication technologies in practical applications and real-world environment within the "*Hub Nacional de Excelencia de Comunicaciones Cuánticas*" Spanish national initiative.

In particular, quantum communication protocols performances are limited by the great losses across fiber-based optical networks over long distances, making the use of trusted-nodes or quantum-repeaters unavoidable with the current state-of-the-art technology.

On the other hand, satellite-based optical links with the ground allow long distance quantum communication due to the lower losses in the free-space optical transmission. To validate optical satellite-to-ground links, it is essential to have an Optical Ground Station (OGS) capable of supporting classical optical communications (uplink/downlink, at day and night) and quantum communications (downlink, at night).

The OGS will need to enable demonstrations and use-cases with advanced Quantum Key Distribution (QKD) protocols running over optical links established with satellites orbiting in the LEO orbit under real environmental conditions, ensuring compliance with international standards in the space industry. In particular, demonstrations with soon-to-be-launched LEO satellite EAGLE-1 will need to be executed. Furthermore, the OGS will enable the integration of the Barcelona classical and quantum networks with other distant metropolitan networks, both inside and outside national territory.

CLAUSE 3. Essential Requirements

We hereby define OGS as the assembled components (systems and subsystems) necessary to establish optical links with a satellite. The bidder proposal shall contain the following mandatory requirements:

Functional Requirements:

1. **Communication Capabilities**
    a. The OGS components must establish and maintain optical links for classical channels using laser communication (both in uplink and downlink directions, and during both day and night) to transmit and receive data to/from laser communication terminal on a satellite.
    b. The OGS components must be seamlessly upgradable to establish and maintain optical links for quantum channels using QKD protocols to receive quantum signals from a satellite during night, without the need of replacing any of the principal components (telescope system, protecting system, Pointing-Acquisition-Tracking system, uplink/downlink system).

c. The OGS components must have the capability of performing simultaneous classical (uplink and downlink) and quantum communications (downlink) with satellites once upgraded for QKD.
d. The OGS components must be compatible with EAGLE-1 satellite (see EAGLE1-01368-OGS-SPC-TCO document).
e. The OGS must comply with SDA OCT 3.1 and SDA OILS 2.1.2 standards documents with regard to the interested components and functionalities (e.g PAT system, uplink/downlink system).
f. The OGS components must comply with CCSDS 141.0-B-1 (Optical Communication Layer) document with regard to the interested components and functionalities (e.g uplink/downlink system).

2. Orbit Capabilities

a. The OGS must establish and maintain optical links for classical laser and quantum QKD communications with satellites orbiting in the Low Earth Orbit (LEO).
b. The OGS must be able to establish and maintain optical links with a satellite orbiting in the sun-synchronous orbit (SSO) between 454 Km and 600 Km.
c. The OGS must be able to receive ephemeris (tracking data) from the LEO satellites operators, in particular from EAGLE-1 operator, in Consolidated Prediction Format (CPD).

3. Protection Capabilities

a. The OGS must be protected by a system structure able to endure atmospheric condition like rain, wind, hail, storms.
b. The OGS must be protected or allow protection against and endure electric discharges.
c. The OGS system structure must endure small earthquakes and unexpected external vibrations caused by human intervention.

4. Optical Subsystems Capabilities

a. The OGS telescope must have a minimum aperture diameter of 700mm, with a linear central obscuration of equal or less than 35%, and must operate in the C-band region of the electromagnetic spectrum.
b. The OGS Pointing-Acquisition-Tracking system must be compliant with SDA 2.1.2, SDA OCT 3.1, CCSDS 141.0-B-1. Moreover, it must comply with EAGLE1-01368-OGS-SPC-TCO – Chapter 3.3 – “PAT Requirements” and with EAGLE1-SYS-TE-ICD-0087 Chapter 4.4 – “Interface Definition - Pointing, Acquisition and Tracking Strategy”.
c. The uplink/downlink optical system must be compliant with SDA 2.1.2, SDA OCT 3.1, CCSDS 141.0-B-1. Moreover, it must comply with EAGLE1-SYS-TE-ICD-0087 Chapters 4.2 /4.3 – “Uplink”/”Downlink”.
d. The OGS optical fibres interfaces must be compatible with EAGLE-1 specifications or be seamlessly upgradable or substitutable to comply with EAGLE-1 specification described in EAGLE1-00149-SYS-SPC-FAU – Chapter 3 – “QKD Receiver Fibre Interface”).

Operational Requirements:

5. **Control and Monitoring**
   a. The OGS must allow remote-control operation with a control software.
   b. The OGS must allow real-time monitoring of optical links and systems /subsystems health.
   c. The OGS must allow full connection to the public or private internet of its control system.

6. **Performance Targets**
   a. The OGS must be compatible to allow an average net on-axis receive gain > 116.2 dB for quantum channel once upgraded for QKD. (The "net" gain includes the effective on-axis antenna gain and all the sources of loss on the quantum signal between the free-space interface at the telescope aperture and the SMF coupled signal (i.e., any obscuration, transmission losses on the optical path, vignetting, fibre-coupling efficiency. Compliance to this value is strictly connected to the capacity of the QKD system to distribute secret keys).
   b. The OGS must be compatible to allow the quantum channel at 1565.50 nm (ITU-T #15).
   c. The OGS must be compatible to allow background light suppression ≥120 dB for the quantum channel once upgraded for QKD.
   d. The OGS must introduce a phase variation not greater than 30 mrad over 1 ns.
   e. The OGS must be able to operate at irradiance levels defined by document EAGLE1-SYS-TE-ICD-0087 – Chapter 4.2/4.3 – Uplink/Downlink).
   f. The OGS must possess a link-loss recovery strategy and automatic re-acquisition of the satellite with which it has established an optical link.
   g. The OGS must have a time reference with sufficient accuracy to achieve the tracking of LEO satellites in space.

7. **Miscellaneous**
   a. The OGS must operate in the Spanish electrical grid infrastructure.
   b. The OGS components must allow their re-installation in different locations.
   c. The proposal must include defined maintenance routines for the care of the OGS.

Regulatory Requirements:

8. **Warranty and Support**
   a. A **Minimum 1-year Full Warranty** on all parts and components of the system irrespective of the manufacturer. The warranty will include the replacement of any faulty or damaged part(s) during the normal use of the system, no matter the manufacturer of the component(s). It will cover any cost related with the disassembly, transportation, reparation and re-assembly of the damaged component(s), including all travelling and living costs of the required service engineer(s). An on-site repair, or a justified alternative to reduce the system down time to the minimum, will always be the first service option. A team of properly qualified and skilled service engineers will have to be available. It will also cover the costs and the maintenance related to the machine move and installation on the new building. **Additional years of warranty will be evaluated positively as stated in the Annex núm. 3.**

b. System lifetime support: By phone and e-mail with a response within 48 hours. Emergency visit after a system breakdown within 10 working days, once the parts are available and shipped to the customer.
c. Application support within 10 working days.

9. **Test & Validation (FAT) and Payment**
A Factory Acceptance Tests (FAT) must be carried out well in advance so that, whether at principal component level or at full OGS system level, delivery is made before 25th August 2026.

10. **Documents**
a. A complete set of manuals, drawings, schematics and layouts about system assembly and configuration must be provided.
b. A complete systems user manual, including routine servicing, troubleshooting and basic repairs must be provided.
c. A systems components spare list, specifying quantity, manufacturer, part number, etc must be provided.
d. All the above documentation will be supplied in English, in electronic format (USB drive) and in paper copy.
e. Draft document of complete technical project and project management plan must be provided.

11. **Compliance**
a. The bidder must be based in an EU-27 country.
b. The bidder must comply with export regulations controls of the European Union for the procurement of components, sub-systems and the delivery of equipment.
c. The OGS must not make use of ITAR restricted items.
d. The OGS must comply with IEC 60825 for laser safety, or equivalent.

CLAUSE 4. OGS Systems Requirements

The OGS optical link will be used as a communication channel for quantum key distribution protocols at an operating wavelength in the C-band (in downlink direction). Also, the optical link will be used as a bidirectional communication channel for classical laser communications in space, which will serve also as the service channel for the QKD protocols (uplink and downlink direction). The OGS will require a telescope system, a Point-Acquisition-Tracking (PAT) system, an uplink/downlink system for laser communications, a protection infrastructure, free-space-to-fibre interfaces, and a system to mitigate atmospheric distortion to improve the losses through the established optical ground-to-space link. Once the quantum signal of the QKD protocol used by EAGLE-1 satellite is received by the telescope, it will be coupled into Polarization Maintaining Single Mode Fibre (PM SMF) and go to the QKD receiver. The classical downlink channel does not need to be coupled in the PM SMF.

The OGS proposal may contain the following components (systems and sub-systems) and relative requirements that will be evaluated according as established in Annex 3:

General:

1. The OGS will include a control room to accommodate at least a 19-inch rack between 42-48 RU (rack units) to support the station's computer & controller and the potential optical modems and QKD receiver.
2. The OGS will include an environmental monitoring system.
3. The OGS will include an ethernet connector-based interface enabling bidirectional TCP/IP connection for the receive the ephemeris of LEO satellites via internet.
4. The OGS will be able to support QKD at sun elevation lower than -10º with respect to OGS location once upgraded for QKD.
5. The OGS will introduce less than 5% irradiance variation within 1ns for the quantum signal once upgraded for QKD.
6. The OGS will have a Polarization Extinction Ratio better than -25 dB after the coupling in the PM SMF as specified in EAGLE1-00149-SYS-SPC-FAU document.
7. The OGS will allow implementation of an optical fibre interface routing the quantum channel to the QKD receiver from the Turbulence Mitigation system. This interface will consist of a PM SMF with FC/APC connectors, Numerical Aperture of 0.125, core diameter of 8.5 µm and mode field diameter of 10.1 µm ± 0.4 µm.
8. The OGS will support both Left-Hand and Right-Hand polarizations for the quantum signals up to the PM SMF.
9. The OGS system must have a minimum operational temperature range between -10ºC and 45ºC and operational humidity range between 10 – 90 % RH (non-condensing).
10. Minimum lifetime of the OGS of 10 years (without refurbishing).

Telescope System:

11. The telescope will have a moving alt-azimuth motorized, direct-drive mount with high precision encoders, full automatized to interface and operate alongside the PAT system and with the station control software.
12. The telescope will have an azimuthal range of minimum 540º (continuous rotation) and an elevation range of minimum 10º to 90º.
13. The telescope will be compliant with PAT specification standards required in SDA OCT 3.1.
14. The telescope will come with an integrated structure able to accommodate a turbulence mitigation system or will provide a telescope to mitigation-system infrastructure that keeps optical loss as low as possible.
    INFO – The maximum tolerable optical loss from the free-space interface (telescope aperture) to the QKD receiver for the EAGLE-1 QKD protocol is 7 dB (see EAGLE-1-PROT-QKD document).

PAT System:

15. The maximum allowed zenith avoidance angle will be < +/- 8 degrees around the zenith direction.
16. The Optical Ground Station PAT system will be designed to cope with the following position errors (including potential time errors) on the orbital information data:
    Along track: 165m (3σ)
    Cross track: 165m (3σ)
    Radial: 165m (3σ)

17. For acquisition purposes, the OGS Acquisition Sensor (AS) field of view will be large enough to accommodate the initial uncertainty cone and a potential scan over it.

Uplink/Downlink System:

18. The uplink/downlink system will comply with SDA-OISL 2.1.2 and EAGLE1-SYS-TE-ICD-0087 – Chapter 4.2/4.3 – Uplink/Downlink documents.
    INFO - The irradiance levels and elevation angles for start of acquisition and communication are defined in EAGLE1-SYS-TE-ICD-0087 – Chapter 4.2/4.3 – Uplink/Downlink document.
19. The OGS will support unpolarized or polarized optical signal for the uplink channel and any polarization for the downlink channel.

Protection Infrastructure:

20. The protection infrastructure will minimize its footprint, allowing compatibility with the telescope mount and an internal clearance for access and small auxiliary equipment accommodation (e.g electric cabinet, fibre tray, small table etc)
21. The protection infrastructure will support stable airflow and thermal management to avoid turbulence inside the structure.
22. The protection infrastructure will support automatic control interfaced with the control software of the station.
23. The protection infrastructure will allow a reinforced concrete pillar decoupled from the infrastructure floor needed to support the telescope and its mount.

CLAUSE 5. Additional Requirements

We will evaluate the following optional improvements included in the proposal as stated in Annex 2:

Turbulence Mitigation System:

We will evaluate the turbulence mitigation system's ability to couple the quantum signal in a polarization-maintaining Single Mode Fibre with specified performance in the atmospheric conditions typical of the identified OGS location.
INFO - The atmospheric transmission model used to design the QKD protocols performances is based on 10 Km visibility in an urban environment, with a turbulence model corresponding to the Hufnagel-Valley 5/7 and a Fried Coherence Length of 10.3 cm at 1550 nm, at 20º elevation.
INFO – The maximum tolerable optical loss from the free-space interface (telescope aperture) to the QKD receiver for the EAGLE-1 QKD protocol is 7 dB, and it includes also the potential turbulence mitigation system loss between them.

Uplink/Downlink:

Optical Modems
We will evaluate the inclusion of optical modems in the uplink/downlink system for carrying out classical laser communication (uplink/downlink) with LEO satellites.

Regulation:

FAT (Factory Acceptance Test)
We will evaluate the quality of the Factory Acceptance Test (FAT) Plan provided in terms of measurability of the tests, integration of the components and functionalities tested.

CLAUSE 6. Transportation, installation and start-up

6.1. The proposal will include transportation to ICFO's facilities including insurance and all export/import and customs duties.

6.2. The machine will be placed in the selected location by within the facilities it has in the metropolitan area of Barcelona. Contract winner will cover all costs, organization and coordination of machine placement, including any required specialized equipment or vehicle, and any required component disassembly and reassembly for system unloading and transportation inside the building.

6.3. Onsite system installation and training to ICFO personnel included: included training of the full OGS use and process to ICFO users and specific maintenance and service training to ICFO lab technicians at ICFO's facilities to occur after the 25th August 2026. The number of training days and approximate schedule will be specified in the proposal.

CLAUSE 7. Timing Conditions

The required activities that must be completed **by 25th August 2026 are the following**:

1. **Project Initiation**
   Documentation required: Project initiation report.

2. **Critical Design Review (CDR) Approval**
   Documentation required: CDR Report.

3. **Procurement of Critical Components**
   Documentation required: Procurement Report.

4. **Factory Acceptance Test (FAT) Completion**
   Documentation required: FAT Report, FAT Protocol signed by both parties.

5. **Delivery of the components Completion**
   Documentation required: Shipment Report.

The following general activities may be executed, according to the awarded proposal**, within a period of 6 months after the delivery date:**

6. Definition of a final Installation project management plan.
7. Site Acceptance Test (SAT) Plan.
8. Execution of the SAT Plan.

The reduction in delivery time will be scored according to the automatic criteria established in Annex 2

CLAUSE 8. Target price

The target price for the system is 1.840.000,00€ (VAT excluded).

The payment method will be as follows:

98% of the total price: after the delivery, that must be completed by 25th August 2026.
2% of the total price: once the installation and starting-up are completed (in a maximum period of 6 months from the delivery date).

Castelldefels, on the date of its digital signature

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