

SPECIFICATION SHEET

SUPPLY, INSTALLATION AND COMMISSIONING OF A “QUANTUM FREE-SPACE LINK FOR PHOTON LEVEL COMMUNICATIONS FOR THE OPTOELECTRONICS GROUP AT ICFO”, THROUGH AN OPEN PROCEDURE SUBJECT TO HARMONIZED REGULATION

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CLAUSE 1. Object of the contract

The purpose of this contract is the supply, installation and commissioning of a "Supply, installation and commissioning of a QUANTUM FREE-SPACE LINK FOR PHOTON LEVEL COMMUNICATIONS FOR THE OPTOELECTRONICS GROUP AT ICFO.

The types of items supplied are linked to the CPV (Common Public Procurement Vocabulary), **38000000-5** Laboratory, optical and precision equipment (except glasses).

CLAUSE 2. Needs to satisfy

The Optoelectronics Group (OptoGroup) has successfully established a classical free-space link over 20 km, connecting the ICFO building with the Collserola tower. However, implementing a quantum free-space link is essential to performing experiments in the quantum realm. The improvement will enable the distribution and detection of single photons over long distances.

Although state-of-the-art quantum communications over long distances were proven over a decade ago, its implementation towards practical quantum communications remains pending. This step is fundamentally essential to achieve unbreakable communication on a global scale. This type of link is also helpful as an initial test for quantum technology employed over satellite-based links. To evaluate the technological advances developed in the OptoGroup in a real-world quantum channel, it is crucial to have the technology to synchronize, distribute, and measure the quantum signals over a free-space link.

CLAUSE 3. System overview

The horizontal free-space optical link will be used as an optical communication channel for quantum communication experiments at an operating wavelength in the near-infrared. The information will be encoded in the polarization degree of freedom of the photons. It will require a detection unit and a timing synchronization system with a specific characteristic. And a system to mitigate atmospheric distortion is necessary to improve the losses through the established free-space link. Other requirements accompany it on the conditions of installation, transportation, and training of ICFO staff:

- a. Free-space polarization analysis and single-photon detection module
- b. Fast tip-tilt system for turbulence mitigation
- c. Timing synchronization system
- d. Training
- e. Timing conditions
- f. Initial transportation, installation and start-up
- g. Documentation
- h. Warranty and Support
- i. Financing

a. Free-space polarization analysis and single-photon detection module

Polarization analysis and single-photon detection module should count with the following minimum specifications to be evaluated:

1. The polarization analysis module (PAM) and the single-photon detection module must be compatible with a 406 mm aperture, f/8 telescope, and 12 mm beam radius.
2. PAM must have an operational wavelength around 785 nm and 810 nm.
3. PAM must contain individual optical filters for 785 nm and 810 nm with a Full width at half maximum (FWHM) < 20 nm and channel isolation > -5dB.
4. PAM should be compact and able to be hosted in the free-space receiver unit.
5. PAM should be capable of performing polarization measurements in both the D/A and H/V bases, applicable to protocols based on prepare-and-measure as well as entanglement-based approaches. PAM should introduce a mean excess polarization error < 0.5%
6. PAM must include four fast and efficient single-photon detectors.
7. The detectors included in the PAM must be capable of receiving signal with an atmospheric distortion with $r_0 > 2$ cm, detector jitter < 500 ps and field of view < 110 urad.
8. The extinction ratio of the detection module must be better than 1:200.
9. The detection module must be capable to separate, isolate and detect an optical synchronization signal.

b. Fast tip-tilt system for turbulence mitigation

The tip-tilt system must comply with the following requirements:

10. Fast steering mirror.
11. Controller electronics.
12. Stabilization software.
13. Tip-tilt module in the receiver platform must have a detection system for feedback signal with a bandwidth 500 Hz; angular resolution < 1.2 urad and angular range +/- 1.5°.
14. Tip-tilt module in the sender platform must include a wavelength multiplexer with a transmission > 95% and special beam displacement $r_0 = 1.8$ cm.

c. **Timing synchronization system**

The timing synchronization system should comply with the following requirements:

15. Two Rb- clock systems
16. Two GPS clock receivers
17. Two computers for the quantum sender and polarization receiver unit with synchronization software and operation interface.
18. The time synchronization must have a course timing drift of 10 ns/h, time deviation < 50 ps/sec and sync interval of 1 sec.
19. Two time tagging modules with minimum 6 channels, phase locked loop (PLL) 10 MHz, jitter < 50 ps and 80 M tags/sec.
20. The proposal must include a complete set of pictures and diagrams of each subsystem and their integration in the full system, including dimensions, weights and all possible details of the different components.
21. The proposals must include full start-up requirements of power, isolation and installation conditions for the specific configuration of the offered systems.

d. **Training**

System use and process training to ICFO research users and specific maintenance and service training to ICFO lab technicians at ICFO's facilities should be included. The number of training days and approximate schedule will be specified in the proposal.

e. **Timing conditions**

After the Commissioning of the acquiring procedure (T0) these are the required activities that should be complied by T0+6 Month:

22. Factory Acceptance test
23. Delivery of the platforms
24. Hands-on ICFO research personnel training.
25. Site Acceptance Test (ICFO-Torre del Collserola).

f. **Initial transportation, installation and start-up**

List of essential requirements:

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

27. The equipment will be placed in the sender unit (ICFO) and receiver unit (Torre Collserola). The contract winner will cover all costs, organization, and coordination of machines' placement, including any required specialized equipment or vehicle and any required component disassembly and re-assembly for systems unloading and transportation inside the buildings/facilities, following the route specified by ICFO and its partners, if it applies.
28. The contract winner will be responsible for checking the compatibility with the operation of the systems already installed in both sites and user mobility will also have to be guaranteed.
29. Installation and start-up of the system, including system checking, functional tests and process qualification.
30. The contract winner will be responsible for the removal and proper disposal of the packaging when the machine is delivered and unpacked, or its storage during the warranty period in case the original packaging needs to be kept.

g. Documentation

31. Complete set of manuals, drawings, schematics and layouts about system assembly and configuration
32. Complete systems user manual, including routine servicing, troubleshooting and basic repairs.
33. Systems components spare list, specifying quantity, manufacturer, part number, etc.
34. All the above documentation will be supplied in English, in electronic format (USB drive) and in paper copy

h. Warranty and Support

35. A 1-year full warranty, starting at system acceptance. 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.
36. 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.
37. Application support within 10 working days.

i. Financing

This equipment was supported by EuroQCI/PDA

CLAUSE 4. Target price

- The target price for the system is 570.000,00 € (VAT excluded).
- Payment terms:
 - 50% upon drawing signing,
 - 40% upon delivery,
 - 10% after installation training and acceptance.

CLAUSE 5. Delivery time

The system must be delivered and installed at ICFO within a maximum period of **6 months**.

- Delivery time is defined as the time elapsed since the signature of the contract until the system delivery at ICFO facilities. It includes the manufacture of the system, the transportation, the installation and the acceptance test at ICFO's premises.

Castelldefels, on the date of its digital signature

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