

Title: Improving metrological capabilities for testing QKD-systems to facilitate EuroQCI

Abstract

The European Quantum Communication Infrastructure (EuroQCI) Initiative, launched by the European Commission, aims to boost national Quantum Communication Infrastructures (QCIs) to deploy commercially available Quantum Key Distribution (QKD)-systems and other quantum communication systems. This development is particularly relevant, as information security is of critical concern, but the technology has not yet reached widespread practical adoption. Proposals addressing this topic should therefore establish optical measurement capabilities, which are essential to carry out the necessary measurements for the preparation of essential security tools like future certification of Discrete Variable Quantum Key Distribution (DV-QKD) Systems.

Keywords

EuroQCI, Discrete Variable Quantum Key Distribution (DV-QKD), metrology, regulation, standardisation, certification, capacity building

Background to the Metrological Challenges

A key element to protect key EU and national digital assets is to offer critical infrastructures and services a channel for secure communications. The European Commission is working with Member States to put in place a certified secure end-to-end quantum infrastructure, terrestrial and space-based, in combination with the secure governmental satellite communications system laid out in the Space Programme Regulation (EU) 2021/696.

The European Commission launched the European Quantum Communication Infrastructure (EuroQCI) initiative in 2019, which aims to facilitate deployment of fibre communications networks at national level and further cross-border connection in between EU member states. In the Regulation (EU) 2023/588 of the European Parliament and of the Council, responsible for establishing the Union Secure Connectivity Programme for the period 2023-2027, it is foreseen to develop further and gradually integrate EuroQCI into the secure connectivity system. To solve the main issues concerning QKD security, such as standardisation and certification of QKD protocols, side channel analysis and evaluation methodology, the European Commission in 2024 launched project "NOSTRADAMUS". That project aims to set up a testing and evaluation infrastructure that will enable QKD-based technologies and services to be assessed and validated with a possibility of future certification. Operational activities are planned to start in 2026. The next step – cross-border linking of the member state quantum communication infrastructures (QCI-s) is already in preparation. Measurement capabilities that adhere to metrological principles are needed to materialise the vision of more secure critical infrastructure and associated services within all EU member states. This will bring significant benefit to EU citizens in terms of next generation security. The EURAMET EMN Quantum Technologies identified a need for further work in this area in their Strategic Research Agenda (SRA) [1].

EMPIR 19NRM06 METISQ project delivered substantial contribution to the development of traceable methods and protocols for characterisation of assembled QKD modules. Presently, most of the commercially available QKD-systems operate deploying BB84 protocol and are aimed for Discrete Variable QKD due to its performance, especially over longer links and stability. EuroQCI encourages national QCI-s to deploy already existing QKD-systems, preferably of European origin. These requirements present challenges to emerging European national metrology institutes and designated institutes to develop specific measurement capabilities

needed to assure performance of QKD-systems and respond to national QCI deployment and implementation authorities' requirements, which is crucial in securing communication between member states.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The proposal shall focus on the development of metrology capability in QKD-systems.

The specific objectives are

1. To develop measurement systems for the traceable characterisation of QKD-transmitter properties, i.e. mean photon number μ , photon statistics (second-order and higher-order correlation function $g^{(2)}$ and $g^{(n)}$), spectral and temporal characteristics, polarisation state purity, as well as single-photon purity and indistinguishability at the nominal wavelength of 1550 nm with uncertainty values that are required in order to fulfil the requirements for the security proofs;
2. To establish and validate measurement capabilities in necessary range for detecting vulnerabilities (e.g. backflash) of the QKD-receivers. These capabilities include: (i) spectral characterisation of the receiver and the photonic components between emitter and receiver in a broad spectral domain; (ii) temporal analysis at the single photon level of the backflashes emitted by the emitter; (iii) laboratory testing of blinding attacks.
3. To implement traceable measurement capabilities for quantifying loss and monitoring of noise in quantum channels in laboratory conditions and in situ fibre-optic networks connecting QKD-systems at the wavelength of 1550 nm.
4. To facilitate the take up and long-term operation of the capabilities, technology and measurement infrastructure for optical measurements of QKD-systems developed in the project, by the measurement supply chain (NMIs/DIs, calibration and testing laboratories), standards developing organisations (ETSI, CEN/CENELEC, ISO/IEC) and end users (e.g. industry, instrument manufacturers, regulators). The approach should be discussed within the consortium and with other EURAMET NMIs/DIs, e.g. via EURAMET Technical Committee on Photometry and Radiometry (TC-PR) and EURAMET EMN Quantum Technologies, to ensure that a coordinated and optimised approach to the development of traceability in this field is developed for Europe as a whole.

Joint Research Proposals submitted against this SRT should identify

- the particular metrology needs of stakeholders in the region,
- the research capabilities that should be developed (as clear technical objectives),
- the area for which the capabilities will be built (Green Deal, Digital Transformation, Health, Integrated European Metrology, Industry, Normative or Fundamental Metrology) and in which future main call the developed research capabilities are planned to be employed,
- the impact the developed research capabilities will have on the industrial competitiveness and societal needs of the region,
- how the research capability will be sustained and further developed after the project ends.

Where relevant, proposals are encouraged to build on, or seek collaboration with, existing projects and develop synergies with other relevant European, national or regional initiatives and funding programmes. In particular, links are encouraged with (i) the projects funded under earlier relevant topics of the Horizon Europe programme; or (ii) other relevant European Partnerships.

Proposers should establish the current state of the art and explain how their proposed research goes beyond this. In particular, proposers should outline the achievements of the EMPIR 19NRM06 METISQ project and how their proposal will build on those.

The development of the research potential should be to a level that would enable participation in other TPs.

Proposers should note that the programme funds the activity of researchers to develop the capability, not the required infrastructure and capital equipment, which must be provided from other sources.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.7 M€ and has defined an upper limit of 0.9 M€ for this proposal.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 20 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the 'end user' community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the "end user" community (e.g. letters of support) is also encouraged.

You should detail how your proposal's results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Provide a lasting improvement in the European metrological capability and infrastructure beyond the lifetime of the project,
- Facilitate improved industrial capability or improved quality of life for European citizens in terms of personal health, protection of the environment and the climate, or energy security,
- Transfer knowledge to the quantum technology sector and the metrology community.

You should detail other impacts of your proposed JRP as specified in the document "Guide 4: Writing Joint Research Projects (JRPs)"

You should also detail how your approach to realising the objectives will further the aim of the Metrology Partnership to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work.

Timescale

The project should be of up to 3 years duration.

Additional information

The links provided in this section are only correct at the time of publication up until the end of the Call year.

The reference below was provided by PRT submitters; proposers should therefore establish the relevance of any references.

- [1] EMN Quantum Technologies Strategic Research Agenda
<https://www.euramet.org/research-innovation/metrology-partnership/strategic-research-and-innovation-agendas>