



## Publishable Summary for 19NET02 EMN-Quantum Support for the European Metrology Network on Quantum Technologies

### Overview

Quantum technologies are a rapidly growing field that no longer sit within the confines of academic research. Spin-off companies have become well established and larger companies are now developing quantum devices. Europe leads in this field, spurred on by coordinated efforts such as the European Quantum Flagship. The recently established European Metrology Network for Quantum Technologies (EMN-Q) provides an urgently needed reference/contact point to support the growing European quantum technology industry. This project aims to accelerate the implementation of this network through activities that will establish an efficient, coordinated metrology infrastructure ready for quantum-related measurement and technology requirements.

### Need

Quantum technologies (QT) offer significant opportunities in many applications; however, translating such technologies from laboratory or specialist environments into the market is as challenging as communicating the complexities of quantum physics to end users. Therefore, active dialogue between the relevant stakeholders (e.g., governments, NMIs and DIs, developers, standardisation bodies and end-users) is necessary for aligning the metrological requirements of industry with the European Commission's QT Flagship and other QT programmes to ensure that appropriate metrological input is provided to standardisation bodies so industrial requirements can be met. Recognising this need, EURAMET formally established the European Metrology Network for Quantum Technologies (EMN-Q) on 1 July 2019.

Since this is the first time that the NMIs and DIs have pulled resources together over such a wide range of QT, it is paramount that knowledge is shared in alliance with the QT communities and that the transfer of information occurs in the most efficient and effective manner. The project will address this need by identifying key stakeholders from the different areas (academia, industry, standardisation bodies, both upcoming and future applications). It will contribute to establish the EMN-Q Stakeholder Council, and specific contact groups to ensure each QT area is represented. Moreover, the project will enable the EMN-Q to have prioritised and focused communications with stakeholders through: the EMN-Q Strategic Research Agenda (SRA), roadmaps for the different technological sections of the EMN-Q (quantum photonics, quantum electronics, quantum clocks and atomic sensors), and the EMN-Q web platform to enable easy access to information for end users, events and workshops: as well as liaison with the QT Flagship.

Given that standardisation is one of the key elements for the commercial success of any new technology, especially at the beginning of its development. The creation of globally accepted standards and an anticipatory approach will facilitate the worldwide growth and take up of the quantum technologies (QT) market. To support this standardisation effort, test and measurement infrastructure is required for certifying the compliance of the commercial quantum devices to such standards. The project will support the EMN-Q in addressing this need by coordinating the development of the necessary metrological infrastructure for the characterisation of the new quantum devices and their certification. This should maintain European competitiveness in the QT field for future decades.

### Objectives

The overall goal of the project is to support and accelerate the development and full implementation of the European Metrology Network on Quantum Technologies (EMN-Q).

The specific objectives are:

1. To establish and promote regular, constructive dialogue between stakeholders (quantum industry and representatives of European and national research programmes) and the EMN-Q, including



- the creation of a stakeholder advisory board (referred to as the Stakeholder Council in the Memorandum of Understanding of the EMN-Q, and from now on) within the EMN-Q, and
  - the creation of EMN-Q contact groups as stable liaisons with the EC Quantum Flagship (on quantum technologies), European and national research programmes, and other relevant stakeholder organisations.
2. To develop the EMNQ **Strategic Research Agenda**, and the related science and technology roadmaps for each EMNQ research area, namely, quantum electronics, quantum photonics, quantum clocks and atomic sensors, which will
    - identify the metrological research needs of quantum technologies
    - address the metrological requests emerging from quantum industries
    - identify strategies for the development of emerging member states in metrology for quantum technologies e.g., specialisation and cooperation.
  3. To develop a **knowledge-sharing programme** in order to promote the dissemination and uptake of EMNQ results, based on:
    - a web-based platform to facilitate interactions with stakeholders, which will include easy access to a wide range of quantum technology metrology data and a service desk for stakeholders to submit questions and requests for further information,
    - a range of regularly hosted activities, such as metrology workshops, stakeholder events, training courses, and the exchange of personnel between organisations to increase collaboration between quantum industry, metrology, and standardisation bodies.
  4. To promote and contribute to the standardisation and certification processes for quantum technologies, including establishing regular and constructive dialogue between relevant standardisation organisations (SDOs) and the EMN-Q, so that the needs of the SDO can be accommodated.

## Results

The results of this project will accelerate the establishment and full implementation of the EMN-Q as the recognised regional central point of contact representing European metrology for Quantum Technologies.

*To establish and promote regular, constructive dialogue between stakeholders (quantum industry and representatives of European and national research programmes) and the EMN-Q (Objective 1).*

The EMN-Q Stakeholder Council has been established and the actual core group is composed by six members. Proposal of new other members has been submitted to the EMN-Q Steering Committee and to the General Meeting. Six of them have been approved to be additional members of the Stakeholder Council and official invitations are going to be sent by the EURAMET Chair.

The stakeholder communication plan was developed, established and approved by the General Meeting, and it will be continuously updated to ensure that the needs related to QT metrology R&D are adequately captured.

The project activities towards coordinating the EMN-Q liaisons with different relevant key European “quantum” stakeholders have increased the EMN-Q visibility at the European level, providing a clear benefit to its members. Specifically, the project supported the establishment of the EMN-Q contact group with the EC Quantum Flagship, the participation in the EC Quantum Flagship SRA working group, the strong interaction with the main relevant Standards Development Organisations, the connection with the Quantum Industry Consortium (QuIC). EMN-Q representatives are actually members of the Quantum Coordination Board, set up by QUCATS (Coordination and support action of the Quantum Flagship) mandated by the European Commission (EC).



The EMN-Q presenting itself as a whole, with its impressive portfolio of facilities and measurement services, was invited to join the EU Framework Partnership Agreements (FPA) for “open testing and experimentation and for pilot production capabilities for quantum technologies” (QuTest), as well as to participate to the proposal answering to the call “Coordination Support Action (CSA) on the development of a QKD certification infrastructure” (lead by QuIC). It is worth to notice that at M24 the Qu-Test FPA proposal was accepted by the European Commission, then the Qu-Test Project received funding from the European Union’s Horizon Europe and was recently officially launched.

*To develop a Strategic Research Agenda (SRA) (Objective 2)*

The project guided the writing of the first draft of the EMN-Q **Strategic Research Agenda (SRA)**, based on the science and technology Roadmaps for each EMN-Q research area. The EMN-Q SRA provides guidance towards quantum technologies industrial and research metrology needs and the technical challenges that need to be solved as a priority through collaborative efforts between stakeholders and NMIs/DIs. This document will be revised continuously in accordance with priority changes from the “quantum” stakeholder community.

The EMN-Q Roadmaps, that represent the core of the EMN-Q SRA, were prepared reflecting the pillars of the EC Quantum Flagship and represent the points of contact between the EC Quantum Flagship and the Research and Development activities of the members of the EMN-Q. The roadmaps developed are on Quantum Computing by the Quantum Electronics Section, on Quantum Communication by the Quantum Photonics Section, and obviously all the three Sections have developed their respective roadmaps on Quantum Metrology and Sensing. The first draft of these Roadmaps was previously discussed by the members of the EMN-Q Stakeholder Council, with the EURAMET Technical Committees – specifically TC-TF, TC-PR, TC-EM, TC-T, TC-L.

This first draft of the EMN-Q SRA was shared with the QuIC, in particular with the “Strategic Industry Roadmap” working group, for comments and advice regarding potential metrology needs emerging from the QuIC SRA (which this working group is responsible for).

Furthermore, the EMN-Q SRA has been also shared with the CEN-CENELEC Focus Group on Quantum Technologies (FGQT) and the CEN/CLC JTC 22 QT, with an impact on their recently published documents: in fact, suitable contents included in the SRA were adopted and included in the preparation of both (i) CEN CENELEC FGQT Q04 Standardization Roadmap on Quantum Technologies, and (ii) CEN CENELEC FGQT Q05 Quantum Technologies Use Cases.

The EMN-Q SRA, together with the five QT Roadmaps are now publicly available (free download) on the new version of the EMN-Q website for consultation by Stakeholders, in the dedicated webpage:

<https://www.euramet.org/european-metrology-networks/quantum-technologies/strategy/strategic-research-agenda>

*To develop a knowledge-sharing programme that will provide multiple communication channels to disseminate the results and uptake of EMN-Q results (Objective 3)*

The project consortium supported the EMN-Q Communication working group in preparing the contents and the structure of the web platform, as well as in the compilation of the portfolio of the measurement facilities and services of the EMN-Q.

A definitive version of the web-based platform to facilitate communication with EMN-Q stakeholders was successfully developed and approved by EMN-Q General Meeting, and is available at the web address:

<https://www.euramet.org/european-metrology-networks/quantum-technologies/>



The relative interactive multifunctional platform, based on the database of EMN-Q of capabilities and services, is expected to be soon ready and available for stakeholders in a dedicated area of the EMN-Q web portal, in order to provide easy access to a wide range of quantum technology metrology data, to the aforementioned EMN-Q database of capabilities and measurement service platform across Europe, to a service desk for stakeholders to submit enquiries, and to dedicated areas for the promotion of exchange programmes to help emerging countries establish QT metrology work in their labs.

The project supports the EMN-Q also in the organisation of workshops, stakeholder events and training courses. In particular, after supporting in 2021 a workshop in the context of the EC Quantum Flagship conference (EQTC 2021), the JNP is actually involved in the organization of the EQTC 2023 (16-20 October, in Hannover, Germany), in which it is already planned a EMN-Q Session on "Deployment of Quantum Technologies: Pilot lines, Test & Measurements and Standardization", in collaboration with CEN CENELEC JTC 22 QT and EURAMET.

#### *To contribute to the QT standardisation and certification processes (Objective 4)*

The EMN-Q is committed to establish regular and constructive dialogue with relevant standardisation organisations (SDO) so that the needs of these organisations can be accommodated, whilst also ensuring that any standardisation requirements identified by other stakeholders are conveyed to the relevant standardisation bodies to inform their work programmes.

More specifically, the project has performed an initial review of 27 EMPIR and pre-EMPIR EURAMET metrology projects and identified relevant SDO committees, plus the CEN-CENELEC Focus Group on Quantum Technologies and the recently established CEN/CLC JTC 22 QT, that these projects interact with to varying degrees.

This project is then actively supporting EMN-Q to provide relevant interactions and substantial contributions to the quantum technologies standardisation and certification processes, as it is testified by the engagement with more than 20 standardisation bodies participated by the EMN-Q. NMI personnel have been identified as liaisons with these committees.

It is worth to mention in particular that the contents of the Strategic Research Agenda developed inside the EMN-Q provided inputs to the main documents prepared by the CEN-CENELEC FGQT and JTC 22 QT and in particular to the CEN CENELEC FGQT Q04 Standardization Roadmap on Quantum Technologies, and the CEN CENELEC FGQT Q05 Quantum Technologies Use Cases. In this context, a co-authored joint paper summarising the contents of these Standardisation Roadmaps of quantum technologies was published in EPJ Quantum Technologies 9, 33 (2022), <https://doi.org/10.1140/epjqt/s40507-022-00150-1>

EMN-Q members participated in the kick-off of CEN-CENELEC JTC 22 "Quantum Technologies". The vice-chair is from the EMN-Q, and the EMN-Q is also represented in all 4 working groups. The EMN-Q participates also in ISO/IEC JTC1 and IEC SEG 14 "Quantum Technologies" which is transitioning to ISO/IEC JTC-Q.

Finally, some JNP and EMN-Q partners support the organization of the 2nd in person meeting of the CEN-CENELEC JTC 22 Quantum Technologies, hosted by UNI CT 535 TQ and INRIM (Turin, Italy), an event planned at M42.

#### **Impact**

The partners of this project have shown an excellent level of engagement, which has ensured that the activities inside the project's tasks have been carried on and delivered to a very high standard of quality, in some cases above the expectation.

The project has been extremely successful in: the realization of the first draft of the EMN-Q Strategic Research Agenda (SRA), based on the science and technology Roadmaps developed for each EMN-Q research area of Quantum Electronics, Quantum Photonics, Quantum clocks and atomic sensors; the coordination and completion of the stakeholder mapping exercise; the support in the creation of and consultation with the EMN-



Q Stakeholder Council; the creation of and consultation with EMN-Q contact-groups as stable liaisons with EU and national research programmes; several interactions and engagement with relevant organisations and stakeholders operating in the Quantum Technologies domain, in particular EC Quantum Flagship key representatives and Quantum Industry Consortium (QuIC); engagement with relevant metrology technical committees and working groups, like CCPR WGs, CCTF, CCEM, Euramet TC-PR, Euramet TC-EM, Euramet TC-TF, Euramet TC-T, COOMET TC-PR, COOMET TC-EM, and even with EMNs, such as, e.g., EMN Mathmet.

It is worth to mention that thanks to the impressive portfolio of facilities and measurement services, the EMN-Q was invited to join the Framework Partnership Agreements (FPA) for “open testing and experimentation and for pilot production capabilities for quantum technologies” (QuTest), as well as to participate to the proposal answering to the call “Coordination Support Action (CSA) on the development of a QKD certification infrastructure” (lead by QuIC) as well as the co-development of a survey on Quantum Technology standardization needs. It is worth to notice that at M24 the Qu-Test FPA proposal was accepted by the European Commission, then the Qu-Test Project received funding from the European Union’s Horizon Europe and was recently officially launched.

The support of the project lead also to a substantial number of interactions with and inputs to Standardisation Development Organisations at different levels (National, Regional/European, International), and their respective sub-committees. The project partners are actively providing support, information and updates from the outputs of the above mentioned projects monitored by the EMN-Q and related to more than 20 SDOs Committees.

Furthermore, the project favoured the writing of co-authored open access peer-reviewed papers on the EMN-Q and promoted the organization of symposia, lectures, trainings for internal partners and relevant stakeholders, together with dissemination activities in workshops and conferences for relevant stakeholders, as for examples events organised by EC Quantum Flagship and QuIC.

An early uptake result also emerged from this project: contents included in the EMN-Q SRA were adopted and included in the preparation of the following documents recently published by the CEN/CENELEC JTC 22 “Quantum Technologies” (established on the basis both of the previous considerable work done and documents prepared by CEN/CLC Focus Group on Quantum Technologies – FGQT).

Other relevant activities realised thanks to this project, are on one side the definitive version of the new external web-based platform to facilitate communication with EMN-Q stakeholders ([www.euramet.org/european-metrology-networks/quantum-technologies/](http://www.euramet.org/european-metrology-networks/quantum-technologies/)), and on the other the mapping exercise performed by the partners of this project and by all the other members of the EMN-Q on the operational metrological services, measurement facilities and calibration platforms (dubbed EMN-Q measurement services and facilities portfolio), to build the network of services to be offered soon on the new EMN-Q web platform to companies and industries operating in Quantum Technologies.

### List of publications

Degiovanni, I.P., Gramegna, M., Bize, S., Scherer, H., Chunnillal C. EURAMET EMN-Q: The European metrology network for quantum technologies. (2022) Measurement: Sensors 18, 100348. <https://doi.org/10.1016/j.measen.2021.100348>

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This list is also available here: <https://www.euramet.org/repository/research-publications-repository-link/>





Project start date and duration:		01 June 2020, 48 months
Coordinator: Ivo Pietro Degiovanni, INRIM      Tel: +39 011 3919245      E-mail: <a href="mailto:i.degiovanni@inrim.it">i.degiovanni@inrim.it</a>		
Project website address: <a href="https://www.euramet.org/european-metrology-networks/quantum-technologies/">https://www.euramet.org/european-metrology-networks/quantum-technologies/</a>		
Internal Funded Partners:	External Funded Partners:	Unfunded Partners:
1. INRIM, Italy 2. CMI, Czech Republic 3. GUM, Poland 4. LNE, France 5. NPL, United Kingdom 6. OBSPARIS, France 7. PTB, Germany 8. TUBITAK, Turkey		
Linked Third Parties: 9. CNRS, France (linked to OBSPARIS)		