European Commission

SCIENCE FOR POLICY BRIEFS

Making Quantum Technology ready for Industry

The Quantum Technologies Flagship

Headlines

- The Quantum Technologies (QT) Flagship is a EUR 1 billion initiative funding leading scientists and engineers over the next ten years.
- Standardisation activities are increasing signalling the entry of Quantum Technologies into the market.
- There is a need for the standardisation of a QT terminology, the development of an EU standardisation roadmap, and of common benchmarks for measuring the performance of QT standardisation activities.

The QT Flagship aims to:

- place Europe at the forefront of the second quantum revolution;
- kick-start a competitive European quantum industry, envisioning Europe as a dynamic and attractive region for innovative research, business and investments in Quantum Technologies.

The QT Flagship is structured around mission-driven research and innovation domains, representing four major applied areas in the fields of: Communication, Computation, Simulation, and Sensing and Metrology (Figure 1).

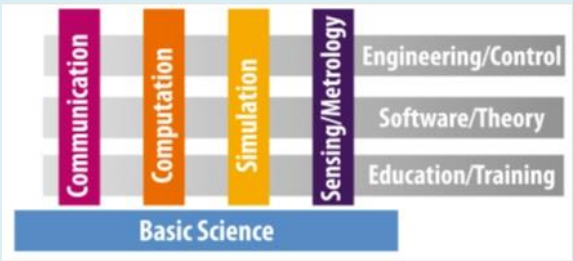

Figure 1 Structure of the research and innovation domains of the Quantum Flagship

The QT Flagship aims also at integrating national and European metrological and standardisation institutes in developing quantum-based standards for the most mature technologies.

The role of standards in the dissemination of technical knowledge and their resulting contribution to continuous economic growth has already been demonstrated in past studies.[1] In Germany, for example, the total economic benefit of standardisation to economic growth averages about EUR 16.77 billion per year from 2002 to 2006, corresponding to 0.72% of Germany's GDP, and similar results have been found in other countries. Standards ensure the quality and safety of products and services, and achieve compatibility and interoperability between products and components, thus reducing costs and improving efficiency.

Putting Science Into Standards

The Putting-Science-Into-Standards (PSIS) Workshops are a joint initiative between the European Commission and CEN-CENELEC[2] bringing together the scientific, industrial, and standardisation communities on a regular basis. The initiative aims to facilitate the identification of emerging science and technology areas which could benefit from standardisation activities to enable innovation and promote industrial competitiveness.

Six PSIS workshops have been held since 2013 in different fields of science, with the most recent event organized in Brussels on 28-29 March 2019 on Quantum Technologies. In this workshop for the first time more than 77 quantum physicist and experts from different European countries working in different quantum disciplines gathered to discuss how to bring inventions to the market, thus completing the pathway of innovation. Planning at an early stage and incorporating standardisation can be crucial for accelerating market uptake of research findings.

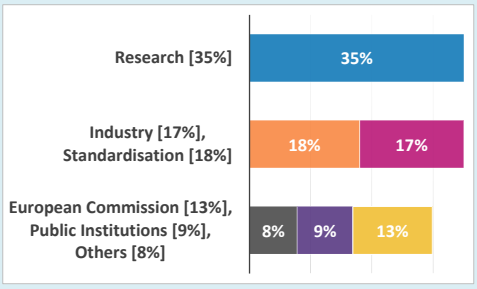

Figure 2 Breakdown per participant type at the workshop

By successfully bringing together the relevant stakeholders in the whole quantum technology standardisation value chain – research, standardisation and the industry sectors, and public

[1] See The Economic Benefits of Standardization and references therein.

[2] European Committee for Standardization and European Committee for Electrotechnical Standardization

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administrations/institutions – the workshop provided a timely opportunity for a balanced (Fig. 2) and representative overview on the status quo in Quantum Technologies, and for drawing informed conclusions on a strategic way forward.

Quo vadis quantum technology?

While the scientific Quantum Technology community is traditionally rarely exposed to standardisation, the workshop showed there is a clear opportunity and interest in exploring how the research and innovation community can actively contribute to standardisation, and how in return standardisation can benefit this community.

In the field of Quantum-enabled security a number of standards already exist since more than a decade, in particular within ETSI[3]'s Industry Specification Group on Quantum Key Distribution and in ISO[4]/IEC[5] JTC[6] 1/SC 27 on test and evaluation methods. These standards are essential for security as they give trust and add value to the technology.

Besides established standards, several world-wide standardisation activities exist within technical committees, study groups, and focus groups signalling the growing interest for standards in Quantum Technology. Technical committees (TC) such as the IEC/TC 65 upgrade standards on Quantum-enabled 'industrial process measurement and automation' from IEC 62443, while the ITU-T study group 17 on 'security' evaluates opportunities to mirror activities elaborated in other groups.

In the field of quantum computing, study group 2 of ISO/IEC JTC 1/WG 7 is compiling relevant work, while a focus group on 'Quantum information technology for networks' is investigating the impact of Quantum Technology on networks, while identifying gaps and issues in standardization. Impacts of quantum computing on current standards produced by ISO /IEC JTC 1/SC 7 are investigated by a dedicated study group.

The Institute of Electrical and Electronics Engineers started in liaison with ISO/IEC JTC 1 the elaboration of a general nomenclature, performance metrics and the definition of a Software-Defined Quantum Communication protocol. Meanwhile, the Internet Engineering Task Force started standardisation in the following Quantum Internet fields: routing, resource allocation, connection establishment, interoperability, security and design of an API.

Due to the maturity of Quantum Key Distribution (QKD) technologies, standardisation processes in this area are more advanced than in others. Quantum Technologies are also being used in many other application areas that will play a major role in the near future where standardisation can enhance existing capabilities and offer a competitive advantage. Examples are within the Quantum Sensing and Metrology that include quantum enhanced medical imaging devices, quantum gravity sensing devices, quantum timing devices, etc, that will require the creation of new standardisation activities in existing groups or to the creation of new groups, with a focus on specific applications or technologies. As the demand for Quantum Technologies is no longer limited to the IT or telecom sector, but spreading to other market sectors like logistics, manufacturing, medical, geology, etc., Europe needs to take a holistic approach in order not to be falling behind the leading economies.

Standardisation can be well incorporated in the Quantum Technology Flagship, which envisions an accelerated development and market uptake of Quantum Technologies. The protection and 'commercialization' of knowledge with patenting and standardisation is essential to prevent the 'brain drain' from the EU to other competitor countries, thus ensuring the capitalisation of EU investments.

Europe has already important and world leading standards in the field of QKD, and the European Union together with some Member States have recently declared their commitment to work together in order to build a quantum communication infrastructure that will enable transmitting and storing information and data in a fully secure manner, as well as integrating quantum technologies and systems like QKD into conventional communication infrastructures. This European success story provides a path that needs to be explored further to take full advantage of Quantum Technologies.

Towards a roadmap

Based on lessons learned from the Graphene Flagship, where a successful interaction with standardisation organisations has taken place, concrete actions for addressing standardisation in the Quantum Technologies include the standardisation of a terminology and the development of an EU standardisation roadmap for Quantum Technologies.

The roadmap should take input from existing standards: for example standards for High-Performance Computing could be the starting point for drafting standards on Quantum Computing. There is also a need for objective metrics and common benchmarks for measuring the performance of Quantum Technologies. Investment into and training on the drafting of new quantum-based standards in the future is essential.

An active dialogue and cooperation between the communities of researchers and standardisers will be beneficial for future interactions and cooperation. A practical step could be a continuous interchange with the QT Flagship through, for example, the Coordination and Support Action of the QT Flagship (CSA QFLag).

Lightweight standardisation processes designed to facilitate the direct contributions by the quantum research community such as CEN-CENELEC Workshop Agreements (CWA) or a CEN-CENELEC Focus Group are recommended. In the area of Quantum Technologies it may be premature to directly aim for formal standards.

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[4] International Organization for Standardization
[5] International Electrotechnical Commission
[6] Joint Technical Committee