ISO FORM 1
ISO TS/P XXX

PROPOSAL FOR A NEW FIELD OF TECHNICAL ACTIVITY

PROPOSER:

BSI

DATE OF CIRCULATION:

Click or tap to enter a date.

CLOSING DATE FOR VOTING:

Click or tap to enter a date.

A proposal for a new field of technical activity shall be submitted to the Office of the CEO, which will process the proposal in accordance with ISO/IEC Directives, Part 1, Clause 1.5.

Furthermore, a proposal will be considered as complete if every information field is complete and follows the guidelines for proposing and justifying a new field of activity given in the ISO/IEC Directives, Part 1, Annex C.

TITLE

(Please see the ISO/IEC Directives, Part 1, Annex C, Clause C.4.2)

ISO/IEC/JTC Quantum technologies

SCOPE

(Please see the ISO/IEC Directives, Part 1, Annex C, Clause C.4.3)

Standardisation in the field of quantum technologies.

PURPOSE AND JUSTIFICATION (Please use the field immediately below or attach an annex.)

(Please see the ISO/IEC Directives, Part 1, Annex C, Clause C.4.13)

Quantum technology (QT; quantum computing and closely related technology) is the second generation of technologies to exploit quantum effects, manipulating the quantum states of individual particles (eg photons or atoms). It promises revolutionary advances for some sectors of industry and society, with rapid financial growth.

For example, quantum sensing has applications in a wide variety of fields, including distributed, high-precision time, magnetic-field sensors, inertial sensors, and distributed quantum computing; quantum communications, in principle, will be invulnerable to eavesdropping.

Standards for some aspects of QT have already begun development but there is a pressing need to begin standardization, at global level, for example in: quantum computing (device characterization, hardware and software benchmarking), quantum simulation (validation of results, common languages), quantum sources (characterization of single photon/electron sources), quantum detectors (calibration and characterization of single-photon avalanche photodiodes), quantum communications (characterization of quantum random number generators, specifications for quantum key distribution products and systems).

To prevent multiple and competing standards from confusing and fragmenting the market, taxing the limited community of experts, it is vital that ISO and IEC establish a new Joint Technical Committee to produce a comprehensive, robust, and consistent suite of standards to serve the global quantum marketplace.

QT is unprecedented in how rapidly and unpredictably it is developing. QT standardization needs: independent and agile leadership, reliable information about market development and related standards needs, proactive liaison with committees in ISO and IEC (including JTC 1) and other SDOs, and rapid road-mapping and business-case development. The strategic goals have to be clear and, once agreed by consensus, used fairly and consistently to develop the work programme to match standards-users' needs.

A comprehensive report on road mapping, prioritisation and market readiness is attached to this proposal.

PROPOSED INITIAL PROGRAMME OF WORK (Please use the field immediately below or attach an annex) Please see the [ISO/IEC Directives, Part 1, Annex C.4.4 and C-4.5])

For each item, the initial work programme shall define the deliverable type and target dates. The initial work programme shall also assign priorities to the different items.

Proposed priority areas and deliverables:

Quantum computing

- device characterization, classification;
- qubit and gate characterization, test methods
- hardware and software benchmarking, specifications and test methods
- quantum internet definition and requirements, vocabulary and specifications

Fundamental quantum technologies

- characterization of ion traps, colour centres, etc, test methods

Quantum simulation

- validation of results, test methods
- common languages, specification

Quantum sources

- characterization of single photon/electron sources, test methods
- characterization of entangled photon sources, test methods

Quantum detectors

- calibration and characterization of single-photon detectors, test methods

Related areas and deliverables, for which the JTC would monitor and provide expertise:

Quantum communications

- characterization of quantum random number generators, test methods
- quantum key distribution products and systems, guides, specifications and test methods
- guidance on integrated approach with post-quantum cryptography, guides

Low-loss photonics

- characterization of photonic integrated circuits
- requirements for low insertion-loss and low-loss fibre couplers, specifications
- requirements for fibre couplers outside the 1550 nm telecoms window, specifications

Radio-frequency electronics for cryogenic temperatures

- requirements for RF connectors and other components to operate at <4K or <77K

Within this new JTC a detailed work programme delivery plan will be agreed once it has been constituted, including initial work items and the process by which the delivery plan will evolve with the rapidly changing QT industry. Device characterisation, benchmarking, use case are examples of active discussions already under way. Existing work on planning, prioritization and consideration of opportunities for collaboration can be seen in the annex, which will be useful reference material in developing future deliveries. We expect the work programme to evolve based on input from groups such as the IEC/SEG, maturity of each type of quantum technology and input from stakeholders.

RELATION OF THE PROPOSAL TO EXISTING INERNATIONAL STANDARDS AND ON-GOING STANDARDIZATION WORK

☒ The proposer has checked whether the proposed scope of the new committee overlaps with the scope of any existing ISO or IEC committee or JTC1 sub-committee

☐ If an overlap or the potential for overlap is identified, the affected committee has been informed and an agreement has been reached between proposer and committee on

i. modification/restriction of the scope of the proposal to avoid overlapping,

ii. potential modification/restriction of the scope of the existing committee to avoid overlapping.

☐ If agreement with the existing committee has not been reached, please explain why the proposal should be approved.

Click or tap here to enter text.

☐ Have proposals on this subject been submitted into an existing committee and rejected? If so, what were the reasons for rejection?

Click or tap here to enter text.

LISTING OF RELEVANT DOCUMENTS (SUCH AS STANDARDS AND REGULATIONS) AT INTERNATIONAL, REGIONAL AND NATIONAL LEVEL

(Please see the ISO/IEC Directives, Part 1, Annex C, Clause C.4.6)

General quantum technologies

IEEE

In draft

P7130 Standard for Quantum Technologies Definitions

Quantum communications

ETSI

Published

ETSI GS QKD 002 V1.1.1 (2010-06) Quantum Key Distribution (QKD); Use Cases

ETSI GR QKD 003 V2.1.1 (2018-03) Quantum Key Distribution (QKD); Components and Internal Interfaces

ETSI GS QKD 004 V2.1.1 (2020-08) Quantum Key Distribution (QKD); Application Interface

ETSI GS QKD 005 V1.1.1 (2010-12) Quantum Key Distribution (QKD); Security Proofs

ETSI GR QKD 007 V1.1.1 (2018-12) Quantum Key Distribution (QKD); Vocabulary

ETSI GS QKD 008 V1.1.1 (2010-12) Quantum Key Distribution (QKD); QKD Module Security Specification

ETSI GS QKD 011 V1.1.1 (2016-05) Quantum Key Distribution (QKD); Component characterization: characterizing optical components for QKD systems

ETSI GS QKD 012 V1.1.1 (2019-02) Quantum Key Distribution (QKD); Device and Communication Channel Parameters for QKD Deployment

ETSI GS QKD 014 V1.1.1 (2019-02) Quantum Key Distribution (QKD); Protocol and data format of REST-based key delivery API

ETSI GS QKD 015 V2.1.1 (2022-04) Quantum Key Distribution (QKD); Control Interface for Software Defined Networks

ETSI GS QKD 018 V1.1.1 (2022-04) Quantum Key Distribution (QKD); Orchestration Interface for Software Defined Networks

ETSI White Paper No. 27 Implementation Security of Quantum Cryptography: Introduction, challenges, solutions

In draft

ETSI GS QKD 013 V1.1.2 Quantum Key Distribution (QKD); Characterisation of Optical Output of QKD transmitter modules

ETSI GS QKD 016 V1.1.1 QKD Common Criteria Protection Profile for QKD

ETSI GS QKD 017 V1.1.1 Quantum Key Distribution (QKD) Network architectures

ETSI GS QKD 018 V1.1.1 Quantum Key Distribution (QKD) Orchestration Interface of Software Defined Networks

ETSI GS QKD 019 V1.1.1 Quantum Key Distribution (QKD) Design of QKD interfaces with Authentication

ISO/IEC

In draft

ISO/IEC 23737-1 Information technology security techniques — Security requirements, test and evaluation methods for quantum key distribution — Part 1: Requirements

ISO/IEC 23837-2 Information technology security techniques — Security requirements, test and evaluation methods for quantum key distribution — Part 2: Evaluation and testing methods

IEEE

In draft

P1913 Software-Defined Quantum Communication

ITU-T

Published

Y.3800 Cor1 Overview on networks supporting quantum key distribution

Y.3801 Functional requirements for quantum key distribution networks

Y.3802 Cor1 Quantum key distribution networks – Functional architecture

Y.3803 Quantum key distribution networks – Key management

Y.3804 Quantum key distribution networks – Control and management

Y.3805 Quantum key distribution networks – Software-defined networking control

Y.3806 Quantum key distribution networks – Requirements for quality of service assurance

Y.3807 Quantum key distribution networks – Quality of service parameters

Y.3808 Framework for integration of quantum key distribution network and secure storage network

Y.3809 A role-based model in quantum key distribution networks deployment

Y Suppl 70 ITU-T Y.3800-series – Quantum key distribution networks - Applications of machine learning

X.1710 Security framework for quantum key distribution networks

X.1712 Cor1 Security requirements and measures for quantum key distribution networks – key management

X.1714 Key combination and confidential key supply for quantum key distribution networks

In draft

Y.QKDN-iwfr Quantum key distribution networks - interworking framework

Y.QKDN-iwrq Quantum key distribution networks - interworking requirements

Y.QKDN-ml-fra Quantum key distribution networks - functional requirements and architecture to enable machine learning

Y.QKDN-rsfr Quantum key distribution networks - resilience framework

Y.supp.QKDN-roadmap Standardization roadmap on Quantum Key Distribution Networks

Y.TR-QEFN ITU-T's Views for Quantum-Enabled Future Networks

Quantum computing and simulation

IEEE

In draft

P3155 Standard for Programmable Quantum Simulator
P3120 Standard for Quantum Computing Architecture
P2995 Trial-Use Standard for a Quantum Algorithm Design and Development
P7131 Standard for Quantum Computing Performance Metrics & Performance Benchmarking

ISO/IEC

In draft

ISO/IEC 4879 Information technology -- Quantum computing -- Terminology and vocabulary

CEN/CENELEC

In draft

No identifier Quantum Technologies Standardisation Roadmap

The listing of relevant documents are limited to standards at this moment as no regulation on this topic has been identified.

LISTING OF RELEVANT COUNTRIES WHERE THE SUBJECT OF THE PROPOSAL IS IMPORTANT TO THEIR NATIONAL COMMERCIAL INTERESTS
(Please see the ISO/IEC Directives, Part 1, Annex C, Clause C.4.8)

Australia, Belgium, Canada, China, Denmark, France, Germany, India, Japan, Korea, Netherlands, Switzerland, UK, US. This list is not exhaustive.

LISTING OF RELEVANT EXTERNAL INTERNATIONAL ORGANIZATIONS OR INTERNAL PARTIES (OTHER THAN ISO AND/OR IEC COMMITTEES) TO BE ENGAGED AS LIASONS IN THIS WORK
(Please see the ISO/IEC Directives, Part 1, Clause C.4.9)

Interested organisations might include ITU, ETSI, EC, IEEE, and IETF. QED-C, European QuIC and other regional industry organizations should also be invited as liaison organizations.

IDENTIFICATION AND DESCRIPTION OF RELEVANT AFFECTED STAKEHOLDER CATEGORIES
(Please see ISO Connect)

	Benefits/Impacts/Examples
Industry and commerce – large industry	Improved confidence and the simplification of trade in products and services/faster, more sustainable growth in the market/for example, in selling access to quantum computer services
Industry and commerce – SMEs	Simplified access to markets for innovative SMEs and SMEs providing support services, subcomponents and products to a new market as it grows and changes/faster, more confident growth and greater certainty in the stability of the market/for example, software developers focused on detailed aspects of algorithm development or error-correction.

Government	Enhanced return-on-investment in a new industry by avoiding nation- or region-specific approaches/promotion of national policy through consensus of international standards/for example, ensuring the consideration of qubit technologies in which their nation/region is invested
Consumers	Ensure that consumer issues such as equitable access to new technology is considered and that its implementation does not disproportionately affect any group in society (poorer, vulnerable, ethnic minorities, etc)/internationally agreed guidelines/for example, in quantum computing for optimisation of public transport provision, awareness that routes provided to less able groups might be inherently slower.
Labour	Ensure that workers in these new industries are respected and rewarded in compliance with internationally recognised rights, with support for a diverse workforce/the new industry will be more sustainable and will benefit from direct involvement of diverse individuals
Academic and research bodies	Quantum technology is still under rapid development from proof-of-principle to commercialization, so academics and research bodies will play a vital role in ensuring that innovation is not inadvertantly stifled in standards development/both the pace of development and content of new standards will remain open to innovation/for example, qubit characterization will remain technology agnostic, to remain relevant to technologies that are not yet commercialized
Standards application businesses	Certification and accredditation of quantum technologies will be comparable globally/providers of certification services will be more easily comparable and setting up schemes will be straightforward/for example, in certifying components for use in cryogenic temperatures.
Non-governmental organizations	Include guidance on sustainable and socially equitable operations, products and services/help avoid unjustified claims of the benefits of the new technology (which in turn would discredit the industry)/for example, provide a holistic estimate of energy impact of quantum computing
Other (please specify)	Related technical and subcommittees across ISO, IEC, CEN, CENELEC.

EXPRESSION OF LEADERSHIP COMMITMENT FROM THE PROPOSER

(Please see the ISO/IEC Directives, Part 1, Annex C, Clause C.4.12)

BSI commits to provide secretariat and chair appointment for the new JTC if approved.

☒ **The proposer confirms that this proposal has been drafted in compliance with iso/iec directives, part 1, annex c**

SIGNATURE OF THE PROPOSER

Amanda Richardson BSI / Oliver Hateley UKNC

COMMENTS OF THE ISO CENTRAL OFFICE (IF ANY)

This new JTC proposal has also been submitted to the IEC Secretariat, as a joint approval is required by ISO and IEC.

Analysis in support of proposal for a joint technical committee on quantum technology

Summary

Quantum technology (QT; quantum computing and closely related technology) is the second generation of technologies to exploit quantum effects, manipulating the quantum states of individual particles (eg photons or atoms). It promises revolutionary advances for some sectors of industry and society, with rapid financial growth.

For example, quantum sensing has applications in a wide variety of fields, including distributed, high-precision time, magnetic-field sensors, inertial sensors, and distributed quantum computing; quantum communications, in principle, will be invulnerable to eavesdropping.

Standards for some aspects of QT have already begun development but there is a pressing need to begin standardization, at global level, for example in: quantum computing (device characterization, hardware and software benchmarking), quantum simulation (validation of results, common languages), quantum sources (characterization of single photon/electron sources), quantum detectors (calibration and characterization of single-photon avalanche photodiodes), quantum communications (characterization of quantum random number generators, specifications for quantum key distribution products and systems).

To prevent multiple and competing standards from confusing and fragmenting the market, taxing the limited community of experts, it is vital that ISO and IEC establish a new Joint Technical Committee to produce a comprehensive, robust, and consistent suite of standards to serve the global quantum marketplace.

Quantum computing and closely related technology (quantum technology; QT) is unprecedented in how rapidly and unpredictably it is developing. QT standardization needs: independent and agile leadership, reliable information about market development and related standards needs, proactive liaison with committees in ISO and IEC (including JTC 1) and other SDOs, and rapid road-mapping and business-case development. The strategic goals have to be clear and, once agreed by consensus, used fairly and consistently to develop the work programme to match standards-users' needs.

Background

ISO/IEC/JTC 1 has 43 subcommittees, the scopes of which all fit within the general scope of JTC 1: "Standardization in the field of information technology." QT (quantum computing and closely related technology), however, is not a straightforward extension of conventional IT.

In order to develop a strategy and business plan for the development of standards in support of QT, it is important to understand the fundamental elements of the second generation of all quantum technologies. Where the first generation of quantum technologies required an understanding about quantized energy levels, eg in lasers and semiconductors, the second generation involves direct manipulation of quantum states in particles (or virtual particles).

In particular, quantum computing requires the co-ordinated establishment of, and interaction between, quantum states. There are a few different practical approaches to this puzzle, but for direct control of individual atoms or photons, some or all of cryogenic temperatures, radio/microwave electronics, and photonic signals are needed. Standards for coding and the necessary processor-to-processor interaction should be developed with liaison to JTC 1. Supplementary standards should be developed by related committees in ISO and IEC. But there is no obvious home for standardization around quantum processors/quantum computers.

Quantum computing is also closely related to quantum communications, quantum simulation, quantum sensors and the quantum internet. Again, supplementary standards in ISO (eg TC 172, *Optics and photonics*), IEC (eg TC 46, *Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories*), JTC 1 (eg SC 22, *Programming languages, their environments and system software interfaces*) and elsewhere are anticipated to support these technologies. The proper way to do so would be through liaisons with existing committees in ISO and IEC (including JTC 1) and other SDOs where appropriate and where standardization is already underway, eg quantum key distribution in ETSI.

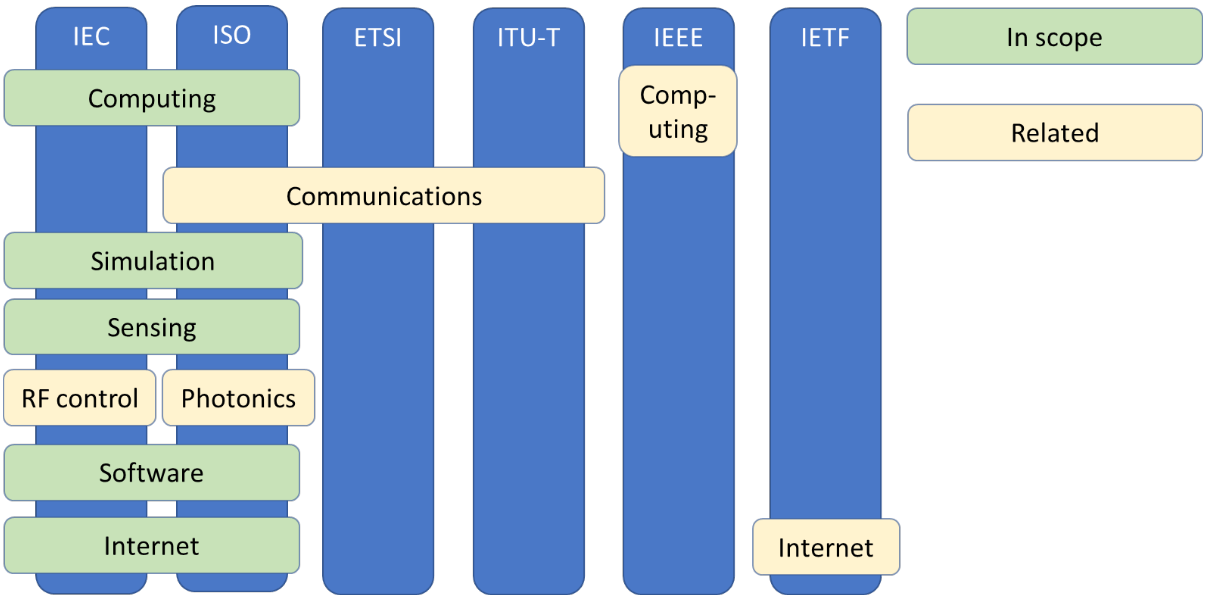
At present the priority is to give QT support and space to develop. In terms of standards, that means not developing high-level standards that might stifle innovation or be overly prescriptive. Instead, standards development should agree the fundamental characteristics of QT and how to perform the fundamental characterization. In other words, having defined the basic elements of quantum computing and closely related technology, we need to develop test methods to assess them.

QT might not be ready for top-to-bottom standardization but it is maturing very rapidly, driven by investment from both governments and private sources. Predictions vary, but many market forecasts see the quantum computing market, alone, being worth billions of dollars by 2030, and the technology will have to develop rapidly to meet that expectation. Every year, more powerful and sophisticated products and services will be brought to market and standards will have to keep pace.

QT scope

At a high-level quantum technologies can be mapped to standards organizations in ways similar to those shown in the following diagram. And this demonstrates the complexity of the direction and the decisions that need to be made.

Potential mapping: (*Details may be both correct and incorrect at the same time*).



Conclusion

Considering all the above, QT standardization needs: independent and agile leadership, reliable information about market development and related standards needs, proactive liaison with committees in ISO and IEC (including JTC 1) and other SDOs, and rapid road-mapping and business-case development. The strategic goals have to be clear and, once agreed by consensus, used fairly and consistently to develop the work programme to match standards-users' needs. Technical expertise and market insight will be needed, not only from national mirror committees, but also from global metrology organizations and industry stakeholder bodies.

What's more, with rapid and diverse development of QT, workload will develop rapidly and need the parent structure of a full joint technical committee. Each of the topics identified as potentially within scope will need its own subcommittee within a few years.

The only way that all these needs can be met adequately is to ensure that a structure in place can accommodate the technical depth of QT but also enables collaboration and surveillance across the horizontal breadth of the different quantum domains/technologies. The only way to achieve this is by establishment of a new ISO/IEC Joint Technical Committee.

INTERNATIONAL PRIORITIZATION OF QUANTUM TECHNOLOGY STANDARDS

Summary

Analysis of the current quantum-technologies standardization landscape points to the need or a new committee for quantum computing and closely related technology (quantum technology; QT).

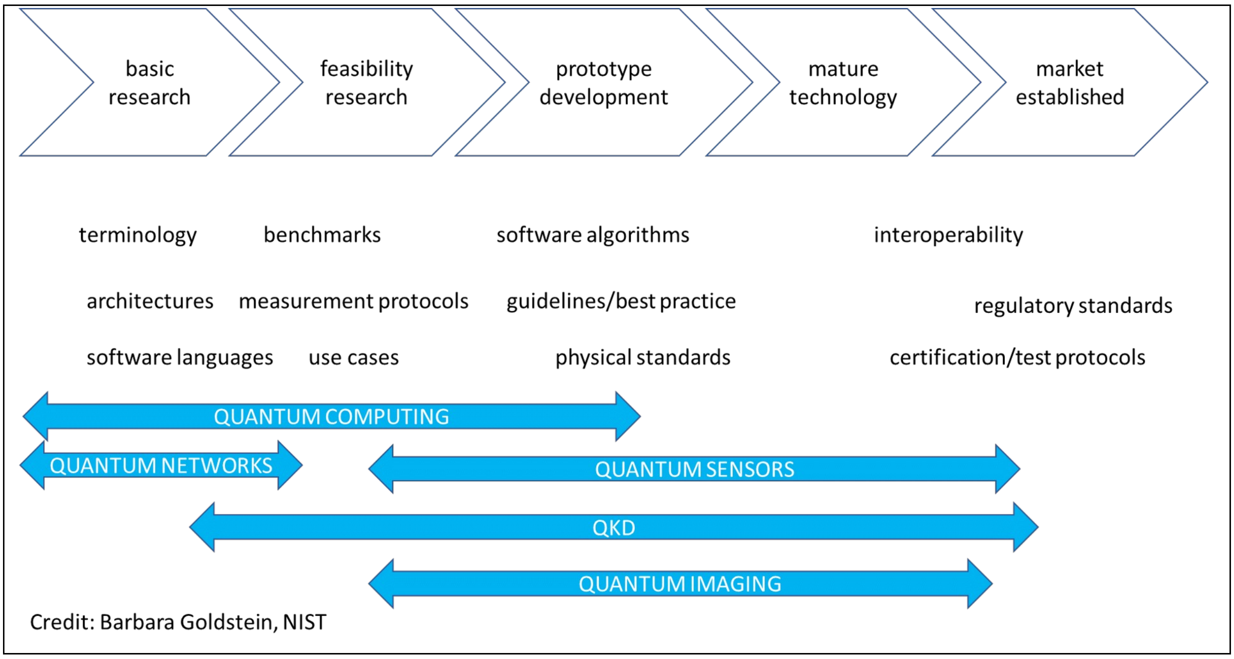
Background

Quantum technologies topics (categorized in line with the UK Quantum Hubs and National Quantum Computing Centre)

- Computing, including: potential physical qubits/qudits for coding and decoding, interactions to create entanglement and quantum logic gate operations, quantum computer architectures, quantum-classical computing interaction, quantum algorithms, quantum processor coding and higher-level software
- Communications, including quantum random number generation, quantum key distribution by fibre, by air and by satellite, quantum key distribution networks and quantum internet
- Sensors and timing, including quantum magnetoencephalography and other applications of quantum magnetic sensing, quantum gravity sensors, quantum clocks for global navigation satellite systems and reliable and accurate distribution of reference time.
- Enhanced imaging, including: Single photon cameras, single pixel cameras, extreme time resolution imaging, 3D profiling, hyper-spectral, ultra-low flux covert illumination, imaging beyond line-of-sight, and imaging of local gravity fields

Also worthy of note is post-quantum cryptography (PQC). Not strictly a Quantum Technology as such, but includes algorithm design, key exchange, signatures, hybrids, migration, quantum-safe VPNs. Work on relating to QKD and QKD networks has to be co-ordinated with those working on PQC, and combined QKD-PQC information security is expected to be the best solution for many secure communication applications. Significant work on standardization of PQC is underway in ETSI and the National Institute of Standards and Technology, USA (NIST).

The following figure gives a rough estimate of the "standardization readiness level" (a concept developed by NIST) for different quantum technologies. In general terms, most quantum technologies are only ready for the earliest stages of standardization but all sectors have technologies at different stages. The ranges of maturity are a highly subjective estimate.



Standards development has already started in the following standards development organizations (SDOs) and their committees. Standards development drafts and publications are listed in the annex.

Standards development organizations and their committees for quantum technologies standardization (far from comprehensive)

Europe/Europe-based

CEN/CENELEC, *Focus Group on Quantum Technologies*

ETSI, *Industry Specification Group on Quantum Key Distribution*

US-based

IEEE, P3155, P3120, P2995, P7131, P7130, P1913 (see standards annex)

IETF, *Quantum internet research group*

International

ISO/IEC/JTC 1/WG 14, *Quantum computing*

ISO/IEC/JTC 1/SC 27/WG 3, *Security certification of QKD systems*

IEC/SEG, *Quantum technologies* (awaiting first meeting)

ITU-T, SG 13/WP 3/Q 16, *Future Networks: Trustworthy and Quantum Enhanced Networking and Services* (also SG 13/Q 6, SG 17/Q 15 and SG 11/Q2)

Strategic evaluations by SDOs

The following strategic evaluations have been published or are in development. Each brings the perspective of the body responsible and the goal of identifying the standards needs that might be met by that body.

ITU-T, *Focus Group on Quantum Information Technology for Networks* (FG-QIT4N) published:

- D1.1: *Quantum information technology for networks terminology: Network aspects of quantum information technologies*
- D1.2: *Quantum information technology for networks use cases: Network aspects of quantum information technologies*
- D1.4: *Standardization outlook and technology maturity: Network aspects of quantum information technologies*
- D2.1: *Quantum information technology for networks terminology: QKDN*
- D2.2: *Quantum information technology for networks use cases: QKDN*
- D2.3: *Quantum key distribution network protocols: Quantum layer*
- D2.3: *Quantum key distribution network protocols: Key management layer, QKDN control layer and QKDN management layer*
- D2.4: *Quantum key distribution network transport technologies*
- D2.5: *Standardization outlook and technology maturity: Quantum key distribution network*

IEC white paper, *Quantum Information Technology*

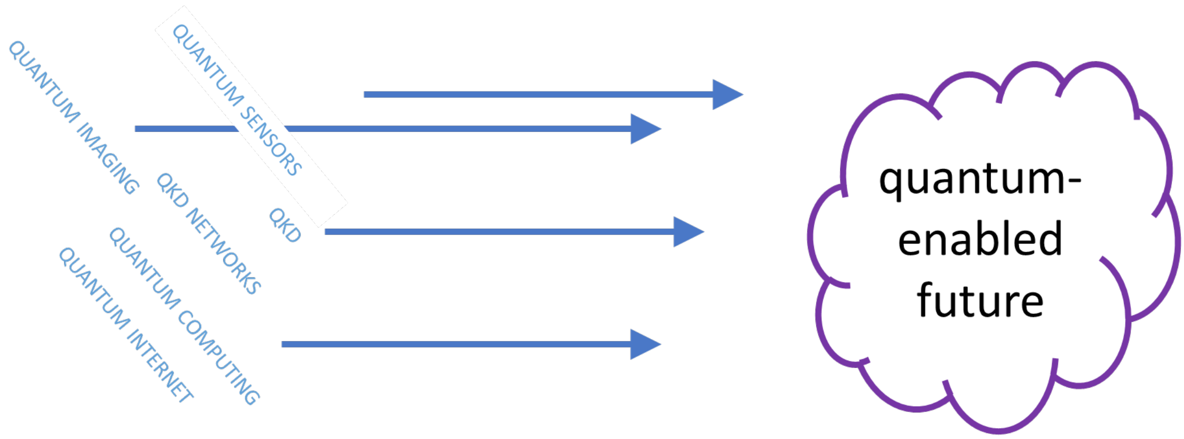
CEN/CENELEC/FGQT roadmap, *Towards European Standards for Quantum Technologies* (in development)

DCMS commissioned, *Standards and the road to the quantum future*, by Oxford Information Labs (publication pending)

NPL, *Quantum Programme standardisation review* (2022 edition pending, 2021 edition)

Initial framework for discussion and analysis

At the risk of over-simplifying the road ahead, we can see a diverse collection of research and early-stages commercialization of a new generation of quantum technologies, each of which with the potential to radically change some aspect(s) of society, economies and the environment.

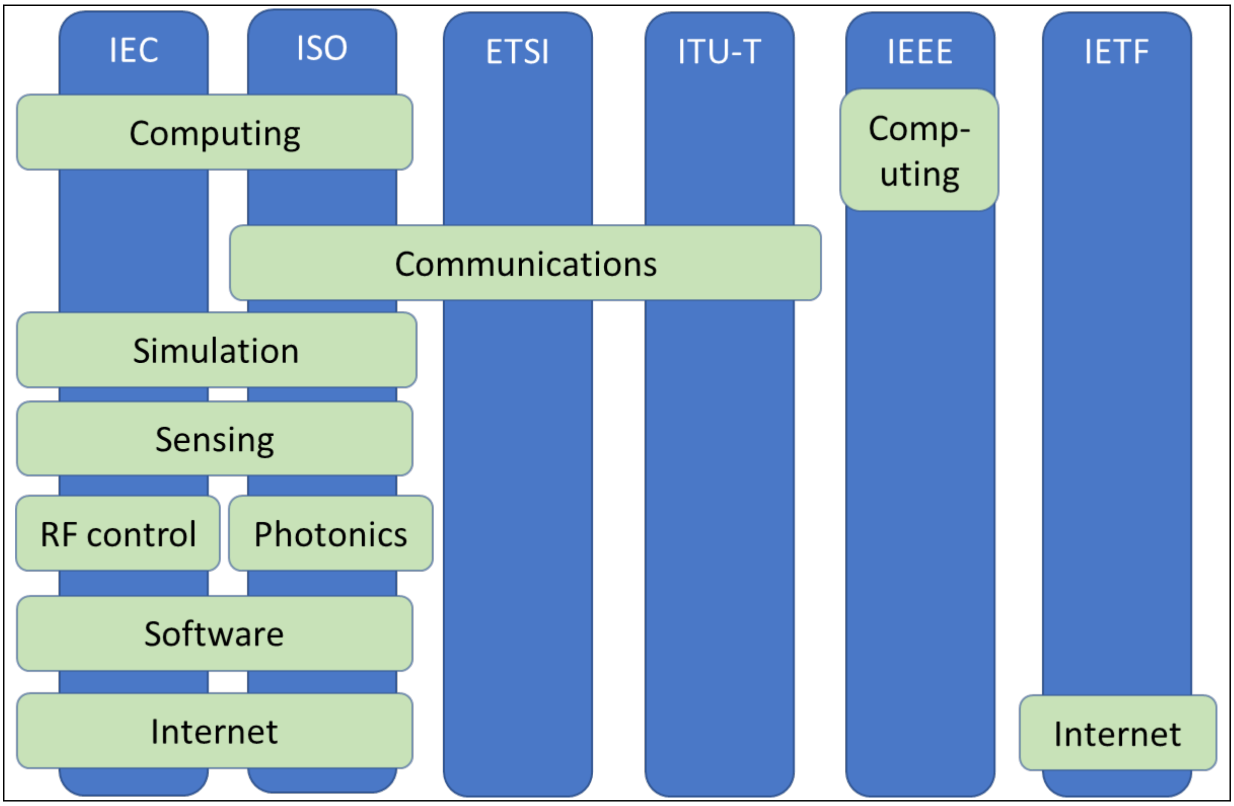


Although the picture cannot be drawn precisely, some things are certain.

First, for each area of quantum technologies to develop and be commercialized, it will support and need support from other areas. For example, QKD networks need QKD sources and receivers, which can require single- or entangled-photon sources and single-photon (quantum) sensors.

Second, development and commercialization of each technology has to be supported by an ecosystem of other technologies such as fabrication, low-loss photonics and low-temperature RF electronics. Hence, as the core technologies are commercialized and its standardization needs mature, the surrounding supply chains will also develop and benefit from updated and improved standards.

Understandably, as a result of all these interdependencies, each SDO needs to be aware of standardization in every area, even if they are only focused on one or two. In the following diagram, the scope of the standards (or pre-standardization) work in quantum technologies is mapped against SDOs with significant global reach.



Formal liaison and common membership already exists between many of these committees, which goes some way toward avoiding duplication of effort and incompatibility between standards developed. However, there is already *some* duplication of standards development activity.

Standards users are, in principle, agnostic to which SDO helps them develop standards, but the choice is influenced by objective reasons such as the purpose and remit of the organization, and more subjective reasons such as familiarity and user-friendliness.

Standardization for QT

QT is at an early stage of standardization readiness, with a market in early prototypes.

Some important questions remain unanswered, namely: what will be the dominant physical qubit when quantum computers are fully commercialized? and will there be a long period in which there is no universal, programmable quantum computer but rather quantum processors adept at a particular application?

With such uncertainty, there cannot be standardization of quantum computing products and services in anticipation of a given physical solution, architecture or coding system. Instead, standards development should be restricted to vocabulary (already underway in ISO/IEC/JTC 1) and basic physical characterization such as the number of distinct qubits in a processor or qubit coherence time.

Some quantum computing technology has already been commercialised (eg quantum annealing) or is near commercialisation (eg quantum simulators). Standards for the basic physical characterization of the hardware in these devices would also be beneficial in clarifying what is being bought and sold.

Proposed strategy for standardization in the field of QT

1. Support the global SDOs that have already started standards development for a clearly defined area of quantum technologies.
2. Global SDOs are preferred to regional (or regionally based) SDOs or national (or nationally based) SDOs for the primary SDO, unless there are special regional or national conditions, which is unlikely in quantum technologies.
3. Standardization for QT should be restricted initially to vocabulary and basic physical characteristics. Following the first two principles, this would be best done in ISO/IEC.
4. A committee for QT should identify standards in supporting technologies (eg photonics) that need further development to support the new quantum industries. Co-ordination of standards development should be by liaison between new and existing committees.

Conclusion

A new international standards committee is needed to be the focus of quantum technology (QT) standards development. A strong collaborative approach with related groups is expected once the new joint technical committee is established. That committee will be the pacemaker that ensures that the right standards are developed at the right time, in step with related committees and SDOs.

The roadmap and the criteria needed to progress at each stage will be agreed by consensus but then applied rigorously. In other words, the first task under the committee will be to agree a business plan, including the roadmap of anticipated standards within its scope.

It is anticipated that the first proposals for standards publications by the new joint technical committee will be test methods to characterize the fundamental elements of quantum computing, but each new proposal will be closely scrutinized.

Annex
Standardization activity by UK Quantum Programme subject

General quantum technologies

IEEE	
In draft	
P7130	Standard for Quantum Technologies Definitions

Quantum communications

NOTE Does not include (quantum) random number generation standards publications.

ETSI	
Published	
ETSI GS QKD 002 V1.1.1 (2010-06)	Quantum Key Distribution (QKD); Use Cases
ETSI GR QKD 003 V2.1.1 (2018-03)	Quantum Key Distribution (QKD); Components and Internal Interfaces
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ISO/IEC	
In draft	
ISO/IEC 23737-1	Information technology security techniques — Security requirements, test and evaluation methods for quantum key distribution — Part 1: Requirements
ISO/IEC 23837-2	Information technology security techniques — Security

	requirements, test and evaluation methods for quantum key distribution — Part 2: Evaluation and testing methods
IEEE	
In draft	
P1913	Software-Defined Quantum Communication
ITU-T	
Published	
Y.3800 Cor1	Overview on networks supporting quantum key distribution
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Y.3802 Cor1	Quantum key distribution networks – Functional architecture
Y.3803	Quantum key distribution networks – Key management
Y.3804	Quantum key distribution networks – Control and management
Y.3805	Quantum key distribution networks – Software-defined networking control
Y.3806	Quantum key distribution networks – Requirements for quality of service assurance
Y.3807	Quantum key distribution networks – Quality of service parameters
Y.3808	Framework for integration of quantum key distribution network and secure storage network
Y.3809	A role-based model in quantum key distribution networks deployment
Y Suppl 70	ITU-T Y.3800-series – Quantum key distribution networks - Applications of machine learning
X.1710	Security framework for quantum key distribution networks
X.1712 Cor1	Security requirements and measures for quantum key distribution networks – key management
X.1714	Key combination and confidential key supply for quantum key distribution networks
In draft	
Y.QKDN-iwfr	Quantum key distribution networks - interworking framework
Y.QKDN-iwrq	Quantum key distribution networks - interworking requirements
Y.QKDN-ml-fra	Quantum key distribution networks - functional requirements and architecture to enable machine learning
Y.QKDN-rsfr	Quantum key distribution networks - resilience framework
Y.supp.QKDN-roadmap	Standardization roadmap on Quantum Key Distribution Networks
Y.TR-QEFN	ITU-T's Views for Quantum-Enabled Future Networks

Quantum computing and simulation

IEEE	
In draft	
P3155	Standard for Programmable Quantum Simulator
P3120	Standard for Quantum Computing Architecture

P2995	Trial-Use Standard for a Quantum Algorithm Design and Development
P7131	Standard for Quantum Computing Performance Metrics & Performance Benchmarking
ISO/IEC	
In draft	
ISO/IEC 4879	Information technology -- Quantum computing -- Terminology and vocabulary
CEN/CENELEC	
In draft	
No identifier	Quantum Technologies Standardisation Roadmap