Appendix 3: UK National Quantum Technologies Programme

The UK National Quantum Technologies Programme was founded in 2014 by UKRI, EPSRC, STFC, IUK, MoD, NPL, BEIS, GCHQ and NCSC as a ten-year programme. Its strategic vision is to create a 'quantum-enabled economy' and to stimulate market growth and security. The first phase provided £400M of investment and involved over 150 partner companies. The second phase is now in progress, with a commitment to fund to a total of about £1bn.

There are four Quantum Technology Hubs and Scottish companies and universities are active participants across all four: Quantic (imaging); Sensors and Timing; Quantum Communications; and Quantum Computing and Simulation.In addition to the Hubs, the Quantum Technologies Programme supports the National Quantum Computing Centre (NQCC) and the Quantum Metrology Institute (hosted by the National Physical Laboratory, NPL), launched in 2015. An overview of the UK quantum technologies landscape is provided in Appendix 4.

In 2017, BEIS published summary reports from Wave 2 Science and Innovation Audits, from eight regional consortia. Three of these, Glasgow Economic Leadership, Innovation South and Oxford Transformative Technologies Alliance, all emphasised the opportunities provided by quantum technologies. Each region emphasised the synergistic relationships between the university research base and manufacturing companies, usually SMEs, and often in their early stages. The Oxford report concentrated almost exclusively on quantum computing and its applications whereas Innovation South identified opportunities primarily in the supply chain. The Glasgow report noted Scotland's strengths in photonics as a significant element in providing quantum technology opportunities, including in sensing and imaging.

A3.1 National Quantum Computing Centre

To quote from the NQCC Strategic Intent document, *'The primary purpose of the NQCC is to fill a key gap in the research and innovation landscape by providing a capability to address the challenge of scaling quantum computing. It will convene all necessary stakeholders across academia, business and government to achieve this'*. The NQCC is funded from the Quantum Technology Programme, receiving £93M. The facility is based on the Harwell campus and is due for completion in 2023.

Regarding the UK infrastructure, the NQCC notes that the UK has no predominant large industrial systems integrator but has a growing start-up community and developing supply chain. They classify the potential opportunities to include:

- Full stack providers;
- Hardware and systems;

UK National Quantum Technologies Programme Organisations

- UKRI: UK Research and Innovation
- EPSRC: Engineering and Physical Sciences Research Council
- STFC: Science and Technology Facilities Council
- IUK: Innovate UK
- MoD: Ministry of Defence
- NPL: National Physical Laboratory
- BEIS: Department for Business, Energy and Industrial Strategy
- GCHQ: the UK's intelligence, security and cyber agency
- NCSC: National Cyber Security Centre

- Software and services;
- Electronics: chips, data acquisition, nano fabrication, microwaves and radio-frequency equipment;
- Photonics: components, lasers, on-chip photonics, single-photon sources and detectors; and
- Cryo (low temperature) and vacuum: components, cryogenic systems, cold-atom systems.

The UK is considered to have particular strength in cryogenics, vacuum, lasers, photonics, microwave technologies and nanofabrication.

The NQCC considers that there will be three phases in the development of quantum computing:

- Noisy intermediate-scale quantum computing ('NISQ');
- Intermediate quantum computing (sometimes called 'Quantum Advantage'); and
- General purpose quantum computing (sometimes called 'Universal, Fault Tolerant').

In the first five years (to 2025), the NQCC intends to achieve an NISQ demonstrator.

The NQCC's 'Strategic Intent' document sets the scene in reviewing current technologies and notes:

- Superconducting circuits are the only technology to have demonstrated quantum advantage globally.
- Trapped ions are the most mature technology with high connectivity between qubits but none yet suitable for 'leaving the laboratory'. The ions are trapped by electromagnetic fields and read with microwaves and lasers.
- Spin states offer an alternative to trapped ions, e.g. diamond and other crystals as solid-state ion traps, but limited fidelity has been demonstrated.
- Photonics is a candidate technology, with on-chip operation via waveguides. Room temperature operation has been achieved but photons have weak interactions so operations are non-deterministic.

A3.2 Quantum Metrology Institute

The Quantum Metrology Institute is part of the National Physical Laboratory (NPL), and the NPL participates in the UK Quantum Technology Programme.

The measurement infrastructure world-wide relies on the existence of standards to support the metrology needed for validation of quantum enabled measurement systems and procedures. Quantum technology also enables new metrological techniques to be developed. Examples where quantum technology will require future standards to be developed include:

- Creating a framework which provides potential end-users and other stakeholders with a standardised way to compare different products and technologies (primarily for quantum computing);
- Adherence to standards, which is a legal requirement in telecommunications, and hence development of international standards for quantum key distribution (QKD);
- Standards for photonic integrated circuits and;
- A certification process for quantum random number generation (used for cryptography).

The NPL has responsibility for the co-ordination of UK representation in quantum technology standards development and the raising of awareness among the UK quantum community of current activity. A key part of the proposal is the establishment of a UK quantum standards committee run by BSI (the British Standards Institute) with NPL support.

scottish
science
advisory
council

© Crown copyright 2022

Produced for Scottish Science Advisory Council by APS Group Scotland, 21 Tennant Street, Edinburgh EH6 5NA
(June 2022)

scottishscience@gov.scot