National Quantum Computing Centre

Annual Report 2024

"Following design, construction and commissioning, the inauguration of our facility was an important milestone. Our state-of-the-art facility will serve as a focus for innovation and collaboration, bringing together academia, industry and government to unlock the transformative potential of quantum computing.

I am incredibly proud of our team and our construction partners, who have worked tirelessly to create such an outstanding facility enabling this amazing technology".

Dr Michael Cuthbert, Director, NQCC

Executive Summary

2024 has been a year of operational ramp-up for the National Quantum Computing Centre (NQCC). Completion of our facility construction, commissioning, and population of our laboratories and the deployment of our SBRI Testbed platforms, capped many years of planning to reach this stage. The highlight of the year was our Ministerial Opening with Lord Vallance, Minister of State for Science, Research and Innovation. In parallel, we have been charting a route to quantum advantage at scale, in support of the UK Quantum Missions.

A year ago, I reflected on 2023, a busy year of new initiatives, growth and ambition across the National Quantum Technologies Programme. A breathless year on, I look back at 2024 as a year of delivery and deployment.

For the National Programme, following the publication of the National Quantum Strategy in March 2023, this year has seen many of the early commitments to that strategy come to life. Five National Quantum Missions were published towards the end of 2023, and have been followed through with working groups helping shape their purpose and scope. Mission 1 focuses on quantum computing driving towards a machine capable of running one trillion quantum operations such that it can approach large-scale commercially relevant computation. The NQCC has been leading on this work alongside key representatives from other National Laboratories, industry, academia and government, gathering evidence and seeking consultation to best shape this proposal.

March 2024 saw the announcement of £16 m of funding to support five new quantum Centres for Doctoral Training (CDT) as part of a £479 m wider commitment to PhD studentships across a range of disciplines, followed in July by the announcement of £106 m awarded across five new Quantum Technology Hubs. The NQCC strongly welcomes these investments and look forward to collaborating with the new CDTs and Hubs, through new programmes, as well as renewing existing partnerships.

Reception area

Independent of these National Quantum Technologies Programme (NQTP) initiatives, the NQCC's focus has remained on our own infrastructure development, technology programmes and continued ecosystem engagement. On infrastructure, our efforts have been concentrated on bringing our new facilities online. Our Innovation Hub was commissioned at the start of the year and enabled our acceleration of both in-house R&D activities and external collaborations. We took ownership of the NQCC facility in June, with initial commissioning bringing the offices and collaboration space online, followed by the setting up of the laboratories. Part of this challenge has been to ensure laboratory access for new equipment, moving existing equipment from temporary locations and setting up of the testbeds. This brings commercial platforms on site to sit alongside our in-house technology development. We were thrilled to welcome Lord Vallance, Minister of State for Science, Research and Innovation to formally open our new facility in October.

Whilst commissioning our new facilities, we have continued to support the quantum ecosystem. Along with well-established events such as our annual hackathon, we have introduced new activities through expressions of interest for future PhD studentships and industry-led 'Proof of Concept' projects. Instrumental in this effort has been our strategic partnership with Quantum Software Lab at University of Edinburgh. We have also contributed to the growing quantum technologies portfolio of Science and Technology Facilities Council (STFC). Recently, we have further strenghtened our expertise by appointing Professor Gerard Milburn FAA, FAPS, FRS as the first NQCC Quantum Fellow.

During the centre opening, Lord Vallance encouraged us to maintain our focus and our mission of not only building, hosting and operating quantum computers but ensuring that as we build our user community, we maintain our focus on application development and the utilisation of quantum computing for societal good. In November, we will launch our QC Access Programme making an ever-greater toolkit of cloud services available to the UK research community.

It has been a year of incredible effort to bring so many aspects of our programme to fruition, and it is my privilege to work alongside so many dedicated and talented people.

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Leadership Team

Dr Michael Cuthbert, Director

With a background in superconductivity and cryogenic systems, Michael has had a number of technical and commercial leadership roles with Oxford Instruments in Japan, US and the UK, most recently as Head of Quantum Technologies.

Michael is a member of the Institute of Physics, sits on several advisory panels, including the NQTP Programme Board and is an Aegis Professor in Quantum Technologies at the University of Bristol.

Professor Elham Kashefi, Chief Scientist

Elham is Professor of Quantum Computing at the School of Informatics, University of Edinburgh, and Directeur de recherche au CNRS at LIP6 Sorbonne Universite.

Elham co-founded the fields of quantum cloud computing and quantum computing verification and has pioneered a trans-disciplinary interaction of hybrid quantum-classical solutions from theoretical investigation to actual experimental and industrial commercialisation.

Ash Vadgama, Deputy Director for Operations

Ash has worked within High Performance Computing for almost 35 years for UK Government. Ash started his career as a computer scientist developing scientific software on early vector supercomputers, then led early developments in secure Linux clusters, various emerging technologies, Petascale HPC systems and resilient data centres, whilst also collaborating with US national laboratories and other international partners, later moving into Business Leadership, HPC programme and financial management.

Dr Simon Plant, Deputy Director for Innovation

Simon's technical background spans quantum nanomaterials, nanophysics and quantum sensors. He has led work across various roles in research, government and the public sector to drive the development and commercialisation of quantum technologies (QT) and support the growth of the industry.

Simon was previously the technology lead at Innovate UK responsible for shaping and implementing the UK's innovation strategy for QT.

Anne-Claire Blet, Deputy Director for Programme Delivery

Anne-Claire has extensive experience in large-scale complex programmes across both the public and private sector, as well as having commercial experience in the UK quantum industry.

Anne-Claire previously worked at the United Nations as part of its Sustainability Programme supporting strategy, policy and programme delivery. She went on to join the start-up what3words as Director of Strategic Partnerships before becoming the Chief Operating Officer at Oxford Quantum Circuits.

A strategic outlook for quantum advancement

The NQCC was established in 2020 through a UK Research and Innovation (UKRI) collaborative programme between Engineering and Physical Sciences Research Council (EPSRC) and Science and Technology Facilities Council (STFC) to address the challenges of scaling in quantum computing. One can reflect that this early vision was very much technology focused. However, increasingly the NQCC has been turning its attention to scaling not only the technology but also the user community, recognising the need for access to real quantum machines, upskilling users and developing clear and impactful use cases.

Part of our remit is to act as a trusted authority, and here we try to walk a careful line of both cheerleader to our UK quantum ecosystem, as well as challenger on results, reproducibility and impact. As we move into the second five years of our programme, our vision remains clear but with a growing recognition that the technology is developing rapidly, and that the nascent quantum industry has growing demand for long-term and sustained investment. To this end, we recognise that alongside the delivery focus of the Quantum Missions, the NQCC will renew its technology readiness focus. We aim to raise the bar, grow UK capabilities to capitalise on emerging opportunities, and continue to seek demonstrable quantum advantage.

Broadening our role as an early customer on behalf of government, as well as nurturing collaborative relationships across the UK and beyond, is key to our support of the Quantum Missions and ensuring the UK remains at the forefront of quantum computing technology.

NQCC's first Quantum Fellow: Professor Gerard Milburn

We are delighted to welcome Professor Gerard Milburn as our first NQCC Quantum Fellow.

Gerard is a pioneer in quantum technologies, having worked extensively in the fields of Quantum Computing, Quantum Optics, Quantum Measurement and Control, and Quantum Machine Learning. He is a Fellow of the Australian Academy of Science, a Fellow of The Royal Society of London and The American Physical Society and has published over 290 peer-reviewed papers with over 26,000 citations, as well as co-authoring several scientific monographs and books on quantum optics and photonics.

National Quantum Computing Centre

Gerard received his BSc (Hons) in Physics from Griffith University (Australia) in 1980. He completed his PhD in physics under Daniel Frank Walls at the University of Waikato (New Zealand) in 1982, with a thesis entitled Squeezed States and Quantum Non-demolition Measurements. Following his PhD, Gerard joined Imperial College in the Department of Mathematics and was soon awarded a Royal Society Fellowship to work in the Quantum Optics group of Sir Peter Knight.

Gerard served the Australian National University and the University of Queensland as Head of the Department of Physics in the 1990s and later as Deputy Director of the Australian Research Council Centre of Excellence for Quantum Computer Technology. He was the Chair of the Scientific Advisory Committee of the Canadian Institute for Quantum Computing and served on the scientific advisory committee for the Perimeter Institute for Theoretical Physics from 2007 to 2010. From 2011 to 2017 he was the Director and Chief Investigator of the Australian Research Council Centre of Excellence for Engineered Quantum Systems.

Gerard was instrumental in providing strategic advice to the fledging UK National Quantum Technologies Programme and has provided international oversight in support of the NQTP Strategic Advisory Board throughout the first decade of the UK programme.

NQCC programme overview

The NQCC is leading an ambitious programme of activities to drive technical innovation in quantum computing and stimulate the growth of a quantum-ready economy. Progress against our strategic objectives has accelerated in 2024 as a result of additional funding of £41 m through the UK's National Quantum Strategy and the UKRI Technology Missions Fund.

Technology development

We have commissioned seven experimental testbeds from leading technology providers, which will be installed and fully operational by Spring 2025. Our internal technology programmes have also advanced rapidly, with laboratories now established developing hardware platforms based on trapped ions, cold atom tweezer arrays and superconducting circuits. Further to our qubit development initiatives, the NQCC is actively involved across the quantum stack developing and validating hardware, software and third party middleware control solutions, error suppression and novel quantum algorithms.

Quantum readiness

We have developed partnerships with commercial businesses, government organisations and charities to explore the value of quantum computing for economic growth and societal benefit. Applications engineers from the NQCC, together with software developers at the Quantum Software Lab, have delivered a number of collaborative projects with end-users such as HSBC and Rolls-Royce. The projects aim to translate computational roadblocks into research problems, that can be addressed with quantum techniques.

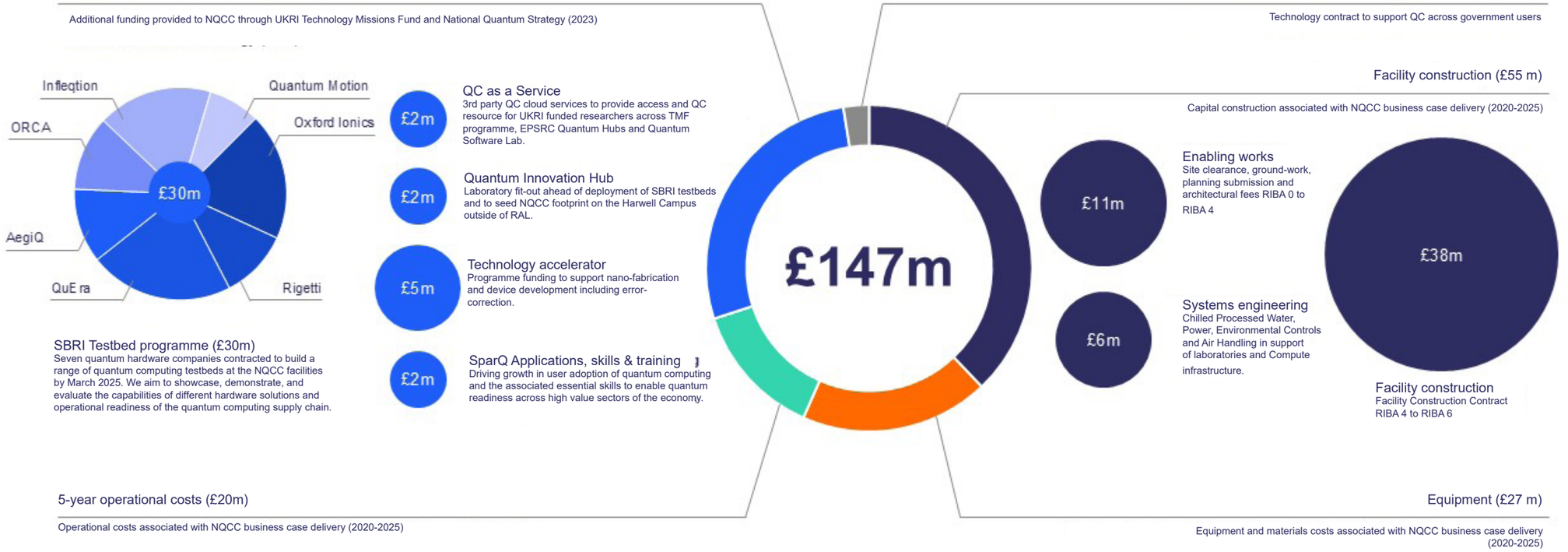
We are also engaging with industry sectors such as pharmaceuticals, financial services and healthcare, to identify and investigate use cases for societal benefit utilising quantum computing.

Our wider work on skills, public engagement and responsible and ethical quantum computing aims to increase society's trust and confidence in the technology.

Infrastructure and workforce

Two state-of-the-art facilities have been commissioned this year, the NQCC Innovation Hub on the Harwell Campus and the NQCC on the Rutherford Appleton Laboratory site, also at Harwell. The completion of these two facilities marks a key milestone in NQCC's programme. It provides purpose-built infrastructure to enable ramp-up technology development and scaling efforts of both in-house and collaborative projects.

As the facilities have been established, so has our team. The NQCC now has over 75 staff, with over 70% joining in the past 2 years. Over two-thirds of our staff are directly working on development or elevation of readiness levels related to scaling and utilisation of quantum computing technology.



Purpose-built facilities to develop and exploit the potential of quantum computing in the UK

Two state-of-the-art facilities commissioned

Throughout 2024, the NQCC has brought online and opened two state-of-the-art facilities to support the development of quantum computing in the UK. Our primary facility on the Harwell Campus was commissioned over the summer and formally opened by Lord Vallance on 25th October, providing dedicated laboratory space for building, hosting and operating quantum computers. These world-class laboratories are complemented by collaborative workspaces, an open office environment, and dedicated areas for training, networking and sharing expertise among the UK's quantum ecosystem.

The NQCC Innovation Hub, which opened in December 2023, was also commissioned providing additional laboratory and collaboration space on the Harwell Campus. With two fully equipped experimental laboratories, as well as collaboration and meeting spaces, the early availability of the Innovation Hub has accelerated our technology programmes ahead of the NQCC facility completion. The NQCC superconducting circuit team was able to take delivery and install three dilution refrigerators ahead of schedule and prior to relocating onto the NQCC facility. The Innovation Hub is now hosting both industry R&D collaborative work and testbeds. As an anchoring institution, we are already seeing wider impact on the Harwell Campus, with NQCC collaboration partners securing premises to grow their own activities elsewhere on site.

Across these two facilities the NQCC now has five state-of-the-art laboratories for building, testing and operating quantum computers. Most of the leading qubit modalities are represented including trapped ions, superconducting circuits, cold-atom tweezer arrays, photonic systems, and silicon-spin systems. Beyond the technical work, the NQCC's facilities provide an open and collaborative environment for driving innovation, building skills and expertise, and accelerating the adoption of quantum computing in the UK.

> *"It's fair to say that the new NQCC facility is world class. They've struck just the right balance in terms of creating an environment for collaboration, while establishing a highly professional lab space, and keeping a firm eye on the future, particularly with regards to network hygiene and data protection. This facility will no doubt play a big role in attracting others to join the testbed programme and will quickly become an invaluable resource for the UK quantum community".*
>
> Richard Moulds, General Manager – Amazon Braket, the quantum computing service of AWS.

Construction programme

Construction, fit-out and commissioning was completed in particularly challenging times for large infrastructure projects, given economic and supply chain pressures of the post-pandemic period. With demanding specifications for both the buildings and the technical spaces, our operations team and the STFC Estates team used their specialist expertise to guide the construction programme and help to find creative solutions to tackle supplier issues, evolving contractor relationships, and mitigating the rising cost of materials.

An important outcome of these efforts is that the building is on target to achieve its primary sustainability objectives:

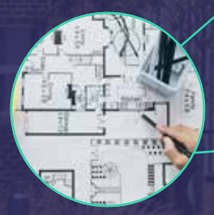
- Achieving a BREEAM rating of "Excellent" for the completed building
- Achieving a 40% reduction in regulated CO_2 emissions during operation
- Supporting UKRI in meeting the government's Net Zero policy objectives.

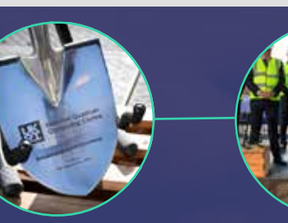
Throughout the project, principally through our primary contractor Wates Construction, significant social value for the local community was generated. Wates provided 12 apprenticeships and invested £670 k in training for local people. The construction project generated over £550 k in economic benefit for the local community contributing to over £1.22 m of socio-economic benefit in Oxfordshire and surrounding community.

NQCC facilities progress timeline

NQCC construction

Jan - Jul 2019
Preparation and planning brief defined - objectives, budget, requirements, risks and timeline



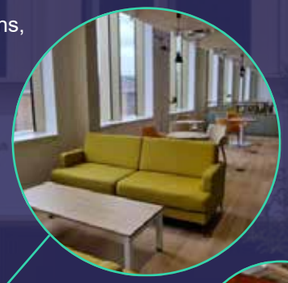


June 2020
Concept design and architectural modelling

September 2021
Breaking ground ceremony by Sir Peter Knight, Chair of the NQTP Strategic Advisory Board

December 2021
Wates Construction appointed as the NQCC's main contractor

February 2022
Early works including the construction of concrete foundations, lift cores, ground beams and a sustainable drainage system for the building commences

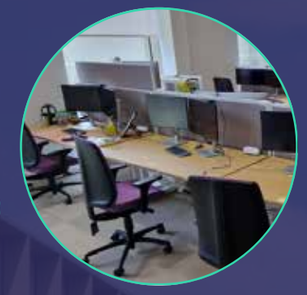


February 2023
Internal fit out of plant, office space and laboratories commences

June 2024
Facility handover

July 2024
First testbed deployment

August 2024
NQCC team fully relocated



NQCC Innovation Hub

March 2022
Harwell Campus lease completed

August 2023

December 2023
Fit-out and commissioning complete

Jan/Feb 2024
Team moved in

National Quantum Computing Centre

National Quantum Computing Centre

Ministerial Opening

The National Quantum Computing Centre was formally opened by Lord Vallance, the Minister of State for Science, Research and Innovation on 25th October, 2024. The event was joined by representatives from leading quantum companies, academia, the National Quantum Technologies Programme, and government, including officials from the Office for Quantum. Many of the NQCC's key partners and collaborators were in attendance.

Lord Vallance, said: "The National Quantum Computing Centre marks a vital step forward in the UK's efforts to advance quantum technologies. By making its facilities available to users from across industry and academia, and with its focus on making quantum computers practically useable at scale, this centre will help them solve some of the biggest challenges we face, whether it's delivering advances in healthcare, enhancing energy efficiency, tackling climate change, or inventing new materials."

UKRI CEO, Professor Dame Ottoline Leyser, said: "With our rich national heritage in quantum computing research the UK is well-placed to lead the development of this transformative new technology, which has such huge potential across society and the economy. The National Quantum Computing Centre is central to this critical work, bringing together internationally-leading researchers and technologists from across academia and industry to ensure that the UK's quantum computing ecosystem thrives, delivering benefits to people across the UK and beyond. The innovations that will emerge from the work the NQCC will do will ultimately improve lives across the country and ensure the UK seizes the economic benefits of its leadership in quantum technologies."

"The inauguration of the NQCC marks a significant milestone for the UK, underscoring our commitment to advancing quantum technologies and fostering collaboration. This state-of-the-art facility will serve as a central hub for innovation, bringing together researchers, businesses, and stakeholders to unlock the transformative potential of quantum computing for the future," said Dr Michael Cuthbert, NQCC Director.

UKRI National Quantum Computing Centre

Technology development and scaling

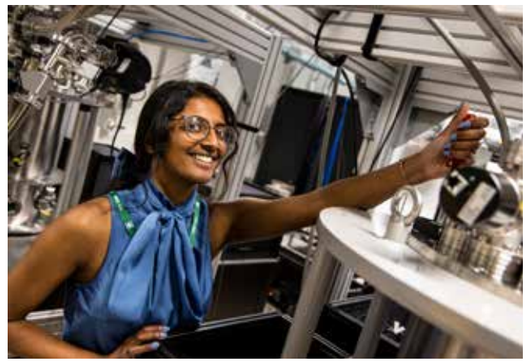
The technical programme at the NQCC is focused on scaling early-stage quantum architectures, that can offer real value for the UK's economy and society. To achieve that aim, our technical work spans the full quantum computing stack, from the physical hardware and software-based control systems to quantum algorithms that address specific computational problems.

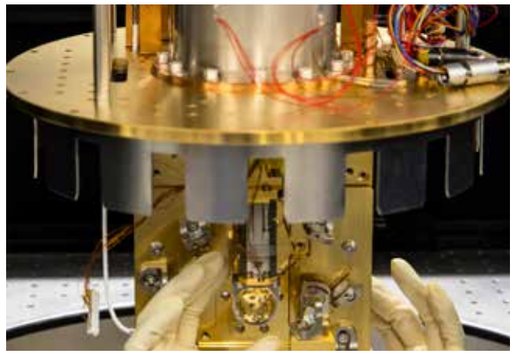
Within the hardware domain, we have developed internal capabilities in three of the most promising qubit modalities: trapped ions, superconducting qubits and cold-atom tweezer arrays. Those in-house efforts are complemented by seven commercial testbeds that are being delivered in partnership with Innovate UK through the Small Business Research Initiative (SBRI). Due to be installed by leading technology providers by 2025, these testbeds will provide a unique opportunity to understand and compare the capabilities of different qubit architectures.

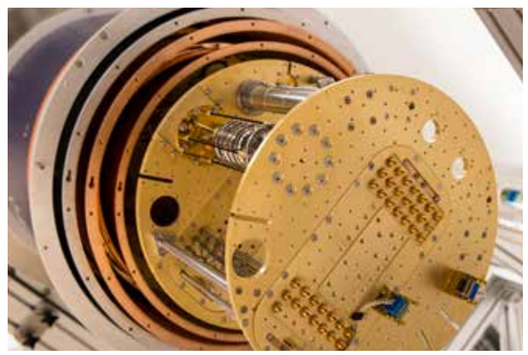
Meanwhile, the NQCC's software specialists have been developing real-time control systems for our internal hardware platforms. A concept architecture has been created to allow components of the stack to be selected to run a specific algorithm, allowing jobs to be tailored, submitted and monitored using an interactive interface. An advanced quantum emulator called QUEST, originally developed at the University of Oxford, has been extended to run on a high-performance compute GPU cluster at the NQCC. At the same time, our partnership with the Quantum Software Lab (QSL) at the University of Edinburgh is allowing us to explore emerging software approaches for addressing key scaling challenges, such as error correction, hybrid quantum–classical architectures, and distributed quantum computing.

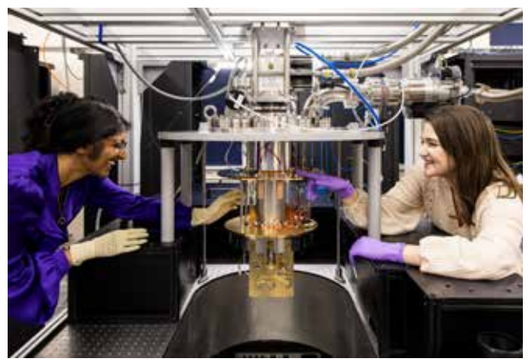
Applications development through novel quantum algorithms is another area of focus, as we work to build a quantum computing user community. Across 18 feasibility studies to date, we have engaged with 45 partners on projects spanning key industrial sectors such as environmental sustainability, financial services, materials science, and healthcare and pharmaceuticals. In one example, our applications engineers have been working with the high-street bank HSBC, hardware provider Rigetti and our colleagues at the QSL to explore the potential of quantum computing for tackling the growing problem of financial fraud.

2020	2021	2022	2023	2024
• NQCC programme setup • Internal technology road mapping	• Internal development of Trapped Ion QC starts • MOU: QCS hub, OQC • 1st NQCC Proof of Concept projects awarded • Internal project on Control architecture starts • NQCC work contracts	• Internal development of superconducting circuits • NQCC SPARQ launch • 1st NQCC Bristol University Quantum course • 3 EPSRC Fellowships funded • NQCC joins ISCF QuPharma consortium • 1st NQCC hackathon	• Feasibility studies in quantum computing applications awards • 2nd NQCC Proof of Concept projects awarded • 2nd NQCC hackathon • MOU: NPL, University of Edinburgh • 2nd NQCC-Bristol University course • QSL launch • NQCC-Q-Ctrl online learning	• Internal development of Cold atoms QC starts • NQCC SBRI Testbeds awards • Responsible Quantum Industry Forum launched • Quantum STATES principles launched • 3rd NQCC- Bristol University course • 3rd NQCC hackathon









Collaborative projects

Proof of Concept call in quantum computing

In July 2024, NQCC, in collaboration with the STFC's Campus and Cluster Team, announced the launch of a call for Proof of Concept (POC) projects in quantum computing, funded through the NQCC's SparQ programme.

Through this call, which aims to stimulate industry engagement and interactions with the NQCC, 9 projects have already been funded through previous rounds. Five of the POC projects received around £2 million of further funding in total. This points to the important relationships that NQCC can build, to try out, test and validate ideas before bidding for larger or long terms grants.

Project IDRA for distributed quantum computing

The NQCC and Nu Quantum announced Project IDRA – the first phase in building an innovative optically connected, multi-node distributed quantum computing system, to be based at the NQCC's facilities in Harwell, Oxfordshire. The project aims to overcome scientific roadblocks to scaling quantum computers, placing the UK in a world-leading position. It is funded by the National Security Strategic Investment Fund and supported by NQCC through project co-location, access to specialist equipment and technical collaboration.

Nu Quantum will develop a complete distributed quantum processor system, comprising high-efficiency qubit-photon interfaces and high-fidelity Quantum Networking Units (QNUs). These innovations will be tested at Harwell in collaboration with the NQCC.

By advancing distributed quantum computing, Project IDRA is set to distinguish the UK among other leading global quantum efforts, and further establish Harwell as a thriving hub for quantum innovation.

UKRI National Quantum Computing Centre

Quantum Business Incubation Centre (QuBIC)

The QuBIC aims to help early-stage technology companies achieve their full commercial potential by de-risking the route from 'Proof of Concept' to market for innovative new products and ideas. In December 2023, the NQCC collaborated with STFC's new business support programme, that was announced for quantum technology start-ups.

NQCC is supporting three companies providing consultancy and advice. NQCC's expertise will be of benefit to these companies, who have the potential to be a vital part of the QC supply chain in the UK. The profile of the three companies are as follows:

Applied Quantum Computing
AQC is a small start-up focussed on developing applications for optimisation, quantum simulation and quantum machine learning, and was one of the first companies to join QuBIC. The programme will assist AQC to scale up and help in its mission to assist organisations in taking advantage of quantum computing. The company is focussed on the use of quantum optimisation techniques to help in providing better solutions, with a particular focus on the finance and healthcare sectors.

Finchetto
Finchetto develops photonic processors and network switches that enable faster, more sustainable computing and is looking to enter the quantum computing market. By using photons instead of electrons, Finchetto's technology achieves higher data transfer rates and greater processing capacity. Finchetto operates in the global market, targeting regions with a high demand for advanced computing solutions in sectors such as data centers, telecommunications, and advanced research facilities.

OpenQuantum
OpenQuantum is focussed on developing control system electronics and leveraging cutting-edge open-source tools to accelerate utility-scale quantum computers in partnership with industry and government partners.

Quantum computing testbeds, delivered through InnovateUK

With the aim to accelerate growth of the UK's quantum computing ecosystem, explore critical bottlenecks in technology development, and further improve understanding of technology readiness, integration and performance, alongside enabling growth in user adoption of quantum computing, NQCC in partnership with Innovate UK launched a SBRI competition inviting proposals to develop and deliver a quantum computing testbed (prototype quantum computers) to the NQCC as a lead customer and end user.

£30 million was allocated between the seven proposals that were successfully funded through this competition. Successful companies are AegiQ Ltd, ColdQuanta UK Limited, Orca Computing Limited, Oxford Ionics Limited, Quantum Motion Technologies Limited, QuEra Computing UK Limited, and Rigetti UK Limited. The testbeds will cover a range of quantum computing modalities such as, photonics, neutral-atom, trapped-ion, superconducting circuits, and silicon spin (quantum dots).

Quantum testbed by Infleqtion, located at the NQCC's Innocation Hub at Harwell.

Quantum testbed: Aegiq

ARTEMIS: Advanced Research TEstbed Manipulating PhotonIc Statesfeedback

Aegiq will deliver a photonic QC platform based on the interfacing of hybrid semiconductor components.

Quantum testbed: Orca

Asteroidea: A flexible photonic quantum computing testbed for machine learning

Orca Computing will deliver a photonic QC testbed featuring multiple highly innovative, novel technologies in a single infrastructure platform.

Quantum testbed: Quantum Motion

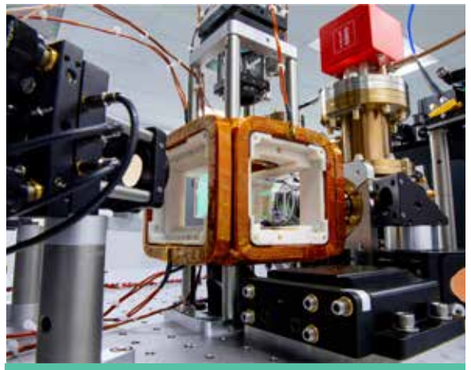
Silicon Cloverleaf: Quantum system based on spin qubit technolog

Quantum Motion's system is based on spin qubit technology with a two dimensionally scalable QPU, with control systems and a user interface.

Quantum tesbed: QuEra

Towards an error-corrected neutral-atom quantum computer

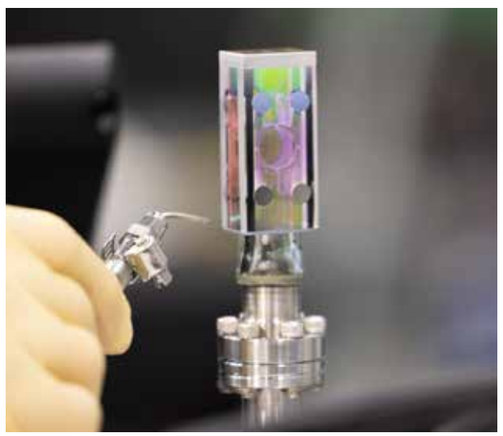
QuEra's project is designed to develop a more robust, scalable, and user-friendly neutral-atom testbed, offering an error-corrected operation.



Quantum testbed: Infleqtion

SQALE: Scalable Quantum Atomic Lattice computing tEstbed

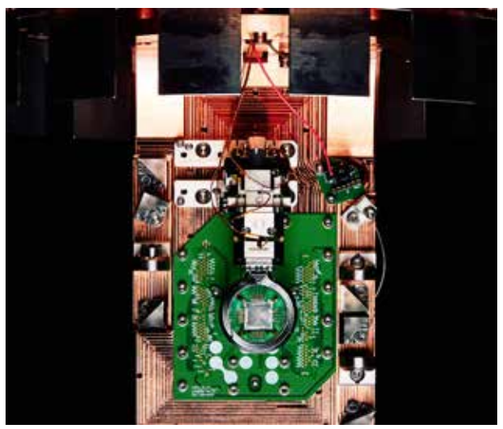
Infleqtion's (formerly, Cold Quanta) neutral-atom QC testbed will provide benefits of intrinsically stable high-performance atomic qubits.



Quantum testbed: Oxford Ionics

QUARTET: The QUantum Advantage-Ready Trapped-Ion Exploration Testbed

Oxford Ionics will develop QUARTET, a complete trapped-ion QC testbed providing ultra-low error rates, that supports field-replaceable QPUs.



Quantum tesbed: Rigetti

Full-stack superconducting testbed with tunable couplers and scalable control system

Rigetti's 24-qubit quantum computer will feature 4th-generation QPUs based on its US-based 84-qubit quantum computer.

"The NQCC played a crucial role in QuEra's decision to establish a base in the UK. Being involved in the NQCC's testbed program not only provided us with valuable exposure to the UK's vibrant quantum ecosystem but also created a sense of urgency and priority to capitalise on the collaborative opportunities available here. The support and infrastructure offered by the NQCC were instrumental in accelerating our entry into the UK market and aligning our strategy with the region's growing quantum capabilities."

Steve Suarez, UK Corporate Director, QuEra Computing.

Quantum Software Lab

Software expertise powers up quantum computing

Combining research excellence and the strategic partnership with the NQCC, the Quantum Software Lab led by Professor Elham Kashefi, NQCC's Chief Scientist, is focused on delivering effective solutions to real-world problems.

The Quantum Software Lab (QSL) established in April 2023 at Edinburgh under the leadership of NQCC Chief Scientist, Professor Elham Kashefi is working closely with quantum application engineers at NQCC to accelerate the development of quantum computing and investigate new ways in which quantum computers can provide benefits, beyond the reach of traditional computers. QSL is well positioned to tap into University of Edinburgh's excellent computer science and existing HPC capabilities, increasing NQCC's reach and engagement by attracting industry partners and developers. This will help to grow the UK's developer and user communities.

Since its formation, QSL has made significant strides in advancing its core mission of accelerating the search for practical quantum advantage. The approach has been inclusive, engaging experts from academia, industry, and government, including end-users and quantum hardware and software specialists. Together with the NQCC, the QSL has successfully engaged with this ecosystem.

The collaboration between the NQCC and the QSL aims to drive user adoption and maximise the benefit of quantum computing for industry and society. The QSL provides academic expertise and rigour when engaging with the user community to investigate emerging quantum algorithms, examine industry pain points, and choose the most appropriate hardware resources. Active projects across healthcare and life sciences, finance, logistics, and cyber security benefit from the QSL's targeted scientific knowledge creation in complementary domains, including foundations of quantum information, programming, algorithm and protocol design, quantum error correction and mitigation, verification and benchmarking. During its first year, QSL's researchers have co-authored over 60 papers exploring the full stack of quantum software research.

QSL has delivered a wide variety of events including upskilling workshops with industry partners, hosting guest lectures and the Quantum week. In April 2024, the QSL hosted Quantum Week, a first-of-its-kind five-day programme of three events. This programme brought together over 500 academics, researchers, and students with globally leading quantum computing companies and government representatives to explore scientific advancements, innovation, and impact in the field of quantum computing. QSL has engaged with 80+ industry and HEI partners to explore opportunities for scientific knowledge-sharing and to promote UK's quantum computing strengths overseas in Denmark, France, Germany, Japan, South Korea, and the USA.

QSL has evolved under the leadership of NQCC. and aims to expand its activities further to target Missions 1 and 2 with an immediate focus on supporting the NQCC's Testbed programme. QSL will continue to serve as the research and development pillar of NQCC, developing the architecture design, benchmarking and verification protocols, software tools, and algorithmic solutions. Together, NQCC and QSL can act as a strategic bridge to connect the UK quantum industry and start-ups to its world-leading scientific community.

"We are all academic researchers, but within the QSL we are nurturing a start-up culture where we want to understand and address the needs of the ecosystem," says Kashefi. "For each project we are following the full pathway from the initial pain point identified by our industry partners through to a commercial application where we can show that quantum computing has delivered a genuine advantage."

In just one example, applications engineers from the NQCC and software developers from the QSL have been working with the high-street bank HSBC to explore the benefits of quantum computing for tackling the growing problem of financial fraud. HSBC already exploits classical machine learning to detect anomalous transactions that could indicate criminal behaviour, and the project team – which also includes hardware provider Rigetti – has been investigating whether quantum machine learning could deliver an advantage that would reduce risk and enable the bank to improve its anti-fraud services.

Alongside these problem-focused projects, the discovery-led nature of the academic environment also provides the QSL with the freedom to reverse the pipeline: to develop optimal approaches for a class of quantum algorithms or protocols that could be relevant for many different application areas. For example, one of the projects is investigating how hybrid quantum/classical algorithms could be exploited to solve big data problems using a small-scale quantum computer, while another project is developing a unified benchmarking approach that could be applied across different hardware architectures.

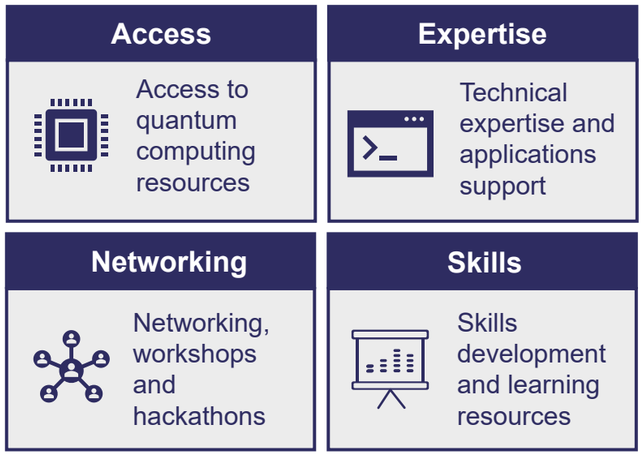
For the NQCC, meanwhile, Michael Cuthbert believes that the insights gained from this more universal approach will be crucial for planning future activities at the national lab. "Theoretical advances that are focused on the practical utilisation of quantum computing will inform our technology programme and help us build an effective quantum ecosystem," he says. "It is vitally important that we understand how different elements of theory are developing, and what new techniques and discoveries are emerging in classical computing."

Developing the UK quantum ecosystem: user engagement, skills & learning, and public outreach

SparQ user engagement programme

Catalysing quantum readiness

SparQ aims to support the pathway to quantum readiness by building knowledge and expertise in applications discovery, and developing the UK quantum computing user community. The programme is aimed at current and future professionals in industry, business, academia, and beyond.



Quantum Computing Access Programme (QCAP)

The NQCC has launched the Quantum Computing Access Programme to provide access to quantum compute services for the UK's quantum computing user community.

The programme seeks to remove access barriers and support multi-platform exploration and development. This will enable the quantum computing users to request access to a range of state-of-the art quantum computing platforms from leading technology providers. Dedicated streams will open for specific user groups, facilitating cloud access to quantum computing resources.

The National Quantum Computing Access Programme aims to accelerate scientific research, innovation, skills development and applications discovery, as a part of its **SparQ** initiatives to support the pathway to quantum readiness for the UK.

UKRI National Quantum Computing Centre

Sectoral engagement: Aviation

Enabling long term visions of sustainability

Aircraft loading optimisation
Project lead: Unisys
Consortia: NQCC, Unisys, Newcastle University

In the competitive air cargo market, airlines strive to optimise aircraft payload to maximise revenue while minimising operational costs, particularly fuel consumption. Efficiently loading air cargo not only increases profitability but also affects the aircraft's centre of gravity, which plays a critical role in reducing aerodynamic drag. For example, maintaining optimal balance on a long-haul flight (over 10,000 km), with a centre of gravity shift of less than 75 cm can save up to 4,000 kg in fuel, significantly reducing both fuel costs and CO_2 emissions.

While current solutions offer sophisticated analytics to optimise air cargo operations, they face limitations in accommodating last-minute adjustments. These adjustments, such as unexpected high-priority cargo or changes in aircraft due to technical or operational constraints, often exceed the capabilities of classical computing to process rapidly. Consequently, airlines may miss out on efficiency gains and revenue from unforeseen opportunities.

This feasibility study aims to harness the power of quantum computing to address these limitations, developing algorithms to enable more agile and optimised aircraft loading strategies. By leveraging quantum technology, the project aims to increase fuel efficiency and support sustainable, cost-effective air cargo operations, positioning airlines to better respond to the dynamic needs of the cargo industry.

This study aligns with the NQCC's commitment to pioneering quantum applications with direct impact on industry sustainability and operational resilience.

De-carbonisation in aviation
Project lead: Quantum Base Alpha
Consortia: Quantum Software Lab, NQCC

The UK is the first nation globally, to commit to legally-binding targets to achieve net-zero Greenhouse Gas (GHG) emissions by 2050. In its 2020 Carbon Budget report, the Climate Change Committee (CCC) noted that aviation contributes 8% of the UK's total GHG emissions, amounting to 39.6 million tonnes, and is projected to become the country's largest remaining emitter by mid-century. Given the long lead times for development, certification, and fleet renewal, traditional technological advances alone are unlikely to sufficiently reduce aviation emissions within the timeframe required.

With traditional computers gradually approaching theoretical limits, the Quantum Computer (QC) promises to deliver a new level of computational power and it's intuitive to investigate QC's theoretical strength in optimisation and to counter the impacts of climate change in several sectors including aviation.

In response to this challenge, this feasibility study focuses on leveraging quantum computing to develop advanced algorithms aimed at reducing aviation carbon emissions through optimised flight paths. This approach has the potential to enhance operational efficiency and reduce fuel consumption, contributing directly to aviation's decarbonisation. Additionally, the project explores Quantum Machine Learning (QML) applications to augment these optimisations, pushing the boundaries of current technological capabilities.

This work aims to complement the National Air Traffic Service's (NATS) advancements in safety and efficiency through Machine Learning (ML) and Artificial Intelligence (AI). Although ML and AI have primarily targeted safety and long-term planning, carbon emission optimisation has remained a secondary consideration, hindered by stringent safety regulations and the complexity of replacing legacy systems within a continuous 24/7 operational environment. By integrating quantum computing innovations, the project aims to overcome these limitations, enabling air traffic control to contribute meaningfully to the UK's ambitious climate goals and reduce the environmental footprint of aviation.

The projects above reflect the NQCC's dedication to pioneering breakthroughs, that address critical global challenges. Through these efforts, we aim to support the UK's journey towards a sustainable, net-zero future in aviation.

Skills and learning

Skills development provides pathways into quantum workforce. The NQCC offers a range of learning opportunities for people from diverse backgrounds to gain the skills needed to develop and program quantum computers.

The quantum community agrees on the need for more scientists and engineers with the specialist skills needed to build, operate and use quantum computers. While increased investment into the sector is certainly helping to swell the ranks of PhD students and early-career researchers with experience of both quantum hardware and software, their numbers are still likely to fall short of rising demand across academia, the burgeoning start-up sector, and larger organisations that are now looking to develop their own capability in this transformative technology. Skills development and training has therefore become a crucial priority for the NQCC, as it works to build a quantum-ready economy.

By offering a range of learning programmes, the NQCC aims to lower the barrier to entry, ensure that quantum computing is perceived as a desirable and attainable career option, and make it easier for people to imagine themselves as part of the future quantum workforce.

Doctoral studentship

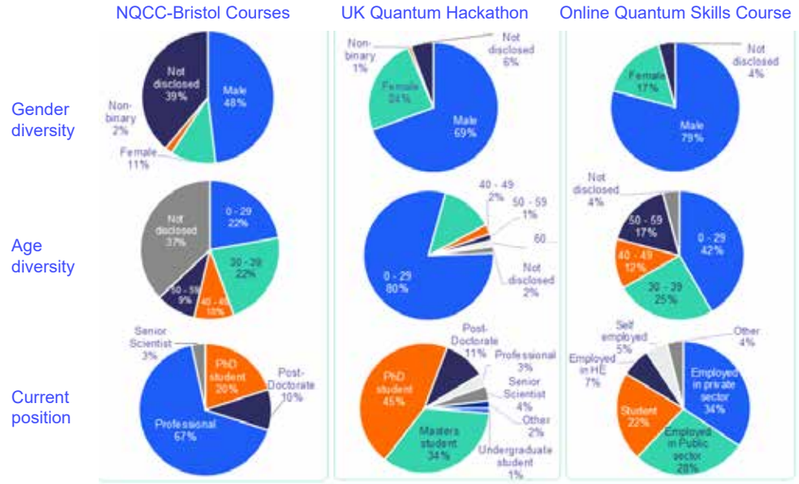
In June 2024, the NQCC announced its own doctoral studentship scheme to provide support for up to 30 students over 8 years. There are 6 doctoral studentships available for eligible UK universities, to run from autumn 2025. The studentships will be supported through EPSRC's Industrial Cooperative Awards in Science & Engineering (ICASE) scheme, with the NQCC as the industrial partner.

Early career placements and apprenticeships

The NQCC has hosted several apprenticeship placements, 8 summer placement students and an industrial placement student this year. On 25th October 2024, the Science Minister Lord Vallance met the NQCC summer students, apprentices and industrial placement students over a roundtable, held at the NQCC facility.

Developing the quantum ecosystem

The skills courses run by NQCC are successful in attracting their target groups. 77% of the NQCC-Bristol course participants are post docs or professionals. 79% of the hackathon developers are Masters or PhD students, whereas 74% of those enrolling for the NQCC's online course are in employment.



NQCC-Bristol courses and Quantum Skills course on Q-Ctrl

As a starting point, the NQCC runs an introductory, self-paced online course on Q-Ctrl's Black Opal platform, that offers a flexible and interactive learning environment for exploring the physics underpinning quantum computing through to creating quantum algorithms. For those who want to take a deeper dive, two intensive short courses are being run in partnership with the University of Bristol, with the NQCC offering a number of bursaries to cover the costs of the training. The first six-week programme provides a thorough grounding in quantum information theory, while the second builds on that knowledge to enable participants to understand key quantum algorithms and error-correction techniques. These courses are now in their third year, with participants including industry professionals, academic researchers and staff from the public sector.

Learning and engagement events

The NQCC organises and participates in a wide range of events, providing platforms for learning and networking, that all can take forward into their own work and future careers.

National Quantum Computing Centre

Alongside the formal courses, the NQCC also offers opportunities for industry professionals to experiment with emerging quantum algorithms and hardware. Through its SparQ user engagement programme, the national lab has convened workshops focusing on particular industry sectors, including financial services, healthcare and pharmaceuticals, to explore the potential of quantum computing for tackling specific use cases. This has led to a number of pilot studies that are enabling end-users to work alongside quantum experts to tackle problems that are relevant for their industries.

Industry events

In 2024, the NQCC supported and participated in a wide range of industry events through panel discussions, workshops, presentations and having a NQCC booth for face-to-face interactions.

Sectoral workshops and networking events

Last year, the NQCC participated in over 40 networking events to stay connected with a wide variety of audiences and stakeholders.

Quantum hackathons

The NQCC holds the annual UK Quantum Hackathon. In the 2024 event, over 70 developers (primarily Masters students, PhD students and postdocs), 8 quantum computing providers and 13 user organisations participated.

Careers fairs and talks

Throughout 2024, the NQCC team has delivered careers talks and attended various careers fairs to show students and teachers the variety of different job opportunities and pathways into quantum tech.

Quantum Experience Summer School

In partnership with the University of Oxford, the NQCC supported a summer school for year 12 students, which gave the students a taste of life as a quantum physicist.

Public and school events

In 2024, the NQCC's education and outreach team has exhibited in a variety of events, including Harwell Open Week, New Scientist Live, Oxford Ideas Festival, Imperial College Quantum Day Celebration. The team has also delivered public talks, workshops for schools and talks for teachers. This has enabled staff to have 1:1 interactions with over 3,200 members of the public, teachers and students throughout the year.

Quantum Hackathon 2024

Nurturing quantum talent in the UK

Quantum Hackathon 2024 taps UK talent to reveal quantum computing's potential for real-world impact.

The UK Quantum Hackathon, organised by the NQCC, continues to nurture quantum talent and foster industry-academia collaboration.

The event builds on previous successes, helping to solidify the UK's role in the discovery of applications for quantum computing. Held for the third consecutive year, it continues to provide the resources to elevate the standards of innovation and collaboration in the quantum computing landscape. As part of NQCC's SparQ user engagement program, this flagship event has rapidly become a cornerstone for nurturing quantum talent and demonstrating the practical applications of quantum computing in the UK.

The 2024 edition of the hackathon, however, set a new standard. Over three days, students and early-career researchers formed teams and worked alongside industry mentors to address real-world challenges in sectors as diverse as healthcare, energy, and engineering. Participants gained valuable hands-on experience in coding quantum algorithms and developing solutions that highlight the evolving capabilities of quantum computing.

Beyond the technical achievements, the hackathon fostered a spirit of creativity and collaboration. The team naming competition was particularly popular, with the team 'Trust me, I'm a Doctor…of physics…in training' winning for their clever and humorous name.

Teams were also asked to consider the societal impact of their use cases, drawing on the NQCC's Quantum STATES principles.

The event culminated in a showcase where teams presented their solutions to a panel of judges. The winning projects demonstrate quantum computing's potential in sectors like insurance, telecommunications, and healthcare, giving a glimpse into the transformative potential of quantum computing:

1st place:

Team **KL Divergents** tackled the critical challenge of risk aggregation evaluation for insurance losses due to natural disasters. Supported by Mind Foundry and Aioi R&D Lab, and relying on quantum resources from Quantinuum, IonQ, and Classiq Technologies, their solution demonstrated quantum computing's potential to revolutionise risk management in the insurance industry.

2nd place:

Team **Schrödinger's Apples** focused on optimising the placement of transmitters, receivers and sensors in networks, addressing a challenge presented by BT. With quantum support from D-Wave and IonQ, their solution aimed to enhance the efficiency and reliability of communication networks - an increasingly critical need in today's connected world.

3rd place:

Team **Trust me, I'm a Doctor…of physics…in training** developed a quantum model for NHS forecasting. Their project, supported by NHS England and utilising quantum resources from IonQ, Classiq Technologies, and AWS Braket, provided a novel approach to improving healthcare forecasting and resource allocation, showcasing the potential impact of quantum computing on public health systems.

National Quantum Computing Centre

Responsible and ethical QC

We adopt a responsible, forward-looking approach to consider near and long-term societal, ethical and policy implications of quantum computing research and innovation.

Drawing on our expertise and wider connections, we aim to ensure that quantum computing is used responsibly, safely, and for the benefit of society.

By embedding responsible and ethical quantum computing from the outset, we can manage risks, oversee equitable distribution of benefits, and harness quantum computing's potentially transformative capabilities deliver a brighter future for all.

Quantum STATES principles for responsible and ethical quantum computing (REQC)

To serve as a foundation for responsible and ethical development and use of quantum computing, we have developed the NQCC's Quantum STATES principles. Our principles are informed by our technical expertise and research into the wider societal and ethical implications of quantum computing, and were developed through a collaborative process, with input across our stakeholders.

With the Quantum STATES principles as guidance, we strive to embed responsible and ethical quantum computing throughout all that we do.

Quantum testbed by Infleqtion, located at the NQCC's Innocation Hub at Harwell.

Societally beneficial	*Develop quantum computing capabilities for the benefit of society, taking a pro-active and responsible approach.*	Pro-actively seek to understand the implications of quantum computing on wider society and the environment, leveraging our technical expertise
		Engage inclusively to inform the future trajectory of innovation
		Pursue goals for the good of all
Trusted	*Be a trusted voice, sharing our knowledge with the quantum computing community and wider society.*	Offer unbiased, trustworthy, informed assurance on quantum computing capabilities
		Manage expectations, cutting through overhype
		Accessibly disseminate our understanding of quantum computing and its implications
Accountable	*Recognise our responsibility to the wider community, and hold ourselves accountable for our actions throughout our activities.*	Put in place mechanisms to ensure the responsible development and use of quantum computing, throughout our activities
		Demonstrate our commitment to responsible and ethical quantum computing by sharing our efforts
		Champion a responsible approach among our collaborators and the quantum community
Transparent and explainable	*Provide transparency and explainability in the quantum computing systems we develop, procure, and use, and in our decision-making.*	Be open and honest about the capabilities and limitations of quantum computing
		Be clear about our intentions and decisions throughout our activities
		Aim for explainability, particularly where our technology informs important decisions
Equitable, fair and inclusive	*Embed fairness and inclusivity into our activities, working to build a diverse community in which quantum computing benefits are equitability distributed.*	Design for equitability and fairness, with particular consideration to vulnerable communities
		Allocate and distribute our resources through fair processes
		Provide inclusive opportunities to learn and benefit, building a diverse community
Safe, reliable and secure	*Build and test for safety, reliability, and security.*	Put in place guardrails to mitigate against harms to humans and the environment
		Work to ensure our systems function reliably as intended
		Promote and uphold best practice in data governance and information security

Equality, diversity & inclusion

The NQCC is committed to equality, diversity and inclusion (ED&I) across all of its programme. The NQCC's ED&I Working Group is working with the support of the Leadership Team, to embed a culture that drives equality, values diversity, and has inclusion at the heart of every activity. The group comprises voluntary representatives from each department of the NQCC and is currently chaired by Ion Trap Physicist Dr Georgina Croft.

The group takes an evidence-based approach, implementing practical actions, and gathering feedback to ensure our decisions are informed and representative of staff and user-community needs.

EDI initiatives in 2024

Growing on our work from the previous year, the working group initiatives for 2024 have focused on:

- Designing and implementing a wellbeing room to allow staff a space to recharge
- Delivering ED&I training and interactive activities at the annual organisational away days
- Providing pronoun badges and rainbow lanyards to our staff to show our support of the LGBTQ+ community
- Creating best practice guides for inclusive meetings, presentations, and recruitment
- Developing an internal database of available ED&I resources and training courses
- Initiating regular drop-in sessions to collect suggestions, answer questions, and signpost staff
- Reviewing our communications content to verify that we are accurately representing our diversity externally
- Implementing an annual review objective on ED&I to ensure all staff are considering best practice inclusivity in their activities

Team building

01 Away days

On away days, NQCC members come together to review our progress and discuss future plans. As our organisation continues to grow rapidly, it's equally important to dedicate time to strengthening our relationships and enhancing soft skills like communication and teamwork. Between sessions, we engage in team-building activities that encourage collaboration across different teams.

02 Quantum journal club

As a quantum centre, we strive to stay up-to-date with the latest developments in the quantum field. Each week, we hold technical talks or discussions on key changes in the quantum landscape to ensure we maintain a broad and informed perspective on our area of expertise.

03 Tuesday cake club

In each week we take a brief break to unwind and to socialise over a sweet treat. Many have embraced the challenge of home baking, with fantastic results, while some have used the opportunity to share dish from their own cultures. As we grow fostering of social cohesion remains important to us. These moments allow us all to connect on a personal level and chat about our interests beyond the NQCC.

04 Quantum coffee

The NQCC team meets regularly during the quantum coffee sessions to review the progress made in establishing the NQCC and discuss how its strategy and structure will evolve in the months ahead.

05 Rounders' club

The NQCC rounder's team, Qubats, competed in the Harwell Campus summer rounders tournament for the second year. The team is open to all who work at the NQCC, with no previous experience of this rather niche British sport necessary! The team lead by captains Emma Athawes and Georgina Croft is a great way to develop working relationships across NQCC teams and meet others from the campus.

UKRI National Quantum Computing Centre

Governance

The NQCC is governed by a Programme Delivery Board that ensures regular monitoring and evaluation to EPSRC and STFC, the two research councils that are jointly responsible for delivering the NQCC's programme. Oversight is maintained through the Programme Advisory Committee and Technical Advisory Group, both comprised of external advisors who provide support and expertise to guide the development of the NQCC and its programme.

Programme Advisory Committee

The Programme Advisory Committee (PAC) provides advice, support and challenge on the activities and programme of the NQCC. With complementary expertise across quantum technologies research, programme delivery and technical innovation, this group of external advisors offers informed opinion to the Programme Delivery Board and the NQCC leadership team on the development of the Centre within the wider context of quantum computing in the UK and internationally.

Meeting once a quarter, the PAC ensures that the NQCC links to related activities within the UK's National Quantum Technologies Programme, helps to manage any external risks that might affect the NQCC's programme delivery, and liaises with senior sponsors and external stakeholders across academia, government and industry.

Professor Sheila Rowan, Chair
Professor Rowan holds the Chair of Natural Philosophy and is the Director of the Institute for Gravitational Research in the University of Glasgow. She received the Hoyle Medal and Prize of the UK Institute of Physics in 2016, was elected to Fellowship of the Royal Society of London and received a CBE for services to science in the Queen's New Year Honours list in 2021. In 2023, she was awarded the inaugural Lifetime Achievement Award of the Philip Leverhulme Trust.

From 2016 – 2021, she was seconded (part-time) to serve as Chief Scientific Advisor to the Scottish Government and served as President of the Institute of Physics from 2021 – 2023.

Professor Sir Peter Knight
Sir Peter Knight is Emeritus Professor at Imperial College, a past President of both the Institute of Physics and Optical Society of America, chairs the National Quantum Technology Programme Strategy Advisory Board and the Quantum Metrology Institute at the National Physical Laboratory.

Michael Groves
Michael is Head of the Heilbronn Institute for Mathematical Research. He has worked as a security researcher at Government Communications Headquarters (GCHQ) for over 25 years and served as Vice Chair of the ETSI quantum-safe cryptography working group from 2015 to 2019.

Programme Delivery Board

The Programme Delivery Board (PDB) provides strategic direction and control of the NQCC's programme and activities. The PDB is chaired by the Centre's senior responsible owner – Liam Blackwell, Deputy Director of Cross Council Programmes at EPSRC – and includes the NQCC's leadership team, senior sponsors from EPSRC and STFC, and both finance and HR partners. The PDB takes a strategic role in identifying and developing initiatives to aid the delivery of the NQCC's programme, and in monitoring, managing, and addressing any risks or barriers that might affect progress. The PDB also ensures that the NQCC programme aligns with the wider activities of the research councils and the UK's National Quantum Technologies Programme, provides challenge and assistance on the implementation of the programme, and works to secure the confidence of senior sponsors and stakeholders within UKRI and the external community. The PDB typically meets once every two months, aligned where possible to key milestones in the programme or project delivery.

Technical Advisory Group

The Technical Advisory Group (TAG) provides impartial expertise and insight to help shape the technical roadmap and delivery programme of the NQCC. With extensive experience of quantum computing technologies and adjacent fields, this group of expert advisors offers an informed and independent view on the current state of progress both at the NQCC and the wider quantum computing ecosystem in the UK and internationally. Chaired by the NQCC's Chief Scientist, the TAG works with the NQCC leadership team to review and update the technology roadmap and the centre's technical programme, milestones and objectives. The TAG provides advice and challenge on technical initiatives, informs and reviews the acceptance or quality criteria for the centre's key deliverables, and maintains the technical integrity of the NQCC's programme and projects. The TAG meets twice a year, aligned with the approval process and lifecycle of the technical programme.

TAG Chairperson:
Professor Elham Kashefi, Chief Scientist, NQCC

TAG Members:

- **Dr Carmen Palacios Berraquero**, Founder & Chief Executive, Nu Quantum
- **Jonathan Legh-Smith**, Executive Director, UKQuantum
- **Dr Leonie Mueck**, VP of Product, nPlan
- **Mandy Birch,** CSE, TreQ
- **Professor Martin Dawson**, Director of Research at Institute of Photonics, University of Strathclyde, and Head & Scientific Director, Fraunhofer Centre for Applied Photonics
- **Professor Simon Benjamin**, Professor of Quantum Technologies, University of Oxford, and Co-Founder/CSO, Quantum Motion
- **Dr Tobias Lindstrom**, Principal Scientist in Department of Quantum Technology, NPL
- **Professor Viv Kendon**, Professor of Quantum Technology in Department of Physics, University of Strathclyde.

Sponsors and partners

The NQCC is a flagship programme of UK Research and Innovation (UKRI) that seeks to drive the development and exploitation of quantum computers in the UK. It builds on the strengths in quantum computing established during the first phase of the National Quantum Technologies Programme (NQTP), and operates within a wider landscape for quantum development in the UK that includes the Quantum Technologies Research Hubs, the quantum challenges and programmes within the Industrial Strategy Challenge Fund, doctoral training programmes, and the activities of the emerging quantum industrial sector. The NQCC's programme is jointly delivered by two UKRI research councils – the Engineering and Physical Sciences Research Council (EPSRC) and the Science and Technology Facilities Council (STFC).

Forging partnerships and harnessing complementary expertise

To maximise value and leverage complementary expertise within the UK's quantum computing ecosystem, the NQCC has established several strategic partnerships. These include memorandums of understanding (MoUs) with the University of Edinburgh, the National Physical Laboratory (NPL), Oxford Quantum Circuits (OQC), and the Quantum Computing and Simulation Hub (QCS Hub). Furthermore, NQCC is fostering a network of collaborations by working with academic institutions, government bodies, and NHS/charity organisations to support the development and adoption of quantum computing in the UK. We are currently engaged with 115 organisations in activities aimed at advancing quantum computing, building the future workforce, and aiding organisations in adopting this technology.

UK Research and Innovation

Engineering and Physical Sciences Research Council

Science and Technology Facilities Council

UK National Quantum Technologies Programme

Innovate UK

NPL National Physical Laboratory

Department for Science, Innovation & Technology

Ministry of Defence

GCHQ

[dstl] The Science Inside

National Quantum Computing Centre

Looking ahead

With our facilities, laboratory space and computational infrastructure operational, as well as numerous strategic partnerships in place, the year ahead is going to be the one for continued delivery, moving the focus from infrastructure to growing efforts on technology.

The first half of 2025 will see results from our in-house qubit development work, as well as completion of the deployment phase of our SBRI testbed platforms. As we progress into the second part of the year, we expect early results from our testbed tests and evaluation programmes. As we begin to explore utility across different qubit modalities, and understand noise models and error rates, we anticipate rapid insights into the suitability of algorithms against qubit structures. This benchmarking and verification activities will provide insights in support of the Quantum Mission. Towards the latter part of the year, we will seek to introduce error mitigation approaches into selected testbed qubit arrays to probe novel error codes and error suppression techniques.

We will continue to support UK researchers with an expanded user programme, as well as ongoing industry engagement on quantum readiness through SparQ and the QSL. Identifying use cases and supporting the commercial adoption of quantum computing remains a key focus in the year ahead. Alongside this technical programme, our thought leadership on ethical deployment of quantum computing and standards will continue.

By the end of 2025, we expect to have the first cohort of NQCC sponsored PhD students in post embarking on their research endeavours.

2025 has been designated as the International Year of Quantum, which comes at a fitting moment for the NQCC, as we bring our quantum suite online alongside our in-house technology programme, providing the UK users with unrivalled access to quantum computational tools and techniques.

Disclaimer

NQCC advises that the information contained in this publication comprises general statements based on scientific research and stakeholder consultation. The reader is advised and needs to be aware that such information may be incomplete and will be superseded as research progress is made. To the extent permitted by law, NQCC excludes all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it.

nqcc.ac.uk
nqccinfo@nqcc.ac.uk

Acknowledgements

Our grateful thanks to all the subject matter experts from academia and industry who provided advice and support in our technology roadmapping, work package specification and facility design requirements.

University of Strathclyde
University of Oxford
University of Bristol
University of Edinburgh
University College London
University of Lancaster
University of Bath
University of Glasgow
University of Sussex
Riverlane Research
Lanessan Technology Ltd.
Canvs Ltd.

We also acknowledge the Designers, Architects, Planning and Construction companies:

CPC Project Services LLP (Project Management)
Hawkins\Brown (Architects)
Hoare Lea (Mechanicals, Electrical, Plant and Security Partners)
Ramboll (Civil Engineers)
Arcadis (Cost Consultants)
CML Sustain (Commissioning Management)
Exterior Architecture (Landscape Architects)
Carter Jones (Planning & Development Consultants)
Harwell Science and Innovation Campus
MACE Construction Ltd.
Wates Construction Ltd.

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Released on 8th November, 2024.